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Siege of Acre

Kempton Mine Complex
Kempton, Maryland
Final Report

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Paul Petzrick, PPRP
Heather Wattenbach, ERM
Brent Williams, ERM
Ray Hemmings, Hemmings & Assoc.
Ed Lyons, Maryland Bureau of Mines

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Disclaimer

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- Brenneman Well Drilling, Inc. of Accident, Maryland provided drilling services.
- Buffalo Coal Company, now owned by United Mine Company, donated access to the site.
- CTL Engineering of West Virginia, Inc. provided coring services.
- Dominion Power contributed Coal Combustion Products for evaluation and laboratory testing.
- Environmental Resources Management, Inc. (ERM) under its Environmental Engineering Integrator contract with PPRP provided contract preparation and professional engineering.
- Fairfax Materials, Inc. donated "dirty" sandstone and provided loading and delivery of same to the site.
- The Geospatial Research Group at Frostburg State University provided technical services related to mapping, field reconnaissance, and Kempton Mine Complex research.
- ILF Consultants, Inc. donated consulting on the mechanics of mine subsidence.
- Llewellyn & Associates, Inc. provided GPS and professional surveying services for the Project site.
- The Maryland Department of the Environment Bureau of Mines provided technical support, field coordination, and water monitoring services.
- Mettiki Coal Corporation donated coal combustion products for evaluation and laboratory testing.
- The Thomas West Virginia Historical Society donated access to the Davis Coal and Coke Company historical records.
- The Western Maryland Resource Conservation and Development Council provided contact administration and assistance with reports.

- The landowner, Western Pocahontas Properties, donated right of entry, digitized mine maps and professional surveying services.
- The US Department of Energy (DOE) provided downhole camera services and donated geophysical survey consultation.
- The U S Office of Surface Mining (OSM) donated downhole camera services and interpretation during the investigation.

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ABSTRACT

This report has been prepared to meet the requirements of a subcontract between West Virginia University and Maryland Department of Natural Resources Power Plant Research Program. Under the subcontract, $50,000 of U.S. Department of Energy funding was provided to the Maryland Power Plant Research Program for cost sharing of Phase I of the Siege of Acre Project. The project is named for the Siege of Acre segment of the Kempton Mine Complex. This segment includes a suitably isolated experimental site of sub-aerial mine pavement that can serve as a model of several hundred acres of sub-aerial underground mine pavement draining to the large Kempton mine pool in the 12 square mile complex. Sub-aerial pavement within the complex is the likely source of most of the acid that has resulted in an average of 3.5 million gallons per day of acid mine drainage discharging into Laurel Run, an important tributary of the North Branch of the Potomac River, over the past 52 years. The experimental site is also representative of thousands of acres of sub-aerial pavement in abandoned coal mines throughout Appalachia.

The Siege of Acre Project is a field scale experiment to determine the degree to which acid production is reduced by covering the sub-aerial mine pavement and related mine debris with a hydraulically placed grout compounded from mine water and locally available power plant coal combustion products. The experimental site consists of three 16-foot wide mine tunnels, which are interconnected by several crosscuts developed in the normal manner of up dip room and pillar mining. The three tunnels extend 750 feet up a hill (and up dip) above the mine pool with overburden varying from 175 feet near the edge of the mine pool to 140 feet near the high wall where a surface mine cut into the underground works.

This report describes the work completed and results achieved under the initial three tasks of the Project. These tasks were made the subject of a proposal to the Combustion Byproducts Recycling Consortium for cost sharing and subsequently funded under the subcontract with West Virginia University. These tasks involved:

1. Drilling to locate the lower end of the tunnels and to establish water quality monitoring of water flowing on the mine floor;
2. Drilling to locate the upper end of the tunnels to fully establish the mine geometry for the experimental site; and
3. Initial design of the grout suitable for covering the exposed mine pavement and most of the debris normally left in such mines.

The work described in this document includes the important exercise of translating and rotating the historic mine map of Kempton Mine No. 42 to match it with geospatial reference points that could be identified on recent surface photography of the remote area. The report also describes the drilling program that met the combined needs of providing access for water quality monitoring and establishing the precise location and orientation of the mine tunnels.

This report also includes an extensive description of the laboratory investigations completed to design the grout with locally available power plant combustion products.

The Maryland Power Plant Research Program has developed an aggressive program to fully utilize the combustion products produced by power plants within the State. In general the strategy is to demonstrate that grouts made of combustion products can be used in lieu of ordinary cement mixtures in most geotechnical engineering applications. Three such applications that would make massive use of power plant coal combustion products are:

- Mine restoration;
- treatment of geologic hazards in karst formations; and
- stabilization of dredge materials.

Mine restoration has focused on acid mine drainage but must eventually address subsidence and disruption of water movement patterns in watersheds disturbed by underground mining. The Siege of Acre Project is a field scale experiment designed to evaluate the impact on acid production of covering pyritic mine pavement and high sulfur mine debris left in abandoned mines. The impermeable covering proposed is a hydraulically placed grout of mine water and locally available power plant coal combustion products.

In 1995, the Power Plant Research Program and the Maryland Department of the Environment Bureau of Mines initiated the Western Maryland Coal Combustion Products/Acid Mine Drainage Initiative. The Initiative, which is a joint effort by public and private sectors, spearheads Maryland's research and development of beneficial large-volume uses of coal combustion products to reduce acid formation in Maryland's abandoned, underground coal mines. The Initiative emphasizes the prevention of acid formation rather than acid mine drainage treatment. The Siege of Acre Project is one of several projects underway or planned by the Power Plant Research Program to use coal combustion product grouts to reduce acid formation in Maryland's abandoned coal mines.

The Kempton Mine Complex covers 12 square miles in Maryland and West Virginia, and discharges approximately 3.5 million gallons of acid mine drainage per day into Laurel Run, the first major tributary to the North Branch of the Potomac River in Western Maryland.

The Siege of Acre segment of the Kempton Mine Complex forms the northern extremity of the Complex in Maryland. In particular, it includes an isolated straight run of three tunnels, each 750 feet long by 16 feet wide,

running up dip from the northern edge of the mine pool. As an experimental site, this section is directly representative of several hundred acres of sub-aerial mine pavement along the western edge of the Kempton Mine Pool and sub-aerial pavement in other Upper Freeport mines in Maryland and neighboring states.

Ultimately, the project involves placing a durable, low-permeable barrier to cover the mine pavement and much of the debris normally left behind in such abandoned mines. Phase I of the project, which is the subject of this report , includes preparations for eventual grouting and subsequent water quality monitoring to evaluate the results. Specifically three tasks have been funded and completed:

- Task 1: Drilling Related to Water Quality Monitoring;
- Task 2: Drilling for Mine Void Orientation; and
- Task 3: Initiation of Grout Design.

Drilling activities required for Tasks 1 and 2 were scheduled simultaneously to minimize mobilization costs. Weather considerations and delays in the availability of funds for Phase I forced the drilling to be scheduled at the end of a long drought in Western Maryland. As a result no water was observed on the mine floor at the time of the initial drilling in November 2001. The Program Manager directed the drilling contractor to construct a sump and set a well point in the center tunnel anticipating that it had been used for mine drainage and would be the tunnel most likely to produce mine water. The well point hung up in the sump and was left ungrouted in place, 3.5 feet above its intended position subject to future observations. Drilling and downhole camera observations at the upper end of the tunnels helped verify the exact orientation and geometry of the tunnels proposed at the experimental site.

Subsequent downhole camera observations in December 2001, after a period of rain, revealed water flowing directly under the access hole in one of the side tunnels. The quantity of water that could reasonably be collected from the mine floor by sponge was too small to be analyzed for all analytes, but monitoring showed it to have a persistent pH in the range of 2.7 to 3.0. The Program Manager concluded that the site was suitable to conduct the proposed experiment and proceeded with plans to return in the spring to add sumps in the side tunnels and reposition the well point in the center tunnel as observations dictated.

The laboratory investigation conducted by Hemmings & Associates using locally available power plant coal combustion products focused on the specifics of the mine geometry and conditions observed by the downhole camera. A grout recipe has been selected to provide grout that will spread

and flow long distances through the debris on the mine floor where slopes vary from 15 to 18 percent.

In July 2002, drilling was resumed at the lower end of the tunnels to obtain cores from the pavement in the two side tunnels and to drill through the previously installed well point which was hung up in the center tunnel. The removal of cores from the side tunnels left behind the desired sumps to allow for more efficient water quality monitoring. While drilling through the well point in the center tunnel it dropped an additional 2.5 feet into the previously constructed sump and is now positioned to monitor any mine water flowing near the center of that tunnel.

The completion of the three Tasks of Phase I has provided an excellent basis for continuing pre-gout monitoring and subsequent grout injection and post injection monitoring.

1.0 INTRODUCTION

The Maryland Department of Natural Resources Power Plant Research Program (PPRP) supports an aggressive demonstration program to promote innovative and beneficial use of power plant combustion products . Power plants in Maryland currently produce about 1.5 million tons per year of combustion products and growth to 2 million tons per year is expected. Currently, only about 30% of the cumbustion products generated in Maryland are beneficially used; the remaining 70% are landfilled. The landfilling of combustion products consumes valuable land, and has the potential to adversely impact Maryland's aquatic resources.

The Siege of Acre Project (the Project) is one of several projects planned by PPRP to research, develop, and use coal combustion product (CCP) grouts to reduce acid formation in Western Maryland. Phase I of the Project, which is the subject of this report, is intended to provide baseline information necessary to conduct future injection and monitoring at the site. The technology developed for the Project will contribute to the growing body of research addressing the beneficial use of CCPs to reduce acid formation in abandoned underground coal mines.

In general PPRP attempts to demonstrate that mixtures of power plant combustion products or mixtures of fly ash and high lime content waste products can be used in lieu of normal cement mixtures in most geotechical engineering applications. Three geotechnical applications that have the potential to use massive amounts of power plant coal combustion products have been identified:

- Mine restoration;
- treatment of geologic hazards associated with karst formations; and
- stabilization of dredge material.

Since 1995, PPRP and the Maryland Department of the Environment (MDE) Bureau of Mines (BOM) have sponsored the Western Maryland Coal Combustion Product /Acid Mine Drainage Initiative (the Initiative). The Initiative is a joint effort by the public and private sectors in Maryland with important cooperation of the public and private sectors in West Virginia to reduce acid mine drainage (AMD) in Maryland.

The Initiative emphasizes the prevention of acid formation which can be achieved through mine restoration as an alternative to continuous AMD treatment. After initial success with bulk filling a small Upper Freeport

mine on Winding Ridge the Initiative has focused on the Kempton Mine Complex (the Complex), the largest source of AMD in Maryland. This large Complex offers numerous opportunities to use CCPs from local power plants for environmentally advantageous applications.

Figure 1 shows the Complex in its interstate and regional context with emphasis on its relationship to nearby power plants. Figure 2 illustrates the manner in which the Complex dominates the headwaters of the North Branch of the Potomac and Blackwater Rivers. The hydroglogic influence of the Complex has effectively created a subsurface eastern continental divide that is south and west of the surface continental divide. Figure 2 also shows the limits of the Kempton Mine Pool and the related Coketon Mine Pool in West Virginia. Of particular note is the expanse of sub-aerial mine pavement draining to the Kempton Mine Pool. Figure 3 is a hydrologic profile illustrating the hydrologic relationship of the two mine pools and drainage of the Kempton Mine Pool through an abandoned air shaft and power bore hole located in Maryland's Laurel Run watershed. The northern half of the Complex is dominated by Kempton Mine No. 42 (Mine 42).

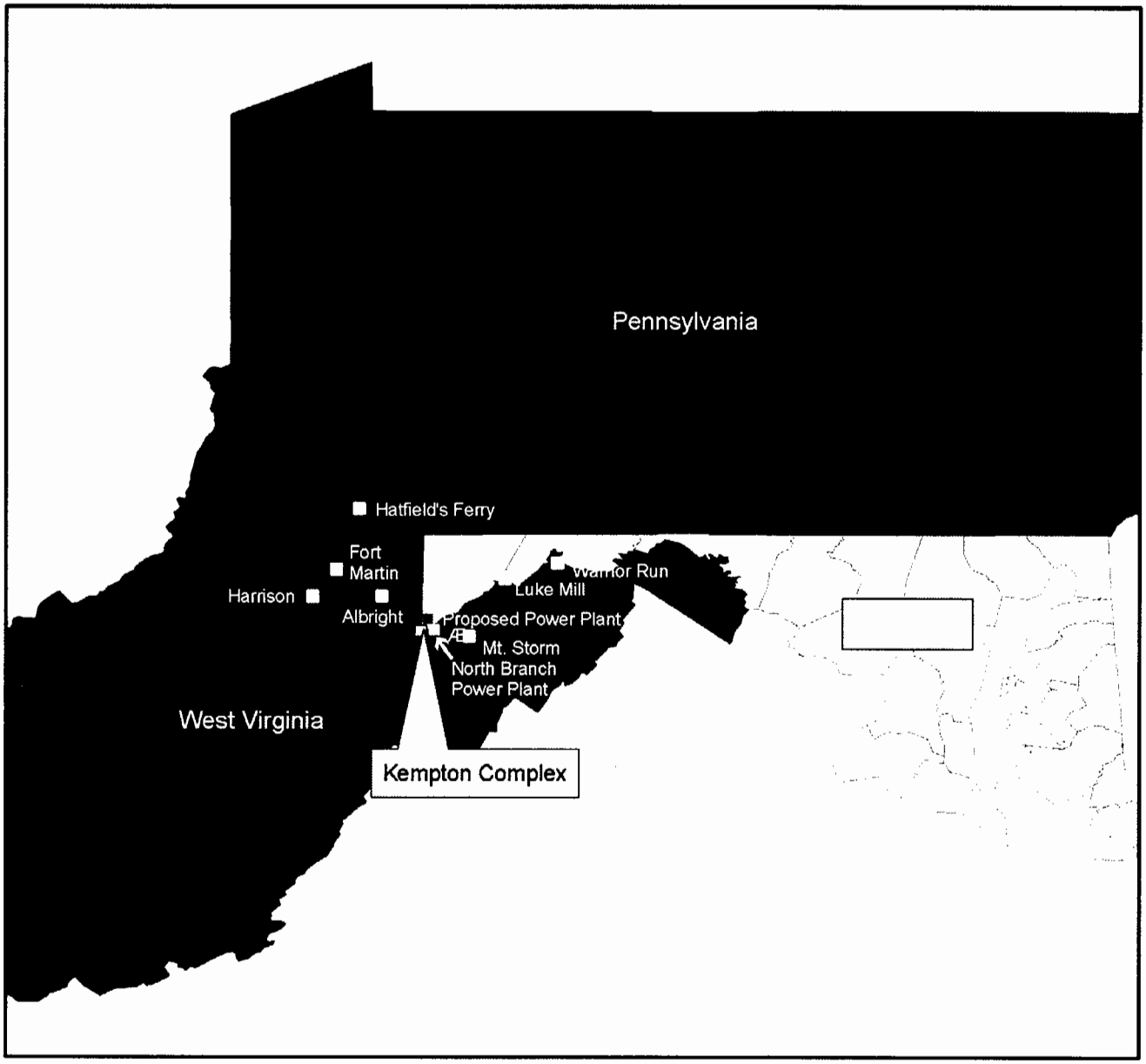
Shaft sinking and development of Mine 42 started in 1913 based on an extensive exploratory coring program initiated in 1911. Figure 4 shows Mine 42 as Davis Coal and Coke Company (DC&C) reported its closure to the U.S. Bureau of Mines on April 15, 1950. The last part of Mine 42 to be developed was the Siege of Acre segment extensively mined during World War II. In preparing Figure 4, DC&C's 1950 submission was enhanced to clearly identify the geospatial reference points used to align the mine map with 1999 aerial photography of the area. The important reference points in Figure 4 are the Kempton Man Shaft/Air Shaft (KMS), the Laurel Run Air Shaft (LRAS), and the power bore hole (PBH).

Figure 5 presents an enlarged view of the Siege of Acre segment to identify the experimental site (ES) selected for the Siege of Acre Project. ES is the isolated section of the three tunnels identified as A17 on Figures 4 and 5. This portion of the mine runs up dip from the limits of the Kempton Mine Pool to the partially mined out area near the outcrop of the Upper Freeport coal seam. Buffalo Coal Company recently mined through a portion of the partially mined area as part of their strip mining of the Upper Freeport outcrop, leaving the three tunnels completely isolated at their up dip end. The partially mined out area is thought to have been a remotely ventilated area of Mine 42 and is designated as RVA on Figure 5.

ES was selected for the grouting experiment because of its geographic and hydrogeologic isolation in the Complex. The three tunnels are prototypes of many miles of sub-aerial tunnels and several hundred acres of sub-

Figure 1

Regional Context of the Kempton Mine Complex



Legend

- Maryland Counties
- Fossil Fuel Power Plants
- Kempton Complex
- Proposed Fossil Fuel Plant

SOURCE:

1. Power Plant Location Data Obtained From PPRP Publication "Electricity in Maryland".

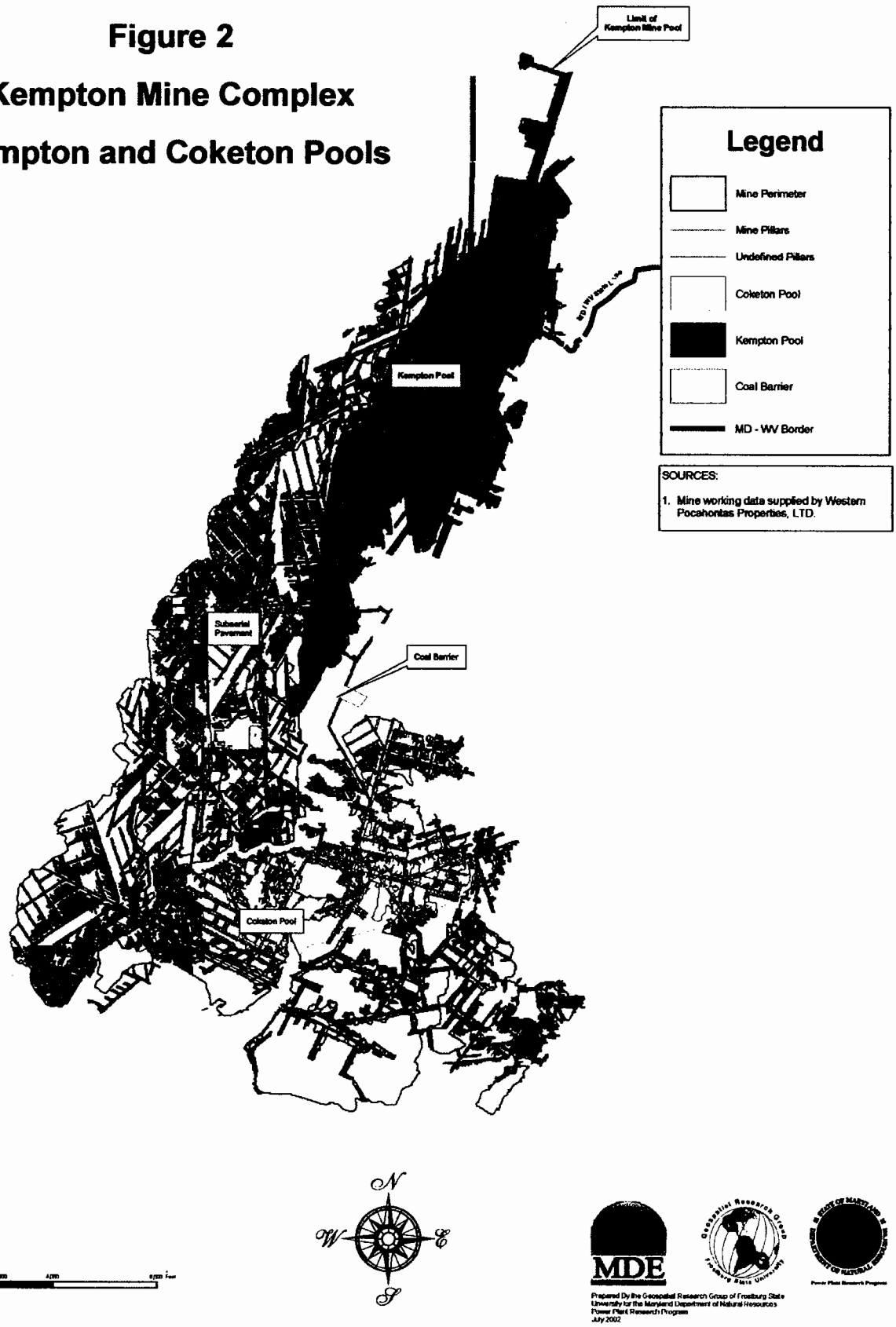
Prepared By the Geospatial Research Group of Frostburg State University for the Maryland Department of Natural Resources Power Plant Research Program
July 2002

