



**US Army Corps  
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Waterways Experiment  
Station

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Miscellaneous Paper GL-93-7  
July 1993

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## **Ground Motion and Air Overpressure Study at the Naval Surface Warfare Center, Crane, Indiana**

*by Michael K. Sharp, Janet Simms  
Geotechnical Laboratory*

*Gary Cox, Jim Pickens  
Instrumentation Services Division*

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Prepared for Crane Army Ammunition Activity

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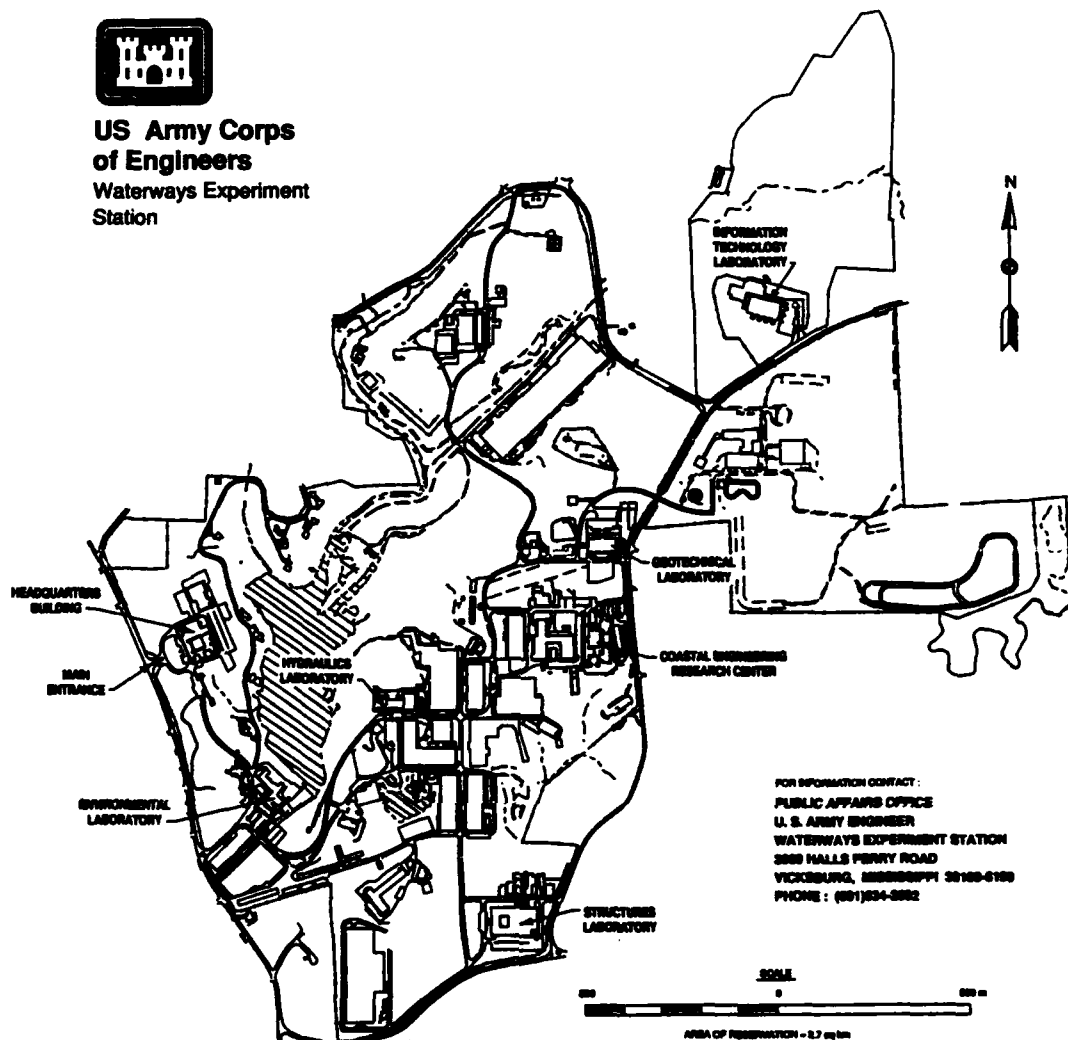
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Crane, IN 47522-5099**



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# Preface

A seismic attenuation and air overpressure study was conducted by the Earthquake Engineering and Geosciences Division (EEGD), Geotechnical Laboratory (GL), U. S. Army Engineer Waterways Experiment Station (WES), during the period 24 August through 5 September 1992. The study was sponsored by the Crane Army Ammunition Activity (CAAA), of the Naval Surface Warfare Center (NSWC) in Crane, Indiana, under MIPR No. RMB 92-749. The CAAA Technical Monitor was Mr. Larry Leonard. The project was coordinated with personnel from the Structures Laboratory, WES, before field testing began.

Field tests were conducted by Mr. Michael Sharp and Ms. Janet Simms of GL, with the assistance of Messrs. Jim Pickens and David Goodin of the Instrumentation Services Division, WES. Mr. Pickens and Mr. Goodin were responsible for the field electronic instrumentation and data recovery. Data processing was by Dr. Cary Cox, ISD. Analysis of the data and preparation of the report was accomplished by Mr. Sharp and Mr. Simms. Dr. Niki Deliman of GL was instrumental in providing technical guidance for the statistical analysis, and Mr. Bill Murphy of GL provided technical guidance for the geologic interpretation. The work was performed under the direct supervision of Mr. J. R. Curro, Chief, Engineering Geophysics Branch, EEGD, GL, and under the general supervision of Dr. A. G. Franklin, Chief, EEGD, GL, and Dr. W. F. Marcuson III, Director, GL. The report was reviewed by Dr. Paul F. Hadala and Messrs. Joseph R. Curro II and Donald E. Yule.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

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# Conversion Factors, Non-SI to SI Units of Measure- ment

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Non-SI units of measurement used in this report can be converted to SI units as follows.

| Multiply                                                                                                                                                                                              | By       | To Obtain                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------------------------|
| Fahrenheit degrees                                                                                                                                                                                    | 5/9      | Celsius degrees or Kelvins <sup>1</sup> |
| feet                                                                                                                                                                                                  | 0.3048   | meters                                  |
| inches                                                                                                                                                                                                | 2.54     | centimeters                             |
| miles (US statute)                                                                                                                                                                                    | 1.609347 | kilometers                              |
| pounds (force)                                                                                                                                                                                        | 4.448222 | newtons                                 |
| pounds (force) per square inch                                                                                                                                                                        | 6.894757 | kilopascals                             |
| <sup>1</sup> To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F-32)$ . To obtain Kelvin (K) readings, use: $K = (5/9)(F-32) + 273.15$ . |          |                                         |

# 1 Introduction

---

## Background

The U. S. Army Engineer Waterways Experiment Station (WES) was requested by the U. S. Army Engineer District, Louisville and the Crane Army Ammunition Activity (CAAA) of the Naval Surface Warfare Center (NSWC), Crane, Indiana (Figure 1) to conduct a blast effects study. The CAAA has as a mission the responsibility for disposing of ammunition, explosives and other dangerous articles by detonation. This activity is conducted at a site on the NSWC facility termed the demolition grounds. Personnel at the demolition grounds detonate this material on a daily basis as site conditions (weather, safety, etc.) dictate. The total amount of material disposed of on a typical day is approximately 15,000 pounds, detonated in several pits each containing less than 500 lbs. There have been at least two claims by private individuals that their property was damaged by explosions originating at the NSWC. The CAAA, having responsibility for these explosions, was interested in determining the potential for ground motions or air blasts to produce damage to structures located off-base. A limited, small scale study (four recording stations located at the North, South, East, and West boundaries) was performed in November of 1971 by Vibration Measurement Engineers, Inc. The CAAA was interested in having a more detailed analysis performed, therefore WES was asked to assist in determining the potential for sonic or seismic energy to produce damage to structures outside the boundary of the NSWC.

## Purpose

The purpose of the study was twofold; determine the attenuation of explosion induced ground motions and air overpressures as a function of distance from subsurface detonated charges, and to develop parameters to predict ground particle velocities and air overpressures at distances beyond the base boundary. The development of these predicting parameters would then allow the CAAA to determine the particle velocities and air overpressures that could be expected at any distance from a particular explosion. These data would also allow the determination of damage potential to structures located on or off base from either seismic or sonic motions.

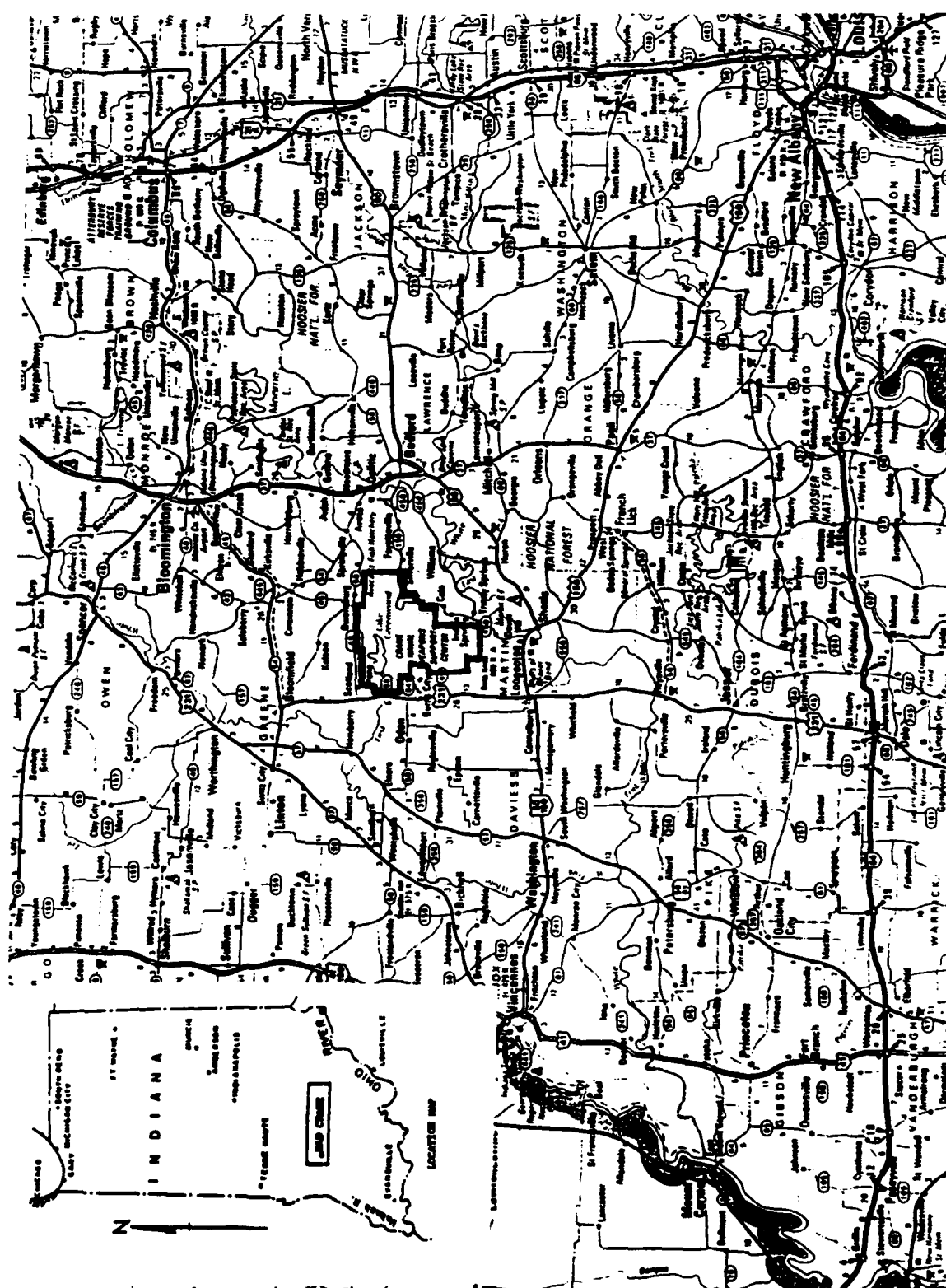


Figure 1. Site map showing the location of the NSWC Crane, Indiana

## 2 Site Descriptions and Source Characteristics

---

### Regional Geology

The Indiana Department of Natural Resources (DNR) prepared a report describing the Pennsylvanian and Mississippian sedimentology of the NSW, Crane (DNR, 1992). The discussion of the geology at Crane is excerpted from this report. The NSW is located in Martin, Greene, Daviess, and Lawrence Counties, in the southwestern part of the state. Martin county has a total area of 217,888 acres, or about 340 square miles. The county lies in the hilly part of Indiana almost entirely within the Crawford Upland, the most rugged and highly dissected part of Indiana. The streams flow southwesterly in narrow, deeply entrenched, meandering channels. The East Fork of the White River, flowing about 250 feet below the general level of the hilltops and containing Wisconsin-age outwash, drains practically all of the county. Land elevation in the county ranges from about 425 to 860 feet above sea level.

The NSW is located in the southeastern portion of the Illinois Basin, which is a large cratonic basin that began forming during Cambrian time (Klein and Hsui, 1988). It is filled by a sequence of Paleozoic sediments of which the youngest preserved are of Pennsylvanian age (320 to 286 Ma). The Pennsylvanian section is most complete in the southern portion of the basin where it reaches a maximum thickness of approximately 3,000 feet in western Kentucky (Wanless, 1975). From there the Pennsylvanian section thins to the northeast into Indiana. Crane is located at the very eastern edge of Pennsylvanian sediments.

The stratigraphic section exposed at Crane consists of both Mississippian and Pennsylvanian sediments. The Mississippian units exposed are Chesterian in age and consist of interbedded shales, limestones and sandstones of the Blue River, West Baden, Stephensport, and Buffalo Wallow Groups. The top of the Mississippian is a major unconformity surface throughout the Illinois Basin (Schloss, 1963). At Crane, Mississippian rocks form a low-angle angular unconformity wherein successively younger Chesterian rocks outcrop along drainages or subcrop beneath Pennsylvanian cover moving from east to west across the Activity. Local relief across the unconformity at Crane is highly

variable but rarely exceeds 100 ft. The Pennsylvanian section at Crane consists almost exclusively of interbedded sandstones, siltstones, shales, coals, and underclays of the Mansfield Formation, although a small interval of the Brazil Formation may be present in the northwestern portion of the center. On the Activity, Pennsylvanian sediments range from zero up to 300 ft in thickness. Thickness variations are controlled by regional dip, local relief on the Mississippian surface, and erosion. Sandstones, siltstones, and coals of the Mansfield Formation tend to be thin and stratigraphically discontinuous. Although some sandstones within the formation can be correlated laterally for up to several miles, most units can be correlated only a few thousand feet and many units can be correlated only a few hundred feet before pinching-out into other facies. The majority of the shaley intervals are also discontinuous.

A series of approximately 60 coreholes containing anywhere from 13 to 246 ft of Pennsylvanian section were obtained by WES during several coring programs conducted over the last eight years. The three sites where cores were taken consist of the Rockeye, Ammunition Burning Ground (ABG), and Demolition Area sites. Three regional cross sections were constructed to stratigraphically tie the Rockeye, Demolition Area, and ABG sites together. The cross sections show lateral and vertical lithostratigraphic facies relationships. In addition to the WES core taken, seven additional wells (Indiana Geological Survey wells) were cored connecting these three sites during the fall of 1991. Figure 2 shows the location of the three cross sections and the wells used in constructing them. Figure 3 is a legend showing the symbols used in the construction of the vertical columnar profiles from which the cross sections were generated. Cross section A-A' (Figure 4) is a northeast to southwest trending cross section that links the Rockeye area to the Demolition area. Cross section B-B' (Figure 5) is a north to south trending cross section that links Rockeye to the ABG, and the C-C' cross section (Figure 6) is an east to west trending section linking the ABG to the Demolition area.

The three sections, which cover most of the northern and eastern portions of the NSWC, reveal a great deal of information about the regional geology of the base. The overburden tends to be relatively shallow, ranging from approximately 10 to 20 ft. The remainder of the sections reveal intermittent layers of sandstones, siltstones, shales, and coal. Therefore, over the distances where ground motions were recorded (up to 22,000 ft) the waves will be travelling through the deeper rock layers.

## Demolition Area

The location of the Demolition Area at the NSWC is shown in Figure 7. Four Demolition Area cores with Pennsylvanian section were available for examination but only two cores contained a significant Pennsylvanian section. However, these cores along with several shallow cores were used to develop a cross section for the Demolition Area. Figure 8 shows a section across the Demolition Area looking north to south (the section runs west to east). The section shows that the thickness of overburden overlying the Pennsylvanian

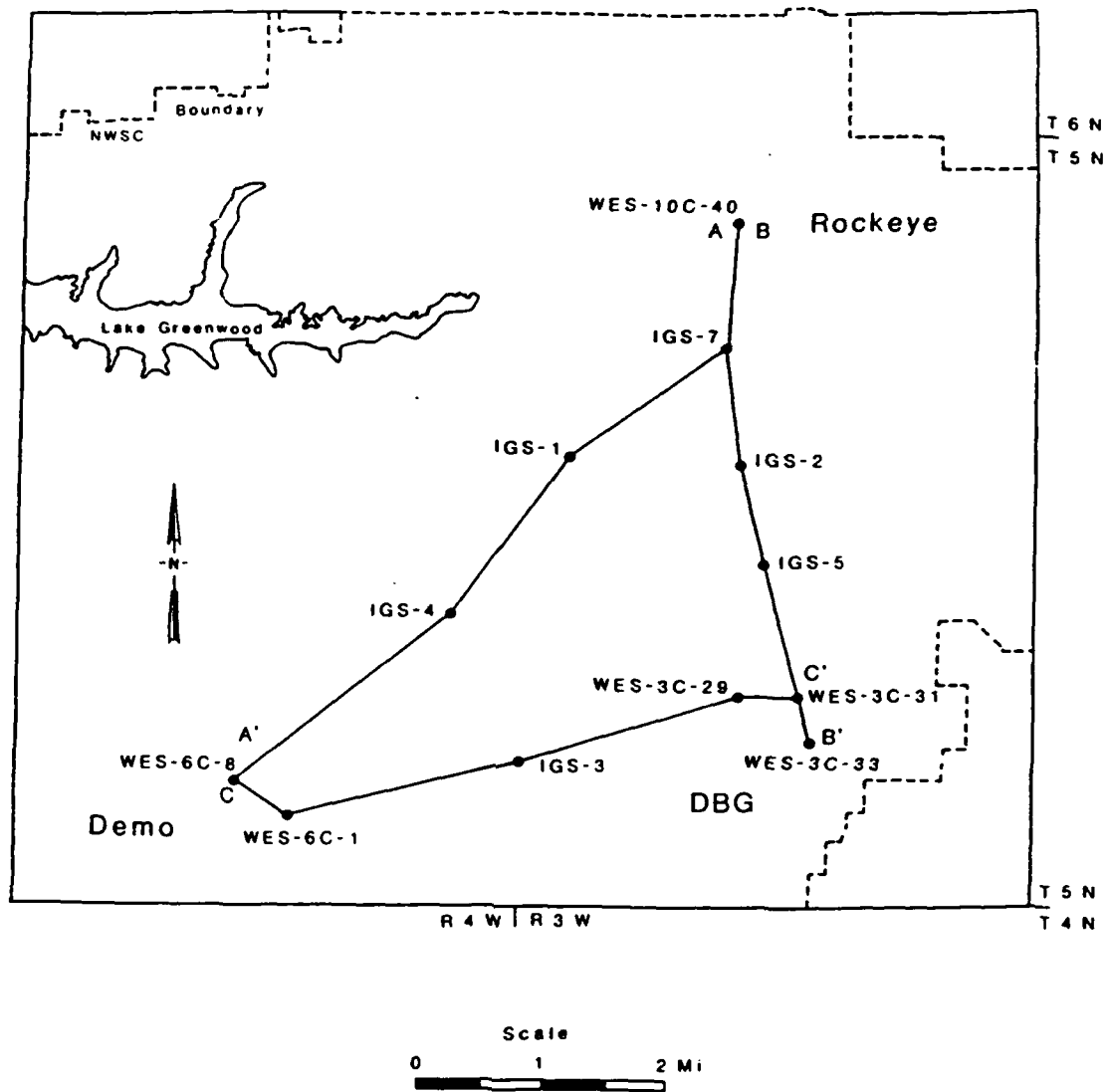


Figure 2. Location of cross sections and cores used to construct cross sections (DNR, 1992)

# LEGEND

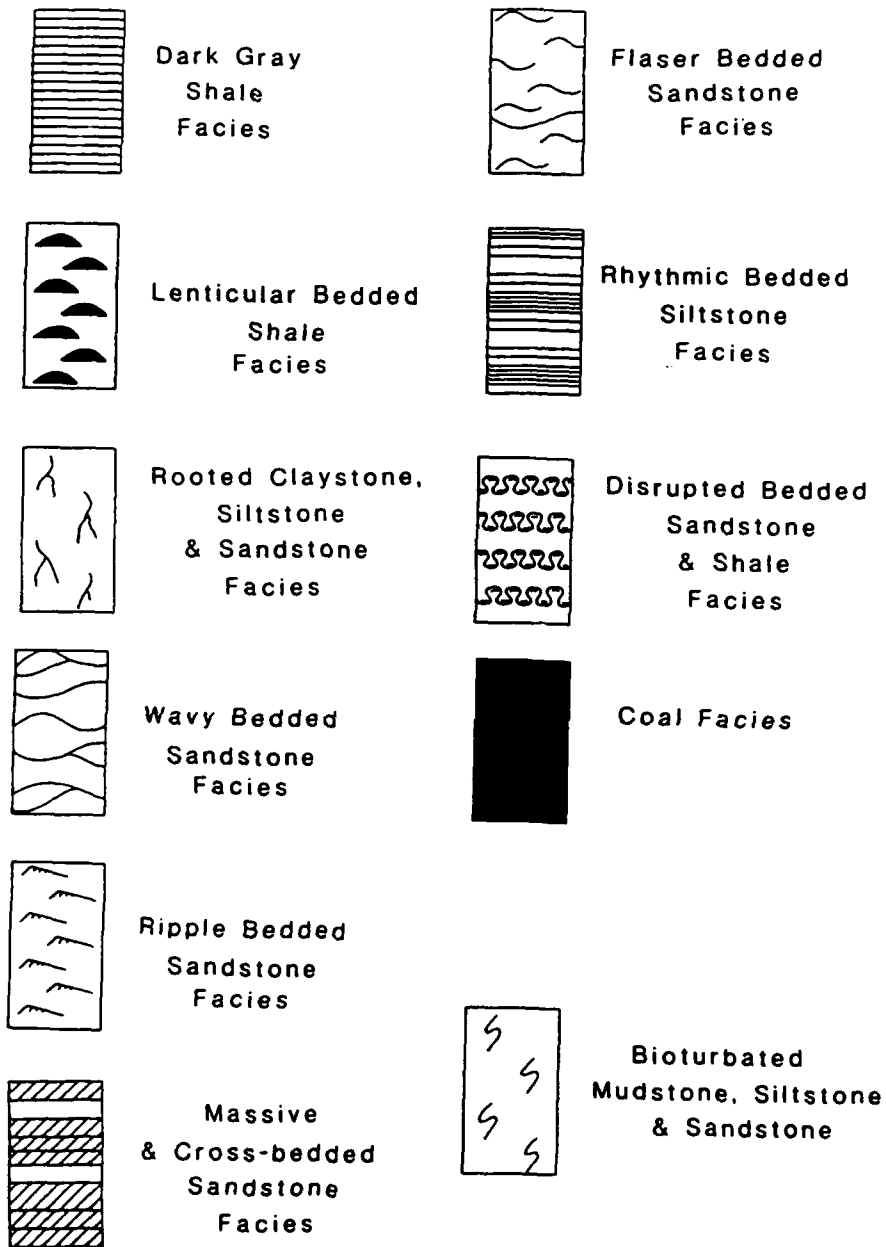


Figure 3. Legend showing the symbols used in the construction of the vertical columnar profiles on the cross sections (DNR, 1992)

A'

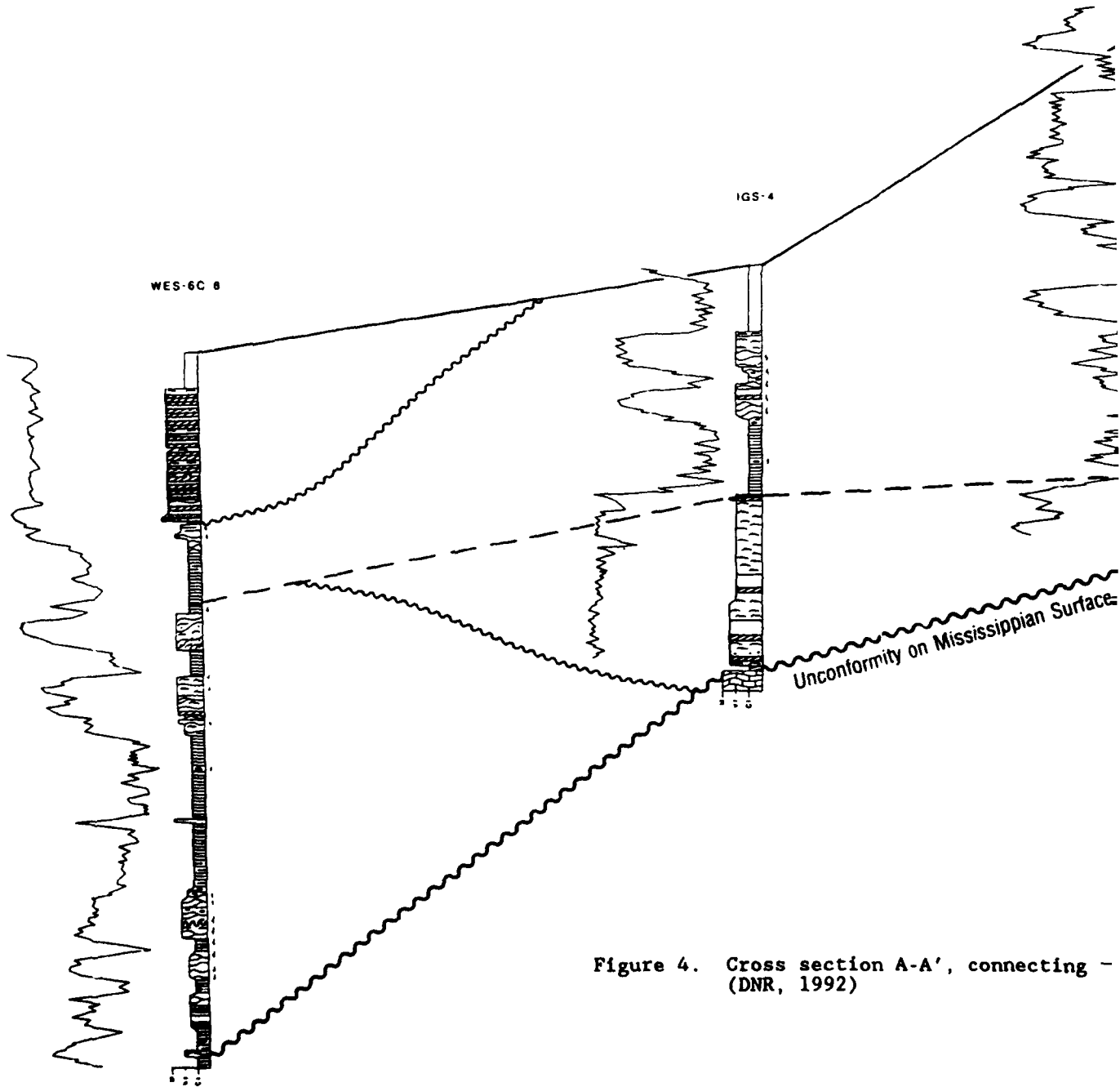


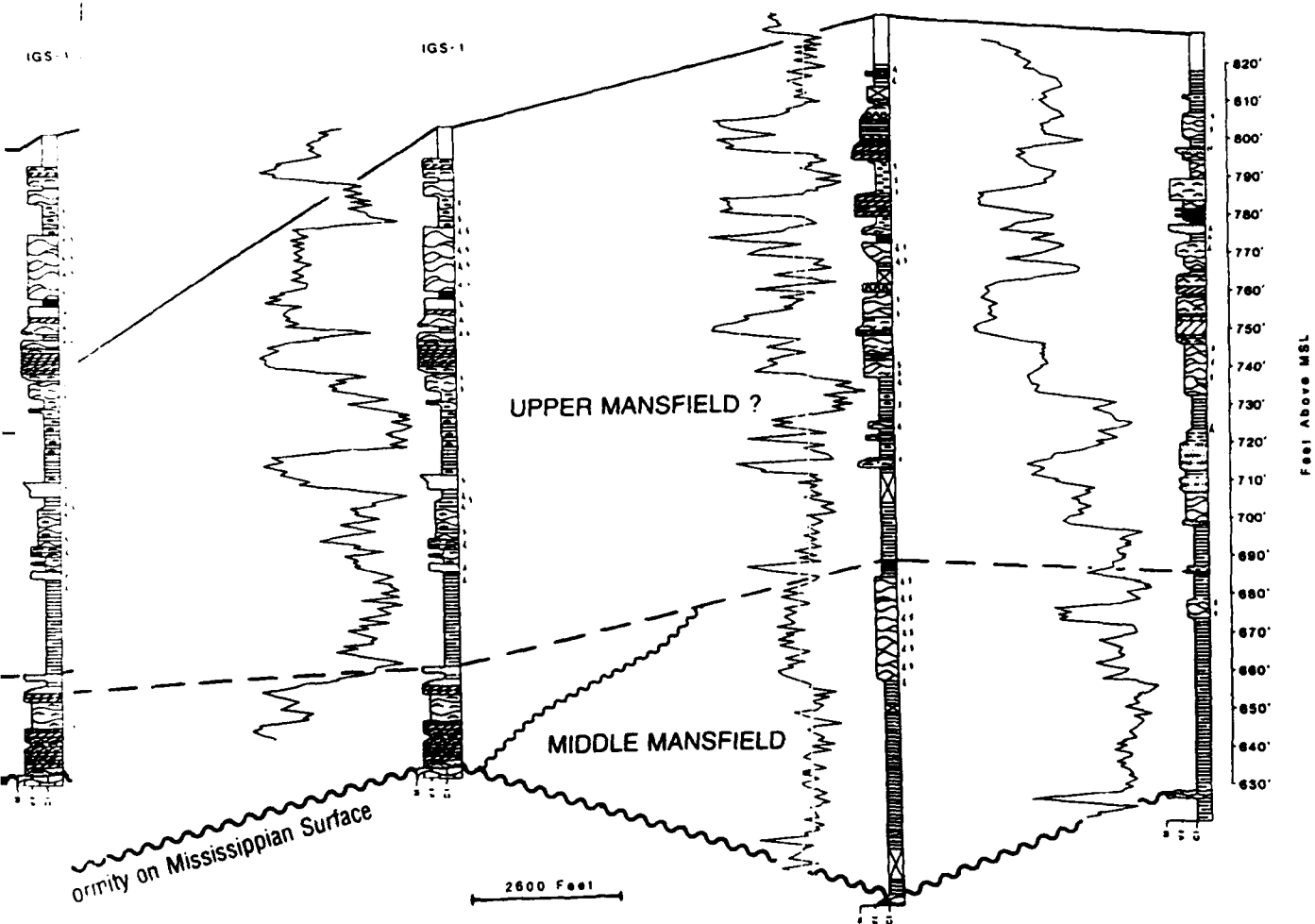
Figure 4. Cross section A-A', connecting -  
(DNR, 1992)

①

A

IGS-7

WES-10C-40



Section A-A', connecting the Rockeye and Demolition Area

2

B'

IGS-5

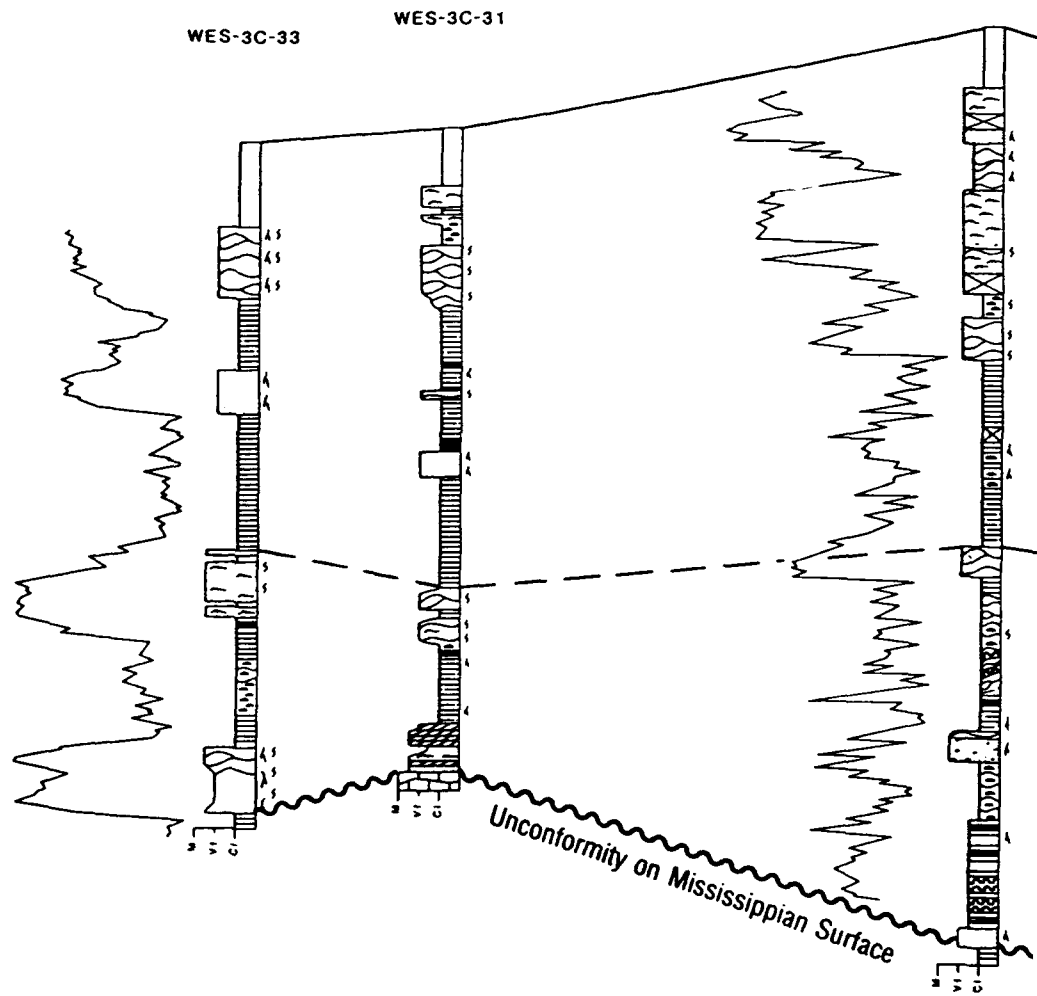
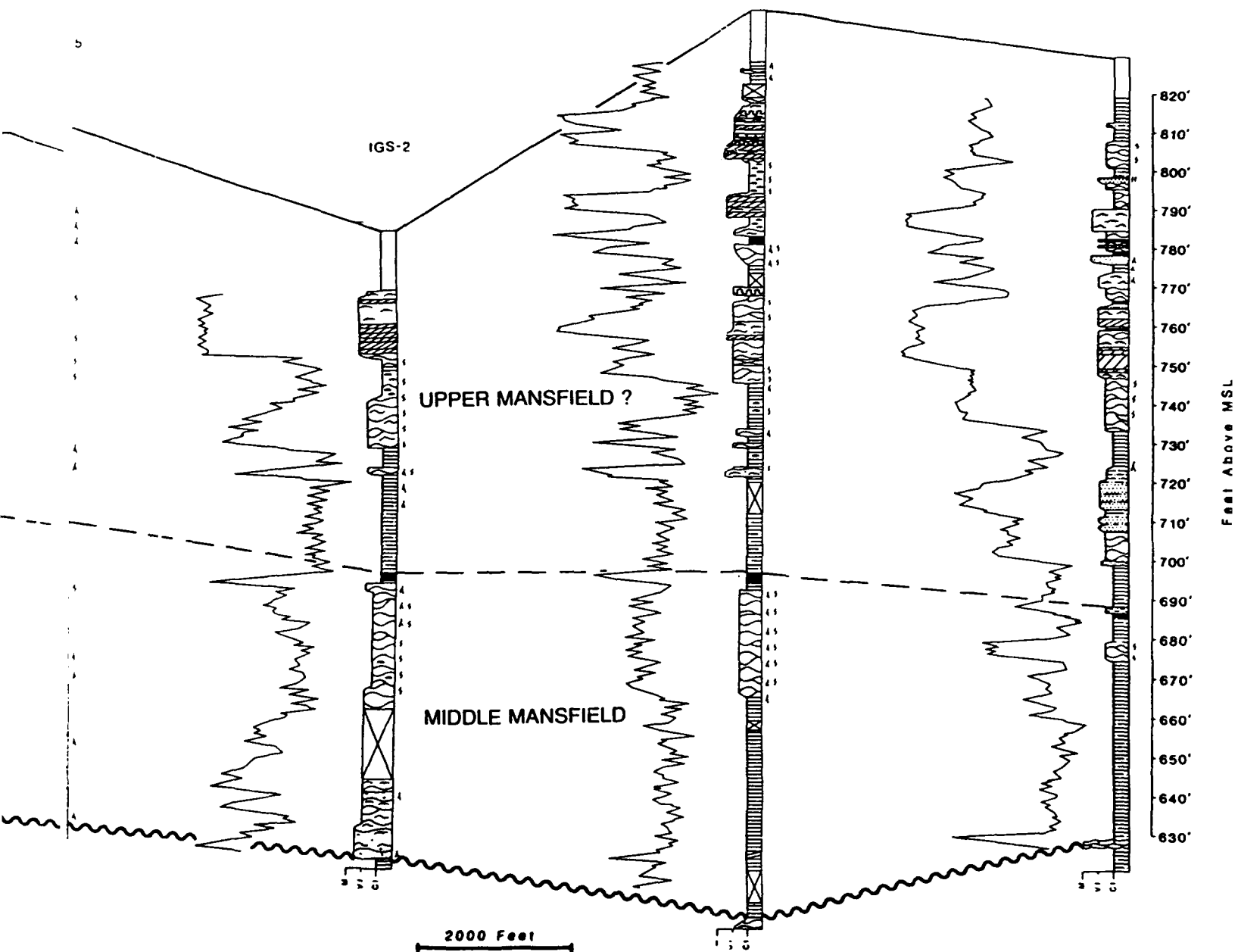


Figure 5. Cross sect

B

IGS-7

WES-10C-40



B-B' section B-B', connecting the Rockeye and ABG sites (DNR, 1992)

2

C

IGS-3

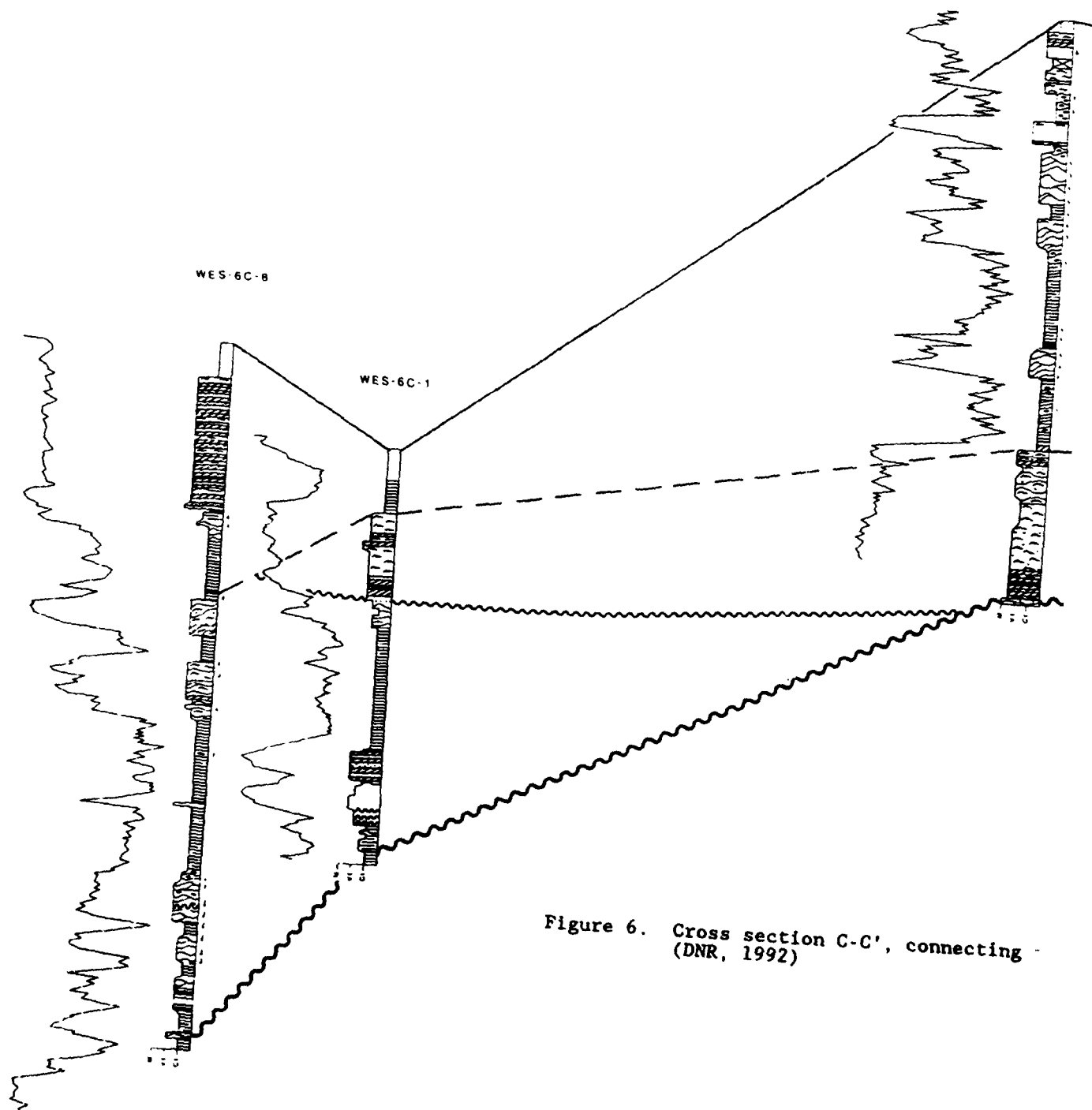


Figure 6. Cross section C-C', connecting -  
(DNR, 1992)

①

IGS-3

C'

WES-3C-29

WES-3C-31

UPPER MANSFIELD ?

