AVOIDING TRAGEDY: LESSONS TO BE LEARNED FROM A FLYROCK FATALITY

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ABSTRACT

Reckless blasting can have tragic consequences: The death of an innocent traveler, the financial demise of a coal company, and even criminal prosecution.

In June 1993, a Tennessee coal mining company was blasting to loosen overburden at its surface mine. The mine was located immediately adjacent to the right-of-way of the northbound lane of Interstate 75. The approved permit included special precautions to be taken when blasting in the area closest to the interstate, including monitoring traffic so as to blast when the northbound lane was clear.

On June 4, 1993, the company detonated a blast in an area less than 300 feet from northbound interstate traffic, and failed to monitor traffic. This blast created a large amount of flyrock, some of which struck a car traveling north on Interstate 75. A 16-year old boy, a passenger in a car driven by his parents, was killed as a result of the flyrock impact.

The investigation by the federal Office of Surface Mining Reclamation and Enforcement identified causes of the fatality, including the company's failure to adhere to safe blasting practices and failure to implement safety measures required in the permit.

The U.S. Department of Justice prosecuted three individuals--the certified blaster, the day shift superintendent, and the mine manager for violations of 30 U.S.C. § 1268(e) and (f). The certified blaster and the superintendent pled guilty to a misdemeanor count of a willful and knowing violation of a permit. The mine manager was acquitted after a trial. The certified blaster was given a ten-month sentence and the superintendent was given an eight-month sentence. The company went out of business within four months of this blasting incident.

Blasters and regulators in the coal mine industry must give increased attention to blasting and oversight in order to prevent future tragedies. Recommendations are:

a. Specify specific blasting plans when blasting in proximity to areas used by the public;

b. Establish procedures to enable inspectors to monitor compliance with special blasting plans; and

c. Emphasize safe blasting techniques in blasting certification and the extent of liability of blasters and operators who fail to follow regulations or permit provisions.

INTRODUCTION*1*

The Surface Mining Control and Reclamation Act of 1977 (Surface Mining Act) "establish[ed] a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations." *2* The Surface Mining Act regulates the environmental and public safety aspects of the effects of surface and underground mining, including blasting. To carry out the purposes of the Surface Mining Act, the Office of Surface Mining Reclamation and Enforcement (OSM) was established within the Department of the Interior. States may assume primary jurisdiction for coal mine regulation. However, the State of Tennessee gave up its program to regulate mining and OSM has operated as the regulatory authority in Tennessee since 1984.

The Surface Mining Act sets forth both specific minimum requirements for obtaining a surface mining permit and minimum environmental performance standards for the operation of a surface coal mine. When blasting, the operator is required to prevent damage to property and to prevent injury to people. The burden is upon the coal mine operator to develop a plan which will meet these standards. The plan should outline how to control the adverse effects of blasting which include flyrock, ground vibrations and airblast, how to protect the blast site through signs, warnings and control of access to the mine site, and how to comply with all applicable State and Federal laws and regulations. All blasting must be conducted by a blaster certified in accordance with OSM procedures. The regulations place the burden of complying with the blasting plan, as well as conducting safe blasting, on the certified blaster. *3*

THE PERMIT'S BLASTING PLAN

In 1991, Sugar Ridge Coal Co. applied for a permit to mine coal adjacent to Interstate 75 in Campbell County, Tennessee. The permit required Sugar Ridge Coal Co. to take special precautions when using explosives near the interstate:

Primarily, shot sizing and proper stemming methods will be used to control flyrock. Stemming will be of adequate quantity to suppress fly rock near the surface of the shot. Hole size, load and spacing will also be adjusted as needed to suppress any flyrock. Special measure that could be used to inhibit flyrock along I-75 include multiple delays, multiple decking, increased stemming and sequential detonation.*4*

In April 1992, Sugar Ridge had a flyrock violation. An OSM inspector noted that one of the blasts had misfired and that flyrock went off the permit area. There was no damage but the inspector was concerned that the permit needed to more specifically state how flyrock would be prevented and how the public would be protected, especially as the mining progressed towards the portion of the permit nearest the interstate.

After meeting with OSM in May 1992, the company submitted, and OSM approved, a special blasting plan for the area closest to the interstate. The special blasting plan identified the area north of the current mining operation as the area where the blasting was the most potentially dangerous. When within 150 feet of the right-of-way, blasts were to be detonated only when the north bound lanes of the interstate were clear of traffic. Also, a specific blast design employing two decks of explosives, one deck per delay interval, was to be used (see Figure 11). Under the plan Sugar Ridge stated that:

> Proper stemming will be stress (sic) to reduce fly rock and will be a minimum of 10 feet of consolidated material. All blast designs will direct the forward movement of the shot away from the interstate toward an open free face....All blasting conducted within 150' of the interstate right-of-way will be detonated from the cleared area adjacent to the interstate so the blaster will have visual coordination of the interstate traffic. The blaster will monitor and observe a 7 second gap between traffic before detonating the shot.5

Initially, the company used a blaster from an explosives supplier to conduct the blasting. In late 1992, an employee of Sugar Ridge, who was a certified blaster, took over the blasting.

