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***BRADLEY SAFETY CONSULTANTS***

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RECEIVED
MAR 6 2002

March 2, 2002

Mr. Daron Haddock
Utah Division of Oil, Gas and Mining
1594 W North Temple, Suite 1210
Salt Lake City, UT 84114-5801

C/007/001
Copy Incoming Mary Ann, Daron, Pete, Wayne

Dear Mr. Haddock:

I appreciate the opportunity of working with you and your division on Utah's first surface coal mine blast on February 28, 2002. Other than for building implosions, it was the largest gathering of individuals that I have witnessed for a blast. Represented were: Division of Oil, Gas and Mining; Lodestar; Questar; AMEC; ORICA; Intermountain West Energy; Wolf Mining Group; and Nielson Construction.

Of concern to everyone involved was the damage potential to Questar's gas line from blasting overburden at Lodestar's Whisky Creek No. 1 Mine (White Oak) at Scofield, Utah. The day before the blast, an informational meeting was held to discuss the detonation of explosives, rock breakage, ground vibration, seismographs, peak particle velocity, and damage potential.

You will recall that I had mentioned that particle velocity and frequency are the most important parameters to consider when assessing the potential effect of ground vibration on structures. I had also mentioned that contrary to public belief, most pipeline damage is not caused by elastic vibrations but rather from block motion or from having the pipeline in the actual blast crater zone.

There have been numerous tests regarding vibration damage to pipelines. In 1981, the Southwest Research Institute for the Pipeline Research Committee of the American Gas Association conducted an extensive study of the blasting and pipelines with particle velocities of 20 IPS (inches per second) without damage to the pipelines.

A recent study conducted by Rachel Bernau, and presented to the International Society of Explosives Engineers (2001) found low responses, strains and calculated stresses to the pipe, even from large blasts. Ground vibrations of 4.7 IPS to 9.8 IPS produced worst case strains that were about 25 % of the strains resulting from normal pipeline operations. She found that no pressurization failures or permanent strains occurred even at vibration levels of 23.6 IPS. Although these particle velocities were sustained without loss of pipe integrity, it was recommended that a safe level criterion of about 5 IPS be used for a larger surface mine blast for Grade B or better steel pipe. This level concurs with an article written for the "Coal Journal" in January 1995 by Jim Ludiczak, a blasting consultant. (See Enclosure 1).

I even ran across the results of a study for the US Army Corps of Engineers conducted by W.L. Huff. (published September 1979). It was on pipeline responses to a 9000 kg TNT blast. Although the pressurized pipeline was only 24 meters from ground zero, no visible breaks occurred. The radial vibration was 168 IPS.

I found particularly interesting the Geologic Hazard study for Questar. It discussed the potential for damage to pipeline from an earthquake. ". . . it is highly unlikely that an earthquake event and potential surface displacement would cause damage to the pipeline. O'Rourke and Palmer (1996) evaluated pipeline performance during 11 major southern California earthquakes (Richter magnitude 5.9 to 7.7) over a 61 year period and concluded that post World War II electric arc welded transmission lines in good repair have not experienced leaks or breaks."

The amplitude of the surface wave from blasting is less than the thickness of these sheets of paper. The pipeline moves with the earth. It is differential pressure that damages pipes, and that occurs in the cratering zone. What about potential damage to the stability of the coal pillars in the Gasline Protection Corridor? The pillar supports that remain consist of 51 to 68 percent of the coal. I have read studies regarding pillar supports in limestone mines, and PPV's of over 9 IPS would be required to cause any damage.

On February 28, Lodestar conducted a shot utilizing a maximum of 746 pounds per 8 ms delay period. (See blast report enclosures 2 and 3). Seismographs were set up at five different locations, ranging from 350 feet to 2500 feet. (See enclosure 4). Enclosure 5 depicts the location of the seismographs in relation to the underground workings, hundreds of feet below surface.

At seismic monitoring location # 1, only 350 feet from the blast, a Nomis Seismograph #1258 recorded a PPV of only .104 IPS, an extremely low reading for this distance. At seismic monitoring location # 2, 800 feet from the blast, a White's seismograph # 1337 recorded a PPV of 0.285 IPS. (See Enclosure # 6). At seismic monitoring location # 3, 1300 feet from the blast, a White's seismograph # 1380 recorded a PPV of 0.1 IPS. (See Enclosure # 7) At seismic monitoring location # 4, 1500 feet from the blast, a Geosonics seismograph recorded a PPV of 0.09 IPS. Finally at seismic monitoring location # 5, 2500 feet from the blast, a White's seismograph # 1291, recorded a PPV of 0.035 IPS.

I would like to point out that these PPV's are surface recordings. As the waves travel through the earth, energy decays due to geometric spreading, and at 100 feet down the actual vibration level is only a small percentage of that recorded on the surface. These vibration levels would have no effect on the pillar supports.

The question of future vibration monitoring did come up. I believe everyone present was satisfied with the recorded vibration levels. With the exception of the closest monitoring location, the vibrations were running one third their anticipated levels based on the DuPont formula for estimating ground vibration. 160 Distance -1.6

Powder Weight

The OSM law allows either seismic monitoring or use of a scaled distance equation. The equation is the only non-site specific option, based on generalized data collected over the whole of the United States. It is the most restrictive, yet undoubtedly the simplest of all the ground motion compliance options. It requires only that the distance from the shot to the point of interest is related to the maximum charge weight per delay, as a square root scaled distance.