60 30 0 60 120 Miles

Figure 2

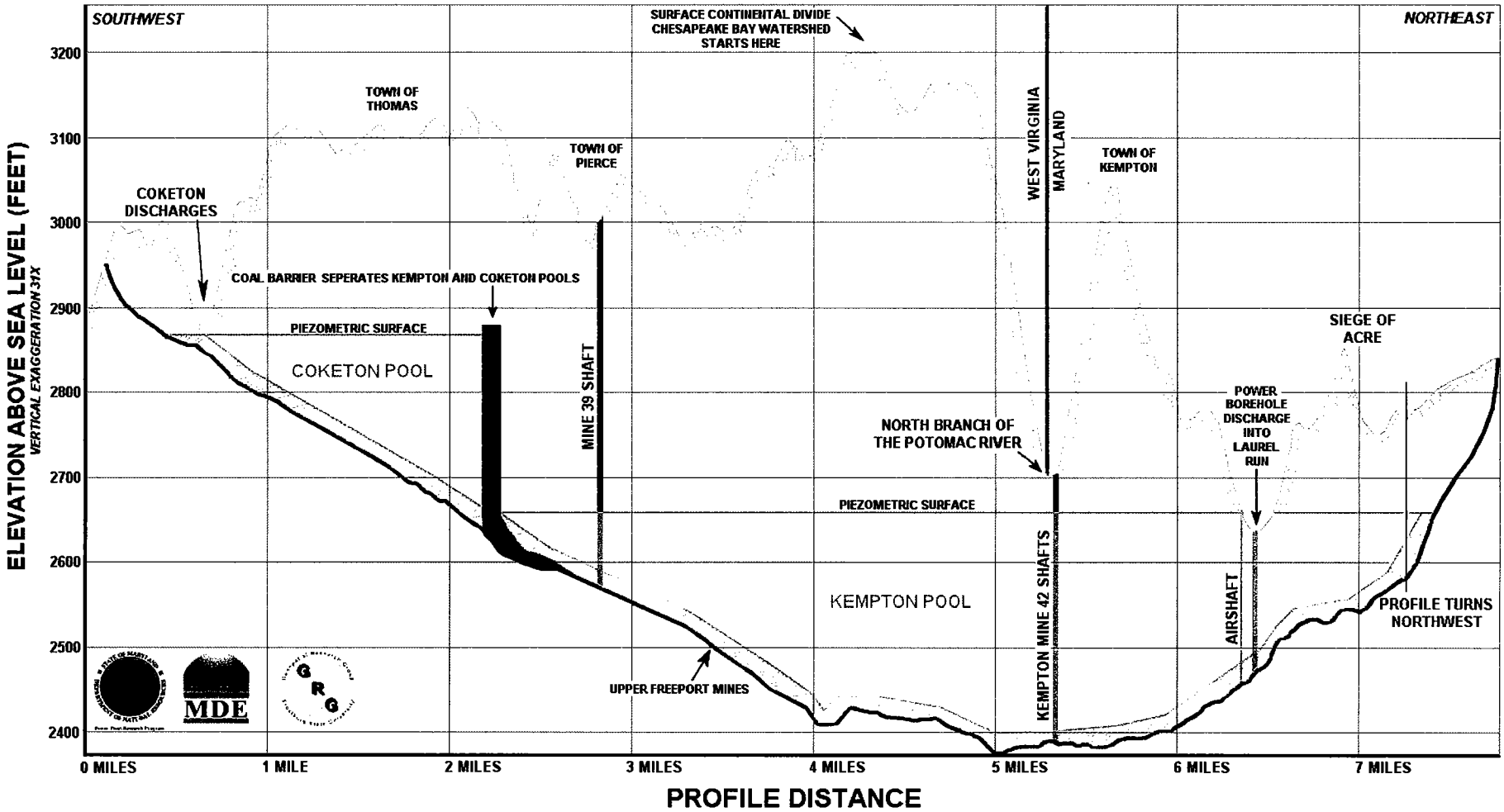
Kempton Mine Complex

Kempton and Coketon Pools



Prepared By the Geospatial Research Group of Frostburg State University for the Maryland Department of Natural Resources Power Plant Research Program
July 2002

Figure 3
Kempton Mine Complex
Hydrologic Profile



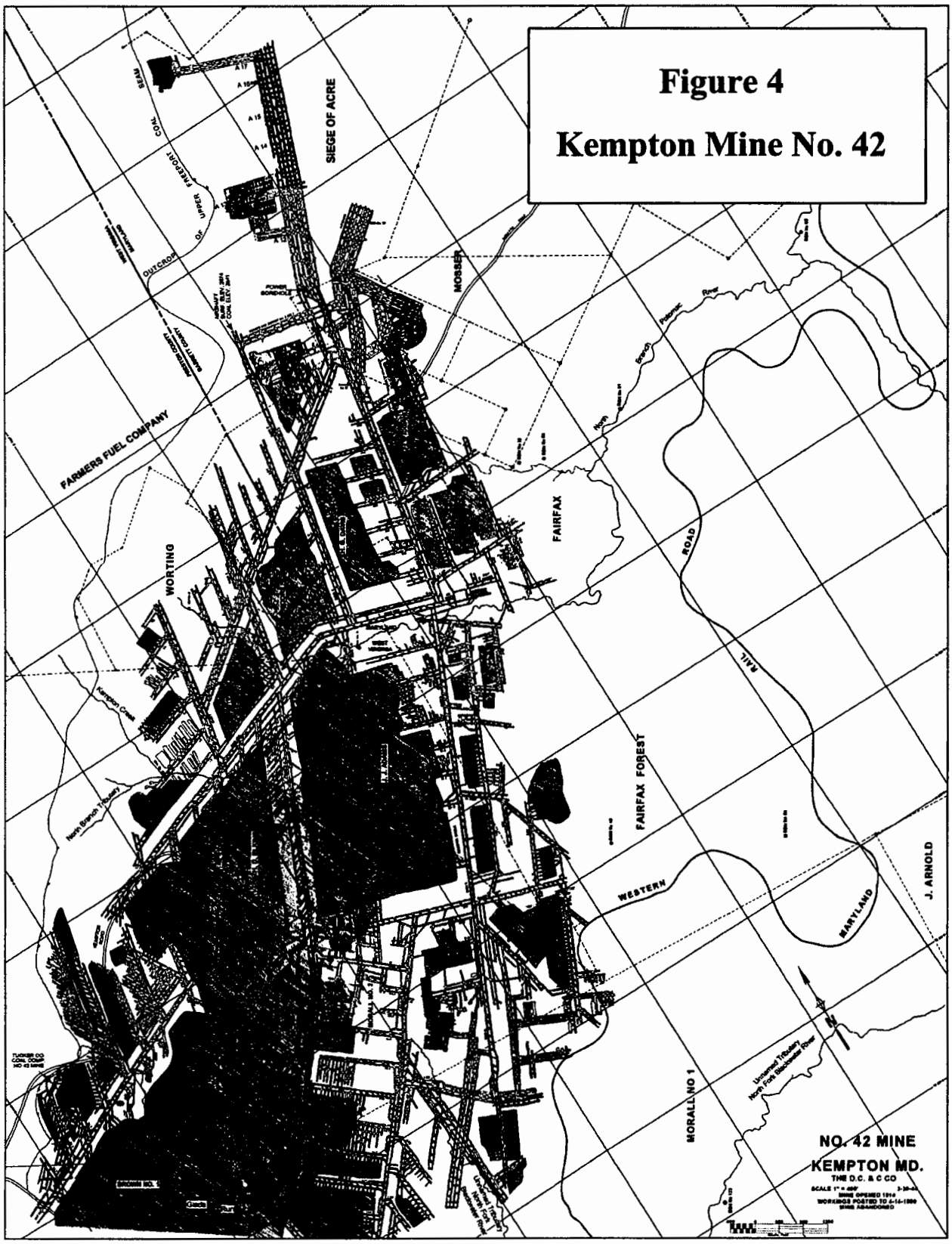


Figure 4
Kempton Mine No. 42
SIEGE OF ACRE
MOSSER
FAIRFAX
FAIRFAX FOREST
ROAD
RAIL
WESTERN
MARYLAND
J. ARNOLD
MORALL NO 1
WORTING
FARMERS FUEL COMPANY
OUTCROP
NO. 42 MINE
KEMPTON MD.
THE D.C. & C CO

Figure 5

Siege of Acre Segment of Kempton Mine 42

Legend - Both Maps

Reference Points
- AS
- PSH

Utility Line
Upper/Lower Trail
Mine Workings

Hydrography
Pond
Stream

Other Features
Subsurface
Upper Prospect
Property Lines

Index Coal Outcrops
Topographic Index Outcrops
Intermediate Coal Outcrops

N W E S

0 250 500 1,000 Feet

SOURCES:
1. Original mine working data provided by Western Pocahontas Properties, LTD.
2. Property data provided by Garrett County Planning and Zoning with linework digitized by the Geospatial Research Group.
3. All other information appearing on this map was supplied by 3DI, LLC.

MDE

Prepared By the Geospatial Research Group of Frostburg State University for the Maryland Department of Natural Resources, Forest Pest Research Program and the Maryland Department of the Environment Bureau of Mines. 17 January 2002. Revised: 17 July 2002

aerial exposed mine pavement in the Complex. ES is similarly representative of thousands of acres of sub-aerial pavement in Appalachia. The site also has the important advantage that if leaching from the grout or any aspect of the grouting operation became a problem the site could be isolated from the mine pool and the remainder of the mine. Advantages of the Project site include the close proximity to sources of both fluidized bed combustion products and fly ash and pre-existing site access via Buffalo's coal haul roads. ES had two major disadvantages:

- The quality and quantity of mine water produced in this section of the mine was unknown; and

- due to the isolated location the site was 4000 feet from the nearest known geospatial surface and sub-surface reference points .

The combined issues of mine orientation and water quality monitoring along with the development of a grout design using the available coal combustion products formed the core of the three tasks that became the subject of Phase I of the Siege of Acre Project. The subcontract (the Subcontract) between PPRP and West Virginia University establishing cost sharing for this Phase of the Project is funded by the Combustion By-Products Recycling Consortium (CBRC) using Department of Energy (DOE) funds.

2.0 *EXPERIMENTAL: WHAT HAS BEEN DONE*

Three tasks were identified in the Subcontract between West Virginia University and PPRP: Drilling and water quality monitoring (Task 1), drilling for mine void orientation (Task 2), and initiate grout design (Task 3).

2.1 *DRILLING FOR WATER QUALITY MONITORING AND MINE ORIENTATION*

2.1.1 *Preparation for Drilling*

Because drilling was the major item of expense in Phase I, the Project Manger (PM) attempted to combine the drilling requirements of Tasks 1 and 2 to reduce mobilization costs and minimize the overall cost of drilling. In addition, the high cost of drilling dictated that the majority of preparation for drilling be completed as computer or desk top studies. These studies were greatly facilitated by three important developments that preceeded the Project:

1. The landowner, Western Pocahontas Properties (WPP), provided a digitized version of the original large scale DC&C mine map to the Geospatial Research Group (GRG) at Frostburg State University (FSU).

2. In 1999 GRG contracted with 3DI of Easton, Maryland to obtain very high quality orthophotograhy of the surface over the Kempton Mine Complex. The resulting digitized surface photography was available for use in the Project.

3. GRG personnel discovered that many of DC&C's local records were stored in their old headquarters building, now known as the Railroad Building, in Thomas, West Virginia. These assets had been taken over by the Thomas Historical Society. The Society Director agreed to share access to these records as well as the core borings remaining in the building. This diverse material includes detail maps, engineering memos and survey notes ; information which has proven to be invaluable in the characterization of the Kempton Mine Complex. These records are referred to collectively as the DC&C Records.

Other information that was pivotal in establishing mine orientation was the presence of surface indicators that are indicative of underground mining activities. When the first field reconnaissance of the surface over

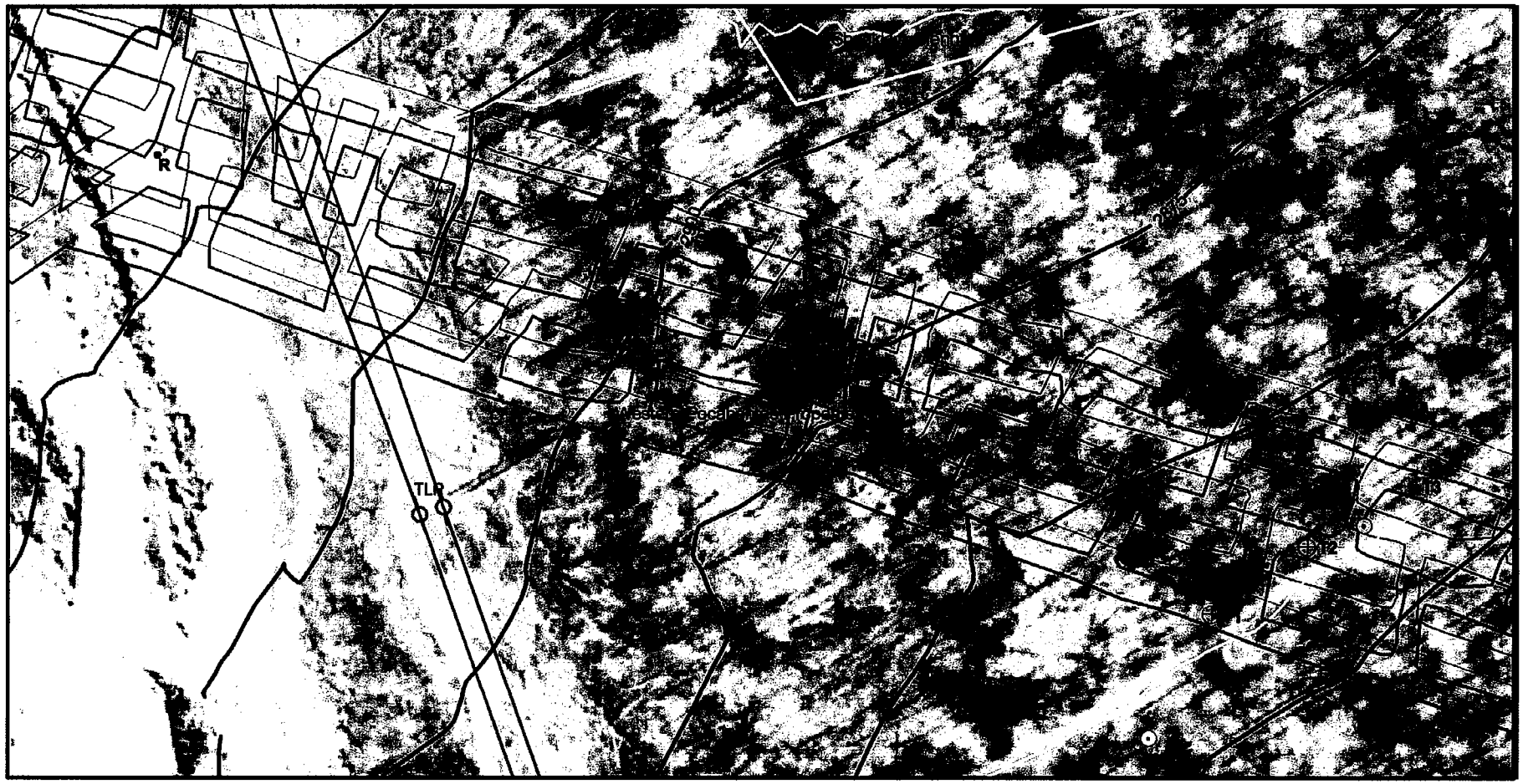
ES was completed in 1998 the logging trail crossing near the edge of the mine pool (referred to as the lower trail) was heavily overgrown and appeared unused for several years and there was no evidence of subsidence to help locate the tunnels . This trail was very important for execution of the project as it provided access to the area close to where the shore line of the Kempton Mine Pool was thought to be. When the area was reconnoitered for detailed planning of the Project in 2001 it was observed that heavy equipment had recently used the trail, apparently in a timbering operation. Numerous large potholes had developed in the trail but three depressions in particular were of length and at uniform intervals corresponding to the dimensions of the mine tunnels along the axis at which the trail crossed the tunnels. These depressions became the subject of greater interest as other options for accurately locating the tunnels were ruled out. After study of the mechanics of mine subsidence and discussions with John Jenkins of ILF Consultants, Inc., the PM decided to proceed on the premise that the depressions were the result of sag subsidence over the mine tunnels.

The depressions were not visible on the surface photography and their location could only be estimated by observing the pattern of tree shadows adjacent to the trail. The locations of the tunnels as mapped onto the surface photography from the mine map were at least 30 feet northwest of the depressions along a line parallel to the 4000 foot advance from PBH to A17. However, distances between other geospatial reference points as measured on the mine maps were frequently longer than the same displacements measured on the surface photography or as determined from differences in latitude and longitude. Thus there may be a systematic error in the mine maps associated with chaining in the mine.

The PM directed RC&D to hire Llewellyn & Associates to locate the suspected subsidence points in the field using a submeter-accuracy global positioning system and to plot the mid point of the depressions on the surface photography. This confirmed that the position of the tunnels as represented on the mine map was about 30 feet from the depressions on a line perpendicular to the tunnels. The PM decided to proceed on the assumption the depressions marked the true positions of the tunnels. The midpoints of the depressions were designated as Tentative Reference Points: T1, T2, and T3 with the corresponding tunnels designated as Tunnel 1, 2, and 3. GRG prepared Figure 6 showing tunnel locations from both the historic mine map and the project site survey to guide the drilling effort. The best available data at the time of the drilling indicated that the edge of the Kempton Mine Pool was almost directly under the trail in the vicinity where the drilling was to start. To keep the trail clear during project activities drilling was initiated at the side of the trail. Because of the uncertainty that still existed regarding the location of the tunnels,

Figure 6

Original Translation of Mine Workings at Experimental Site



Legend

Tentative Reference Points
- I1
- I2
- I3

Other Reference Points
- R
- TLR

- TRANSLATED WORKINGS
- ORIGINAL WORKINGS
- INDEX CONTOURS
- UPPER/LOWER TRAIL
- UTILITY LINE

Control Pts.
- CONTROL POINT 1
- CONTROL POINT 2
- TAX LAYER

100 50 0 100 Ft

SOURCES
1. Original mine working data provided by Western Pocahontas Properties, LTD
2. GPS data supplied by Llewellyn & Associates, Inc. and the Maryland Bureau of Mines
3. Property data provided by Garrett County Planning and Zoning with linework digitized by the Geospatial Research Group
4. All other information appearing on this map was supplied by 3DI, LLC

MDE

Prepared By the Geospatial Research Group of Frostburg State University for the Maryland Departmen of Natural Resources, Power Plant Research Program and the Maryland Department of the Environment Bureau of Mines. 17 January 2002

drilling started with Tunnel 3 as it was at the center of the area of uncertainty.

2.1.2 *Original Sequence of Drilling*

LTBE 3

Brenneman Well Drilling, Inc. (Brenneman), met the PM at the site on 10 November 2001 with the mobile drill rig, crew and all equipment necessary for grouting casings in place and installing well points as directed. Environmental Resources Management, Inc. (ERM) provided a professional geologist to log the holes. Brenneman was directed to start drilling on the down dip side of the trail in line with the projected centerline of Tunnel 3 from reference point T3.

The bore hole did not encounter coal or break through the mine roof at the projected elevation. This indicated a possible problem with the elevations taken from the DC&C Records that was consistent with the systematic error suspected in their chaining in the mine. The drill was slowly advanced and broke through into void space approximately five feet below the anticipated depth. Upon breakthrough the drill bit dropped five feet without encountering resistance, indicating five feet as the height of the tunnel void space. As the drill string and bit were extracted from the hole debris falling in the hole could be heard landing in water at the bottom of the boring. Sounding showed five feet of water in the hole and put the elevation of the water surface at 2,653 feet. This elevation corresponds exactly with the surface of the Kempton Mine Pool as currently controlled by the elevation of the collar where water drains from the Air Shaft and enters Laurel Run. Brenneman was directed to install casing in order to maintain the hole as a reliable access point for monitoring the mine pool adjacent to the experimental site.

LTB 3

Taking into consideration the 15 percent mine slope in the ES area, Brenneman was directed to move 50 feet up dip along the projected center line of the tunnel to ensure that the next hole would be above the mine pool. Drilling at this location intercepted the mine void space at the elevation predicted after correction of the elevation projections based on the previous hole. The DOE camera crew lowered their camera into the hole and observed that the hole had entered near the center of a mine tunnel. The tunnel alignment appeared to be oriented as had been projected. Roof supports could clearly be seen along with what appeared to be the mine pool in the down dip direction. Otherwise, the hole was dry with no visible mine water and a small amount of ground water

below 100 feet. No evidence of crosscuts could bee seen in the northeast wall of the tunnel but there was a clear indication of a crosscut in the southwest wall. The PM concluded with a reasonable degree of certainty that the hole was in Tunnel 3 and drilling for the other tunnels would proceed based on Reference Points T2 and T1.

LTB 2

Based on the observations from the previous bore hole, a point was selected up dip of the trail corresponding with Reference Point T2. Drilling at this location penetrated the void space at the projected elevation and dropped about five feet to solid resistance. Brenneman lowered their axial borehole camera into the hole. Although the view from the camera was limited a rail could be seen on the mine floor close to where the hole entered the tunnel. DC&C Records had shown there was a conveyor located in Tunnel 2 so it was reasoned that this hole was located close to the center of Tunnel 2. While no mine water was observed, after consultation with ERM the PM directed Brenneman to drill a 5 foot sump in the mine pavement for installation of a well point. It was reasoned that Tunnel 2 was the tunnel most likely to have been used for drainage of this part of the mine and would therefore be the most likely source of mine water when the drought ended. The well point hung up in the sump 3.5 feet above its intended location. To keep the drill rig moving the PM directed that the well point be left in place ungrouted until further observations could be made.