MIDDLE MANSFIELD

Unconformity on Mississippian Surface

Feet Above MSL

790'  
780'  
770'  
760'  
750'  
740'  
730'  
720'  
710'  
700'  
690'  
680'  
670'

2000 Feet

ABC  
section C-C', connecting the ABC and the Demolition Area  
(1992)

2

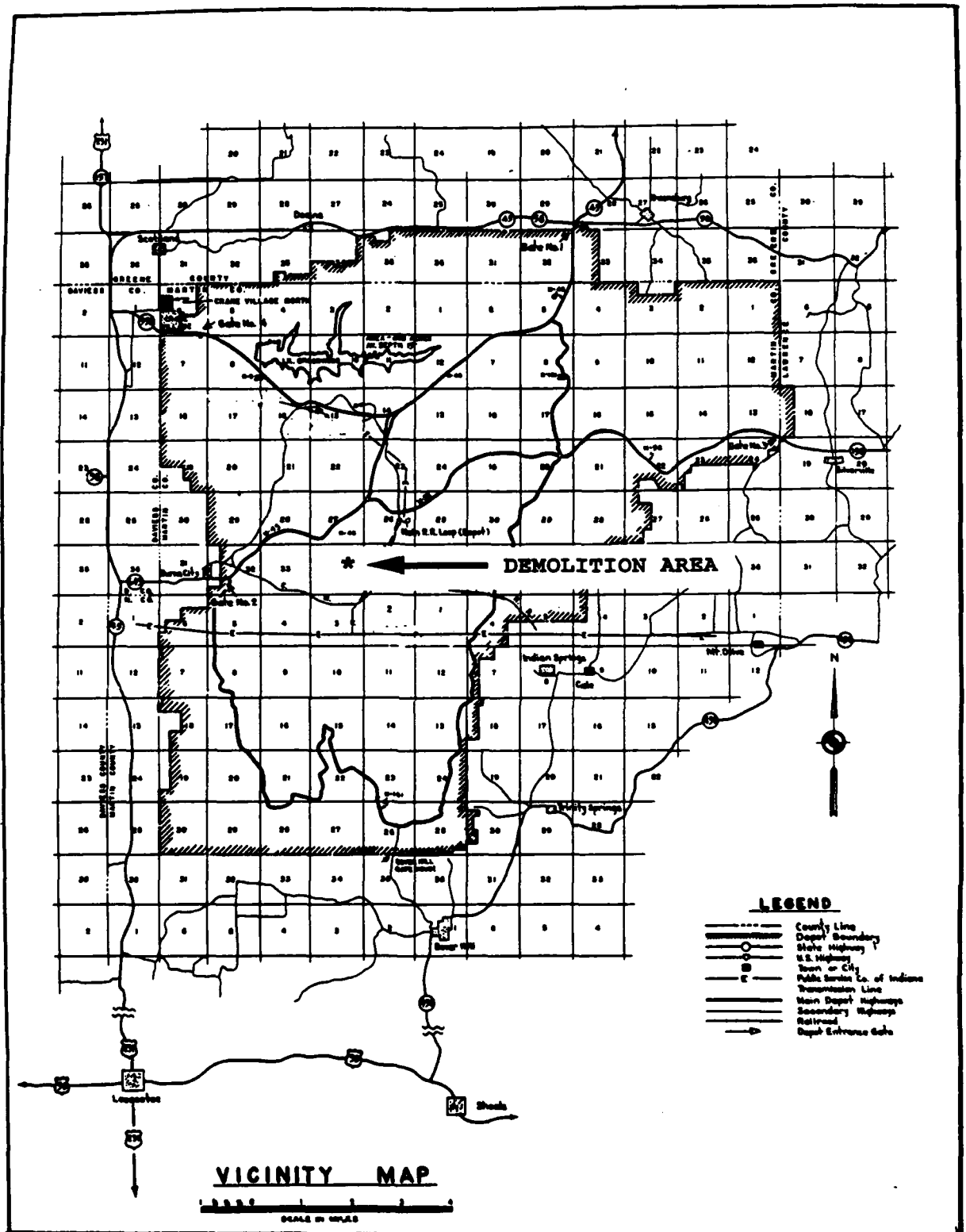


Figure 7. Vicinity map showing the location of the Demolition area at the NSWC

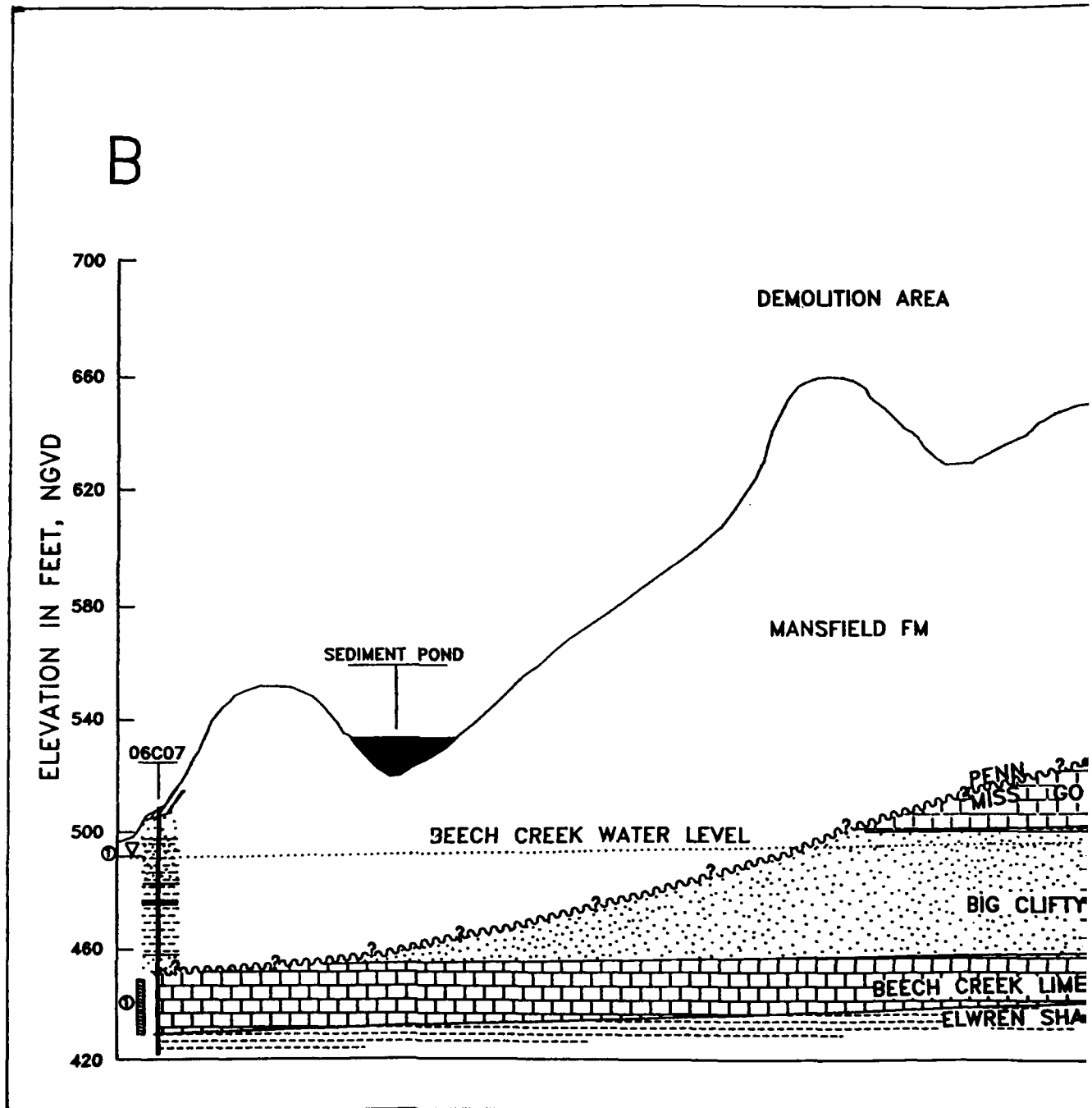
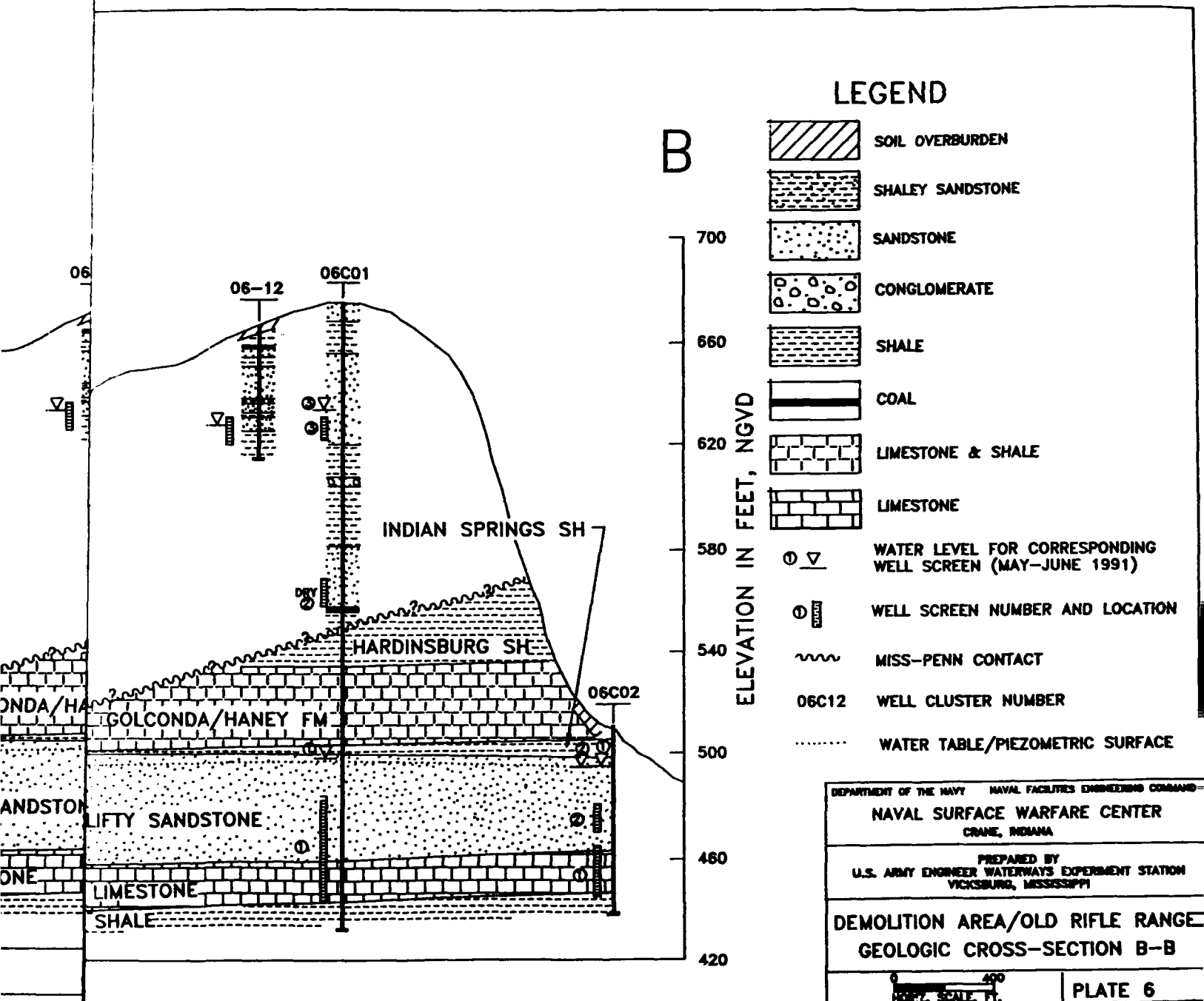


Figure 8. Cross section of the Demolition

①



Demolition Area (DNR, 1992)

2

rock ranges from zero to only a few feet. The actual explosive area encompasses approximately 17 acres, with a 500 ft radius cleared of grass and brush. The site is located on a ridge with the area where detonation occurs lying on the north and south slopes. Demolition can also be performed on the east slope of the ridge. The demolition occurs in pits that are aligned in rows on each slope of the ridge (Figure 9). The north slope has three rows of ten pits each and the south slope has one row of ten pits and two rows of five pits.

## Blast Source Characteristics

The demolition range disposes of many different types of material that are subject to change during the blasting season (the range disposes of material 8-9 months of the year, closing down during the winter). In addition to the material being disposed of, each pit has some type of initiator to insure a complete explosion. Complete information concerning the type of explosive material in each pit is recorded for each sequence of shots. For the period of this investigation, the primary material being disposed of consisted of fuzes, 106 mm shells, H-6 bombs, 20 mm shells, 8 inch and 5 inch projectiles, and 5 inch propellant charges. The primary initiators were TNT, C3, C4, and H-6. The total charge reported per pit is given as the net explosive weight (NEW), which includes the explosive material being disposed of and the initiator. Table 1 gives a listing of the type and amount of charge detonated each day.

| Table 1<br>Type and Amount of Material Detonated Each Day |                                |                               |
|-----------------------------------------------------------|--------------------------------|-------------------------------|
| Recording Date and Radial                                 | Material Detonated             | Net Explosive Weight, lbs/Pit |
| 28 August, N40°E                                          | 34 pits fuzes & TNT            | 370                           |
|                                                           | 8 pits 106 mm & C3             | 440                           |
|                                                           | 3 pits H-6 bombs & C4          | 445                           |
| 29 August, N40°E                                          | 29 pits fuzes & TNT            | 370                           |
|                                                           | 14 pits 106 mm & C3            | 440                           |
|                                                           | 1 pit 5 inch projectiles & TNT | 300                           |
|                                                           | 1 pit 20 mm & TNT              | 480                           |
| 31 August, N40°E                                          | 30 pits fuzes & TNT            | 370                           |
| 1 Sept, S40°W                                             | 31 pits fuzes & TNT            | 370                           |
|                                                           | 1 pit fuzes & H-6              | 422                           |
|                                                           | 13 pits 106 mm & C3            | 440                           |

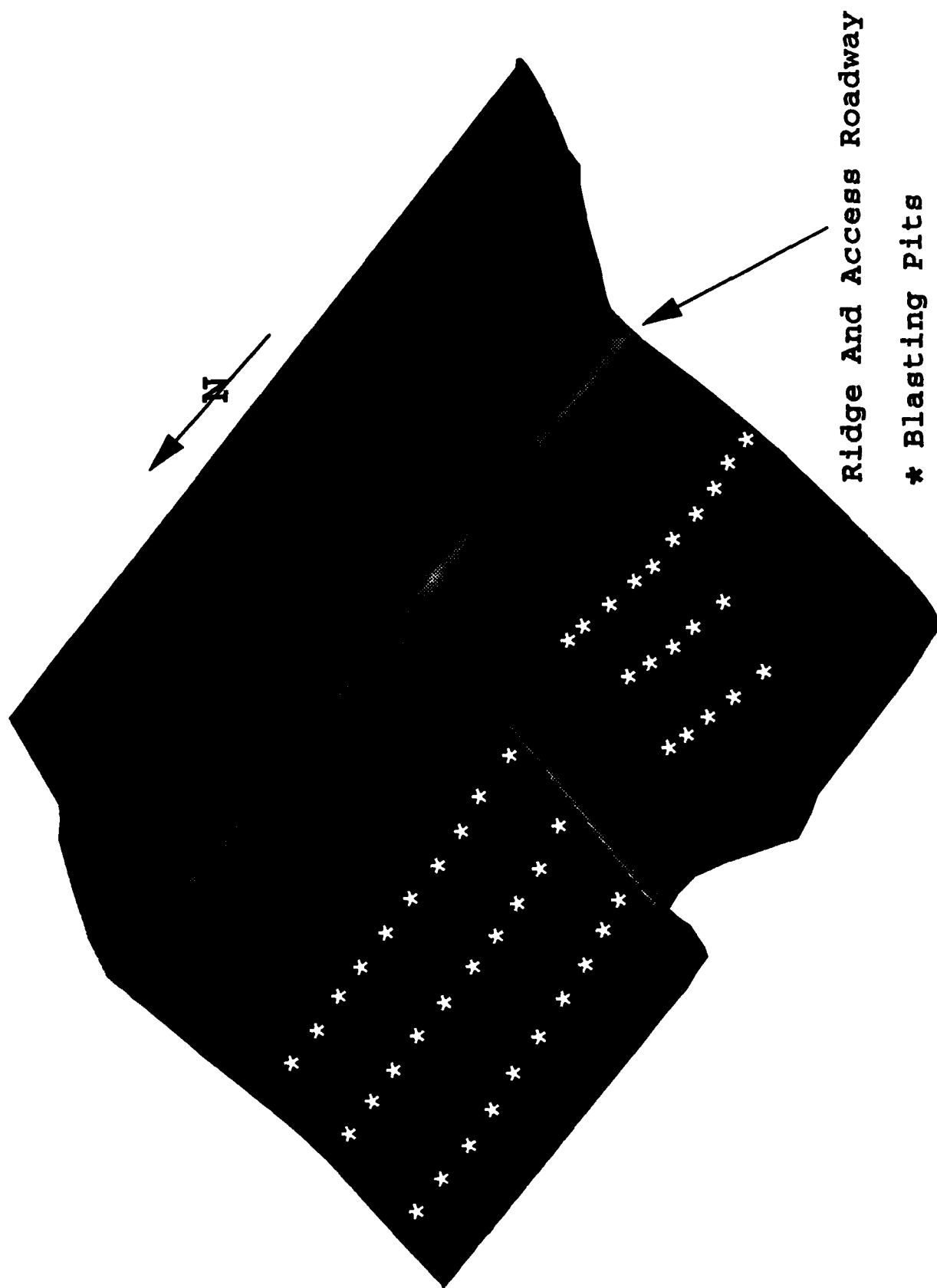


Figure 9. Idealized view of the Demolition area showing the locations of the blasting pits

| Table 1<br>Type and Amount of Material Detonated Each Day |                                 |                                 |
|-----------------------------------------------------------|---------------------------------|---------------------------------|
| Recording Date<br>and Radial                              | Material Detonated              | Net Explosive<br>Weight lbs/Pit |
| 3 Sept, S40°W                                             | 33 pits fuzes & TNT             | 370                             |
|                                                           | 1 pit fuzes & H-6               | 422                             |
|                                                           | 1 pit 8 inch propellants & C3   | 441                             |
|                                                           | 2 pits 5 inch propellants & TNT | 480                             |
|                                                           | 1 pit 8 inch projectiles & C3   | 445                             |
|                                                           | 7 pits 106 mm & C3              | 440                             |

The blasting operations consist of digging pits, unpacking the demolition material, repacking into appropriate containers, adding initiating explosives, setting up the firing system, detonating the material, inspecting the demo range, and repeating the sequence for the next set of shots. The pits are typically dug to a depth of 8-10 ft and backfilled 5-6 ft above the ground surface before detonation. Each pit is allowed a maximum quantity of explosives of 500 lbs, and the total explosive weight permitted on the demolition grounds is 35,000 lbs.

## 3 Test Methodology

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### General

Explosion generated waves can be divided into three main categories; compressive (P), shear (S), and surface as shown in Figure 10. These three main wave types can be divided into two varieties; body waves which propagate through the body of the rock and soil, and surface waves which are transmitted along a surface (usually the ground surface). Body waves are the sound-like P waves and the distortional S waves, while the most important surface waves are the Rayleigh (R) waves. Explosions produce predominantly body waves at small distances which propagate outward in a spherical manner until they intersect a boundary such as another rock layer, soil, or the ground surface. At this intersection, shear and surface waves are produced. At larger transmission distances, the R waves become important. All three wave types arrive together at small distances but begin to separate at larger distances as shown in Figure 10. The three wave types produce radically different patterns of motion in soil and rock particles as they pass. The P wave produces particle motions in the same direction as it is propagating, the S wave produces motions perpendicular to its direction of propagation, and the R wave produces motions both in the vertical direction and parallel to its direction of propagation. To define the motion, three mutually perpendicular components are measured (vertical, radial, and transverse). No one of these perpendicular components always dominates in blasting, and the peak component varies with each blasting sequence.

A typical velocity time history is shown in Figure 11. The most important parameters that describe the time history are peak amplitude, principal period (1/principal frequency), and duration of the vibration. All these parameters are dependent on the blast and the transmission medium.

Scaling of distance is necessary to predict peak particle velocities when both the charge weight (W), and the distance or range (R), vary. The two most popular approaches are square root,  $R/W^{1/4}$ , scaling and cube root,  $R/W^{1/3}$ , scaling. Square root scaling, plotting peak particle velocity or air overpressure as a function of the distance divided by the square root of the charge weight, is more traditional than cube root scaling. Typically, for close-in measurements (closer than 6 meters) cube root scaling is more conservative, and for far-out measurements (beyond 31 meters) square root

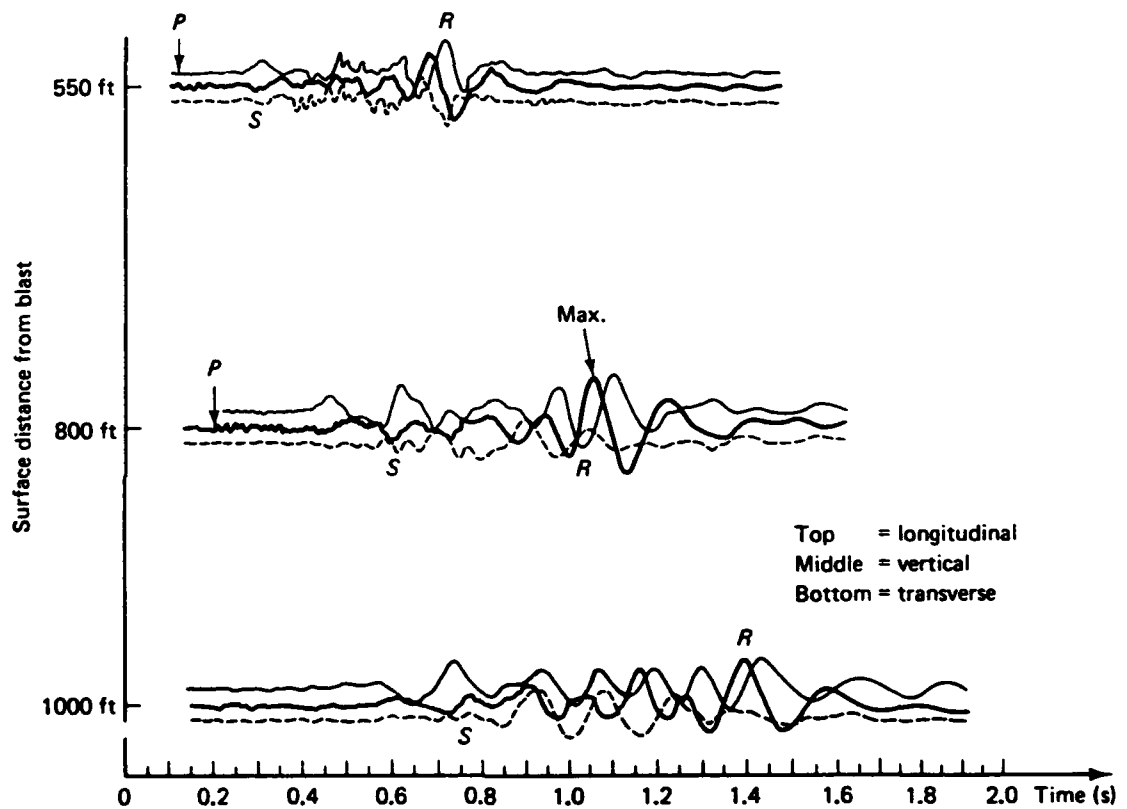


Figure 10. Generalized time histories showing compressive (P), shear (S), and surface (Rayleigh (R)) waves as a function of time (Dowding, 1985)

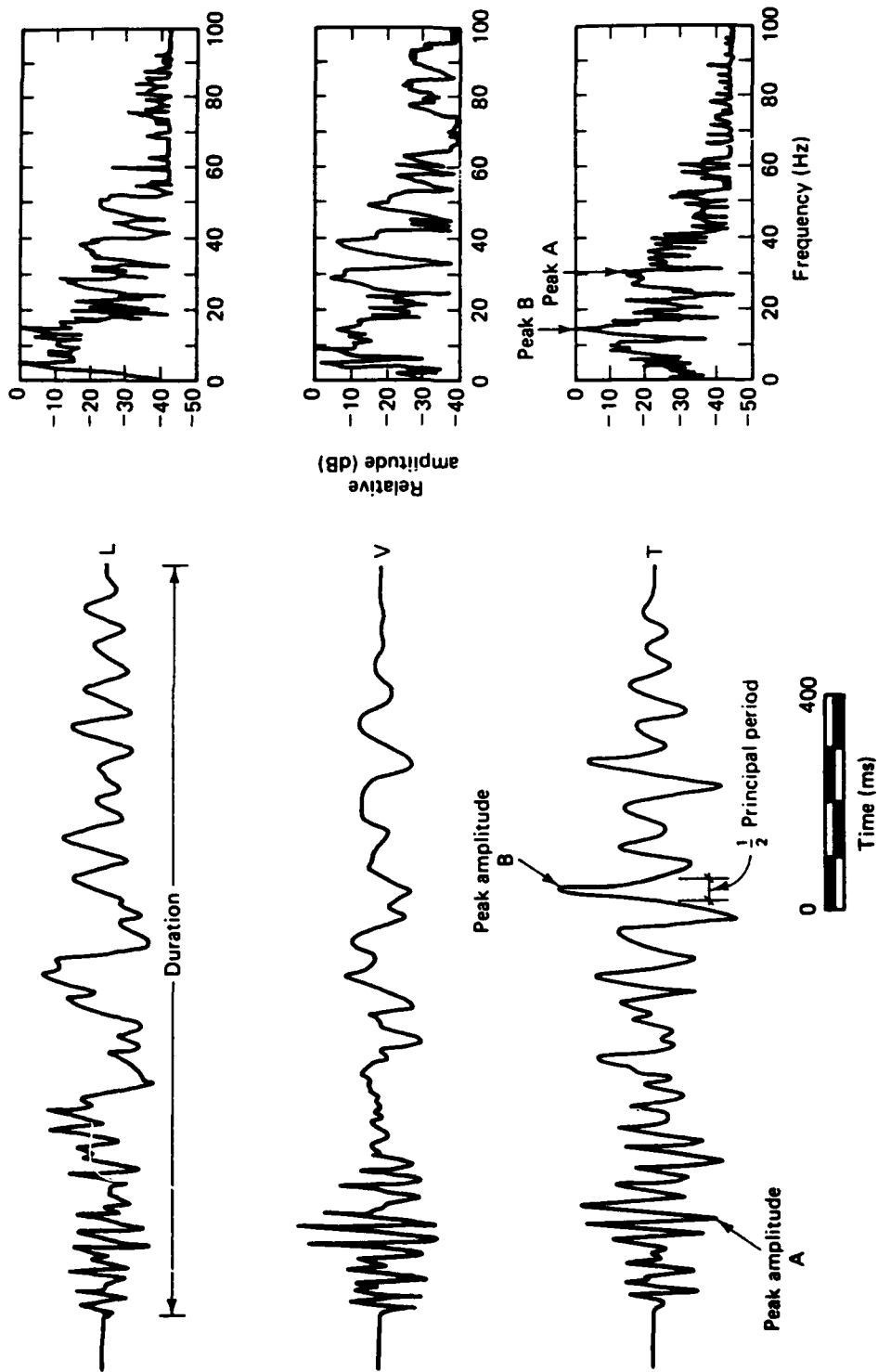


Figure 11. Typical time histories showing peak amplitude, principal period, and duration (Dowding, 1985)

scaling is more conservative. Also, scaling relationships are the most accurate when they are derived from similar W and R values and not similar ratios of  $R/W^*$ .

Air blasts are the air pressure waves generated by explosions. Just as with ground vibrations, these pressure waves can be described with time histories where the amplitude is air pressure instead of particle velocity. The higher-frequency portion of the pressure wave is audible and is the sound that accompanies a blast; the lower-frequency portion is not audible but excites structures and in turn causes a secondary and audible rattle within a structure. Air blasts are of interest for three reasons. First, by themselves or in combination with ground motions, they can produce structural motions that create cracks. Second they may crack windows, although the air blast would have to be unusually high (0.1 psi or 150 Db). The third reason being that most humans have adverse reactions to loud noises, and perceive that damage is resulting. Sound is reported in two different units of measurement, pressure (psi) or decibels (dB). When pressure units are reported they are often called overpressures to indicate that the measured pressure is that above atmosphere.

## Instrumentation

Each measurement station consisted of four data channels; three seismic monitoring channels and one air overpressure monitoring channel. The measurement stations were a triaxial array of calibrated L4-3D geophones (velocity transducers manufactured by Mark Products Inc., Houston, Tx) oriented to detect the vertical, radial, and transverse components of the ground motion (Figure 12) and a microbarograph (air pressure transducer) to detect air overpressure. The microbarographs are composed of pressure cell transducers (manufactured by Valydine) and WES built amplifiers. The geophones had a natural frequency of 1.0 Hz and sensitivities of 3.07-4.55 volts/in/sec (v/ips) depending on the particular geophone. The microbarographs had a frequency response from 0 to 1000 Hz and a sensitivity of 10.0 - 45.0 volts/lb/in<sup>2</sup> (v/psi). Instrument sensitivities and frequency responses are given in Table 2 for each station. All geophones and microbarographs were calibrated before being utilized in the field. The geophones were calibrated on a shaker table to determine the frequency response. The microbarographs were tested using a standard water column calibration scheme. The data acquisition instrumentation consisted of multi-channel FM tape recorders (TEAC R41 and R71), oscillograph, and WES developed amplifiers, all of which were battery operated. All data were recorded on tape and an immediate data playback was obtained from the oscillograph to insure data quality and enable determination of recorded signal levels.

## GEOPHONE ORIENTATION

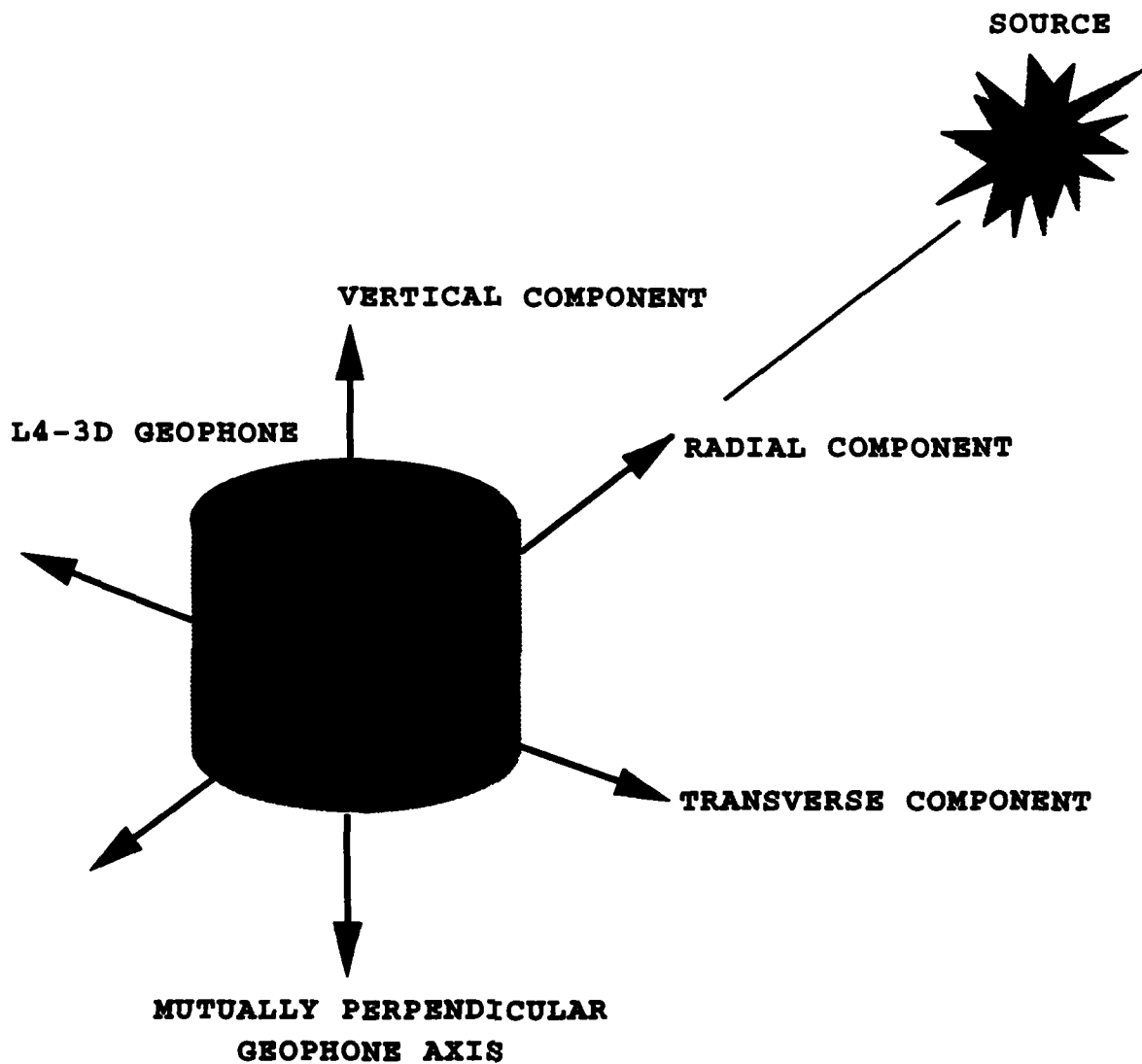


Figure 12. Diagram of geophone showing vertical, radial, and transverse recording directions

| Table 2<br>Transducer and Microbarograph Characteristics |            |              |                        |
|----------------------------------------------------------|------------|--------------|------------------------|
| Sensor                                                   |            | Sensitivity  | Frequency Response, Hz |
| Geophone #507                                            | Vertical   | 3.510 v/ips  | 1.0 natural            |
|                                                          | Radial     | 3.822 v/ips  | 1.0 natural            |
|                                                          | Transverse | 3.851 v/ips  | 1.0 natural            |
| Geophone #508                                            | Vertical   | 3.455 v/ips  | 1.0 natural            |
|                                                          | Radial     | 3.826 v/ips  | 1.0 natural            |
|                                                          | Transverse | 3.937 v/ips  | 1.0 natural            |
| Geophone #511                                            | Vertical   | 4.552 v/ips  | 1.0 natural            |
|                                                          | Radial     | 4.243 v/ips  | 1.0 natural            |
|                                                          | Transverse | 4.128 v/ips  | 1.0 natural            |
| Geophone #517                                            | Vertical   | 3.046 v/ips  | 1.0 natural            |
|                                                          | Radial     | 4.070 v/ips  | 1.0 natural            |
|                                                          | Transverse | 4.220 v/ips  | 1.0 natural            |
| Geophone #518                                            | Vertical   | 2.799 v/ips  | 1.0 natural            |
|                                                          | Radial     | 2.708 v/ips  | 1.0 natural            |
|                                                          | Transverse | 2.716 v/ips  | 1.0 natural            |
| Microbarograph #48321                                    |            | 39.612 v/psi | 0 - 1000               |
| Microbarograph #48322                                    |            | 40.328 v/psi | 0 - 1000               |
| Microbarograph #72383                                    |            | 9.861 v/psi  | 0 - 1000               |
| Microbarograph #72384                                    |            | 46.115 v/psi | 0 - 1000               |
| Microbarograph #72388                                    |            | 39.721 v/psi | 0 - 1000               |

## Test Layout and Procedure

The actual test program consisted of recording data on consecutive days under varying blasting and weather conditions, and along two separate radials (Figure 13). The recording days were from 26 August through 3 September 1992. The data recorded on 26 August served to calibrate the instrumentation for the conditions at the site and is therefore not presented in the results. No data was recorded on 27 August or 2 September due to poor weather conditions (rain), postponing any blasting activity. Also, no data are presented for 30 August due to damaged equipment and equipment failure. The two radials selected were based on conversations with CAAA personnel,

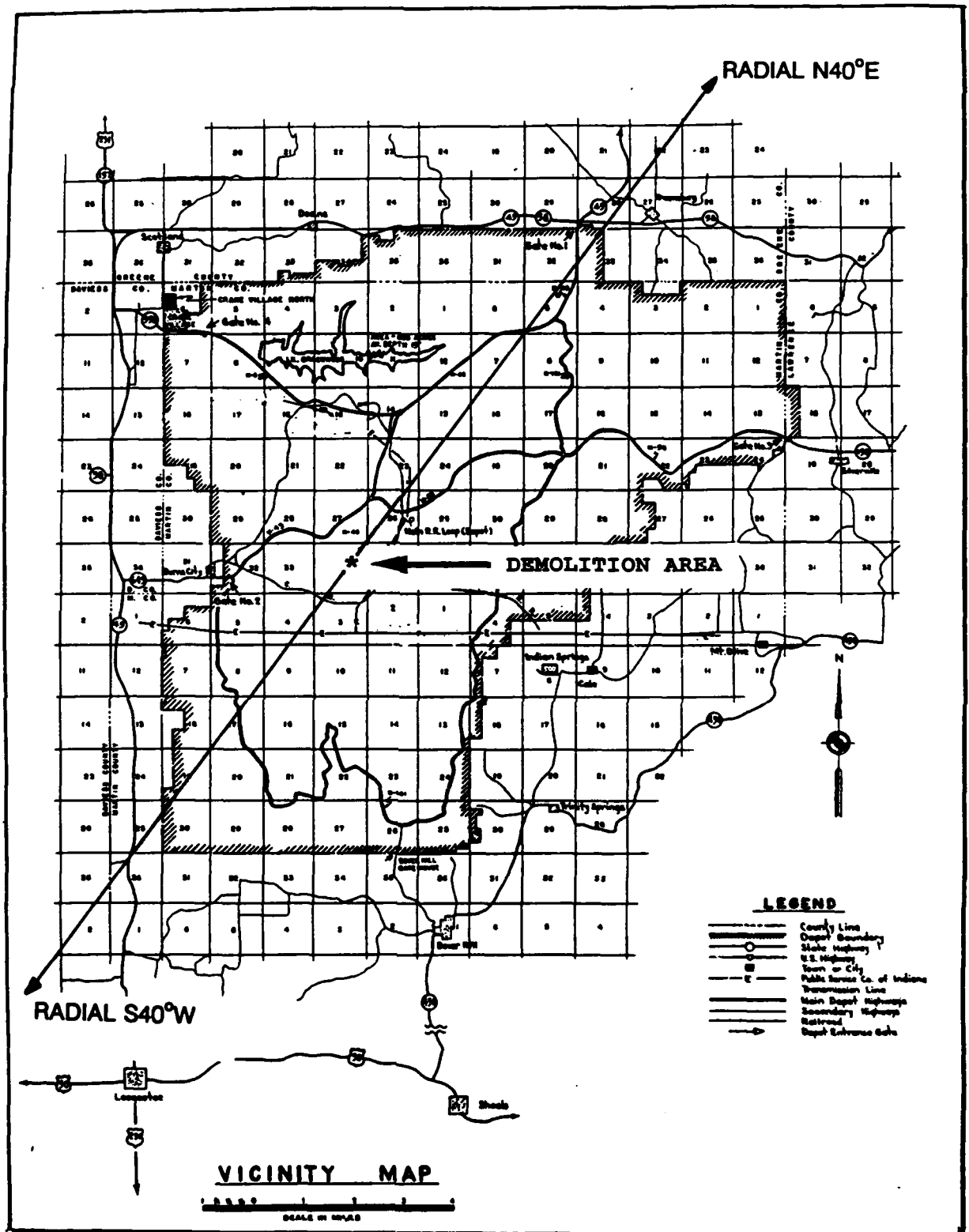


Figure 13. Vicinity map showing the two radial directions in which data were recorded

and have bearings N40°E and S40°W. Each day's recording consisted of either four or five stations placed at varying distances from the blast source. Table 3 contains information about the number of recording stations, locations for each days testing, and the pertinent weather information. The locations listed in Table 3 are nominal distances from the blasting area to the recording stations, the exact distances from each blasting pit to each recording station are presented in Appendix A.

| <b>Table 3</b><br><b>Nominal Locations of Recording Stations and</b><br><b>Weather Information for Each Day</b> |                               |                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------|-------------------------------|-------------------------------------------------------------------------------------------------|
| Recording Date and Radial                                                                                       | Nominal Station Locations, ft | Weather Information                                                                             |
| 28 August, N40°E                                                                                                | 500                           | Temp 69°<br>Humidity 63%<br>Wind N 9 mph<br>Barometer 29.98<br>Partly Cloudy<br>Ceiling 2500 ft |
|                                                                                                                 | 5800                          |                                                                                                 |
|                                                                                                                 | 10,000                        |                                                                                                 |
| 29 August, N40°E                                                                                                | 500                           | Temp 73°<br>Humidity 57%<br>Wind S 9 mph<br>Barometer 30.11<br>Clear<br>Ceiling Unlimited       |
|                                                                                                                 | 1000                          |                                                                                                 |
|                                                                                                                 | 5800                          |                                                                                                 |
| 31 August, N40°E                                                                                                | 500                           | Temp 71°<br>Humidity 57%<br>Wind W 5 mph<br>Barometer 30.20<br>Partly Cloudy<br>Ceiling 3000 ft |
|                                                                                                                 | 750                           |                                                                                                 |
|                                                                                                                 | 1000                          |                                                                                                 |
|                                                                                                                 | 1450                          |                                                                                                 |
|                                                                                                                 | 5800                          |                                                                                                 |
| 1 Sept, S40°W                                                                                                   | 500                           | Temp 73°<br>Humidity 62%<br>Wind SE 7 mph<br>Barometer 30.20<br>Hazy<br>Ceiling 5000 ft         |
|                                                                                                                 | 2900                          |                                                                                                 |
|                                                                                                                 | 5800                          |                                                                                                 |
|                                                                                                                 | 10,800                        |                                                                                                 |
|                                                                                                                 | 22,000                        |                                                                                                 |
| 3 Sept, S40°W                                                                                                   | 250                           | Temp 77°<br>Humidity 74%<br>Wind W 6 mph<br>Barometer 30.08<br>Partly Cloudy<br>Ceiling 1500 ft |
|                                                                                                                 | 500                           |                                                                                                 |
|                                                                                                                 | 750                           |                                                                                                 |
|                                                                                                                 | 2900                          |                                                                                                 |

To record the data, each day the instrumentation was first checked to verify that it was functioning properly, then each station was set up at the selected location to record the vertical, radial, and transverse ground motions in addition to the air overpressure. The geophones were buried flush with the ground surface to reduce the amount of extraneous noise. The microbarographs were placed on a flat stable surface approximately 1 ft above the ground surface. The instrumentation was zeroed, calibrated, and readied for the blasting sequence. One person was left at each station to initiate the recording, and monitor any unusual occurrences that might occur. The recorders lying outside a 3000 ft radius (safe distance secured before each shot) were typically started 2-3 minutes before the blasting began, and would record approximately 20 minutes worth of data. The recorders lying inside a 3000 ft radius were typically started 12-15 minutes before blasting began. After the shots were completed, all instrumentation was picked up and returned to a central point for data verification, and to ready for the next days activity. A log was made of each days shots which records the type and amount of material in each pit, start and completion time of blasting, and pertinent weather information. The weather information includes temperature, ceiling, wind speed and direction, humidity, and barometric pressure.

## 4 Results and Analysis

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### Data Processing and Presentation

The calibrated field data were recorded analog and unfiltered. A gain was employed on the far stations (5000 ft and greater) to enhance the signal detection. The data were then digitized (512 samples/second), stored in files on a computer, and processed using a program that allows data inspection and calculation. The calculations determine maximum peak particle velocities (PPV) and peak air overpressures (PAO) for each seismic and acoustic data set. The data were then displayed in the form of amplitude versus time plots (time histories). Due to the large amounts of data obtained (3,084 time histories), it is not possible to show a time history plot for every piece of data collected. Rather, a representative sample of the data has been selected and the time histories are presented. Appendix B contains the representative time histories for data collected at the NSWC.

### Development of Attenuation Relationships

The maximum unfiltered peak particle velocity detected by each geophone at each station from each test is shown in Appendix A. These velocities were plotted versus scaled range, both square and cubic. This type of plot is the conventional way of representing the attenuation of ground motions from surface or sub-surface charges. These sets of data were then statistically analyzed using simple regression to determine the best fit ground motion attenuation curves. These curves represent the average expected value predictions, but do not account for data scatter. The assumed mathematical model is:

$$PPV = C_1(R/W^{C_2})^{C_3} \quad \text{EQN 1}$$

PPV - peak particle velocity, ips

C2 - scaling constant equal to 1/2 or 1/3

R - distance from source in feet

W - charge size in pounds

C1 & C3 - constants determined from regression analysis

The results of the regression analysis along with the plotted data are presented in Appendix C. The plots consist of square and cubic scaling of:

- vertical motions for each day
- radial motions for each day
- transverse motions for each day
- air overpressures for each day
- vertical motions for radial N40°E, days 28, 29, 31 August combined
- radial motions for radial N40°E, days 28, 29, 31 August combined
- transverse motions for radial N40°E, days 28, 29, 31 August combined
- vertical motions for radial S40°W, days 1, 3 September combined
- radial motions for radial S40°W, days 1, 3 September combined
- transverse motions for radial S40°W, days 1, 3 September combined.

The results of the air overpressure measurements detected by each microbarograph at each station for each test are shown in Appendix A, with representative time histories shown in Appendix B. These set of data were also statistically analyzed using simple regression to determine the best fit curves, which represent the average expected values but do not account for data scatter. The plots are shown in Appendix C, with air overpressures versus cubic scaling, (air overpressure plots are generally not shown as a function of square scaling). The assumed mathematical model is:

$$PAO = C1(R/W^2)^{C2} \quad \text{EQN 2}$$

PAO - peak air overpressure, psi

C2 - scaling constant equal to 1/3

R - distance from source in feet

W - charge size in pounds

C1 & C3 - constants determined from regression analysis

## Analysis of Data Variance

Collection of scaled distance for determination of attenuation relationships for particle velocity will result in a good deal of scatter about the mean line (median line for log-log relationships). Because of this scatter, most regulations require that blasts be designed on the basis of maximum probable velocities rather than average values. Many factors are responsible for the variation of particle velocities at a given scaled distance. They include changes of geological conditions, differences between types of explosives, different wave types, differences in the geometry of the explosions, as well as errors in blast timing and measurement. The same factors, with the exception of geology, are responsible for the variation of air overpressure. Since overpressures are transmitted through air, weather conditions replace geology as a principal variable. Therefore, for the final analysis the data were also fitted with an equation representing the bound below which fall 95% of the data.

The data plots and corresponding average (50%) predictive equations as presented in Appendix C, have been evaluated and grouped into a final set of

plots and equations to help characterize the entire site. The average or 50% lines were determined from regression analysis (Power method) of the log normally distributed data. Also shown on these plots are the 95% non-exceedance equations. These equations were determined by converting the data into logarithmic (base 10) values and running regression analysis (linear) of the transformed data. From the regression analysis, the standard error of the y estimate is obtained which can be used to determine the values on the 95% non-exceedance line. These values are determined by the following formula:  $y_{95\%} = y_{50\%} * 1.645 * 10^{\text{standard error of the y estimate}}$ . The 95% non-exceedance line is presented so that predictions of ground motions or air overpressures can be made with a 95% confidence that the values will not be exceeded. This also implies however, that 5% of the time the predicted values will be exceeded.

## Monitoring Results

The predominant motions at the site were recorded by the vertical and radial components of the geophones. Therefore, the data recorded by the transverse component is not considered in this analysis. Also, the air overpressures recorded were small and will be discussed separately. The final analysis plots are presented in Figures 14-20.

### Vertical Motions

Figures 14 and 15 are the vertical motions from all the data recorded at the NSWC regardless of line direction (N40°E or S40°W) or the day (28, 29, 31 August, 1, 3 September). Figure 14 is the square scaled range, and Figure 15 is the cubic scaled range data. In general, the data are well behaved except for that located at an approximate scaled range of 1000 ft in Figure 14 and 3000 ft in Figure 15. The PPV's recorded at this location appear to be slightly less than would be predicted by the best fit line (all the points fall below the line). This could be a result of the station recording different wave forms (traveling at a slower velocity) than the wave forms being recorded by the closer stations. It could also be an indication that the particular area where the station was located has a larger attenuation thereby reducing the amount of energy reaching the geophone. Lastly, the slower PPV's could be due to the frequency content of the motions, since the frequency tends to lower as the distance from source increases.

### Radial Motions

Figures 16 and 17 (square and cubic scaling respectively) are the radial motions from all the data recorded at the NSWC regardless of line direction or the day recorded. Here again, the data located at 1000 ft in Figure 16 and 3000 ft in Figure 17 appears to be lower than expected. The reasons for this would be the same as discussed in the above paragraph.