Although the blast at the Whisky Creek Mine was basically a non-event, it was exciting to be present as history was made.

If I can be of further assistance, please contact me.

Sincerely,

C. W. Bradley

C. W. "Mickey" Bradley
Enclosures

# What are safe vibration levels near buried gas lines?

By JIM LUDICZAK
CONTRIBUTING WRITER
THE COAL JOURNAL JAN '95

For many years, the main interest for protecting structures from damaging blasting-related ground vibrations has been for structures such as buildings and other manmade surface structures. Even the regulatory agencies have focused on limitations for the protection of "controlled structures."

Current industry and regulatory standards regulating the limitations of ground vibrations from blasting are also mainly concerned with damage control to man-made surface structures. Many of the regulations, especially for surface coal mining, are based on the Bureau of Mines Report of Investigation 8507, titled "Structural Response and Damage Produced by Ground Vibrations From surface Mine Blasting."

Essentially, the report suggest a safe level of one inch of peak particle velocity (PPV) for builidings. As the title indicates, this work was for the development of safe vibration levels for surface structures/builidngs, not underground mines, buried pipelines or other utilities.

Underground utilities, such as pipelines, are known to react differently than buildings and are able to withstand vibrations at much higher levels than those recommended for buildings. This fact caused the Federal government and many states not to establish a safe vibration limit for buried pipelines/utlities.

The vibration limitation was commonly established by the owner of the line. Unfortunately, in most cases, the pipeline owners used the same vibration limitations as those established for buildings. Because of the lack of historical data on the effects of ground vibrations on buried pipelines, it was dificult—if not impossible—to convince the pipeline owner that one or two inches of PPV was too strigent for pipelines. These limitations caused the blaster to design very complicated and expensive blasting programs to comply with the limitations.

In recent years, the effects that blasting vibrations had on pipelines has become increasingly more important. This is because of both encroachment of surface mining and construction blasting. The construction blasting also included the construction of new pipeline next to existing lines. With the increase of new hish pressure gas pipeline construction, the pipeline owners fell under the same limitations that they had established for others.

Tey discovered that their own contractors had a very difficult and expensive time blasting next to existing lines and staying within one or two inch vibration limitations. As a result, the pipeline owners started working closer with the blasting industry to learn more about the "real" effects the the blast-induced vibrations had on the pipelines. The fruit of this research has proven to be very beneficial for both industries.

As a result of this cooperative effort between the pipelin owners and the blasting industry, many pipeline owners have increased the vibrations levels allowed at the line. Many owenrs have increased the vibration levles for both large and small scale blasting to four, and to as much as six, inches of PPV.

These higher levels were not only supported by data collected by the line owners, but have now been supported by recent Bureau of Mines (BOM) studies. Depending on the construction and age of the line, the BOM studies have recommended an initial safe vibration level of five inches of PPV. After additional data is analyzed, the BOM expects this level could even be higher.

After working for years with some of the major gas transmissions companies in both blast designs and monitoring blast vibrations at the pipelines.

One can appreciate the concerns of the gas transmission industry. The danger and liability of rupturing a gas pipeline is tremendous. Their initial vibration limitations had to be very conservative for the safety of the pipeline.

Blasting effects on te pipelines were just as new to them as they were to the blasting industry. It was never their intent to stop blasting next to the line. Tey had to make sure that the line would not be damaged. As a result, they used the only existing data available to them when developing the initial vibration limitations.

Now with the past and present studies, they have realized that the line can withstand mush higher levels of vibration than buildings.

This does not, and should not, mena that all buried high pressure gas pipelines, or other utilities, can withstand the same vibration levels. The blaster must consider each line on a case-by-case basis and work with the owners when establishing the limitations.

ENCLOSURE 1

# BLAST REPORT

DATE: 2-28-02 EXACT TIME OF SHOT: 5:30

CUSTOMER: Lodestar JOB NO: 5214

JOB LOCATION: Scofield TICKET NO:

TYPE EXPL: Magnafrac Gold - Emulsion PRIMER: 1# 2#

TYPE OF MATERIAL: Over Burden FACE HEIGHT 15 ft

NO. OF HOLES 42 HOLE DIA. 6.75

NO. OF HOLES ——— HOLE DIA. ——— POWDER FACTOR 0.65

BURDEN 18 ft. SPACING 18 ft. HOLE DEPTH 20-21 ft.

☐ ELEC ☐ SEC. TIMER ☐ NONEL ☒ EZ DET

AMOUNT STEMMING 13-14 ft. WEATHER Sunny

WIND from South MATS? -0- NO. OF PERSONS ON BLAST CREW 8

NAMES 1) Jim Cox HRS.
2) Troll HRS.
3) Rick HRS.
4) Cory HRS.
5) Hoick HRS.
6) Bob HRS.
7) Shane HRS.