LTB 1

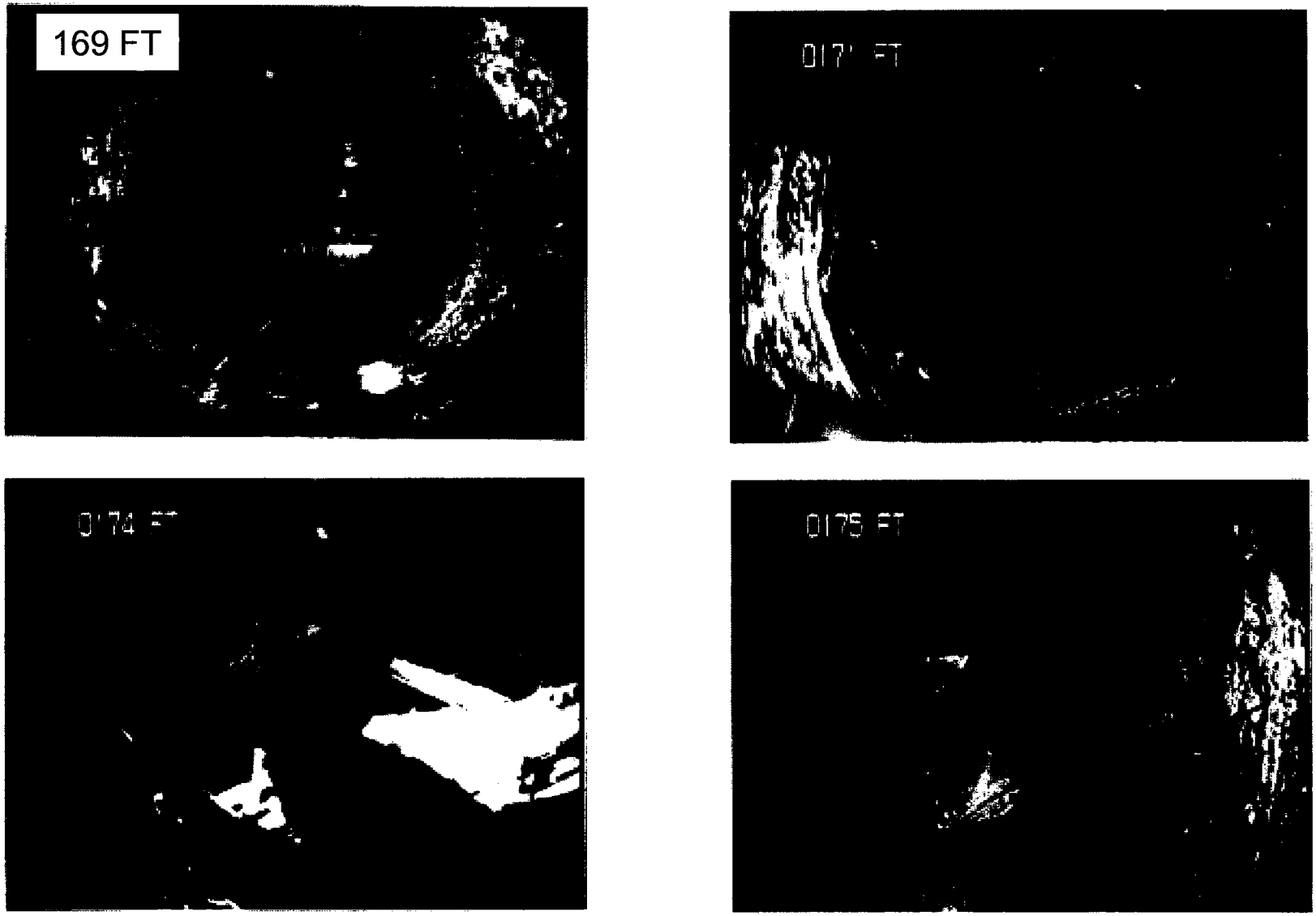
After checking elevations, the PM directed Brenneman to drill for Tunnel 1 in line with Reference Point T1 but in a location down dip of the trail. Upon entering the tunnel, the drill struck and broke through a roof support. Brenneman's axial camera was used to investigate the mine void at this location and took the pictures shown in Figure 7. The camera was not lowered any further into the hole for fear it would hang up on the broken timber but the view showed that the hole and mine floor were dry. Brenneman was directed to install a flared casing in the hole which terminates just below the mine roof so the hole could be used for further observations with less danger to equipment from the broken roof support.

UTB 4

More confident now regarding the tunnel location and alignment, the PM directed the Brenneman to a location as far north as practical in the narrow space between the stockpile of top soil from the current surface mining operation and a drainage ditch to drill for Tunnel 3. While the

Figure 7

Downhole Camera Pictures at LTB 1



drilling position was determined using the same method that had worked at the lower end of the experimental site, the hole encountered only coal at the expected elevation of the mine. Brenneman was directed to remove the steel casing and seal the hole for proper abandonment.

UTB 5

The PM decided to focus on finding the upper end of Tunnel 2 as there was more room to maneuver the drill rig and the slope was not as steep if additional exploratory drilling was needed. Brenneman was directed to drill at a location assuming that the miss at UTB 4 was just north of Tunnel 3. Drilling at the identified site encountered only coal at the projected elevation of the mine. Brenneman was directed to remove the casing and properly seal the hole for abandonment.

UTB 6

After encountering coal in the previous two borings, the PM met with the landowner's surveyor at WPP's office in Davis, WV to review all available information. WPP had the original large-scale maps of Mine 42 and computer programs to plot the location of the boreholes that had been completed as shown on Figure 8. They also had downloaded the surface photography from GRG. This permitted a comparison of the mine map and surface features for testing options that included both translation and rotation of the mine map. The fit at the lower end of the tunnels was very accurate after the 30 foot translation which amounted to only foreshortening of the six 4000-foot tunnels from PBH to A17. Consequently it was concluded that the source of error must be with the exact rotation of the mine map. After testing several options on the light table, the PM found that a clockwise rotation of the mine map of approximately one degree provided the best fit to all of the data collected so far. The rotation put UTB 4 and UTB 5 one or two feet into pillars southwest of Tunnels 3 and 2 respectively. It was observed that this alignment put the centerline of Tunnel 2 almost directly under the boulder visible on the surface photography, Reference Point R. Brenneman was directed to drill as close as possible to the southwest side of the boulder. Drilling at this location encountered void space at the expected elevation of the mine. Brenneman's camera revealed the hole had entered a mine tunnel near its southwest wall and struck and knocked down a roof support post.

UTB 7

Based on the observations at UTB 6 Brenneman was directed to drill for Tunnel 1 at a point 75 feet southwest of the center of the boulder. The

Figure 8

Location of First Six Boreholes at the Experimental Site

Legend

Tentative Reference Points
- T1
- T2
- T3

Other Reference Points
- R
- TLP

- TRANSLATED WORKINGS
- ORIGINAL WORKINGS
- INDEX CONTOURS
- UPPER/LOWER TRAIL
- UTILITY LINE

Control Pts.
- CONTROL POINT 1
- CONTROL POINT 2
- TAX LAYER

N W E S

100 50 0 100 Ft

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4. All other information appearing on this map was supplied by 3DI, LLC

MDE

Prepared By the Geospatial Research Group of Frostburg State University for the Maryland Department of Natural Resources, Power Plant Research Program and the Maryland Department of the Environment Bureau of Mines. 17 January 2002

Table 1
Borehole Specifications for the Siege of Acre Project
Kempton Mine Complex

		SURVEY DATA [1]								
BOREHOLE DESIGNATION	MARYLAND WELL PERMIT NUMBER	X (EAST)	Y (NORTH)	GROUND ELEVATION (FEET MSL)	TOP OF CASING ELEVATION (FEET MSL)	CASING INTERVAL (FEET BGS)	PVC RISER INTERVAL (FEET BGS)	PVC SCREEN INTERVAL (FEET BGS)	MINE VOID (FEET BGS)	WELL DIAMETER (INCHES)
LTB 1	GA-94-2031	2006703	266441.700	2831.48	2833.13	+ 2 to 42	+2 to 170	(2)	169 to 174.5	4
LTB 2	GA-94-2030	2006716	266498.100	2839.82	2842.00	+2 to 36	+2 to 169	169 to 174	170 to 175.5	4
LTB 3	GA-94-2029	2006779	266539.500	2838.18	2840.36	+2 to 45	(3)	(3)	177 to 181.5	8
LTBE 3	GA-94-2028	2006836	266523.300	2824.91	2826.54	+2 to 40	+2 to 181	181 to 186	181 to 186	4
UTB 4	(4)	2005993	266806.900	2978.52	NA	NA	NA	NA	NA	NA
UTB 5	(4)	2006005	266735.500	2952.32	NA	NA	NA	NA	NA	NA
UTB 6	GA-94-2066	2006014	266736.235	2960.38	2961.48	+2 to 40	+2 to 144	(2)	144 to 147.5	4
UTB 7	GA-94-2067	2006037	266684.974	2941.54	2943.04	+2 to 42	+2 to 141	(2)	141 to 146	4

All boreholes completed using Air Rotary/Air Percussion methods by Brenneman Drilling (Maryland license # 373) of Accident, Maryland.
(1) Survey data provided by Geospatial of Frostburg, Maryland. X and Y coordinates are in North West Virginia State Plane Feet, 1927.
(2) Polyvinyl Chloride (PVC) riser was installed to top of mine void. No screen was installed.
(3) LTB 3 was completed as an open bedrock well with no PVC riser or screen.
(4) UTB 4 and UTB 5 did not drill into the mine void. Subsequently they were sealed with a high yield bentonite grout slurry.
Surface casing is steel with welded joints.
PVC joints are secured with stainless steel screws and glue.
NA is not applicable.

boring encountered void space at the expected elevation of the mine. The PM concluded that the number of borings available for observation was sufficient to establish the exact orientation of the tunnels at the experimental site using the bearing and distance measurement capabilities of the Office of Surface Mining (OSM) camera. UTB 6 and UTB 7 were cased to remain as observation and possible injection holes. The drilling activities were concluded on November 14, 2002.

Construction details regarding the monitoring points and boreholes are summarized in Tables 1 and 2. Boring logs were created for each boring and are included in Appendix A.

Table 2: Siege of Acre Project Investigative Boreholes

ID #	Description
LTB 1	Completed with 4" PVC riser pipe to the approximate top of mine
LTB 2	Constructed with PVC riser pipe and screen combination
LTB 3	Completed as an open borehole
LTBE 3	Intersected mine pool and was completed with PVC riser pipe and screen
UTB 4	Not in mine void, casing pulled, properly abandoned
UTB 5	Not in mine void, casing pulled, properly abandoned
UTB 6	Completed with 4" PVC riser pipe to the approximate top of mine
UTB 7	Completed with 4" PVC riser pipe to the approximate top of mine

The monitoring points were accurately located using Global Positioning System (GPS). This data have been incorporated into a Geographic Information System (GIS) and related database for the Kempton Mine Complex. GRG continues to update the GIS and database files as new resources are identified and project needs arise. The data generated for the Project and other mine restoration projects is readily available to PPRP and stakeholders.

2.1.3 *Down Hole Camera Observations*

Brenneman's axial camera was adequate to guide drilling operations, produce still photographs as seen in Figure 7 and provided a view of the mine floor in the vicinity of the hole. The camera produced a limited view of the tunnels via a mirror attached below the camera. The DOE camera crew had trouble with their camera and lights at the time of drilling but produced useful video of LTB 3.

At the request of the PM the BOM arranged for the OSM camera to come to the site on 15 November. With the help of BOM personnel, Bill Ehler of OSM made 360 degree down-hole observations in holes LTB 1, LTB 3, UTB 6, and UTB 7. The OSM camera provides bearing and distances that are important for refining the location of the entry into each tunnel. As a result of an equipment malfunction the videos recorded on November 15 did not turn out and a second day of video observation had to be scheduled. December 10, the date of the second down-hole video observation, occurred shortly after a rain event in Western Maryland at which time mine water was observed running under LTB 1.

2.1.4 *Coring and Drilling Sumps*

As a result of the low pH observed in the mine water collected from UTB 1 and after consultation with ERM, the PM concluded collecting mine water in sumps drilled directly into the mine floor would be acceptable. The PM arranged for CTL's tracked wireline drill to come to the site on July 8, 2002 to collect 5 foot cores from Tunnels 1 and 3. Taking the cores through the casing left behind the sumps required to more efficiently collect samples of even small amounts of water flowing on the mine floor such as had been observed in LTB 1. While the rig was at the site a rotary drill bit was lowered into LTB 2 to drill out the end of the hung up well point to provide better access to mine water that may flow in Tunnel 2. The rotary drill bit easily drilled through the plastic cap and dropped slightly, dislodging whatever caused the well point to hang up at 177 feet. The plastic casing and well point dropped 2.5 feet providing the desired access if mine water is observed in Tunnel 2.

2.2 *SITE IMPROVEMENTS AND MODIFICATIONS*

Brenneman provided the necessary improvements on the access trail to get the drill rig and equipment to the drill sites. Brenneman was very conscientious in limiting activities to avoid disturbance of the surrounding forested area. When rain was forecast, the PM arranged for "dirty" sandstone to be brought from Fairfax Materials, Inc. Brenneman spread

this material and their drill chips on the trail and in the vicinity of each borehole. This has provided a good all-weather surface for future activity.

2.3 *EQUIPMENT USED*

The list of equipment used is provided in Appendix B.

2.4 *WATER MONITORING*

Baseline water quality monitoring activities commenced upon completion of borehole installation. Since completion of the monitoring points, periodic water quality monitoring has been conducted. Initially monitoring was to continue on a monthly basis for a minimum of 6 months. The data was examined and the sample collection frequency re-evaluated.

The mine water and ground water samples collected from the boreholes and monitoring points are analyzed for the parameters shown in Table 3. Table 3 also identifies analytical methods utilized for the monitoring.

Maryland's laboratory at BOM in Frostburg, Maryland and the University of Maryland Center for Environmental Science Appalachian Laboratory in Frostburg analyze samples collected from the experimental site. In general, the analysis of major ions, general chemistry, and trace element analyses will be performed in the laboratories while specific conductivity and pH will be measured in the field. Due to the low water levels at the key monitoring point, LTB 1, several water sampling techniques have been tried for the monitoring points. The sampling techniques are described in detail in Section 2.3.1.

Under a contract with the PPRP, the University of Maryland is conducting a stable isotope study of the entire Kempton Mine Pool. The stable isotope study has allowed PPRP to track and identify sources of water infiltration to the Kempton Mine Pool. In view of access now being available, the stable isotope study can be expanded to include water collected at the Siege of Acre.

2.4.1 *Water Sampling Techniques*

Based on the amount of water present at LTB 1 various innovative methods are employed to sample the water. Several sampling methods are being used to determine which method best suits the location. Each method is evaluated for sample size. Water is monitored through water

Table 3 List of Analytes and Analytical Methods
Pre-Construction Monitoring at the Siege of Acre

Analyte	Analytical Method	Laboratory[1]	Analyte	Analytical Method	Laboratory[1]
Major Ions					
Calcium	EPA (215.1)	MDE	Sulfate	EPA (375.4)	MDE
Iron	EPA (236.1)	MDE	N-nitrate	EPA (300.0)	MDE
Magnesium	EPA (242.1)	MDE	N-nitrite	EPA (300.0)	MDE
Potassium	EPA (258.1)	MDE	Silica	APHA (1998) 4500E	UMCES-AL
Sodium	EPA (273.1)	MDE			
Chloride	EPA (300.0)	MDE			
Trace Elements					
Aluminum	EPA (202.1)	MDE	Lead	EPA (239.1)	MDE
Antimony	EPA (1999b) 6020A	UMCES-AL	Manganese	EPA (243.1)	MDE
Arsenic	EPA (1999b) 6020A	UMCES-AL	Mercury	APHA (1998) 3112B	UMCES-AL
Barium	EPA (1999b) 6020A	UMCES-AL	Nickel	EPA (249.1)	MDE
Beryllium	EPA (1999b) 6020A	UMCES-AL	Selenium	EPA (1999b) 6020A	UMCES-AL
Boron	EPA (1999b) 6020A	UMCES-AL	Silver	EPA (272.1)	MDE
Cadmium	EPA (213.2)	MDE	Thallium	EPA (1999b) 6020A	UMCES-AL
Chromium	EPA (218.2)	MDE	Zinc	EPA (289.1)	MDE
Cobalt	EPA (1999b) 6020A	UMCES-AL			
Copper					
Other Analyses					
Acidity	EPA (305.1)	MDE	---	---	---
Alkalinity	St Method 2320B	MDE	---	---	---
Total Dissolved Solids	EPA (160.1)	MDE	---	---	---
pH	field	---	---	---	---
Conductivity	field	---	---	---	---

(1) Laboratory - MDE is the Maryland Department of the Environment Bureau of Mines
UMCES-AL is the University of Maryland Center for Environmental Science Appalachian Laboratory.

APHA. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association, Washington, DC.

EPA. 1999a. Methods and Guidance for Analysis of Water. EPA 821-C-99-004. Office of Water, U.S. Environmental Protection Agency, Washington, DC.

EPA. 1999b. SW-846: Test Methods for Evaluating Solid Waste Physical/Chemical Methods. Draft Update IVA. U.S. Environmental Protection Agency, Washington, DC.

levels, traditional sampling techniques, and innovative techniques. The variety of specific techniques for sampling water at LTB 1 and LTBE 3 are described below.

2.4.1.1 *Water Levels*

A depth to water meter is used in LTBE 3 to determine the static water level. The static water level is measured and recorded.

2.4.1.2 *Mine Pool Water Sample from LTBE 3*

Traditional sampling techniques are used at location LTBE 3, which is the only borehole completed within the mine pool. A mine pool sample is collected from the borehole with a dedicated bailer or clean, new disposable bailer.

2.4.1.3 *Collecting mine water samples from the mine pavement at LTB 1*

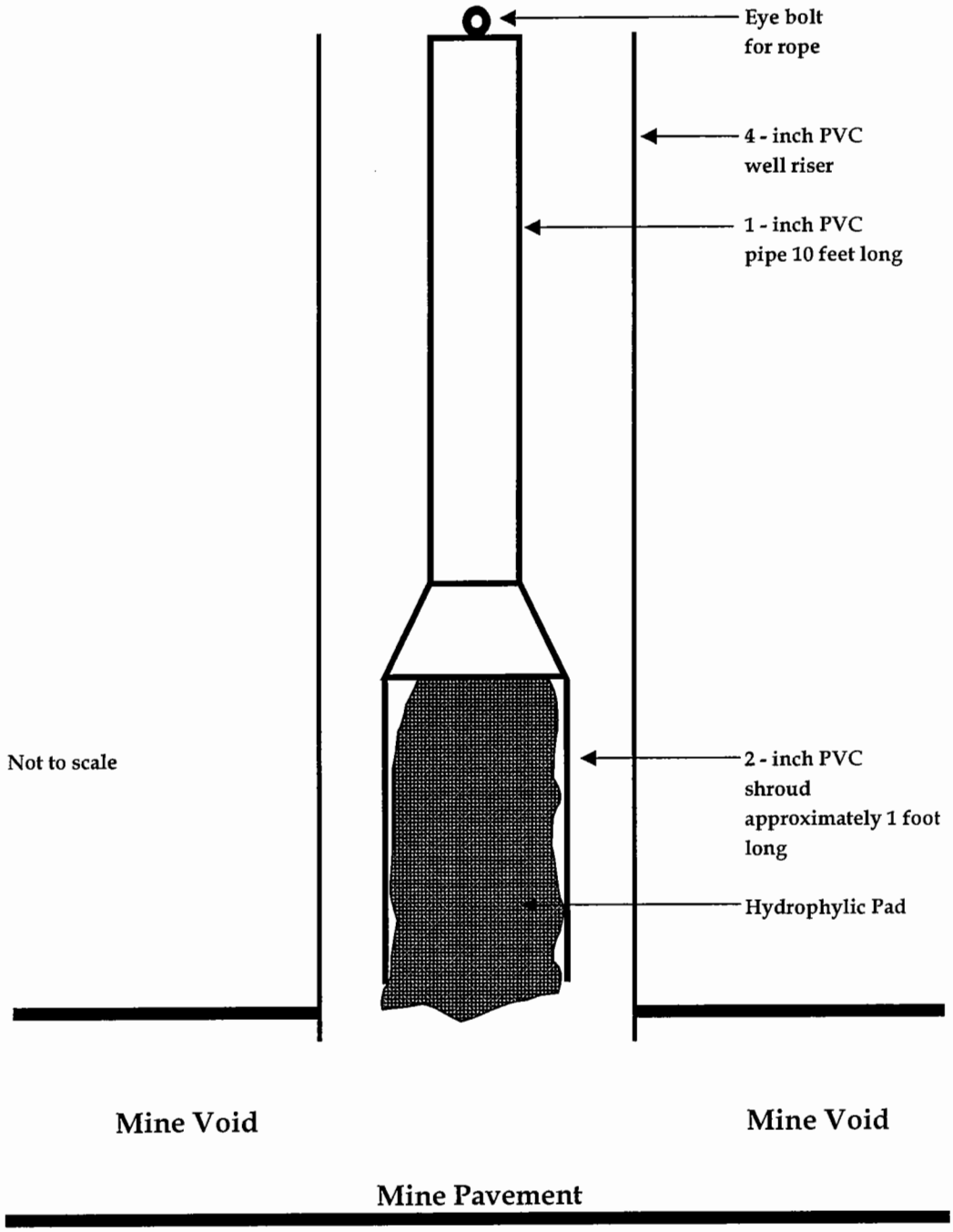
Initially, mine water had to be collected at open borehole LTB 1using hydrophilic pad material (HPM) or sponge to soak-up mine water. It is important to isolate the HPM or sponge from condensate that is not representative of water on the mine pavement. A shroud is used to isolate the HPM or sponge from the condensate as it is lowered into and subsequently retrieved from the well. Figure 9 is a schematic of the HPM shroud. This sampling point has now been improved to allow for sampling with conventional bailers.

2.5 *GROUT DEVELOPMENT / FINAL DESIGN*

Task 3 is the initiation of the design of a grout mix to cover the mine pavement at the ES. The grout design will be based on CCPs available from sources near the Complex and likely to be used in future mine restoration activities in this area. It is expected that CCP raw materials for the Project will be obtained from the following two electric power plants: pulverized coal fly ash (FA) from the Mount Storm Power Plant; and fluidized bed combustion (FBC) ash from the North Branch Power Plant. FA and FBC materials used for the experimental grout design were acquired from these plants.

The purpose of the experimental testing was to develop a recipe for a grout that will spread and flow long distances through the debris on the mine floor where slopes vary from 15 to 18 percent. Fly ash, bottom ash, Flue Gas Desulfurization material and FBC ash were evaluated for use at the experimental site. Each of these materials typically exhibits general

Figure 9
Hydrophilic Pad Shroud for the Siege of Acre Project
Kempton Mine Complex



physical and chemical properties that must be considered in the design. Engineering performance testing was performed to evaluate the following:

- Rheological properties to provide sufficient fluidity to ensure good pumpability, and lateral transport underground;
- Assurance that the grout will set up and develops adequate strength;
- Grout stability so the grout does not degrade in the mine environment; and
- Leachability to ensure that there will be no adverse effects on the environment.