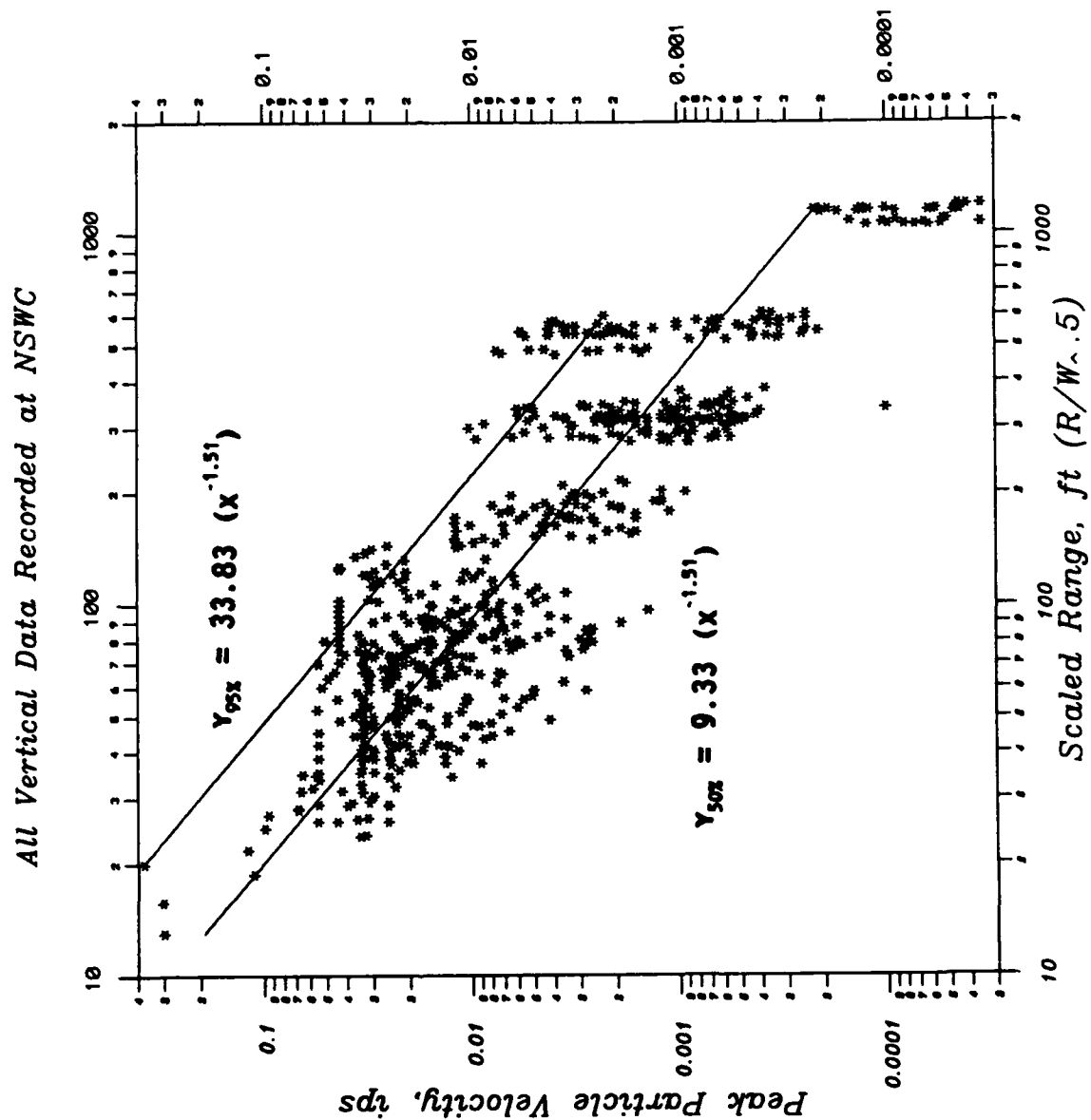


Figure 14. All data recorded in the vertical direction from source at the NSWC, versus square root scaling

*All Vertical Data Recorded at NSWC*

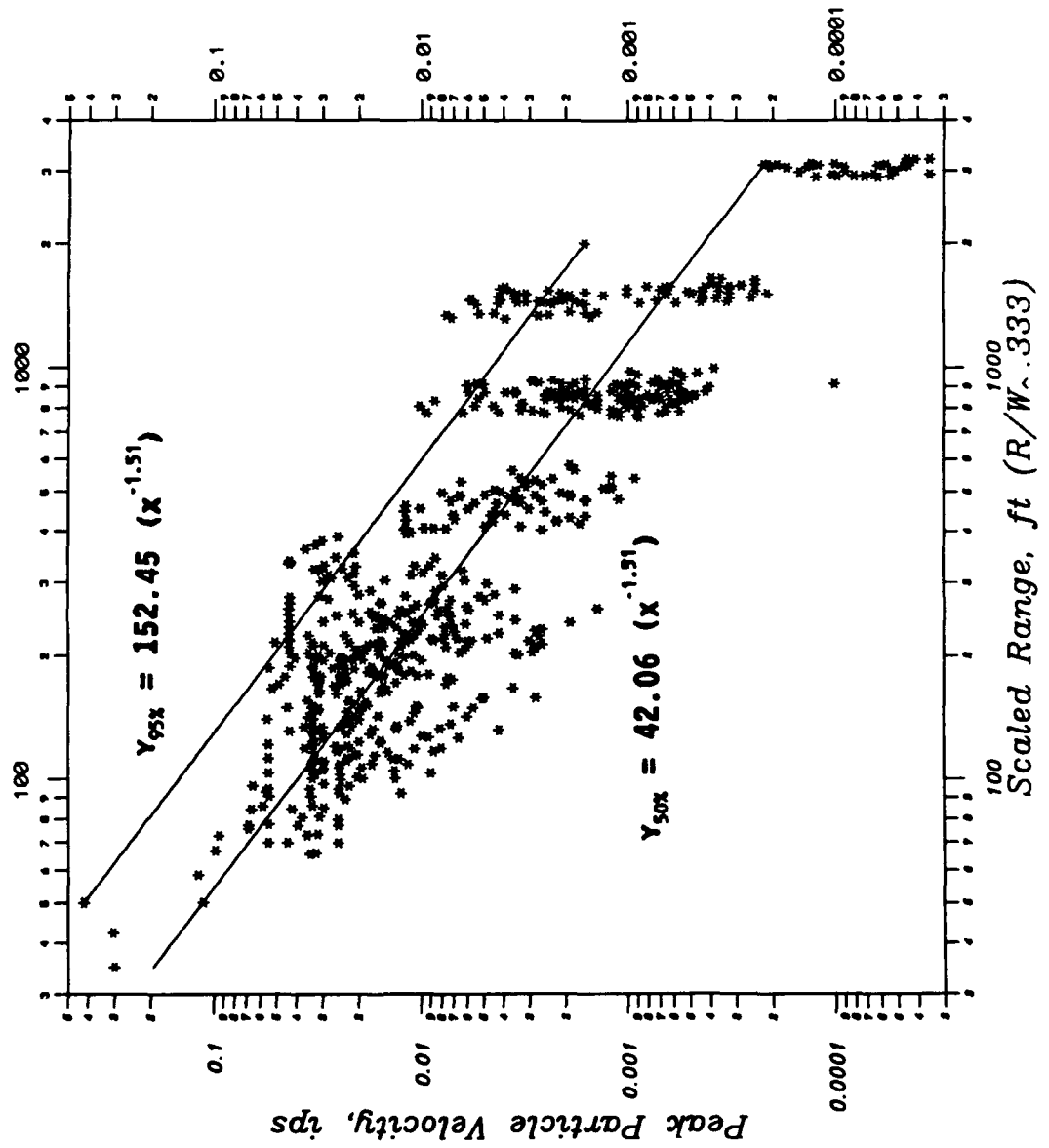


Figure 15. All data recorded in the vertical direction from source at the NSWC, versus cube root scaling

*All Radial Data Recorded at NSWC*

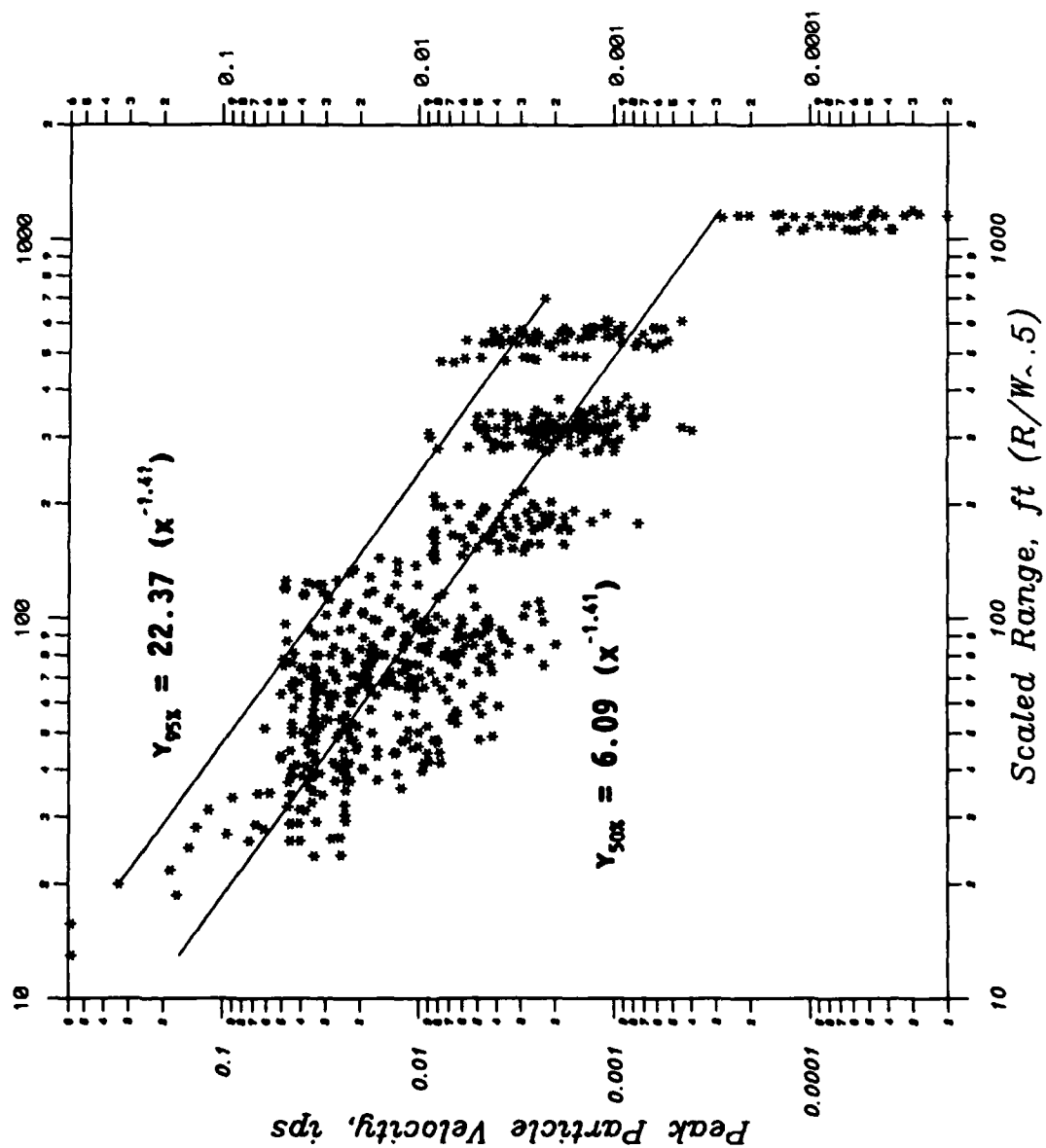


Figure 16. All data recorded in the radial direction from source at the NSWC, versus square root scaling

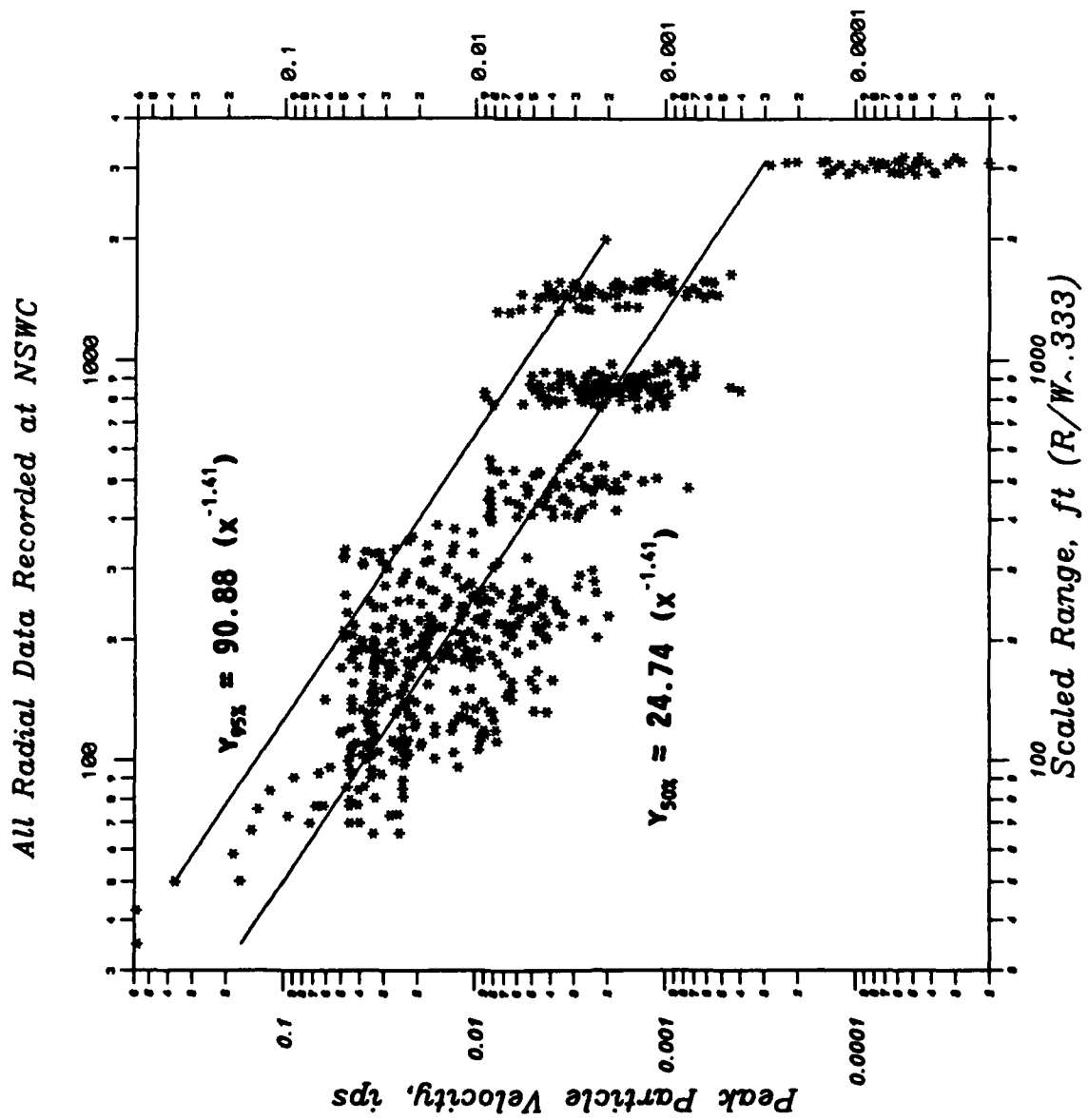


Figure 17. All data recorded in the radial direction from source at the NSWC, versus cube root scaling

### **Air Overpressures**

Figure 18 shows the air overpressures recorded at the NSWC regardless of line direction or day recorded. On this plot, two sets of data located at an approximate scaled range of 1500 ft appear to be inconsistent with the other data. Since the air overpressure data is influenced by weather rather than geology, this must be having an influence on the results at this station. The data having the high values (0.001 to 0.01 ips) were recorded when the ceiling was 2500 ft and the skies were partly cloudy. The data having the low values (0.00001 to 0.0001) were recorded when the ceiling was 5000 ft and the skies were clear. The low ceiling and cloudy conditions could account for the increased PAO's recorded for that particular day.

### **Maximum Motions**

Since both the vertical and radial motions are predominating at the site, Figures 19 and 20 were prepared by plotting the maximum of the two (for every shot, every day) versus scaled range. Figure 19 shows the square scaled range, and Figure 20 the cubic scaled range. The regression analysis from this plot produces a predictive equation based on the maximum peak particle velocities recorded at the site. As shown in Figures 14 through 17, the values at the largest scaled range appear to be inconsistent with the other data, this has been explained previously.

### **Extrapolation of Motions Off-Site**

Since no data were actually recorded off-site, it is necessary to perform an extrapolation of the recorded data to make an estimate of PPV and PAO levels at locations off-site. The predominant factors that would effect utilizing the equations obtained from the regression analysis for off-site predictions would be the geology, and the weather. From the discussion of the regional geology, there does not appear to be any dramatic changes in the material in which the ground motions will be travelling across the site. Also, there is no indication that the motions are being amplified, rather the contrary, as they travel across the site. The weather conditions at the time of blasting can have a profound effect on the resulting air overpressures. The amount of cloud cover, location of the ceiling, wind velocity, and wind direction all have a large effect on recorded motions. However, since data were recorded under a variety of weather conditions this factor should be accounted for in the predictive equations determined. Therefore, the following equations are presented to predict motions off-site.

*All Air Overpressure Data Recorded at NSWC*

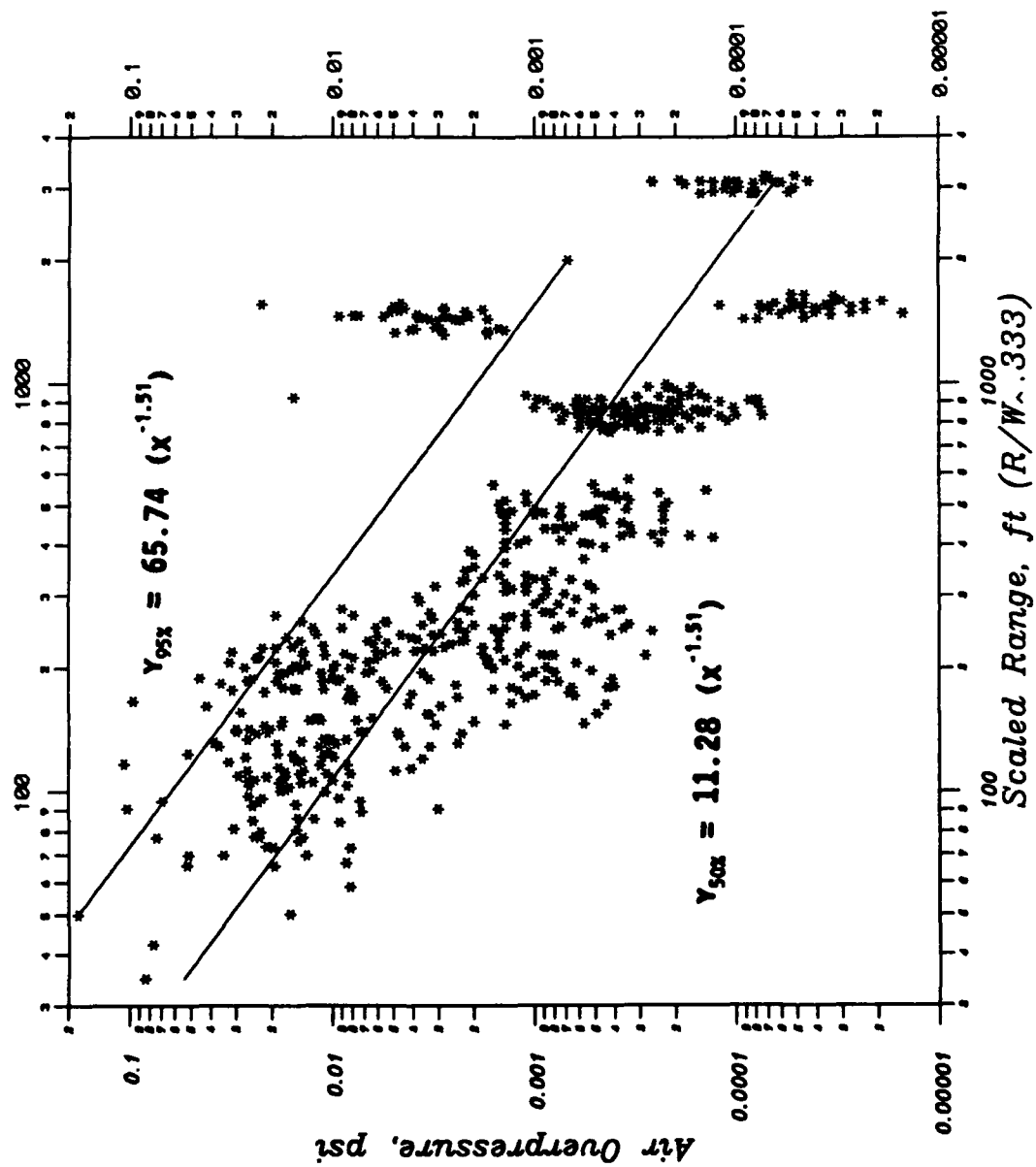


Figure 18. All air overpressure data recorded at the NSWC, versus cube root scaling

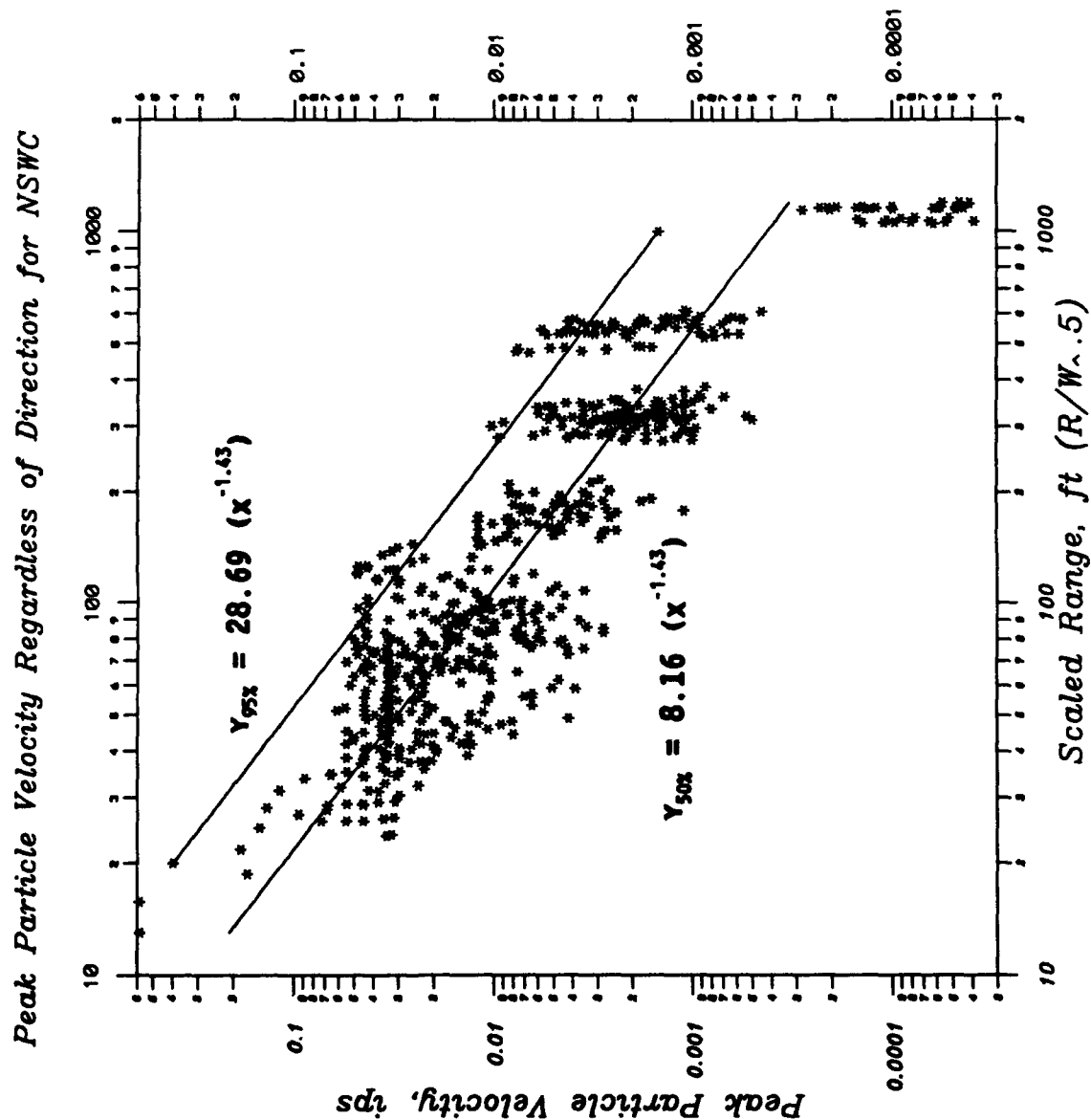


Figure 19. Maximum velocities recorded, regardless of orientation, versus square root scaling

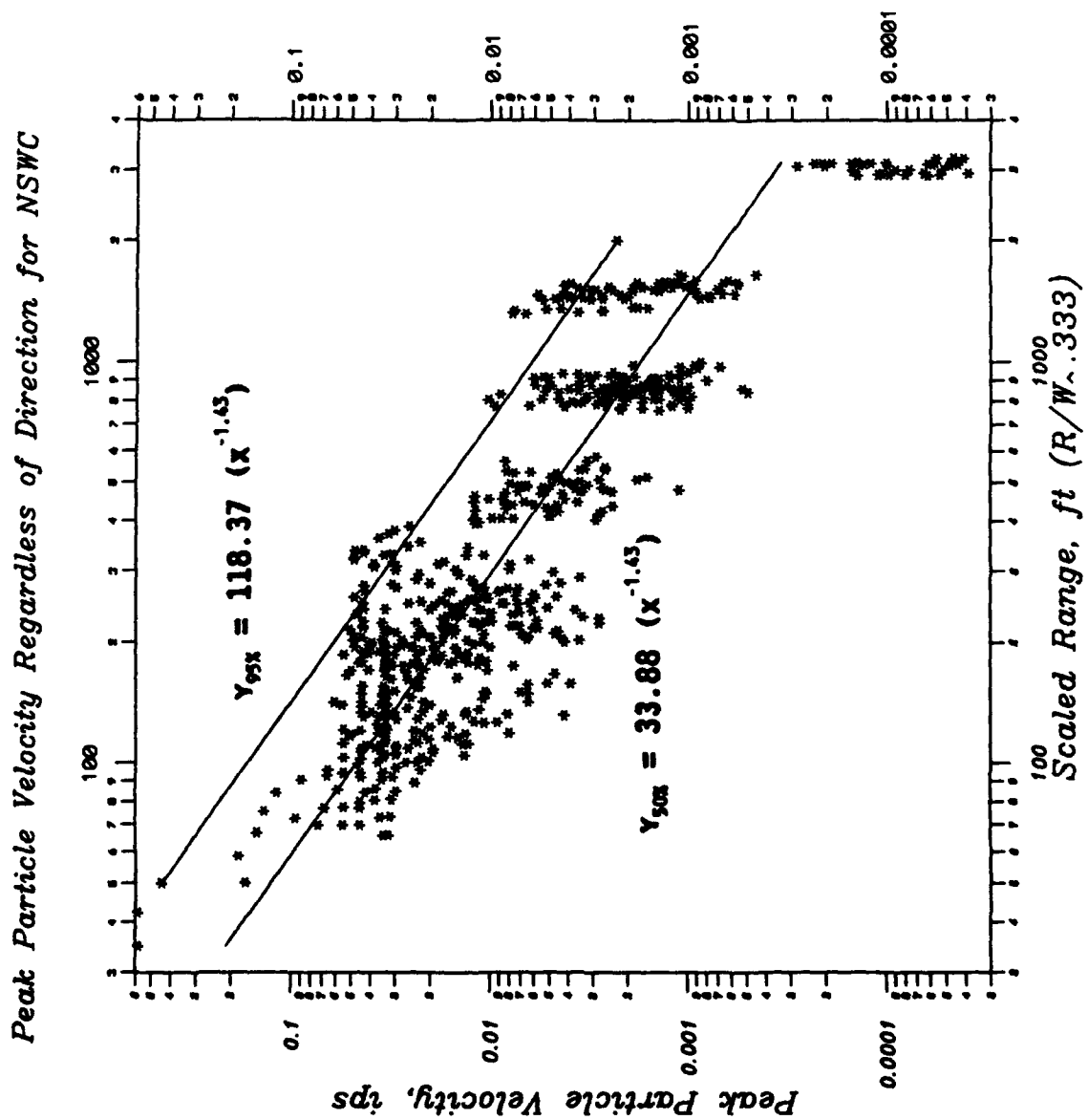


Figure 20. Maximum velocities recorded, regardless of orientation, versus cube root scaling

Ground motion predictions:

Average

$$y_{50\%} = 33.88 (x^{-1.43}) \text{ less conservative} \quad \text{EQN 3}$$

$$y_{50\%} = 8.16 (x^{-1.43}) \text{ most conservative} \quad \text{EQN 4}$$

y - peak particle velocity, ips

x - scaled range, ft

distance from shot divided by square root of shot weight for 4

distance from shot divided by cubic root of shot weight for 3

95% Non-exceedance

$$y_{95\%} = 118.37 (x^{-1.43}) \text{ less conservative} \quad \text{EQN 5}$$

$$y_{95\%} = 28.69 (x^{-1.43}) \text{ most conservative} \quad \text{EQN 6}$$

y - peak particle velocity, ips

x - scaled range, ft

distance from shot divided by square root of shot weight for 6

distance from shot divided by cubic root of shot weight for 5

Air overpressure predictions:

Average

$$y_{50\%} = 11.28 (x^{-1.51}) \quad \text{EQN 7}$$

y - peak air overpressure, psi

x - scaled range, ft

distance from shot divided by cubic root of shot weight

95% Non-exceedance

$$y_{95\%} = 65.74 (x^{-1.51}) \quad \text{EQN 8}$$

y - peak particle velocity, ips

x - scaled range, ft

distance from shot divided by cubic root of shot weight

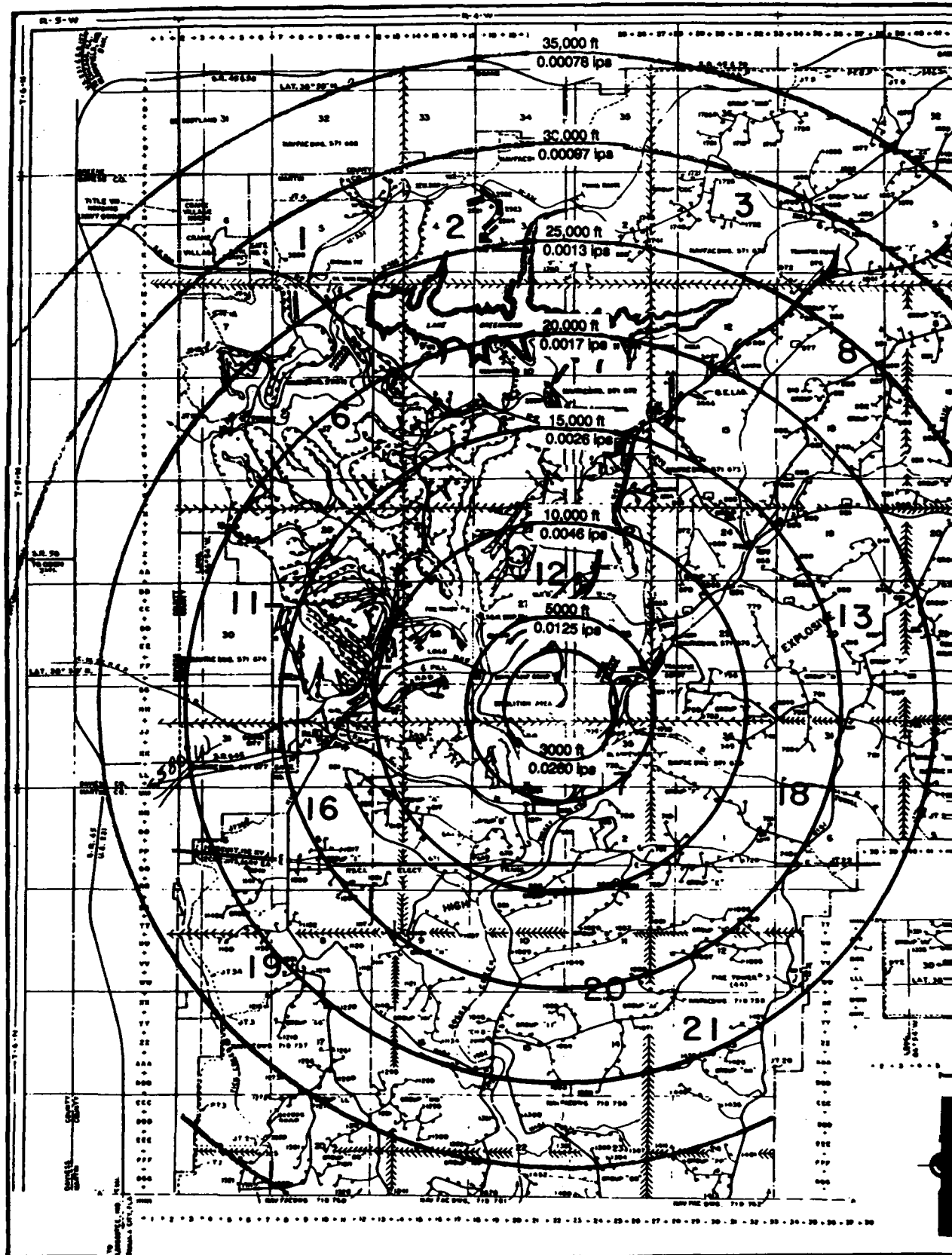
For the ground motion equations, the reference to being more or less conservative refers to how large a motion the equation predicts (larger motions in this case are more conservative). Equations based on a square scaled range will predict larger ground motions than equations based on a cubic scaled range. In all cases, equations 6 and 8 should be used to predict ground motions and air overpressures respectively. These equations will give the most conservative predictions, and have 95% confidence that the predictions will not exceed the limiting criteria. Equation 6 for ground motion

predictions is also shown in Figure 21. This Figure is an isodiametric plot with concentric circles representing distances from the explosive source and 95% non exceedance predicted PPV's. The PPV's were determined from equation 6 by holding the shot weight constant in all cases. This value was set at 500 lbs since this is the maximum charge weight permitted per blasting pit, and would therefore constitute a worse case condition. However, the values for PPV's reported on this Figure will change if a different shot weight is selected for the corresponding distances. Equation 6 should be consulted for the proper PPV associated with any given distance and shot weight.

## **Blast Safety Criteria and Analysis**

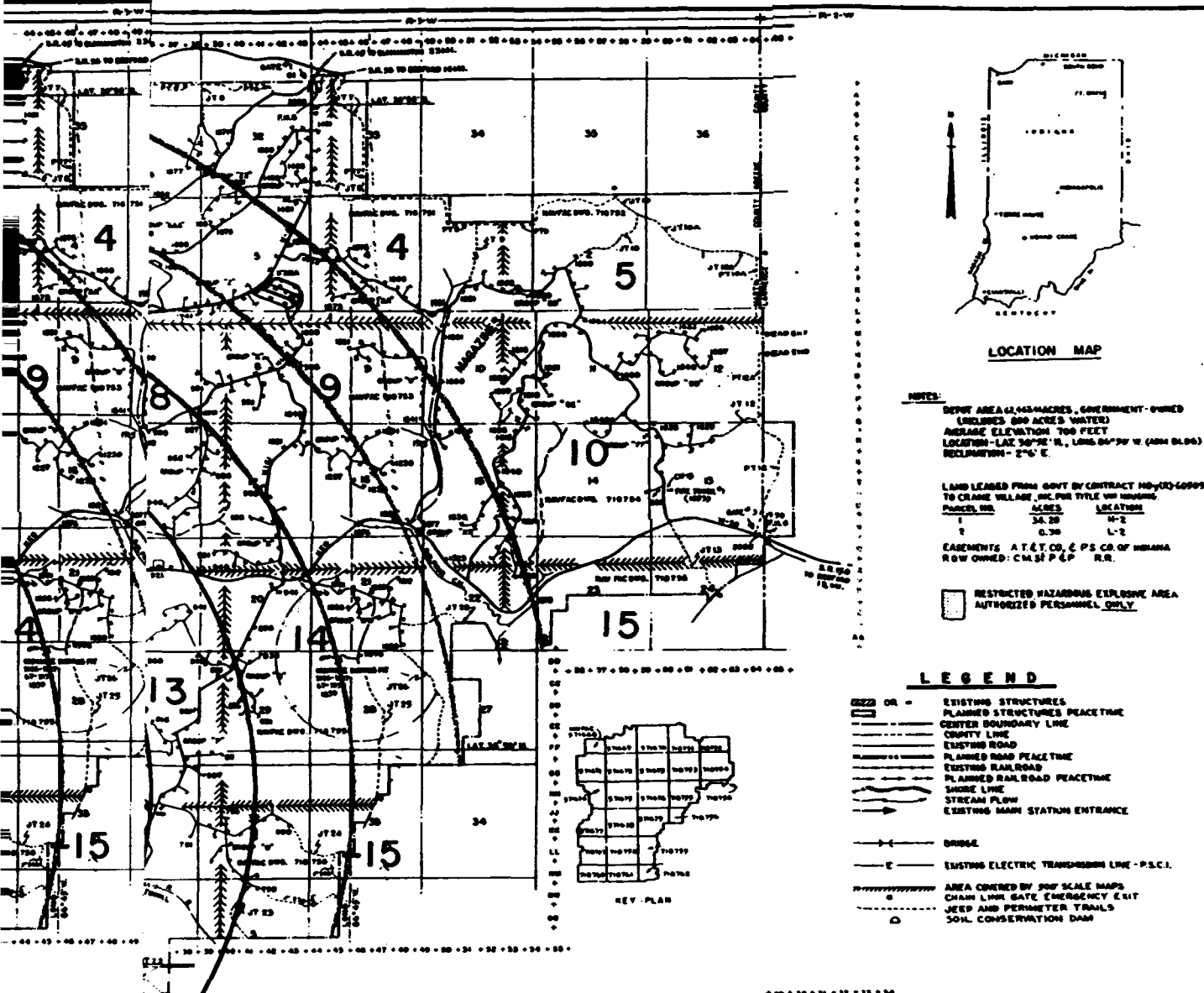
The next phase in the analysis is to compare the velocities and air overpressures obtained at the site to the safe limiting criteria established. The first criteria checked was established for structures located between 300 and 5000 ft from a blast by the U. S. Department of Interior Office of Surface Mines Reclamation and Enforcement 30 CFR Part 715, effective April 7, 1992 (see Figures 22 and 23). These criteria allow for peak particle velocities of 1.0 ips (allowable vibration limits) and peak air overpressures of 0.015 psi (allowable air blast limit). These criteria are based on open coal mine blasting which utilizes very large shots and many delays. From Figure 24, it is clear that most of the energy of a coal mine blast is in the low frequency range of 5 - 25 Hz. Quarry blasting is in the range of 10 - 35 Hz, and construction blasting in the range of 15 - 60 Hz. The safe limiting criteria are based on surface coal mine blasting because the lower frequency motions produce much more structural damage than do the higher frequency motions. The blasting that occurs at the NSWC is very similar to quarry or construction blasting which utilizes smaller shots and produces more high frequency motions. Therefore, the predictions of safety based on coal mine blasting criteria would be even more safe for quarry or construction type blasting. All of the data recorded at the site, are well below these criteria.

A second method to establish safe limiting criteria has been developed by the Department of the Interior, Office of Surface Mining (OSM) Reclamation and Enforcement. These rules and regulations are established in 30 CFR Parts 715, 780, 816, and 817. The new alternative blasting criteria is based on the particle velocity in ips versus the frequency in Hz as shown in Figure 25. Once the time history from a ground vibration monitoring station has been recorded, the spectral content can be found by calculating power spectral densities (PSD) from which peak frequencies can be determined. These peak frequencies are used in Figure 25 to determine safe particle velocities. For frequencies up to 4 Hz, a constant maximum displacement amplitude of 0.30 inch will be allowed. Over this frequency range the maximum allowable particle velocity increases from 0.19 ips to 0.75 ips. At frequencies of 4 through 11 Hz a constant allowable particle velocity of 0.75 ips is set. The fundamental modes of most one story residential buildings lie in this range. Over the frequency range of 11 through 30 Hz, a constant amplitude of 0.0107 inch is allowed. This correlates to maximum particle velocities of 0.75 ips to 2.0 ips. Above 30 Hz, a constant peak particle velocity of 2.0 ips



1

Figure 21. Isodiametric plot of PFV's distances and a constant s



LOCATION MAP

**NOTES:**  
 DEPT AREA 6,443 ACRES, GOVERNMENT-OWNED  
 (EXCLUDES 800 ACRES WATER)  
 AVERAGE ELEVATION 700 FEET  
 LOCATION - LAT 36° 52' N, LONG 84° 30' W (NAD 83)  
 DECLINATION - 2° 0' E

LAND LEASED FROM GOVT BY CONTRACT NO. 100-60909  
 TO CRANE VILLAGE, INC. FOR TITLE VII HOUSING  
 PARCELS ARE: ACRES LOCATION  
 1 34.28 10-E  
 2 0.30 10-E

EASEMENTS: A.T.E.T. CO. & P.S. CO. OF INDIANA  
 ROW OWNED: C.M.S.P. & P. R.R.