BLASTER IN CHARGE [signature]

LICENSE NO. [signature]

COMMENTS: [illegible]

MONITOR: L 0.05 T 0.03 V 0.09 PVS ——— dB ———

DISTANCE TO BLAST 1500 MAX. POUNDS PER DELAY 746

## TOTALS

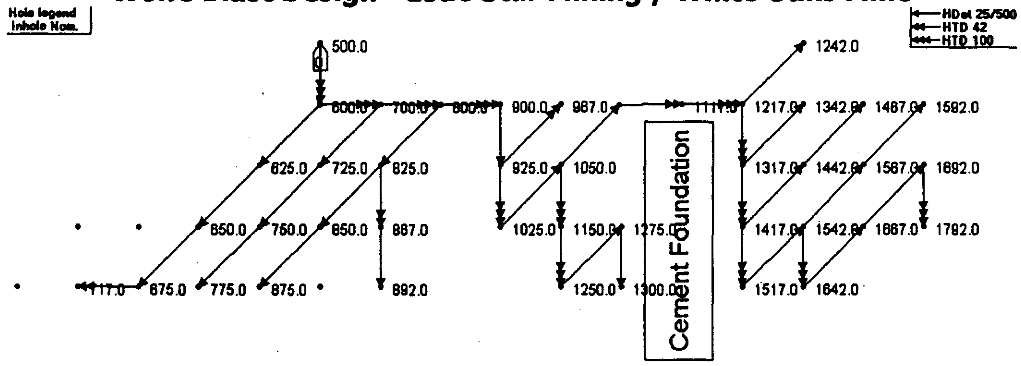
HOURS LABOR 8 YARD OF ROCK 26088
[illegible] 14767 CAPS
DYES POWDER SIZE
[illegible] SIZE [illegible]
[illegible] SIZE
[illegible] OTHER
SIGNATURE SLURRY AMOUNT 14,775 SIZE 6,[illegible]

NOTE: PLEASE DRAW SKETCH OF SHOT ON BACK.

