UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION

Surface Impoundment Facility
Underground Coal Mine

Noninjury Impoundment Failure/Mine Inundation Accident
October 11, 2000

Big Branch Refuse Impoundment, I. D. No. 1211KY60035-01
Preparation Plant, I. D. No. 15-05106
1-C Mine, I. D. No. 15-03752
Martin County Coal Corporation
Inez, Martin County, Kentucky

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OVERVIEW

In the early morning hours of Wednesday, October 11, 2000, a breakthrough of slurry (fine coal refuse and water) occurred from the sixty-eight acre impounding area of Martin County Coal Corporation's (MCCC) Big Branch Refuse Impoundment which inundated the underground active mine workings of MCCC's 1-C Mine (refer to Figure 1). The breakthrough occurred a few minutes after a belt examiner, who was performing a preshift inspection, exited the 1-C Mine.

The slurry from the impoundment ultimately breached two underground sealed areas of the active mine (Figure 2) and subsequently exited the mine at two drift openings of the 1-C Mine: the South Mains Portal and the No. 2 North Portal (Figure 3). In addition, a relatively small volume of water exited the mine near the Big Branch Punch Out. The outflow from the impoundment was stopped by using dozers to push spoil mixture from above the impoundment into the area where the breakthrough had occurred. An estimated 306 million gallons of slurry flowed from the impoundment into the mine, causing the impoundment pool level to drop an average of 14 feet. The released volume represented 22 percent of the volume of slurry impounded above the 1-C Mine.

The flow of slurry out of the mine resulted in flooding and downstream "black-water" contamination of Wolf Creek and Coldwater Fork (Figure 4). No fatalities or personal injuries resulted from the breakthrough or mine inundation; however, extensive environmental damage occurred in these waterways and successive downstream areas.

MSHA's investigation of the accident included the following:

- Interviews of past and present MCCC employees, contractors, and persons living along the affected streams; and
- A comprehensive geotechnical evaluation of the breakthrough area.

The failure of the Big Branch Refuse Impoundment and subsequent inundation of the 1-C Mine occurred because Martin County Coal Corporation failed to follow its approved Impoundment Sealing Plan, dated August 8, 1994, and subsequent plan modification dated September 7, 1995. The approved plan included provisions to reduce seepage from the impoundment into mine workings. Failure to fully comply with these provisions resulted in internal erosion (piping) of the material between the impoundment and the mine workings. Over a period of time, the seepage into this area began to carry sand (weathered material) into the mine opening (Figure 5). As this material was carried away, a "pipe" (void) formed and worked its way toward the impoundment. As more material was carried into the mine, a larger seepage path was created allowing additional and larger particles to be carried away. This process continued until the void developed close enough to the impoundment that the remaining plug of material failed suddenly, allowing the contents of the impoundment to discharge uncontrolled into the mine.

GENERAL INFORMATION

MCCC is a mining complex located near Inez, Martin County, Kentucky (Figure 6). It is a wholly owned subsidiary of A.T. Massey Coal Company, Incorporated, of Richmond, Virginia.

MCCC's Preparation Plant is located near the mouth of the Big Branch Hollow, a tributary of Wolf Creek. The preparation plant employs 23 persons and processes approximately 7,500 tons of clean coal daily from MCCC's underground and surface mines. The preparation plant operates two 9-hour production shifts and one 6-hour maintenance shift each day, an average of 5½ days per week. Once processed, the clean coal is loaded into railroad cars of the Norfolk & Southern Railroad for shipment.

The solid waste by-product of the coal cleaning process (coarse coal refuse) is used in the construction of the Big Branch Refuse Impoundment (Figure 7), located in the valley of Big Branch Hollow. An overland belt conveyor transports the coarse coal refuse to the impoundment site. Slurry is pumped into the impounding area of the dam.

Prior to the October 11, 2000, breakthrough of the Big Branch Refuse Impoundment into the 1-C Mine, the impoundment contained 6,520 acre-feet (2.125 billion gallons) of water and slurry. The pool was 221 feet in depth at its deepest location with a surface area of 68 acres. The dam was 256 feet high, as measured vertically from the low point at its upstream toe to the low point on its crest. The volume of water and slurry stored in the impoundment above the elevation of the 1-C Mine floor at the breakthrough location was 3,280 acre-feet (1.069 billion gallons).

MCCC's 1-S and 1-C Mines are the only underground mines located adjacent to the impoundment. The 1-S Mine is in the Stockton coal seam at an elevation of approximately 1060 feet. All underground mining had ceased in this mine and it was not involved in the October 11, 2000, breakthrough accident.

The 1-C Mine is in the Coalburg coal seam which has a mined height ranging from eight to ten feet. The elevation of the Coalburg coal seam in the area of the impoundment is approximately 960 feet. The mine employs 6 underground employees and 2 surface employees. The mine operates two 9-hour shifts per day, an average of 5½ days per week. Coal is not currently produced in the 1-C Mine. The only active portions of the 1-C Mine are the No. 1, No. 2, and No. 3 North Mains (Figure 1). Belt conveyors transport coal through these mains from various MCCC mines to the preparation plant. These mains are isolated from the abandoned workings nearest to the impoundment by seals constructed in the 1st Left off of the No. 2 North Mains. On some mine maps, the locations of the seals are also identified as those constructed in the 1st Left off of the South Mains. For purposes of this accident investigation report, we will consistently identify the seals at issue as those constructed in the 1st Left off of the No. 2 North Mains.

The following were the principal officials for the Preparation Plant and 1-C Mine at the time of the accident:

Dennis R. Hatfield, President
Larry Muncie, Superintendent (Preparation Plant)
David M. Hensley, General Underground Superintendent (1-C Mine)
Troy (Ed) Chafin, Manager of Safety

Before the October 11, 2000, accident, the last MSHA regular Health and Safety Inspection of the Preparation Plant, which included the impoundment, was completed on September 29, 2000. The Nonfatal Days Lost incident rate during the previous quarter for the Preparation Plant was 0.00. The last MSHA regular Health and Safety Inspection of the 1-C Mine was completed on August 11, 2000. The Nonfatal Days Lost incident rate during the previous quarter for the 1-C Mine was 0.00.

DESCRIPTION OF THE ACCIDENT

On Tuesday, October 10, 2000, at approximately 4:00 p.m., Matthias Simpkins, Belt Examiner, arrived at the West 1 Portal of the 1-C Mine to begin his normal duties. These duties included cleaning and examining surface belts and conducting examinations of the underground 1 North, 2 North, and 3 North belt lines. He finished cleaning the outside belts at the West 1 Portal by 6:00 p.m. At this time, Lovell Tony Bowen, Electrician, transported Simpkins to the North Mains Portal where Simpkins continued cleaning surface belts. At approximately 9:00 p.m., Simpkins began examining the underground belts, beginning at the 1 North belt. By 11:00 p.m., Simpkins had reached the portion of the 2 North belt which was adjacent to the 1st Left off the No. 2 North Mains seals. At this point, he left the belt and explored adjacent entries and crosscuts, traveling past the seals, while searching for potential gob storage locations.

Simpkins observed the seals while traveling through this area. At that time, no hazardous conditions or abnormal water conditions were noticed. Simpkins then resumed his belt examination and exited the mine at the West 1 Portal at approximately 11:50 p.m. Simpkins telephoned the dispatcher, Sammy Branham, to report that he had exited the mine.

At approximately 12:05 a.m., Bowen was working beside the overland belt near the West 1 Portal when he noticed that the overland belt had stopped. Bowen radioed Branham (who was still talking to Simpkins on the mine phone) to report his observation. Branham then displayed the belt monitor screen on his computer, which indicated that the 2 North belt was off. Simpkins unsuccessfully attempted to restart the belt while Bowen traveled in his truck to the No. 2 North Portal. Upon arrival, Bowen observed slurry flowing out of the drift openings at a high velocity and at a depth of approximately three feet (Figure 8). Bowen reported his findings over the radio just before being joined by Simpkins at approximately 12:15 a.m.

At 12:30 a.m., Bowen and Simpkins traveled to the South Mains Portal where they observed significant flow from this opening, which they estimated to be greater than that at the No. 2 North Portal. The force of this flow caused significant erosion, creating a large gully just below the portal (Figure 9). Simpkins reported their findings to Steve Gooslin, Preparation Plant Foreman. Simpkins returned to the No. 2 North Portal at approximately 1:00 a.m., and observed that the slurry flow had increased to a depth of approximately five feet. Meanwhile, Gooslin and Terry Music, Utility Man, traveled to the Big Branch Refuse Impoundment. They drove around the impoundment, stopping at several locations to look and listen for indications of a breakthrough. On the fourth stop, at approximately 1:30 a.m., they observed flowing water converging at a point offshore.

Meanwhile, at approximately 1:15 a.m., Branham contacted Dennis Hatfield, MCCC President, regarding the occurrence and was instructed to contact the following: John R. Stepp, Manager of Surface Mining; Larry Muncie, Plant Superintendent; Troy (Ed) Chafin, Manager of Safety; and Robert Jordan, Chief of Security. At approximately 1:40 a.m., Gooslin notified Muncie that slurry from the impoundment was flowing into the 1-C Mine. Muncie ordered Gooslin to immediately close the preparation plant and to withdraw all miners. Dozer operators were brought to the impoundment, at 2:00 a.m., to begin pushing material into the area where the breakthrough had occurred. The flow of slurry into the 1-C Mine was stopped at approximately 4:30 a.m.

Security guards were posted on Coldwater Fork and Wolf Creek to monitor the flow of slurry and to monitor the streams' elevation. Slurry continued to accumulate for several days in Coldwater Fork, raising the stream level and prompting the evacuation of several families from nearby homes. Berms were constructed to prevent the slurry from flowing into several of these dwellings (Figure 10).