The mine manager and the certified blaster changed the design of the blasts from those described in the special blasting plan. They increased the hole sizes from 6 3/4 inches to 7 7/8 inches and increased the burden and spacing pattern from 14 feet by 12 feet to 18 feet by 18 feet because of transitions in the geology--a sandstone caprock. The company blasted every day and there were two shifts of workers--a day and evening shift. The day shift would drill and detonate a blast, the evening shift would move the spoil and take out the coal.

THE FATAL BLAST

June 4, 1993, was a Friday, the end of the work week. Twenty-eight holes were drilled for the fatal blast. The 7 7/8 inch holes were drilled in a pattern of 18 foot burden and 18 foot spacing. The closest hole was only 70 feet from the right-of-way of the interstate and less than 225 feet from the interstate pavement. The blaster in charge was not at the site during the drilling, having been sent off the site by the mine superintendent on other business. At about 3:30 pm, the blaster-in-charge returned and directed workers to start filling the holes with ANFO. Each of the 28 holes was filled with 573 pounds of explosives. The holes were a single column, not double decked. The blaster's helper asked the driller about the material they drilled through. There was at least eight feet of clay before hitting competent rock. One driller claimed he told the blaster that one hole was "real soft." The holes were stemmed with 11 feet of drill cuttings.

No measurements were made to determine the distance to the interstate. The certified blaster set off the blast without going to the interstate to be sure that the traffic was clear. The blast was uncontrolled and flyrock hit the interstate, causing the death of a 16-year-old boy, a passenger in a car traveling north on the interstate.

CONSEQUENCES OF THE BLAST

Sugar Ridge attempted to start blasting again under a revised blasting proposal. OSM refused to approve the plan and the matter went to an administrative law judge. In August 1993, the judge rejected the blasting plan as providing insufficient protection to the public. The company was experiencing financial difficulties caused in part by its inability to conduct blasting and coal removal and in October 1993, had to surrender its permit because of the failure to make payments under an agreement to pay off past due reclamation fees.

In November 1993, OSM revoked the certification of the blaster. He has not requested re-certification.

In May 1995, a grand jury returned a federal indictment of the company, the certified blaster, the shift superintendent and the mine manager. To find the defendants guilty, the prosecution had to show that the permit was violated and the violations were knowing and willful. A criminal conviction would not require bad intent by the defendants. A criminal conviction for willful and knowing conduct could be based upon an intentional act which violated the permit or upon an act which showed a reckless disregard for the known requirements of the permit.*6*

On August 5, 1996, the corporation pled guilty to six counts of knowingly and willfully violating a condition of its permit in violation of 30 U.S.C. § 1268(e).' The certified blaster and the day shift superintendent each pled guilty to one count of knowingly and wit/fully violating the permit for the June 4th blast. The mine manager was acquitted at a trial in December of 1996.

On January 28, 1997, the United States District Court for the Eastern District of Tennessee held the sentencing hearing for the blaster and the superintendent of Sugar Ridge Coal Co. The district court judge sentenced the blaster to ten months, five months to be served in a penitentiary and five months to be served under home detention (with electronic monitoring) followed by a year of supervised probation. The judge noted that superintendent's actions were those of omission rather than commission and sentenced him to eight months, three months to be served in a halfway house and five months to be served in home detention.

NOTES ON INVESTIGATING THE CAUSES OF FLYROCK

Immediately after the blast, OSM conducted an investigation using both in-house and outside experts. OSM determined that the permit requirements (as discussed earlier in the blast plan section) were violated in a number of ways:

- insufficient stemming;
- each hole was detonated on a single delay instead of being "double decked" and delayed;
- traffic was not monitored;
- ignored changes in geology which would have required further stemming; and
- on previous occasions the company blasted within 150 feet of the right-of-way to I-75

without following the blasting plan.

The mine was located approximately 40 miles north of Knoxville (Figure #l/Map) parallel to, east of, and extending some two miles along I-75 (Figure #2). Within hours after the accident, MSHA shut the mine operation down until both OSM and MSHA could do a detailed investigation that would include testimony from the drilling and blasting crews. By this time, the mine personnel had already disturbed the blast site by partly cleaning the drill bench north of the muck pile and flatting a portion of the muck pile itself.

OSM, MSHA, and representatives of the coal company determined that the portion of the blast disturbance nearest to the interstate was 48 feet from the right-of-way (ROW) and 189 feet from the guard rails of the north bound lanes of I-75 (Figure #3). Flyrock impacted the wooded area within the ROW, over the guard rail onto the roadway, and into the median strip between the north and south bound lanes. The flyrock consisted of rock and clay material. The blasting lead lines extended to a drill rig east of the blast site, away from the highway. Walking on top of the muck pile, investigators observed two distinct craters in the two back rows of the blast. The highwall along the westerly face showed a thick upper clay zone below the crest, and the exposed north face of the pit from the floor at the toe of the muck pile showed a distinct change in the extent of and thickness of a hard sandstone caprock.