Mix design was developed by Hemmings & Associates through a course of several laboratory studies. The objective of the laboratory studies was to develop optimum compositions for the Project. This involved the review of flow/rheology, strength development, and long-term durability. The design variables evaluated include:

- Component ratios (example fly ash to FBC ash);
- Solids content - C_w;
- Time – pot life, rate of setting and strength development;
- Equipment; and
- Cost.

2.5.1 *Grout Mix Design*

For the Project, three broad mix designs were produced where the FBC component ranged from 10 to 50 percent weight of the total dry solids (i.e., FA:FBC ratios of 90:10, 75:25 and 50:50). The solids contents of the mixes were in the range 60 to 80% of solids (*Cw)*. Small-scale screening trials were conducted before commencement of the rheology and strength testing to qualify these ranges for the test matrix. Qualitative information on mix consistency was noted, along with temperature rise (due to hydration of the lime in the FBC systems) and preliminary set time.

The CCP grout mixes were prepared in sufficient quantity for complete rheological testing using the MC-III rheometer while allowing the same mixes to be cast into test cylinders for strength evaluation.

2.5.2 *Strength Development*

The purpose of injecting grout into the experimental site is to coat the sub-aerial mine pavement. Therefore, the capability to achieve high strengths

is not a key design criteria. The majority of the grout samples for strength testing were cured at 100% relative humidity and ambient temperature, as this is the most common condition to which the grout will be exposed during the Project. Selected mix designs were also subjected to several worst-case curing scenarios of exposure to mine water at the experimental site to test for physical and chemical stability.

Hydraulic grout mixes were cast into 3" x 6" plastic cylinders which were cured under controlled laboratory conditions (21°C ± 3°, 100% RH), intended to be baseline conditions that simulate the exposures underground. The cylinders were periodically tested for uniaxial compressive strength development (unconfined) at incremental test ages from 3 to 90 days age. Strength development of the FA-FBC mix designs was monitored with *Cw* ranging from 60 to 80%.

2.5.3 *Rheological Properties*

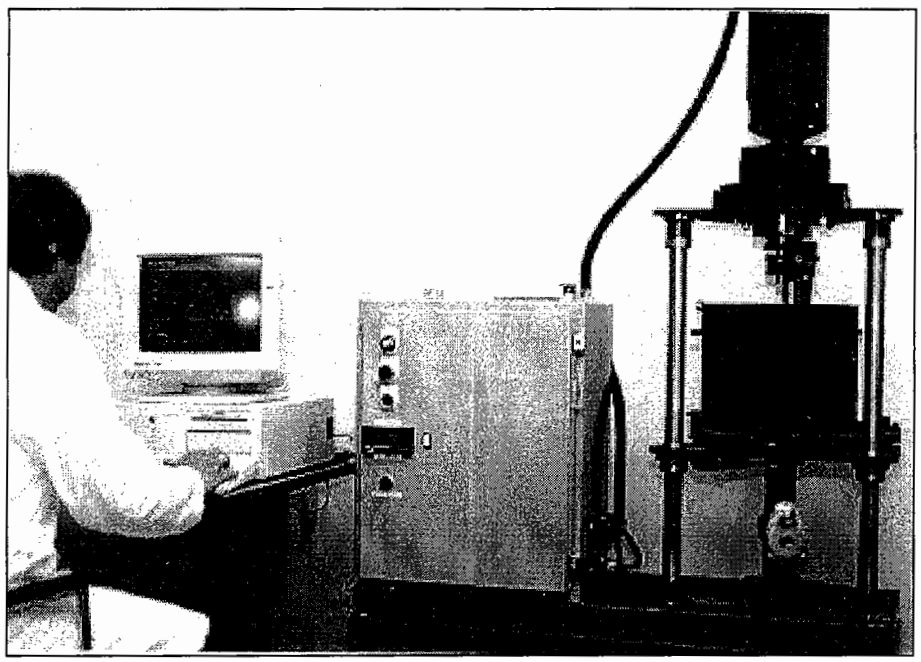
It is important to have a measure of the rheological properties of the CCP grouts under real-world conditions of variable shear. This understanding can then be used to screen a wide range of CCP grout designs for optimal flow. Slump (in the case of concrete materials) or flowtime (in the case of hydraulic grouts) by themselves are neither objective nor reliable indicators of the workability, pumpability and injectability of high solids content pastes such as CCP grouts. Workability is a characteristic property of a given hydraulic mix which can be shown to be dependent on the mixing action applied to the mix.

The relationship between flow and the applied shearing action can be conveniently measured in the laboratory in a specially designed mixer rheometer, pioneering work on which was conducted by Tattersall in the U.K. with further refinement by Hemmings *et al* in Canada. Fluid characteristics determined by the rheometer include cohesiveness and stability under shear. Measurements taken over time provide additional information on the time-dependency of the mix. The rheological properties of the CCP grouts developed for testing for the experimental site were measured with the computer controlled Matex MC-III mixer rheometer (Figure 10).

2.5.4 *Grout Stability and Durability*

A prediction of stability and durability is needed to determine the effect of exposure of the CCP grouts to water infiltrating into the mine. There is a need to be sure that prolonged exposure of the *in-situ* CCP grouts to mine water and, in particular, the chemical agents dissolved in the water do not

Figure 10
Matex MC-III Mixer Rheometer



have deleterious effects on the long-term physical and chemical stability of the grouts.

3.0 *RESULTS AND DISCUSSION*

The work completed and described in Section 2.0 has provided a firm basis for water quality monitoring, mine orientation and initial grout design as required by the Subcontract with West Virginia University. The results and deliverables specified for each Task are presented in Section 3.1. Interpretation of the data is presented in Section 3.2.

3.1 *RESULTS*

The statistically relevant data associated with each Task and deliverable is presented in the following paragraph.

3.1.1 *Task 1 - Drilling and Water Quality Monitoring*

- Borehole LTBE 3 provides access to the Kempton Mine Pool adjacent to the experimental site for monitoring local changes to the mine pool.

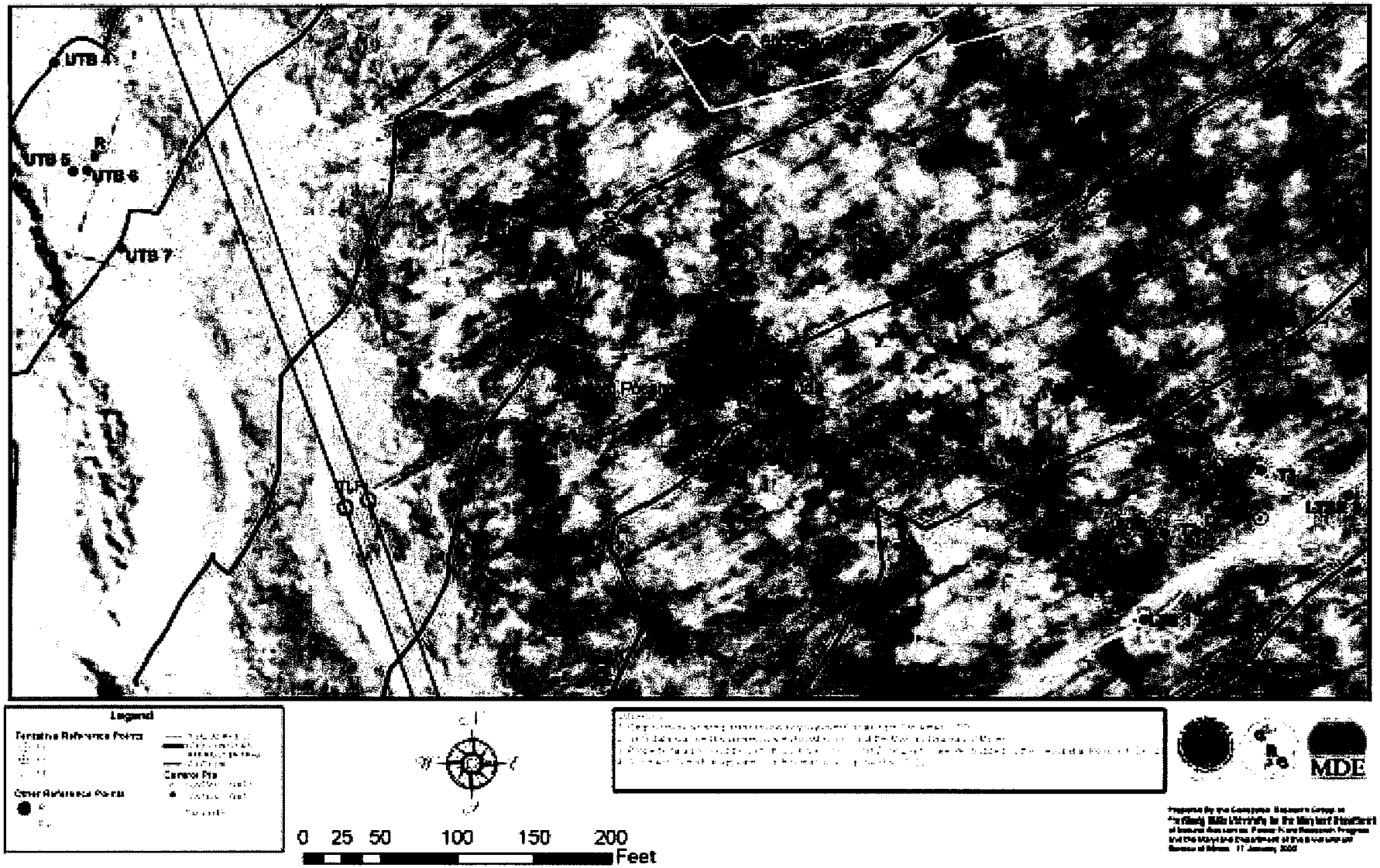
- Borehole LTB 1 provides access to the mine water currently being generated at the experimental site and flowing to the mine pool in Tunnel 1.

- Boreholes LTB 2 and LTB 3 provide access for observation of Tunnels 2 and 3 and potential sampling of mine water if it appears in these tunnels.

Figure 11 is the specified map showing the locations of the exploratory holes at the lower end of the tunnels. The numerous pH field readings taken while developing sampling techniques and training students and BOM personnel to use them were all in the range of pH 2.7 to pH 3.0. These readings constitute a statistically significant data set supporting the decision regarding the suitability of the experimental site for the pavement grouting experiment. The balance of the water quality parameters require laboratory analysis. One set of samples has been sent to laboratories for analysis of all parameters. The monitoring frequency has been increased to weekly to study the relationship of mine water quality to hydrologic events. On the revised schedule a statistically significant data set will be develop for all water quality parameters more rapidly than on the quarterly schedule specified.

Figure 11

Final Location of Mine Map at Experimental Site



3.1.2 *Task 2 - Mine Orientation*

The combination of LTB 1, LTB 2, and LTB 3 at the lower end of the tunnels, UTB 6 and UTB 7 at the upper end of the tunnels, and the downhole camera observations in each hole provides the accurate location and orientation of the mine at the experimental site as shown in Figure 11. Specifically, Reference Points T1, T2, and T3 are over the center line of their respective tunnels at the lower end of the experimental site. Reference Point R is over the center line of Tunnel 2 and UTB 7 is at the center of Tunnel 1. Reference Points R and TLP provide convenient survey control points from which to locate any future drilling of injection, monitoring, or observatiion holes anywhere in the experimental site.

3.1.3 *Task 3 -Initial Grout Design*

The laboratory investigations of locally available CCP's resulted in the grout design shown in Table 4 being considered suitable for the majority of the pavement grouting. These investigations also provide the limits of flexibility in the design to accommodate field conditions. Table 4 provides the specified deliverable.

Table 4: Grout Recipe for 50:50 FA-FBC Grout

Components of Grout Mix	Optimal Percent by Weight	As-Received Moisture Content (%)	Target Dry Weight per Cubic Yard (lbs.)	Batch Weight per Cubic Yards (lbs.)
Fly Ash	35	10*	1,007	TBD*
FBC Ash	35	0*	1,007	TBD*
Water	30	--	863 (103.6 gal)	TBD*

*To be determined in the field.

3.2 *DISCUSSION*

Key considerations in evaluating the data presented in Section 3.1 were related to the overall suitibility of the proposed experimental site for the pavement grouting experiment in terms of:

- Mine water quality being representative of other Upper Freeport mines and the ability to reliably monitor mine water quality before, during, and after grout injection.
- Mine orientation and geometry permitting efficient injection of grout where needed and the ability to monitor grout movement in the mine.
- Suitability of the locally available CCPs for the Project.

3.2.1 *Mine Water Quality*

The desk top studies of the mine location resulted in a very efficient drilling program in terms of ability to monitor the mine water. Based on observation of a dry wash in Tunnel 1, it now seems certain the mine operators drained this section of the mine via Tunnel 1. The sump under LTB 1 is therefore ideally located to intercept mine water coming off the experimental site. The field pH readings are adequate to judge the mine

water quality is similar to that being discharged from the Kempton Mine Complex and AMD from other Upper Freeport mines.

3.2.2 *Mine Orientation*

The eight boreholes drilled at the experimental site coupled with down hole camera observations in all but the one that entered the mine pool clearly establish the orientation and geometry.of the mine for the grouting experiment. The down hole camera obsevations also made it possible to estimate the depth of grout that would be necessary to cover most of the mine debris. Two conditions were noted. The 100 feet of mine seen above the upper bore holes will require about one cubic yard of grout per square yard of mine pavement to fill the mine full as debris reaches close to the mine roof for most of this area. The tunnels and crosscuts between the upper and lower bore holes will require one half cubic yard of grout per square yard of mine pavement resulting in grout two feet deep covering most of the mine debris..

3.2.3 *Grout Design*

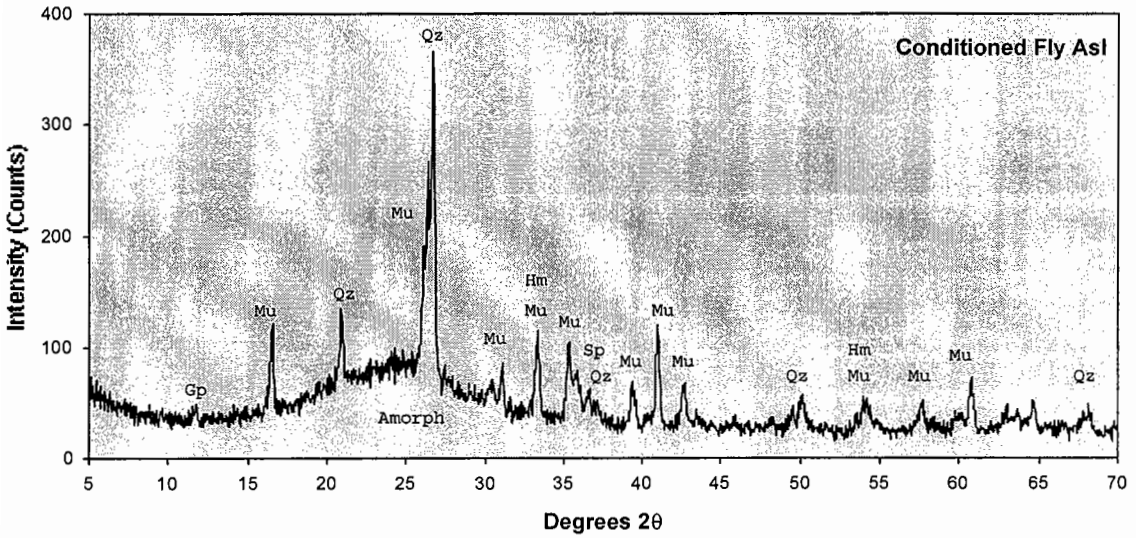
Optimizing the balance between the fluidity/injectability of the CCP hydraulic grout and its self-cementing capability is one of the key technical challenges for the design of CCP grouts for use at the experimental site. Key observations while developing the receipe provided in Section 3.1.3 are discussed below.

Raw Material Evaluation

The X-ray powder diffraction (XRD) patterns and mineralogical phase assignments for the CCP raw materials are given in Figure12. The FA is conditioned with water for handling at the power plant and is predominantly a glassy aluminosilicate, with quartz and mullite being the dominant crystalline species present, typical of an ASTM C-618 Class F ash produced from a bituminous coal. A small amount of gypsum is also present and is likely the result of some fine anhydrite ($CaSO_4$) in the ash being hydrated during conditioning. The FBC material contains ~50% of amorphous dehydroxylated clays/shales, with anhydrite and quartz being the major crystalline species observed. The FBC ash is considered to have low to moderate reactivity based on the relatively low free lime (~2% CaO), portlandite (~5% $Ca(OH)_2$) and anhydrite contents.

Scanning electron microscopy (SEM) images showing the morphology of the FBC material and FA are given in Figure 13. The FA exhibits typical spherical particles, together with significant quantities of irregular unburned carbon (UBC = 7.6%). At higher magnifications the surfaces of

Figure 12
XRD Patterns (CuK) for Raw Materials



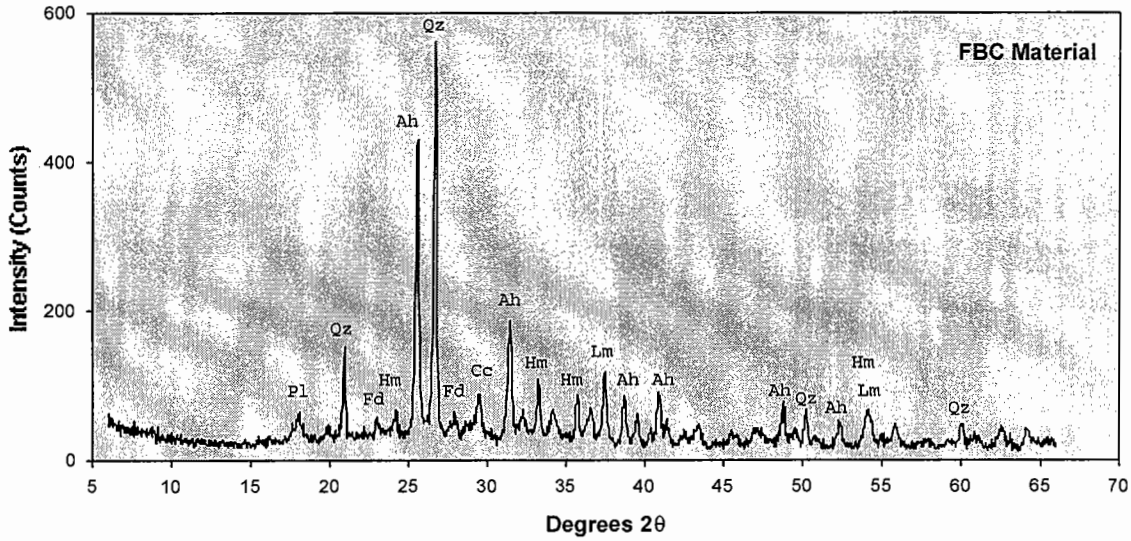
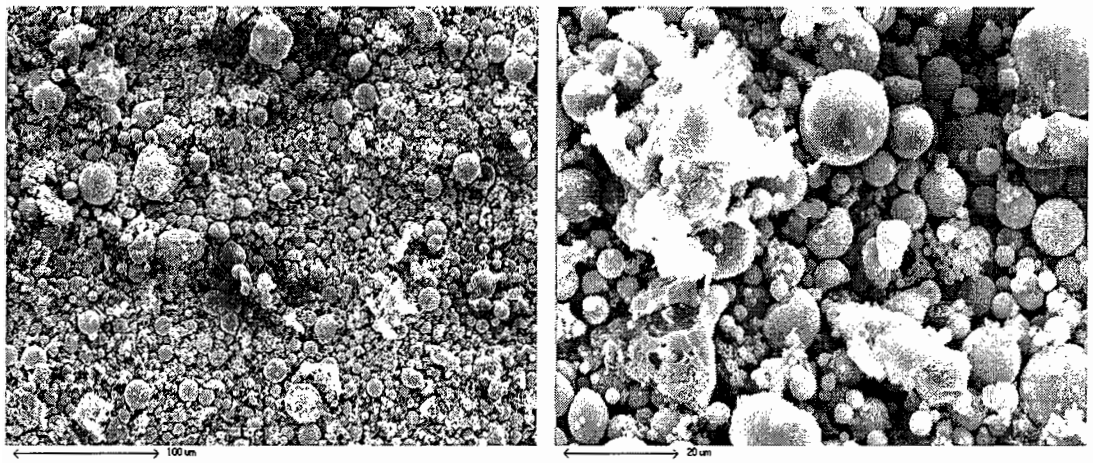
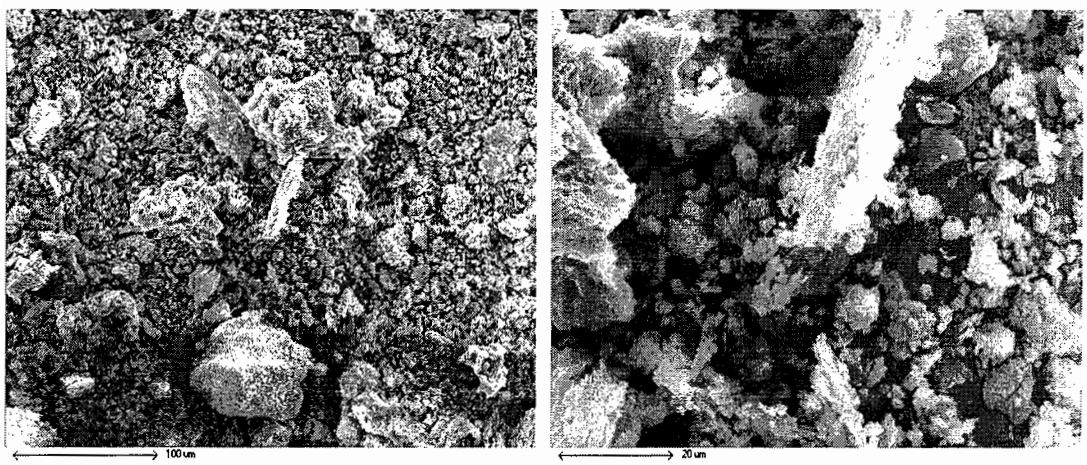


FIGURE 13
SEM Images of CCP Raw Materials



(a) Conditioned Fly Ash



(b) FBC Bottom Ash

the spherical (glassy) FA particles show evidence of some reaction with water during conditioning. The FBC particles are characteristically irregular in shape and larger than the FA particles. Spherical particles are uncommon in FBC ash, as a consequence of the lower temperatures, and hence less melting of mineral matter, experienced in the fluidized bed combustion unit as compared to a pulverized coal unit.