The slurry traveled for several miles in Coldwater Fork and Wolf Creek, before flowing into the Tug Fork of the Big Sandy River and eventually reaching the Ohio River (Figure 11). More than 300 million gallons of slurry were released from the impoundment during the accident. Slurry exiting from the underground mine visibly affected over 100 miles of waterways.

NOTIFICATION OF THE ACCIDENT

At approximately 3:00 a.m. on October 11, 2000, Stevie Justice, Acting Supervisor of MSHA's Martin, Kentucky, Field Office received a telephone call from Ed Chafin, Manager of Safety. Chafin reported a breakthrough of slurry from the Big Branch Refuse Impoundment into the 1-C Mine. He also reported that slurry flowed out of the mine and into the waters of Coldwater Fork and Wolf Creek. At 6:00 a.m., Justice and Hank R. Bellamy, Mining Engineer from MSHA's District 6 Office, arrived at the mine to assess the situation and secure the scene of the accident. MSHA Headquarters in Arlington, Virginia, was notified by MSHA's District 6 Office. Tony Oppegard, Advisor to the Assistant Secretary, was dispatched to the mine to coordinate MSHA's response with the other involved agencies.

MCCC notified Dallas Sweeney, Emergency Services Director, Martin County, Kentucky, at approximately 3:30 a.m. of the incident.

The Kentucky Division of Emergency Management received a call from Philip Meade, Mining Engineer, MCCC. At 3:45 a.m., Meade's call was referred to Gene Blair, who was duty officer that day for the Kentucky Division of Water, Department for Environmental Protection, Kentucky Natural Resources and Environmental Protection Cabinet. Blair, who was in charge of the Division of Water's Environmental Response Team, mobilized the team.

Hershell Tackett, Supervisor, Martin Office, Kentucky Department of Mines and Minerals, was notified by Chafin at 3:35 a.m.

Jeff Benton, Environmental Inspector, of the Kentucky Department for Surface Mining Reclamation Enforcement's (KDSMRE) Prestonsburg Regional Office was notified by Meade sometime between 7:00 a.m. and 7:30 a.m.

INVESTIGATION OF THE ACCIDENT

Drilling Operations and Geotechnical Investigation

Immediately after discovering the October 11, 2000, breakthrough location in the Big Branch Refuse Impoundment, MCCC personnel utilized dozers to push soil and rock into the impounding area to stop the breakthrough of slurry into the 1-C underground mine. This created a pad extending into the impoundment. Later, MCCC contracted with their consultant, Geo/Environmental Associates, Inc. (GA), to drill holes using this pad as the drill base. Drilling was discontinued by MCCC following the completion of one hole.

MSHA determined that it was necessary to utilize a geotechnical investigation and a geophysical survey to aid in determining the cause or causes of the breakthrough and to reveal its location. MSHA contracted with Triad Engineering, Inc. (TRIAD), St. Albans, West Virginia, to conduct surveying, drilling, material testing and geotechnical investigations. A copy of TRIAD's report is provided in Appendix D.

Before MSHA's drilling program could commence, the existing pad had to be further extended into the impoundment to provide an expanded drilling base (Figure 12). At MSHA's request, MCCC extended the pad by hauling, dumping, and spreading coarse coal refuse in the area of the breakthrough.

The Engineering Department of MCCC furnished TRIAD with the coordinates of the underground workings located in close proximity to the breakthrough area. Using a closed loop survey, TRIAD "staked-out" the pertinent mine entries, crosscuts, and pillars on the coarse refuse drill pad. Base lines were established and used to locate the drill holes (Figure 13). A separate part of this report describes the surveying in more detail.

The purposes of drilling the breakthrough area were the following:

- Determine the exact location of the breakthrough;
- Define the limits of the strata;
- Ascertain the composition of the overburden of the Coalburg seam in the area of the breakthrough;
- Find out if the underground workings and the outcrop barrier were accurately plotted in relation to the impoundment; and
- Delineate the location and thickness of the seepage barrier near the location of the breakthrough.

TRIAD provided geologists on site at all times during drilling. Their functions were to log all holes and direct the drill crews. Additionally, MSHA had a geologist full time at the site to direct the actual location of drilling and the logging of holes. Drilling started on November 28, 2000. A second drill rig from TRIAD commenced operation on November 30, 2000. Other parties that had geologists present during all or most of the drilling were P & A Engineering and Consultants, Inc. (P & A), and GA (as contracted by MCCC), and the KDSMRE.

The drilling program consisted of a total of 47 test borings. Figure 13 illustrates the location of the drill holes with respect to the 1-C Mine workings. Forty-four of the test borings were advanced through the unconsolidated portions of the overburden using 3¼-inch inside diameter hollow stem augers. Three test borings were advanced using four-inch inside diameter flush-joint casing. Standard penetration testing and sampling of the unconsolidated overburden were done in selected borings at designated intervals. In addition to these standard penetration tests, undisturbed samples (Shelby tube) were collected within the overburden of designated borings at various depths.

Once solid rock was encountered during drilling, rock core samples were obtained by a NQ double core barrel (47.6 mm). Most of the test borings that encountered mine voids were cased down to bedrock with 2-inch inside diameter flush-joint PVC pipe to enable sampling of material in the mine void and allow video photography of the overlying bedrock of the borings. All split spoon, Shelby tube, rock core, and mine void samples were visually classified at the site by TRIAD geologists. All samples were transported to the TRIAD laboratory in St. Albans, West Virginia, for testing.

In addition to the drilling, a test pit was excavated into the “seepage barrier” at a point where the barrier was still exposed above the level where fines had been deposited. The purpose was to obtain a bulk sample of the barrier material for a grain-size distribution analysis. The location of the test pit is shown on Figure13.

To complement the drilling operations, a geophysical survey was undertaken. TRIAD subcontracted with Enviroscan, Inc., Lancaster, Pennsylvania, to perform a mise-a-la-masse electrical profiling field survey on the nights of December 19 and 20, 2000.

During TRIAD's drilling for MSHA, the KDSMRE videotaped the strata in 20 of the 47 drill holes using a borehole camera. A videotape of each hole was given to the MSHA investigation team for use and review. The video information gathered was consistent with other core hole data. On site drilling ended on January 23, 2001.

Attempted Exploration of the 1-C Mine

On November 27, 2000, members of MSHA's Mine Emergency Unit (MEU) prepared to enter the underground workings of the 1-C Mine to ascertain the extent of damage caused by the slurry inundation. Prior to the underground exploration, an examination was made of the mine portals to determine air direction, quantity, quality, and to ensure that all power had been removed from the mine. No appreciable airflow could be detected at the No. 2 North Portal. Since the exhaust fan was located near the North Mains Portal, it was assumed that slurry was roofed at some location between the fan and the No. 2 North Portal mine openings. Due to the depth of slurry present in the area, no underground exploration was attempted from the No. 2 North Portals.

On November 28, 2000, the rescue team entered the mine through the belt entry at the North Mains Portal. The team was equipped with Draeger Model BG 174A breathing apparatuses. However, they did not go under oxygen during the exploration. The team encountered the first evidence of slurry approximately one crosscut inby spad no. 76 in the belt entry, approximately 2,000 feet inby the portal (Figure 14). The slurry was present across five of the entries in the main entries, and excessive depths of water prevented exploration of the one remaining entry. It was estimated that the slurry was in contact with the mine roof at a location near spad no. 93, approximately 2,300 feet inby the portal. Excessive depths of water were encountered at various locations during exploration. The underground pumps had not been operated since the inundation. The exploration was terminated due to the depth of slurry and the rescue team exited the mine.

Interviews

From December 5, 2000, to February 1, 2001, MSHA took accident investigation statements from past and present employees of MCCC and contractors who had first hand knowledge of the operation and engineering of the impoundment. Residents of the affected areas of the release were interviewed. Several retired employees that worked in the 1-C Mine, who had knowledge of how the panel (located where the impoundment breakthrough occurred) was mined, also provided statements. A total of forty-four people were interviewed and provided voluntary statements. Some of the individuals who provided statements requested that their statements be taken in confidence. For this reason, their names are not listed in Appendix B.

DISCUSSION

History of Coal Waste Disposal in Big Branch Hollow

MCCC started to use Big Branch Hollow for the disposal of coal refuse when the preparation plant began processing coal in February 1972. At that time, disposal of fine coal waste was by pumping it in slurry form into an impoundment located near the mouth of Big Branch. Disposal of coarse coal refuse was by deposition in a refuse pile in Little Branch, which is the hollow immediately to the east of Big Branch. An aerial photo (Figure 15), taken February 20, 1976, shows the location of the original Big Branch Impoundment, as well as the coarse refuse disposal in Little Branch.

For reference purposes, it should be noted that the dam for the original impoundment was located about 2000 feet downstream of the crest of the present Big Branch embankment. The original impoundment, as will be explained below, has been covered by the downstream toe of the present embankment and is roughly 160 feet below the level of the Coalburg seam. Figure 16 shows the location of the original impoundment within the cross-section of the present embankment.

A construction permit for the original impoundment had been issued on June 17, 1971, by the Division of Water, Department of Natural Resources, Commonwealth of Kentucky. The impoundment was formed by earthen embankments at both the upstream and downstream ends. The original downstream embankment was 65 feet high with a crest elevation of 775 feet.

On August 28, 1973, the Big Branch Impoundment was inspected as part of a nationwide inspection of coal refuse disposal impoundments in the aftermath of the Buffalo Creek[1] dam failure. That inspection identified a slurry impoundment with a surface area of about 7 acres and a downstream embankment that was 75 feet high.

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[1] On February 26, 1972, the failure of a coal waste dam at Buffalo Creek, West Virginia, resulted in the deaths of 125 people.