OSM and MSHA interviewed the mine personnel several days after the fatal blast. The shot was prepared by the certified blaster and blaster's helper. Neither watched the drilling, although the helper asked the drillers about the composition of the overburden. There is some contradiction regarding whether the certified blaster was told 8-10 feet of dirt or 7-8 feet of dirt. One driller told the helper that the drill penetration rate was faster than previous shots, but the certified blaster did not recall hearing that information. A drill hole log was not maintained. No measurement was made of the distance to the interstate. The certified blaster was under the impression that they were far enough away from the interstate that they did not need to go to the interstate to set off the shot. The superintendent cleared the site to prepare for the blast. The blast was detonated from the shelter of a drill rig without monitoring interstate traffic.

According to the blasting log (Figure #5), the blast consisted of 4 rows of 7 holes, each with a diameter of 7 7/8 inches. The blast was drilled on an 18 by 18 foot pattern, loaded with 32 feet of ANFO and 11 feet of stemming per hole, one non-electric delay cap per blasthole and the presumed strata blasted as sandstone.

OSM surveyed the muck pile, pit floor, exposed toes and crest of the highwalls (Figure #4) prior to the coal removal, showing the location of the craters and the area of debris thrown onto the bench and off the permit. After the muck pile and coal were removed, the exposed highwalls were mapped and surveyed (Figure #6). The highwall in the area of the June 4th blast contained sandy day with the consistency of weathered shale in the upper 8 to 12 foot of strata below the crest. The hard sandstone caprock that existed in earlier blasts had ceased some 25 to 30 feet to the east of the location of June 4th blast.

Using the surveys, the visible half-cast boreholes, and the company's blasting log, OSM's investigator reconstructed the locations of the drill holes before the blast. Figure #7 shows the hole locations and the hole detonation sequence. He projected the free face Ethology for each successive row of blast holes, using the visible highwall geology and the drill operators' testimony (Figure #8). Figure #9 shows a probable cross section of the muck pile including the crater location, and clay material.

Blasting lead lines leading to the northbound lane guard rails confirmed that the certified blaster had, on previous occasions, stationed himself along the highway to monitor traffic in accordance with the approved special blasting plan. By conducting an extensive review of the blasting logs from 13 months of blasting, and by matching the information in the logs to the permit cut sequence information, OSM recreated the location of blasts within close proximity to the interstate ROW. Based upon a review of the logs for these blasts, OSM identified previous blasts in which the company had failed to adhere to the designs specified in the approved special blasting plan. See Figure #10.

The company had difficulty accepting that the blast pattern and loading procedures, including stemming, caused the throw on the interstate, since blasting the previous pit along the ROW had similar material and didn't throw. OSM's reconstruction showed that the two blasts in the area of increasing thickness of clay material (5/11/93 and 5/12/93) complied with the approved plan. Each of these two blasts was two rows in depth, which allowed for optimum forward displacement and reduced probability of back break and rear row cratering. In addition, each blast employed double delays per blasthole and increased stemming, with a powder factor of 0.78 Lbs./Yd^3 (compared to the 1.11 Lbs./Yd^3 for the blast of June 4th) and resulted in no cratering or throw. See Figure #11.

Improper blast design and inattention to details caused the flyrock. The company increased the drill hole size to accommodate the sandstone, and increased the burden and spacing. To insure breakage of the caprock, stemming was decreased. The certified blaster failed to adjust the blast procedures for the major changes in overburden material to be blasted on June 4, 1993. The blaster failed to account for the proximity of the interstate and did not adjust the blast pattern or use decking or increased stemming to reduce the probability of flyrock. His failure to double-deck with delays and to provide adequate stemming into competent material, violated the special blasting plan. The fatality would have been avoided if the certified blaster had detonated the shot from the edge of the interstate as mandated by the approved special blasting plan.

RECOMMENDATIONS FOR REGULATORS

Under the Surface Mining Act, it is the mine operator's responsibility to develop a plan to blast safely and to follow that plan. The regulatory authority must review the plan to ensure that it will protect public persons and property. Also, the regulatory authority will inspect to determine if the company is blasting in accordance with its approved blasting plant. However, many surface mines blast daily, and a complete inspection of the mining operation will only take place about every three months, and thus may not coincide with a blast. If a

mining company proposes to blast in the vicinity of traveled or populated areas, the plan should give specific descriptions of what precautions and designs will be used to ensure safe blasting. The authority issuing the permit should give careful consideration to the plan and to how the inspector will determine that the plan is being properly implemented. The following suggestions may improve the regulation of blasting:

1) Schedule critical blasts. If a company is blasting in a sensitive area, the regulator may want to have advance notice of the critical blasts, or may want such blasts conducted on a set schedule to allow for inspector observation.

2) Require drill logs. If the safety of a critical blast will depend upon the site geology then the drillers should keep logs to allow for proper blast design. If blasters rely only on verbal reporting, miscommunication can occur. When the Sugar Ridge drillers, blaster and blaster's helper were interviewed, they gave different accounts regarding how much soft material was reported to the blaster prior to his loading of the holes.

3) Require the recording of compliance with the special blasting plan on blasting logs. The Surface Mining Act requires logs to include the "location of blasts, the pattern and depth of the drill holes, the amount of explosives and the order and length of delay in the blasts."8 Identification of blasts that fall under any special blasting plan and information documenting compliance with the plan, such as the person monitoring traffic when blasting is conducted in proximity to roads, should also be made a part of the blasting log.