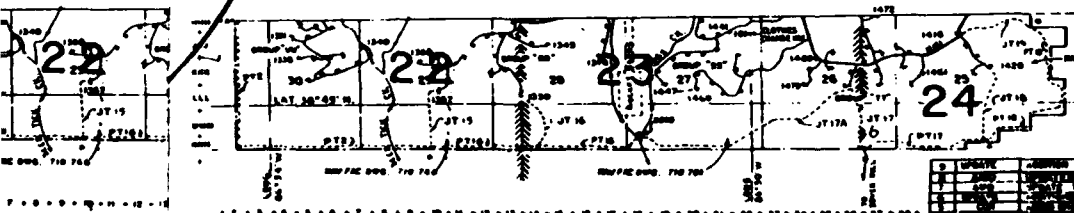
RESTRICTED HAZARDOUS EXPLOSIVE AREA  
 AUTHORIZED PERSONNEL ONLY

**LEGEND**

- EXISTING STRUCTURES
- PLANNED STRUCTURES
- CENTER BOUNDARY LINE
- COUNTY LINE
- EXISTING ROAD
- PLANNED ROAD
- EXISTING RAILROAD
- PLANNED RAILROAD
- SHORE LINE
- STREAM FLOW
- EXISTING MAIN STATION ENTRANCE
- BRIDGE
- EXISTING ELECTRIC TRANSMISSION LINE - P.S.C.I.
- AREA COVERED BY 500 SCALE MAPS
- CHAIN LINK GATE
- EMERGENCY EXIT
- JEEP AND PERIMETER TRAILS
- SOIL CONSERVATION DAM



KEY PLAN



|                                                                                                                                                                                                                    |                                         |                                                                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| 1. CHECKED BY: [Signature]<br>2. DATE: [Date]<br>3. BY: [Signature]<br>4. DATE: [Date]<br>5. BY: [Signature]<br>6. DATE: [Date]<br>7. BY: [Signature]<br>8. DATE: [Date]<br>9. BY: [Signature]<br>10. DATE: [Date] |                                         | 11. BY: [Signature]<br>12. DATE: [Date]<br>13. BY: [Signature]<br>14. DATE: [Date]<br>15. BY: [Signature]<br>16. DATE: [Date] |
| 17. DESCRIPTION OF ASSIGNMENT OR CORRECTION: [Text]<br>18. DATE: [Date]<br>19. BY: [Signature]                                                                                                                     |                                         |                                                                                                                               |
| 20. AUTHORITY OF THE MAP: [Text]<br>21. NAVAL WEAPONS SUPPORT CENTER<br>22. CRANE, INDIANA<br>23. GENERAL DEVELOPMENT MAP<br>24. KEY MAP                                                                           |                                         |                                                                                                                               |
| 25. BY: [Signature]<br>26. DATE: [Date]                                                                                                                                                                            | 27. BY: [Signature]<br>28. DATE: [Date] | 29. BY: [Signature]<br>30. DATE: [Date]                                                                                       |

from equation of PPV's from equation based on selected weight of constant shot weight of 500 lbs

(2)

## DAMAGE LEVELS FROM GROUND VIBRATIONS

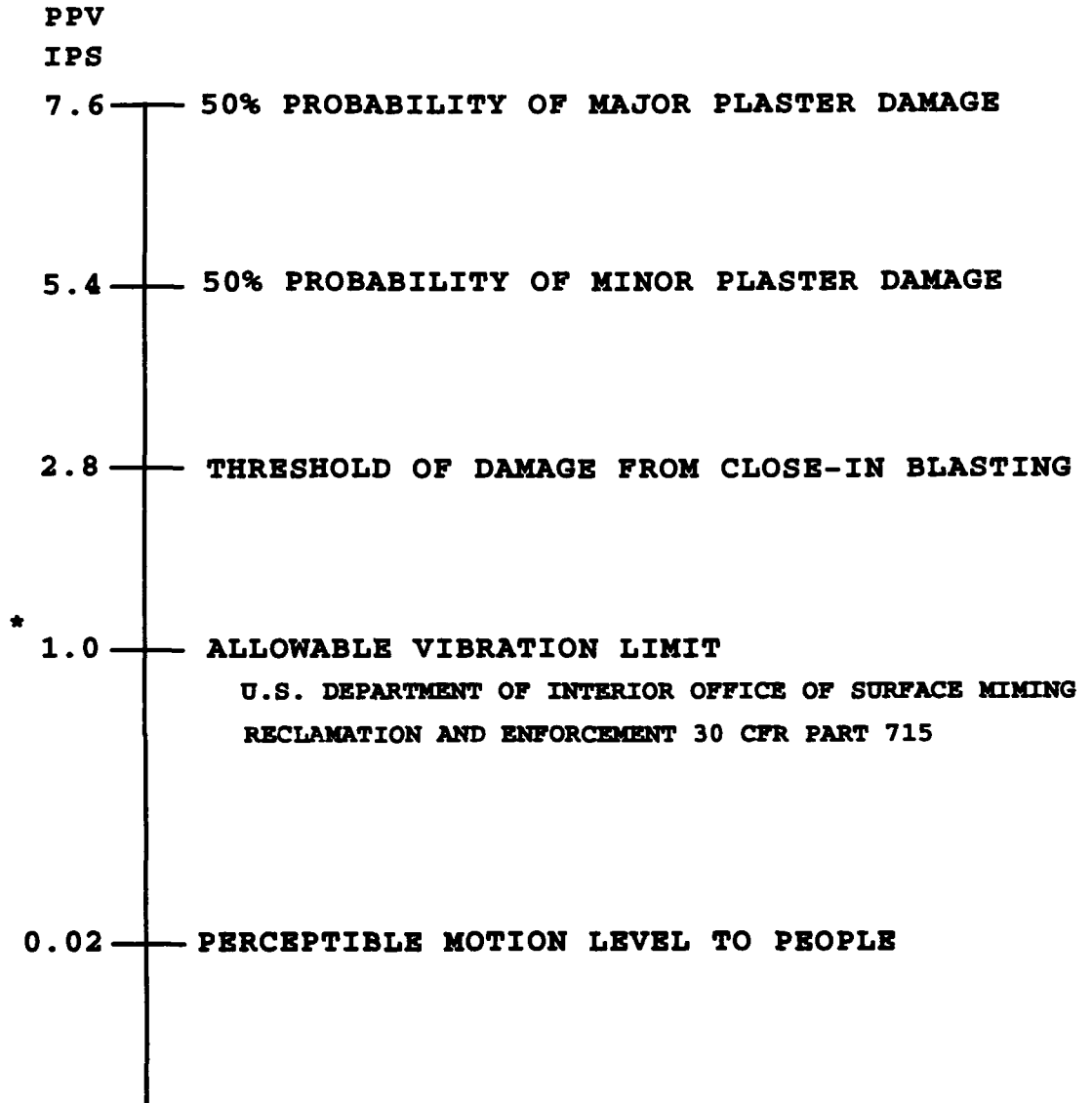


CHART FROM DUPONT BLASTER'S HANDBOOK, 16TH ED., 1977

\* FEDERAL REGISTER VOL 48 NO. 46 MARCH 8, 1983

Figure 22. Chart of various damage levels produced from ground vibrations

## AIR BLAST EFFECTS

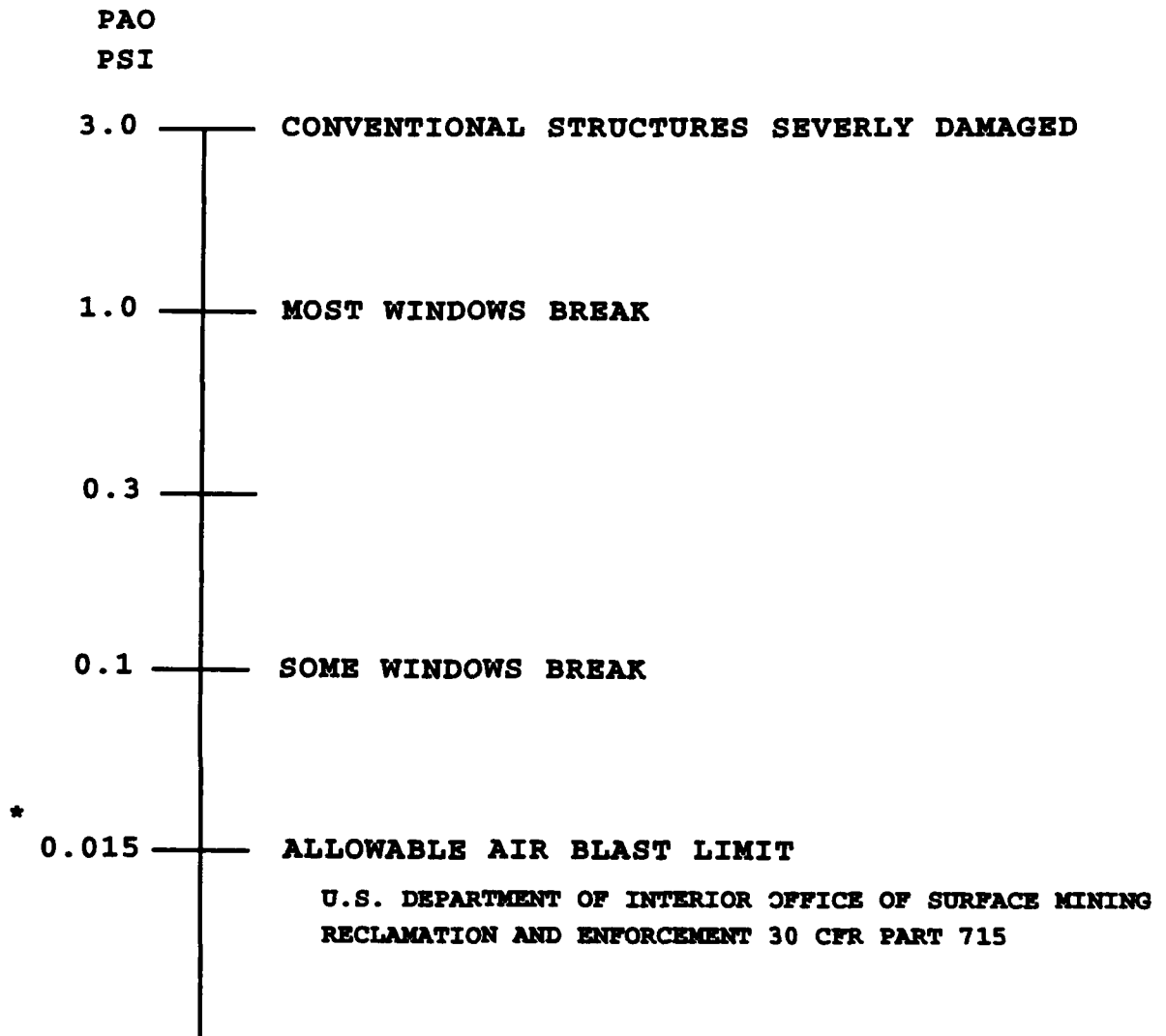


CHART FROM DUPONT BLASTER'S HANDBOOK, 16TH ED., 1977

\* FEDERAL REGISTER VOL 48 NO. 46 MARCH 8, 1983

Figure 23. Chart of various damage levels produced from air blast

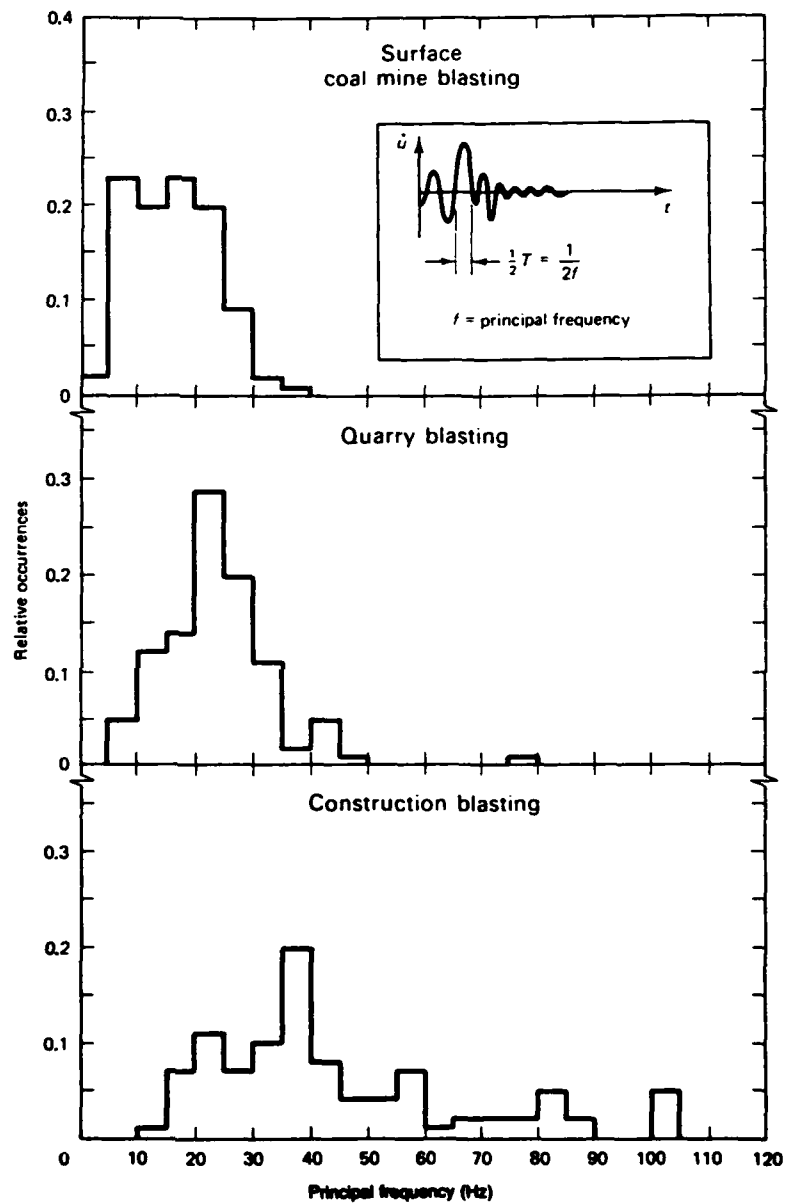


Figure 24. Predominant frequency histograms at structures of concern (Dowding, 1985)

# ALTERNATIVE BLASTING LEVEL CRITERIA

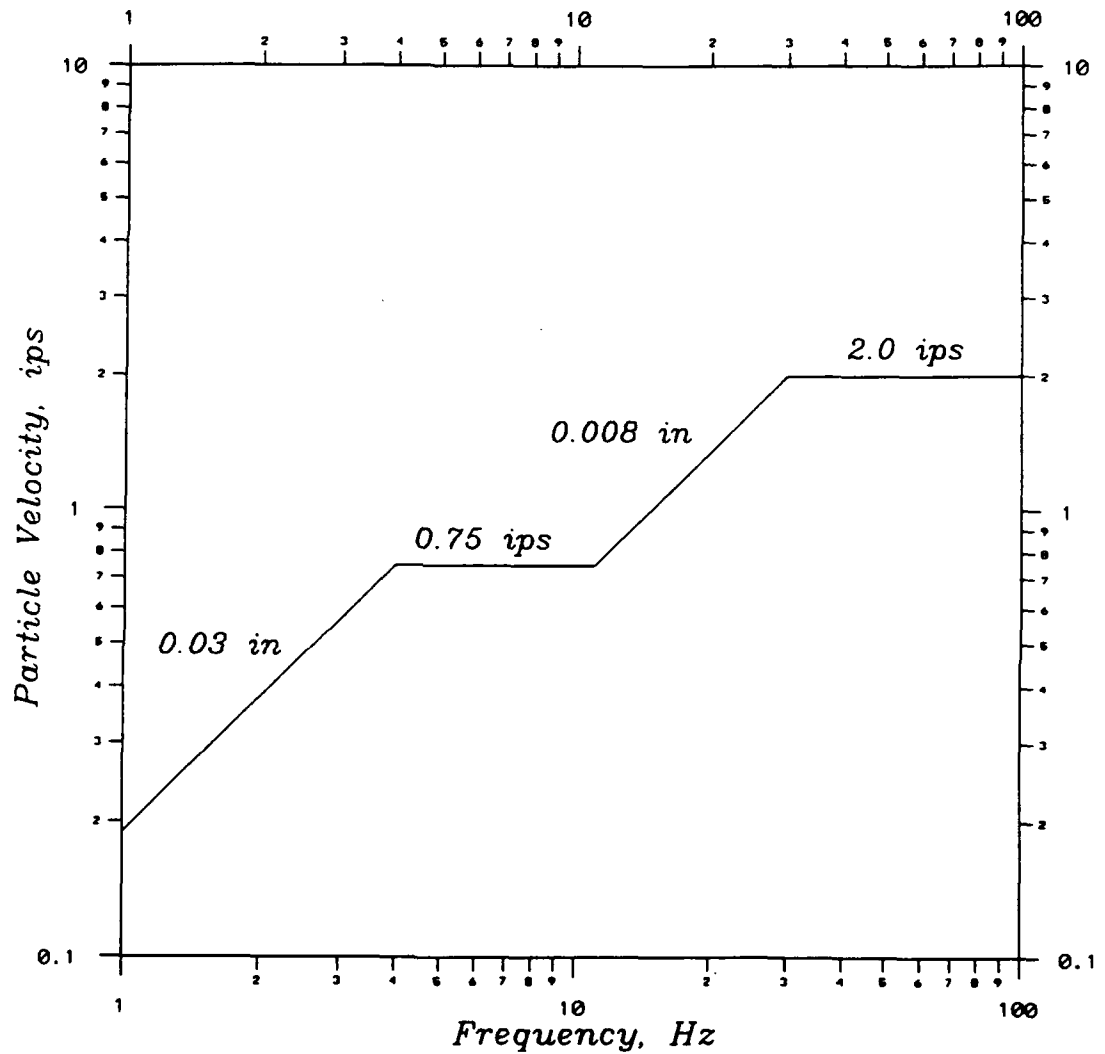


Figure 25. Determination of allowable ground vibration limits using the alternative blasting criteria (source: USBM R1-8507)

will be allowed. The OSM has established the following peak particle velocities to prevent the occurrence of threshold damage and has set such as a standard; 1.25 ips for 0-300 ft from source, 1.0 ips for distances of 301 to 5,000 ft from the source, and 0.75 ips for 5,001 ft and beyond from the source.

The data collected at the NSWG was analyzed to produce PSD's from which the peak frequency associated with the various blasts could be determined. A selected sample of the PSD's are presented in Appendix D. These types of plots are normally presented as a function of the velocity squared divided by the frequency versus the frequency. From the plots, the peak frequency ranges from 10 to 40 Hz, with the predominant frequency being approximately 20 Hz (more like quarry or construction blasting). Comparing this value with the data on Figure 25, reveals that the motions are well below the safe limiting criteria. Ground motions having a frequency content of 20 Hz could produce peak particle velocities of 1.3 ips and still be considered safe.

## 5 Conclusion

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An investigation to determine the attenuation of explosion induced ground motions and air overpressures as a function of distance from subsurface detonated charges, and to develop parameters to predict motions at distances beyond the base boundary was successfully completed. A total of 255 shots were monitored producing 3048 time histories of ground motions recorded in the vertical, radial, and transverse directions, in addition to recording air overpressures. The data were analyzed for peak particle velocities and peak air overpressures, then plotted versus scaled range. A best fit line was put through the data to give average and 95% non-exceedance predictive equations for the site and locations off-site. As a result of the analysis, the following equations are recommended for use in predicting ground motions and air overpressures.

### Ground motion predictions

$$y_{95\%} = 28.69 (x^{-1.43}) \quad \text{EQN 6}$$

y - peak particle velocity, ips

x - scaled range, ft

distance from shot divided by square root of shot weight

### Air overpressure predictions

$$y_{95\%} = 65.74 (x^{-1.51}) \quad \text{EQN 8}$$

y - peak air overpressure, psi

x - scaled range, ft

distance from shot divided by cubic root of shot weight

In addition to the analysis as described above, the data were also compared to the alternative blasting source criteria utilizing the frequency content of the motions. This analysis also revealed that the ground motions recorded at the site are well below the safe limiting criteria.

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**Appendix A: Table of Distances, Peak Particle Velocities, and  
Air Overpressures for Each Days Blasting**

| A  | B                                        | C                       | D                         | E                         | F                       | G                           | H                       |
|----|------------------------------------------|-------------------------|---------------------------|---------------------------|-------------------------|-----------------------------|-------------------------|
| 1  | Naval Surface Warfare Center (NSWC)      |                         |                           |                           |                         |                             |                         |
| 2  | Crane Army Ammunition Activity (CAAA)    |                         |                           |                           |                         |                             |                         |
| 3  | Ground Motion and Air Overpressure Study |                         |                           |                           |                         |                             |                         |
| 4  |                                          |                         |                           |                           |                         |                             |                         |
| 5  |                                          |                         |                           |                           |                         |                             |                         |
| 6  |                                          |                         |                           |                           |                         |                             |                         |
| 7  |                                          | Scaled Range<br>R/W^0.5 | Scaled Range<br>R/W^0.333 | Ground Motion<br>Vertical | Ground Motion<br>Radial | Ground Motion<br>Transverse | Air Overpressure<br>psi |
| 8  |                                          | ft                      | ft                        | ips                       | ips                     | ips                         |                         |
| 9  | 28 August N40E                           |                         |                           |                           |                         |                             |                         |
| 10 | 500 ft station row 1                     | 24                      | 66                        | 0.0343                    | 0.034                   | 0.0225                      | 0.0194                  |
| 11 |                                          | 26                      | 73                        | 0.0355                    | 0.0276                  | 0.0204                      | 0.0197                  |
| 12 |                                          | 29                      | 81                        | 0.0377                    | 0.0332                  | 0.0223                      | 0.0151                  |
| 13 |                                          | 35                      | 95                        | 0.0344                    | 0.0344                  | 0.0232                      | 0.0073                  |
| 14 |                                          | 38                      | 103                       | 0.0322                    | 0.0344                  | 0.0226                      | 0.0085                  |
| 15 |                                          | 42                      | 112                       | 0.0322                    | 0.0337                  | 0.0225                      | 0.014                   |
| 16 |                                          | 45                      | 122                       | 0.0328                    | 0.01619                 | 0.006967                    | 0.009927                |
| 17 |                                          | 49                      | 131                       | 0.03355                   | 0.0362                  | 0.02296                     | 0.009677                |
| 18 |                                          | 52                      | 140                       | 0.0333                    | 0.02049                 | 0.00877                     | 0.00739                 |
| 19 |                                          | 56                      | 150                       | 0.03353                   | 0.02388                 | 0.02247                     | 0.007649                |
| 20 |                                          | 70                      | 189                       | 0.03344                   | 0.03343                 | 0.02241                     | 0.003328                |
| 21 |                                          | 74                      | 197                       | 0.03331                   | 0.03398                 | 0.02155                     | 0.006392                |
| 22 |                                          | 77                      | 206                       | 0.02084                   | 0.0233                  | 0.01983                     | 0.01902                 |
| 23 |                                          | 80                      | 215                       | 0.03347                   | 0.03348                 | 0.02249                     | 0.000867                |
| 24 |                                          | 83                      | 224                       | 0.0234                    | 0.01964                 | 0.01729                     | 0.01906                 |
| 25 | row 2                                    | 31                      | 86                        | 0.0335                    | 0.0376                  | 0.0236                      | 0.0149                  |
| 26 |                                          | 33                      | 91                        | 0.0341                    | 0.0349                  | 0.0246                      | 0.003                   |
| 27 |                                          | 36                      | 100                       | 0.0336                    | 0.0365                  | 0.023                       | 0.0181                  |
| 28 |                                          | 38                      | 106                       | 0.0339                    | 0.0351                  | 0.023                       | 0.0125                  |

|    | A               | B     | C   | D   | E        | F        | G        | H        |
|----|-----------------|-------|-----|-----|----------|----------|----------|----------|
| 29 |                 |       | 40  | 111 | 0.0334   | 0.0356   | 0.0233   | 0.0107   |
| 30 |                 |       | 42  | 116 | 0.03327  | 0.03368  | 0.02212  | 0.01154  |
| 31 |                 |       | 44  | 122 | 0.03351  | 0.03563  | 0.02238  | 0.01122  |
| 32 |                 |       | 50  | 135 | 0.03309  | 0.02535  | 0.01053  | 0.0102   |
| 33 |                 |       | 52  | 141 | 0.03313  | 0.02333  | 0.022    | 0.007    |
| 34 |                 |       | 66  | 177 | 0.03318  | 0.03126  | 0.02257  | 0.01493  |
| 35 |                 |       | 69  | 186 | 0.03335  | 0.02613  | 0.02015  | 0.005683 |
| 36 |                 |       | 72  | 194 | 0.02972  | 0.03352  | 0.02182  | 0.006808 |
| 37 |                 |       | 76  | 203 | 0.003519 | 0.002285 | 0.002757 |          |
| 38 |                 | row 3 | 39  | 105 | 0.0336   | 0.0319   | 0.0168   | 0.0143   |
| 39 |                 |       | 41  | 109 | 0.0338   | 0.0378   | 0.0239   | 0.0171   |
| 40 |                 |       | 42  | 114 | 0.0168   | 0.0334   | 0.0227   |          |
| 41 |                 |       | 44  | 119 | 0.0365   | 0.0358   | 0.0234   | 0.0143   |
| 42 |                 |       | 46  | 124 | 0.0333   | 0.0204   | 0.0204   | 0.0187   |
| 43 |                 |       | 48  | 129 | 0.0332   | 0.0121   | 0.0046   | 0.0044   |
| 44 |                 |       | 50  | 134 | 0.03675  | 0.03938  | 0.02326  | 0.0086   |
| 45 |                 |       | 52  | 140 | 0.03388  | 0.03556  | 0.02304  | 0.00476  |
| 46 |                 |       | 54  | 145 | 0.0332   | 0.02886  | 0.01292  | 0.01799  |
| 47 |                 |       | 56  | 151 | 0.03325  | 0.01047  | 0.01121  | 0.01177  |
| 48 | 5800 ft station | row 1 | 275 | 761 | 0.00088  | 0.0014   | 0.00059  | 0.00042  |
| 49 |                 |       | 278 | 768 | 0.0017   | 0.0012   | 0.00098  | 0.00043  |
| 50 |                 |       | 280 | 776 | 0.0025   | 0.0042   | 0.0041   | 0.00028  |
| 51 |                 |       | 310 | 832 | 0.00099  | 0.0021   | 0.0019   | 0.00028  |
| 52 |                 |       | 313 | 840 | 0.0025   | 0.0045   | 0.0037   | 0.00048  |
| 53 |                 |       | 316 | 848 | 0.0018   | 0.0018   | 0.00069  | 0.00039  |
| 54 |                 |       | 319 | 856 | 0.0023   | 0.0016   | 0.0012   | 0.00039  |
| 55 |                 |       | 322 | 864 | 0.0025   | 0.0018   | 0.0015   | 0.00023  |
| 56 |                 |       | 325 | 872 | 0.0024   | 0.0024   | 0.0017   | 0.0008   |
| 57 |                 |       | 328 | 880 | 0.0017   | 0.00098  | 0.0006   |          |

| A  | B     | C   | D   | E       | F       | G       | H       |
|----|-------|-----|-----|---------|---------|---------|---------|
| 58 |       | 340 | 913 | 0.005   | 0.0026  | 0.0014  | 0.00046 |
| 59 |       | 343 | 920 | 0.0021  | 0.00083 | 0.00056 | 0.0156  |
| 60 |       | 346 | 928 | 0.0029  | 0.00069 | 0.00054 |         |
| 61 |       | 348 | 935 | 0.0029  | 0.0036  | 0.0015  | 0.0011  |
| 62 |       | 351 | 943 | 0.0016  | 0.0024  | 0.001   |         |
| 63 | row 2 | 283 | 782 | 0.0042  | 0.0036  | 0.0015  |         |
| 64 |       | 285 | 787 | 0.00056 | 0.001   | 0.00048 | 0.00043 |
| 65 |       | 286 | 791 | 0.0033  | 0.0036  | 0.0036  | 0.00031 |
| 66 |       | 288 | 796 | 0.0012  | 0.0017  | 0.0017  | 0.00039 |
| 67 |       | 290 | 800 | 0.0014  | 0.0039  | 0.0033  | 0.00028 |
| 68 |       | 291 | 805 | 0.0021  | 0.001   | 0.00099 | 0.00033 |
| 69 |       | 293 | 809 | 0.001   | 0.0011  | 0.001   | 0.00023 |
| 70 |       | 295 | 814 | 0.0015  | 0.0015  | 0.0012  | 0.00033 |
| 71 |       | 323 | 867 | 0.0035  | 0.0027  | 0.0019  | 0.00048 |
| 72 |       | 325 | 872 | 0.0039  | 0.0051  | 0.002   | 0.001   |
| 73 |       | 336 | 903 | 0.0009  | 0.0015  | 0.001   |         |
| 74 |       | 339 | 909 | 0.006   | 0.0026  | 0.0015  | 0.00088 |
| 75 |       | 341 | 916 | 0.0054  | 0.005   | 0.0036  | 0.00097 |
| 76 |       | 344 | 923 | 0.0027  | 0.0032  | 0.0027  |         |
| 77 | row 3 | 313 | 840 | 0.0022  | 0.0014  | 0.00084 | 0.00018 |
| 78 |       | 314 | 844 | 0.0018  | 0.0025  | 0.0023  | 0.00024 |
| 79 |       | 316 | 848 | 0.0019  | 0.0017  | 0.0015  | 0.00021 |
| 80 |       | 318 | 853 | 0.0019  | 0.0012  | 0.00094 | 0.00025 |
| 81 |       | 319 | 857 | 0.0025  | 0.004   | 0.0035  | 0.00053 |
| 82 |       | 321 | 861 | 0.0014  | 0.0015  | 0.0014  | 0.00034 |
| 83 |       | 323 | 866 | 0.0016  | 0.00079 | 0.00067 | 0.00031 |
| 84 |       | 324 | 870 | 0.0023  | 0.0016  | 0.0012  |         |
| 85 |       | 326 | 875 | 0.0059  | 0.0023  | 0.0013  | 0.00045 |
| 86 |       | 328 | 879 | 0.002   | 0.0016  | 0.0013  | 0.00075 |

|     | A                     | B     | C   | D    | E      | F      | G       | H      |
|-----|-----------------------|-------|-----|------|--------|--------|---------|--------|
| 87  | 10000 ft static row 1 |       | 474 | 1312 | 0.0039 | 0.0066 | 0.0015  | 0.0028 |
| 88  |                       |       | 477 | 1320 | 0.0071 | 0.0077 | 0.0023  | 0.0017 |
| 89  |                       |       | 479 | 1327 | 0.0015 | 0.0036 | 0.0008  | 0.0049 |
| 90  |                       |       | 528 | 1419 | 0.0054 | 0.0038 | 0.0015  | 0.0003 |
| 91  |                       |       | 531 | 1426 | 0.0016 | 0.0031 | 0.00082 | 0.0023 |
| 92  |                       |       | 534 | 1434 | 0.0024 | 0.0027 | 0.0013  | 0.0025 |
| 93  |                       |       | 537 | 1442 | 0.0026 | 0.004  | 0.0016  | 0.0035 |
| 94  |                       |       | 540 | 1450 | 0.0027 | 0.0038 | 0.0016  | 0.0056 |
| 95  |                       |       | 543 | 1457 | 0.0041 | 0.0057 | 0.0019  | 0.0074 |
| 96  |                       |       | 546 | 1465 | 0.0035 | 0.0042 | 0.0012  | 0.0038 |
| 97  |                       |       | 558 | 1497 | 0.0019 | 0.0013 | 0.00075 | 0.0047 |
| 98  |                       |       | 560 | 1505 | 0.0034 | 0.0029 | 0.0015  |        |
| 99  |                       |       | 563 | 1512 | 0.0031 | 0.0017 | 0.0012  | 0.0018 |
| 100 |                       |       | 566 | 1519 | 0.0016 | 0.0019 | 0.0012  | 0.0049 |
| 101 |                       |       | 569 | 1527 | 0.0036 | 0.0031 | 0.0012  | 0.0028 |
| 102 |                       |       | 571 | 1534 | 0.0024 | 0.0025 | 0.0012  | 0.0005 |
| 103 |                       |       | 574 | 1541 | 0.0039 | 0.0042 | 0.002   |        |
| 104 |                       |       | 577 | 1549 | 0.0041 | 0.003  | 0.0014  |        |
| 105 |                       |       | 580 | 1556 | 0.0039 | 0.003  | 0.0015  | 0.0224 |
| 106 |                       |       | 582 | 1563 | 0.0039 | 0.0036 | 0.0013  | 0.0046 |
| 107 |                       | row 2 | 483 | 1335 | 0.0027 | 0.0025 | 0.0014  |        |
| 108 |                       |       | 485 | 1340 | 0.0075 | 0.0058 | 0.0039  | 0.0017 |
| 109 |                       |       | 486 | 1344 | 0.0024 | 0.0027 | 0.001   | 0.0041 |
| 110 |                       |       | 488 | 1349 | 0.0052 | 0.0048 | 0.0018  | 0.0014 |
| 111 |                       |       | 490 | 1353 | 0.0044 | 0.0029 | 0.0013  | 0.0039 |
| 112 |                       |       | 491 | 1358 | 0.0016 | 0.0014 | 0.0008  | 0.0029 |
| 113 |                       |       | 493 | 1362 | 0.0014 | 0.0018 | 0.0006  | 0.0015 |
| 114 |                       |       | 495 | 1367 | 0.0019 | 0.0016 | 0.0013  | 0.0031 |
| 115 |                       |       | 541 | 1453 | 0.0057 | 0.0034 | 0.0018  | 0.0021 |

|     | A              | B     | C   | D    | E       | F       | G       | H      |
|-----|----------------|-------|-----|------|---------|---------|---------|--------|
| 116 |                |       | 543 | 1458 | 0.00072 | 0.00053 | 0.00079 |        |
| 117 |                |       | 554 | 1488 | 0.0042  | 0.0039  | 0.0015  | 0.0052 |
| 118 |                |       | 557 | 1494 | 0.0013  | 0.0014  | 0.00054 | 0.0022 |
| 119 |                |       | 559 | 1501 | 0.0031  | 0.0025  | 0.00065 |        |
| 120 |                |       | 562 | 1508 | 0.001   | 0.0029  | 0.00046 | 0.0028 |
| 121 |                |       | 564 | 1515 | 0.0021  | 0.0025  | 0.00067 | 0.0044 |
| 122 |                | row 3 | 531 | 1425 | 0.0023  | 0.0031  | 0.0006  | 0.0024 |
| 123 |                |       | 533 | 1430 | 0.0042  | 0.0047  | 0.0018  | 0.0033 |
| 124 |                |       | 534 | 1434 | 0.0017  | 0.0044  | 0.0012  | 0.0017 |
| 125 |                |       | 536 | 1438 | 0.0034  | 0.0033  | 0.00094 | 0.0037 |
| 126 |                |       | 537 | 1443 | 0.0031  | 0.0025  | 0.00054 | 0.0038 |
| 127 |                |       | 539 | 1447 | 0.0018  | 0.002   | 0.00067 | 0.0027 |
| 128 |                |       | 541 | 1452 | 0.0021  | 0.0018  | 0.0006  | 0.0093 |
| 129 |                |       | 542 | 1456 | 0.002   | 0.0027  | 0.0008  | 0.0028 |
| 130 |                |       | 544 | 1460 | 0.0022  | 0.0018  | 0.0011  | 0.0079 |
| 131 |                |       | 546 | 1465 | 0.0057  | 0.0034  | 0.0018  | 0.0095 |
| 132 |                |       |     |      |         |         |         |        |
| 133 | 29 August N40E |       |     |      |         |         |         |        |
| 134 | 500 ft station |       | 24  | 66   | 0.0323  | 0.0248  | 0.0233  | 0.0521 |
| 135 | row 1          |       | 27  | 73   | 0.0317  | 0.0251  | 0.0232  | 0.0213 |
| 136 |                |       | 29  | 81   | 0.0311  | 0.0235  | 0.0221  | 0.0309 |
| 137 |                |       | 32  | 89   | 0.0233  | 0.0238  | 0.0219  | 0.0072 |
| 138 |                |       | 35  | 98   | 0.0296  | 0.0234  | 0.0216  | 0.026  |
| 139 |                |       | 38  | 106  | 0.0296  | 0.023   | 0.0196  | 0.0263 |
| 140 |                |       | 42  | 115  | 0.0203  | 0.0094  | 0.0096  | 0.0185 |
| 141 |                |       | 45  | 123  | 0.02    | 0.013   | 0.008   | 0.0158 |
| 142 |                |       | 48  | 132  | 0.0171  | 0.0084  | 0.008   | 0.0384 |
| 143 |                |       | 56  | 150  | 0.0104  | 0.0064  | 0.0039  | 0.013  |
| 144 |                |       | 70  | 189  | 0.013   | 0.0112  | 0.0055  | 0.0091 |

|     | A | B     | C   | D   | E      | F      | G      | H      |
|-----|---|-------|-----|-----|--------|--------|--------|--------|
| 145 |   |       | 67  | 186 | 0.013  | 0.006  | 0.0049 | 0.0112 |
| 146 |   |       | 70  | 195 | 0.015  | 0.007  | 0.005  | 0.0185 |
| 147 |   |       | 80  | 215 | 0.0223 | 0.0178 | 0.0095 | 0.0109 |
| 148 |   |       | 83  | 224 | 0.0118 | 0.009  | 0.0041 | 0.0015 |
| 149 |   |       | 87  | 233 | 0.0166 | 0.0087 | 0.006  | 0.0067 |
| 150 |   |       | 90  | 242 | 0.011  | 0.0048 | 0.0053 | 0.0046 |
| 151 |   |       | 93  | 251 | 0.0084 | 0.0038 | 0.0028 | 0.0125 |
| 152 |   |       | 107 | 278 | 0.0052 | 0.0051 | 0.0025 | 0.009  |
| 153 |   |       | 100 | 269 | 0.0089 | 0.0044 | 0.0041 | 0.0079 |
| 154 |   | row 2 | 30  | 85  | 0.0297 | 0.0237 | 0.0218 | 0.0249 |
| 155 |   |       | 36  | 96  | 0.0223 | 0.0122 | 0.0123 | 0.0223 |
| 156 |   |       | 38  | 101 | 0.0204 | 0.0162 | 0.0127 | 0.017  |
| 157 |   |       | 40  | 106 | 0.0194 | 0.0096 | 0.0105 | 0.01   |
| 158 |   |       | 42  | 112 | 0.0137 | 0.0077 | 0.0058 | 0.0172 |
| 159 |   |       | 40  | 111 | 0.0295 | 0.0191 | 0.0105 | 0.0146 |
| 160 |   |       | 42  | 116 | 0.0145 | 0.0088 | 0.0089 | 0.0085 |
| 161 |   |       | 48  | 129 | 0.0176 | 0.0113 | 0.0063 | 0.0117 |
| 162 |   |       | 50  | 135 | 0.0131 | 0.01   | 0.005  | 0.0111 |
| 163 |   |       | 48  | 133 | 0.0132 | 0.0049 | 0.0039 | 0.0107 |
| 164 |   |       | 66  | 177 | 0.016  | 0.0094 | 0.0067 | 0.0153 |
| 165 |   |       | 69  | 186 | 0.0174 | 0.015  | 0.0082 | 0.0189 |
| 166 |   |       | 72  | 194 | 0.01   | 0.005  | 0.003  | 0.0114 |
| 167 |   |       | 76  | 203 | 0.013  | 0.01   | 0.008  | 0.0134 |
| 168 |   |       | 79  | 212 | 0.0181 | 0.0221 | 0.0085 | 0.0079 |
| 169 |   | row 3 | 39  | 105 | 0.03   | 0.024  | 0.022  | 0.0183 |
| 170 |   |       | 41  | 109 | 0.0298 | 0.0234 | 0.0219 | 0.0292 |
| 171 |   |       | 42  | 114 | 0.021  | 0.024  | 0.022  | 0.0041 |
| 172 |   |       | 44  | 119 | 0.022  | 0.009  | 0.016  | 0.0152 |
| 173 |   |       | 46  | 124 | 0.0157 | 0.01   | 0.0106 | 0.0516 |

|     | A               | B     | C   | D   | E      | F      | G      | H       |
|-----|-----------------|-------|-----|-----|--------|--------|--------|---------|
| 174 |                 |       | 48  | 129 | 0.0295 | 0.0214 | 0.0145 | 0.0364  |
| 175 |                 |       | 50  | 134 | 0.0301 | 0.0228 | 0.0209 | 0.0263  |
| 176 |                 |       | 52  | 140 | 0.02   | 0.009  | 0.007  | 0.021   |
| 177 |                 |       | 54  | 145 | 0.0108 | 0.0068 | 0.0046 | 0.0218  |
| 178 |                 |       | 56  | 151 | 0.0106 | 0.0048 | 0.0042 | 0.0121  |
| 179 | 1000 ft station | row 1 | 48  | 132 | 0.0311 | 0.0337 | 0.0231 | 0.0024  |
| 180 |                 |       | 50  | 139 | 0.0233 | 0.0333 | 0.0202 | 0.0023  |
| 181 |                 |       | 53  | 147 | 0.0315 | 0.0337 | 0.0236 | 0.0014  |
| 182 |                 |       | 56  | 154 | 0.0186 | 0.0234 | 0.0117 | 0.0033  |
| 183 |                 |       | 59  | 162 | 0.0313 | 0.0284 | 0.0232 | 0.0029  |
| 184 |                 |       | 62  | 170 | 0.0316 | 0.0339 | 0.0234 | 0.0024  |
| 185 |                 |       | 65  | 178 | 0.0305 | 0.0313 | 0.0162 | 0.0016  |
| 186 |                 |       | 68  | 187 | 0.0268 | 0.0301 | 0.0188 | 0.00087 |
| 187 |                 |       | 71  | 195 | 0.0242 | 0.0201 | 0.0156 | 0.0036  |
| 188 |                 |       | 80  | 216 | 0.0118 | 0.0149 | 0.0071 | 0.0008  |
| 189 |                 |       | 94  | 253 | 0.0213 | 0.0221 | 0.0151 | 0.0011  |
| 190 |                 |       | 89  | 247 | 0.0169 | 0.0191 | 0.005  | 0.00026 |
| 191 |                 |       | 92  | 255 | 0.0176 | 0.0141 | 0.0115 | 0.002   |
| 192 |                 |       | 104 | 279 | 0.0309 | 0.0243 | 0.0238 | 0.00037 |
| 193 |                 |       | 107 | 287 | 0.0175 | 0.0234 | 0.0173 | 0.001   |
| 194 |                 |       | 110 | 296 | 0.021  | 0.0228 | 0.0079 | 0.00093 |
| 195 |                 |       | 113 | 305 | 0.0149 | 0.014  | 0.0092 | 0.00088 |
| 196 |                 |       | 117 | 313 | 0.0111 | 0.0182 | 0.0028 | 0.00087 |
| 197 |                 |       | 133 | 345 | 0.0085 | 0.0128 | 0.0035 | 0.00081 |
| 198 |                 |       | 123 | 331 | 0.0107 | 0.0101 | 0.0068 | 0.00089 |
| 199 |                 | row 2 | 53  | 149 | 0.0312 | 0.0337 | 0.0229 | 0.002   |
| 200 |                 |       | 61  | 165 | 0.031  | 0.0334 | 0.0229 | 0.0013  |
| 201 |                 |       | 63  | 170 | 0.0246 | 0.0335 | 0.0148 | 0.0011  |
| 202 |                 |       | 65  | 175 | 0.0236 | 0.0335 | 0.0192 | 0.00067 |

|     | A               | B     | C   | D   | E       | F      | G       | H       |
|-----|-----------------|-------|-----|-----|---------|--------|---------|---------|
| 203 |                 |       | 67  | 180 | 0.0316  | 0.0335 | 0.0239  | 0.0013  |
| 204 |                 |       | 63  | 175 | 0.0316  | 0.0289 | 0.0239  |         |
| 205 |                 |       | 65  | 180 | 0.0162  | 0.0179 | 0.0185  | 0.00065 |
| 206 |                 |       | 73  | 196 | 0.0224  | 0.0279 | 0.0104  | 0.00079 |
| 207 |                 |       | 75  | 201 | 0.016   | 0.0175 | 0.0047  | 0.00087 |
| 208 |                 |       | 71  | 195 | 0.0192  | 0.0179 | 0.0077  | 0.0008  |
| 209 |                 |       | 90  | 242 | 0.0297  | 0.0336 | 0.0158  | 0.0015  |
| 210 |                 |       | 93  | 250 | 0.0256  | 0.0254 | 0.0235  | 0.0016  |
| 211 |                 |       | 96  | 258 | 0.0127  | 0.0104 | 0.0039  | 0.0011  |
| 212 |                 |       | 99  | 266 | 0.0156  | 0.0163 | 0.0075  | 0.0014  |
| 213 |                 |       | 102 | 275 | 0.0281  | 0.0296 | 0.024   | 0.0009  |
| 214 |                 | row 3 | 64  | 172 | 0.0312  | 0.0337 | 0.0231  | 0.001   |
| 215 |                 |       | 66  | 177 | 0.023   | 0.0334 | 0.0093  | 0.0012  |
| 216 |                 |       | 68  | 181 | 0.0168  | 0.033  | 0.023   | 0.0004  |
| 217 |                 |       | 69  | 186 | 0.0212  | 0.0339 | 0.0101  | 0.00076 |
| 218 |                 |       | 71  | 191 | 0.0137  | 0.0219 | 0.0064  | 0.0011  |
| 219 |                 |       | 73  | 196 | 0.031   | 0.0337 | 0.0236  | 0.001   |
| 220 |                 |       | 75  | 201 | 0.0315  | 0.0341 | 0.0239  | 0.0016  |
| 221 |                 |       | 77  | 206 | 0.0186  | 0.0188 | 0.0197  | 0.0017  |
| 222 |                 |       | 79  | 211 | 0.0152  | 0.0129 | 0.0071  | 0.0017  |
| 223 |                 |       | 81  | 216 | 0.0155  | 0.0159 | 0.0084  | 0.00092 |
| 224 | 5800 ft station | row 1 | 277 | 764 | 0.0011  | 0.0022 | 0.0014  | 0.00024 |
| 225 |                 |       | 279 | 771 | 0.0012  | 0.0022 | 0.0018  | 0.0003  |
| 226 |                 |       | 282 | 779 | 0.0007  | 0.0012 | 0.001   | 0.0006  |
| 227 |                 |       | 284 | 786 | 0.0011  | 0.0021 | 0.001   | 0.0004  |
| 228 |                 |       | 287 | 793 | 0.0019  | 0.0034 | 0.0018  | 0.00053 |
| 229 |                 |       | 290 | 801 | 0.0009  | 0.0028 | 0.0017  | 0.00049 |
| 230 |                 |       | 292 | 808 | 0.00065 | 0.001  | 0.00086 | 0.00047 |
| 231 |                 |       | 295 | 815 | 0.0014  | 0.002  | 0.0015  | 0.00073 |

|     | A | B     | C   | D   | E       | F       | G       | H       |
|-----|---|-------|-----|-----|---------|---------|---------|---------|
| 232 |   |       | 298 | 823 | 0.00058 | 0.0011  | 0.00062 | 0.00031 |
| 233 |   |       | 328 | 880 | 0.0012  | 0.0023  | 0.0012  | 0.00029 |
| 234 |   |       | 340 | 913 | 0.0011  | 0.0007  | 0.001   | 0.00046 |
| 235 |   |       | 314 | 869 | 0.00072 | 0.0014  | 0.00084 | 0.00035 |
| 236 |   |       | 317 | 876 | 0.002   | 0.0031  | 0.0019  | 0.00045 |
| 237 |   |       | 348 | 935 | 0.0023  | 0.0043  | 0.0023  | 0.00017 |
| 238 |   | row 2 | 277 | 771 | 0.0009  | 0.001   | 0.0006  | 0.00046 |
| 239 |   |       | 310 | 833 | 0.0009  | 0.0024  | 0.0014  | 0.0001  |
| 240 |   |       | 312 | 838 | 0.0011  | 0.002   | 0.0011  |         |
| 241 |   |       | 314 | 843 | 0.0014  | 0.0029  | 0.0015  | 0.00035 |
| 242 |   |       | 316 | 848 | 0.0018  | 0.0026  | 0.0018  | 0.0007  |
| 243 |   |       | 291 | 805 | 0.001   | 0.0026  | 0.0013  | 0.0005  |
| 244 |   |       | 293 | 809 | 0.00084 | 0.0025  | 0.0014  | 0.00025 |
| 245 |   |       | 321 | 862 | 0.0005  | 0.00045 | 0.00053 |         |
| 246 |   |       | 323 | 867 | 0.00053 | 0.0011  | 0.0008  | 0.0002  |
| 247 |   |       | 298 | 823 | 0.001   | 0.0022  | 0.0016  | 0.00054 |
| 248 |   |       | 336 | 903 | 0.0019  | 0.0031  | 0.0018  | 0.00036 |
| 249 |   |       | 339 | 909 | 0.0007  | 0.0015  | 0.00093 | 0.00021 |
| 250 |   |       | 341 | 916 | 0.0001  | 0.00073 | 0.0015  | 0.00055 |
| 251 |   | row 3 | 313 | 840 | 0.0016  | 0.0027  | 0.0017  | 0.00031 |
| 252 |   |       | 314 | 844 | 0.0005  |         | 0.0004  |         |
| 253 |   |       | 316 | 848 | 0.00086 | 0.0012  | 0.0009  | 0.0002  |
| 254 |   |       | 318 | 853 | 0.0007  | 0.0012  | 0.0008  | 0.0003  |
| 255 |   |       | 319 | 857 | 0.0019  | 0.004   | 0.0024  | 0.00025 |
| 256 |   |       | 321 | 861 | 0.0011  | 0.0017  | 0.001   | 0.00016 |
| 257 |   |       | 323 | 866 | 0.0008  | 0.0016  | 0.00081 | 0.00022 |
| 258 |   |       | 324 | 870 | 0.00054 | 0.00099 | 0.0006  | 0.0002  |
| 259 |   |       | 326 | 875 | 0.00064 | 0.0014  | 0.00096 |         |
| 260 |   |       | 328 | 879 | 0.001   | 0.0022  | 0.0016  | 0.00014 |

|     | A                    | B     | C   | D   | E       | F       | G       | H       |
|-----|----------------------|-------|-----|-----|---------|---------|---------|---------|
| 261 |                      |       |     |     |         |         |         |         |
| 262 | 31 August N4DE       |       |     |     |         |         |         |         |
| 263 | 500 ft station row 1 |       | 26  | 70  | 0.0547  | 0.0402  | 0.0381  | 0.0346  |
| 264 |                      |       | 29  | 78  | 0.0544  | 0.0408  | 0.0385  | 0.0244  |
| 265 |                      |       | 32  | 86  | 0.0582  | 0.0464  | 0.0288  | 0.0124  |
| 266 |                      |       | 35  | 95  | 0.0545  | 0.0348  | 0.0383  | 0.02318 |
| 267 |                      |       | 38  | 103 | 0.0545  | 0.0394  | 0.0382  | 0.0258  |
| 268 |                      |       | 42  | 112 | 0.0545  | 0.0273  | 0.0377  | 0.0264  |
| 269 |                      |       | 45  | 122 | 0.0545  | 0.0208  | 0.022   | 0.0269  |
| 270 |                      |       | 49  | 131 | 0.0432  | 0.0262  | 0.0212  | 0.0189  |
| 271 |                      |       | 52  | 140 | 0.0554  | 0.0314  | 0.0297  | 0.0298  |
| 272 |                      |       | 56  | 150 | 0.0442  | 0.0127  | 0.0224  | 0.0115  |
| 273 |                      |       | 70  | 189 | 0.0431  | 0.0098  | 0.00909 | 0.0249  |
| 274 |                      |       | 74  | 197 | 0.0408  | 0.0118  | 0.0143  | 0.0161  |
| 275 |                      |       | 77  | 206 | 0.0203  | 0.0117  | 0.0127  | 0.0322  |
| 276 |                      |       | 80  | 215 | 0.0507  | 0.028   | 0.0194  | 0.014   |
| 277 |                      |       | 83  | 224 | 0.035   | 0.012   | 0.0176  | 0.0222  |
| 278 |                      |       | 87  | 233 | 0.0165  | 0.0118  | 0.0142  | 0.0145  |
| 279 |                      |       | 90  | 242 | 0.02    | 0.0146  | 0.0149  | 0.012   |
| 280 |                      |       | 93  | 251 | 0.0164  | 0.0082  | 0.0119  | 0.009   |
| 281 |                      |       | 97  | 260 | 0.01107 | 0.00595 | 0.00834 | 0.01417 |
| 282 |                      |       | 100 | 269 | 0.0156  | 0.00606 | 0.00786 | 0.01906 |
| 283 |                      | row 2 | 66  | 177 | 0.0455  | 0.0104  | 0.0133  | 0.01106 |
| 284 |                      |       | 69  | 186 | 0.0232  | 0.0103  | 0.0109  | 0.00939 |
| 285 |                      |       | 72  | 194 | 0.0249  | 0.0186  | 0.0179  | 0.0171  |
| 286 |                      |       | 76  | 203 | 0.0277  | 0.0179  | 0.0176  | 0.0147  |
| 287 |                      |       | 79  | 212 | 0.0297  | 0.0233  | 0.0178  | 0.0233  |
| 288 |                      | row 3 | 69  | 186 | 0.0544  | 0.0104  | 0.0132  | 0.0262  |
| 289 |                      |       | 73  | 195 | 0.0296  | 0.0139  | 0.0155  | 0.0114  |