By October of 1974, the downstream embankment had been raised to a height of 90 feet and the impoundment area was approximately 10 acres. During the life of the original impoundment, inspections by personnel from the Mine Enforcement and Safety Administration (MESA, a predecessor to MSHA) and the Kentucky Department of Natural Resources and Environmental Protection (KDNREP) had identified various site deficiencies, including unstable slopes and an inadequate spillway. MCCC used the impoundment for slurry disposal until January 31, 1975, when MESA issued a closure order on the impoundment for a failure to abate violations and required MCCC to discontinue its use for slurry disposal. This action was based on the failure to correct the site's safety deficiencies, including the failure to provide an adequate spillway.

When the Big Branch Impoundment could no longer be used for slurry disposal, MCCC disposed of the fine coal waste by pumping the slurry either into underground mine workings or into small cells constructed to the north of Big Branch Hollow. In March of 1979, MCCC began using a filter press system to recover water from the slurry thickener underflow. This system processed the fine coal refuse into a "filter cake" material. This "filter cake" was disposed of by mixing it with the coarse coal refuse, trucking the combined waste into Big Branch, and spreading it with bulldozers.

The closure order on the Big Branch Impoundment was terminated on June 4, 1979, after MCCC submitted a plan, developed by L. Robert Kimball & Associates (Kimball), to improve the stability of the downstream embankment by constructing a buttress. This was followed by another report by Kimball, dated July 1979, entitled "Future Use and Abandonment Plan for the Big Branch Coal Refuse Disposal Area". This report called for the existing slurry impoundment to be filled with the combined coarse refuse/filter cake material. Once the impounding capability was eliminated, the combined refuse product was to be disposed of by continuing to place it in Big Branch as a non-impounding valley-fill. The plan showed contours for the disposal of the combined refuse for a period extending over 25 years. In a letter dated January 4, 1980, MSHA approved this plan, with some minor modifications.

It was during this period, when the combined refuse product was being disposed of in a non-impounding valley fill, that underground mining took place in three panels in the area where the Coalburg seam outcrops in Big Branch Hollow (Figure 17).

No specific dates could be determined, but sometime in the early 1980's, MCCC disposed of some of their fine coal refuse by pumping it into abandoned sections of the 1-C Mine in the Big Branch area. In the vicinity of the eventual impoundment location, these underground slurry disposal areas are depicted on Figure 18.

The Kimball plan had called for a series of three diversion ditches to be constructed around the back of the Big Branch Hollow valley fill as the combined refuse level rose. "Channel 1" was to be constructed just below the level of the Coalburg seam outcrop in the back end of the hollow. A May 1, 1984, aerial photo (Figure 19) shows a road and diversion ditch constructed around the back end of the impoundment that appears to be just below the Coalburg seam level. The trees had been removed in a zone above the road and areas below the road had been cleared and grubbed.

The combined refuse was deposited in Big Branch until 1985. At that time, Big Branch was converted back to a slurry impoundment, based on a plan developed for MCCC by ESMER and Associates, Inc., Consulting Engineers (ESMER). This plan called for the fine coal refuse to once again be pumped in slurry form into an impoundment which would be created by an embankment constructed of coarse refuse generated by the preparation plant. In this way, the plan accounted for 41 years of coarse refuse production while creating capacity for 62 years of slurry disposal. The crest of the embankment was planned to be raised to an eventual elevation of 1200 feet. In developing this plan, a total of 53 borings were drilled to obtain information on the geologic conditions in Big Branch Hollow (Figure 20).

Concerning the underground mining in the vicinity of the impoundment, the ESMER plan (dated June, 1984) stated the following:

> There are underground mines in two coal seams around the perimeter of the impoundment site. Mine 1-S beneath the eastern edge of the site in the Stockton seam was abandoned on November 30, 1972. The Stockton seam outcrop is at elevation 1075 on the western perimeter of the site. Mine No. 1-C extends around the entire perimeter of the site in the Coalburg seam and is still in operation. The Coalburg seam outcrops between elevation 960 and elevation 1000. The locations of the mining areas are shown on Drawing No. 83014-1 in Appendix B. It is not anticipated that subsidence will be a problem, since the underground mines are situated only beneath the perimeter of the impoundment site and do not extend for any appreciable distance directly below the proposed structure.

Phase I of the ESMER plan was approved by MSHA on March 5, 1985. Phase I called for construction of an embankment with 3 to 1 side slopes to a crest elevation of 940 feet. The Phase I embankment was constructed on the existing combined coal refuse.

In November 1986, MSHA approved Phases IA and II of the ESMER plan which would bring the crest to an elevation of 960 feet. This is roughly the elevation of the Coalburg seam. The rest of the plan (Phases III through VI) was approved on December 4, 1986, after some revisions to the decant design and the construction specifications. These phases would raise the crest of the embankment from an elevation of 1095 feet (Phase III) to its final elevation of 1200 feet (Phase VI), which is approximately 240 feet above the level of the Coalburg seam.

An aerial video of the site, taken on June 1, 1989, shows a road around the back end of the impoundment at a higher elevation than the road that had previously been constructed near the elevation of the Coalburg seam. The impoundment level, at that time, had risen to an elevation of approximately 958 feet. Although precise information is not available, the elevation of this road, in the area where the October 2000 breakthrough occurred, appears to be in the range of 980 to 990 feet. A zone above the road had been cleared and grubbed. Some vegetation was visible growing back in the area below the road that had previously been cleared. No specific information is available on how much the original hillside may have been disturbed, in the area of the 2000 breakthrough, by road construction.

The impoundment was developed and operated without incident until May 1994. The embankment had reached a crest elevation of 1040 feet and the pool level had risen to an elevation of 992 feet. On May 22, 1994, water and slurry from the impoundment broke into abandoned mine workings in the 1-C Mine. The location of this breakthrough is shown in Figure 21 and details about the breakthrough are provided in a separate section of this report.

Following the May 1994 breakthrough, Ogden Environmental & Energy Services Company (OGDEN) prepared a report entitled "Impoundment Sealing Plan - Big Branch Slurry Impoundment", dated August 8, 1994, which addressed remedial measures. OGDEN had taken over as MCCC's engineering consultant on the impoundment in April 1994. The remedial measures included constructing a "seepage barrier" around the perimeter of the impoundment where the Coalburg seam had been mined near the outcrop; opening up the South Mains to provide free drainage from the 1-C Mine in that area; and constructing an underground seal to provide added protection for the active area of the 1-C Mine. Details on the remedial measures are provided in a separate section of this report. After review by MSHA and some revisions, the Impoundment Sealing Plan was approved on October 20, 1994.

Aspects of the Impoundment Sealing Plan regarding the underground seals and the drainage out of the South Mains Portal were modified in subsequent submittals from MCCC. These revisions were approved on September 29, 1995.

In 1996 and 1997, MCCC submitted various plans, prepared by GA, to modify Phase III of the impoundment plan. GA had taken over as MCCC's engineering consultant for the impoundment in February 1996. The engineering personnel, who developed the impoundment plans under OGDEN, were then employed by GA, where they continued to develop plans for and monitor the impoundment. The Phase III changes included modifying the coarse refuse compaction specifications in certain areas, extending the coarse refuse belt conveyor, and installing a new decant pipe. In a letter dated October 6, 1998, MSHA approved the changes. The approved crest elevation in Phase III was 1095 feet.

Stage IV (previously referred to as Phase IV) modifications were submitted by GA in December 1998. These modifications proposed to raise the crest of the embankment to elevation 1140 feet using upstream construction methods. On October 26, 1999, MSHA requested additional information on aspects of the plan involving the stability of the embankment under seismic loading and the potential for subsidence due to the additional loading on the pillars in the Coalburg and Stockton seams. A response prepared by GA dated February 3, 2000, concerning the potential for subsidence, included calculations of a factor of safety of 4.8 for the coal pillars underlying the raised embankment. The submittal also stated:

> Nevertheless, recognizing that the potential for subsidence in previously deep mined areas always exists, even though the potential may be low, we have included mitigative measures in our design to reduce the potential for damage due to subsidence. Specifically, free water in the impoundment will be kept pumped down during normal operations and fine refuse will be discharged evenly across the upstream face of the embankment to form a beach of coarse-sized refuse particles. In the unlikely event that surface cracks were to develop, we expect that the fine refuse embankment matrix will be 'self-healing' in that the cracks would fill with filter-size sand particles of fine refuse.

Review of this submittal had not yet been completed by MSHA when the October 11, 2000, breakthrough occurred.

Geology

The Big Branch Refuse Impoundment is located in the Cumberland Plateau of eastern Kentucky, an area of sharp ridges, V-shaped valleys, and high topographic relief, commonly of 400 to 600 feet. The Cumberland Plateau is underlain by rocks of the Lower and Middle Pennsylvanian Series, consisting predominantly of sandstone and shale with lesser amounts of claystone and coal. The two coalbeds associated with the impoundment site are situated in the Breathitt Formation and are the Stockton seam of the Broas coal zone and the Coalburg seam of the Peach Orchard coal zone (Figure 22).

The Stockton seam (approximately 4 to 5 feet thick) outcrops between 1060 and 1075 feet elevation at the impoundment site with varying overburden thickness depending on topography. Under the steep ridges, overburden may be as high as 300 feet and often the seam outcrops above the bottom of the V-shaped valleys. The sandstone overlying the Stockton seam contains a set of regular spaced near vertical joints and minor shale lenses, easily identified in the highwall near the drill site. The Coalburg seam (approximately 8 to 10 feet thick) has an outcrop elevation between 960 and 975 feet and lies roughly 100 feet below the Stockton seam. The interburden between the two coal seams is predominately sandstone.