RECOMMENDATIONS FOR BLASTERS

If a blaster lacks the time, resources, or ability to blast safely, then he should not blast. The certified blaster is "directly responsible for the use of explosives in a surface coal mining operation." 30 C.F.R. § 850.13. Responsibility for blasting may not be delegated to anyone who is not a certified blaster. 30 C.F.R. § 850.15(e)(3). One of the allegations of the Sugar Ridge blaster was that the company placed him in a work environment that prevented him from ensuring full compliance with the blasting plan. The Interior Board of Land Appeals rejected this defense when OSM revoked the blaster's certification. "As the certified blaster on the permit, it was his job to ensure compliance with the plan. Any interference with his ability to perform his duty as a blaster should have been brought to the attention of his employer or OSM. "*9*

Prevention of flyrock requires constant attention to changing geologic conditions. The Sugar Ridge blaster probably relied on the success of previous blasts. As a result of being away from the mine during the drilling, the blaster failed to pick up on indications from the drillers of the change in geology; failed to note the visible changes in geology and ignored the results of earlier drilling which indicated that the hard sandstone cap which had contained previous blasts had pinched out. Drill logs, plotting the location of blasts on maps, and review of the geologic information in the permit application, will decrease the risk of similar tragic mistakes.

Prevention of flyrock requires vigilant attention to controlling the distribution of energy in the drill hole. Particular attention should be addressed to stemming when blasting in critical areas. "Proper stemming is critical to good blast results. The poorly stemmed shot not only results in environmentally objectionable flyrock and blast noise but also degrades the blast action."~° Sugar Ridge failed to maintain even the minimum stemming of seven-tenths of the burden (rule of thumb) in its last blast.

Careful blasting requires adjusting to site-specific conditions. If an operation will be blasting in a critical area, the certified blaster should consider consulting with the expertise available through explosive suppliers or blasting consultants. A blasting consultant should be able to provide a second opinion on modifications to blasting parameters to ensure safe blasts.

CONCLUSION

The certified blaster is responsible for safe blasting at a coal mining operation. The regulatory authority can give its approval to a company's blasting proposal, but cannot provide the necessary day-to-day supervision. Thus, liability and responsibility rest upon the company and its blaster. To maintain control of the conditions of the blast, the certified blaster must determine blasting conditions through observations or through communication with a competent and reliable crew. Otherwise, the blaster places his or her livelihood in peril. Disregarding blasting plans and safe blasting procedures can have drastic consequences for a certified blaster: loss of certification, disruption of the mining operation and even criminal liability.