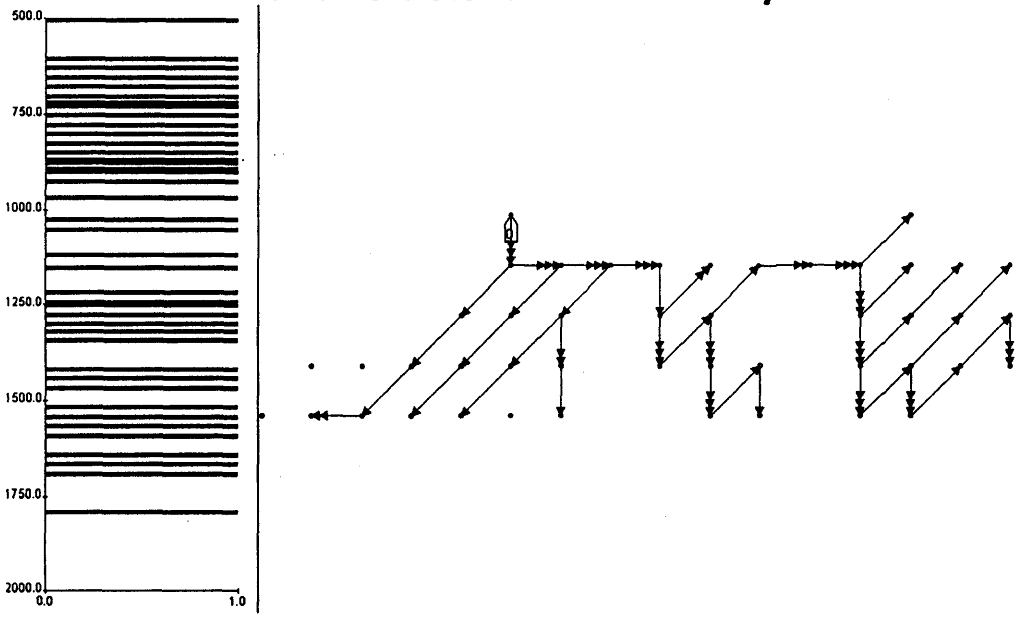
11767
+ 108
14875 | 26088

ENCLOSURE 2

## Wolfe Blast Design - Lode Star Mining / White Oaks Mine




## Number of Blast Holes Per 8 ms Delay

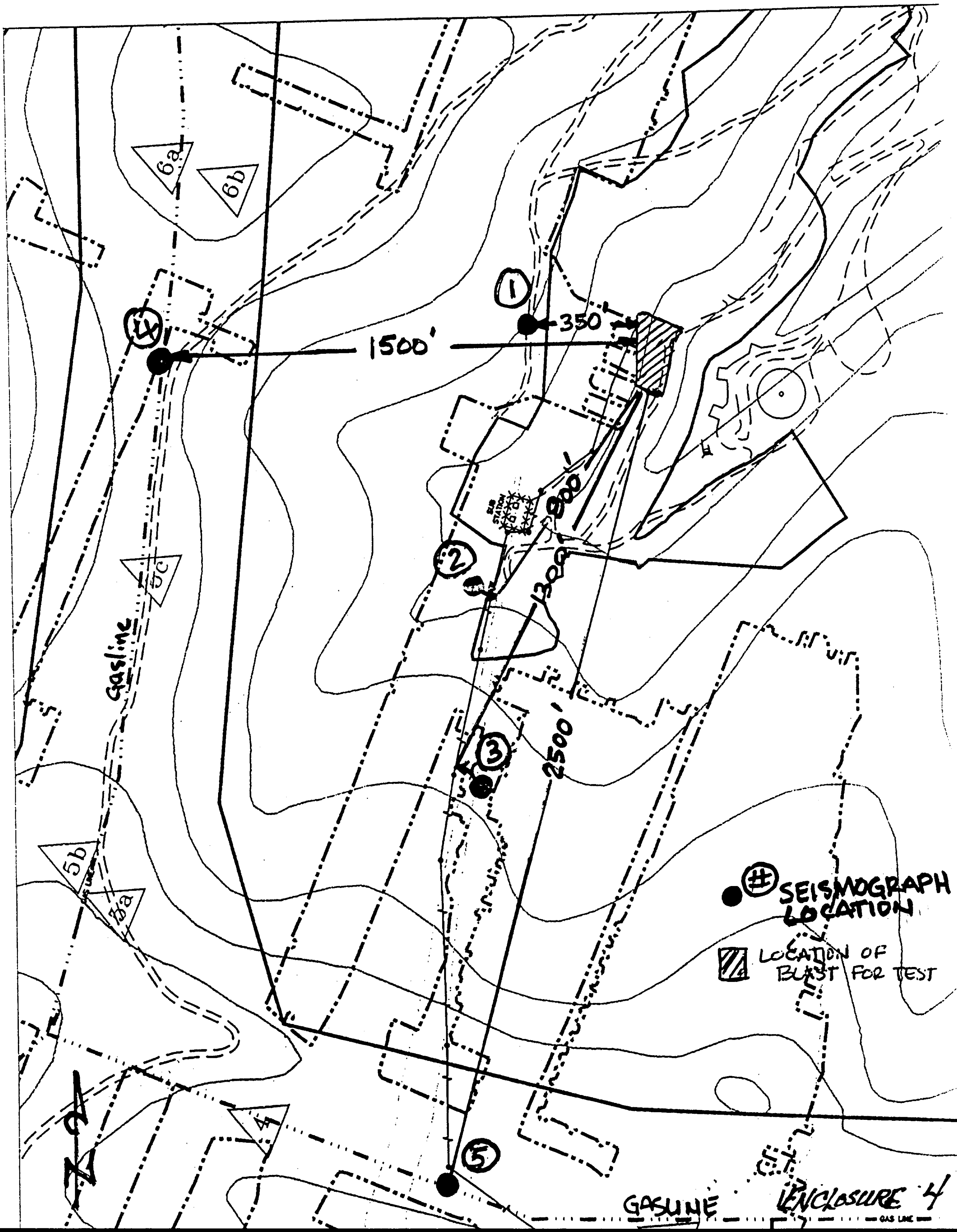


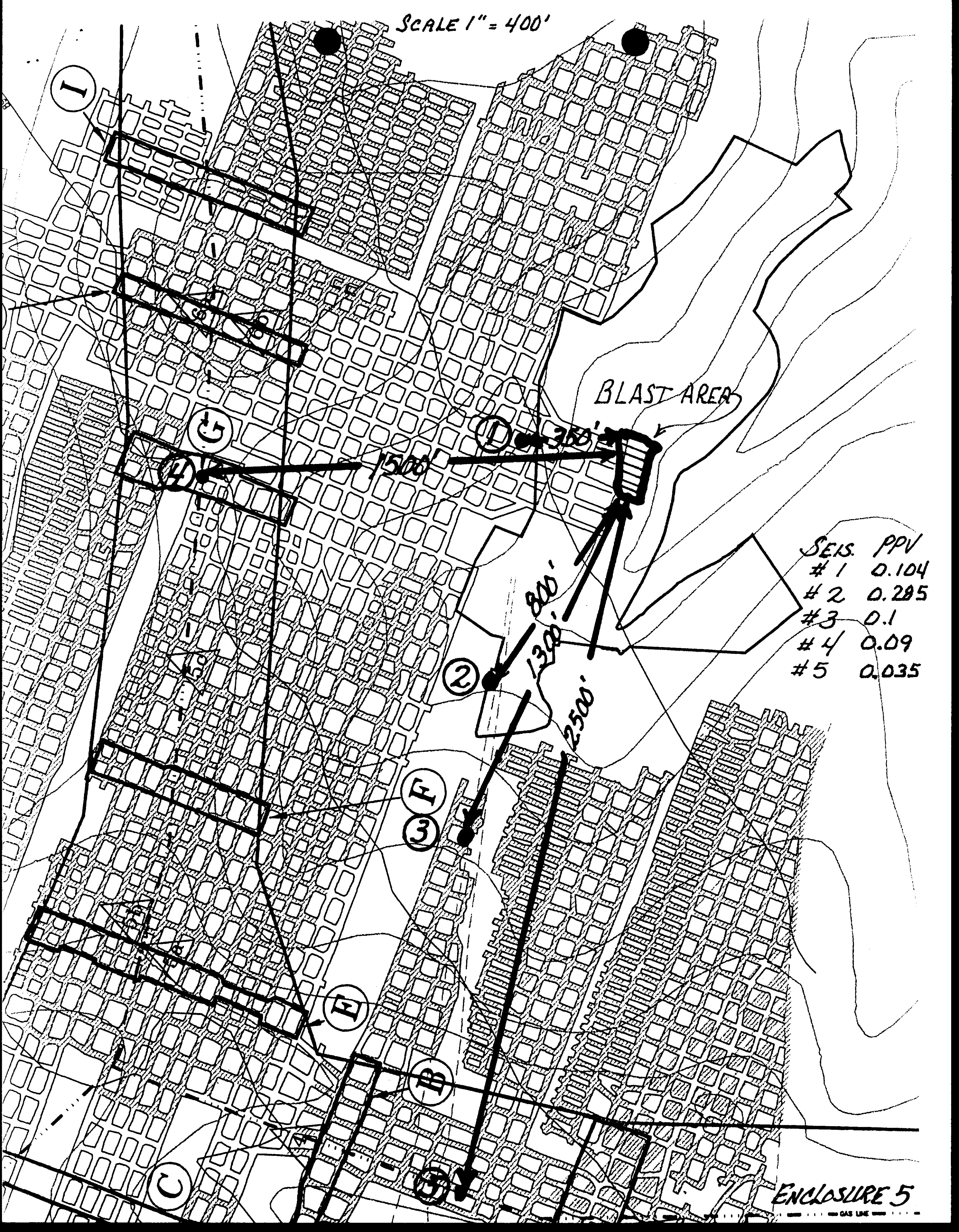

## Blast Information Estimation

| | |
|---|---|
| Total Number of Loadable Holes | 41 |
| Vibration Concern – Gas Line | 1,500 ft from shot |
| Maximum lbs per hole | 76 ft deep – 13 ft stem = 63 ft of Column = 756 lbs |
| Product Used | 5" x 27lb Packaged Emulsion |