Mix Design Evaluation

The rheological flow parameters were determined over a set period of time for each mix design to evaluate the effects on flow of stiffening occurring as a result of early hydration reactions. A summary of the rheological results for the various FA-FBC fluid grout mixes is presented in Table 5, together with a set of typical rheometer flow curves shown in Figure 14.

The CCP grout mixes generally exhibited stable Bingham flow when *Cw* is in the range of 65 to 71%, together with cohesiveness and time-based reproducibility. Above this range, pseudoplastic flow and hysteresis were typically observed, along with rapid increases in yield stress and plastic viscosity. Examination of this variation of *g* or *h* with *Cw* (Figure 15) shows that an exponential relationship exists between these parameters. Many of the grout mixes with *Cw* < 65%, exhibited solid-liquid separation when allowed to stand for several minutes.

Table 6 summarizes the measured compressive strengths obtained for the mixes under moist curing conditions. Figure 16 shows the relationships between 90-day compressive strength and both FBC ash content and water-to-FBC ash (*w/fbc*) ratio. The variation in compressive strength development, alternatively plotted at constant FA:FBC ratios vs. *Cw* and constant *Cw* vs. FA:FBC ratios, are given in Figure 17. Consistent with the relative low reactivity of the North Branch FBC material, the 90:10 FA-FBC grout shows low strength potential, reaching only 85 psi at 90 days at *Cw* = 80%. In contrast, the 50:50 FA-FBC grout can achieve 500 psi at *Cw* = 65%, 1250 psi at *Cw* = 70%, and over 2400 psi at *Cw* = 80% at 90 days. The 75:25 FA-FBC grout exhibits intermediate strengths. For most mixes, over 90% of the ultimate strength is generated in the first 28 days.

The most notable trend in these data is the strong correlation between the FBC ash content and strength. At a given *Cw*, the higher FBC ash content grout mix is invariably stronger. This is consistent with the FBC ash functioning as the primary cementing agent in these mixes. In fact, when the *w/fbc* ratio is considered independently, all of the strength data fit on a smooth curve, with the lower *w/fbc* ratio mixes producing the highest strengths (Figure 16).

Table 5 Rheology Data for FA-FBC Fluid Grouts

Mix ID FA-FBC	Density Cw, %	Yield Stress g (N.m)	Plastic Viscosity h (N.m.s.)	Flow Type
50-50	72.5	3.13	1.26	Bingham / pseudoplastic
	71.25	0.39	0.49	Bingham
	70	0.22	0.31	Bingham
	68.75	0.04	0.1	Bingham
	67.5	0.04	0.05	Bingham / Onset separation
75-25	70	1.8	0.54	Bingham / pseudoplastic
	69	0.14	0.43	Bingham
	68	0.16	0.23	Bingham
	66.5	0.12	0.16	Bingham
	65	0.01	0.11	Bingham / Onset separation
90-10	70.8	2.79	0.72	Bingham / pseudoplastic
	69	0.48	0.38	Bingham
	67	0.05	0.2	Bingham
	65	0.01	0.1	Bingham

Figure 14
Typical Rheometer Flow Curves for FA-FBC Fluid Grouts

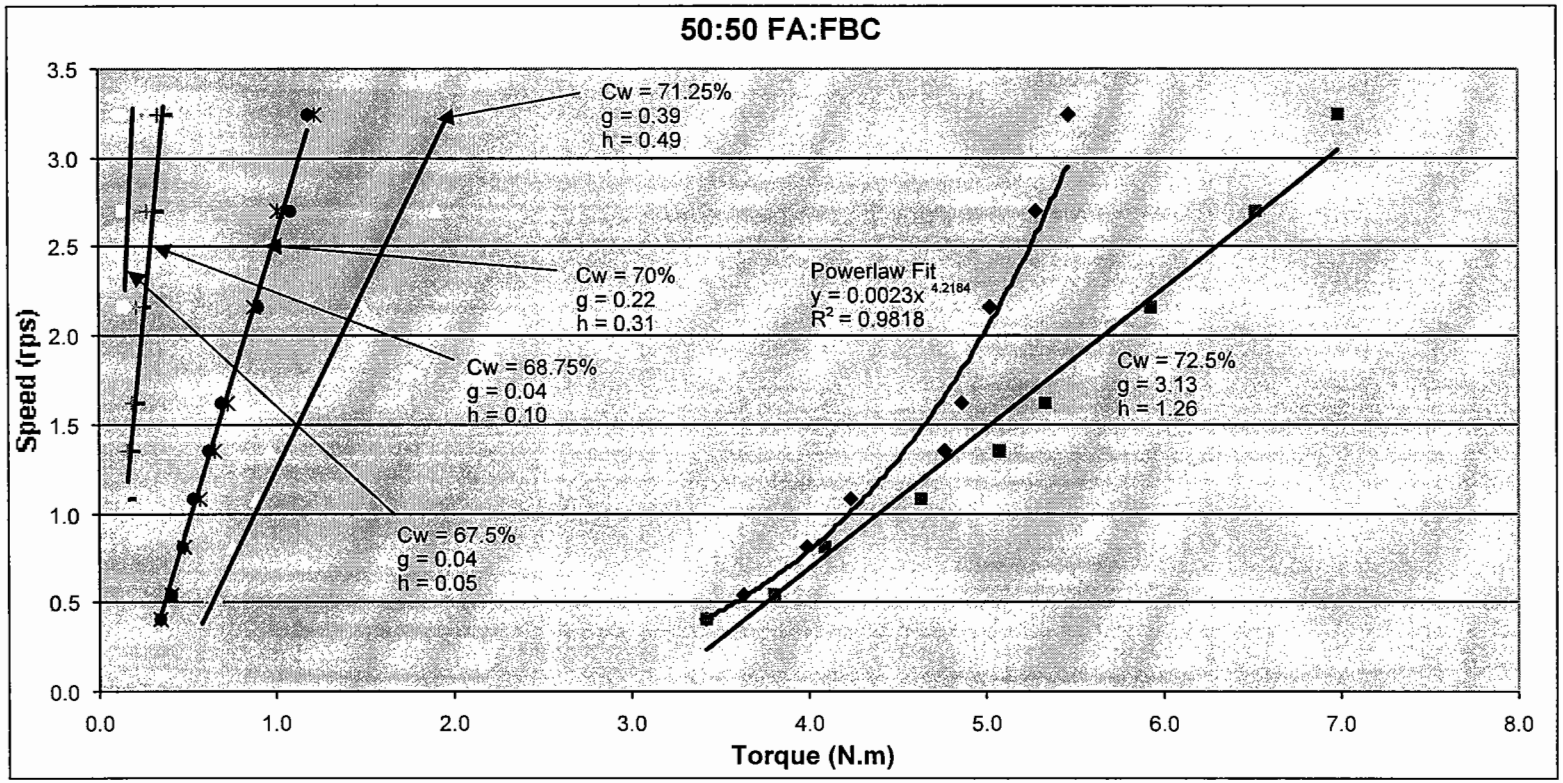


Figure 15
Relationship Between Solids content (*Cw*) and Rheological Parameters (Plastic Viscosity and Yield Stress) for FA-FBC Grouts

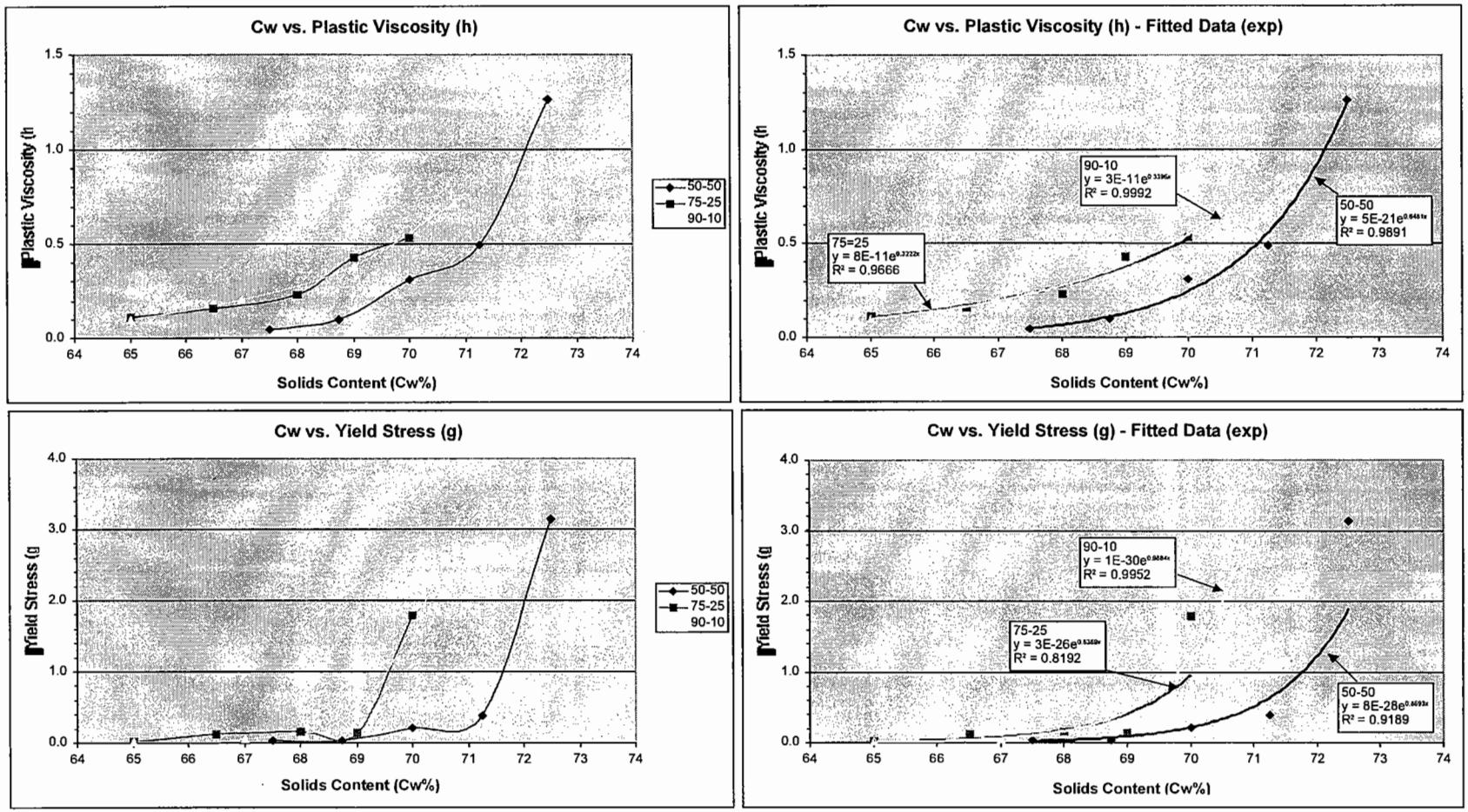
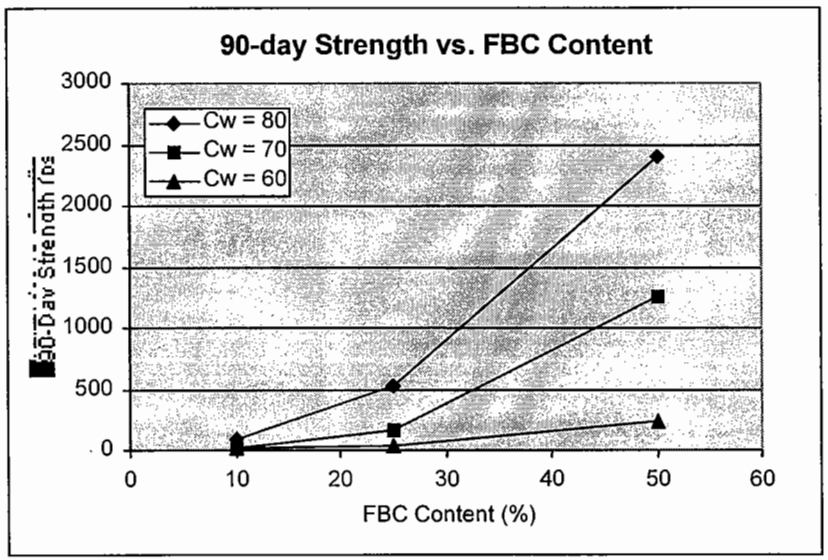


Table 6 Strength Development Data for FA-FBC Fluid Grouts

Mix ID	Density	w/s	w/fbc	Unconfined Compressive Strength (psi)				
FA-FBC	Cw,%			3d	7d	14d	28d	90d
50-50	80	0.25	0.5	174	542	1369	2538	2405
	75	0.33	0.67	85	309	1225	1310	1439
	70	0.43	0.86	27	90	410	975	1248
	65	0.54	1.08	23	85	427	433	526
	60	0.67	1.33	0	34	176	264	230
75-25	80	0.25	1	64	259	464	545	523
	75	0.33	1.33	43	157	323	315	270
	70	0.43	1.71	16	63	163	160	156
	65	0.54	2.15	0	60	102	112	118
	60	0.67	2.67	0	23	48	44	50
90-10	80	0.25	2.5	53	62	82	83	85
	75	0.33	3.33	34	44	35	34	24
	70	0.43	4.29	0	19	30	31	22
	65	0.54	5.38	0	17	18	18	19
	60	0.67	6.67	0	10	8	11	10

Figure 16
Relationship Between Compressive Strength, FBC Content and *w/fbc* Ratio for FA-FBC Fluid Grouts



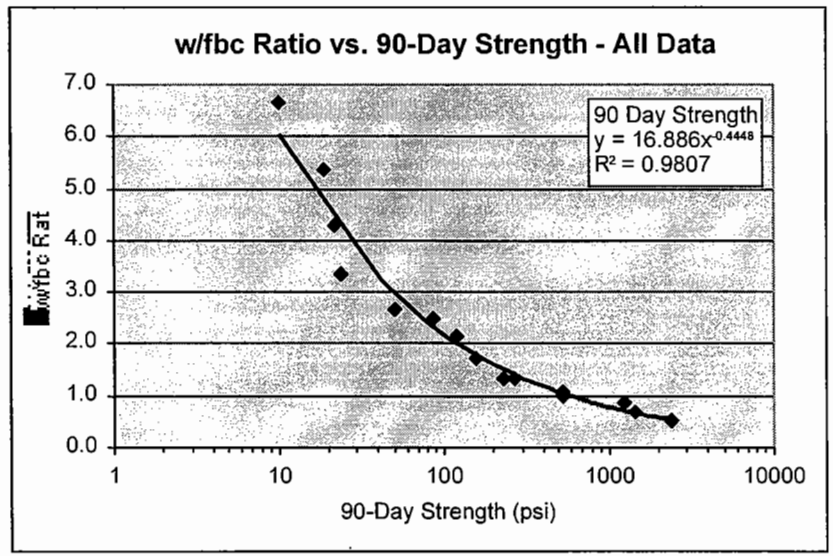
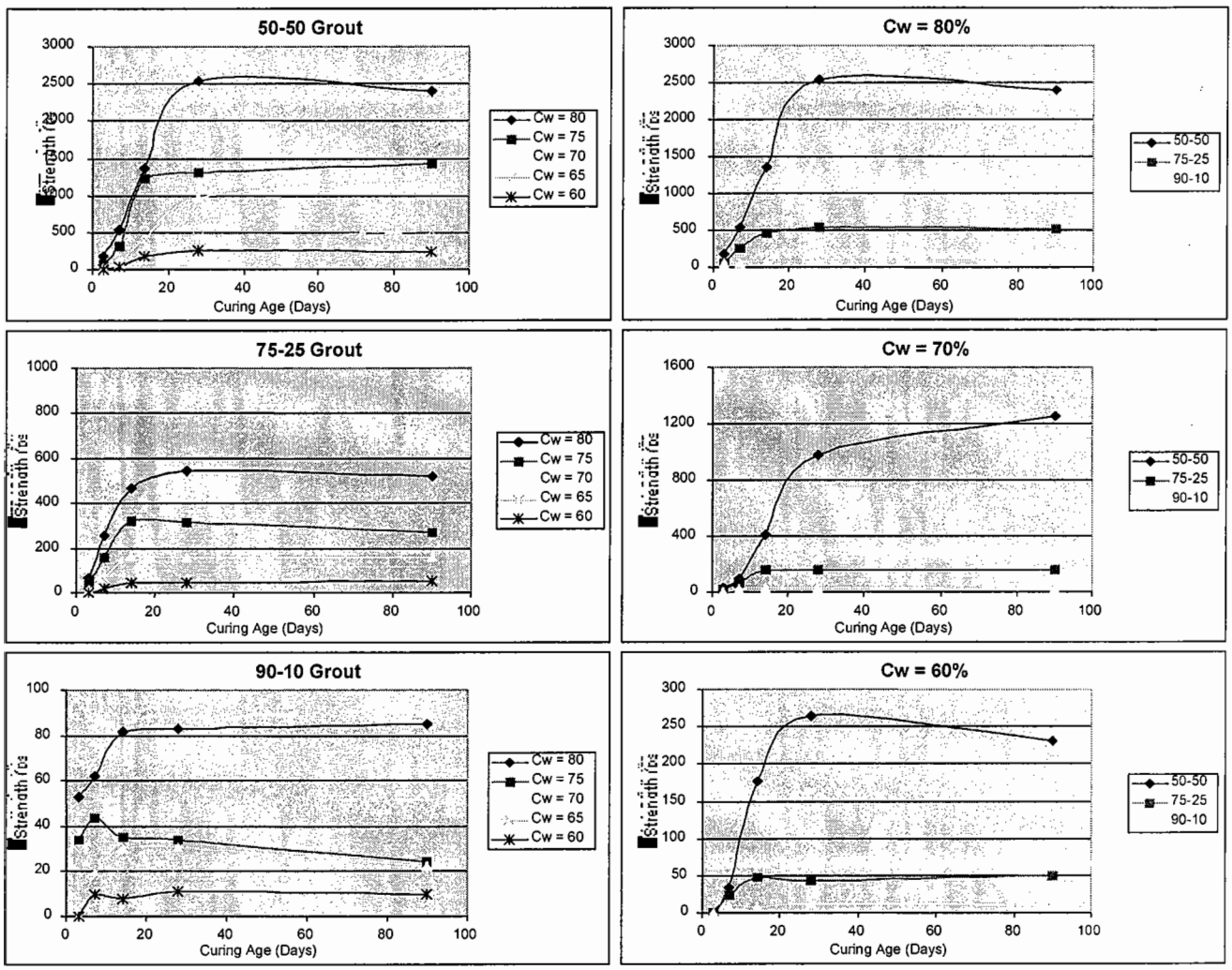


Figure 17
Compressive Strength Development for FA-FBC Fluid Grouts
by FA:FBC Ratio *(left)* and *Cw (right)*



The data show that this particular FA-FBC combination can produce a wide range of compressive strengths by varying both the FBC content and *Cw*. These parameters can be used in conjunction with the rheological data to customize grouts with the desired flow characteristics and design strength.

Mineralogical Changes

The CCP grout system is a three-component system comprised of FA, FBC ash and water. The important factors to be considered are the reactive phases in the FA and FBC ash and the amount of water in the grout mix. The mineralogical data confirm that the reactive phases in the North Branch FBC material are anhydrite (~21%), free lime (~2%), portlandite (~5%), and dehydroxylated clays/shales (~47%). The reactive component in the Mount Storm FA is principally the aluminosilicate glass (50-60 wt%). The unburned carbon, detrital quartz, mullite, hematite, and ferrite spinel in the FA can be considered as largely inert. Other potentially reactive components will include soluble alkali sulfates (typically deposited on the surface of the FA particles) and free lime.

The experimental data confirm that the growth of ettringite strongly parallels strength development in the CCP grout system and can therefore be attributed as the major cementing agent of the grouts. This is similar to the findings in the related systems. In the FA-FBC grout system, the formation of ettringite is dominant early in the cementation process. Both processes bind considerable quantities of water.

Overall Evaluation

Based on the experimental grout design and subsequent rheology and strength testing, a variety of grout mixtures are possible for the Project. The final grout mixtures will be determined based on the conditions observed in the mine workings, results of water quality monitoring data, and results of changes in combustion conditions and future CCP testing. The grout design will take into account the optimum rheology and strength characteristics required to meet the Project goals. The specific recipe for the grouts to be used in the Project will be designed as the Project proceeds to engineering and injection.

Using the historic mine maps and down-hole camera video footage, preliminary estimates of mine void volume and mine pavement area were calculated. The estimated total mine pavement area for the Siege of Acre mine tunnels is 6,225 square yards. Using an average tunnel height of five feet, the total mine void volume is estimated to be 10,375 cubic yards. Based on the downhole camera observations it is estimated that 3,550

cubic yards of grout will be needed to cover the mine pavement and 95 plus percent of the mine debris. These estimates will be used in conjunction with the final grout design to calculate raw material requirements for the grout injection phase of the project.

4.0 *CONCLUSION*

The proposed experimental site in the isolated three A17 tunnels of Kempton Mine No. 42, up dip of the Kempton Mine Pool, is representative of hundreds of acres of sub-aerial mine pavement in the Kempton Mine Complex. It is also representative of thousands of acres of additional Upper Freeport mine pavement in Maryland and neighboring states. The proposed experimental site has suitable access and mine geometry to conduct the proposed grouting experiment.