The Big Branch Refuse Impoundment was constructed near the top of a narrow V-shaped valley, which strikes northwest with two hollows branching to the north and one hollow branching to the southwest. The hillside slopes of the hollows within the valley are steep and heavily wooded. The valley walls are made-up of thick sequences of resistant sandstone that have formed very steep slopes with pronounced cliffs. The Stockton seam was surface-mined around the impoundment in 1995; leaving a highwall 100 to 150 feet high and a bench 100 to 200 feet wide. The impounding structure is constructed across the southeastern portion of the valley (Figure 1).

The soils in the Big Branch watershed have been mapped by the Natural Resources Conservation Service as part of the National Soil Survey. The hillsides around the impoundment, where not disturbed by surface mining activities, are mapped as being the Hazleton-Shelocta-Fedscreek soil complex, which occur on 30% to 80% slopes on mountainsides that face south and west in the area. It is colluvium formed from weathered material and can contain as much as 80% angular sandstone rock fragments in its lower horizons. The natural soil on the hillside at the location of the breakthrough can be expected to be the Hazleton series, which is a very deep, very stony, well-drained soil with rapid permeability.

Mine Development

The 1-C Mine was developed from drift openings in the Coalburg seam by room and pillar mining from the surface with the first cut of coal occurring in March, 1971. The mine produced coal by utilizing continuous mining machines and diesel powered haulage units through December 1994. At the time of the breakthrough on October 11, 2000, the No.1 North, No. 2 North, and No. 3 North Mains were the only active areas of the 1-C Mine. The belt conveyor in these entries was utilized to convey coal from adjacent underground and surface mines to the preparation plant. A map showing the extent of the 1-C Mine development in the vicinity of the impoundment can be found in Figure 23.

The October 11, 2000, breakthrough occurred in the abandoned 1st Right Panel off the 1st Left Off South Mains of the 1-C Mine (Figure 24). Mining was conducted in this panel from 1978 through August 1981. The 1st Right Panel entries extended south off the 1st Left Off South Mains for a distance of approximately 1000 feet toward the outcrop beneath a point adjacent to Big Branch. Rooms were mined east and west off the entries on 50-foot centers, also toward the outcrop, creating an overall panel width of approximately 1200 feet. There was no second mining of the coal pillars in the 1st Right Panel.

The earliest available approved roof control plan for the 1-C Mine was dated December 14, 1994. This plan depicted a typical columnar section of mine strata. It showed the immediate roof consisting of 0-10 feet of shale and/or sandstone and the main roof consisting of 60 feet of sandstone. The approved roof control plan also required ⅝-inch diameter steel roof bolts on centers not exceeding 4 feet. The minimum required lengths for roof bolts were 30 inches for conventional roof bolts and 42 inches for resin grouted bolts.

Interviews with miners from this section indicated that it was a common practice not to bolt the roof in the last cut of coal in entries extending toward the outcrop. Reportedly, there were no major roof falls in the 1st Right Panel. On MCCC mine maps, the ends of some entries are shown with a dashed line, rather than a solid line. This indicates that the location of the face of this entry was estimated, rather than actually surveyed, either because the roof conditions were poor, or more likely, because the final cut had not been roof-bolted.

May 22, 1994, Breakthrough Event

During an on-shift examination at approximately 11:30 p.m. on May 22, 1994, Steve Gooslin, 3rd Shift Preparation Plant Foreman, observed an unusual amount of water flowing across a strip bench in an area near the downstream portion of the right abutment of the Big Branch

Impoundment. Further investigation revealed that slurry from the impoundment had broken into the 2nd Left Off South Mains panel of the 1-C Mine. The water was discharging from the 3rd Left Off South Mains panel at a point where the water had broken through a thin coal barrier where the Coalburg seam had been both underground and surface mined (Figure 25).

The exact location of the flow from the impoundment was not discovered until approximately 2:55 a.m. on May 23, 1994. MSHA was notified at 3:17 a.m. Emergency repairs to plug the breakthrough area were started at approximately 3:30 a.m. and the flow was reportedly stopped at 6:30 a.m. Emergency repairs consisted of using bulldozers to push material from the surrounding hillside out into the impoundment over the area where the breakthrough had occurred.

The mine workings in the vicinity of the impoundment in the area where the breakthrough occurred had been abandoned and sealed prior to the breakthrough. Drift openings at the South Mains Portals and Mill Branch had been backfilled with overburden and were blocked. The impoundment inflow accumulated in the lower elevations of the mine in the 2nd and 3rd Left Off South Mains sections and eventually built up to approximately 4 feet deep behind a set of seals across the 1st Left off of the No. 2 North Mains (Figure 26). These seals separated the abandoned section of the mine from the No. 2 North Mains, which were active and used to maintain a belt conveyor for transporting coal through the ridge to the preparation plant. The 1st Left off of the No. 2 North Mains seals were reportedly constructed of 16-inch thick solid block.

The impoundment inflow eventually broke out of the mine in three places (Figure 25). Reportedly, the majority of the flow exited the mine by breaking through the thin section of outcrop barrier in the area observed by Gooslin. This was about 3100 feet to the southeast of the point where the impoundment broke into the mine. Flow also broke out of the mine through the backfilled South Mains Portal (approximately 2600 feet to the west) and seepage occurred through the backfilled Mill Branch portals (approximately 2200 feet to the southwest).

An estimated 343 acre-feet, or nearly 112 million gallons, of water and slurry discharged from the impoundment in this event. At the time of the breakthrough, the water and slurry level in the impoundment was at an elevation of 992 feet. This put the water and slurry level roughly 32 feet above the base of the mine workings in the Coalburg seam. Following the event, the impoundment level had dropped approximately 6 feet.

According to the MCCC mine map, in the area where the breakthrough occurred, an entry had been driven to within approximately 38 feet horizontally of the original ground surface (Figure 27). Based on a contour map of the area, the minimum amount of cover above the mine entry in the vicinity of the breakthrough, assuming a mining height of 8 feet, was approximately 18 feet (measured diagonally). No information is available on how much of this cover was rock and how much was soil.

The outflow in the 1994 breakthrough was mostly water and caused no significant downstream damage. According to the MSHA accident report, the breakthrough occurred through an opening created by a collapse of the mine roof or by water from the impoundment penetrating a natural hillseam in the roof rock. The report recommended that the impoundment plan be modified to ensure against a similar occurrence.

In a follow-up investigation to the 1994 breakthrough, MSHA identified a number of issues concerning the future monitoring and use of the site. These included installing weirs to monitor the outflow from the mine and evaluating the seals, separating the active and abandoned portions of the mine, to determine their structural adequacy in the event of another breakthrough. Additionally, it was recommended that MCCC have their geotechnical consultant formulate a plan to prevent another failure of this type. This information was forwarded to MCCC by letter dated July 6, 1994.

MCCC responded by having a plan for the future use of the site developed by their consultant, OGDEN. The plan was titled “Impoundment Sealing Plan - Big Branch Slurry Impoundment” (Impoundment Sealing Plan) and was dated August 8, 1994. When MSHA reviewed the plan, it was not approved. By letter dated September 9, 1994, to MCCC, questions were raised about the placement of the proposed “seepage barrier”, the opening of the South Mains Portal for drainage, and the construction of the mine seal in the 1-C Mine. Following discussions with MSHA, additional information was provided by MCCC in a letter dated October 5, 1994. The plan was then approved by MSHA on October 20, 1994. Details about the plan are explained in the following sections of this report.

Remedial Plan Following the 1994 Breakthrough

The remedial plan following the 1994 breakthrough included both short-term and long-term measures. The short-term measures included the following: restricting miner access into the active belt conveyor area of the 1-C Mine until the water behind the 1st Left off of the No. 2 North Mains seals receded to below the middle water pipe level; opening the South Mains Portal to allow discharge; continuing to backfill the impoundment leak area; and performing preshift examinations of the 1st Left off of the No. 2 North Mains seals. The short-term plan also included the following statement:

> Flow from the South Mains will be monitored daily, until the remedial work at the seepage point is completed. Monitoring will be done during regular impoundment inspections after that. Any unusual change in flow quantity or quality that would indicate possible impoundment leakage will be reported immediately to MSHA and appropriate mine management.

The long-term measures included analyzing the relationship of the mine workings to the impoundment to determine if additional remedial work was needed and placing a 30-foot wide lift of coarse refuse along the outcrop where the breakthrough occurred.

The detailed long-term plan was contained in the Impoundment Sealing Plan. The two main features of the plan were 1) to construct a “seepage barrier” around the perimeter of the impoundment above the area where the Coalburg seam had been mined near the "outcrop", and 2) to construct an underground seal across the 1st Left off of the No. 2 North Mains to provide added protection for the active area of the 1-C Mine.

"Seepage Barrier" in 1994 Impoundment Sealing Plan

The "seepage barrier" specified in the 1994 Impoundment Sealing Plan was to be constructed using the spoil produced from surface mining the Stockton seam around a significant portion of the impoundment. The Stockton seam lies about 100 feet above the Coalburg seam. According to the plan, "...the primary purpose of the barrier will be to reduce, to the extent practical, seepage from the impoundment that could contribute to the occurrence of another breakthrough." The secondary purpose of the barrier was to "provide bulk that will collapse into the subsided area in the event another 'breakthrough' occurs and should form a 'plug', limiting the amount of fine coal refuse and water entering the mine." In a plan view, the "seepage barrier" is shown in Figure 28.

According to the plan, the spoil "should contain primarily shot sandstone rock", and the barrier "should be compacted until stable and graded using a dozer." The barrier was to be constructed with 2 to 1 slopes, with a minimum vertical thickness of 12 to 25 feet, and with at least a 12-foot wide bench at about mid-height. The surface of the completed "seepage barrier" was to be seeded and mulched to reduce erosion. A drawing of a "typical seepage barrier section" was included in the plan and is shown in Figure 29.