|     | A              | B     | C   | D   | E      | F       | G      | H       |
|-----|----------------|-------|-----|-----|--------|---------|--------|---------|
| 290 |                |       | 76  | 203 | 0.035  | 0.0185  | 0.017  | 0.0154  |
| 291 |                |       | 79  | 211 | 0.0334 | 0.0167  | 0.0178 | 0.0238  |
| 292 |                |       | 82  | 220 | 0.0434 | 0.0237  | 0.0186 | 0.0139  |
| 293 |                |       |     |     |        |         |        |         |
| 294 | 750 ft station | row 1 | 39  | 105 |        |         |        |         |
| 295 |                |       | 42  | 112 | 0.0229 | 0.0225  | 0.023  | 0.0049  |
| 296 |                |       | 45  | 121 | 0.0227 | 0.0241  | 0.0231 | 0.0036  |
| 297 |                |       | 48  | 129 | 0.0229 | 0.0224  | 0.023  | 0.0033  |
| 298 |                |       | 51  | 137 | 0.0228 | 0.024   | 0.026  | 0.0047  |
| 299 |                |       | 54  | 146 | 0.0228 | 0.025   | 0.024  | 0.0031  |
| 300 |                |       | 58  | 155 | 0.0226 | 0.0176  | 0.0169 | 0.0034  |
| 301 |                |       | 61  | 164 | 0.0146 | 0.0071  | 0.0076 | 0.0042  |
| 302 |                |       | 64  | 173 | 0.0229 | 0.0224  | 0.0221 | 0.00405 |
| 303 |                |       | 68  | 182 | 0.0181 | 0.0112  | 0.0072 | 0.00245 |
| 304 |                |       | 82  | 220 | 0.0078 | 0.0042  | 0.0052 | 0.00317 |
| 305 |                |       | 85  | 229 | 0.0069 | 0.0044  | 0.0101 | 0.0026  |
| 306 |                |       | 89  | 238 | 0.0071 | 0.00367 | 0.0054 | 0.0041  |
| 307 |                |       | 92  | 246 | 0.0151 | 0.0095  | 0.0129 | 0.0022  |
| 308 |                |       | 95  | 255 | 0.0125 | 0.0088  | 0.0056 | 0.0036  |
| 309 |                |       | 98  | 264 | 0.006  | 0.0023  | 0.0035 | 0.0032  |
| 310 |                |       | 102 | 273 | 0.0072 | 0.0029  | 0.0045 | 0.0033  |
| 311 |                |       | 105 | 282 | 0.0044 | 0.00235 | 0.0031 | 0.0023  |
| 312 |                |       | 108 | 290 | 0.0035 | 0.0028  | 0.0029 | 0.0037  |
| 313 |                |       | 111 | 299 | 0.0048 | 0.0024  | 0.0035 | 0.0038  |
| 314 |                | row 2 | 78  | 209 | 0.0125 | 0.017   | 0.0101 | 0.0017  |
| 315 |                |       | 81  | 217 | 0.0087 | 0.0172  | 0.0048 | 0.0018  |
| 316 |                |       | 84  | 226 | 0.0122 | 0.0095  | 0.0081 | 0.0028  |
| 317 |                |       | 87  | 234 | 0.0132 | 0.0112  | 0.0137 | 0.0022  |
| 318 |                |       | 90  | 243 | 0.0154 | 0.0118  | 0.0088 | 0.0029  |

|     | A               | B     | C   | D   | E       | F       | G       | H       |
|-----|-----------------|-------|-----|-----|---------|---------|---------|---------|
| 319 |                 | row 3 | 81  | 217 | 0.0159  | 0.0064  | 0.00434 | 0.0056  |
| 320 |                 |       | 84  | 225 | 0.0077  | 0.0098  | 0.0075  | 0.0018  |
| 321 |                 |       | 87  | 233 | 0.0152  | 0.0169  | 0.0129  | 0.0023  |
| 322 |                 |       | 90  | 242 | 0.0141  | 0.0059  | 0.0054  | 0.0032  |
| 323 |                 |       | 93  | 250 | 0.0072  | 0.0045  | 0.0061  | 0.0024  |
| 324 |                 |       |     |     |         |         |         |         |
| 325 | 1000 ft station | row 1 | 55  | 147 | 0.0194  | 0.0347  | 0.0107  | 0.00057 |
| 326 |                 |       | 58  | 155 | 0.0222  | 0.0342  | 0.0152  | 0.00049 |
| 327 |                 |       | 61  | 163 | 0.0197  | 0.0225  | 0.0159  | 0.00044 |
| 328 |                 |       | 64  | 172 | 0.0133  | 0.0213  | 0.0105  | 0.00063 |
| 329 |                 |       | 67  | 180 | 0.0234  | 0.018   | 0.0128  | 0.00043 |
| 330 |                 |       | 70  | 189 | 0.0145  | 0.0138  | 0.0047  | 0.00041 |
| 331 |                 |       | 74  | 198 | 0.0121  | 0.0115  | 0.0043  | 0.00052 |
| 332 |                 |       | 77  | 207 | 0.0189  | 0.0234  | 0.0069  | 0.00062 |
| 333 |                 |       | 80  | 216 | 0.0127  | 0.0148  | 0.0033  | 0.00028 |
| 334 |                 |       | 94  | 253 | 0.0117  | 0.0098  | 0.0047  | 0.00074 |
| 335 |                 |       | 97  | 262 | 0.0074  | 0.00737 | 0.00515 | 0.00054 |
| 336 |                 |       | 101 | 270 | 0.0086  | 0.0116  | 0.0024  | 0.0011  |
| 337 |                 |       | 104 | 279 | 0.0189  | 0.01047 | 0.0066  | 0.00039 |
| 338 |                 |       | 107 | 287 | 0.0085  | 0.0124  | 0.0036  | 0.00076 |
| 339 |                 |       | 110 | 296 | 0.0078  | 0.0143  | 0.0021  | 0.00062 |
| 340 |                 |       | 113 | 305 | 0.00613 | 0.00798 | 0.00336 | 0.00071 |
| 341 |                 |       | 117 | 313 | 0.0079  | 0.0075  | 0.003   | 0.00051 |
| 342 |                 |       | 120 | 322 | 0.0063  | 0.0053  | 0.002   | 0.00054 |
| 343 |                 |       | 123 | 331 | 0.00903 | 0.0131  | 0.0035  | 0.00066 |
| 344 |                 | row 2 | 90  | 242 | 0.01002 | 0.0114  | 0.0064  | 0.00042 |
| 345 |                 |       | 93  | 250 | 0.0073  | 0.0087  | 0.0032  | 0.00036 |
| 346 |                 |       | 96  | 258 | 0.0082  | 0.0101  | 0.0058  | 0.00055 |
| 347 |                 |       | 99  | 266 | 0.0091  | 0.0091  | 0.0052  | 0.00045 |

|     | A               | B     | C   | D   | E      | F      | G      | H       |
|-----|-----------------|-------|-----|-----|--------|--------|--------|---------|
| 348 |                 |       | 102 | 275 | 0.0086 | 0.0107 | 0.0038 | 0.00065 |
| 349 |                 | row 3 | 93  | 249 | 0.0129 | 0.0138 | 0.0035 | 0.00078 |
| 350 |                 |       | 96  | 257 | 0.0075 | 0.0103 | 0.0051 | 0.00034 |
| 351 |                 |       | 99  | 265 | 0.0105 | 0.0096 | 0.0071 | 0.00048 |
| 352 |                 |       | 102 | 273 | 0.0049 | 0.0081 | 0.0023 | 0.00082 |
| 353 |                 |       | 105 | 281 | 0.02   | 0.0192 | 0.0024 | 0.00051 |
| 354 |                 |       |     |     |        |        |        |         |
| 355 |                 |       |     |     |        |        |        |         |
| 356 | 1450 ft station | row 1 | 75  | 202 | 0.043  | 0.0487 | 0.027  | 0.0012  |
| 357 |                 |       | 78  | 210 | 0.0435 | 0.049  | 0.0434 | 0.0014  |
| 358 |                 |       | 81  | 218 | 0.0433 | 0.043  | 0.037  | 0.0012  |
| 359 |                 |       | 84  | 226 | 0.0435 | 0.0269 | 0.0237 | 0.0011  |
| 360 |                 |       | 87  | 234 | 0.0432 | 0.0469 | 0.0239 | 0.0015  |
| 361 |                 |       | 90  | 242 | 0.0431 | 0.0304 | 0.0141 | 0.0015  |
| 362 |                 |       | 93  | 251 | 0.0433 | 0.036  | 0.0145 | 0.0014  |
| 363 |                 |       | 97  | 259 | 0.0433 | 0.0478 | 0.0153 | 0.0024  |
| 364 |                 |       | 100 | 268 | 0.043  | 0.0171 | 0.0107 | 0.0013  |
| 365 |                 |       | 103 | 277 | 0.043  | 0.0192 | 0.0108 | 0.0021  |
| 366 |                 |       | 117 | 313 | 0.0279 | 0.0384 | 0.0152 | 0.0013  |
| 367 |                 |       | 120 | 321 | 0.0304 | 0.0483 | 0.0247 | 0.0011  |
| 368 |                 |       | 123 | 330 | 0.0207 | 0.034  | 0.013  | 0.0022  |
| 369 |                 |       | 126 | 338 | 0.0427 | 0.0475 | 0.0273 | 0.0011  |
| 370 |                 |       | 129 | 346 | 0.0257 | 0.0177 | 0.0179 | 0.0022  |
| 371 |                 |       | 132 | 355 | 0.021  | 0.0223 | 0.009  | 0.002   |
| 372 |                 |       | 135 | 363 | 0.036  | 0.0213 | 0.0094 | 0.0014  |
| 373 |                 |       | 138 | 372 | 0.0322 | 0.0103 | 0.0072 | 0.00057 |
| 374 |                 |       | 142 | 380 | 0.0302 | 0.0128 | 0.0097 | 0.002   |
| 375 |                 |       | 145 | 389 | 0.0253 | 0.0158 | 0.012  | 0.0021  |
| 376 |                 | row 2 | 112 | 302 | 0.03   | 0.0283 | 0.0125 | 0.002   |

|     | A               | B     | C      | D      | E        | F        | G        | H        |
|-----|-----------------|-------|--------|--------|----------|----------|----------|----------|
| 377 |                 |       | 115    | 310    | 0.0225   | 0.0295   | 0.0143   | 0.0014   |
| 378 |                 |       | 118    | 318    | 0.0098   | 0.017    | 0.0136   | 0.0031   |
| 379 |                 |       | 121    | 326    | 0.0239   | 0.0478   | 0.0208   | 0.0023   |
| 380 |                 |       | 124    | 334    | 0.0431   | 0.0372   | 0.0183   | 0.0018   |
| 381 |                 | row 3 | 115    | 309    | 0.0271   | 0.0382   | 0.0135   | 0.0011   |
| 382 |                 |       | 118    | 316    | 0.021    | 0.0308   | 0.012    | 0.0011   |
| 383 |                 |       | 121    | 324    | 0.0327   | 0.0483   | 0.0163   | 0.0014   |
| 384 |                 |       | 123    | 331    | 0.0293   | 0.031    | 0.0138   | 0.001    |
| 385 |                 |       | 126    | 339    | 0.043    | 0.0261   | 0.0162   | 0.0015   |
| 386 |                 |       |        |        |          |          |          |          |
| 387 | 5800 ft station | row 1 | 301.53 | 809.5  | 0.00084  | 0.0014   | 0.00086  | 0.00033  |
| 388 |                 |       | 304.36 | 817.12 | 0.00059  | 0.0017   | 0.00086  | 0.00035  |
| 389 |                 |       | 307.22 | 824.78 | 0.00158  | 0.00262  | 0.00131  | 0.00059  |
| 390 |                 |       | 284.36 | 785.82 | 0.00065  | 0.001    | 0.00121  | 0.00035  |
| 391 |                 |       | 312.98 | 840.25 | 0.00077  | 0.00106  | 0.00084  | 0.00059  |
| 392 |                 |       | 350.81 | 909.4  | 0.00065  | 0.00145  | 0.000578 | 0.000086 |
| 393 |                 |       | 318.81 | 855.9  | 0.00048  | 0.0014   | 0.00067  | 0.0005   |
| 394 |                 |       | 321.75 | 863.79 | 0.00056  | 0.0026   | 0.0014   | 0.00024  |
| 395 |                 |       | 324.7  | 871.72 | 0.00056  | 0.00157  | 0.000969 | 0.000103 |
| 396 |                 |       | 327.67 | 879.69 | 0.00056  | 0.00146  | 0.00082  | 0.00039  |
| 397 |                 |       | 339.95 | 912.64 | 0.00056  | 0.00122  | 0.00077  | 0.00019  |
| 398 |                 |       | 342.73 | 920.11 | 0.00099  | 0.00185  | 0.00111  | 0.000475 |
| 399 |                 |       | 345.52 | 927.6  | 0.00071  | 0.0011   | 0.00081  | 0.00031  |
| 400 |                 |       | 319.41 | 882.7  | 0.0012   | 0.0021   | 0.0015   | 0.00057  |
| 401 |                 |       | 351.13 | 942.68 | 0.00072  | 0.00099  | 0.00073  | 0.00015  |
| 402 |                 |       | 353.96 | 950.26 | 0.00054  | 0.00109  | 0.00058  | 0.00019  |
| 403 |                 |       | 327.18 | 904.16 | 0.00104  | 0.00205  | 0.00116  | 0.000213 |
| 404 |                 |       | 359.63 | 965.49 | 0.000897 | 0.000813 | 0.00058  | 0.000193 |
| 405 |                 |       | 362.48 | 973.14 | 0.000458 | 0.00069  | 0.000416 | 0.00021  |

|     | A                | B     | C      | D      | E        | F        | G        | H        |
|-----|------------------|-------|--------|--------|----------|----------|----------|----------|
| 406 |                  |       | 365.34 | 980.82 | 0.000585 | 0.000925 | 0.000577 | 0.000165 |
| 407 |                  |       |        |        |          |          |          |          |
| 408 |                  | row 2 | 310.37 | 833.23 | 0.00054  | 0.00117  | 0.00071  | 0.00023  |
| 409 |                  |       | 312.15 | 838.01 | 0.00069  | 0.0015   | 0.00081  | 0.00041  |
| 410 |                  |       | 313.94 | 842.81 | 0.00062  | 0.0014   | 0.0006   |          |
| 411 |                  |       | 315.73 | 847.64 | 0.00075  | 0.00185  | 0.00099  | 0.00059  |
| 412 |                  |       | 317.54 | 852.5  | 0.00106  | 0.00185  | 0.001    | 0.00015  |
| 413 |                  |       | 354.67 | 919.39 | 0.0018   | 0.0013   | 0.0023   | 0.00061  |
| 414 |                  |       | 321.19 | 862.28 | 0.00047  | 0.00121  | 0.00059  | 0.000136 |
| 415 |                  |       | 358.73 | 929.93 | 0.00061  | 0.00125  | 0.00086  | 0.00024  |
| 416 |                  |       | 324.87 | 872.16 | 0.00055  | 0.0016   | 0.00091  | 0.00035  |
| 417 |                  |       | 336.19 | 902.55 | 0.000403 | 0.0008   | 0.00068  | 0.00021  |
| 418 |                  |       | 376.22 | 975.26 | 0.00056  | 0.0011   | 0.00068  | 0.00022  |
| 419 |                  |       | 379.1  | 982.72 | 0.00097  | 0.0019   | 0.0013   | 0.00027  |
| 420 |                  |       | 343.96 | 923.43 | 0.00076  | 0.00217  | 0.00109  | 0.00031  |
| 421 |                  |       | 384.9  | 997.76 | 0.00038  | 0.00086  | 0.00048  | 0.00022  |
| 422 |                  |       |        |        |          |          |          |          |
| 423 |                  | row 3 | 314.31 | 843.83 | 0.00076  | 0.0018   | 0.00099  | 0.00048  |
| 424 |                  |       | 315.94 | 848.18 | 0.001    | 0.0023   | 0.0013   | 0.00015  |
| 425 |                  |       | 352.68 | 914.23 | 0.00115  | 0.00151  | 0.00064  | 0.000078 |
| 426 |                  |       | 319.21 | 856.98 | 0.00094  | 0.0017   | 0.0012   | 0.00059  |
| 427 |                  |       | 356.34 | 923.73 | 0.00095  | 0.0025   | 0.0012   | 0.00014  |
| 428 |                  |       | 322.53 | 865.89 | 0.00101  | 0.00272  | 0.00153  | 0.00026  |
| 429 |                  |       | 343.3  | 904.19 | 0.00061  | 0.00154  | 0.00059  | 0.000079 |
| 430 |                  |       | 345.08 | 908.9  | 0.00068  | 0.0014   | 0.00085  | 0.00021  |
| 431 |                  |       | 327.59 | 879.48 | 0.00042  | 0.00128  | 0.00057  | 0.00051  |
| 432 |                  |       |        |        |          |          |          |          |
| 433 | 1 September S40W |       |        |        |          |          |          |          |
| 434 | 500 ft station   | row 1 | 26     | 70     | 0.0252   | 0.0449   | 0.0226   | 0.0514   |

| A   | B     | C  | D   | E      | F       | G      | H      |
|-----|-------|----|-----|--------|---------|--------|--------|
| 435 |       | 29 | 77  | 0.0252 | 0.0451  | 0.0225 | 0.0739 |
| 436 |       | 29 | 80  | 0.0252 | 0.0448  | 0.0129 | 0.0228 |
| 437 |       | 34 | 92  | 0.0249 | 0.0444  | 0.022  | 0.0249 |
| 438 |       | 34 | 95  | 0.0251 | 0.0448  | 0.0224 | 0.0691 |
| 439 |       | 40 | 109 | 0.0247 | 0.0442  | 0.0144 | 0.0175 |
| 440 |       | 44 | 117 | 0.0256 | 0.0502  | 0.0228 | 0.1065 |
| 441 |       | 43 | 118 | 0.0251 | 0.0503  | 0.0229 | 0.0326 |
| 442 |       | 50 | 134 | 0.0247 | 0.0441  |        |        |
| 443 |       | 53 | 142 | 0.0211 | 0.0442  |        | 0.0204 |
| 444 |       | 62 | 171 | 0.0245 | 0.0409  |        | 0.0078 |
| 445 |       | 65 | 180 | 0.0246 | 0.0438  |        | 0.0175 |
| 446 |       | 68 | 189 | 0.0246 | 0.0437  |        | 0.0451 |
| 447 |       | 72 | 198 | 0.0242 | 0.0269  |        | 0.0144 |
| 448 |       | 82 | 220 | 0.0089 | 0.0174  |        | 0.0049 |
| 449 |       | 86 | 230 | 0.0103 | 0.0174  |        | 0.0063 |
| 450 |       | 89 | 239 | 0.0061 | 0.0054  |        | 0.006  |
| 451 |       | 85 | 235 | 0.0077 | 0.0052  |        | 0.0038 |
| 452 |       | 96 | 259 | 0.0059 | 0.0043  |        | 0.0054 |
| 453 | row 2 | 66 | 177 | 0.0246 | 0.0207  |        | 0.0312 |
| 454 |       | 68 | 184 | 0.0112 | 0.0082  |        | 0.0354 |
| 455 |       | 65 | 180 | 0.0121 | 0.0333  |        | 0.0175 |
| 456 |       | 73 | 197 | 0.0246 | 0.0397  |        | 0.01   |
| 457 |       | 76 | 204 | 0.0065 | 0.0064  |        | 0.0097 |
| 458 |       | 78 | 210 | 0.006  | 0.0069  |        | 0.0061 |
| 459 |       | 81 | 217 | 0.006  | 0.0035  |        | 0.0087 |
| 460 |       | 83 | 224 | 0.0117 | 0.0167  |        | 0.0035 |
| 461 |       | 86 | 230 | 0.0028 | 0.00198 |        | 0.0054 |
| 462 | row 3 | 38 | 103 | 0.0247 | 0.0447  | 0.0107 | 0.0164 |
| 463 |       | 39 | 107 | 0.0249 | 0.0444  | 0.022  | 0.0242 |

|     | A               | B     | C   | D   | E      | F      | G      | H       |
|-----|-----------------|-------|-----|-----|--------|--------|--------|---------|
| 464 |                 |       | 45  | 121 | 0.026  | 0.045  |        |         |
| 465 |                 |       | 44  | 122 | 0.0157 | 0.0338 |        |         |
| 466 |                 |       | 52  | 139 | 0.0113 | 0.0441 |        | 0.0237  |
| 467 |                 |       | 67  | 179 | 0.0248 | 0.0448 |        | 0.0156  |
| 468 |                 |       | 63  | 175 | 0.0245 | 0.0274 |        | 0.0216  |
| 469 |                 |       | 72  | 192 | 0.0133 | 0.0191 |        | 0.0178  |
| 470 |                 |       | 68  | 188 | 0.0175 | 0.0405 |        | 0.0102  |
| 471 |                 |       | 77  | 206 | 0.0161 | 0.0441 |        |         |
| 472 |                 |       | 73  | 200 | 0.0109 | 0.0087 |        | 0.0271  |
| 473 |                 |       | 82  | 219 | 0.0112 | 0.009  |        | 0.0313  |
| 474 |                 |       | 84  | 226 | 0.0107 | 0.0099 |        | 0.0158  |
| 475 | 2900 ft station | row 1 | 151 | 405 | 0.012  | 0.0083 | 0.0083 | 0.0012  |
| 476 |                 |       | 153 | 412 | 0.0049 | 0.0033 | 0.0041 | 0.00074 |
| 477 |                 |       | 143 | 395 | 0.0118 | 0.0082 | 0.0083 | 0.0014  |
| 478 |                 |       | 159 | 426 | 0.0118 | 0.0082 | 0.0083 |         |
| 479 |                 |       | 148 | 409 | 0.0119 | 0.0083 | 0.0084 | 0.0014  |
| 480 |                 |       | 164 | 440 | 0.007  | 0.0046 | 0.0077 | 0.0008  |
| 481 |                 |       | 167 | 448 | 0.012  | 0.0085 | 0.0084 | 0.00071 |
| 482 |                 |       | 155 | 430 | 0.0069 | 0.0057 | 0.0083 | 0.00033 |
| 483 |                 |       | 172 | 463 | 0.0119 | 0.0053 | 0.0082 | 0.00023 |
| 484 |                 |       | 175 | 470 | 0.0055 | 0.0024 | 0.0029 | 0.00048 |
| 485 |                 |       | 172 | 476 | 0.0035 | 0.0017 | 0.0022 | 0.001   |
| 486 |                 |       | 175 | 484 | 0.0037 | 0.0031 | 0.0032 | 0.0014  |
| 487 |                 |       | 178 | 492 | 0.0065 | 0.0022 | 0.0035 | 0.001   |
| 488 |                 |       | 181 | 500 | 0.0041 | 0.0013 | 0.0023 |         |
| 489 |                 | row 2 | 183 | 492 | 0.0049 | 0.0021 | 0.0027 | 0.00035 |
| 490 |                 |       | 185 | 498 | 0.0079 | 0.0018 | 0.0019 | 0.00023 |
| 491 |                 |       | 172 | 476 | 0.0034 | 0.0019 | 0.0022 | 0.00052 |
| 492 |                 | row 3 | 152 | 407 | 0.0087 | 0.0039 | 0.0028 | 0.00058 |

|     | A               | B     | C   | D   | E       | F       | G       | H        |
|-----|-----------------|-------|-----|-----|---------|---------|---------|----------|
| 493 |                 |       | 145 | 397 | 0.0113  | 0.0083  | 0.0083  | 0.00045  |
| 494 |                 |       | 157 | 423 | 0.0045  | 0.0018  | 0.0024  | 0.00037  |
| 495 |                 |       | 147 | 407 | 0.0076  | 0.006   | 0.0063  | 0.00024  |
| 496 |                 |       | 163 | 439 | 0.0046  | 0.0032  | 0.0023  | 0.0014   |
| 497 |                 |       | 177 | 475 | 0.0072  | 0.0018  | 0.0018  | 0.00057  |
| 498 |                 |       | 164 | 454 | 0.0101  | 0.0034  | 0.0046  | 0.00046  |
| 499 |                 |       | 181 | 487 | 0.0065  | 0.0022  | 0.0035  | 0.001    |
| 500 |                 |       |     |     |         |         |         |          |
| 501 | 5800 ft station | row 1 | 302 | 810 | 0.00447 | 0.00452 | 0.00024 | 0.00011  |
| 502 |                 |       | 304 | 816 | 0.0033  | 0.0023  | 0.00039 | 0.00074  |
| 503 |                 |       | 281 | 777 | 0.0094  | 0.008   | 0.00047 | 0.00019  |
| 504 |                 |       | 309 | 831 | 0.0086  | 0.0089  | 0.00044 | 0.00037  |
| 505 |                 |       | 286 | 791 | 0.0029  | 0.0027  | 0.0002  | 0.00031  |
| 506 |                 |       | 315 | 845 | 0.0053  | 0.0049  | 0.00043 | 0.00062  |
| 507 |                 |       | 317 | 852 | 0.0021  | 0.0022  | 0.00029 | 0.00021  |
| 508 |                 |       | 293 | 811 | 0.0055  | 0.0042  | 0.00068 | 0.00021  |
| 509 |                 |       | 323 | 866 | 0.002   | 0.0023  | 0.00024 | 0.00016  |
| 510 |                 |       | 325 | 874 | 0.0049  | 0.0046  | 0.00026 | 0.000076 |
| 511 |                 |       | 310 | 856 | 0.0022  | 0.0023  | 0.00019 | 0.00015  |
| 512 |                 |       | 312 | 863 | 0.0022  | 0.0022  | 0.00021 | 0.00015  |
| 513 |                 |       | 315 | 871 | 0.0018  | 0.0013  | 0.0003  | 0.0004   |
| 514 |                 |       | 318 | 879 | 0.0035  | 0.0036  | 0.00029 | 0.00027  |
| 515 |                 | row 2 | 330 | 887 | 0.0021  | 0.0021  | 0.00037 | 0.00063  |
| 516 |                 |       | 332 | 893 | 0.0016  | 0.0035  | 0.00023 |          |
| 517 |                 |       | 307 | 848 | 0.0021  | 0.0036  | 0.00022 | 0.00014  |
| 518 |                 |       | 337 | 903 | 0.0011  | 0.0014  | 0.0005  | 0.00012  |
| 519 |                 | row 3 | 301 | 808 | 0.0102  | 0.0088  | 0.00063 | 0.00059  |
| 520 |                 |       | 284 | 780 | 0.0063  | 0.0056  | 0.00028 | 0.00019  |
| 521 |                 |       | 306 | 822 | 0.0032  | 0.0025  | 0.00047 | 0.00017  |

|     | A               | B     | C   | D    | E       | F       | G        | H        |
|-----|-----------------|-------|-----|------|---------|---------|----------|----------|
| 522 |                 |       | 283 | 782  | 0.0026  | 0.0024  | 0.00018  | 0.00015  |
| 523 |                 |       | 311 | 836  | 0.0021  | 0.0024  | 0.000338 | 0.000074 |
| 524 |                 |       | 323 | 868  | 0.0017  | 0.0014  | 0.00015  | 0.00025  |
| 525 |                 |       | 298 | 824  | 0.00096 | 0.00094 | 0.00013  | 0.00017  |
| 526 |                 |       | 327 | 879  | 0.0024  | 0.002   | 0.00025  | 0.00019  |
| 527 |                 |       | 302 | 835  | 0.0014  | 0.0019  | 0.00015  | 0.00012  |
| 528 |                 |       |     |      |         |         |          |          |
| 529 | 10800 ft static | row 1 | 561 | 1507 | 0.00049 | 0.0014  | 0.00067  | 0.000023 |
| 530 |                 |       | 564 | 1514 | 0.00032 | 0.00093 | 0.00027  | 0.000039 |
| 531 |                 |       | 520 | 1436 | 0.00058 | 0.0021  | 0.00072  | 0.000078 |
| 532 |                 |       | 569 | 1528 | 0.00036 | 0.0013  | 0.00037  | 0.000047 |
| 533 |                 |       | 524 | 1449 | 0.00033 | 0.00078 | 0.00051  | 0.000046 |
| 534 |                 |       | 575 | 1542 | 0.00069 | 0.0017  | 0.00089  | 0.000068 |
| 535 |                 |       | 577 | 1549 | 0.001   | 0.0018  | 0.0011   | 0.00012  |
| 536 |                 |       | 532 | 1469 | 0.00037 | 0.00058 | 0.00047  | 0.00006  |
| 537 |                 |       | 582 | 1564 | 0.00042 | 0.0011  | 0.00038  | 0.000023 |
| 538 |                 |       | 585 | 1571 | 0.00062 | 0.0018  | 0.00081  | 0.000046 |
| 539 |                 |       | 547 | 1513 | 0.00021 | 0.0015  | 0.00024  | 0.000056 |
| 540 |                 |       | 550 | 1520 | 0.00065 | 0.0025  | 0.0011   | 0.000075 |
| 541 |                 |       | 553 | 1528 | 0.00044 | 0.0011  | 0.0012   | 0.000041 |
| 542 |                 |       | 556 | 1535 | 0.00024 | 0.00103 | 0.00024  | 0.000027 |
| 543 |                 |       | 609 | 1635 | 0.00024 | 0.00105 | 0.00026  | 0.000033 |
| 544 |                 |       | 612 | 1643 | 0.00035 | 0.00045 | 0.00017  | 0.000046 |
| 545 |                 |       | 615 | 1651 | 0.00039 | 0.0011  | 0.00022  | 0.000053 |
| 546 |                 | row 2 | 585 | 1569 | 0.0008  | 0.0014  | 0.00084  | 0.000051 |
| 547 |                 |       | 586 | 1573 | 0.00032 | 0.00056 | 0.00032  | 0.000033 |
| 548 |                 |       | 539 | 1489 | 0.00043 | 0.00076 | 0.00091  | 0.000041 |
| 549 |                 |       | 589 | 1582 | 0.00028 | 0.0013  | 0.00027  | 0.000019 |
| 550 |                 |       | 591 | 1586 | 0.00028 | 0.00062 | 0.00021  | 0.00003  |

|     | A                | B     | C    | D    | E         | F         | G        | H        |
|-----|------------------|-------|------|------|-----------|-----------|----------|----------|
| 551 |                  |       | 592  | 1590 | 0.00024   | 0.00091   | 0.00019  | 0.00032  |
| 552 |                  |       | 594  | 1594 | 0.00039   | 0.0011    | 0.00022  | 0.00053  |
| 553 |                  | row 3 | 560  | 1504 | 0.00064   | 0.0024    | 0.00087  | 0.00068  |
| 554 |                  |       | 526  | 1444 | 0.00044   | 0.00077   | 0.00042  | 0.00046  |
| 555 |                  |       | 564  | 1514 | 0.00032   | 0.00071   | 0.00041  | 0.00034  |
| 556 |                  |       | 519  | 1434 | 0.00087   | 0.00062   | 0.00037  | 0.00091  |
| 557 |                  |       | 568  | 1525 | 0.00051   | 0.0017    | 0.00084  | 0.00052  |
| 558 |                  |       | 577  | 1549 | 0.00065   | 0.00097   | 0.00037  | 0.00076  |
| 559 |                  |       | 531  | 1466 | 0.00043   | 0.0022    | 0.00049  | 0.00034  |
| 560 |                  |       | 580  | 1557 | 0.00032   | 0.00056   | 0.00037  | 0.00036  |
| 561 |                  |       | 533  | 1474 | 0.00032   | 0.00067   | 0.00039  | 0.00015  |
| 562 |                  |       | 583  | 1566 | 0.00066   | 0.00062   | 0.00023  | 0.00064  |
| 563 |                  |       | 536  | 1482 | 0.00025   | 0.00092   | 0.00016  | 0.00027  |
| 564 |                  |       | 586  | 1574 | 0.00036   | 0.0012    | 0.00027  | 0.00053  |
| 565 |                  |       |      |      |           |           |          |          |
| 566 | 22000 ft station | row 1 | 1144 | 3071 | 0.000205  | 0.000069  |          |          |
| 567 |                  |       | 1146 | 3077 | 0.00009   | 0.000099  | 0.000089 | 0.00011  |
| 568 |                  |       | 1054 | 2912 | 0.000123  | 0.00014   | 0.00012  | 0.00015  |
| 569 |                  |       | 1152 | 3091 | 0.00013   | 0.000058  | 0.000057 | 0.000098 |
| 570 |                  |       | 1058 | 2925 | 0.0000808 | 0.0000577 | 0.000061 | 0.000104 |
| 571 |                  |       | 1157 | 3105 | 0.00012   | 0.000074  | 0.000065 | 0.00026  |
| 572 |                  |       | 1159 | 3112 | 0.00021   | 0.000204  | 0.00017  | 0.00015  |
| 573 |                  |       | 1066 | 2945 | 0.000065  | 0.000065  | 0.000054 | 0.00013  |
| 574 |                  |       | 1165 | 3126 | 0.0001    | 0.000082  | 0.000068 |          |
| 575 |                  |       | 1167 | 3134 | 0.00013   | 0.00014   | 0.000126 | 0.00019  |
| 576 |                  |       | 1081 | 2988 | 0.000148  | 0.000132  | 0.000085 | 0.000114 |
| 577 |                  |       | 1084 | 2995 | 0.000089  | 0.00009   | 0.00005  | 0.0001   |
| 578 |                  |       | 1086 | 3002 | 0.000051  | 0.000052  | 0.000038 | 0.000097 |
| 579 |                  |       | 1089 | 3010 | 0.000053  | 0.000077  | 0.000061 | 0.000052 |

|     | A                | B     | C    | D    | E        | F        | G         | H        |
|-----|------------------|-------|------|------|----------|----------|-----------|----------|
| 580 |                  |       | 1191 | 3196 | 0.000041 | 0.00003  |           | 0.000069 |
| 581 |                  |       | 1193 | 3204 | 0.000035 | 0.000046 |           | 0.000072 |
| 582 |                  |       | 1196 | 3212 | 0.000045 | 0.000056 |           | 0.000051 |
| 583 | row 2            |       | 1158 | 3108 | 0.00022  | 0.00023  | 0.00015   | 0.00013  |
| 584 |                  |       | 1158 | 3109 | 0.00013  | 0.00015  | 0.0001    |          |
| 585 |                  |       | 1063 | 2937 | 0.000035 | 0.000039 | 0.000037  | 0.000079 |
| 586 |                  |       | 1160 | 3113 | 0.000045 | 0.000048 | 0.000044  | 0.000044 |
| 587 |                  |       | 1160 | 3115 | 0.000046 | 0.000028 |           | 0.000073 |
| 588 |                  |       | 1161 | 3117 | 0.000057 | 0.000028 |           | 0.00011  |
| 589 |                  |       | 1162 | 3119 | 0.000189 | 0.000061 | 0.00011   | 0.00026  |
| 590 | row 3            |       | 1142 | 3066 | 0.00017  | 0.00028  | 0.00017   | 0.00018  |
| 591 |                  |       | 1070 | 2937 | 0.000103 | 0.000106 | 0.000056  | 0.00013  |
| 592 |                  |       | 1144 | 3071 | 0.000047 | 0.000048 | 0.000036  | 0.000082 |
| 593 |                  |       | 1050 | 2901 | 0.000062 | 0.000048 | 0.000036  | 0.000082 |
| 594 |                  |       | 1146 | 3076 | 0.000136 | 0.00012  | 0.0000954 | 0.00011  |
| 595 |                  |       | 1150 | 3087 | 0.000044 | 0.000042 | 0.000031  | 0.00006  |
| 596 |                  |       | 1055 | 2915 | 0.000072 | 0.00011  | 0.000075  | 0.000085 |
| 597 |                  |       | 1151 | 3090 | 0.000059 | 0.000033 | 0.000041  | 0.000065 |
| 598 |                  |       | 1056 | 2919 | 0.000054 | 0.000038 |           | 0.000081 |
| 599 |                  |       | 1153 | 3094 | 0.000062 | 0.00002  |           | 0.0001   |
| 600 |                  |       | 1058 | 2923 | 0.000097 | 0.000061 |           | 0.000055 |
| 601 |                  |       |      |      |          |          |           |          |
| 602 | 3 September S40W |       |      |      |          |          |           |          |
| 603 | 250 ft station   | row 1 | 13   | 35   | 0.2994   | 0.5813   | 0.2135    | 0.0836   |
| 604 |                  |       | 16   | 42   | 0.3025   | 0.5849   | 0.2174    | 0.077    |
| 605 |                  |       | 19   | 50   | 0.1119   | 0.1692   | 0.0569    | 0.0162   |
| 606 |                  |       | 22   | 58   | 0.1189   | 0.1829   | 0.0705    | 0.0082   |
| 607 |                  |       | 25   | 67   | 0.0984   | 0.1472   | 0.0538    | 0.0086   |
| 608 |                  |       | 28   | 76   | 0.0682   | 0.1357   | 0.0572    | 0.0148   |

|     | A              | B     | C  | D   | E      | F      | G      | H      |
|-----|----------------|-------|----|-----|--------|--------|--------|--------|
| 609 |                |       | 31 | 84  | 0.0661 | 0.1173 | 0.0593 | 0.0093 |
| 610 |                |       | 35 | 93  | 0.0561 | 0.0655 | 0.0342 | 0.0152 |
| 611 |                |       | 35 | 96  | 0.0651 | 0.0573 | 0.0544 | 0.0093 |
| 612 |                |       | 41 | 111 | 0.0229 | 0.0421 | 0.0125 | 0.0082 |
| 613 |                |       | 51 | 142 | 0.035  | 0.0608 | 0.0409 | 0.03   |
| 614 |                |       | 55 | 151 | 0.0182 | 0.0302 | 0.0137 | 0.0064 |
| 615 |                |       | 63 | 170 | 0.0488 | 0.0501 | 0.0475 | 0.0083 |
| 616 |                |       | 67 | 180 | 0.0152 | 0.015  | 0.0143 |        |
| 617 |                |       | 71 | 190 | 0.0239 | 0.0364 | 0.0167 |        |
| 618 |                |       | 74 | 200 | 0.0204 | 0.0393 | 0.0264 | 0.0082 |
| 619 |                |       | 80 | 213 | 0.0172 | 0.0323 | 0.0067 | 0.0229 |
| 620 | row 2          |       | 27 | 73  | 0.0944 | 0.0947 | 0.0603 | 0.0082 |
| 621 |                |       | 28 | 77  | 0.0681 | 0.0617 | 0.0401 | 0.0231 |
| 622 |                |       | 34 | 91  | 0.0542 | 0.0882 | 0.025  | 0.1031 |
| 623 |                |       | 37 | 100 | 0.0245 | 0.0459 | 0.0111 | 0.0109 |
| 624 |                |       | 41 | 109 | 0.0173 | 0.0258 | 0.0115 | 0.0212 |
| 625 |                |       | 56 | 149 | 0.0198 | 0.0346 | 0.0117 | 0.0177 |
| 626 |                |       | 58 | 156 | 0.0356 | 0.0436 | 0.0244 | 0.0283 |
| 627 |                |       | 61 | 163 | 0.0159 | 0.0224 | 0.0085 |        |
| 628 |                |       | 63 | 169 | 0.0264 |        | 0.0164 | 0.0239 |
| 629 |                |       | 60 | 166 | 0.0524 | 0.0285 | 0.0303 | 0.0958 |
| 630 |                |       | 70 | 186 | 0.0231 | 0.0184 | 0.0121 | 0.0259 |
| 631 | row 3          |       | 60 | 162 | 0.0258 | 0.0217 | 0.0135 | 0.0416 |
| 632 |                |       | 63 | 168 | 0.0153 | 0.0264 | 0.0065 | 0.0084 |
| 633 |                |       | 65 | 175 | 0.031  |        | 0.0076 |        |
| 634 |                |       | 68 | 182 | 0.0175 | 0.0196 | 0.0041 |        |
| 635 |                |       | 64 | 178 | 0.0153 | 0.0229 | 0.0047 | 0.0082 |
| 636 |                |       | 73 | 195 | 0.0211 |        | 0.0124 | 0.0479 |
| 637 | 500 ft station | row 1 | 26 | 70  | 0.0442 | 0.0727 | 0.0296 | 0.0135 |

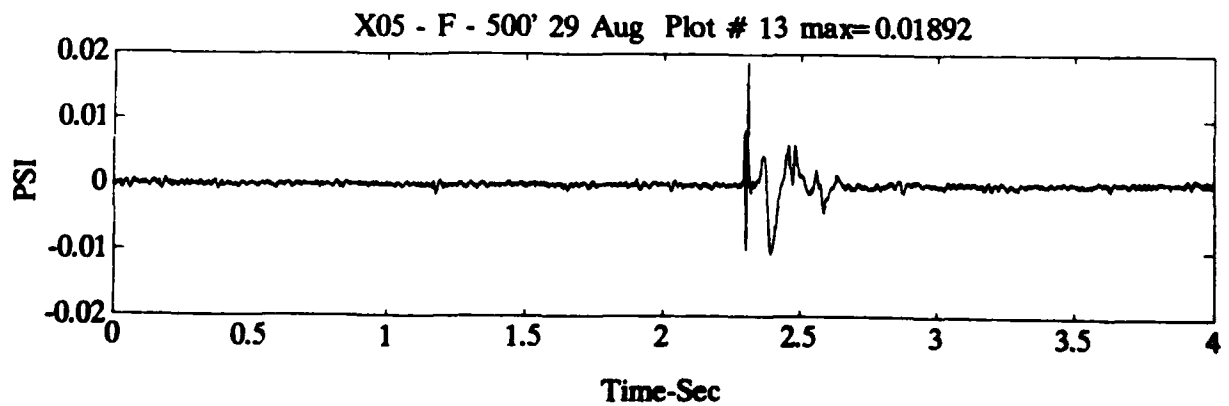
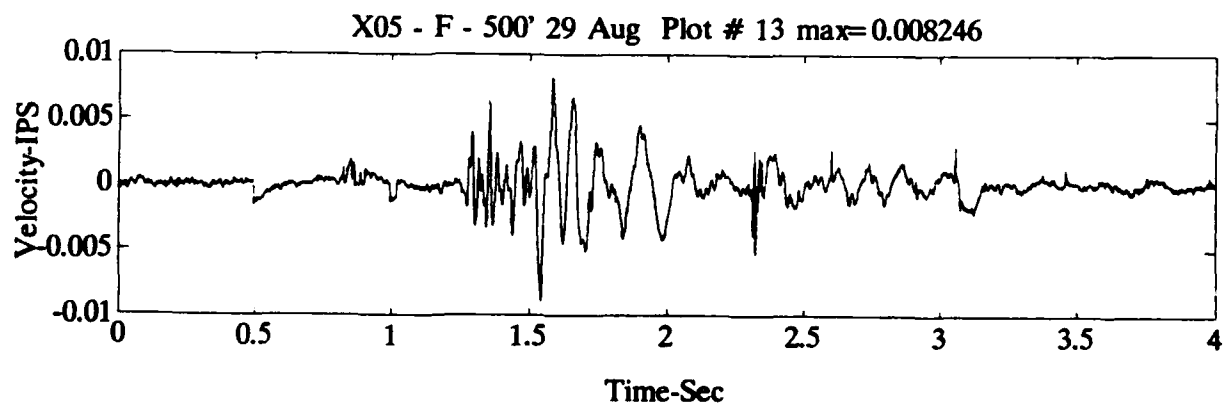
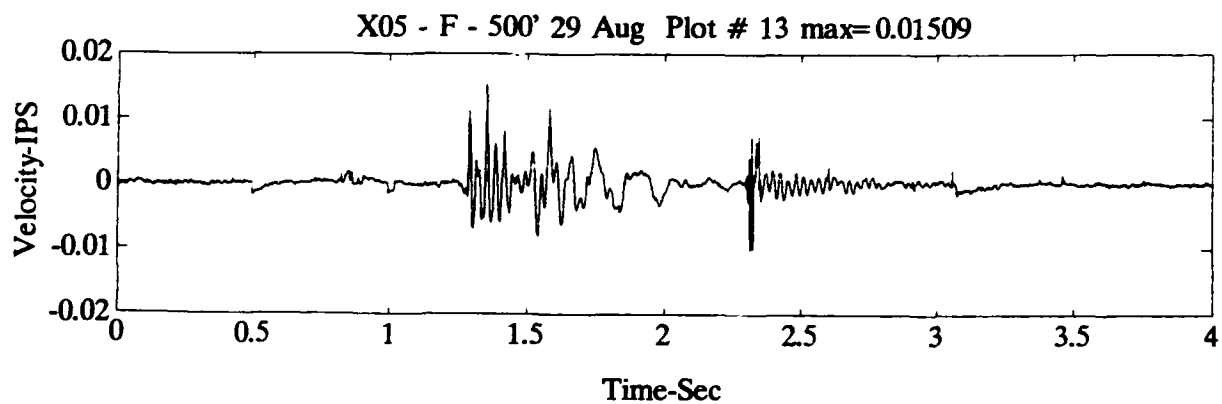
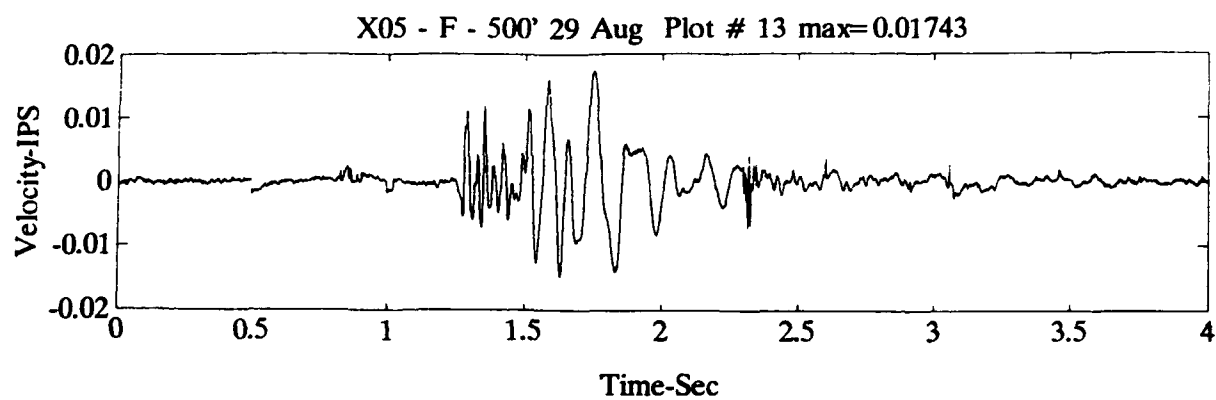
|     | A              | B     | C  | D   | E      | F      | G      | H      |
|-----|----------------|-------|----|-----|--------|--------|--------|--------|
| 638 |                |       | 29 | 77  | 0.0395 | 0.0674 | 0.0319 | 0.0141 |
| 639 |                |       | 31 | 84  | 0.0421 | 0.0403 | 0.0265 |        |
| 640 |                |       | 34 | 92  | 0.0125 | 0.0308 | 0.0142 |        |
| 641 |                |       | 37 | 100 | 0.0134 | 0.0265 | 0.0148 |        |
| 642 |                |       | 40 | 109 | 0.0116 | 0.0193 | 0.0111 |        |
| 643 |                |       | 44 | 117 | 0.0087 | 0.0163 | 0.0075 |        |
| 644 |                |       | 47 | 125 | 0.03   | 0.0371 | 0.0157 | 0.0105 |
| 645 |                |       | 46 | 126 | 0.0066 | 0.0107 | 0.0048 |        |
| 646 |                |       | 53 | 142 | 0.0161 | 0.0216 | 0.0093 | 0.0259 |
| 647 |                |       | 62 | 171 | 0.0076 | 0.0103 | 0.0064 |        |
| 648 |                |       | 65 | 180 | 0.0092 | 0.0104 | 0.0046 |        |
| 649 |                | row 2 | 37 | 100 | 0.0192 | 0.0233 | 0.0077 |        |
| 650 |                |       | 37 | 103 | 0.009  | 0.0221 | 0.0081 |        |
| 651 |                |       | 44 | 118 | 0.0108 | 0.0133 | 0.0072 |        |
| 652 |                |       | 47 | 128 | 0.0099 | 0.012  | 0.0093 |        |
| 653 |                |       | 51 | 137 | 0.0072 | 0.0113 | 0.0064 |        |
| 654 |                |       | 66 | 177 | 0.0074 | 0.0115 | 0.0054 |        |
| 655 |                |       | 68 | 184 | 0.0129 | 0.0136 | 0.0074 |        |
| 656 |                | row 3 | 67 | 179 | 0.0105 | 0.0129 | 0.0054 | 0.0054 |
| 657 | 750 ft station | row 1 | 39 | 105 | 0.0135 | 0.0129 | 0.0118 |        |
| 658 |                |       | 42 | 112 | 0.0128 | 0.0094 | 0.0081 |        |
| 659 |                |       | 44 | 119 | 0.008  | 0.0078 | 0.0063 |        |
| 660 |                |       | 47 | 127 | 0.0092 | 0.008  | 0.005  |        |
| 661 |                |       | 50 | 135 | 0.0217 | 0.0173 | 0.0162 |        |
| 662 |                |       | 53 | 142 | 0.006  | 0.0064 | 0.0062 |        |
| 663 |                |       | 56 | 151 | 0.007  | 0.0065 | 0.0038 |        |
| 664 |                |       | 59 | 159 | 0.005  | 0.0051 | 0.003  |        |
| 665 |                |       | 57 | 158 | 0.0051 | 0.0064 | 0.0053 |        |
| 666 |                |       | 65 | 175 | 0.0071 | 0.0076 | 0.004  |        |