4.1 *WATER QUALITY MONITORING*

Under normal meteorological conditions there will be adequate mine water flowing from the experimental site in Tunnel 1 to monitor for the impact of changes associated with grouting the mine pavement. Delays in the receipt of funds for Phase I and drought conditions limited the development of statistically significant data during Phase I to field pH readings. These readings were sufficient to conclude that the mine water quality at the experimental site is representative of acid mine drainage from Upper Freeport mines in the region.

4.2 *MINE ORIENTATION*

The mine orientation fixed to well established surface reference points by downhole camera observations provides an adequate basis to accurately drill to any point desired in the experimental site for injection of grout, observation, or monitoring.

4.3 *EXPERIMENTAL GROUT DESIGN*

Locally available CCP's are suitable for designing a grout that is hydraulic for placement and will set up into an impermeable barrier over the mine pavement and entombed mine debris.

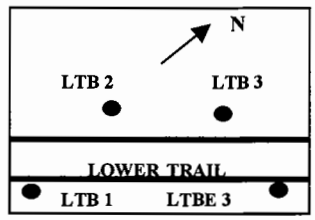
Appendix A
Boring Logs

Environmental Resources Management

Lower Trail Boring LTB 1

Maryland Well Permit GA-94-2031

WO No:	15437.1B.01			Date Completed	10 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		174.5		Diameter	8-inch
North		Surface Elev		2834.72	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42		Diameter	8-inch
Riser	PVC	Length (ft)		170		Diameter	4-inch
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							(Feet BGS)
2834.72	0						
							3 SILT with Shale fragments, medium tan
2829.72	5						
							6 SHALE, highly weathered, medium tan
							7 SILTSTONE with trace Sand, very fine grain, medium tan
2824.72	10						
							12 SANDSTONE, highly weathered, very fine grain, dark
							red-tan
2819.72	15						
							17 SANDSTONE, highly weathered, very fine grain, dark
							red-tan
2814.72	20						

Environmental Resources Management

Lower Trail Boring LTB 1

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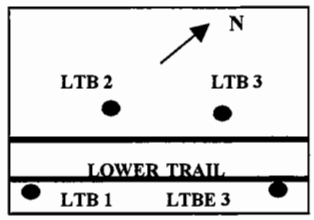
Riser	PVC	Length (ft)		170		Diameter	4-inch
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						24	SANDSTONE, very fine grain, medium tan
2809.72	25					25	SANDSTONE, very fine grain, light tan, competent
						28	SANDSTONE, very fine grain, light tan
2804.72	30					29.5	SANDSTONE, highly weathered, very fine grain, dark
							brown
						32	SANDSTONE, very fine grain, medium gray
						33	SANDSTONE, highly weathered, very fine grain, dark
							brown
2799.72	35					34	SANDSTONE, very fine grain, medium gray
2794.72	40					40	SANDSTONE, very fine grain, medium gray
						42	CASING DEPTH
2789.72	45						
						46	SHALE, dark gray

Environmental Resources Management

Lower Trail Boring LTB 1
Maryland Well Permit GA-94-2031

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Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
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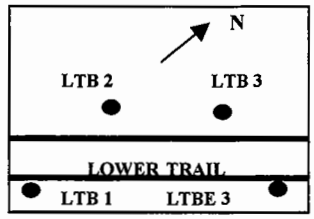
North		Surface Elev	2834.72	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42		Diameter	8-inch	
Riser	PVC	Length (ft)	170		Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						49	SHALE, black
2784.72	50						
						54	SANDSTONE, very fine grain, dark gray
2779.72	55						
						58	SHALE, black
2774.72	60					60	COAL, black
						62	CLAYSTONE, light gray
						63	SILTSTONE with trace Sand, very fine grain, dark gray
2769.72	65						
						66	SANDSTONE, very fine grain, dark gray
						67	SANDSTONE, very fine grain, medium gray
2764.72	70						
						72	SILTSTONE with trace Sand, very fine grain, dark gray

Environmental Resources Management

Lower Trail Boring LTB 1

Maryland Well Permit GA-94-2031

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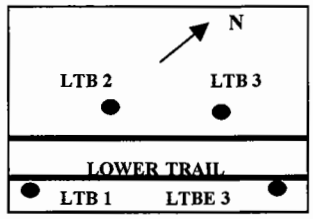
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42		Diameter	8-inch
Riser	PVC	Length (ft)		170		Diameter	4-inch
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2759.72	75						
						78	CLAYSTONE, medium gray
2754.72	80						
						81	CLAYSTONE, light gray
						84	CLAYSTONE, white-light gray
2749.72	85						
						87	SILTSTONE with trace Sand, very fine grain, medium
							gray
						89	SANDSTONE, very fine grain, medium gray
2744.72	90						
						92	SANDSTONE, very fine grain, medium gray
2739.72	95						
						96	SHALE, dark gray
						98	SANDSTONE, very fine grain, dark gray
						99	SHALE, dark gray
2734.72	100						

Environmental Resources Management

Lower Trail Boring LTB 1
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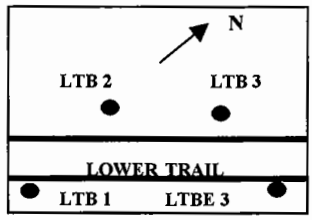
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42		Diameter	8-inch
Riser	PVC	Length (ft)		170		Diameter	4-inch
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						102	SANDSTONE, very fine grain, dark gray
2729.72	105						
						109	CLAYSTONE, red-gray
2724.72	110						
						111	CLAYSTONE, light gray
						113	CLAYSTONE, yellow-tan
2719.72	115						
						116	SANDSTONE, very fine grain, dark gray
						119	SILTSTONE with trace Sand, very fine grain, dark gray
2714.72	120						
						122	SANDSTONE, very fine grain, medium gray
2709.72	125						

Environmental Resources Management

Lower Trail Boring LTB 1

Maryland Well Permit GA-94-2031

WO No:	15437.1B.01			Date Completed	10 Nov 01		
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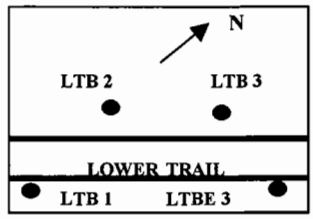
Location	Kempton, MD	Bore Depth (ft)		174.5		Diameter	8-inch
North		Surface Elev		2834.72	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42		Diameter	8-inch
Riser	PVC	Length (ft)		170		Diameter	4-inch
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						128	SHALE, black
2704.72	130					130	SHALE, light gray
						134	SILTSTONE with trace Sand, very fine grain, medium
2699.72	135						gray
						137	SANDSTONE, very fine grain, medium gray
2694.72	140						
						143	SILTSTONE with trace Sand, very fine grain, dark gray
2689.72	145						
2684.72	150						
						151	SILTSTONE with trace Sand, very fine grain, dark gray

Environmental Resources Management

Lower Trail Boring LTB 1

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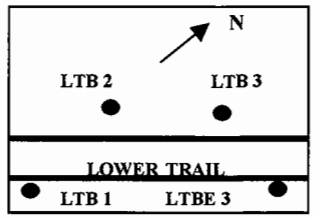
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42		Diameter	8-inch
Riser	PVC	Length (ft)		170		Diameter	4-inch
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2679.72	155						
						157	SILTSTONE with trace Sand, very fine grain, dark gray
2674.72	160						
						161	SILTSTONE with trace Sand, very fine grain, dark gray
2669.72	165						
						167	SILTSTONE with trace Sand, very fine grain, dark gray
						168	SHALE, black
2664.72	170			MINE CEILING 169 feet BGS			
				MINE VOID 169 to 174.5 feet BGS			
2659.72	175			MINE PAVEMENT 174.5 feet BGS			

Environmental Resources Management

Lower Trail Boring LTB 1

Maryland Well Permit GA-94-2031

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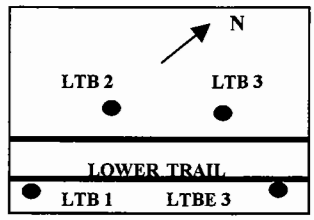
North		Surface Elev		2834.72	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42	Diameter	8-inch	
Riser	PVC	Length (ft)		170	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



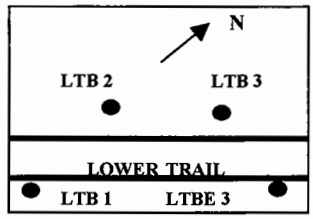
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification	
2654.72	180						***LTB 1 Borehole Specifications***	
							Surface Casing	+2 to 42 feet BGS
							Bentonite Grout	0 to 164 feet BGS
							Riser Interval	+2 to 170 feet BGS
2649.72	185						Screen Interval	No Screen Installed
							Grout Traps	165 and 168 feet BGS
							Mine Void	169 to 174.5 feet BGS
							Wellhead completed as a stick-up configuration, expansion	
2644.72	190						plug, aluminum well cap and padlock	
2639.72	195							
2634.72	200							
								Page 8 of 8

Environmental Resources Management

Lower Trail Boring LTB 2

Maryland Well Permit GA-94-2030

WO No:	15437.1B.01			Date Completed	8 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	180.5		Diameter	8-inch	
North		Surface Elev	2843.00	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	36		Diameter	8-inch	
Riser	PVC	Length (ft)	169 / 3		Diameter	4-inch	
Screen	PVC	Length (ft)	5		Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

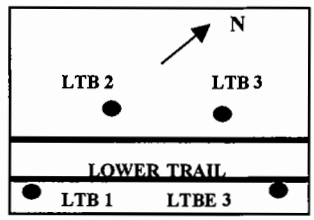


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							(Feet BGS)
2843.00	0						
							2 SILT with Shale fragments, medium tan
2838.00	5						5 SHALE, highly weathered, medium tan
							6 SILTSTONE with trace Sand, very fine grain, medium tan
							7 SHALE, medium tan with trace red
							7.5 SILTSTONE with trace Sand, very fine grain, medium tan
							9 SHALE, highly weathered, dark tan with trace red
2833.00	10						
							13 SHALE, highly weathered, medium yellow-tan
2828.00	15						
							17 SHALE, highly weathered, dark tan with trace red
							19 SHALE, moderately weathered, red-tan
2823.00	20						21 SHALE, red-tan
							22 SILTSTONE with trace Sand, very fine grain, medium tan

Environmental Resources Management

Lower Trail Boring LTB 2
Maryland Well Permit GA-94-2030

WO No:	15437.1B.01			Date Completed	8 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		180.5	Diameter	8-inch	
North		Surface Elev		2843.00	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		36	Diameter	8-inch	
Riser	PVC	Length (ft)		169 / 3	Diameter	4-inch	
Screen	PVC	Length (ft)		5	Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



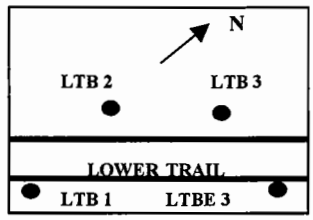
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						24	SANDSTONE, very fine grain, light tan
2818.00	25						
						27	SANDSTONE, very fine grain, medium tan
						28	SANDSTONE, very fine grain, light tan
2813.00	30					30	SANDSTONE, very fine grain, dark tan-brown
						32	SANDSTONE, very fine grain, dark tan
						33	SANDSTONE, very fine to medium grain, highly weathered, dark brown, Potential Water Bearing Zone
2808.00	35					34	SILTSTONE with trace Sand, very fine grain, dark gray
						36	CASING DEPTH
						38	SANDSTONE, very fine grain, dark gray
2803.00	40						
						41	SILTSTONE with trace Sand, very fine grain, medium gray
						44	SILTSTONE with trace Sand, very fine grain, dark gray
2798.00	45						

Environmental Resources Management

Lower Trail Boring LTB 2

Maryland Well Permit GA-94-2030

WO No:	15437.1B.01			Date Completed	8 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		180.5	Diameter	8-inch	
North		Surface Elev		2843.00	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		36	Diameter	8-inch	
Riser	PVC	Length (ft)		169 / 3	Diameter	4-inch	
Screen	PVC	Length (ft)		5	Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						49	SHALE, dark gray
2793.00	50						
2788.00	55						
						57	SHALE, black-dark gray
2783.00	60						
						61	COAL, black
						63	SHALE, medium gray
2778.00	65						
						68	SILTSTONE with trace Sand, very fine grain, dark gray
2773.00	70						
						71	CLAYSTONE, medium gray
						73	SILTSTONE with trace Sand, very fine grain, dark gray

Environmental Resources Management

Lower Trail Boring LTB 2

Maryland Well Permit GA-94-2030

WO No:	15437.1B.01			Date Completed	8 Nov 01		
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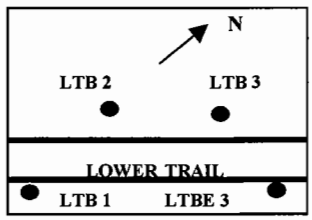
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		36		Diameter	8-inch
Riser	PVC	Length (ft)		169 / 3		Diameter	4-inch
Screen	PVC	Length (ft)		5		Diameter	4-inch
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling			Maryland License 373			

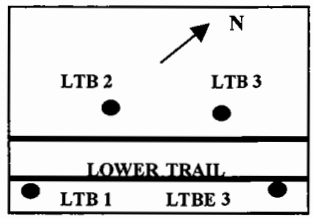


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2768.00	75						
						76	SILTSTONE with trace Sand, very fine grain, medium gray
						78	SHALE, dark gray
2763.00	80						
						81	CLAYSTONE, light gray
2758.00	85					85	CLAYSTONE, white-light gray
						89	SANDSTONE, very fine grain, medium gray
2753.00	90						
						91	SANDSTONE, very fine grain, light gray
						93	SANDSTONE, very fine grain, medium gray
2748.00	95						
						98	SHALE, dark gray
2743.00	100						

Environmental Resources Management

Lower Trail Boring LTB 2
Maryland Well Permit GA-94-2030

WO No:	15437.1B.01			Date Completed	8 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		180.5		Diameter	8-inch
North		Surface Elev		2843.00	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		36		Diameter	8-inch
Riser	PVC	Length (ft)		169 / 3		Diameter	4-inch
Screen	PVC	Length (ft)		5		Diameter	4-inch
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						102	SHALE, medium gray
2738.00	105					105	SANDSTONE, very fine grain, dark gray
						107	SHALE, dark gray
2733.00	110						
						111	SHALE, black-dark gray
						112	SHALE, red-gray
						113	SHALE, dark gray
2728.00	115					115	CLAYSTONE, medium gray
						119	SHALE, dark gray
2723.00	120					120	SILTSTONE with trace Sand, very fine grain, dark gray
						122	SANDSTONE, very fine grain, medium gray
						124	SANDSTONE, very fine grain, light gray
2718.00	125					125	SANDSTONE, very fine grain, medium gray

Environmental Resources Management

Lower Trail Boring LTB 2

Maryland Well Permit GA-94-2030

WO No:	15437.1B.01			Date Completed	8 Nov 01		
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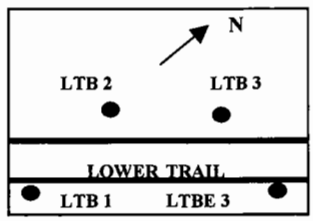
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		36	Diameter	8-inch	
Riser	PVC	Length (ft)		169 / 3	Diameter	4-inch	
Screen	PVC	Length (ft)		5	Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						129	SHALE, black-dark gray
2713.00	130						
						131	SHALE, medium gray
2708.00	135						
						137	SHALE, medium gray
2703.00	140						
						142	CLAYSTONE, medium gray
2698.00	145					145	SILTSTONE with trace Sand, very fine grain, medium gray
						149	SANDSTONE, very fine grain, medium gray
2693.00	150						
						152	SILTSTONE with trace Sand, very fine grain, dark gray

Environmental Resources Management

Lower Trail Boring LTB 2

Maryland Well Permit GA-94-2030

WO No:	15437.1B.01			Date Completed	8 Nov 01		
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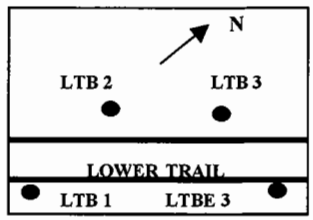
North		Surface Elev		2843.00	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		36		Diameter	8-inch
Riser	PVC	Length (ft)		169 / 3		Diameter	4-inch
Screen	PVC	Length (ft)		5		Diameter	4-inch
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2688.00	155						155 SILTSTONE with trace Sand, very fine grain, medium gray
							157 SANDSTONE, very fine grain, medium gray
2683.00	160						
							164 SILTSTONE with trace Sand, very fine grain, dark gray
2678.00	165						166 SHALE, dark gray
2673.00	170						
				MINE CEILING 170 feet BGS			
				MINE VOID 170 to 175.5 feet BGS			
2668.00	175						
				MINE PAVEMENT 175.5 feet BGS			
				OVERDRILLED SUMP 175.5 to 180.5 feet BGS (Collapsed to 177 feet BGS)			

Environmental Resources Management

Lower Trail Boring LTB 2

Maryland Well Permit GA-94-2030

WO No:	15437.1B.01			Date Completed	8 Nov 01		
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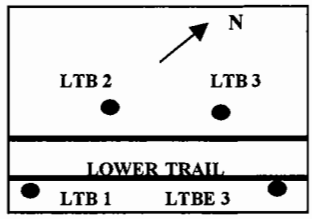
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		36	Diameter	8-inch	
Riser	PVC	Length (ft)		169 / 3	Diameter	4-inch	
Screen	PVC	Length (ft)		5	Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



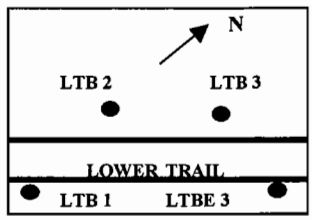
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification	
2663.00	180			OVERDRILLED SUMP 175.5 to 180.5 feet BGS (Collapsed to 177 feet BGS)				
							LTB 2 Borehole Specifications	
2658.00	185							
							Surface Casing	+2 to 36 feet BGS
							Bentonite Grout	0 to 36 feet BGS
							Riser Interval	+2 to 169 feet BGS
							Screen Interval (10 Slot)	169 to 174 feet BGS
2653.00	190						Grout Traps	160.5 and 174 feet BGS
							Mine Void	170 to 175.5 feet BGS
							Borehole Sump	175.5 to 180.5 feet BGS
							Wellhead completed as a stick-up configuration, expansion	
2648.00	195						plug, aluminum well cap and padlock	
							NOTE: PVC well materials were unsuccessfully installed. Bottom of	
							screen interval is approximately 1.5 feet above the mine pavement.	
							Annulus between the 8-inch borehole and 4-inch PVC was not grouted.	
2643.00	200							
								Page 8 of 8

Environmental Resources Management

Lower Trail Boring LTB 3

Maryland Well Permit GA-94-2029

WO No:	15437.1B.01			Date Completed	6 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		181.5		Diameter	8-inch
North		Surface Elev		2842.88	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		47		Diameter	8-inch
Riser		Length (ft)				Diameter	
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							(Feet BGS)
2842.88	0						
							0 HUMUS, leaves and roots
							0.5 SHALE, highly weathered, medium tan
2837.88	5						5 SILT, dark tan
							7 SILT, dark tan-orange
2832.88	10						
							12 SILT, dark tan-orange
2827.88	15						
							18 SILT, dark tan-orange
2822.88	20						

Environmental Resources Management

Lower Trail Boring LTB 3

Maryland Well Permit GA-94-2029

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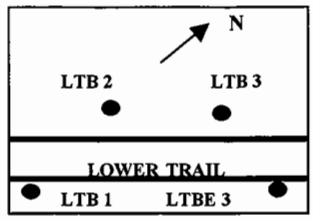
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)		Sample Description/Classification
							23	SANDSTONE, very fine to medium grain, medium tan,
								decreased drill speed indicating more competent bedrock
2817.88	25						25	SANDSTONE, very fine to medium grain, medium gray
2812.88	30						30	SANDSTONE, very fine to medium grain, medium gray
							33	SANDSTONE, very fine to medium grain, light gray
2807.88	35							
							38	SANDSTONE, very fine to medium grain, medium tan
2802.88	40							
							41	SILTSTONE with trace Sand, very fine, dark gray
							43	SHALE, dark gray
							44	SANDSTONE, very fine to medium grain, dark gray
2797.88	45						45	CASING DEPTH
							46	SANDSTONE, very fine grain, medium gray

Environmental Resources Management

Lower Trail Boring LTB 3

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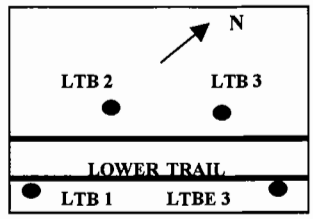
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		47	Diameter	8-inch	
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2792.88	50						50 SHALE, dark gray
							SANDSTONE, very fine to medium grain, dark gray
							54 SILTSTONE with trace Sand, very fine, dark gray
2787.88	55						
							59 SHALE, dark gray
2782.88	60						
							61 SHALE, black-gray
							62 SHALE, dark gray
2777.88	65						
							67 COAL, black
							68 SHALE, dark gray
2772.88	70						
							71 SHALE, medium gray
							73 SILTSTONE with trace Sand, very fine, dark gray

Environmental Resources Management

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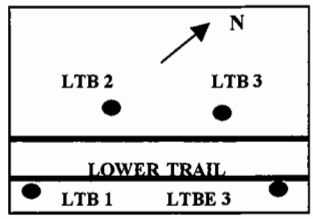
Riser		Length (ft)				Diameter	
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2767.88	75						
						76	SHALE, dark gray
						79	SILTSTONE with trace Sand, very fine, dark gray
2762.88	80					80	SHALE, dark gray
						82	SHALE, dark gray
2757.88	85						
						89	CLAYSTONE, medium gray
2752.88	90						
						91	CLAYSTONE, light gray
2747.88	95						
						100	SANDSTONE, very fine grain, dark gray
2742.88	100						