When the barrier was constructed, the impoundment level was already above the Coalburg seam level. Records indicate that the pool level would have been at about an elevation of 1000 feet when the barrier was placed in the area of the October, 2000, breakthrough. The plan called for the shot rock to be placed into the existing pool but did not specify that the barrier extend down to the level of the Coalburg seam. The plan did specify that the toe of the "seepage barrier" would extend at least 50 feet out into the impoundment.

The plan included two provisions concerning the operation of the impoundment with the "seepage barrier" in place. One provision was that "fine refuse shall be directed along the barrier by periodically redirecting the discharge of fine refuse slurry." This was so that, as the fine refuse settled and consolidated on the surface of the barrier, seepage would be further reduced due to the low permeability of the consolidated fine refuse. The second provision was that "to further reduce the seepage from the impoundment, the pool level in the impoundment should be maintained as low as possible, thereby, reducing the quantity of clear water in the impoundment and the hydraulic head".

After review by MSHA and some revisions, the Impoundment Sealing Plan was approved on October 20, 1994. The "seepage barrier" was constructed between February and September of 1995 (Figure 30). Persons interviewed who had observed the barrier being constructed indicated that it was generally constructed as called for in the plan. The annual impoundment certifications submitted for 1995 and 1996 by GA certify that impoundment construction during these periods had been "in general accordance with the approved plans and specifications".

Discussion of "Seepage Barrier" Design

Based on contour maps produced after the barrier was constructed, it appears that, at least in the area where the breakthrough occurred, the "seepage barrier" had actually been made thicker than called for in the design (Figure 31). Instead of having a slope of 2 horizontal to 1 vertical, portions of the barrier are at 3 to 1, or flatter. Instead of being 25 feet thick, portions of the barrier appear to be as much as 40 feet thick. These resulted from there being a higher volume of spoil available than what was needed to construct the minimum approved "seepage barrier" thickness at this location.

The primary purpose of the barrier was to reduce the amount of seepage occurring from the impoundment into the mine workings. But the shot-sandstone, due to its relatively high permeability, could not be expected, by itself, to significantly reduce the quantity of seepage. In their response dated October 3, 1994, to questions raised by MSHA about barrier placement, OGDEN acknowledged that "...the primary seepage control is provided by fine refuse deposited in the impoundment against the fill as operations progress. This control reduces the potential for piping of material from the fill into the openings and seams." This is why the plan specified that the slurry be directed along the barrier. Based on information obtained during the investigation, it was determined that the slurry discharge outlet was never relocated along the barrier.

Based on the high water marks following the October 2000 breakthrough, the water surface at the breakthrough area had been approximately 2 feet above the level of the fine refuse. This meant that the water in this area had direct access to the highly permeable barrier material without passing through a layer of fine refuse. Without a layer of fine refuse for "seepage control", the ability of the barrier to significantly reduce seepage was limited.

The secondary purpose of the barrier was to provide bulk that would collapse into a subsided or cracked area and plug the leak in the event another breakthrough occurred. For the barrier material to act as a plug, it would have to either become wedged in an opening, or be large enough that, once it collapsed into the subsided area, the force of the flow would not remove it. Neither of these scenarios occurred since a portion of the "seepage barrier" was carried into the mine with the flow of slurry.

The barrier material did not act to plug the opening because either the opening was larger than had been anticipated and/or the barrier material ended up being finer than anticipated. It was estimated by calculations that an opening larger than 60 square feet was needed to accommodate the quantity of discharge that occurred. The presumption that the overburden was "primarily sandstone with some shale" may have led to the judgment that an opening of this size would not develop. No geotechnical exploration had been done to determine the specific geologic conditions at the 1994 breakthrough or elsewhere around the outcrop. Regarding the size of the barrier material, there is evidence that the shot sandstone may have been poorly cemented and susceptible to breaking down from handling and weathering.

Reinforced Mine Seals

One area of the 1-C Mine that experienced additional water as a result of the 1994 breakthrough was the 1st Left off of the No. 2 North Mains. The No.1 North Mains and No. 2 North Mains beltlines were used to convey coal from adjacent underground and surface mines to the preparation plant. Although water backed up against the lower existing mine seals for the 1st Left off of the No. 2 North Mains, all seals remained intact. Because of the water accumulation behind these mine seals, the operator proposed the construction of a hydraulic mine seal in the 1st Left off of the No. 2 North Mains to protect miners that work along the active beltline if another breakthrough were to occur. A plan addressing the hydraulic mine seal was submitted to the District Manager by letter dated August 10, 1994, from Elmer Howard, Safety Coordinator for MCCC. The design of the hydraulic mine seal was prepared by OGDEN. The seal design consisted of a reinforced concrete wall capable of supporting a hydraulic head of 18 feet. The 18-foot design parameter was based on the maximum anticipated head on the seals in the event of another breakthrough. The submitted plan was approved by the District Manager on September 9, 1994. This plan was not implemented.

A revised mine seal plan was submitted to the District Manager by letter dated September 7, 1995, from Tim Campoy, P.E., Chief Engineer for MCCC. The revised plan proposed strengthening the six existing mine seals by adding a one-foot thickness of gunite with steel reinforcement placed against the existing seals and extending the existing water traps and atmospheric sampling pipes through the new structure. Design calculations for the revised seals were provided by OGDEN. The revised mine seal plan was approved by the District Manager on September 29, 1995.

Construction of the revised mine seals was performed by H&B Contractors, Inc. (H&B), in February and March, 1996. The construction drawings provided by MCCC to H&B showed the mine seals being hitched into the rib to a depth of one foot with a # 6 vertical rebar near the midpoint of the hitch and # 4 horizontal rebars extending to the edge of the coal (Figure 32). The construction drawings also showed three ⅞-inch diameter rock bolts being installed on 5-foot centers into the mine roof, and four ⅞-inch diameter rock bolts on 4-foot centers being installed into the mine floor. However, the mine seal drawing approved by MSHA showed five rock bolts in the mine roof and five rock bolts in the mine floor. The changes incorporated into the construction drawings provided by MCCC to H&B had not been submitted to and approved by the District Manager prior to implementation.

The reinforced seals were not constructed in accordance with the approved plan. The specified number of rock bolts were not installed in the mine floor and roof. Howard Branham, President for H&B, stated during his initial interview that the seals were anchored 2 feet into the ribs with rebar but had not been hitched. After his initial interview, Branham was again contacted to obtain additional information concerning the installation of the reinforced gunite seals. Branham then indicated that he had since spoken with the work crew that had constructed the seals. They reminded him that air-chippers had been rented for the purpose of removing material so the seals could be hitched into the ribs. The seals were then hitched in accordance with the approved plan. During his initial interview, Branham also stated that the mine roof and floor rock bolts were installed per the construction drawings provided to him by MCCC. During the follow-up conversation with Branham, he stated that his crew also reminded him that, for ease of installation, four rock bolts were installed in both the mine floor and roof. However, this rebar configuration was still not in accordance with the drawings detailed in the approved plan.

Analysis of the approved versus as-built construction methods indicated that the seals, built as described by Branham, would have withstood forces equivalent to that of the approved design. Yielding in bending, the weakest mode of failure for both designs, would not have been affected by the number of rebars installed into the roof and floor and was estimated to occur at a head of approximately 27 feet of slurry. Therefore, it was determined that the hydraulic pressure exerted on these seals during the 2000 breakthrough exceeded that which was anticipated in the approved impoundment sealing plan.

The Annual Report and Certification of the Big Branch Refuse Impoundment by GA, dated July, 1996, covering the period from June 27, 1995, through June 27, 1996, stated that MCCC "has constructed the Big Branch Slurry Impoundment in general accordance with the approved plans and specifications." Construction of the six reinforced mine seals, which was part of the approved plan, was not included in the annual report and certification. Representatives of GA, during interviews, stated that the reinforced seals were not part of this certification. This is consistent with the tasks performed by GA during the reporting period. As listed in the Annual Report and Certification, this did not include monitoring of the installation of the reinforced seals. There were no other records found or provided at the time of the investigation that indicated that the reinforced seals were constructed in accordance with the approved plans and specifications.

Mine Map Accuracy

TRIAD was contracted by MSHA to perform surveying work to establish the horizontal and vertical control for use in locating the preliminary and final location of the holes drilled. They also verified the accuracy of MCCC's mapping of the 1-C Mine with relationship to the location of the Big Branch Refuse Impoundment.

The surveying accomplished by TRIAD was done using established surveying methods (Appendix D). The coal company's control points, the control points established by TRIAD to locate the mine works, and the final location of the drilled holes were triangulated to a closure accuracy of 1:100,000.

The surveying was done with the cooperation of MCCC's Engineering Department which furnished coordinates and locations of control points and digital mapping data for the 1-C Mine.

MCCC's underground mine surveying practice is to use closed-loop surveys to a closure accuracy of at least 1:30,000.

It was determined that MCCC's mapping of the 1-C Mine as it applied to the orientation of the mine entries and the locations of the coal pillars in the area of the breakthrough, was accurate with the exception of Drill Holes DHX-10 and DHX-15. Mine voids were found at these two locations where the mine map showed no mining (Figure 13).

Drilling Program Results

The drilling program consisted of forty-seven test borings in the general area of the breakthrough. All drilling was performed from the drill pad prepared by MCCC. The pad was constructed by placing coarse coal refuse overtop of the spoil which had been deposited to stop the slurry discharge. The holes were drilled to define, in the breakthrough area, the breakthrough location, the limits of the Coalburg seam, the composition of the overburden, the thickness of the "seepage barrier", the location of the underground workings, and the material in the mine workings. The test borings ranged from 84 to 120 feet in depth.

The drilling revealed that the "seepage barrier" was variable in composition but generally consisted of silty or sandy material and sandstone rock fragments. Borings through the "seepage barrier" could normally be advanced by augering or driving a split-spoon sampler. Since the barrier was constructed of the same material as was used in plugging the breakthrough, there was no clear distinction between these materials. The layer of natural ground beneath the "seepage barrier" was generally sandy and was identified by higher blow counts than the "seepage barrier" in standard penetration testing.