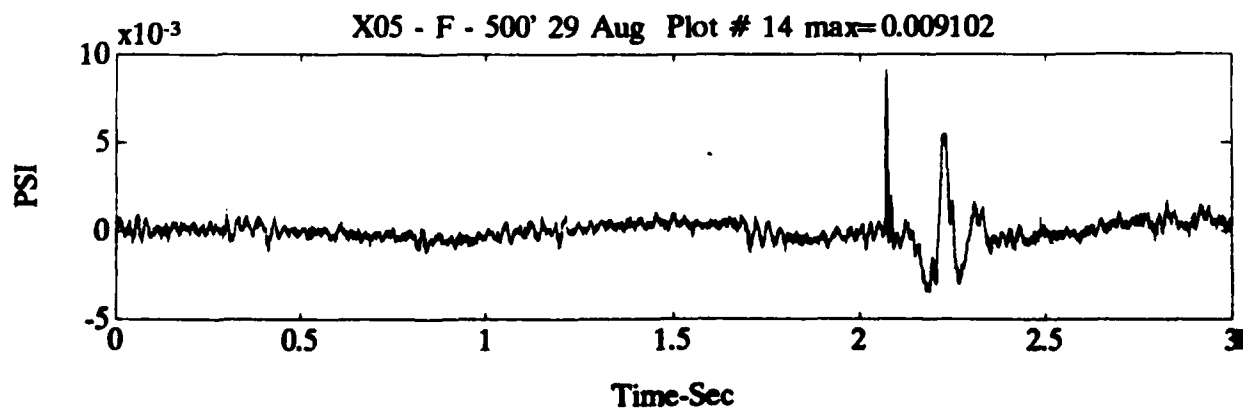
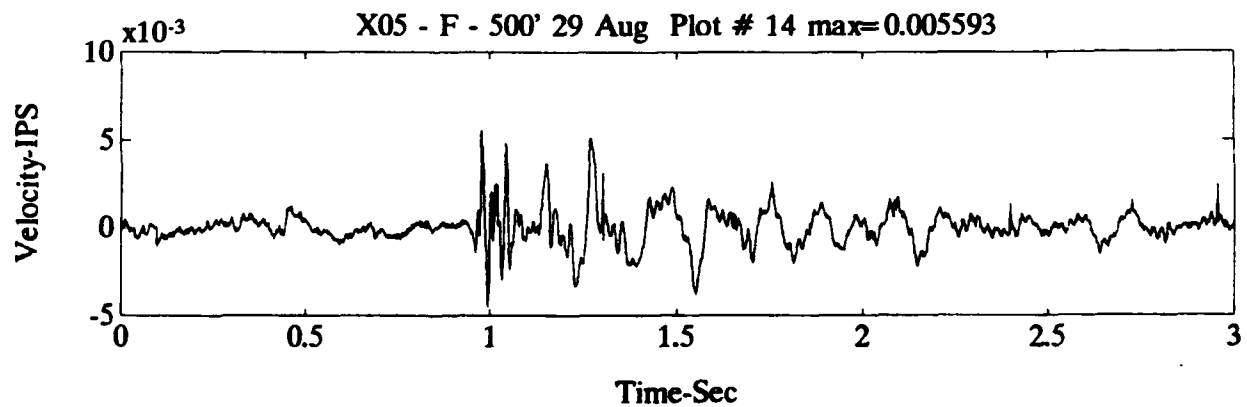
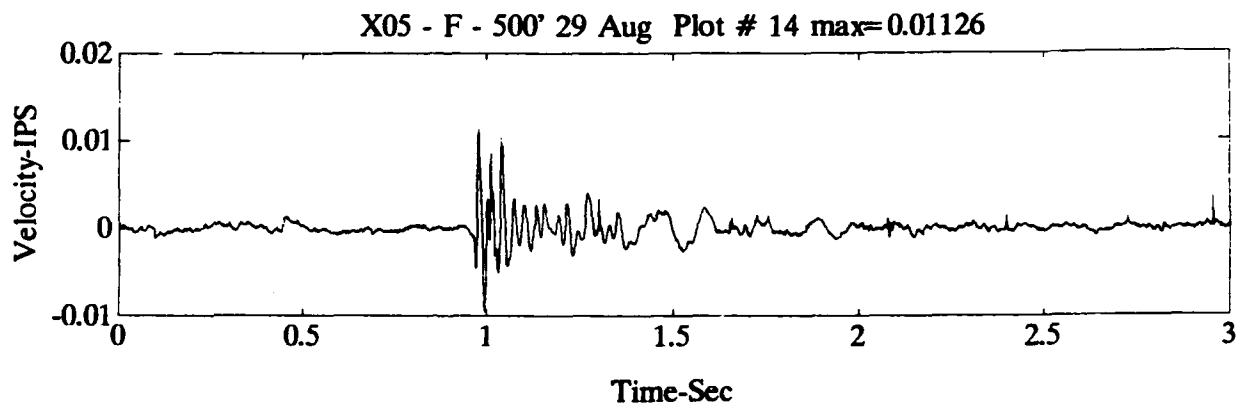
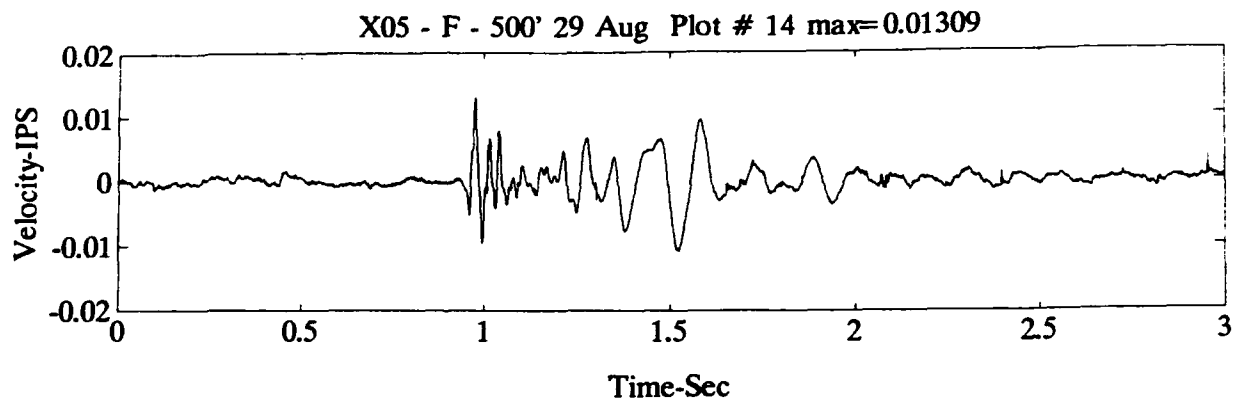
|     | A               | B     | C   | D   | E      | F      | G      | H       |
|-----|-----------------|-------|-----|-----|--------|--------|--------|---------|
| 667 |                 |       | 73  | 201 | 0.0034 | 0.0042 | 0.0029 |         |
| 668 |                 |       | 76  | 210 | 0.0076 | 0.0107 | 0.0055 |         |
| 669 |                 |       | 86  | 232 | 0.0026 | 0.0034 | 0.0027 |         |
| 670 |                 |       | 90  | 242 | 0.0019 | 0.0037 | 0.0024 |         |
| 671 |                 |       | 94  | 251 | 0.0042 | 0.0053 | 0.0043 | 0.0051  |
| 672 |                 |       | 97  | 261 | 0.0014 | 0.0046 | 0.0019 | 0.0055  |
| 673 |                 | row 2 | 49  | 132 | 0.0042 | 0.0042 | 0.0031 |         |
| 674 |                 |       | 48  | 133 | 0.0081 | 0.0081 | 0.0046 | 0.0143  |
| 675 |                 |       | 56  | 149 | 0.0056 | 0.0064 | 0.0046 |         |
| 676 |                 |       | 59  | 158 | 0.0028 | 0.0039 | 0.0031 |         |
| 677 |                 |       | 62  | 167 | 0.0036 | 0.0047 | 0.0031 | 0.0079  |
| 678 |                 |       | 77  | 207 | 0.0062 | 0.0064 | 0.0043 | 0.0067  |
| 679 |                 |       | 80  | 214 | 0.0026 | 0.0045 | 0.0025 |         |
| 680 |                 |       | 82  | 220 | 0.0048 | 0.0071 | 0.0036 | 0.0039  |
| 681 |                 |       | 85  | 227 | 0.0042 | 0.0058 | 0.0042 | 0.0111  |
| 682 |                 |       | 80  | 220 | 0.0067 | 0.0075 | 0.0051 | 0.0061  |
| 683 |                 |       | 92  | 245 | 0.0035 | 0.0051 | 0.0032 |         |
| 684 |                 | row 3 | 76  | 204 | 0.0029 | 0.0043 | 0.0032 |         |
| 685 |                 |       | 79  | 211 | 0.0028 | 0.0047 | 0.0023 |         |
| 686 |                 |       | 81  | 217 | 0.003  | 0.006  | 0.0035 |         |
| 687 |                 |       | 83  | 224 | 0.0027 | 0.0027 | 0.0028 |         |
| 688 |                 |       | 79  | 218 | 0.0057 | 0.0048 | 0.0043 |         |
| 689 |                 |       | 88  | 237 | 0.0098 | 0.0064 | 0.0059 | 0.0168  |
| 690 | 2900 ft station | row 1 | 151 | 405 | 0.0026 | 0.0029 | 0.0029 | 0.00053 |
| 691 |                 |       | 153 | 412 | 0.0033 | 0.005  | 0.0038 | 0.0011  |
| 692 |                 |       | 156 | 419 | 0.0017 | 0.0028 | 0.0026 | 0.00013 |
| 693 |                 |       | 159 | 426 | 0.0022 | 0.0039 | 0.0049 | 0.00026 |
| 694 |                 |       | 161 | 433 | 0.0019 | 0.0043 | 0.0052 | 0.00023 |
| 695 |                 |       | 164 | 440 | 0.0039 | 0.0083 | 0.0058 | 0.00078 |

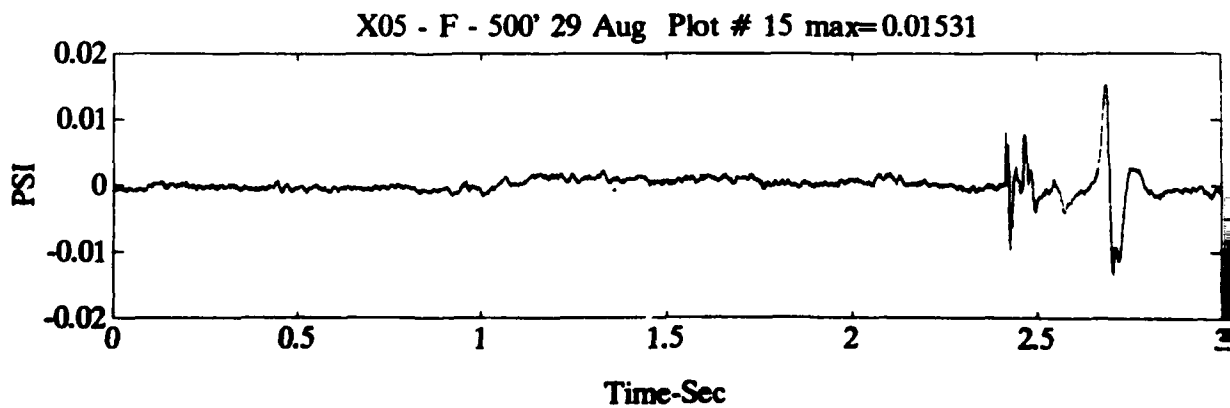
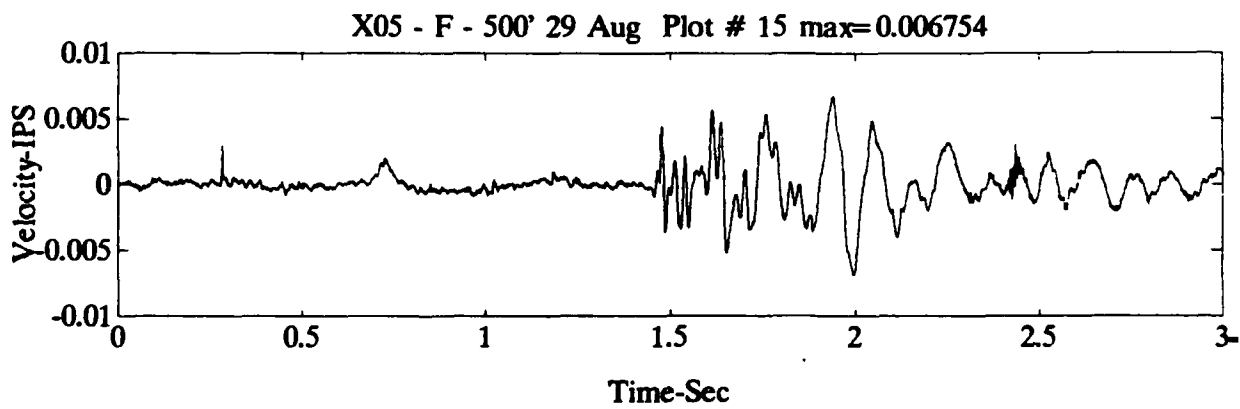
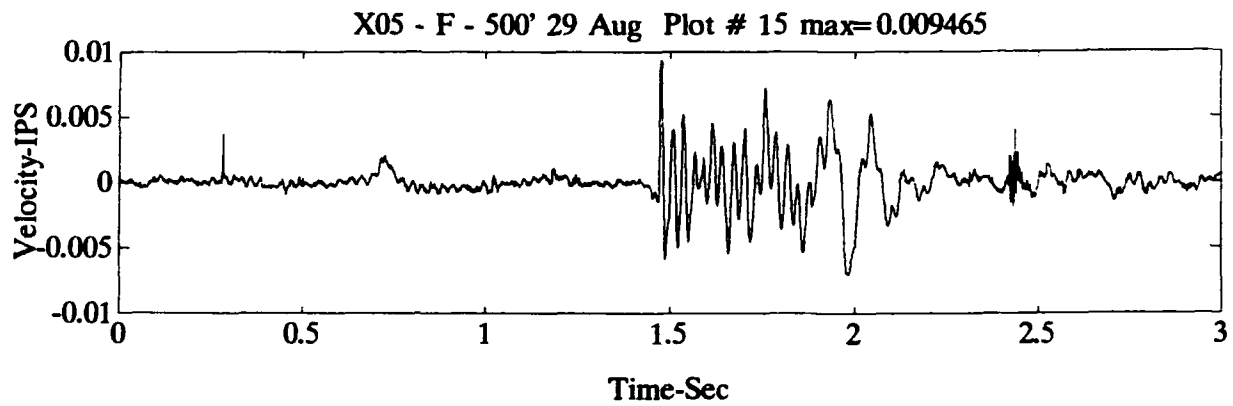
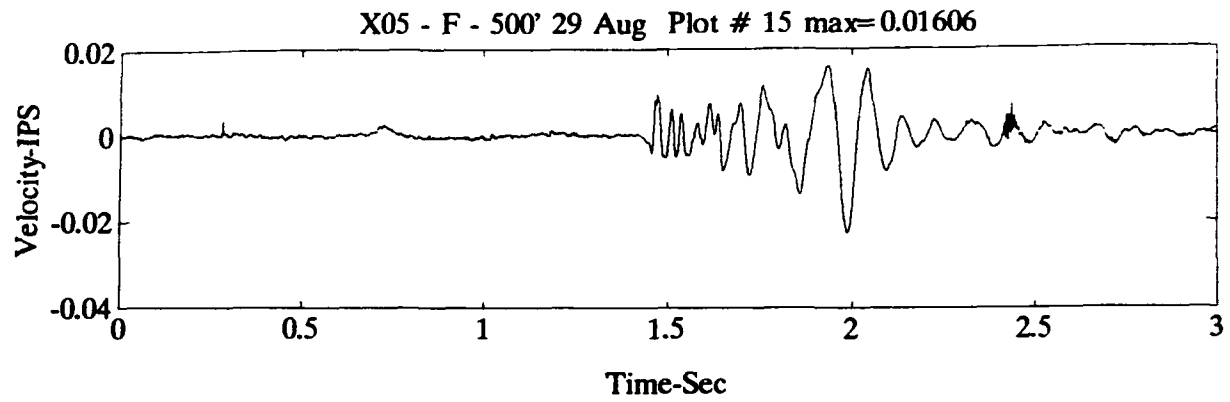
|     | A | B     | C   | D   | E       | F      | G      | H       |
|-----|---|-------|-----|-----|---------|--------|--------|---------|
| 696 |   |       | 167 | 448 | 0.0025  | 0.0035 | 0.0036 | 0.00034 |
| 697 |   |       | 170 | 455 | 0.0059  | 0.0083 | 0.0086 | 0.0014  |
| 698 |   |       | 158 | 437 | 0.0016  | 0.0024 | 0.0018 | 0.00068 |
| 699 |   |       | 175 | 470 | 0.0043  | 0.0041 | 0.0031 | 0.0014  |
| 700 |   |       | 172 | 476 | 0.0026  | 0.0052 | 0.0033 | 0.00054 |
| 701 |   |       | 175 | 484 | 0.0033  | 0.0037 | 0.0033 | 0.00147 |
| 702 |   |       | 194 | 522 | 0.0026  | 0.0046 | 0.0018 | 0.00039 |
| 703 |   |       | 197 | 530 | 0.0064  | 0.0075 | 0.0035 | 0.00041 |
| 704 |   |       | 201 | 539 | 0.0023  | 0.0035 | 0.0018 | 0.00024 |
| 705 |   |       | 204 | 547 | 0.0012  | 0.0021 | 0.0026 | 0.00014 |
| 706 |   |       | 213 | 567 | 0.0018  | 0.0032 | 0.0018 | 0.00051 |
| 707 |   |       | 210 | 565 | 0.0036  | 0.0083 | 0.0041 | 0.0016  |
| 708 |   |       | 196 | 542 | 0.0033  | 0.0025 | 0.002  | 0.0004  |
| 709 |   |       | 217 | 583 | 0.0019  | 0.0029 | 0.002  | 0.00034 |
| 710 |   | row 2 | 158 | 424 | 0.0022  | 0.0027 | 0.0025 | 0.00017 |
| 711 |   |       | 147 | 408 | 0.0097  | 0.0085 | 0.0085 |         |
| 712 |   |       | 164 | 440 | 0.0039  | 0.006  | 0.0035 | 0.00089 |
| 713 |   |       | 167 | 448 | 0.0044  | 0.0067 | 0.003  | 0.00064 |
| 714 |   |       | 170 | 456 | 0.003   | 0.0042 | 0.0023 | 0.00037 |
| 715 |   |       | 183 | 492 | 0.0028  | 0.0071 | 0.0027 | 0.00049 |
| 716 |   |       | 185 | 498 | 0.0021  | 0.0038 | 0.0016 | 0.00074 |
| 717 |   |       | 188 | 504 | 0.0035  | 0.0023 | 0.0032 | 0.0015  |
| 718 |   |       | 190 | 510 | 0.0012  | 0.0011 | 0.0018 | 0.00022 |
| 719 |   |       | 176 | 487 | 0.0037  | 0.0054 | 0.0032 | 0.0013  |
| 720 |   |       | 200 | 532 | 0.0032  | 0.0062 | 0.0035 | 0.00044 |
| 721 |   |       | 197 | 528 | 0.0031  | 0.0046 | 0.0027 | 0.00035 |
| 722 |   |       | 199 | 535 | 0.0028  | 0.0082 | 0.0036 | 0.0011  |
| 723 |   |       | 201 | 541 | 0.00092 | 0.0026 | 0.0016 | 0.00049 |
| 724 |   |       | 187 | 516 | 0.0031  | 0.0049 | 0.0029 | 0.0014  |

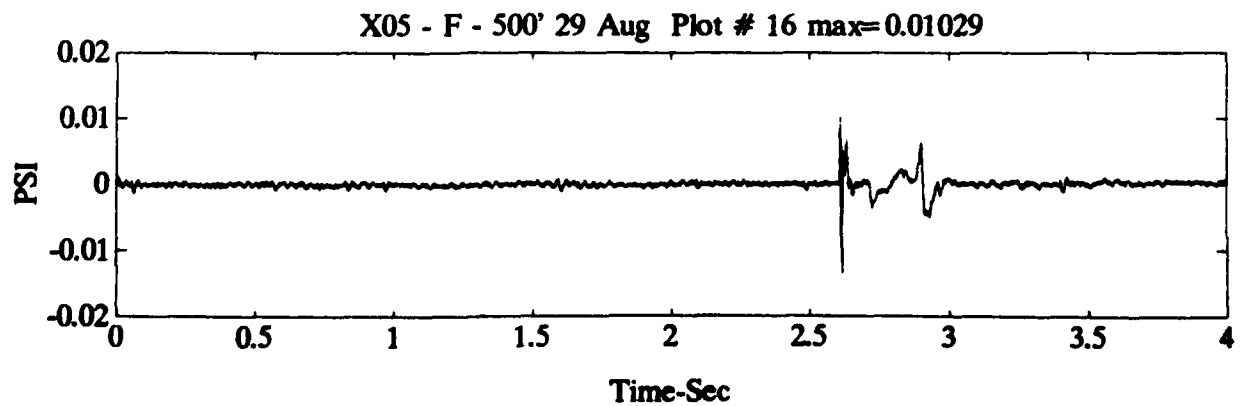
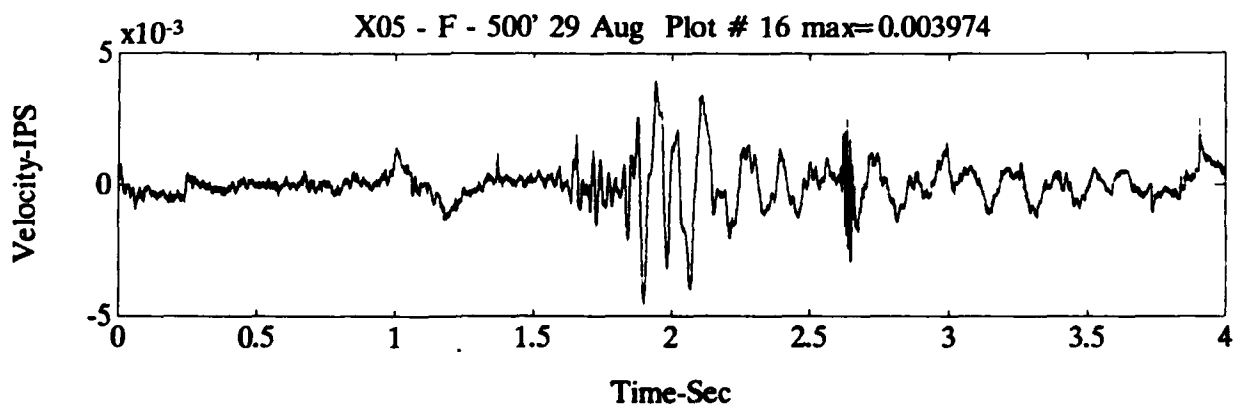
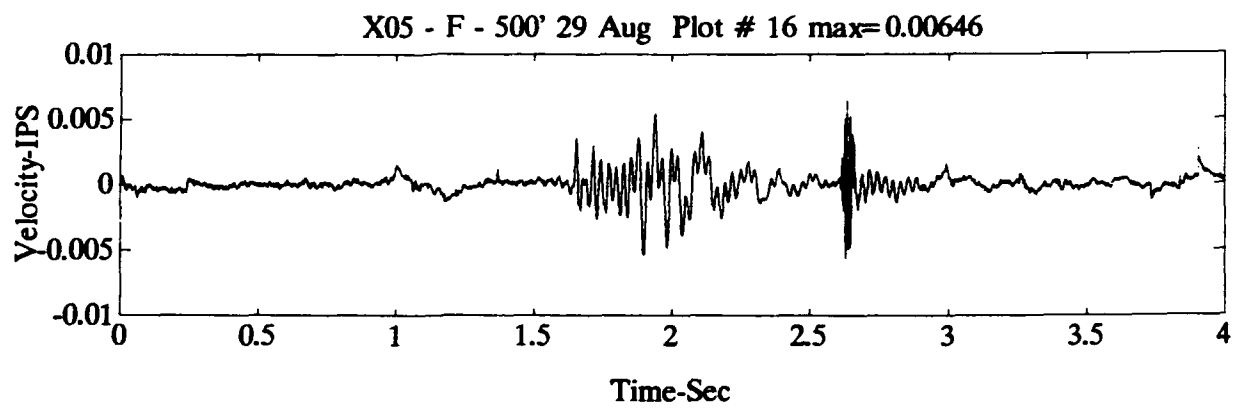
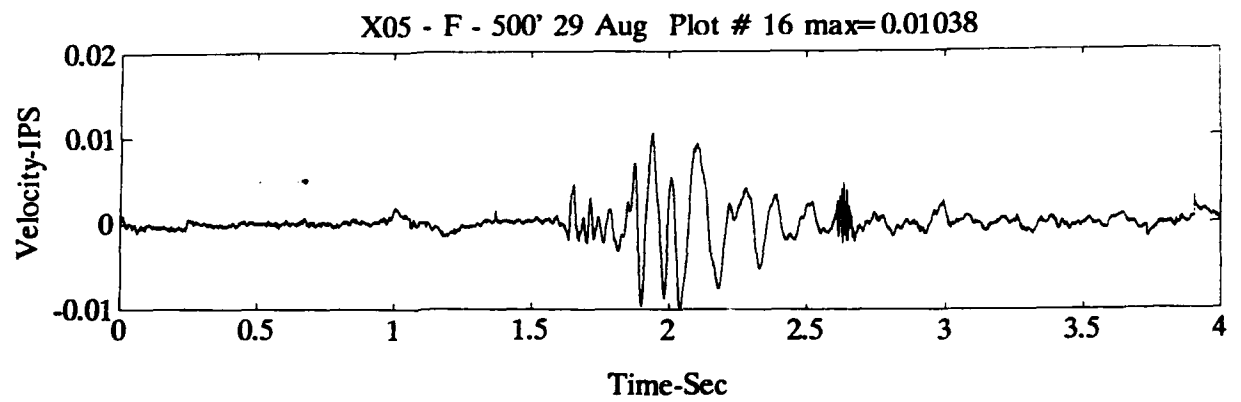
|     | A | B     | C   | D   | E      | F       | G       | H       |
|-----|---|-------|-----|-----|--------|---------|---------|---------|
| 725 |   | row 3 | 177 | 475 | 0.0016 | 0.0024  | 0.0012  | 0.00074 |
| 726 |   |       | 179 | 481 | 0.0011 | 0.00075 | 0.00079 | 0.0009  |
| 727 |   |       | 181 | 487 | 0.0019 | 0.0027  | 0.0017  | 0.00023 |
| 728 |   |       | 184 | 493 | 0.0019 | 0.0032  | 0.0016  | 0.00045 |
| 729 |   |       | 170 | 471 | 0.0033 | 0.0083  | 0.0042  | 0.00075 |
| 730 |   |       | 188 | 505 | 0.0044 | 0.0021  | 0.0027  | 0.0015  |
| 731 |   |       | 191 | 512 | 0.0013 | 0.0028  | 0.0011  | 0.0011  |
| 732 |   |       | 193 | 518 | 0.0012 | 0.0016  | 0.0011  | 0.00034 |
| 733 |   |       | 171 | 480 | 0.0016 | 0.0026  | 0.0014  | 0.00029 |

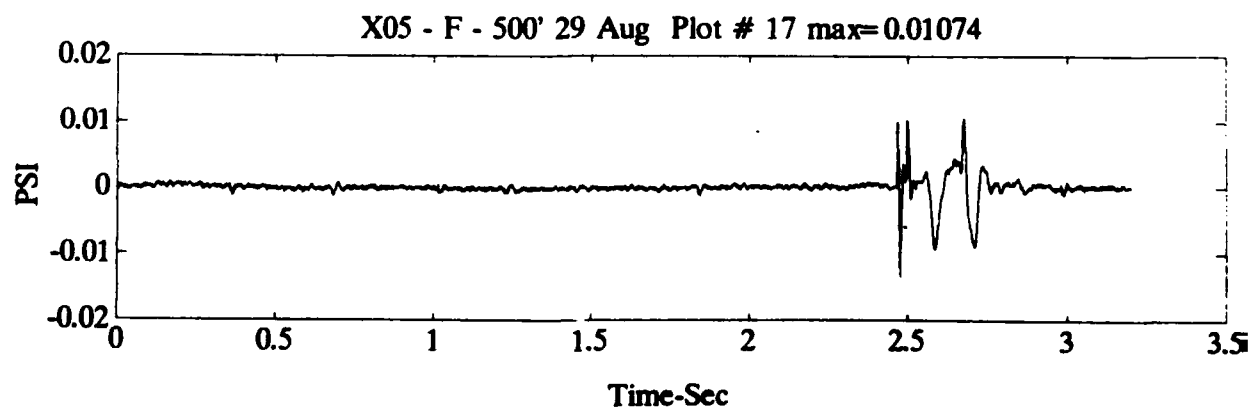
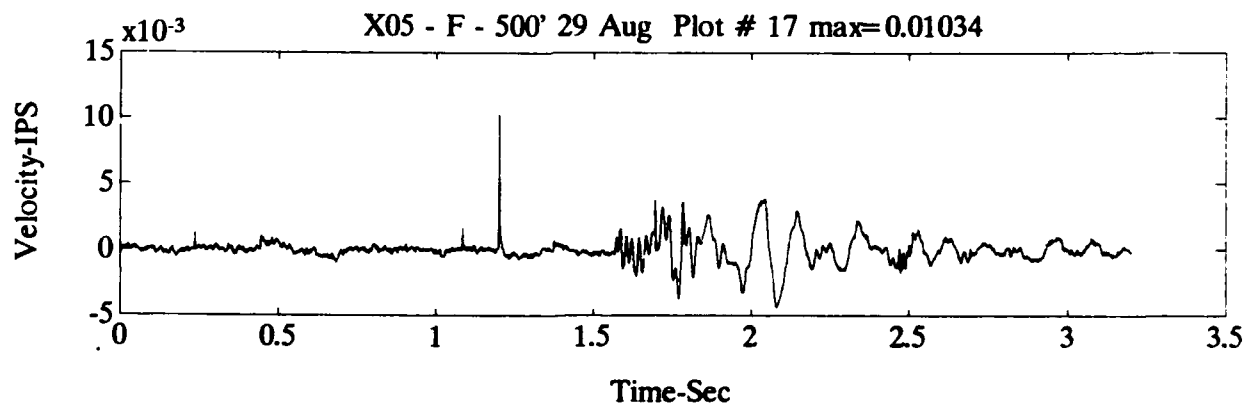
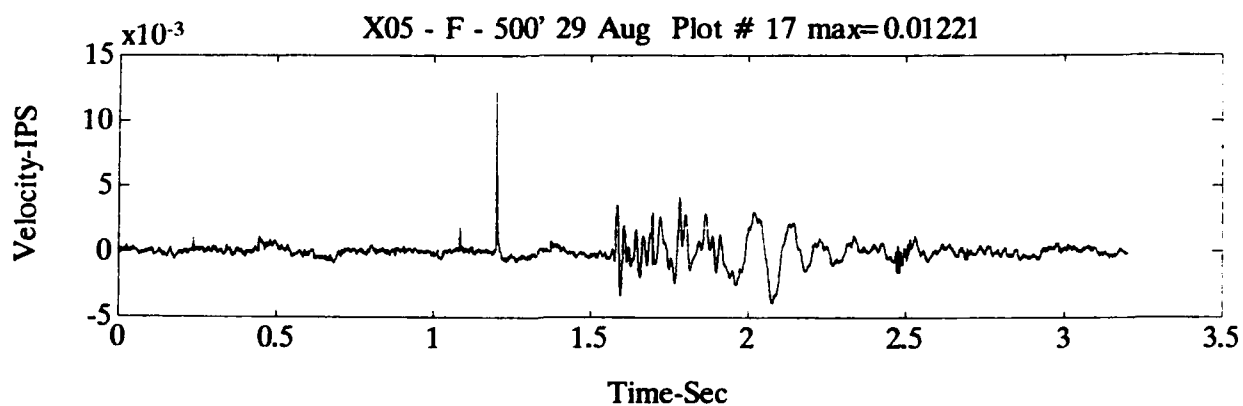
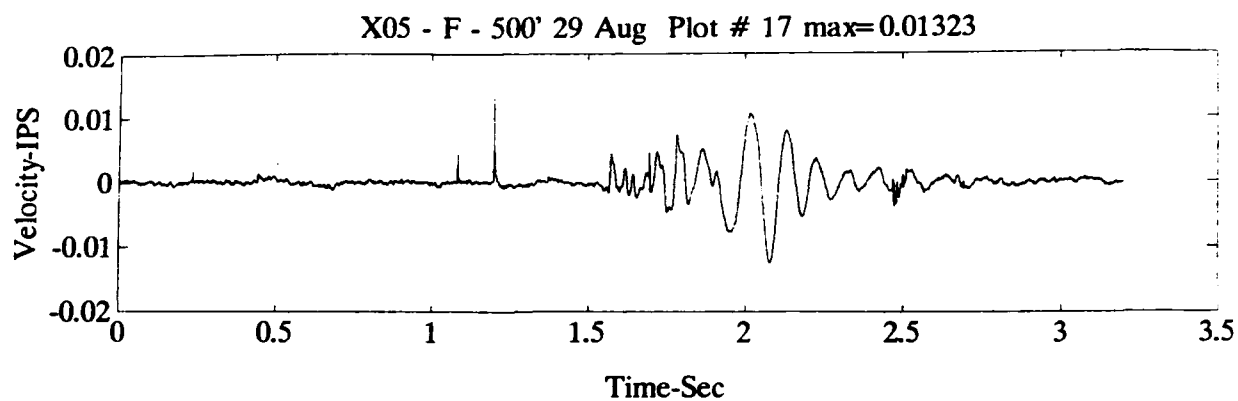
**Appendix B: Selected Particle Velocity Versus Time Records  
and Air Overpressure Versus Time Records for  
Stations Monitored at the NSWC**

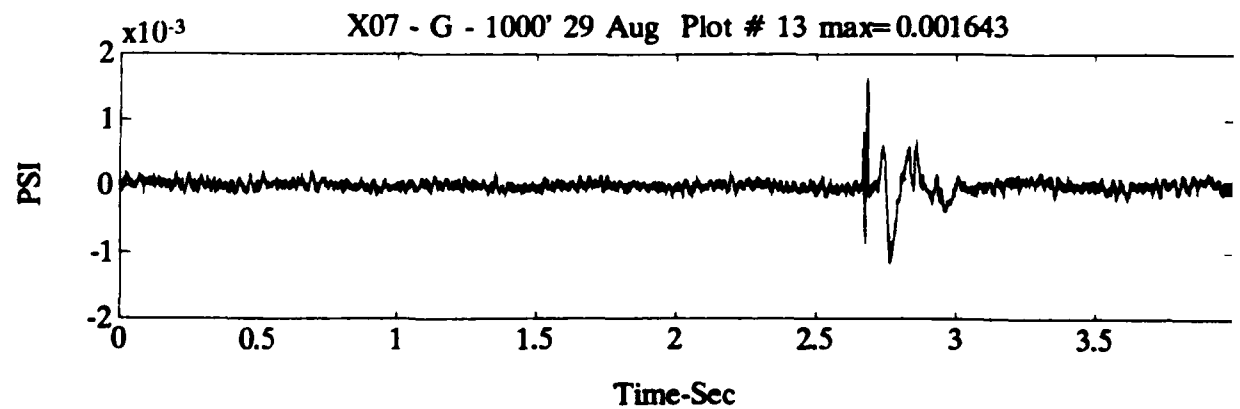
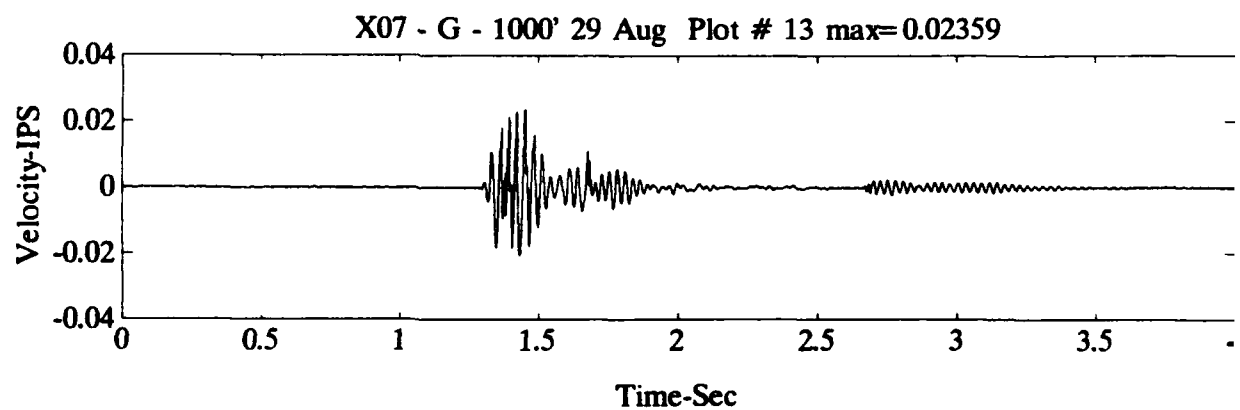
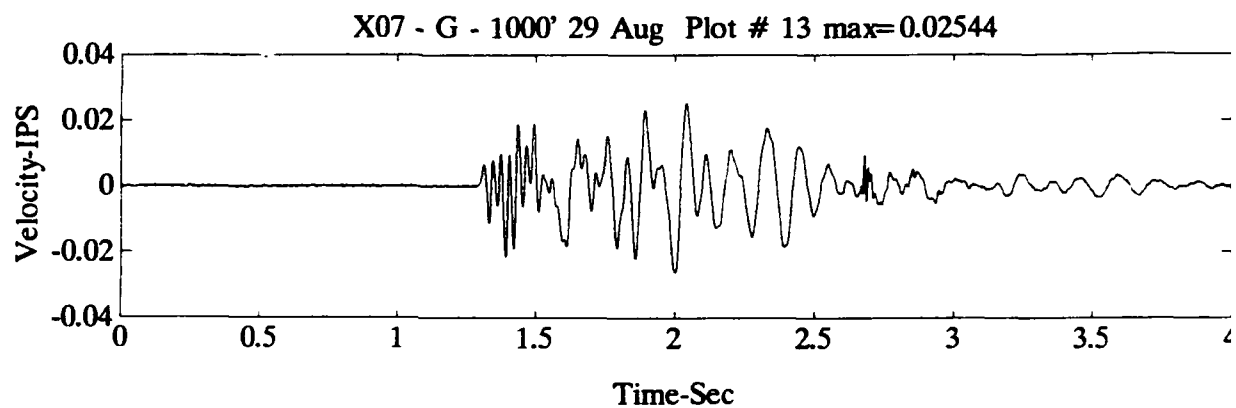
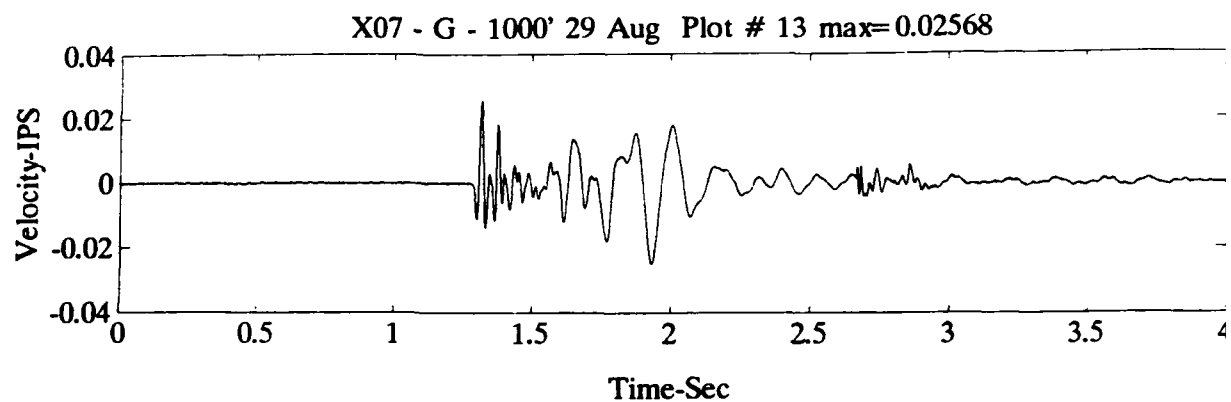


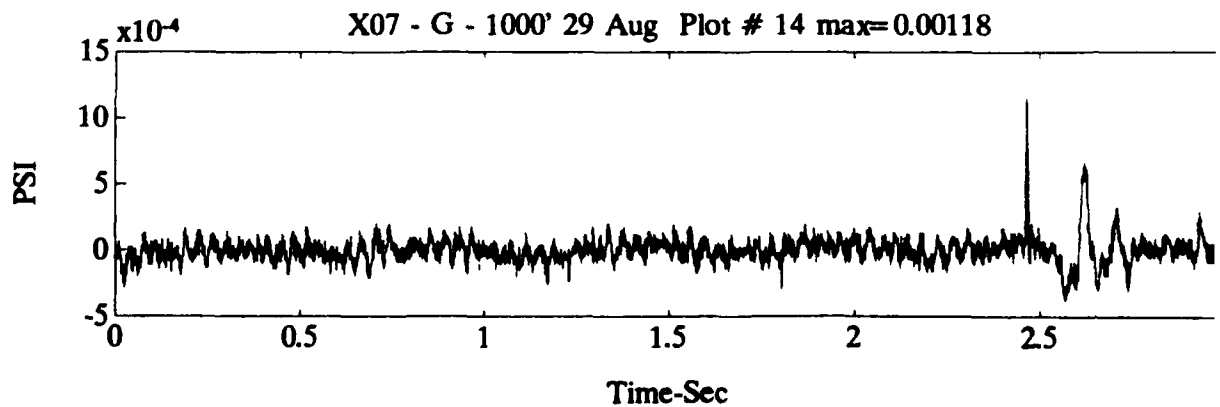
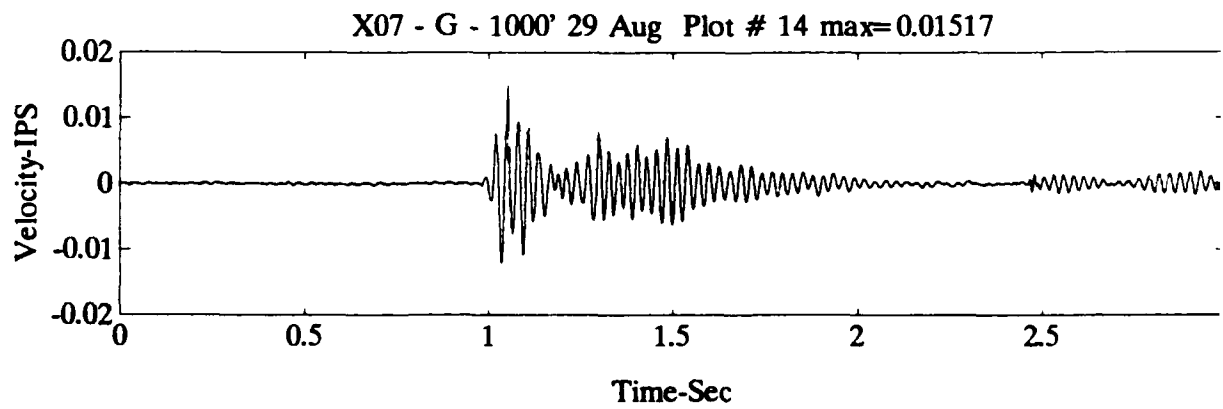
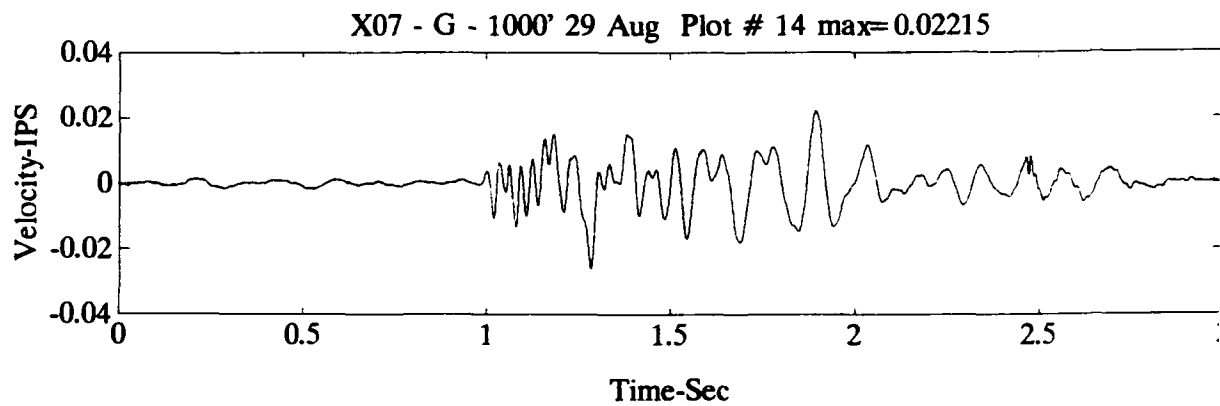
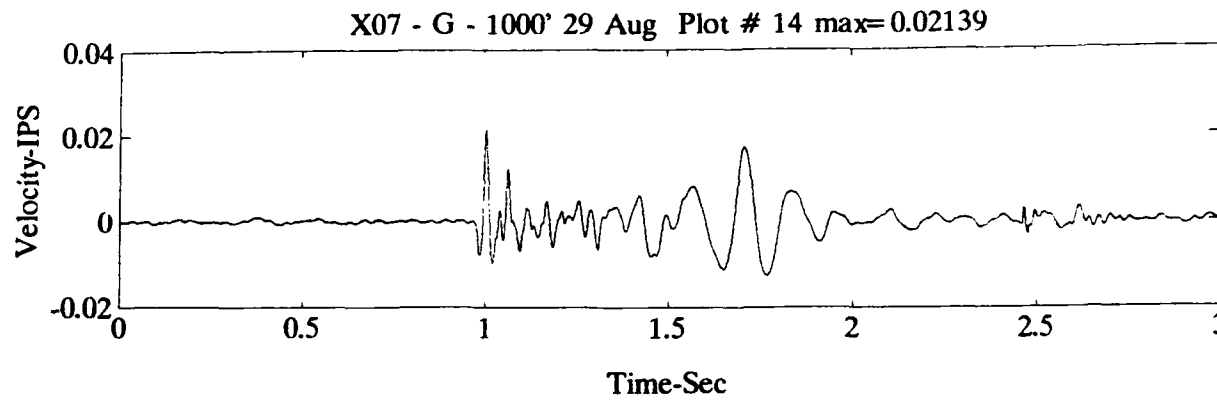