| 1,500 ft @ 55 Scale Distance Factor | 744 lbs/delay |
| Initiation System | Handidets & HTD Surface Delays (Triple primed on deep Holes) Doubled up on Surface Delays & 1 lb cast Booster |

ENCLOSURE 3

**Bradley Safety Consultants, Inc.**
**Utah Division of Oil, Gas and Mining**
**Lodestar Energy, Inc., White Oak Mine**
**Location of seismographs for Questar Test Shot**
**February 28, 2002**

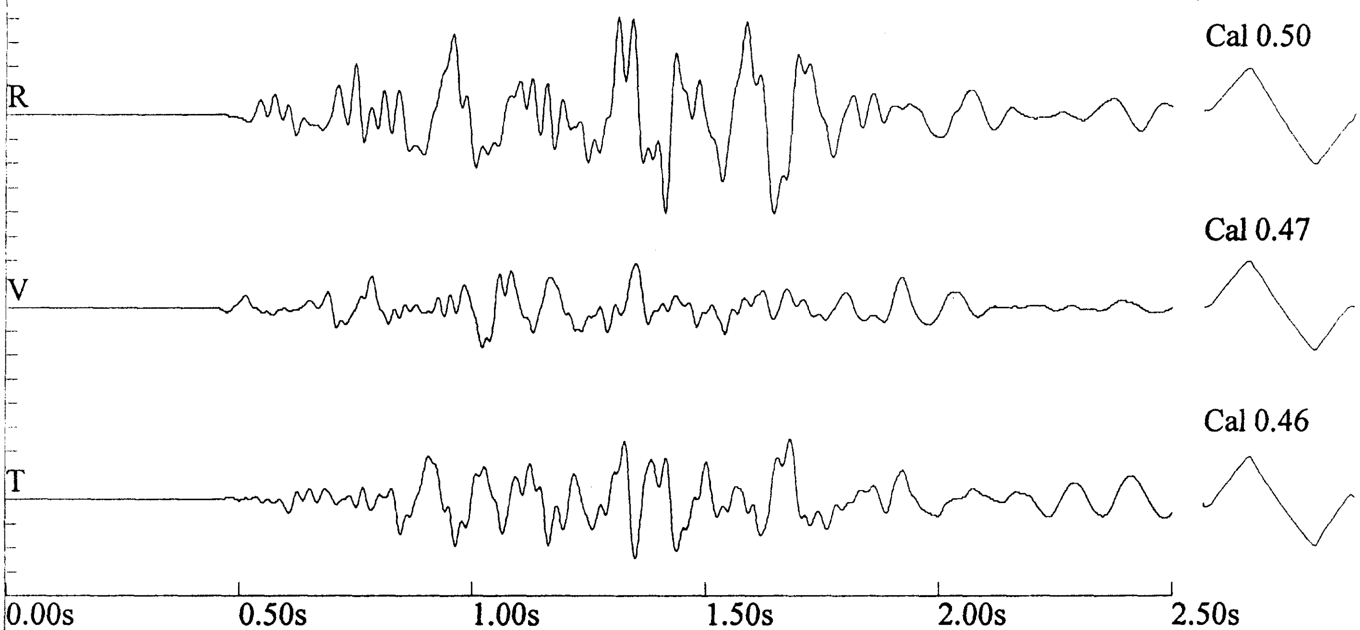



SCALE 1" = 400'
BLAST AREA
350'
1500'
800'
1300'
2500'
SEIS. PPV
#1 0.104
#2 0.285
#3 0.1
#4 0.09
#5 0.035
ENCLOSURE 5
GAS LINE