The sandstone between the Stockton and Coalburg seams was found through the drilling to be gray and massive with a medium to coarse-grained texture. Occasionally this sandstone contained zones of carbonaceous and shale laminations of varying thickness. Iron staining, near vertical fractures, was sometimes observed. A zone of weathering was detectable at the top of the sandstone. This weathered sandstone zone was brown in color and less hard than the unweathered portion. A thin gray shale unit was sometimes present between the coal and the sandstone. This shale unit was not encountered in the test borings which were drilled into the mine workings. The unit likely was either taken during the mining of the Coalburg seam or had sloughed off. The material below the Coalburg seam was a soft gray clay shale which transitioned into sandstone.

The drilling results and available contour mapping were combined to estimate the prefailure conditions at the breakthrough as shown in Figure 31. These results confirmed that MCCC's mine mapping accurately depicted the extent to which entries had been mined toward the outcrop in the area of the breakthrough. At the base elevation of the Coalburg seam, the horizontal distance from the face of the 50-foot long entry (Number 1 Entry) to the original hillside was approximately 70 feet. This is consistent with the topographic map submitted by MCCC with their Impoundment Sealing Plan. Of this 70-foot horizontal distance, there was 15 to 18 feet of full-seam coal beyond the face and the rest of the distance consisted of the thinning-out coal and unconsolidated material.

As also shown on this cross-section, at the end of the 50-foot long entry, the minimum overburden thickness was about 27 feet (Figure 33). Because of the depth of weathered and unconsolidated material, the amount of rock vertically above the face was less than 15 feet thick, with the minimum thickness of rock above the face being approximately 10 feet.

Based on the results of the test borings, Figure 34 is an isopach map depicting the sandstone thickness overlying the 1-C Mine. The map shows the range of thickness of the sandstone from the 65-foot interval to where it was not found (zero-foot interval). This map shows an area at the end of the 50-foot long entry where the sandstone has thinned, due to the washout effect during the breakthrough.

Figure 35 is an isopach map of the Coalburg seam thickness in the area of the breakthrough. Examination of this map reveals a “bulls eye” area, at the end of the 50-foot long entry, showing a thinning of the coal seam due to the washout effect during the breakthrough.

In test borings beyond the 50-foot long entry, specifically DHX-4 and DHX-8, the layer of natural ground and sandstone above the Coalburg seam, as well as a portion of the Coalburg seam, were absent (Figure 36). Test borings DHX-5, DH1-1, and DH1-10 also revealed a portion of the Coalburg seam to be absent, although the overlying sandstone and the layer of natural ground were present. Additional test borings (DHX-3, DHX-6, DHX-12, DHX-13, DHX-16, DH1-6, and DH1-7) were drilled to define the extent of missing coal and/or strata. The ground generally appeared intact in these borings.

Based on examination of the test borings, the profiles, and the isopach maps, it was concluded that the location of the breakthrough was at or near the end of the 50-foot long entry.

As indicated above, the complete drilling results are contained in the TRIAD report which is an appendix to this report. It should be noted that TRIAD did not have access to all of the maps, plans, interviews, and other background information pertaining to the site and the accident. For these reasons, confusion may result. For example, the report indicates that “In summary, the results of our investigation indicate that the impoundment failure is a consequence of mining operations in the Coalburg Coal advancing in close proximity to the outcrop of the coal seam.” In fact, the mining at the point of the breakthrough had been completed in 1981, long before the impoundment was constructed.

Another concern is that, for the purposes of their report, TRIAD defined the term “outcrop” differently than is used by MCCC. TRIAD defines the “outcrop” as the point where the coal seam comes in contact with unconsolidated material, while MCCC typically uses the term to designate the point where the horizontal extension of the coal seam intersects the surface. This difference may cause confusion, such as when TRIAD refers to the MCCC plan-view drawing showing that “a minimum scaled distance of approximately 70 feet...existed between the end of

Entry No. 1 and the Coalburg outcrop line". TRIAD then indicates that based on the test borings the "net distance between the end of Entry No. 1 as depicted on Martin County Coal maps and the actual coal seam outcrop (point at which the top of the coal seam meets unconsolidated material) was on the order of 15 to 18 ft". Because of the different definitions of "outcrop," these distances cannot be directly compared. The 70-foot represents the distance from the end of Entry No. 1 to the original hillside, while the 15 to18-foot distance represents only the portion of that total distance that is coal. It was confirmed during the investigation that the total distance from the end of Entry No. 1 to the original hillside was approximately 70 feet, as depicted on MCCC's mine maps.

Finally, the TRIAD report states, referring to the 15 to18 feet of coal past the end of the 50-foot long entry, that "This minimal thickness of solid coal barrier combined with the continually increasing hydrostatic pressure as a result of the rising slurry level resulted in piping/erosion of the barrier and eventual breakthrough of slurry into the mine workings." This statement may give the impression that the failure occurred strictly through the coal barrier, whereas, the overall results indicate that the failure was likely through a portion of the coal barrier and the thinning layer of rock above it.

Geophysical Survey Results

The purpose of the geophysical survey conducted as part of this investigation was to provide information on the location of the breakthrough. An electrical survey, using the mise-a-la-masse method, was conducted. In brief, this method involved inserting an electrode into the mine (through a borehole) and mapping the flow of current from the mine workings to the surface of the drill pad. Use of the method is based on the presumption that a higher level of electrical conductivity would be detected at the point where the breakthrough occurred versus the surrounding ground.

The mapping of the geophysical results shows two peaks in the voltage readings (Figure 37). One peak is located along the left side of the 50-foot long entry on Line 1. The second is along the edge of, and overtop, a pillar lying between Lines 2 and 3. Holes drilled in the locations of the electrical peaks showed that there was intact rock below these points. Therefore, they could not represent locations of the breakthrough. Taking the findings of the drilling and geophysical work together, leads to the conclusion that the geophysical results did not represent the location of the breakthrough because they were influenced by the presence of mineralized discontinuities.

Potential Modes of Failure

The available information on the geologic and mining conditions in the vicinity of the breakthrough was examined to determine the likely cause or causes of the accident. The main causes considered included pillar failure, roof failure, presence of a hillseam, shear failure, and internal erosion (piping).

Pillar Failure

The pillars in the vicinity of the breakthrough vary in size and shape. The smallest pillar is approximately 20 feet by 25 feet. The average size of the ten pillars closest to the breakthrough is approximately 25 feet by 31 feet. The cover above these pillars, to the original hillside, varies from approximately 60 to 100 feet. Pillar height in the area is 8 to 10 feet and the entries are typically 20 feet wide. No problems had been reported in this mine with the pillars punching into the shale floor.

As shown in Figure 13, two of the sampling holes were drilled into pillars to gain information on the condition of the pillars and to obtain samples of the coal. One hole, DHP-1, was drilled into the smallest pillar located near the breakthrough. Compressive strength testing on ten samples of coal core indicated a range of strengths from 1330 to 4870 pounds per square inch (psi) with an average of 3535 psi. Without making any adjustments for the shape of the coal samples, their average strength converts to an in-situ coal strength of 780 psi. This value is conservative because it was not adjusted to the equivalent strength for a coal cube. The coal strength of 780 psi compares to an in-situ strength of 900 psi, which is now commonly used by the coal industry in pillar design.

At the time of the breakthrough, the average overburden over the smallest pillar consisted of approximately 50 feet of rock, 15 feet of natural soil, 25 feet of "seepage barrier", and 5 feet of slurry. Using the tributary area method, the stress that this loading imposed on the pillar is estimated at 340 psi.

Using Bieniawski's pillar strength formula, the factors of safety of the smallest pillar are found to be 3.1 and 3.6 for in-situ coal strength values of 780 and 900 psi, respectively. These factors of safety indicate that pillar failure was highly unlikely. This is consistent with the findings of the drilling program, which found full columns of coal in the two holes drilled into pillars. Furthermore, in holes drilled adjacent to pillars, the roof was found to be standing intact. The conclusion is that pillar failure was not likely a factor in the breakthrough.

Roof Collapse

With the relatively shallow cover over the mine workings near the coal outcrop, a potential mode of failure is that a roof fall occurred and the material above the mine opening collapsed to the surface. This is especially a concern at the intersections closest to the outcrop. The results of the drilling program, however, provide no evidence of a collapse of the main roof in the area of the investigation. The intersections in the vicinity of the breakthrough were found to be standing, as was the roof in the entries driven toward the outcrop.

Presence of a Hillseam

The term "hillseam"[2] is used in eastern Kentucky to describe a weathered joint that occurs in shallow mine overburden. Hillseams, formed by stress relief, tend to parallel topographic contours. They occur in greatest frequency within 200 feet of the coal outcrop. They can range from an iron or mud-stained crack in the mine roof to zones 1 to 2 feet wide, consisting of intensely weathered rock, rock fragments, or mud. When a hillseam is initially encountered underground, it is not unusual for there to be an inflow of water or mud.

Since the breakthrough apparently occurred in an area where the rock was thinning out and weathered, it is possible that a hillseam existed in this area and played a role. Some open fractures were found during the drilling program, but none were more than about an inch wide. The drilling program found no evidence of a hillseam large enough to have accommodated the quantity of flow that occurred into the mine.

Shear Failure

A potential mode of failure was that the material between the end of the 50-foot long entry and the impoundment failed suddenly from the shear stresses imposed by the ground and water pressures. As indicated by the drilling program and illustrated in Figure 31, such a failure would have required shearing through at least 65 feet of sandstone, natural soil and the "seepage barrier". With this amount of material, the shear stresses would be low and a shear failure would not occur.