Environmental Resources Management

Lower Trail Boring LTB 3

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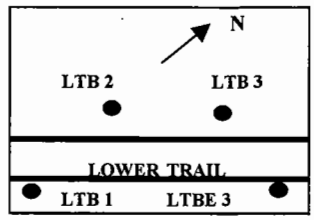
Casing	Steel	Length (ft)		47	Diameter	8-inch	
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						104	SHALE, dark gray
2737.88	105						
2732.88	110					110	SILTSTONE with trace Sand, very fine, dark gray
						113	SHALE, medium gray
2727.88	115						
						117	SHALE, dark gray
						119	CLAYSTONE, light gray-white
2722.88	120						
						122	CLAYSTONE, medium tan
						123	SHALE, dark gray
2717.88	125					125	SILTSTONE with trace Sand, very fine grain, dark gray

Environmental Resources Management

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Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
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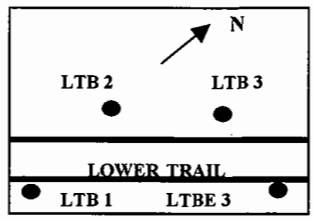
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						128	SANDSTONE, very fine to medium grain, dark gray
2712.88	130						
						133	SHALE, red-gray
						134	CLAYSTONE, light gray
2707.88	135						
						138	SHALE, light gray
						139	CLAYSTONE, light gray
2702.88	140						
						141	SHALE, light gray
2697.88	145						
						146	SILTSTONE with trace Sand, very fine grain, light gray
						147	SILTSTONE with trace Sand, very fine grain, medium gray
						149	SILTSTONE with trace Sand, very fine grain, dark gray
2692.88	150						

Environmental Resources Management

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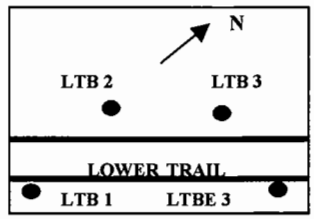

Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2687.88	155						155 SHALE, dark gray
2682.88	160						
							161 SILTSTONE with trace Sand, very fine grain, dark gray
							163 SHALE, dark gray
2677.88	165						
2672.88	170						
							171 SHALE, dark gray
							174 SHALE, black-dark gray
2667.88	175						
				MINE CEILING 177 feet BGS			

Environmental Resources Management

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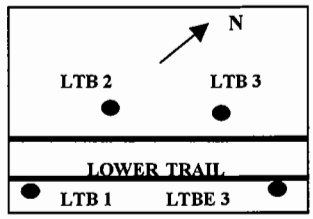
Casing	Steel	Length (ft)		47		Diameter	8-inch
Riser		Length (ft)				Diameter	
Screen		Length (ft)				Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



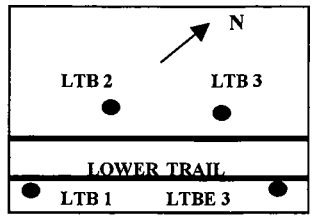
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
				MINE VOID 177 to 181.5 feet BGS			
2662.88	180						
				MINE PAVEMENT 181.5 feet BGS			
2657.88	185						***LTB 3 Borehole Specifications***
							Surface Casing +2 to 45 feet BGS
							Bentonite Grout 0 to 45 feet BGS
							Open Borehole (8-inch) 45 to 177 feet BGS
2652.88	190						Mine Void 177 to 181.5 feet BGS
							Wellhead completed as a stick-up configuration, expansion plug, aluminum well cap and padlock
2647.88	195						
2642.88	200						

Environmental Resources Management

Lower Trail Boring LTBE 3

Maryland Well Permit GA-94-2028

WO No:	15437.1B.01			Date Completed	5 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	186		Diameter	6-inch	
North		Surface Elev	2829.55	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42		Diameter	6-inch	
Riser	PVC	Length (ft)	183		Diameter	4-inch	
Screen	PVC	Length (ft)	5		Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



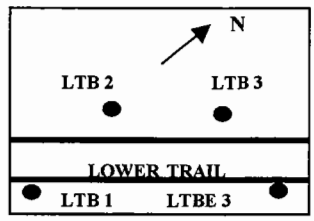
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							(Feet BGS)
2829.55	0						
							0 SILT, dark tan
							2 SILT, dark tan
2824.55	5						4 SHALE, highly weathered, medium tan
							9 SHALE, highly weathered, medium tan
2819.55	10						
2814.55	15						
							16 SHALE, highly weathered, medium tan
2809.55	20						
							21 SHALE, moderately weathered, medium tan

Environmental Resources Management

Lower Trail Boring LTBE 3

Maryland Well Permit GA-94-2028

WO No:	15437.1B.01			Date Completed	5 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	186		Diameter	6-inch	
North		Surface Elev	2829.55	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42		Diameter	6-inch	
Riser	PVC	Length (ft)	183		Diameter	4-inch	
Screen	PVC	Length (ft)	5		Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



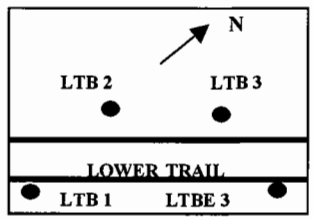
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						22	SILTSTONE with trace Sand, very fine grain, moderately weathered, dark tan
2804.55	25						
						26	SILTSTONE with trace Sand, very fine grain, highly weathered, dark brown
						27	SILTSTONE with trace Sand, very fine grain, moderately weathered, medium tan
2799.55	30					29	SILTSTONE with trace Sand, very fine grain, slightly weathered, dark tan, Potential Water Bearing Zone
						30	SANDSTONE, very fine to medium grain, medium tan, decreased drill speed indicating more competent bedrock
2794.55	35					35	SANDSTONE, very fine to medium grain, light to medium tan
2789.55	40					40	CASING DEPTH
						44	SANDSTONE, very fine to medium grain, highly weathered, dark brown
2784.55	45					45	SHALE, dark gray

Environmental Resources Management

Lower Trail Boring LTBE 3

Maryland Well Permit GA-94-2028

WO No:	15437.1B.01			Date Completed	5 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		186	Diameter	6-inch	
North		Surface Elev		2829.55	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42	Diameter	6-inch	
Riser	PVC	Length (ft)		183	Diameter	4-inch	
Screen	PVC	Length (ft)		5	Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



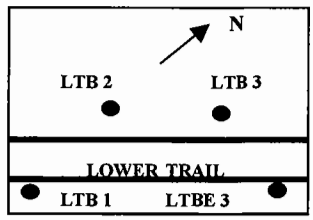
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2779.55	50						50 SHALE, dark gray
							52 SANDSTONE, very fine to medium grain, dark gray
2774.55	55						
							56 SHALE, dark gray
2769.55	60						
							63 SHALE, dark gray
2764.55	65						
2759.55	70						70 SHALE, dark gray
							73 SHALE, black
							74 SHALE, dark gray

Environmental Resources Management

Lower Trail Boring LTBE 3

Maryland Well Permit GA-94-2028

WO No:	15437.1B.01			Date Completed	5 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		186	Diameter	6-inch	
North		Surface Elev		2829.55	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42	Diameter	6-inch	
Riser	PVC	Length (ft)		183	Diameter	4-inch	
Screen	PVC	Length (ft)		5	Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



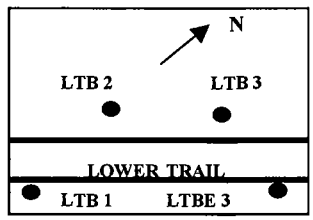
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2754.55	75						
2749.55	80						
							81 SHALE, dark gray
2744.55	85						
2739.55	90						
							91 SHALE, medium gray, increased drill speed
2734.55	95						96 CLAYSTONE, light gray-white
2729.55	100						

Environmental Resources Management

Lower Trail Boring LTBE 3

Maryland Well Permit GA-94-2028

WO No:	15437.1B.01			Date Completed	5 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	186	Diameter	6-inch		
North		Surface Elev	2829.55	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42	Diameter	6-inch		
Riser	PVC	Length (ft)	183	Diameter	4-inch		
Screen	PVC	Length (ft)	5	Diameter	4-inch		
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge		
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



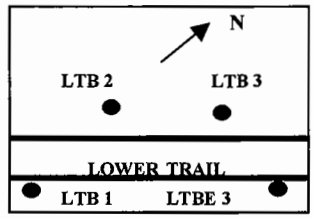
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							101 SHALE, dark gray
2724.55	105						
							108 SANDSTONE, very fine to medium grain, dark gray
2719.55	110						
							111 SHALE, dark gray
2714.55	115						
							116 SILTSTONE with trace Sand, very fine, dark gray
2709.55	120						
							123 SHALE, dark gray-black, increased drill speed
2704.55	125						125 SHALE, dark gray

Environmental Resources Management

Lower Trail Boring LTBE 3

Maryland Well Permit GA-94-2028

WO No:	15437.1B.01			Date Completed	5 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	186		Diameter	6-inch	
North		Surface Elev	2829.55	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42		Diameter	6-inch	
Riser	PVC	Length (ft)	183		Diameter	4-inch	
Screen	PVC	Length (ft)	5		Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



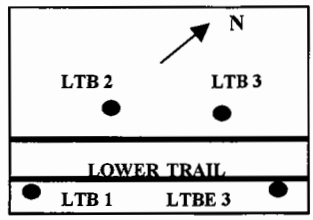
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						127	SILTSTONE with trace Sand, very fine grain, dark gray
2699.55	130						
						131	SHALE, red-gray, thin seam approximately 0.2 feet
						132	SILTSTONE with trace Sand, very fine grain, dark gray
2694.55	135						
						136	SHALE, dark gray
						137	SILTSTONE with trace Sand, very fine grain, dark gray
						138	SHALE, dark gray-black
2689.55	140						
						142	SILTSTONE with trace Sand, very fine grain, dark gray
						144	SHALE, light gray, significant increase in drill speed
2684.55	145						
2679.55	150						
						151	SHALE, medium gray

Environmental Resources Management

Lower Trail Boring LTBE 3

Maryland Well Permit GA-94-2028

WO No:	15437.1B.01			Date Completed	5 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	186		Diameter	6-inch	
North		Surface Elev	2829.55	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42		Diameter	6-inch	
Riser	PVC	Length (ft)	183		Diameter	4-inch	
Screen	PVC	Length (ft)	5		Diameter	4-inch	
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



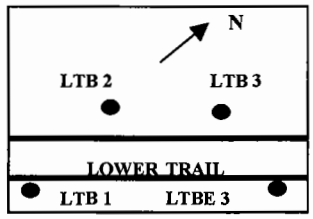
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2674.55	155						
						156	SILTSTONE with trace Sand, very fine grain, dark gray
2669.55	160						
						161	SILTSTONE with trace Sand, very fine grain, dark gray
2664.55	165						
						167	SHALE, medium gray
2659.55	170						
						172	SILTSTONE with trace Sand, very fine grain, dark gray
2654.55	175						
						177	SHALE, dark gray

Environmental Resources Management

Lower Trail Boring LTBE 3

Maryland Well Permit GA-94-2028

WO No:	15437.1B.01			Date Completed	5 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		186		Diameter	6-inch
North		Surface Elev		2829.55	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42		Diameter	6-inch
Riser	PVC	Length (ft)		183		Diameter	4-inch
Screen	PVC	Length (ft)		5		Diameter	4-inch
Drilling Method	Air Rotary	Driller	L. Brenneman			Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



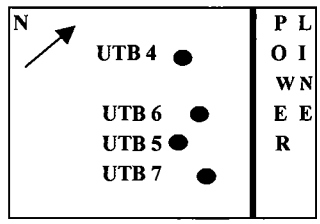
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							179 SHALE, black
2649.55	180						
				MINE CEILING 181 feet BGS			
							MINE POOL ENCOUNTERED
				MINE VOID 181 to 186 feet BGS			
2644.55	185						
				MINE PAVEMENT 186 feet BGS			
							LTBE 3 Borehole Specifications
2639.55	190						Surface Casing +2 to 40 feet BGS
							Riser Interval +2 to 181 feet BGS
							Screen Interval (10 Slot) 181 to 186 feet BGS
							Bentonite Grout 0 to 175 feet BGS
							Grout Traps 175 and 178 feet BGS
2634.55	195						Mine Void 181 to 186 feet BGS
							Wellhead completed as a stick-up configuration, expansion
							plug, aluminum well cap and padlock
2629.55	200						

Environmental Resources Management

Upper Test Boring UTB 4

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	12 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	180	Diameter	6-inch		
North		Surface Elev	2980.73	feet msl			
East		Riser Elev		feet msl			
Casing		Length (ft)		Diameter			
Riser		Length (ft)		Diameter			
Screen		Length (ft)		Diameter			
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge		
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



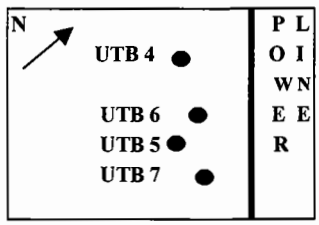
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							(Feet BGS)
2980.73	0						
							1 SILT with Shale fragments, medium tan
							3 SANDSTONE, very fine to medium grain, medium tan
2975.73	5						
							7 SANDSTONE with trace Mica, very fine to medium
							grain, medium tan
2970.73	10						
							12 SANDSTONE, very fine to medium grain, medium tan
							13 SANDSTONE, highly weathered, very fine to medium
							grain, dark brown
2965.73	15						14 SANDSTONE, very fine to medium grain, dark tan
							18 SHALE, dark gray
2960.73	20						

Environmental Resources Management

Upper Test Boring UTB 4

Borehole Abandoned

WO No:	15437.1B.01		Date Completed	12 Nov 01	
Project	Siege of Acre	Owner	Maryland Power Plant Research Project		
Location	Kempton, MD	Bore Depth (ft)	180	Diameter	6-inch
North		Surface Elev	2980.73	feet msl	
East		Riser Elev		feet msl	
Casing		Length (ft)		Diameter	
Riser		Length (ft)		Diameter	
Screen		Length (ft)		Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373		



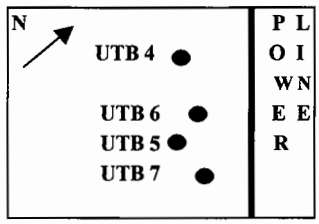
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							22.5 COAL, black
							23 SHALE, dark gray
2955.73	25						
							26 SANDSTONE, very fine to medium grain, dark gray
2950.73	30						
							31 SHALE, dark gray
2945.73	35						35 COAL, black
							36 SANDSTONE, very fine to medium grain, medium gray
2940.73	40						
							42 TEMPORARY CASING DEPTH
2935.73	45						45 SANDSTONE, very fine to medium grain, dark gray
							46 SHALE, dark gray

Environmental Resources Management

Upper Test Boring UTB 4

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	12 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		180	Diameter	6-inch	
North		Surface Elev		2980.73	feet msl		
East		Riser Elev			feet msl		
Casing		Length (ft)			Diameter		
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



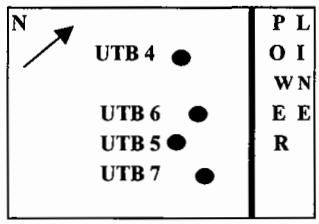
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2930.73	50						
							53 CLAYSTONE, medium gray
2925.73	55						
							56 CLAYSTONE, dark gray
2920.73	60						
							64 SANDSTONE, very fine to medium grain, medium gray
2915.73	65						
							68 CLAYSTONE, light gray
2910.73	70						
							73 SANDSTONE, very fine to medium grain, medium gray
							74 CLAYSTONE, medium gray

Environmental Resources Management

Upper Test Boring UTB 4

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	12 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	180	Diameter	6-inch		
North		Surface Elev	2980.73	feet msl			
East		Riser Elev		feet msl			
Casing		Length (ft)		Diameter			
Riser		Length (ft)		Diameter			
Screen		Length (ft)		Diameter			
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge		
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



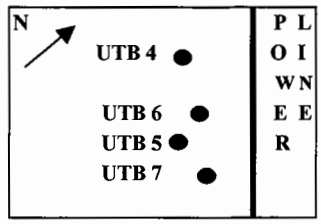
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2905.73	75						
							77 SANDSTONE, very fine to medium grain, medium gray
2900.73	80						
							81 SANDSTONE, very fine to medium grain, medium gray
2895.73	85						
							86 CLAYSTONE, dark gray
2890.73	90						90 CLAYSTONE, light gray
2885.73	95						95 SILTSTONE with trace Sand, very fine grain, dark gray
2880.73	100						

Environmental Resources Management

Upper Test Boring UTB 4

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	12 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		180	Diameter	6-inch	
North		Surface Elev		2980.73	feet msl		
East		Riser Elev			feet msl		
Casing		Length (ft)			Diameter		
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



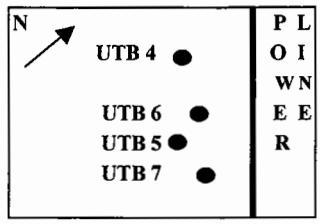
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							102 CLAYSTONE, light gray
2875.73	105						105 CLAYSTONE, medium gray
							109 SANDSTONE, very fine grain, yellow-gray
2870.73	110						110 SANDSTONE, very fine grain, medium gray
							113 SILTSTONE with trace Sand, very fine grain, medium
							gray
2865.73	115						
							116 SANDSTONE, very fine grain, dark gray
2860.73	120						
2855.73	125						125 SANDSTONE, very fine grain, medium gray

Environmental Resources Management

Upper Test Boring UTB 4

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	12 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	180	Diameter	6-inch		
North		Surface Elev	2980.73	feet msl			
East		Riser Elev		feet msl			
Casing		Length (ft)		Diameter			
Riser		Length (ft)		Diameter			
Screen		Length (ft)		Diameter			
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge		
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

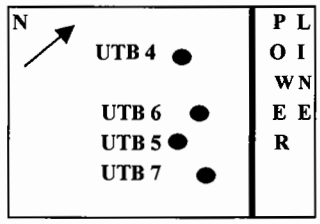


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							128
							SILTSTONE with trace Sand, very fine grain, dark gray
2850.73	130						
							131 SILTSTONE with trace Sand, very fine grain, medium
							gray
2845.73	135						
							139 SHALE, dark gray-black
2840.73	140						
							141 SHALE and COAL, black
2835.73	145						145 SHALE and COAL, black
							148 SHALE and COAL, black
							149 CLAYSTONE, dark gray
2830.73	150						

Environmental Resources Management

Upper Test Boring UTB 4
Borehole Abandoned

WO No:	15437.1B.01			Date Completed	12 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		180	Diameter	6-inch	
North		Surface Elev		2980.73	feet msl		
East		Riser Elev			feet msl		
Casing		Length (ft)			Diameter		
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



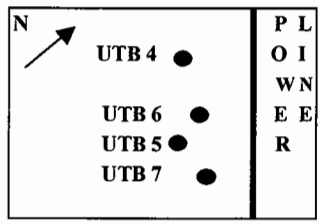
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2825.73	155						155 CLAYSTONE, dark gray
2820.73	160						160 SHALE, black
							164 SHALE, dark gray
2815.73	165						
							169 SANDSTONE, very fine grain, medium gray
2810.73	170						
2805.73	175						175 CLAYSTONE, medium gray

Environmental Resources Management

Upper Test Boring UTB 4

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	12 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	180	Diameter	6-inch		
North		Surface Elev	2980.73	feet msl			
East		Riser Elev		feet msl			
Casing		Length (ft)		Diameter			
Riser		Length (ft)		Diameter			
Screen		Length (ft)		Diameter			
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge		
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



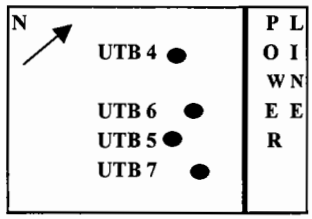
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2800.73	180						180 BOREHOLE TERMINATED
							UTB 4 Borehole Specifications
2795.73	185						Temporary Surface Casing +2 to 42 feet BGS
							Bentonite Grout 0 to 180 feet BGS
							Mine Void Not Encountered
2790.73	190						
2785.73	195						
2780.73	200						

Environmental Resources Management

Upper Test Boring UTB 5

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		159	Diameter	6-inch	
North		Surface Elev		2956.25	feet msl		
East		Riser Elev			feet msl		
Casing		Length (ft)			Diameter		
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



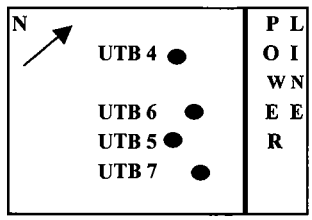
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							(Feet BGS)
2956.25	0						
							4 SANDSTONE, very fine to medium grain, medium tan
2951.25	5						
							9 SANDSTONE CONGLOMERATE, very fine to very
2946.25	10						coarse with well-rounded pebbles, medium tan
							11 SANDSTONE, very fine to medium grain, medium tan
							13 SANDSTONE, very fine to coarse grain, medium
							tan-yellow
2941.25	15						14 SANDSTONE, very fine to medium grain, medium tan
							15.5 SANDSTONE, highly weathered, very fine to medium
							grain, dark brown
							18 SHALE, dark gray
							19 SHALE, black
2936.25	20						20 COAL, black
							21 CLAYSTONE, medium gray
							22 CLAYSTONE, medium tan

Environmental Resources Management

Upper Test Boring UTB 5

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		159	Diameter	6-inch	
North		Surface Elev		2956.25	feet msl		
East		Riser Elev			feet msl		
Casing		Length (ft)			Diameter		
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



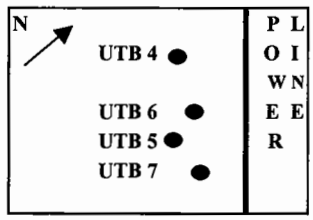
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)		Sample Description/Classification
							23	SILTSTONE with trace Sand, very fine grain, dark gray
2931.25	25							
							26	CLAYSTONE, dark gray
							28	SILTSTONE with trace Sand, very fine grain, dark gray
2926.25	30						30	SILTSTONE with trace Sand, very fine grain, dark gray
							34	SHALE, black
2921.25	35							
							36	CLAYSTONE, dark gray
2916.25	40						40	TEMPORARY CASING DEPTH
							42	SILTSTONE with trace Sand, very fine grain, dark gray
2911.25	45							
							46	SHALE, dark gray