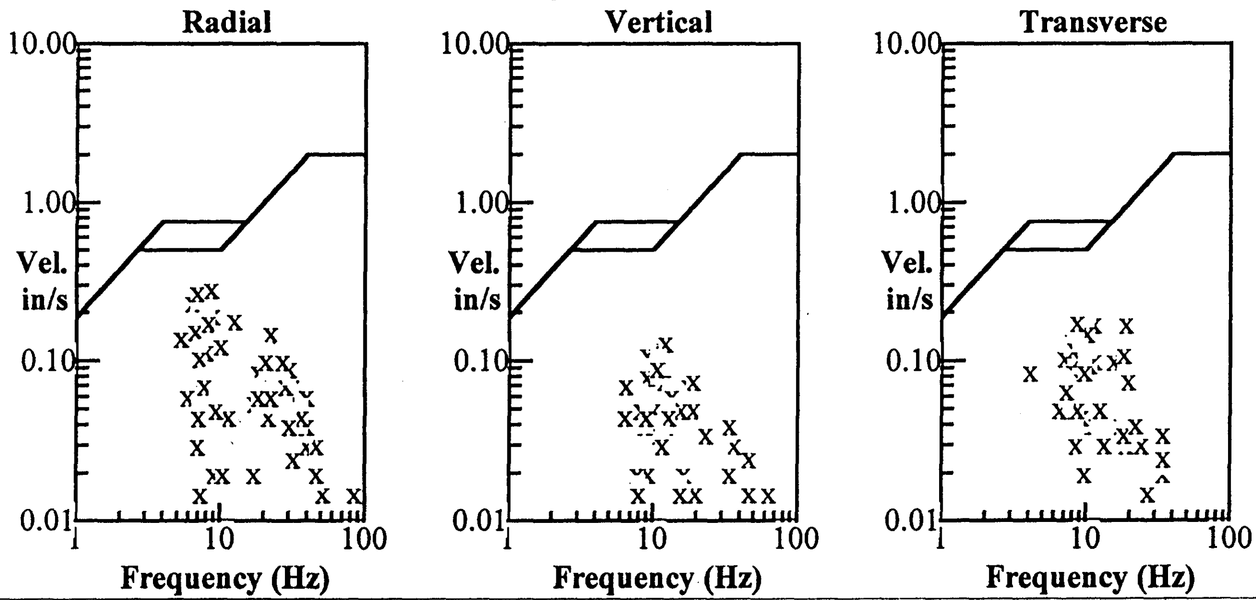
Bradley Safety Consultants, Inc.
Utah Div. of Oil, Gas, & Mining
Lodestar Energy, Inc.-White Oak Mine
Questar Test Shot
Loc.# 2     800 Feet from blast
C.W. "Mickey" Bradley

Event Number: 000   Date: 02/28/02   Time: 17:26
Acoustic Trigger: 128 dB   Seismic Trigger: 0.02 in/s   Serial Number: 1337

| **Amplitudes and Frequencies** | **Graph Information** |
| --- | --- |
| *Radial:* 0.285 in/s @ 8.2 Hz. | *Duration:* 0.000 sec To: 2.500 sec |
| *Vertical:* 0.13 in/s @ 12.4 Hz. | *Seismic:* 0.28 in/s (0.07 in/s/div) |
| *Transverse:* 0.175 in/s @ 8.6 Hz. | *Time Lines at:* 0.50 sec intervals |




**Particle Velocity Versus Frequency - USBM Limits (RI 8507, 1980)**




ENCLOSURE 6

Bradley Safety Consultants, Inc.
Utah Div. of Oil, Gas, & Mining
Lodestar Energy, Inc.-White Oak Mine
Questar Test Shot
Loc.# 3    1300 feet from blast
C.W. "Mickey" Bradley

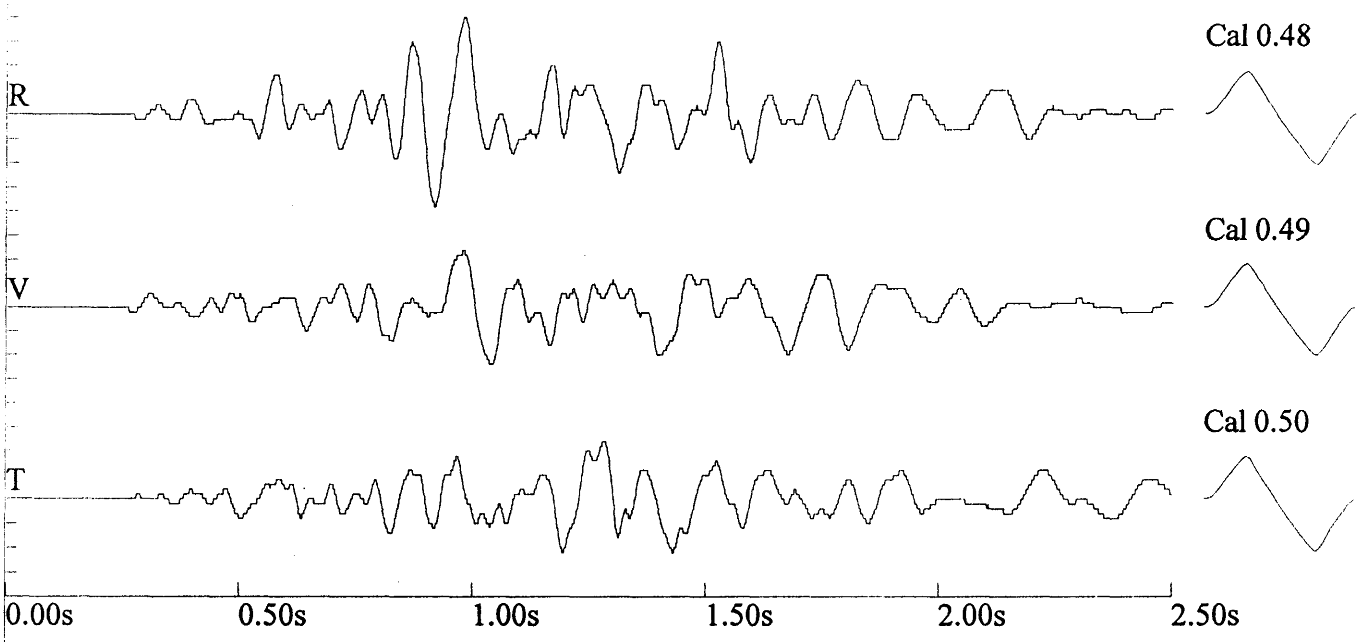
Event Number: 000   Date: 02/28/02   Time: 17:27
Acoustic Trigger: 142 dB   Seismic Trigger: 0.02 in/s   Serial Number: 1380