However, the minimum thickness of rock above the end of the entry (angling diagonally toward the impoundment) was approximately 10 feet. The minimum horizontal width of full-seam coal remaining beyond the end of the entry was 15 to18 feet. With these conditions, a potential failure mode was that the rock or coal left at the end of the mine entry failed from the shear stresses. This would leave only unconsolidated material between the mine and the impoundment.

The water pressure that was acting on the rock and coal at the end of the entry is difficult to estimate due to the variable permeabilities of the materials involved. Another difficulty is that the shear strength, that was available, is unknown. A layer of shale, softened by water, or the presence of joints or highly weathered zones which would be expected near the outcrop, could provide sliding surfaces with a much lower shear strength than intact rock.

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[2] "Hillseam Geology and Roof Instability Near Outcrop in Eastern Kentucky Drift Mines", RI 9267, U.S. Bureau of Mines, 1989.

One scenario is to consider the full hydrostatic pressure from the pool level to have been acting on the thinnest section of rock and on the coal barrier. Combined with the ground pressure, the total pressure is estimated at approximately 50 psi. Considering this pressure to be acting on a plug of rock that is 10 feet long, and the same size in cross section as the end of the 50-foot long entry (10 by 18 feet), the average shear stress on the plug is approximately 16 psi. The average shear stress on an 18-foot long barrier of coal is less than 10 psi. Intact sandstone and coal would be expected to have higher shear strengths than these values. Furthermore, the actual shear stress was likely considerably less than the full hydrostatic value, because of the head loss that occurred as water seeped into the mine. However, without knowing the available shear strength, the factor of safety against a shear failure of the sandstone or coal is unknown.

It is concluded that a sudden shear failure of the full thickness of material between the mine and the impoundment did not occur. However, given the thinness of the strata and the unknown shear strength conditions at the breakthrough, a shear failure of the rock and/or coal at the end of the 50-foot entry could have been a factor by creating a condition where there was only unconsolidated material, subject to internal erosion, between the mine and the impoundment.

Internal Erosion ("Piping")

Seeping water creates a drag force on the material that it passes through or around. Internal erosion ("piping") is a process by which seeping water carries away small particles of soil or weathered rock. As more material is carried away, the amount of concentrated seepage increases allowing larger particles to be removed. This process can continue until a "pipe", or enlarged flow path, develops back to the source of the seepage.

By October 11, 2000, the pool level in the Big Branch Impoundment was at an elevation of approximately 1060 feet, or approximately 90 feet above the level of the mine workings. Water was seeping into the mine workings from the impoundment. One purpose of the "seepage barrier" was to decrease the quantity of seepage from the impoundment.

As the impoundment had been developed, roads and diversion ditches had been constructed around the back end of the impoundment. The original hillside had been cleared and grubbed. As indicated previously, in the area where the October 2000 breakthrough occurred, it appears that there had been one road just below the level of the Coalburg seam (Figure 19). An aerial video of the impoundment, recorded in 1989, shows another road 20 to 30 feet above the Coalburg elevation. Based on the available information, it does not appear that large cuts were made in the original hillside when these roads were constructed, but it is likely that some material had been excavated.

The breakthrough occurred at the end of the 50-foot long entry near the coal outcrop where poorer ground conditions are generally encountered. This is because the material is more weathered and the joints have more of a tendency to be opened from stress-relief. Furthermore, 19 years had passed since the mining in the area of the breakthrough occurred. In that time, the condition of the immediate roof had likely deteriorated due to exposure to water and the mine atmosphere. Based on interview statements, it also would be expected that the final cut in the 50-foot long entry had not been bolted or otherwise supported. Then, over 13 years after the underground mining in the Coalburg seam, the surface mining of the Stockton seam occurred. The Stockton seam is approximately 100 feet above the Coalburg. Approximately 140 blasts were shot during the surface mining. The vibrations from this blasting could have caused spalling of loose roof or rib material at the end of the 50-foot long entry.

One possible scenario is that, over a period of time, seepage at the end of the 50-foot long entry began to carry sand (weathered material) into the mine opening (Figure 5). As material was carried away, a "pipe" (void) formed and worked its way back toward the impoundment. As more material was carried into the mine, a larger seepage path was created allowing more and larger particles to be carried away. This process could have continued until the void developed close enough to the impoundment that the remaining plug of material failed suddenly, allowing the contents of the impoundment to discharge uncontrolled into the mine.

As part of MCCC's impoundment inspection program, the outflow from the South Mains Portal was monitored on a weekly basis. At a small pond that collected the flow coming out of the mine, the discharge was recorded as the depth and clarity of water passing through an 18-inch diameter pipe. From July, 1994, until September 23, 1999, the depth of water in the pipe varied from a low of 2 inches to a high of 9.5 inches, with an average of 5.5 inches. From September 23, 1999, until just before the breakthrough, the depth varied from a low of 7 inches to a high of 12 inches, with an average of 8.6 inches. This amount of increase in the average flow depth means that the average flow rate through the pipe more than doubled after September, 1999.

Figure 38 shows the outflow readings at the South Mains Portal compared to the pool level in the impoundment and the monthly rainfall recorded at Jackson, Kentucky. Jackson, located approximately 50 miles to the southwest of the impoundment, is the closest National Weather Service station to the Big Branch Impoundment. At the time that the readings increased at the South Mains Portal, in September 1999, the rise in the pool level was steady. The amount of rainfall recorded at Jackson for the previous four months was 6 inches below normal, and the rainfall at Jackson for the following six months was over 7 inches below normal. Considering the rainfall records, the South Mains Portal discharge readings indicated that the rate of seepage from the impoundment into the mine more than doubled approximately one year before the breakthrough.

As far as the erosion or movement of the material is concerned, from the area of the breakthrough to the South Mains Portal, the flow path through the mine workings is over 4000 feet long. In flowing over this distance, it is likely that sediment being carried with water would have been deposited at low points in the mine. This could explain why no significant changes were noted in the clarity of the South Mains Portal discharge during the weekly impoundment inspections.

Other factors to consider with respect to this scenario include the following:

- Based on the high water mark evident following the failure, the pool level had been approximately 2 feet above the deposited layer of fines.

- The relatively high permeability of the shot rock portion of the "seepage barrier", combined with the pool level being above the settled fines in the area of the breakthrough, meant that the pool water seeped into the mine without the flow rate being restricted as intended in the approved plan.

- At the end of the 50-foot long entry, the amount of solid rock overburden was pinching out quickly and the width of full-seam solid coal barrier remaining was on the order of 15 to 18 feet. Internal erosion of material could have initiated either from a portion of the thin coal barrier or the roof rock near the face, unraveling or sloughing under the constant seepage forces and the increasing vertical stress.

- There is evidence that the shot rock sandstone used to construct the "seepage barrier" was poorly cemented, making it susceptible to breaking down to soil-sized particles. Samples of the sandstone on the Stockton bench were observed to have weathered into a pile of sandy material. Visual observation of drill hole samples from the "seepage barrier" and natural soil zones indicated that this material was predominantly silt, sand, and weathered rock fragments. A limited number of laboratory tests classified the materials as silty sands or sandy silts ("SM" in the Unified Soil Classification system). With respect to piping potential, as indicated in the "Design Manual, Soil Mechanics, Foundations, and Earth Structures", Department of the Navy (NAVFAC DM-7, 1971), soils in this classification are categorized as having the "Least resistance to piping".

Internal erosion or piping as a failure mechanism is consistent with the findings of the drilling program as shown on (Figure 36).

<u>Other Factors</u>

Other factors considered as possibly playing a role in the breakthrough were the weather conditions, seismic activity, and refuse slippage.

Weather: The following information was reported by the National Weather Service at Jackson, Kentucky, for October 10, 2000: The rainfall for October 10, 2000, was zero. The rainfall for the month of October, up to that date, was 0.05 inches, which is 1.07 inches below normal. The year-to-date rainfall was 39.24 inches, which was 0.23 inches above normal. The temperature on October 10, 2000, ranged from 36^{o} F at 7:59 a.m. to 66^{o} F at 5:07 p.m.

Seismic activity: The U.S. Geological Survey's National Earthquake Information Center maintains a database on earthquakes in the United States. The database includes all earthquakes of magnitude 3 and higher. In the month prior to the breakthrough, no earthquakes are indicated in the database within 1000 kilometers of the Big Branch Impoundment. The Center also keeps records on seismic events induced by mining activity, e.g. explosions and roof falls. These records show no recorded activity in Kentucky or West Virginia in October, 2000. Additionally, a review of the Kentucky Geological Survey (ROKY) seismic station seismogram was conducted by the OSM. Their review found no seismic events around the time of the impoundment failure.

Refuse Slippage: Sometime during the breakthrough of the slurry into the 1-C Mine, about 5 surface acres of coarse refuse fill in the southwest fork area of the impoundment moved downward and toward the center of the pool (Figure 39). While the amount of vertical movement varied, it was as much as 25 feet in some locations. Testimony by MCCC personnel indicated the area was being filled with coarse coal refuse overtop the slurry to extend the refuse belt and that it had been experiencing incremental vertical movement prior to the failure. This is consistent with normal displacement and the consolidation of underlying fine refuse. The timing and extent of the sudden movement of the coarse refuse fill during the breakthrough event indicates this movement was due to a foundation failure. This was as a consequence of a loss of the fine refuse adjacent to and beneath the fill into the 1-C Mine.

Based on the information indicated above, there is no evidence that unusual weather or seismic activity triggered the breakthrough.