APPENDIX

FIGURES

Figure #1: Location Map

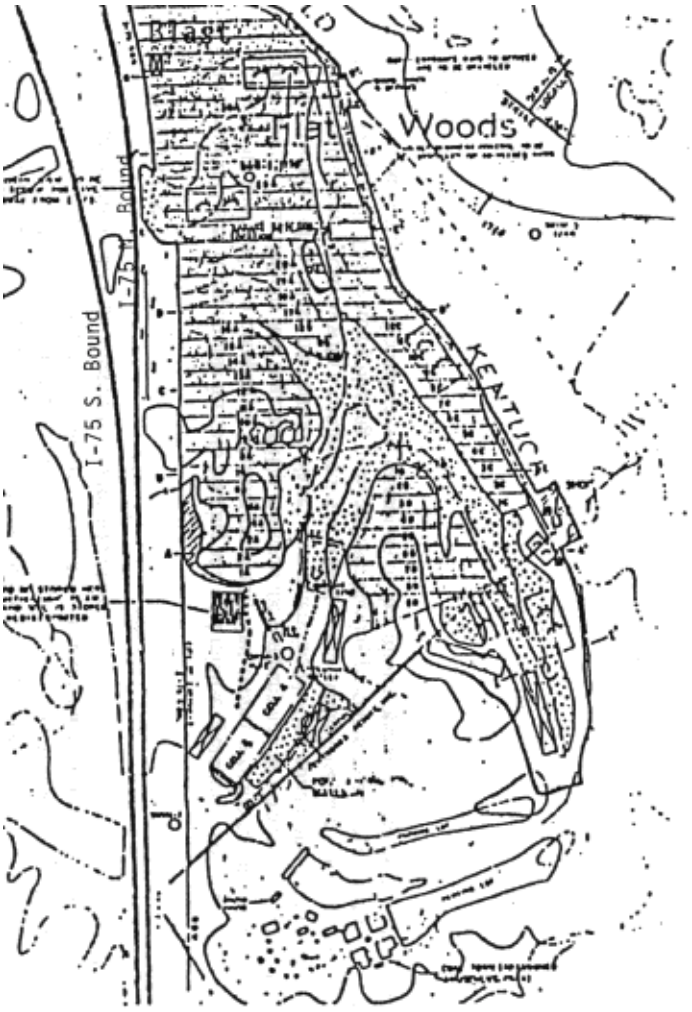
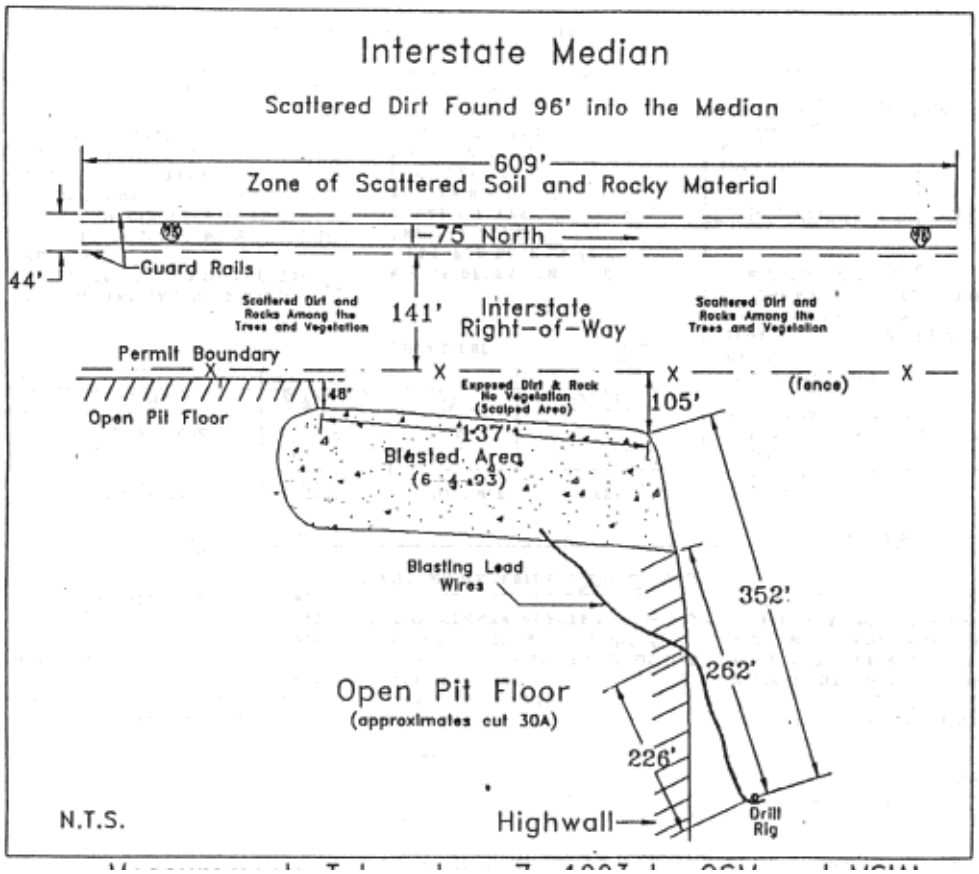
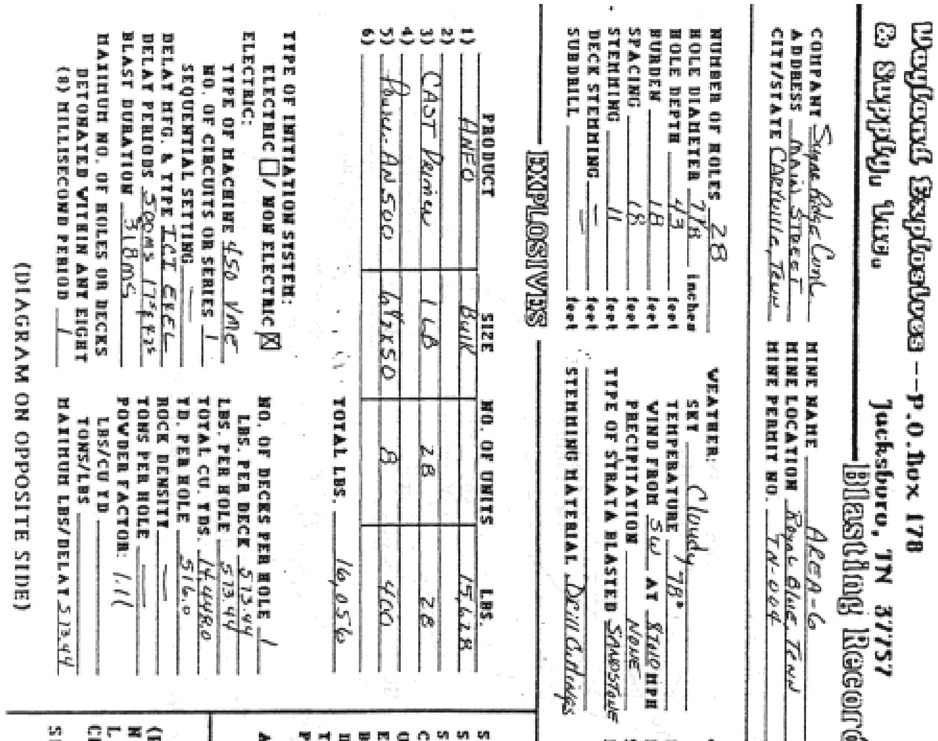