## Amplitudes and Frequencies

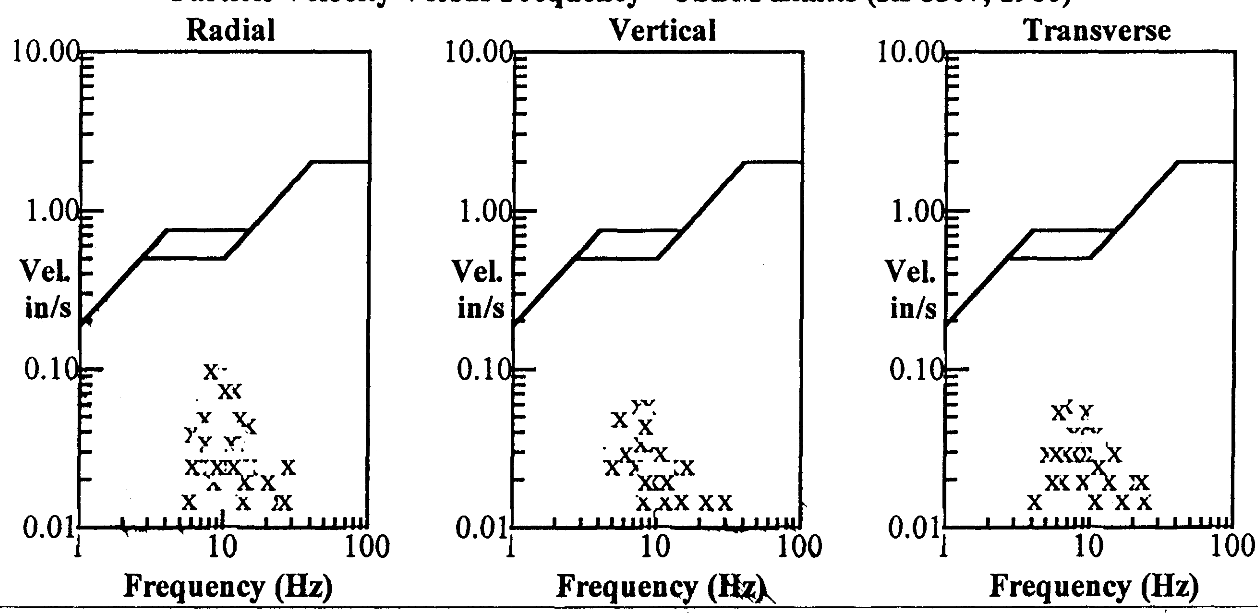
*Radial:* 0.10 in/s @ 8.2 Hz.
*Vertical:* 0.06 in/s @ 7.8 Hz.
*Transverse:* 0.06 in/s @ 7.0 Hz.

## Graph Information

*Duration:* 0.000 sec To: 2.500 sec
*Seismic:* 0.10 in/s (0.025 in/s/div)
*Time Lines at:* 0.50 sec intervals