Summary of Potential Modes of Failure

The Big Branch Refuse Impoundment broke into the 1-C Mine as a result of a progressive failure of a portion of the coal barrier and the thin layer of rock above it, at the end of the 50-foot long entry. With the pool level above the fines at the back end of the impoundment, the impounded water had direct access to the shot rock portion of the "seepage barrier" in the failure area. Over time, the stresses imposed by the overburden and the impoundment, combined with the seeping water acting on and through the weathered coal and rock, caused the materials to loosen, deteriorate, erode and/or slough off. The seepage conditions became more critical as the impoundment level rose. By October 11, 2000, the combination of the erosion or deterioration of the materials at the end of the 50-foot entry and the increasing head in the impoundment reached a point where the remaining material could not resist the pressure. A progressive piping-type failure is consistent with the findings of the geotechnical investigation and the other available information.

Discussion Summary

1. Based on the surveying and the geotechnical investigation, the extent that mining occurred toward the outcrop in the area of the breakthrough appears to have been accurately depicted on the mine map.

2. Where the breakthrough occurred, a dead-end entry had been driven for a distance of 50 feet toward the Coalburg outcrop. On MCCC mine maps, the end of this entry is shown with a

dashed line, rather than a solid line. This indicates that the location of the face of this entry was estimated, rather than actually surveyed, either because the roof conditions were poor or, more likely, because the final cut had not been roof-bolted.

3. The 50-foot long entry was driven to within approximately 70 feet of the location of the Coalburg seam “outcrop” line, as indicated on MCCC mine maps.

4. The Coalburg “outcrop” line shown on MCCC mine maps was reportedly established by projecting the base of the coal seam elevation, as found in exploration holes in the area. Typical practice would have been to locate the “outcrop” line more accurately as additional information became available from mining activities. Reportedly, no prospecting or surveying activities had been conducted in Big Branch Hollow to locate the “outcrop” line.

5. Drilling revealed that the Coalburg coal seam did not extend horizontally to the surface in the area of the breakthrough. For a distance of approximately 40 feet back into the hillside, the material was natural soil at the coal seam elevation.

6. At the end of the 50-foot long entry, the amount of vertical overburden to the original ground surface was approximately 30 feet. The 1994 Impoundment Sealing Plan indicates that “The overburden consist of primarily sandstone with some shale.” Since no exploration holes had been drilled in the vicinity of the outcrop, prior to the breakthrough, the actual thickness of rock over the end of the entries was not known.

7. Subsequent drill holes in the area of the breakthrough indicate the minimum overburden thickness was 27 feet (measured diagonally). Of that distance, 10 feet was weathered and jointed sandstone with the remaining material being sandy soil. The amount of full-seam solid coal remaining was 15 to 18 feet.

8. The geotechnical investigation indicated there was no evidence of a collapse of the main roof in the area of the breakthrough.

9. The geotechnical investigation found no evidence of pillar failure in the vicinity of the breakthrough.

10. A layer of fine refuse had settled out and accumulated along a portion of the “seepage barrier” in the back end of the pool. Based on the high water mark evident following the failure, the pool level had been approximately 2 feet above this deposited layer of fines.

11. With the pool level being above the layer of fine slurry, the impounded water had direct access to the shot rock portion of the “seepage barrier”. The barrier was comprised predominantly of shot sandstone. Evidence, on the surface of the Stockton seam bench and in the drill hole samples, indicated that at least some of this sandstone was susceptible to weathering and breaking down to a sandy material.

12. The relatively high permeability of the shot rock “seepage barrier”, combined with the water level being above the settled fine refuse in the area of the breakthrough, meant that the water seeped into the mine without the flow being restricted as intended in the approved plan.

13. By October 11, 2000, the pool level was at an elevation of approximately 1060 feet, which is approximately 90 feet above the mine workings of the 1-C Mine.

14. A sudden shear failure of the full thickness of material between the mine and the impoundment did not occur. However, given the thinness of the strata and the unknown shear strength conditions at the breakthrough, a partial shear failure of the rock and/or coal at the end of the 50-foot entry could have been a factor. This could have created a condition where there was only unconsolidated material, subject to internal erosion, between the mine and the impoundment.

15. Based on examination of the test borings, the profiles, and the isopach maps, it was concluded that the location of the breakthrough was at or near the end of the 50-foot long entry.

16. A likely scenario appears to be that internal erosion (“piping”) occurred at the end of the 50-foot long entry from a portion of the thin coal barrier or the thinning roof rock, unraveling or sloughing under the constant seepage forces. Over a period of time, the seepage into the 50-foot long entry began to carry sand (weathered material) into the mine opening. As material was carried away, a “pipe” (void) formed and worked its way toward the impoundment. As more material was carried into the mine, a larger seepage path was created allowing more and larger particles to be carried away. This process continued until the void developed close enough to the impoundment that the remaining plug of material failed suddenly, allowing the contents of the impoundment to discharge uncontrolled into the mine.

17. Based on information obtained during the investigation, it was determined that the slurry discharge outlet was never relocated along the barrier.

18. The reinforced seals were not constructed in accordance with the approved plan. The required number of rock bolts were not installed in the mine floor and roof.

19. It appears that the plan, developed by the consultant and submitted by MCCC, was based on the judgment that the “seepage barrier” and strengthened seals would provide control should another breakthrough occur. This assumption was to the point where the active portion of the 1-C Mine would not be adversely affected and the discharge of water and slurry out of the South Mains would not have a significant impact on safety or the environment. Based on the presumption that the overburden overlying the mine workings was “primarily sandstone with some shale”, the potential for a breakthrough of the magnitude that actually occurred on October 11, 2000, had not been anticipated.

20. The barrier material did not act to plug the opening because either the opening was larger than had been anticipated, or the barrier material ended up being finer than anticipated, or a combination of the two.

CONCLUSION

The failure of the Big Branch Refuse Impoundment and subsequent inundation of the 1-C Mine occurred because Martin County Coal Corporation failed to follow its approved Impoundment Sealing Plan, dated August 8, 1994, and subsequent modification, dated September 7, 1995.

The plan, prepared by Ogden Environmental and Energy Services, Inc., specified a seepage barrier to be constructed along the perimeter of the impoundment where mining had occurred near the outcrop of the Coalburg seam. The stated objective of this seepage barrier was to limit the quantity of seepage passing from the impoundment into the underground mine workings of the 1-C Mine in the Coalburg seam. Additionally, the stated objective was limiting the release of impounded water and fine coal refuse from the impoundment should a breakthrough occur.

The plan specifically states, "... following the completion of the 'seepage barrier' fine refuse shall be directed along the barrier by periodically redirecting the discharge of fine refuse slurry. As fine refuse settles and consolidates along the surface of the 'seepage barrier', seepage should be further reduced due to the low permeability of consolidated fine refuse."

Redirecting of the discharge of the fine refuse slurry was not performed. Consequently, approximately 2 feet of water was present against the highly permeable shot sandstone portion of the seepage barrier at the location of the breakthrough. The absence of a fine refuse layer between the water and the shot sandstone in this area made the seepage barrier more permeable than intended. The seepage barrier failed to restrict flow through the barrier into the 1-C Mine, as the approved plan intended.

The August 8, 1994, Impoundment Sealing Plan was developed without the benefit of additional geotechnical investigation of the overburden above the Coalburg coal seam in the area of the proposed seepage barrier. The actual thicknesses of the stratum above the coal seam and the thickness of the colluvial soil deposits were not determined.

The plan, developed by the consultant and submitted by MCCC, was based on the assumption that the "seepage barrier" and strengthened mine seals would control the flow of any future breakthrough to the point where the active portion of the 1-C Mine would not be adversely affected. It was assumed that, if a breakthrough occurred, the discharge of water and slurry out of the South Mains Portal would not have a significant impact on the safety of miners.

Martin County Coal Corporation's failure to follow the approved plan resulted in internal erosion ("piping") occurring at the location of the breakthrough. Over a period of time, the seepage into this area began to carry sand (weathered material) into the mine opening. As material was carried away, a "pipe" (void) formed and worked its way toward the impoundment. As more material was carried into the mine, a larger seepage path was created allowing more and larger particles to be carried away. This process continued until the void developed close enough to the impoundment that the remaining plug of material failed suddenly, allowing the contents of the impoundment to discharge uncontrolled into the mine.

ENFORCEMENT ACTIONS

Two Violations of 30 CFR 77.216(d): *The design, construction, and maintenance of all water, sediment, or slurry impoundments and impounding structures which meet the requirements of paragraph (a) of this section shall be implemented in accordance with the plan approved by the District Manager.* Both of these violations were issued as 104(d) unwarrantable failures, S&S, and high negligence.

Violation 1: Martin County Coal Corporation (MCCC) did not follow the approved plan for the Big Branch Refuse Impoundment (Site ID No. 1211KY060035-01) when it failed to periodically direct the fine refuse slurry discharge along the "seepage barrier". According to sworn statements from MCCC employees, the slurry discharge location was at the upstream face of the dam and was never relocated to other areas of the seepage barrier.

This requirement is found on Page 7 of Ogden Environmental and Energy Services Co., Inc.'s August 8, 1994 report "Impoundment Sealing Plan" which was submitted by MCCC's August 10, 1994 letter and which was approved by MSHA's October 20, 1994 letter.

Violation 2: Martin County Coal Corporation did not follow its approved plan for the Big Branch Refuse Impoundment, ID No. 1211KY060035-01, by failing to immediately report to the MSHA District Manager any unusual change in flow quantity or quality from the South Mains Portal that would indicate possible impoundment leakage and by failing to implement necessary remedial measures. A significant increase in water flow from the South Mains Portal started during September of 1999 and continued until the breakthrough occurred on October 11, 2000. During this period the company's impoundment inspection records, co-signed by Mine management persons, indicate that the average flow rate from the South Main Portal more than doubled.

This plan requirement is found in Appendix I, Remedial Plan, A) Short Term Plan, Item 4), of Ogden Environmental & Energy Services, Inc.'s August 8, 1994, report "Impoundment Sealing

Plan", which was submitted by Martin County Coal Corp.'s August 10, 1994 letter and approved by MSHA's October 20, 1994 letter.

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