Figure #2: Mine Map/Blast Location

SUGAR RIDGE COAL COMPANY TN-004



Measurements Taken June 7, 1993 by OSM and MSHA
Using a 100-Foot and a 25-Foot Tape
Figure #3



Wayland Explosives --P.O. Box 178
& Supply, Inc. Jacksboro, TN 37757
DATE 6-4-93

Blasting Record

COMPANY Sugar Ridge Coal
ADDRESS Main Street
CITY/STATE Caryville, Tenn
MINE NAME AREA-6
MINE LOCATION Royal Blue, Tenn
MINE PERMIT NO. TN-004
SERVICE AGREEMENT----YES ☒ / NO ☐
BLAST TIME 5:45 AM ☐ / PM ☒
"CUT MAP" AREA NO. 28-A

NUMBER OF HOLES 28
HOLE DIAMETER 7/8 inches
HOLE DEPTH 43 feet
BURDEN 18 feet
SPACING 18 feet
STEMMING 11 feet
DECK STEMMING — feet
SUBDRILL feet

WEATHER:
SKY Cloudy
TEMPERATURE 78°
WIND FROM SW AT 8 TO 10 MPH
PRECIPITATION NONE
TYPE OF STRATA BLASTED SANDSTONE
STEMMING MATERIAL Drill Cuttings

CRITICAL STRUCTURE DISTANCE: 4600
MATS OR OTHER PROTECTION NONE
PEAK PARTICLE VELOCITY LIMITS 7.0
SCALED DISTANCE FACTOR 55
MAXIMUM WEIGHT ALLOWED PER DELAY: (W=(D/SD)**2) 6995

EXPLOSIVES

	PRODUCT	SIZE	NO. OF UNITS	LBS.
1)	ANFO	Bulk		15,628
2)				
3)	CAST Primer	1 LB	28	28
4)				
5)	Power AN 500	6 1/2 x 50	8	400
6)				

TOTAL LBS. 16,056

TYPE OF INITIATION SYSTEM:
ELECTRIC ☐ / NON ELECTRIC ☒
ELECTRIC:
TYPE OF MACHINE 450 VME
NO. OF CIRCUITS OR SERIES 1
SEQUENTIAL SETTING —
DELAY MFG. & TYPE ICI EXEL
DELAY PERIODS 500ms 17 & 42
BLAST DURATION 318ms
MAXIMUM NO. OF HOLES OR DECKS DETONATED WITHIN ANY EIGHT (8) MILLISECOND PERIOD 1

NO. OF DECKS PER HOLE 1
LBS. PER DECK 573.44
LBS. PER HOLE 573.44
TOTAL CU. YDS. 14,448.0
YD. PER HOLE 516.0
ROCK DENSITY —
TONS PER HOLE —
POWDER FACTOR: 1.11
LBS/CU YD
TONS/LBS
MAXIMUM LBS/DELAY 573.44

(DIAGRAM ON OPPOSITE SIDE)

SEISMOGRAPH DATA

SEISMOGRAPH TYPE
SEISMOGRAPH NO.
SENSITIVITY
CAL. SIG. ☐ / ANNUAL CERT. ☐
OPERATOR (WITNESS)
EXACT LOCATION
BLAST DISTANCE
DATE
TIME AM ☐ / PM ☐
PARTICLE VELOCITY
TRANS VERT LONG
AIR OVERPRESSURE