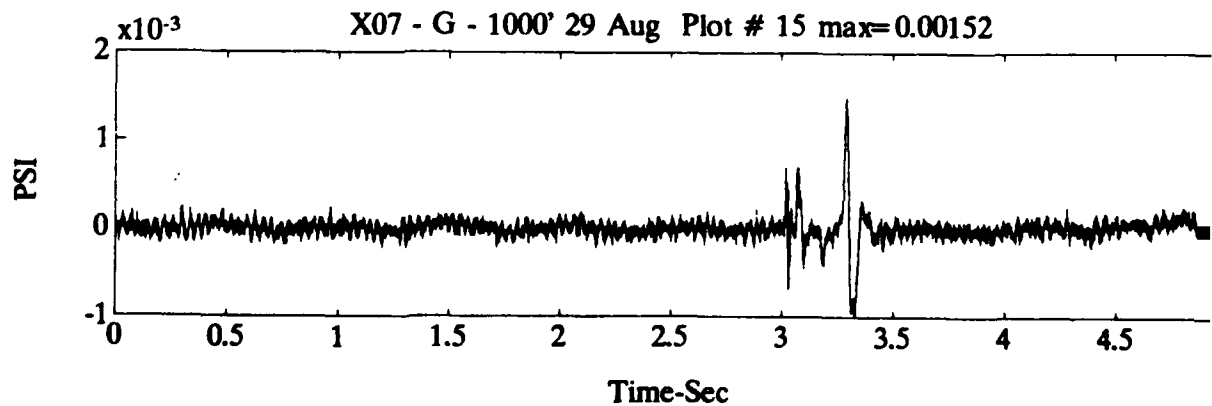
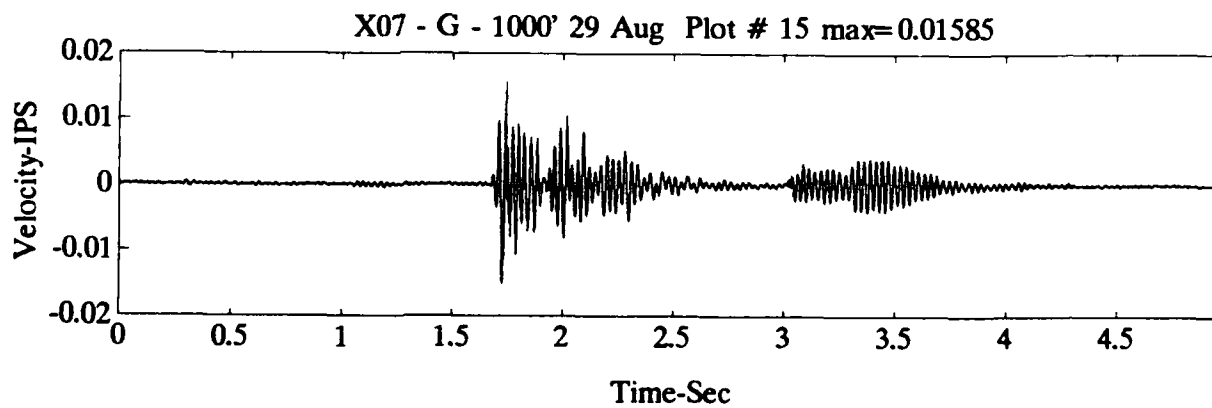
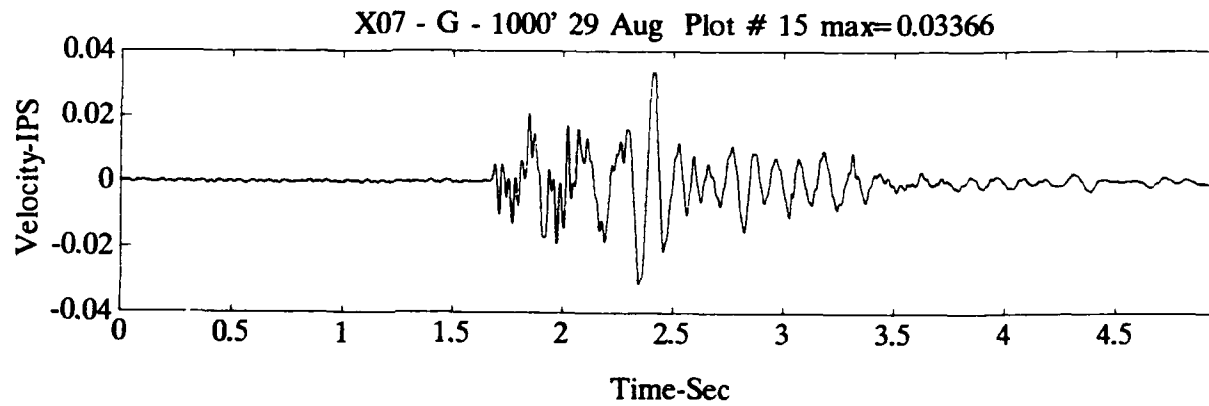
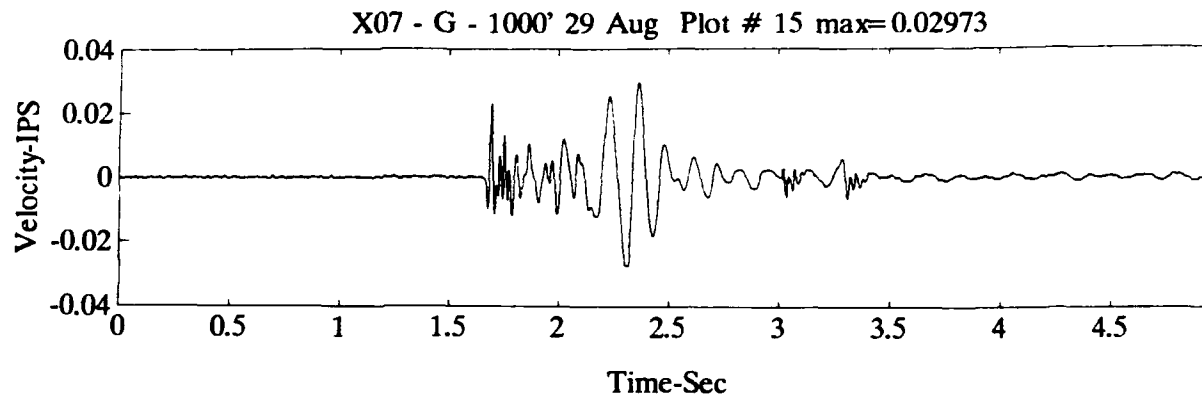


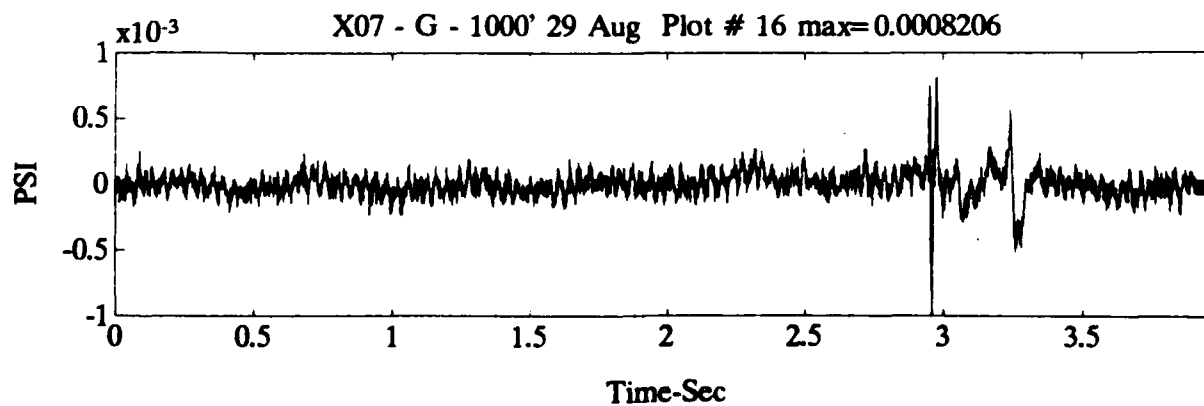
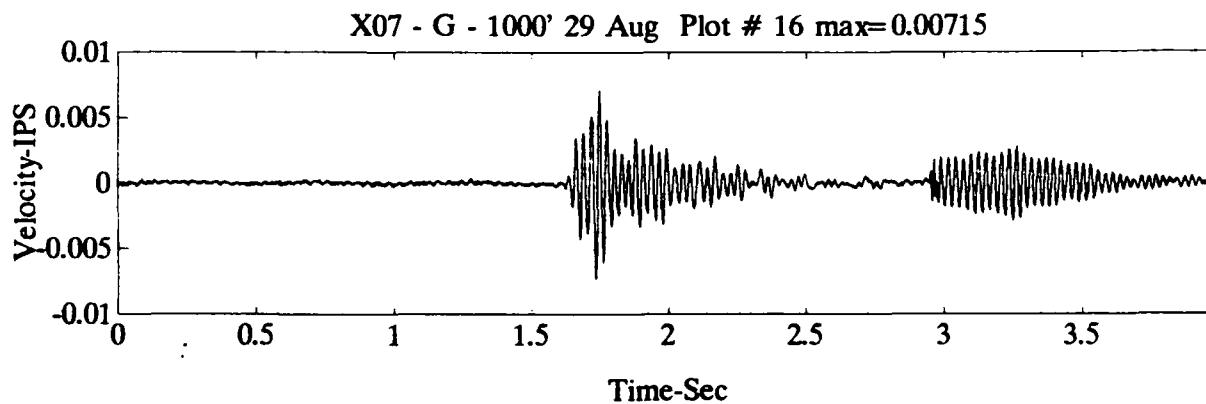
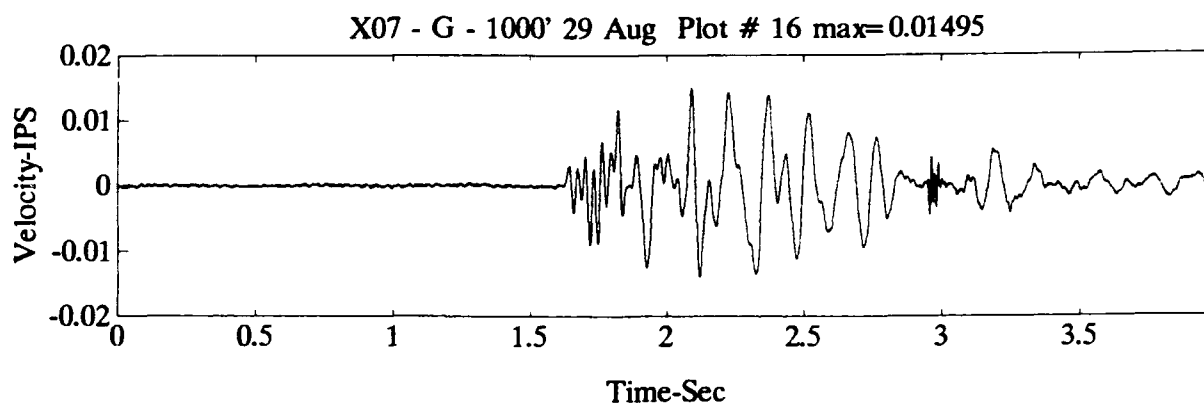
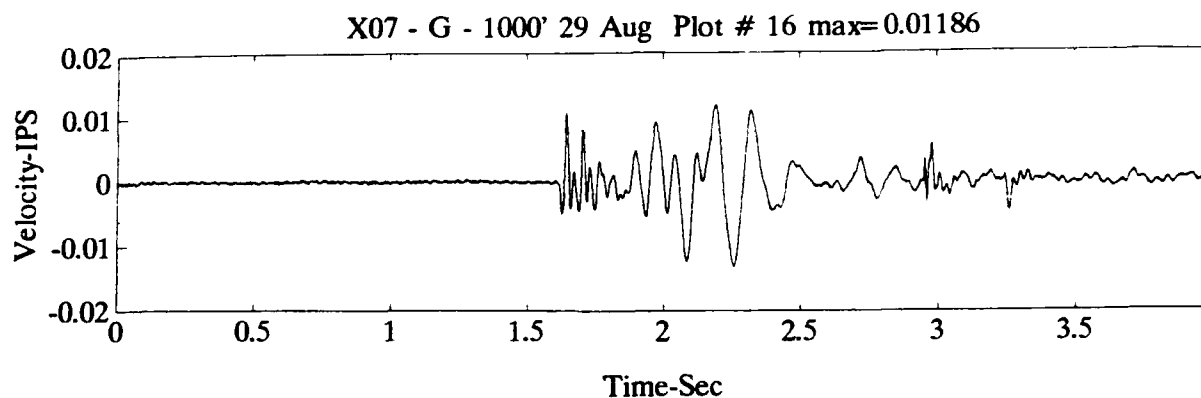


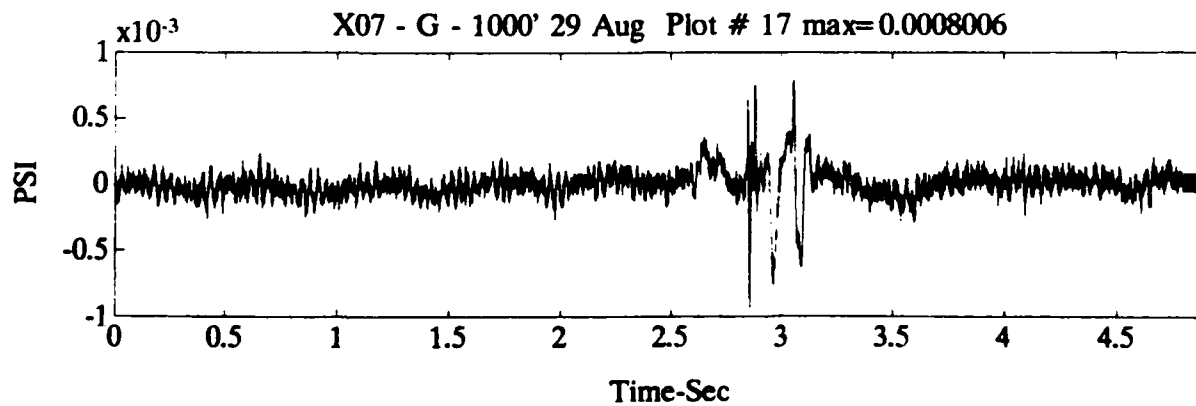
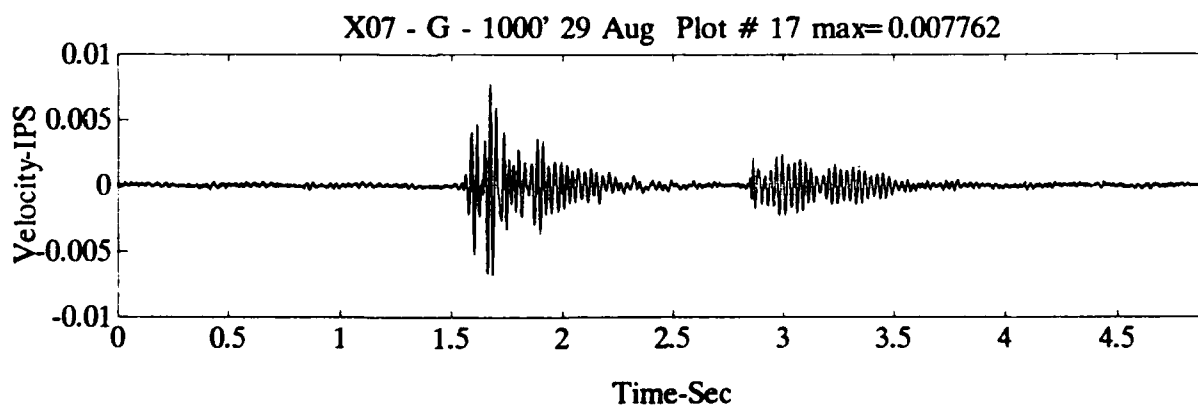
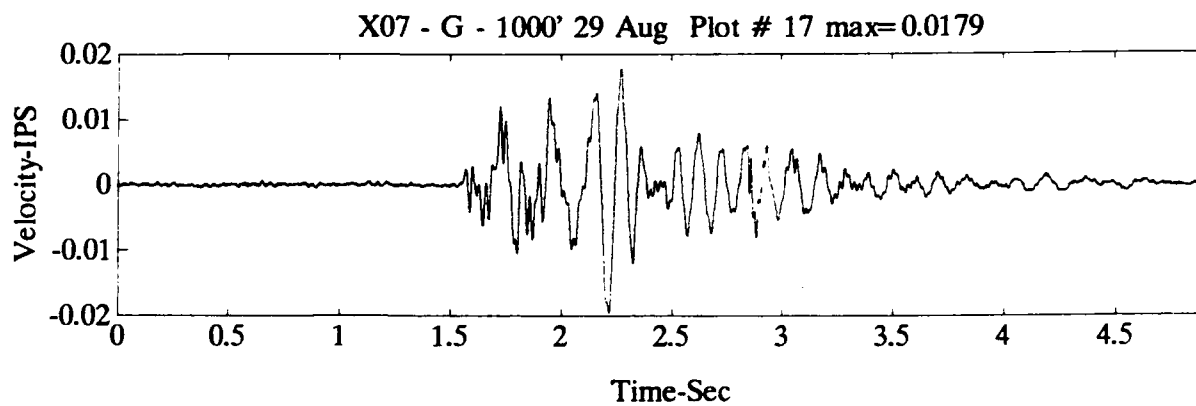
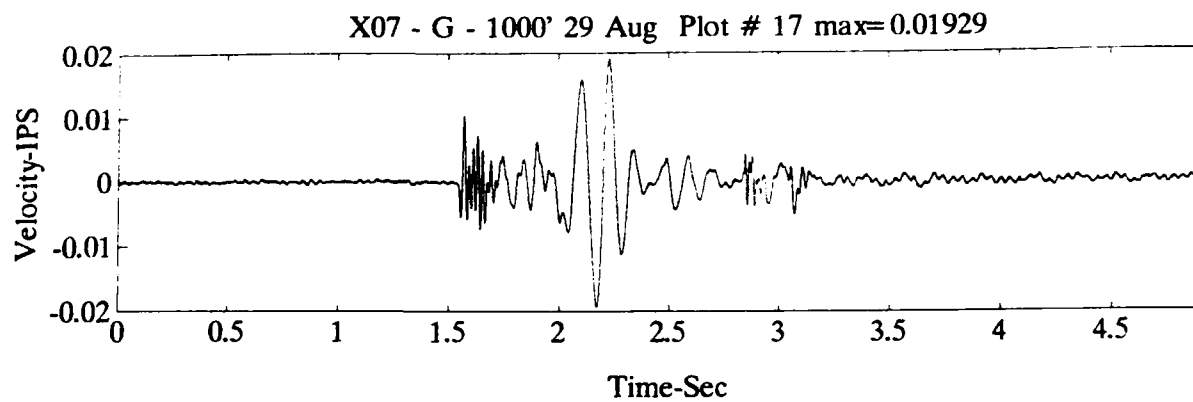


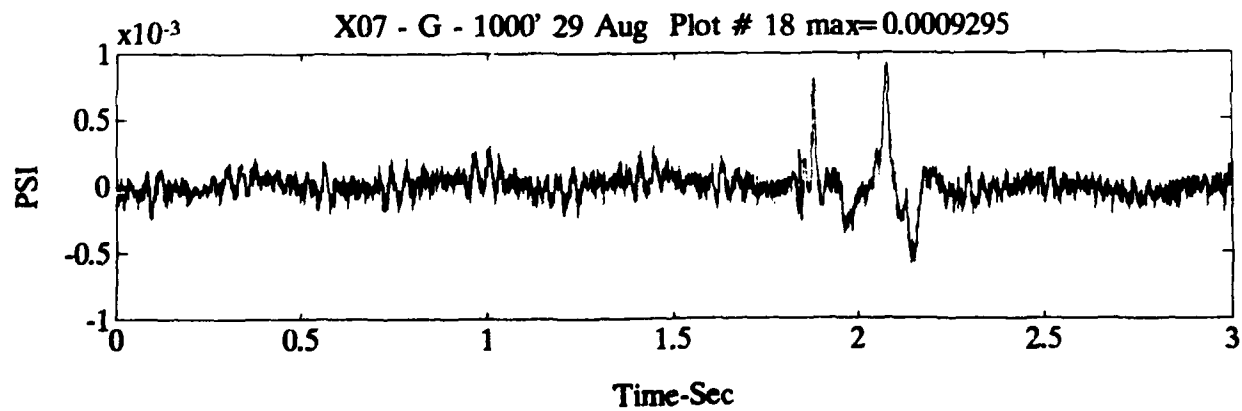
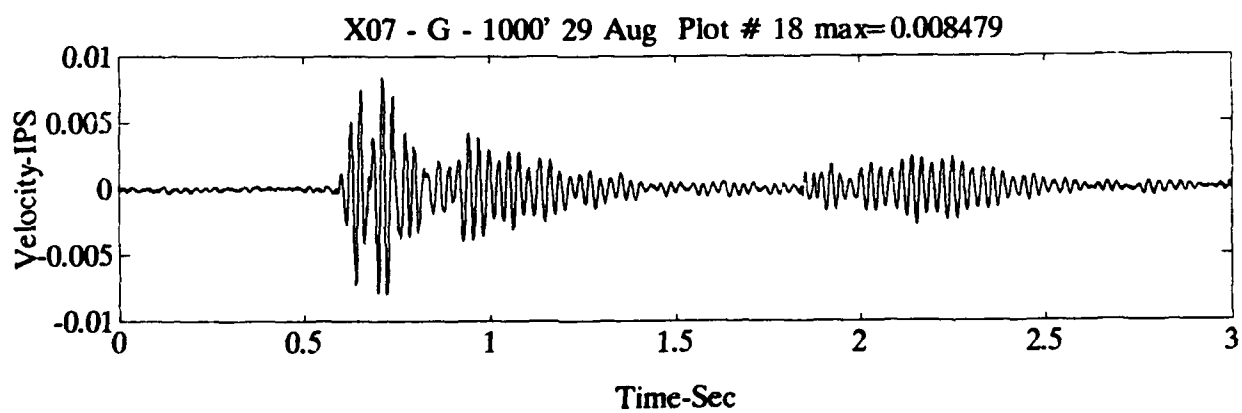
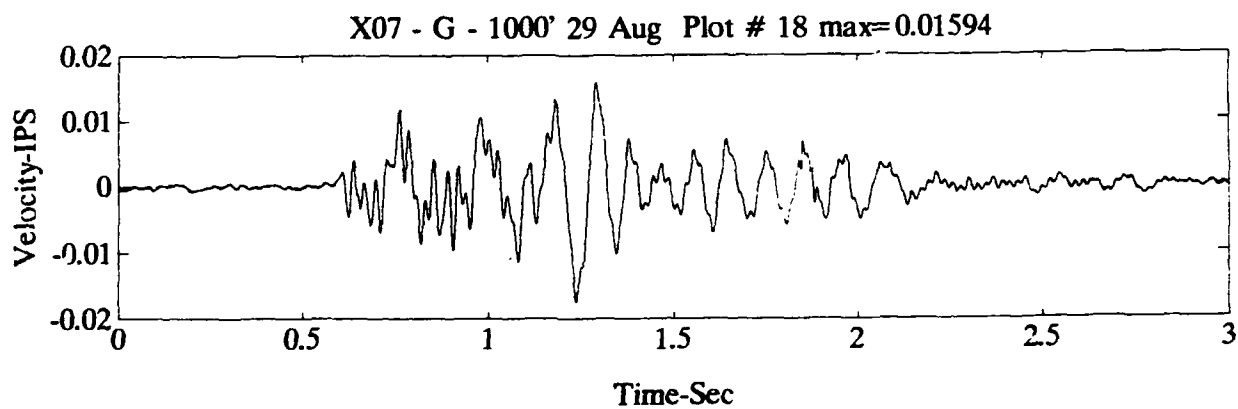
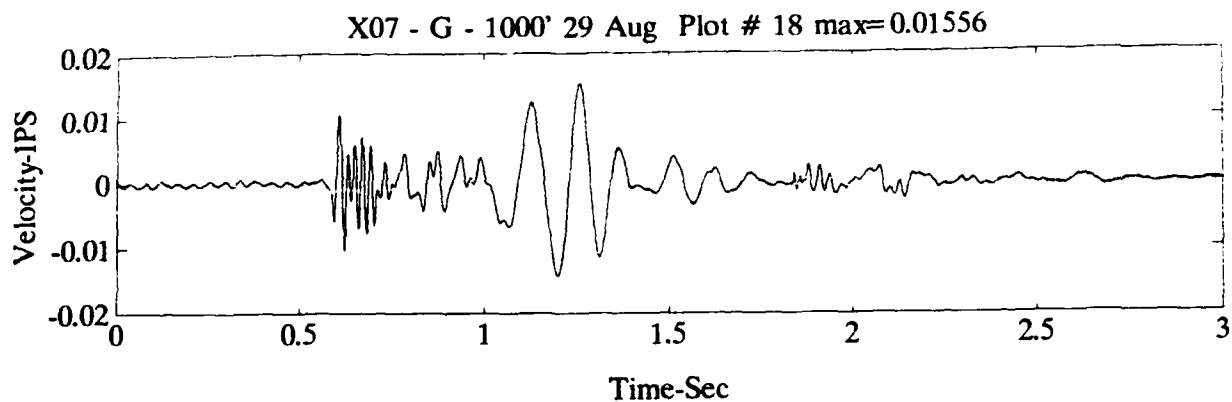


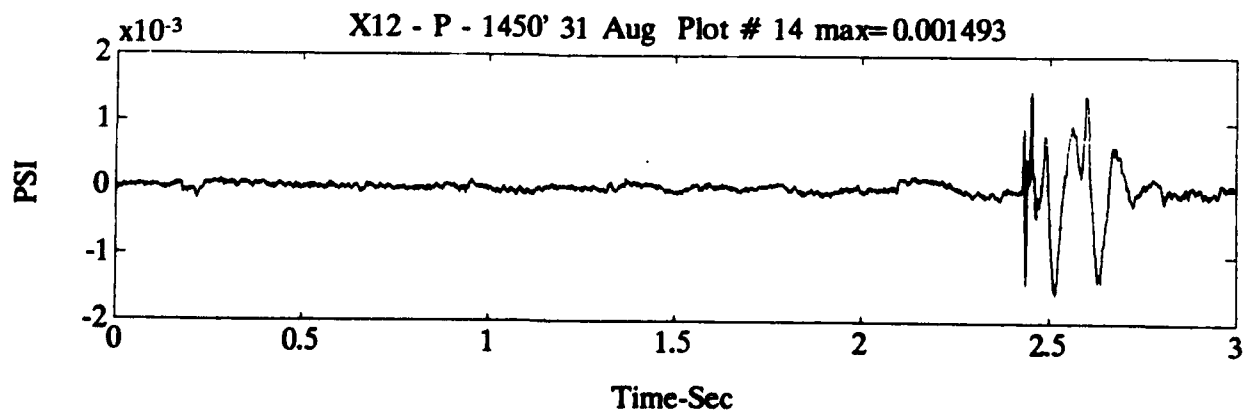
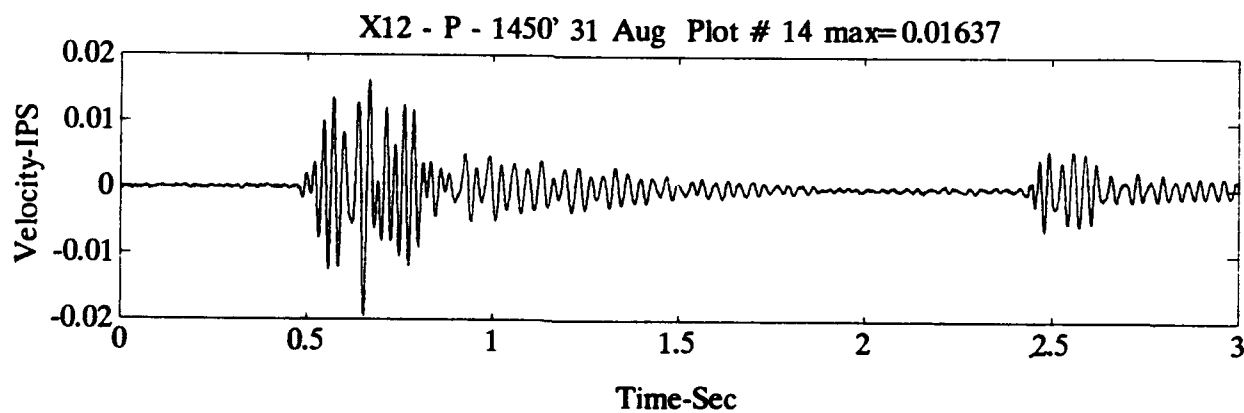
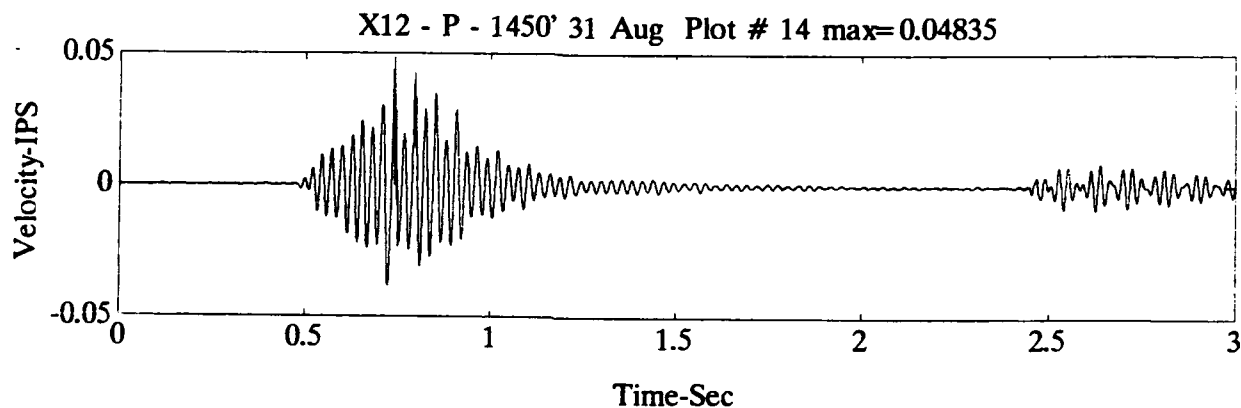
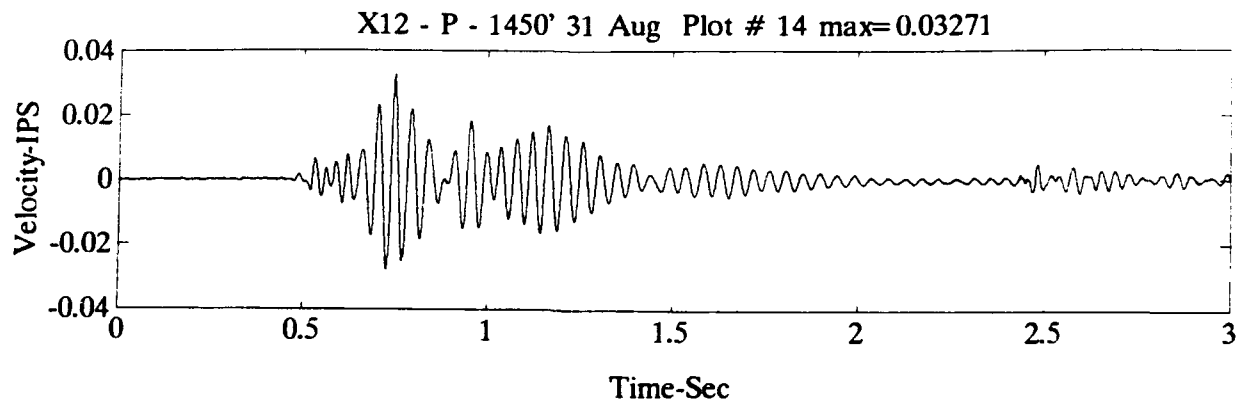


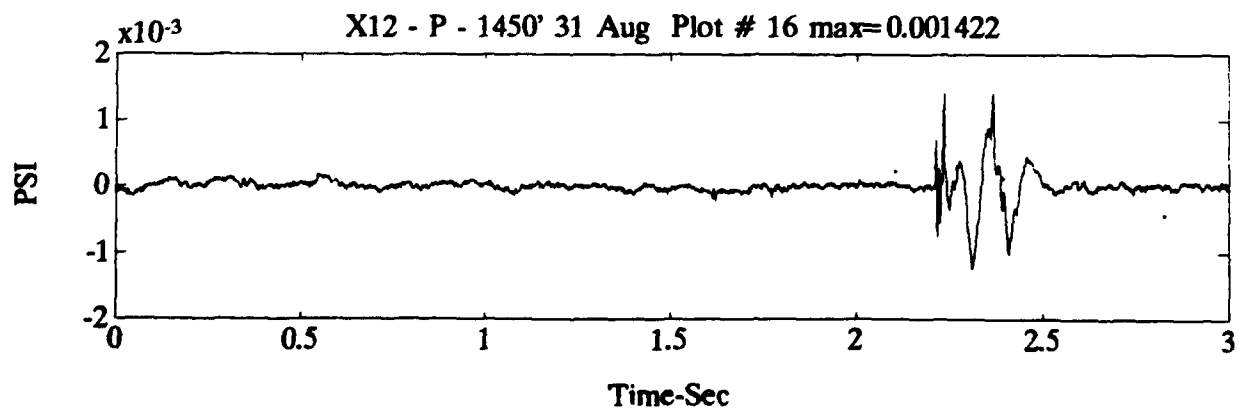
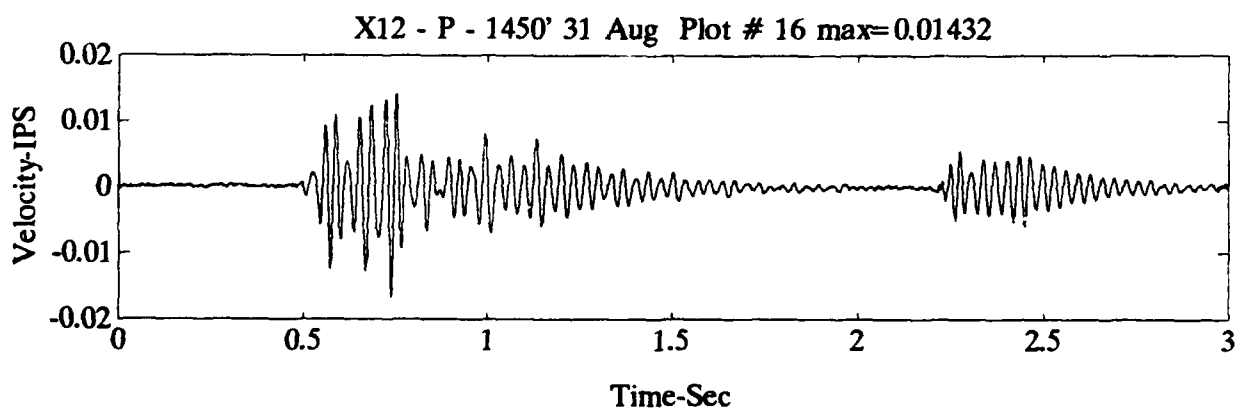
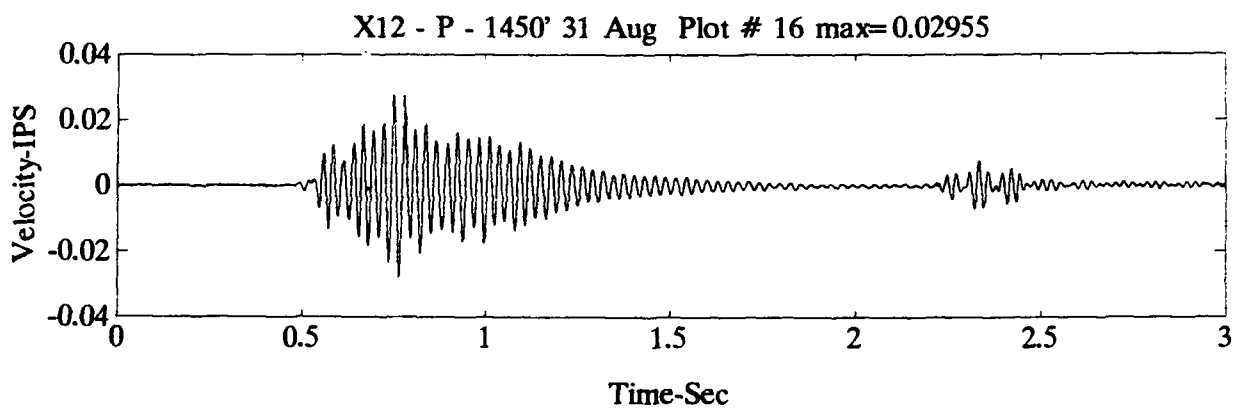
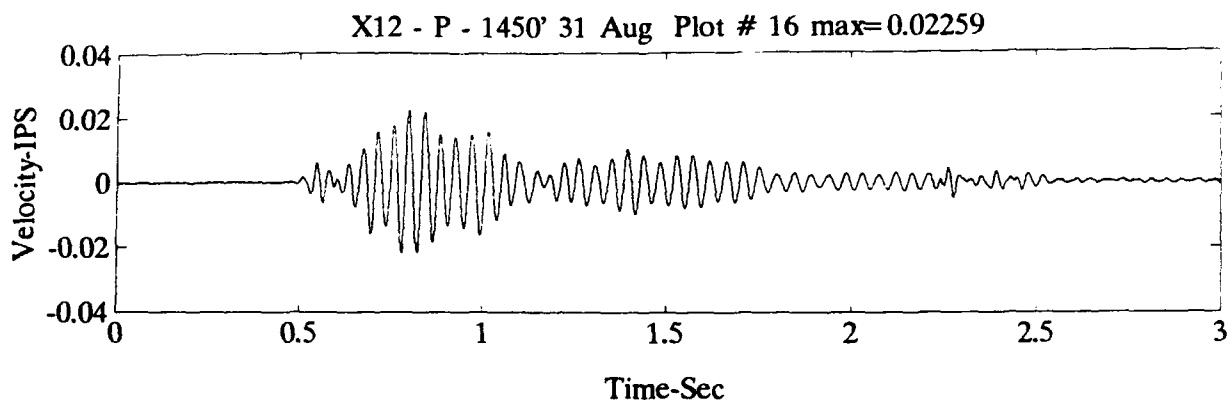


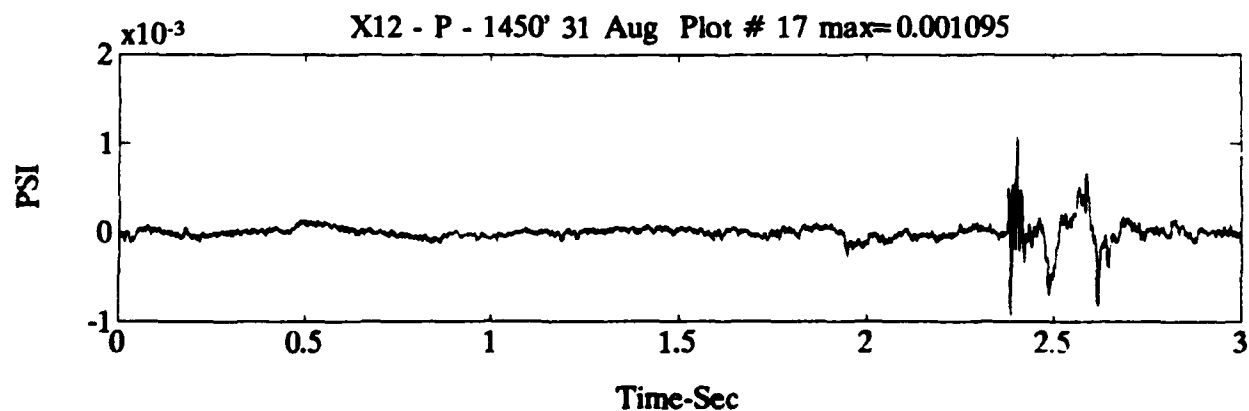
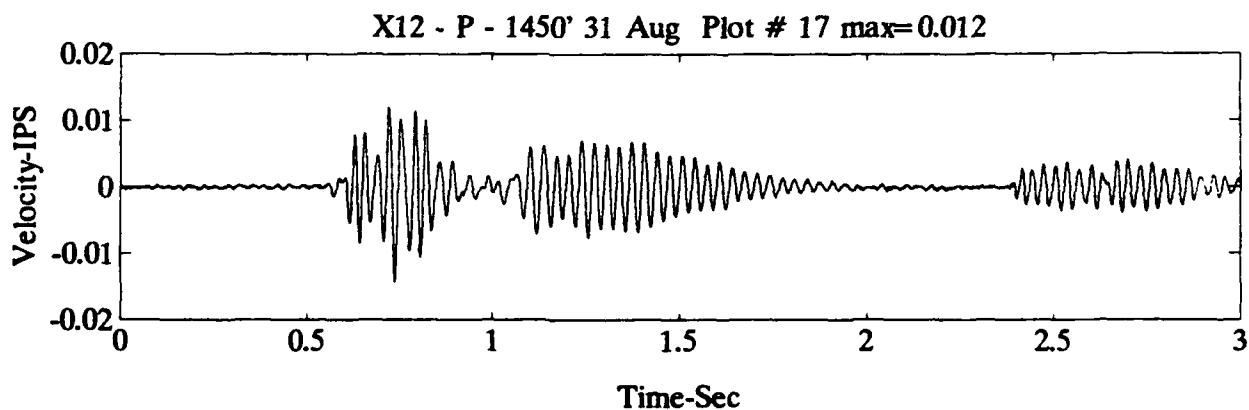
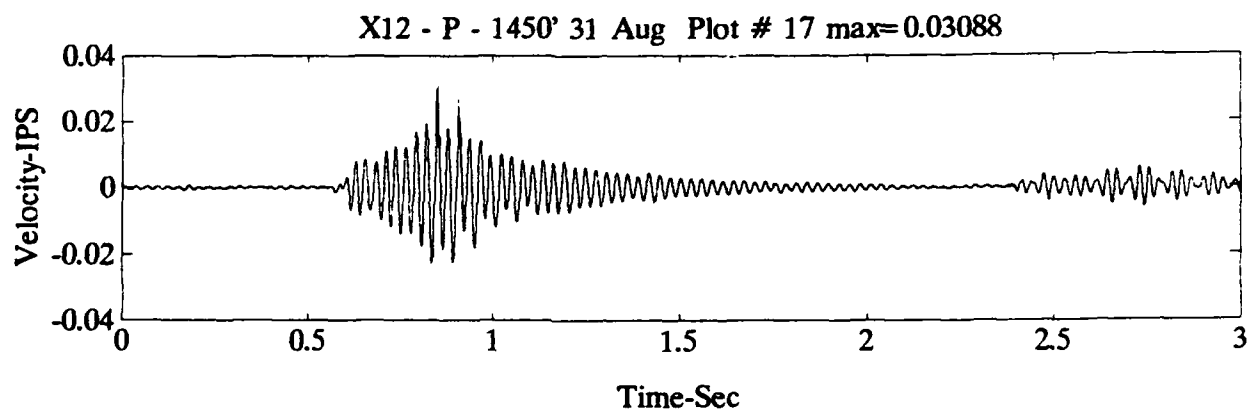
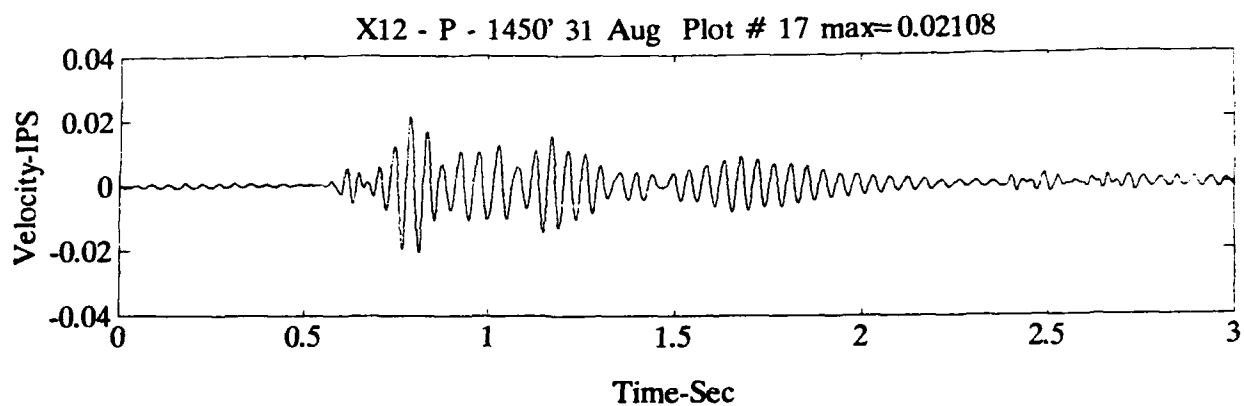