Environmental Resources Management

Upper Test Boring UTB 5

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		159	Diameter	6-inch	
North		Surface Elev		2956.25	feet msl		
East		Riser Elev			feet msl		
Casing		Length (ft)			Diameter		
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



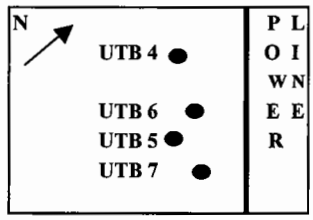
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2906.25	50						
							51 CLAYSTONE, medium gray
							SANDSTONE, very fine grain, dark gray
2901.25	55						
							56 CLAYSTONE, light gray
							58 CLAYSTONE, light gray-white
2896.25	60						
							62 SILTSTONE with trace Sand, very fine grain, medium
							gray
							63 SANDSTONE, fine to medium grain, medium gray
2891.25	65						
							66 CLAYSTONE, medium gray
							68 SILTSTONE with trace Sand, very fine grain, medium
							gray
2886.25	70						69 SHALE, medium gray
							71 SANDSTONE, very fine to fine grain, medium gray
							74 CLAYSTONE, medium gray

Environmental Resources Management

Upper Test Boring UTB 5

Borehole Abandoned

WO No:	15437.1B.01		Date Completed	13 Nov 01	
Project	Siege of Acre	Owner	Maryland Power Plant Research Project		
Location	Kempton, MD	Bore Depth (ft)	159	Diameter	6-inch
North		Surface Elev	2956.25 feet msl		
East		Riser Elev	feet msl		
Casing		Length (ft)		Diameter	
Riser		Length (ft)		Diameter	
Screen		Length (ft)		Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373		



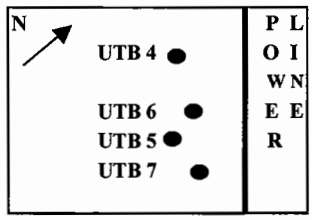
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2881.25	75						
							75.5 SANDSTONE, very fine to fine grain, medium gray
							78 SILTSTONE with trace Sand, very fine grain, medium
							gray
2876.25	80						
							82 SILTSTONE with trace Sand, very fine grain, medium
							gray
2871.25	85						
							86 SHALE, black
							88 SILTSTONE with trace Sand, very fine grain, medium
							gray
2866.25	90						
							94 SANDSTONE, very fine grain, light gray
2861.25	95						
							98 SILTSTONE with trace Sand, very fine grain, light gray
2856.25	100						

Environmental Resources Management

Upper Test Boring UTB 5

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		159	Diameter	6-inch	
North		Surface Elev		2956.25	feet msl		
East		Riser Elev			feet msl		
Casing		Length (ft)			Diameter		
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



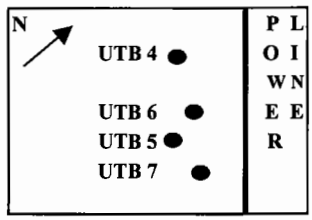
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							101 SANDSTONE, very fine to medium grain, light gray
2851.25	105						
							106 SANDSTONE, very fine to medium grain, medium gray
2846.25	110						
							112 SILTSTONE with trace Sand, very fine grain, medium
							gray
2841.25	115						
							118 SILTSTONE with trace Sand, very fine grain, dark gray
2836.25	120						
							121 SANDSTONE, very fine grain, medium gray
2831.25	125						

Environmental Resources Management

Upper Test Boring UTB 5

Borehole Abandoned

WO No:	15437.1B.01		Date Completed	13 Nov 01	
Project	Siege of Acre	Owner	Maryland Power Plant Research Project		
Location	Kempton, MD	Bore Depth (ft)	159	Diameter	6-inch
North		Surface Elev	2956.25	feet msl	
East		Riser Elev		feet msl	
Casing		Length (ft)		Diameter	
Riser		Length (ft)		Diameter	
Screen		Length (ft)		Diameter	
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge
Drilling Co.	Brenneman Well Drilling		Maryland License 373		



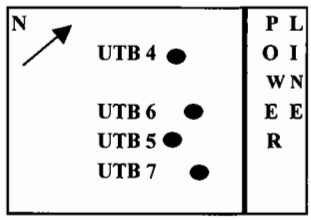
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)		Sample Description/Classification
							129	SANDSTONE, very fine grain, medium gray
2826.25	130							
							131	SILTSTONE with trace Sand, very fine grain, dark gray
2821.25	135							
							137	SILTSTONE with trace Sand, very fine grain, dark gray
							139	CLAYSTONE, dark gray
2816.25	140							
							141	SHALE, black
							143	COAL, black
2811.25	145							
							148	SHALE and COAL, dark gray and black
							148.5	COAL, black
2806.25	150							
							152	CLAYSTONE, dark gray

Environmental Resources Management

Upper Test Boring UTB 5

Borehole Abandoned

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		159	Diameter	6-inch	
North		Surface Elev		2956.25	feet msl		
East		Riser Elev			feet msl		
Casing		Length (ft)			Diameter		
Riser		Length (ft)			Diameter		
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



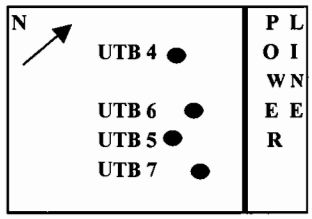
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							154 CLAYSTONE, medium gray
2801.25	155						
							159 BOREHOLE TERMINATED
2796.25	160						
							UTB 5 Borehole Specifications
							Temporary Surface Casing +2 to 40 feet BGS
2791.25	165						Bentonite Grout 0 to 159 feet BGS
							Mine Void Not Encountered
2786.25	170						
2781.25	175						

Environmental Resources Management

Upper Test Boring UTB 6

Maryland Well Permit GA-94-2066

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		147.5	Diameter	6-inch	
North		Surface Elev		2963.04	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		40	Diameter	6-inch	
Riser	PVC	Length (ft)		144	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

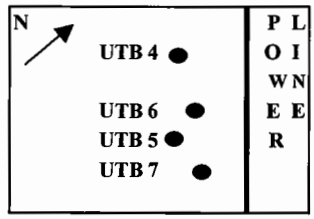


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							(Feet BGS)
2963.04	0						
							4 SANDSTONE, very fine to medium grain, medium tan
2958.04	5						
							7 SANDSTONE, highly weathered, very fine grain, dark
							brown
							9 SANDSTONE, fine to coarse grain, medium tan
2953.04	10						
							13 SANDSTONE CONGLOMERATE, very fine to very
							coarse with well-rounded pebbles, medium tan
2948.04	15						
							16 SANDSTONE, very fine to medium grain, light gray
							17 SANDSTONE CONGLOMERATE, very fine to very
							coarse with well-rounded pebbles, medium tan
							17.5 SHALE, black
2943.04	20						
							22 COAL, black

Environmental Resources Management

Upper Test Boring UTB 6
Maryland Well Permit GA-94-2066

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		147.5	Diameter	6-inch	
North		Surface Elev		2963.04	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		40	Diameter	6-inch	
Riser	PVC	Length (ft)		144	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



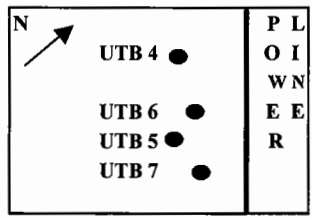
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							23 CLAYSTONE, medium gray
2938.04	25						
							28 SILTSTONE with trace Sand, very fine grain, dark gray
2933.04	30						
							31 SANDSTONE, very fine to medium grain, medium gray
							33 SILTSTONE with trace Sand, very fine grain, medium gray
2928.04	35						
							36 COAL, black
							37.5 CLAYSTONE, dark gray
2923.04	40						40 CASING DEPTH
2918.04	45						45 SILTSTONE with trace Sand, very fine grain, dark gray
							48 SHALE, dark gray

Environmental Resources Management

Upper Test Boring UTB 6

Maryland Well Permit GA-94-2066

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		147.5	Diameter	6-inch	
North		Surface Elev		2963.04	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		40	Diameter	6-inch	
Riser	PVC	Length (ft)		144	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



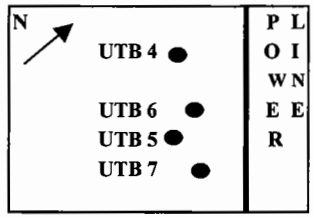
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2913.04	50					50	SHALE, dark gray
2908.04	55						
						56	SHALE, dark gray
						57	CLAYSTONE, medium gray
2903.04	60						
						61	CLAYSTONE, light gray
2898.04	65						
						66	SILTSTONE with trace Sand, very fine grain, medium gray
						68	CLAYSTONE, medium gray
2893.04	70						
						71	SILTSTONE with trace Sand, very fine grain, dark gray
						73	SILTSTONE with trace Sand, very fine grain, medium gray

Environmental Resources Management

Upper Test Boring UTB 6

Maryland Well Permit GA-94-2066

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		147.5	Diameter	6-inch	
North		Surface Elev		2963.04	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		40	Diameter	6-inch	
Riser	PVC	Length (ft)		144	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

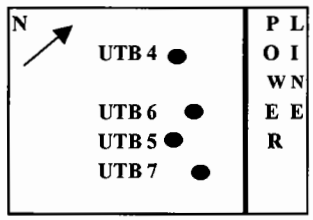


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)		Sample Description/Classification
2888.04	75						75	SANDSTONE, very fine to fine grain, medium gray
							77	CLAYSTONE, medium gray
							78	SILTSTONE with trace Sand, very fine grain, medium
								gray
2883.04	80						79	SANDSTONE, very fine grain, medium gray
							81	SANDSTONE, very fine grain, medium gray
2878.04	85						85	CLAYSTONE, light gray
							89	SHALE, black
2873.04	90						90	SHALE, dark gray
							92	SANDSTONE, very fine grain, medium gray
							94	CLAYSTONE, medium gray
2868.04	95							
							96	CLAYSTONE, medium gray
							98	SILTSTONE with trace Sand, very fine grain, medium
								gray
2863.04	100							

Environmental Resources Management

Upper Test Boring UTB 6
Maryland Well Permit GA-94-2066

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		147.5	Diameter	6-inch	
North		Surface Elev		2963.04	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		40	Diameter	6-inch	
Riser	PVC	Length (ft)		144	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

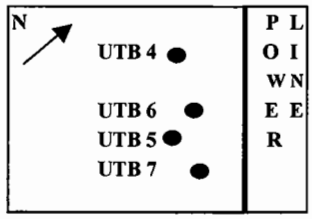


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							101 SANDSTONE, very fine to medium grain, light gray
2858.04	105						
							106 SANDSTONE, very fine to medium grain, medium gray
2853.04	110						110 SILTSTONE with trace Sand, very fine grain, dark gray
							114 SILTSTONE with trace Sand, very fine grain, medium
2848.04	115						gray
2843.04	120						120 SANDSTONE, very fine grain, medium gray
							124 SHALE, medium gray
2838.04	125						125.5 SILTSTONE with trace Sand, very fine grain, dark gray

Environmental Resources Management

Upper Test Boring UTB 6
Maryland Well Permit GA-94-2066

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		147.5	Diameter	6-inch	
North		Surface Elev		2963.04	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		40	Diameter	6-inch	
Riser	PVC	Length (ft)		144	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

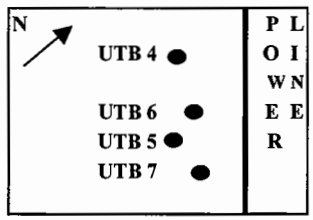


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						129	SANDSTONE, very fine grain, medium gray
2833.04	130						
						133	SHALE, dark gray
2828.04	135					135	SHALE, medium gray
						139	CLAYSTONE, light gray
2823.04	140						
						141	SHALE, medium gray
						142	CLAYSTONE, light gray
						143	SHALE, black
				MINE CEILING 144 feet BGS			
2818.04	145						
				MINE VOID 144 to 147.5 feet BGS			
				MINE PAVEMENT 147.5 feet BGS			
2813.04	150						

Environmental Resources Management

Upper Test Boring UTB 6
Maryland Well Permit GA-94-2066

WO No:	15437.1B.01			Date Completed	13 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		147.5	Diameter	6-inch	
North		Surface Elev		2963.04	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		40	Diameter	6-inch	
Riser	PVC	Length (ft)		144	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

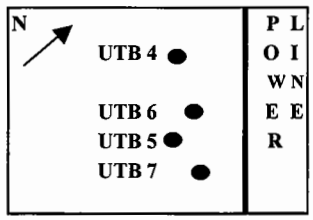


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification	
2808.04	155						***UTB 6 Borehole Specifications***	
							Surface Casing	+2 to 40 feet BGS
							Bentonite Grout	0 to 139 feet BGS
							Riser Interval	+2 to 144 feet BGS
2803.04	160						Screen Interval	No Screen Installed
							Grout Traps	139 and 141 feet BGS
							Mine Void	144 to 147.5 feet BGS
							Wellhead completed as a stick-up configuration, expansion	
2798.04	165						plug, aluminum well cap and padlock	
2793.04	170							
2788.04	175							
								Page 7 of 7

Environmental Resources Management

Upper Test Boring UTB 7
Maryland Well Permit GA-94-2067

WO No:	15437.1B.01			Date Completed	14 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		146	Diameter	6-inch	
North		Surface Elev		2945.35	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42	Diameter	6-inch	
Riser	PVC	Length (ft)		141	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



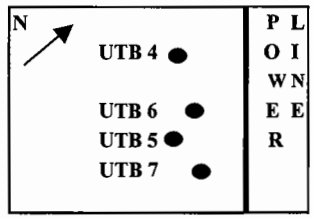
Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
							(Feet BGS)
2945.35	0						
							2 SANDY SILT with rock fragments, medium tan
							3.5 SANDSTONE, highly weathered, very fine grain, medium
							tan
2940.35	5						4.5 SANDSTONE, fine to coarse grain, medium tan
							7 SANDSTONE, fine to coarse grain, medium gray-tan
							8 SANDSTONE, very fine to medium grain, light tan
2935.35	10						
							11 SANDSTONE, highly weathered, very fine to medium
							grain, dark brown
							11.5 SANDSTONE, very fine to medium grain, light tan
							13 SANDSTONE CONGLOMERATE, fine to very
2930.35	15						coarse with well-rounded pebbles, medium tan
							16 SANDSTONE CONGLOMERATE, fine to very
							coarse with well-rounded pebbles, dark tan
							18 SANDSTONE, fine to coarse grain, medium gray
2925.35	20						20 SHALE, black
							20.5 COAL, black
							21.5 CLAYSTONE, medium gray

Environmental Resources Management

Upper Test Boring UTB 7

Maryland Well Permit GA-94-2067

WO No:	15437.1B.01			Date Completed	14 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		146	Diameter	6-inch	
North		Surface Elev		2945.35	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42	Diameter	6-inch	
Riser	PVC	Length (ft)		141	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

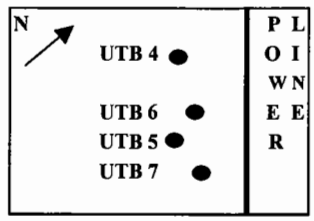


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)		Sample Description/Classification
								CLAYSTONE, medium gray
2920.35	25						25	CLAYSTONE, dark gray
							27	SILTSTONE with trace Sand, very fine grain, dark gray
2915.35	30						31	SILTSTONE with trace Sand, very fine grain, dark gray
2910.35	35						35.5	COAL, black
							37	SILTSTONE with trace Sand, very fine grain, dark gray
							38	SANDSTONE, very fine grain, dark gray
2905.35	40						41	SANDSTONE, very fine grain, medium gray
							42	CASING DEPTH
							43	SANDSTONE, very fine to fine grain, light gray
2900.35	45							
							48	SHALE, dark gray

Environmental Resources Management

Upper Test Boring UTB 7
Maryland Well Permit GA-94-2067

WO No:	15437.1B.01			Date Completed	14 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	146	Diameter	6-inch		
North		Surface Elev	2945.35	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42	Diameter	6-inch		
Riser	PVC	Length (ft)	141	Diameter	4-inch		
Screen		Length (ft)		Diameter			
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge		
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

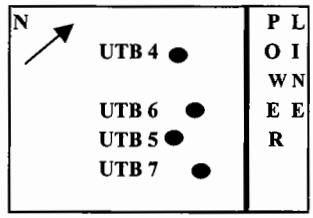


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2895.35	50						50 SHALE, dark gray
2890.35	55						
							58 CLAYSTONE, dark gray
							59 CLAYSTONE, medium gray
2885.35	60						
							62 SILTSTONE with trace Sand, very fine grain, medium gray
2880.35	65						
							68 SANDSTONE, fine to medium grain, light gray
2875.35	70						

Environmental Resources Management

Upper Test Boring UTB 7
Maryland Well Permit GA-94-2067

WO No:	15437.1B.01			Date Completed	14 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	146		Diameter	6-inch	
North		Surface Elev	2945.35	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42		Diameter	6-inch	
Riser	PVC	Length (ft)	141		Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

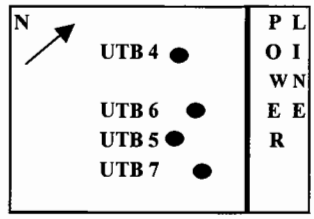


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
2870.35	75						75 SILTSTONE with trace Sand, very fine grain, dark gray
2865.35	80						
2860.35	85						84 SILTSTONE with trace Sand, very fine grain, medium gray
2855.35	90						87.5 SHALE, black 89 SANDSTONE, very fine grain, medium gray
2850.35	95						95 SANDSTONE, very fine grain, medium gray
2845.35	100						100 SANDSTONE, very fine to medium grain, medium gray

Environmental Resources Management

Upper Test Boring UTB 7
Maryland Well Permit GA-94-2067

WO No:	15437.1B.01			Date Completed	14 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	146	Diameter	6-inch		
North		Surface Elev	2945.35	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42	Diameter	6-inch		
Riser	PVC	Length (ft)	141	Diameter	4-inch		
Screen		Length (ft)		Diameter			
Drilling Method	Air Rotary	Driller	L. Brenneman	Geologist	Carl Pidge		
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

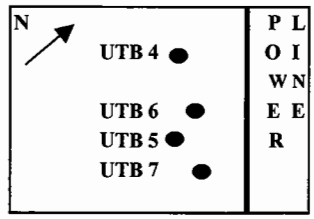


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						103	SANDSTONE, very fine to medium grain, medium gray
2840.35	105						
						108	SANDSTONE, very fine to medium grain, medium gray
						109	SHALE, dark gray
2835.35	110						
						111	SANDSTONE, very fine grain, medium gray
2830.35	115						
						118	SANDSTONE, very fine grain, medium gray
2825.35	120						
						124	SANDSTONE, very fine grain, medium gray
2820.35	125						

Environmental Resources Management

Upper Test Boring UTB 7
Maryland Well Permit GA-94-2067

WO No:	15437.1B.01			Date Completed	14 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)	146		Diameter	6-inch	
North		Surface Elev	2945.35	feet msl			
East		Riser Elev		feet msl			
Casing	Steel	Length (ft)	42		Diameter	6-inch	
Riser	PVC	Length (ft)	141		Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				

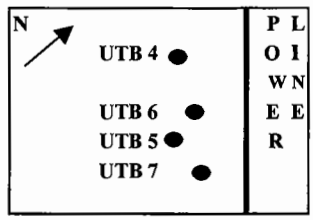


Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification
						127	SANDSTONE, very fine to medium grain, medium gray
2815.35	130						
						131	SILTSTONE with trace Sand, very fine grain, dark gray
2810.35	135						
						137	SILTSTONE with trace Sand, very fine grain, dark gray
2805.35	140					140	SHALE, black
				MINE CEILING 141 feet BGS			
				MINE VOID 141 to 146 feet BGS			
2800.35	145						
				MINE PAVEMENT 146 feet BGS			
2795.35	150						

Environmental Resources Management

Upper Test Boring UTB 7
Maryland Well Permit GA-94-2067

WO No:	15437.1B.01			Date Completed	14 Nov 01		
Project	Siege of Acre	Owner	Maryland Power Plant Research Project				
Location	Kempton, MD	Bore Depth (ft)		146	Diameter	6-inch	
North		Surface Elev		2945.35	feet msl		
East		Riser Elev			feet msl		
Casing	Steel	Length (ft)		42	Diameter	6-inch	
Riser	PVC	Length (ft)		141	Diameter	4-inch	
Screen		Length (ft)			Diameter		
Drilling Method	Air Rotary	Driller	L. Brenneman		Geologist	Carl Pidge	
Drilling Co.	Brenneman Well Drilling		Maryland License 373				



Elevation (MSL)	Depth (Feet BGS)	PID Headspace (PPM)	Well Construction	Blow Count per 0.5 Feet	Sample Interval (Ft BGS)	Recovery (Feet)	Sample Description/Classification	
2790.35	155						***UTB 7 Borehole Specifications***	
							Surface Casing	+2 to 42 feet BGS
							Bentonite Grout	0 to 134 feet BGS
							Riser Interval	+2 to 141 feet BGS
2785.35	160						Screen Interval	No Screen Installed
							Grout Traps	134 and 136 feet BGS
							Mine Void	141 to 146 feet BGS
							Wellhead completed as a stick-up configuration, expansion	
2780.35	165						plug, aluminum well cap and padlock	
2775.35	170							
2770.35	175							
								Page 7 of 7

Appendix B
Equipment List

Appendix B
Siege of Acre - Phase I Equipment List

Company	Make / Model
Brenneman Well Drilling, Inc.	Drill - Ingersol Rand TH60 Camera – GeoVision Micromodel 3
CTL Engineering, Inc	Drill – Central Mining Equipment 45
Department of Energy	Camera – Geovision Junior Model JM3 manufactured by Marks Products Inc.
Office of Surface Mining	Camera – OSM camera manufactured by SAIC