BLASTER'S INFORMATION

(PLEASE PRINT)
NAME Tom Cross
LICENSE NO. 408-62-1064
CERTIFICATION NO. 03-2003
SIGNATURE Tom Cross

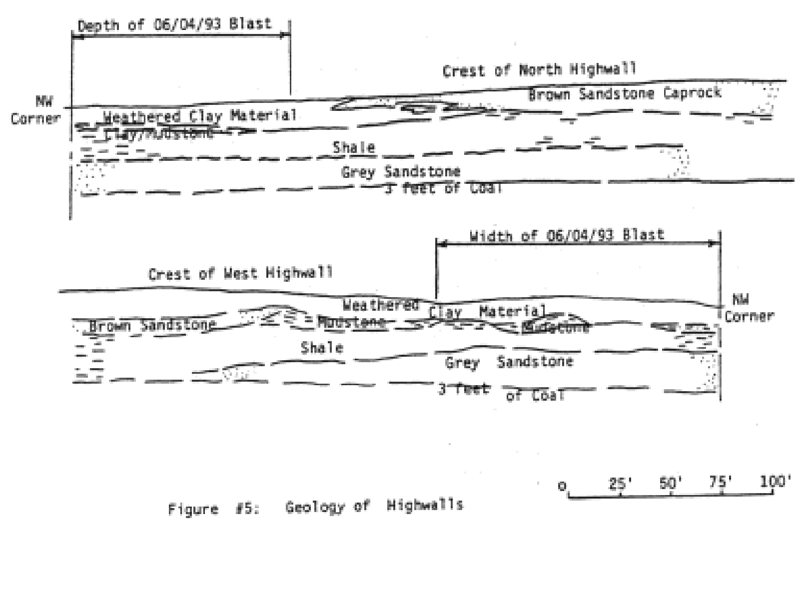


Figure #5: Geology of Highwalls

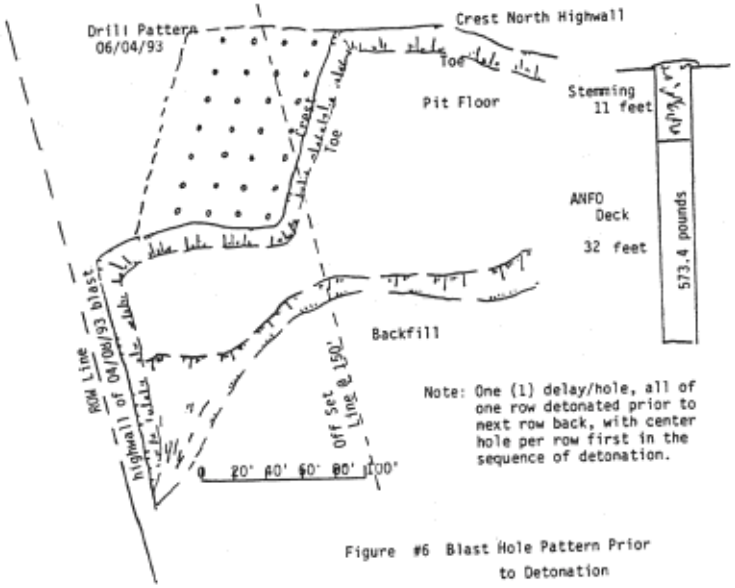


Figure #6 Blast Hole Pattern Prior to Detonation

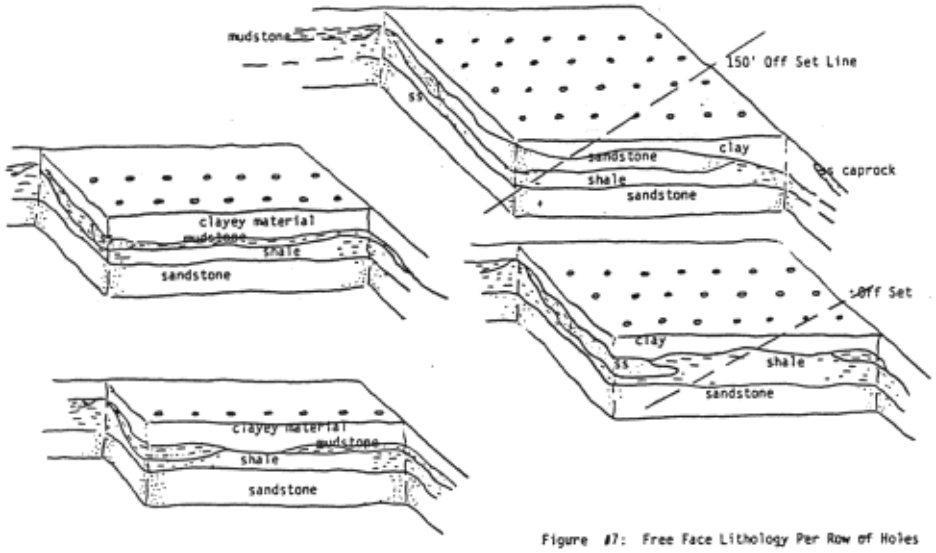


Figure #7: Free Face Lithology Per Row of Holes

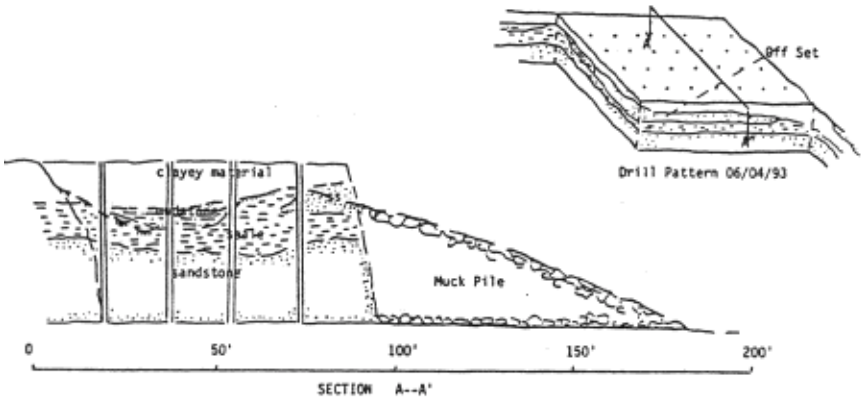


Figure #8: DRILL BENCH & MUCK PILE

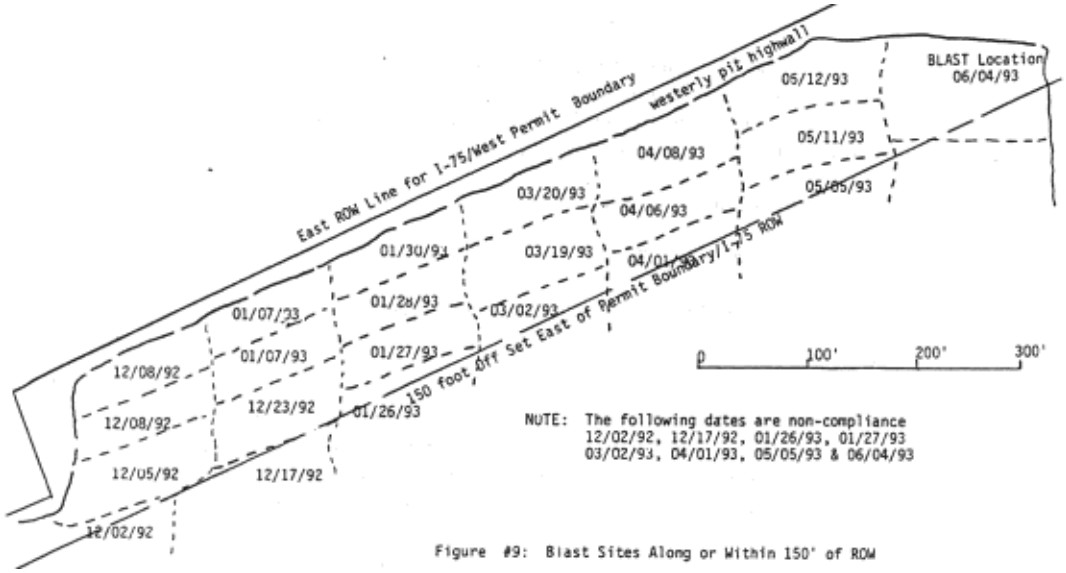


Figure #9: Blast Sites Along or Within 150' of ROW

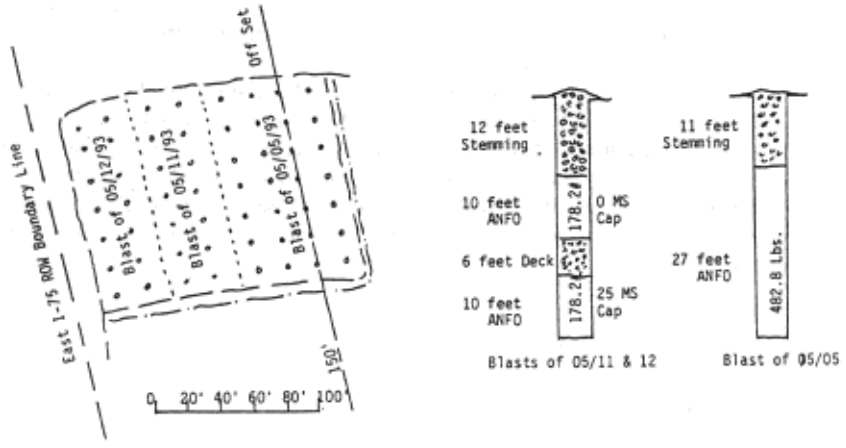


Figure # 10 Previous Adjacent Blasts

FOOTNOTES

1. Any opinions expressed are those of Ms. Shea and Mr. Clark and do not necessarily represent
the official views of the United States Department of the Interior.

2. 30 U.S.C. § 1202(a).

3. 30 U.S.C. §§ 1257(g) and 1265(b)(15) require that a permit application include the procedures and standards by which the applicant will meet the blasting standards including requiring public notice of the blasting schedule and maintaining blasting logs. The regulations establishing standards for blasting plans are codified at 30 C.F.R. §§ 816.61-816.68.

4. Sugar Ridge Coal Co. permit no. TN-004.

5. Sugar Ridge Coal Co. permit no. TN-004.

6. United States v. Jones, 735 F.2d 785, 789 (4th Cir. 1984); United States v. Buckley, 934 F.2d 84 (6th Cir. 1991).

7. 30 U.S.C. §1268(e) and (f) provide:

> (e)Any person who willfully and knowingly violates a condition of a permit issued pursuant to a Federal program, a Federal lands program or Federal enforcement pursuant to section 502 or during Federal enforcement of a State program pursuant to section 521 of this Act or fails or refuses to comply with any order issued under section 521 or section 526 of this Act, or any order incorporated in a final decision issued by the Secretary under this Act, except an order incorporated in a decision issued under subsection (b) of this section or section 704 of this Act, shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than one year or both.
>
> (f) Whenever a corporate permittee violates a condition of a permit issued pursuant to a Federal program, a Federal lands program or Federal enforcement pursuant to section 502 or Federal enforcement of a State program pursuant to section 521 of this Act or fails or refuses to comply with any order issued under section 521 of this Act, or any order incorporated in a final decision issued by the Secretary under this Act except an order incorporated in a decision issued under subsection (b) of this section or section 703 of this Act, any director, officer, or agent of such corporation who willfully and knowingly authorized, ordered, or carried out such violation, failure, or refusal shall be subject to the same civil penalties, fines, and imprisonment that may be imposed upon a person under subsections (a) and (e) of this section.

8. 30 U.S.C. § 1265(b)(15)(B).

9. Marion T. Cross, 134 IBLA 323, 326 (1996).

10. Daniel, J. R., "Dynamic Blast Pattern Adjustments in Multiple Bench Row Blasting", Proceedings of the Twenty-second Annual Conference on Explosives and Blasting Technique, February, 1996, International Society of Explosive Engineers, Orlando, Florida.