**Particle Velocity Versus Frequency - USBM Limits (RI 8507, 1980)**

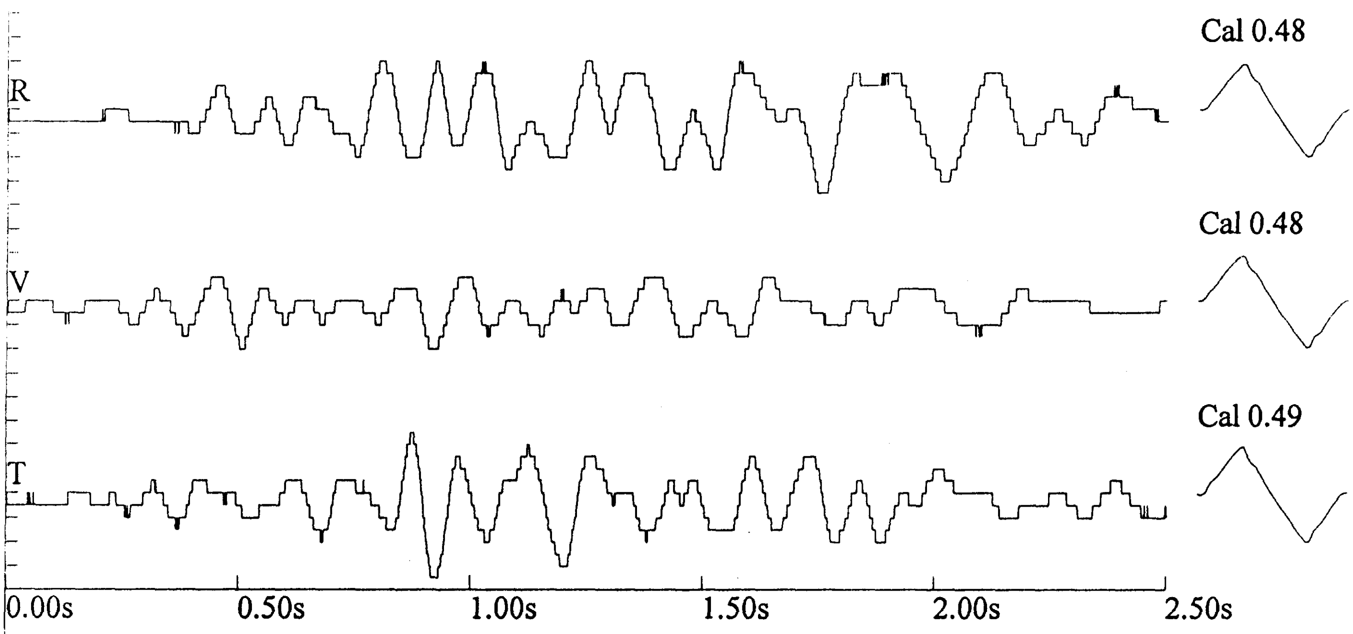



ENCLOSURE 7

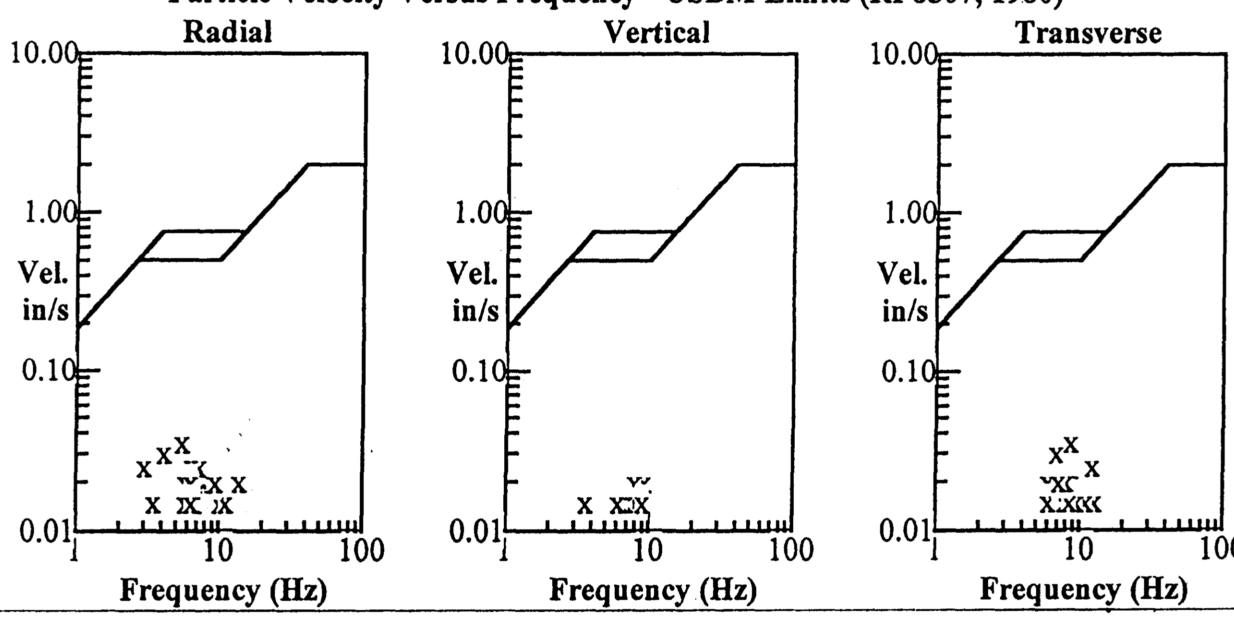
Bradley Safety Consultants, Inc.
Utah Div. of Oil, Gas, & Mining
Lodestar Energy, Inc.-White Oak Mine
Questar Test Shot
Loc.# 5    2500 feet from blast
C.W. "Mickey" Bradley

Event Number: 001    Date: 02/28/02    Time: 17:28
Acoustic Trigger: 125 dB    Seismic Trigger: 0.02 in/s    Serial Number: 1291

| **Amplitudes and Frequencies** | **Graph Information** |
|---|---|
| *Radial:* 0.035 in/s @ 6.3 Hz. | *Duration:* 0.000 sec To: 2.500 sec |
| *Vertical:* 0.02 in/s @ 10.2 Hz. | *Seismic:* 0.04 in/s (0.01 in/s/div) |
| *Transverse:* 0.035 in/s @ 8.9 Hz. | *Time Lines at:* 0.50 sec intervals |




**Particle Velocity Versus Frequency - USBM Limits (RI 8507, 1980)**




ENCLOSURE 8