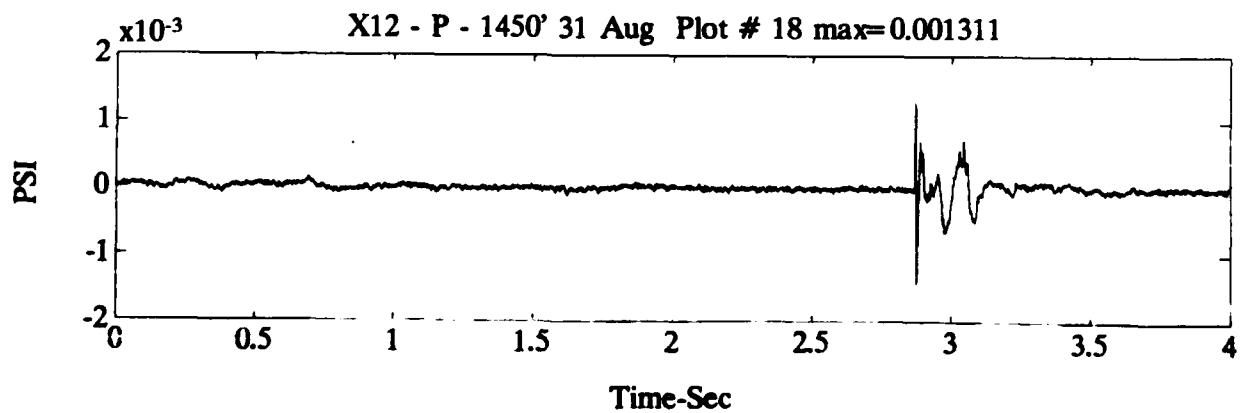
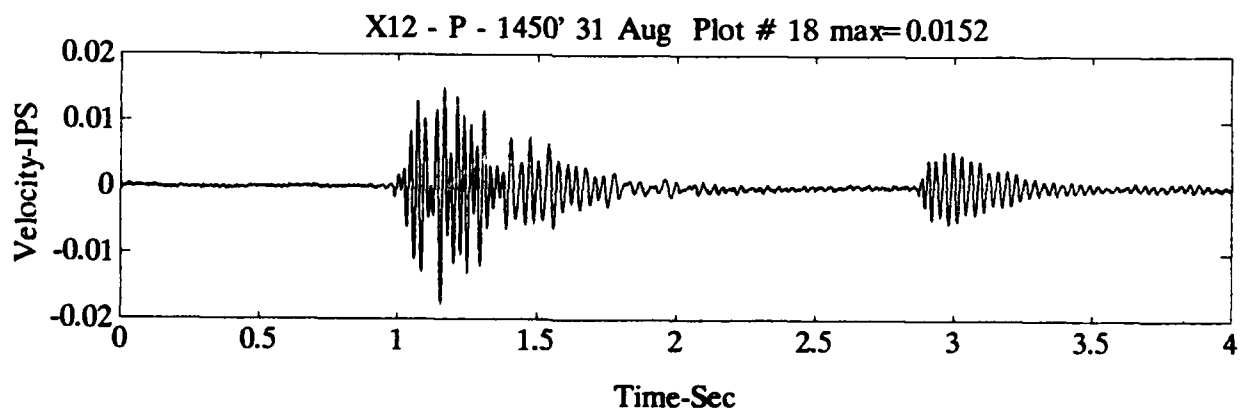
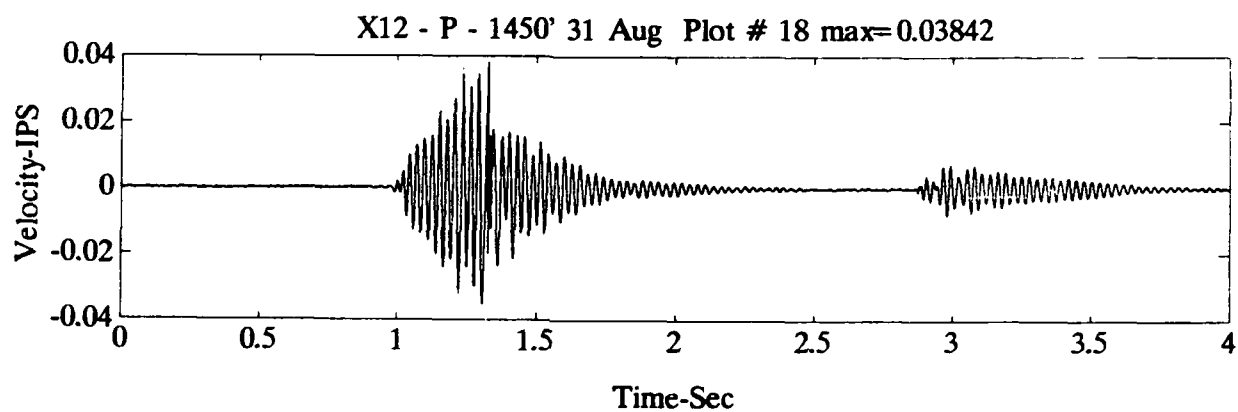
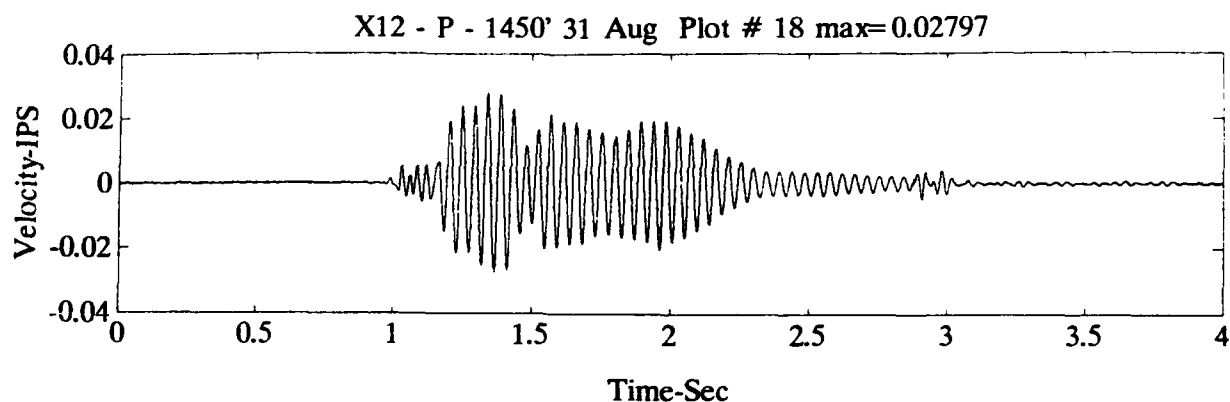


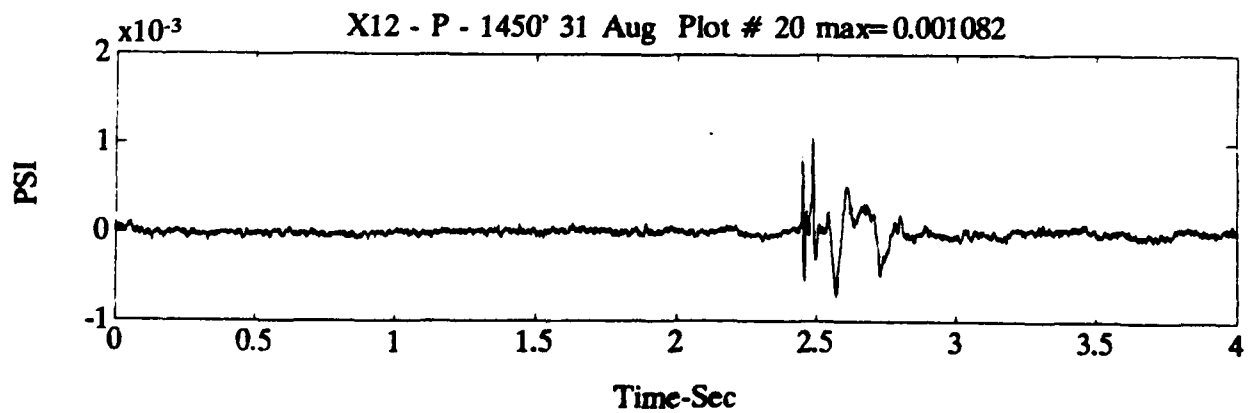
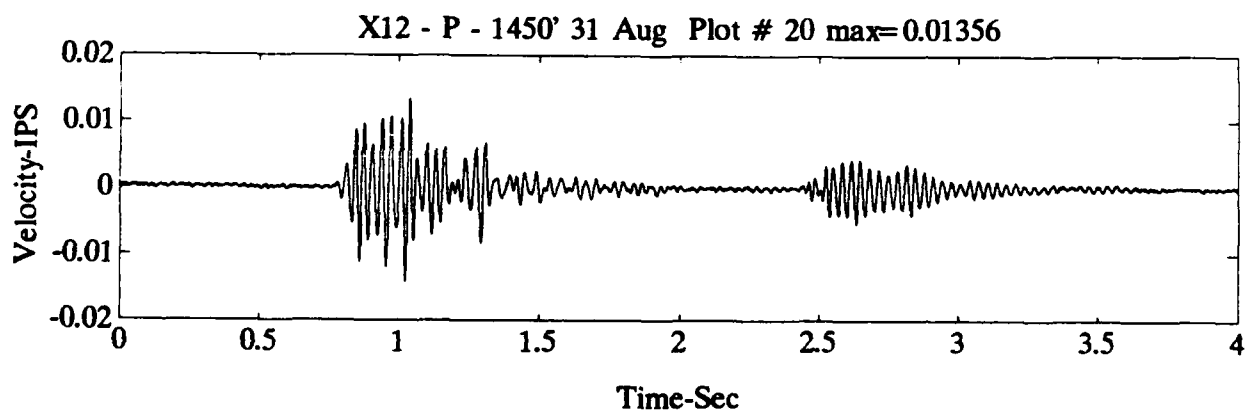
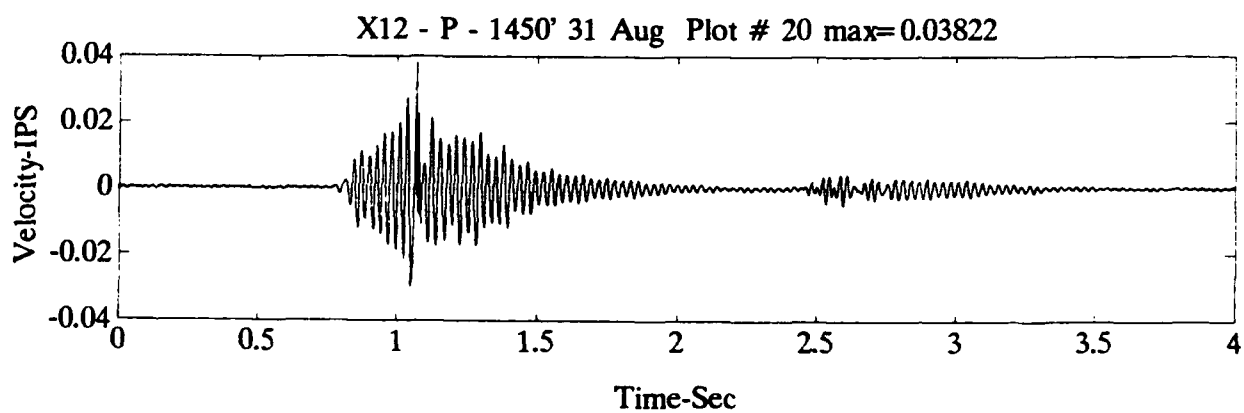
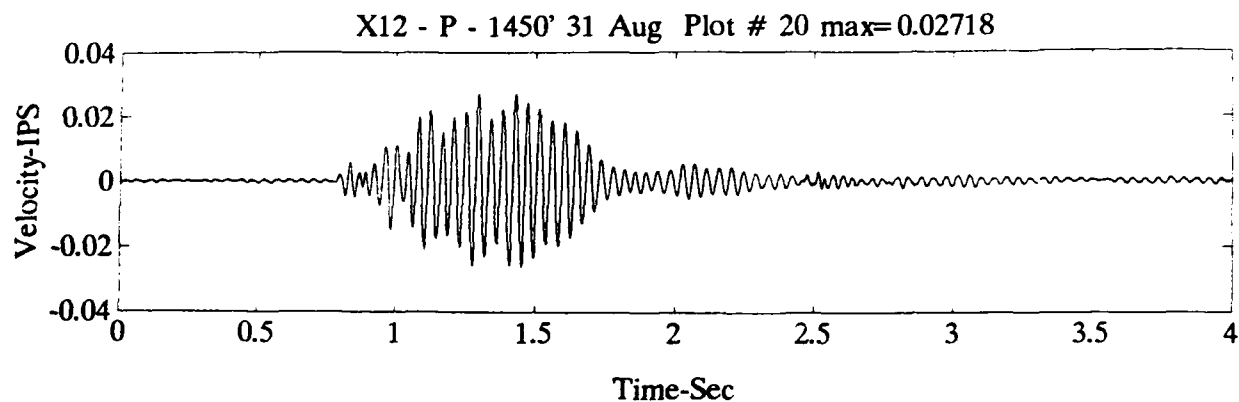


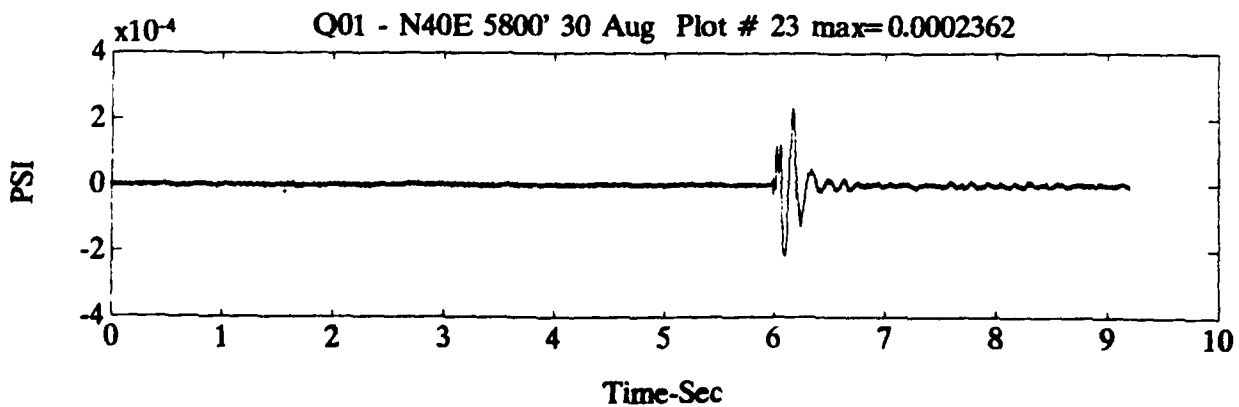
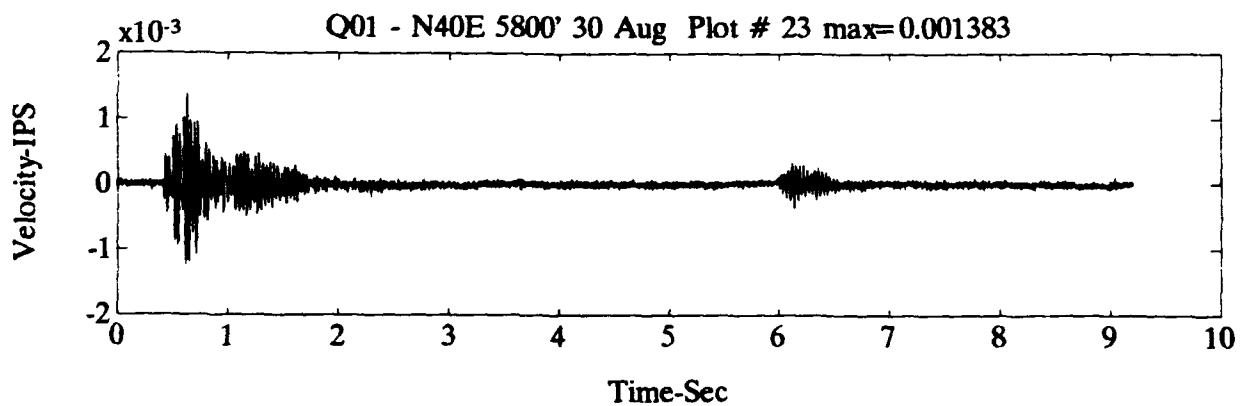
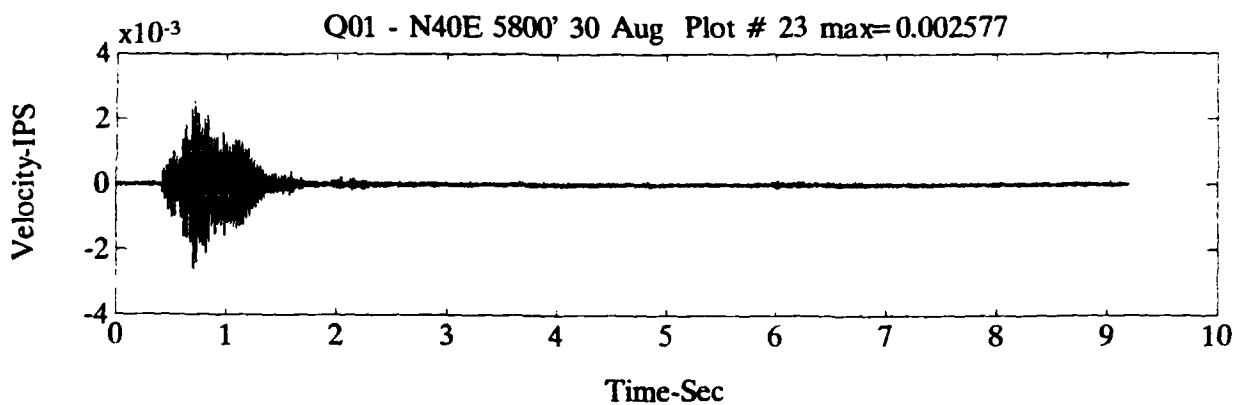
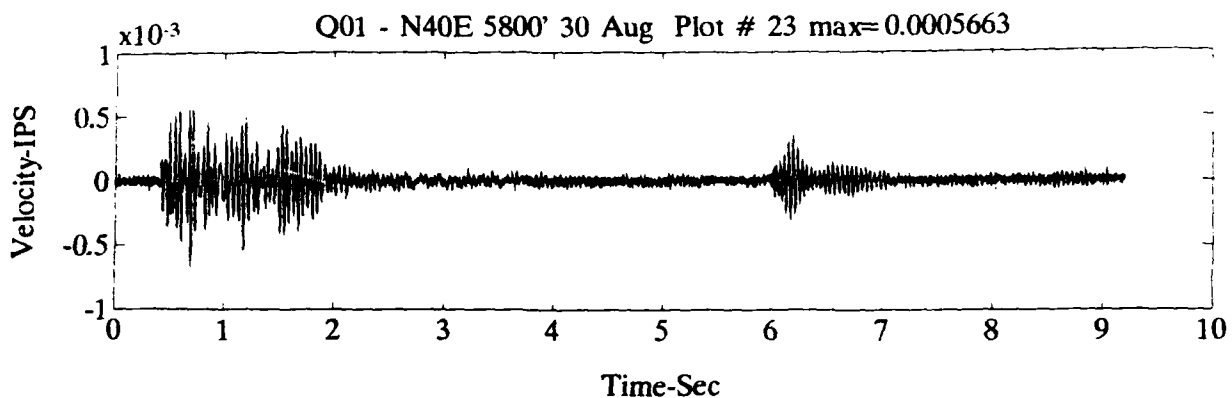


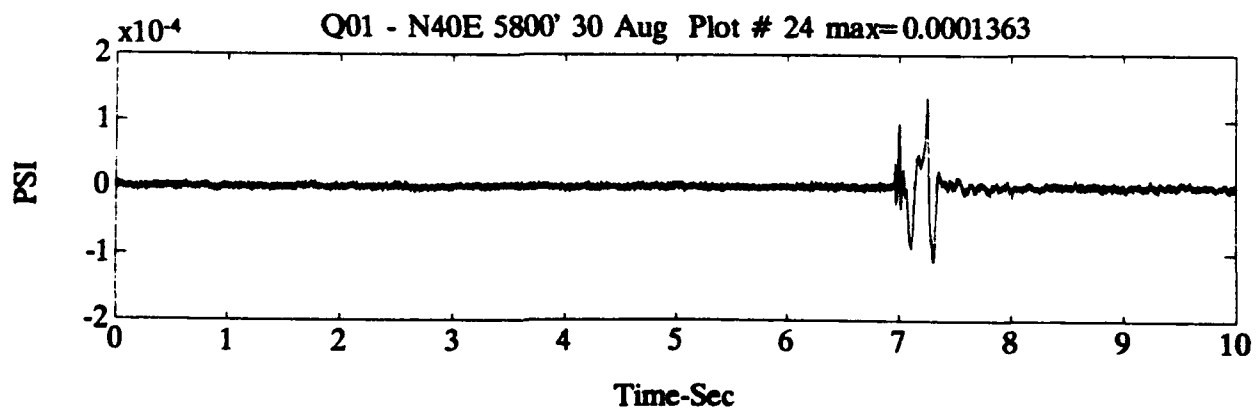
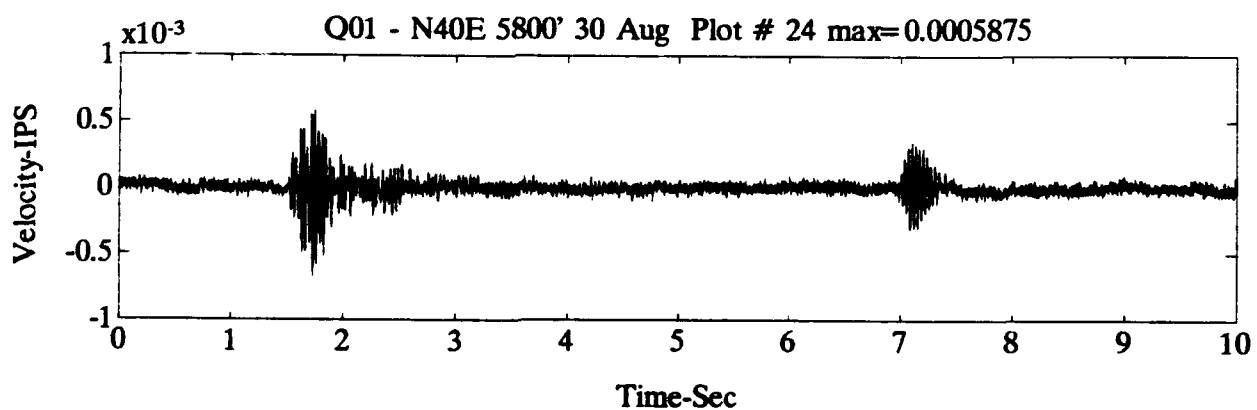
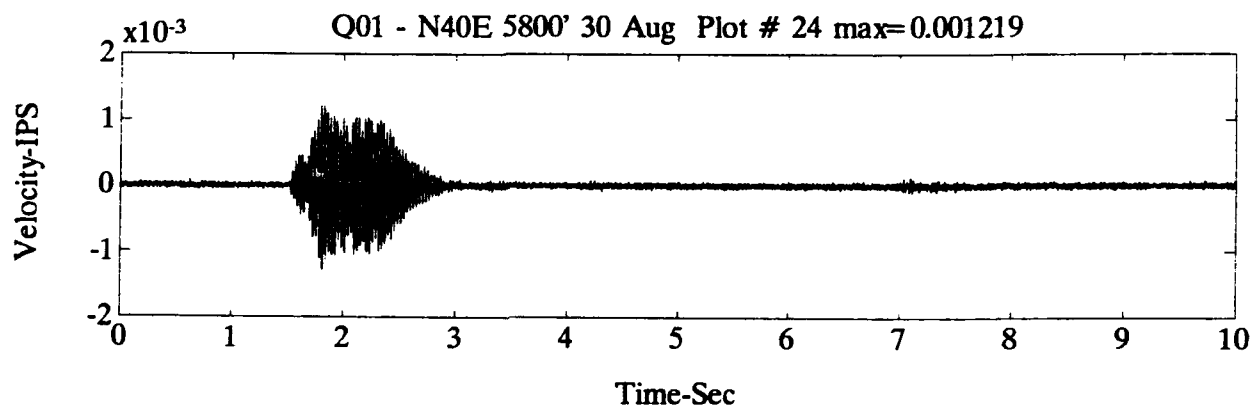
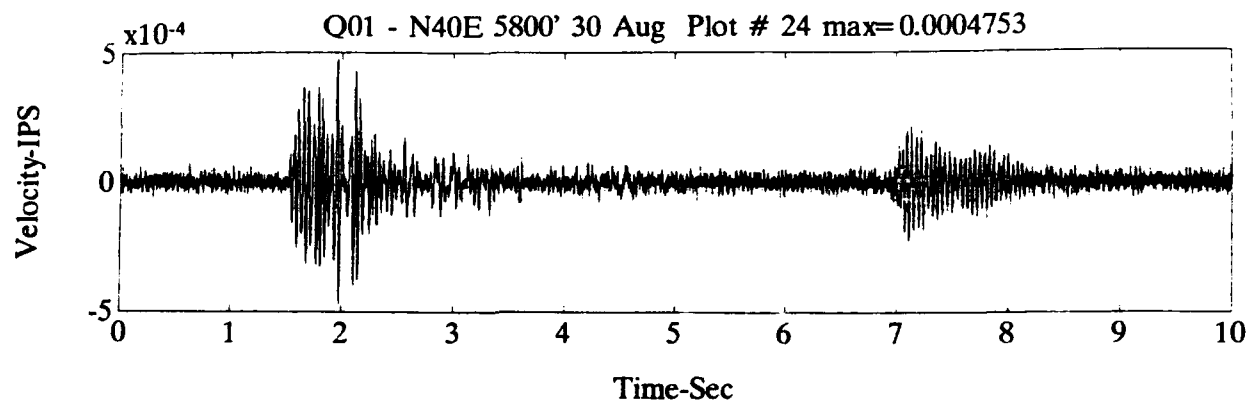


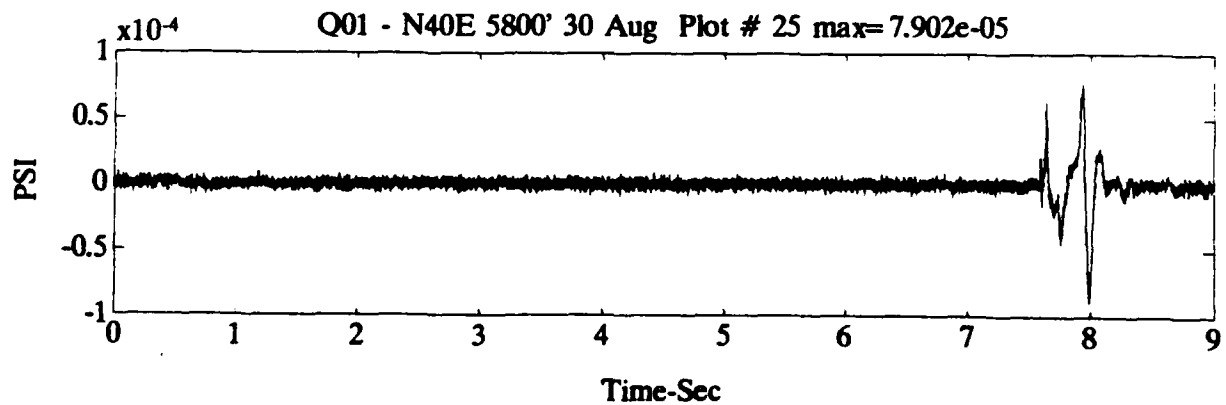
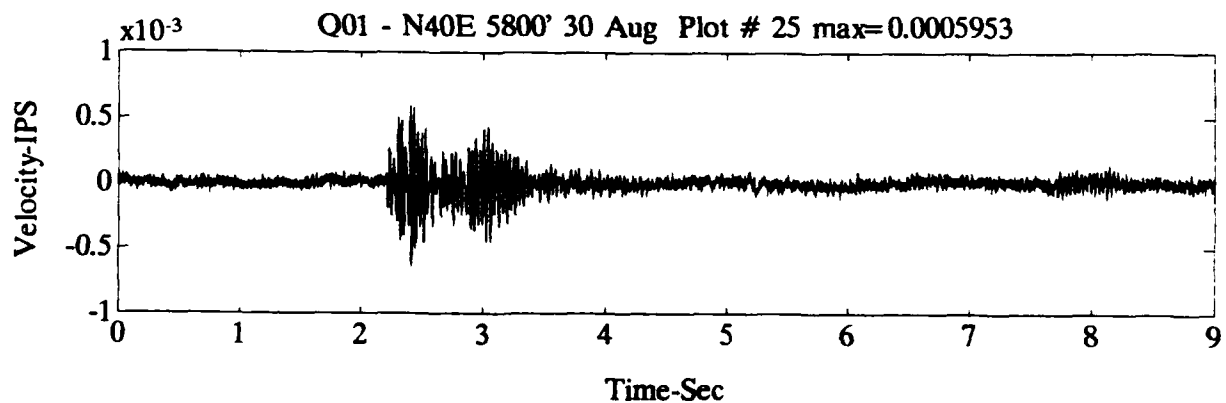
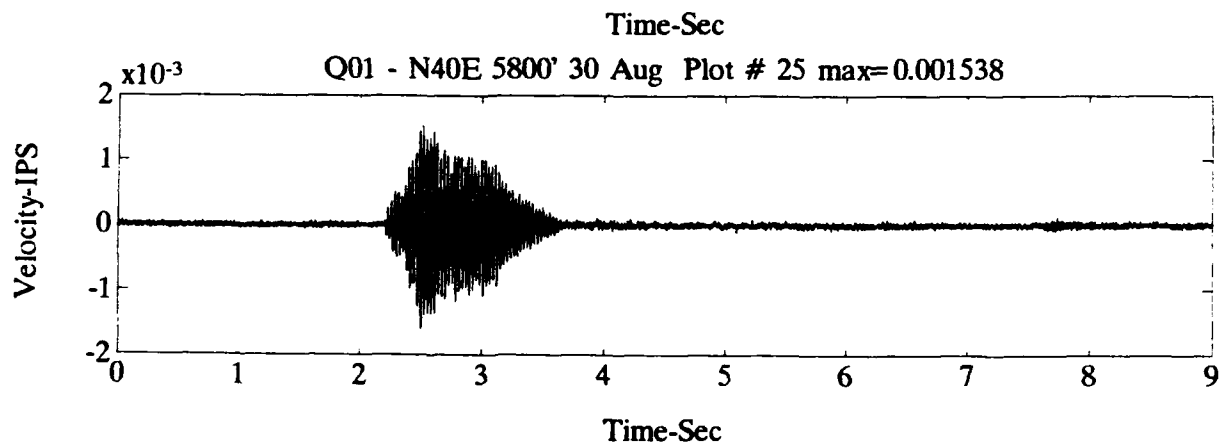
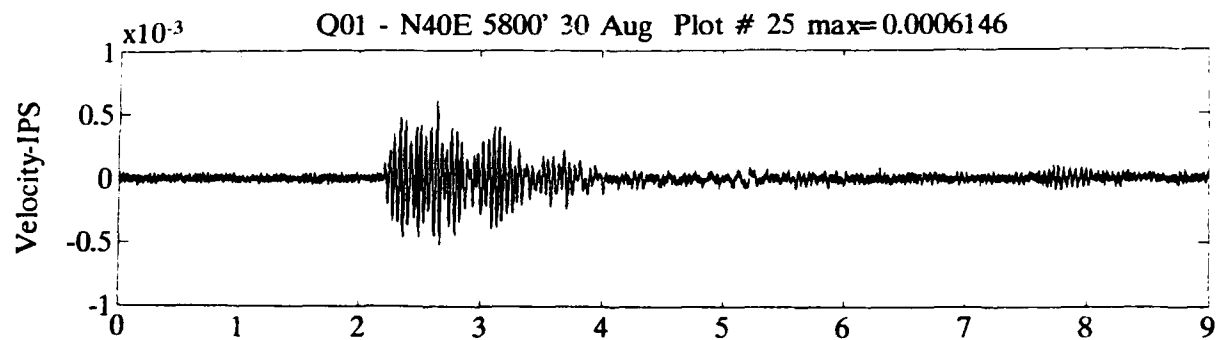


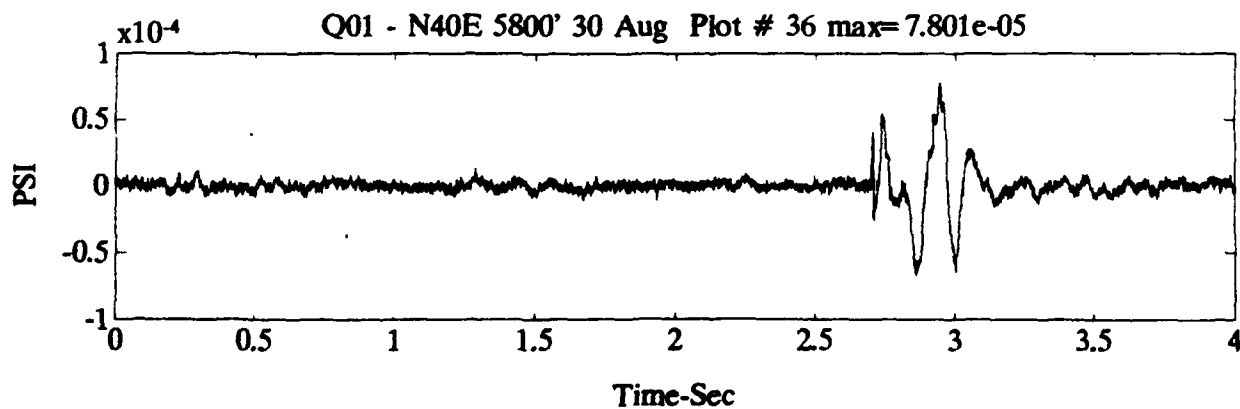
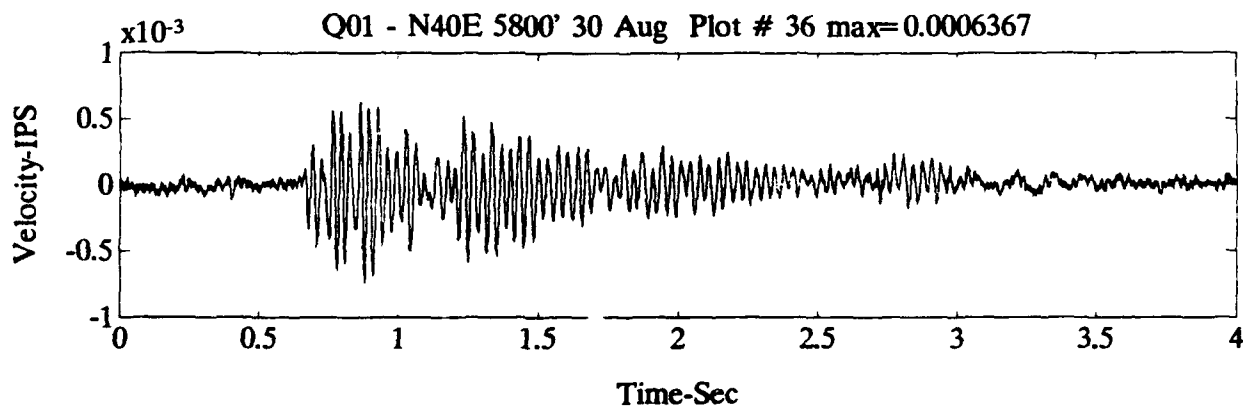
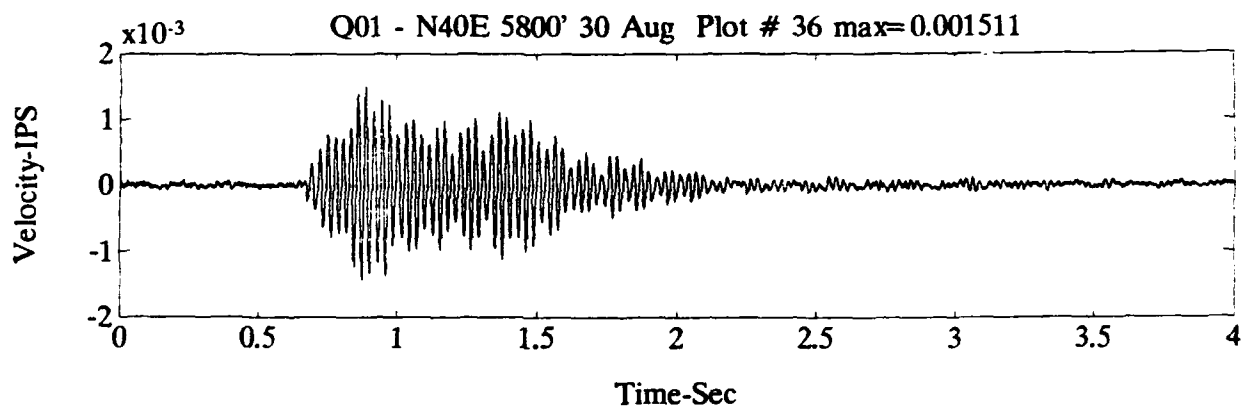
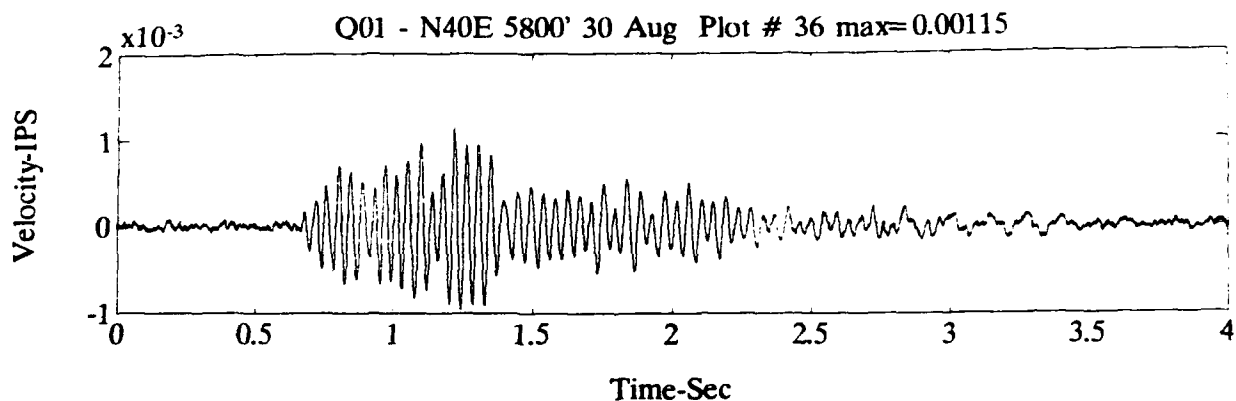


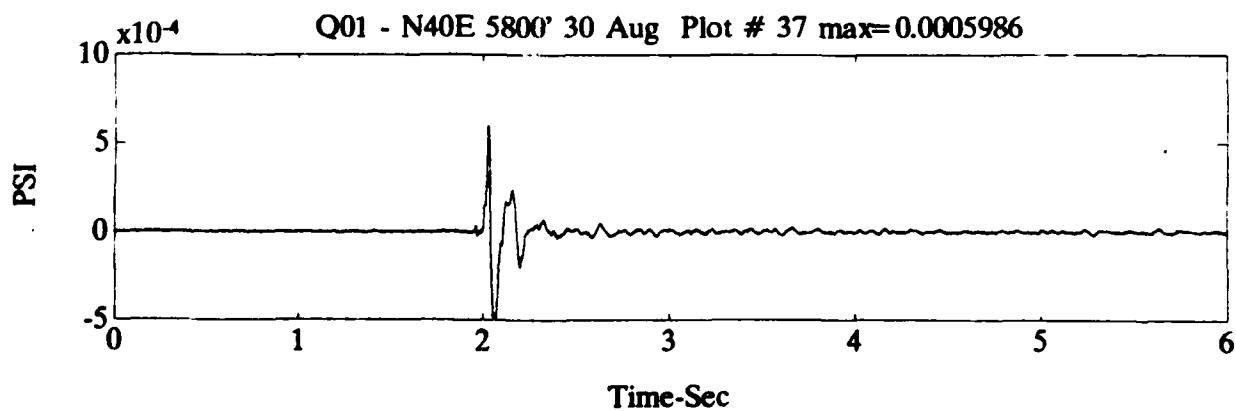
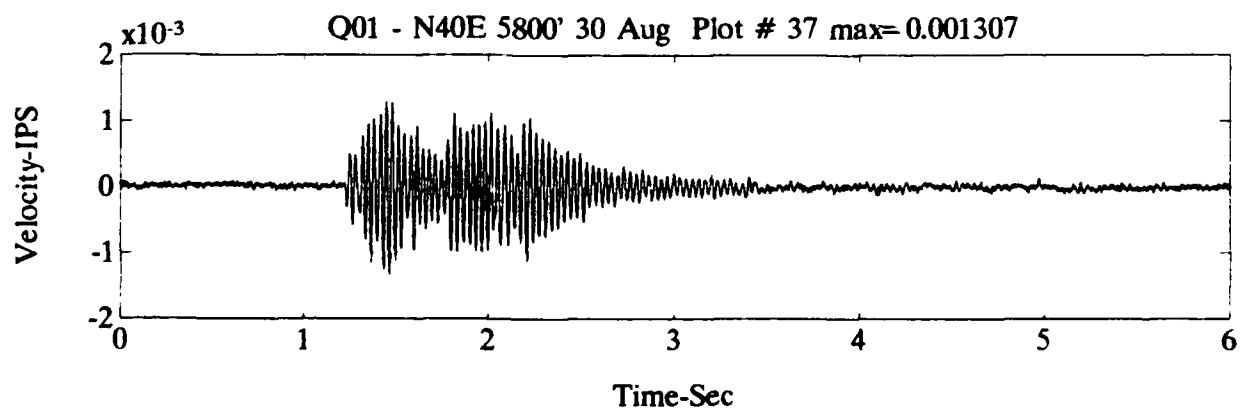
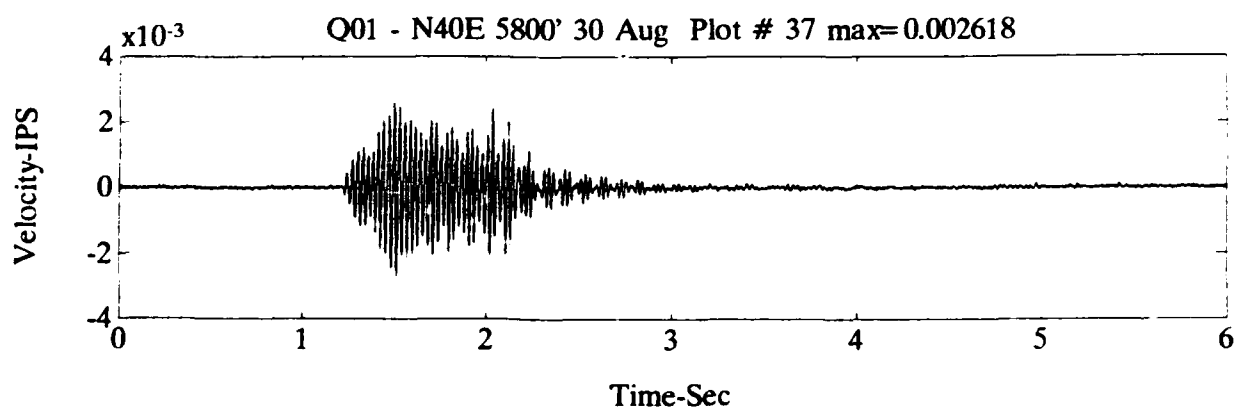
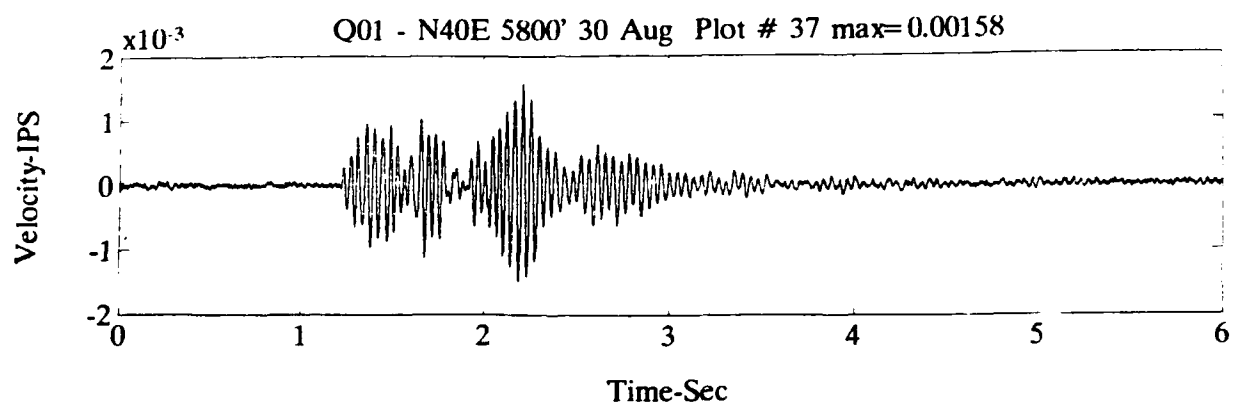




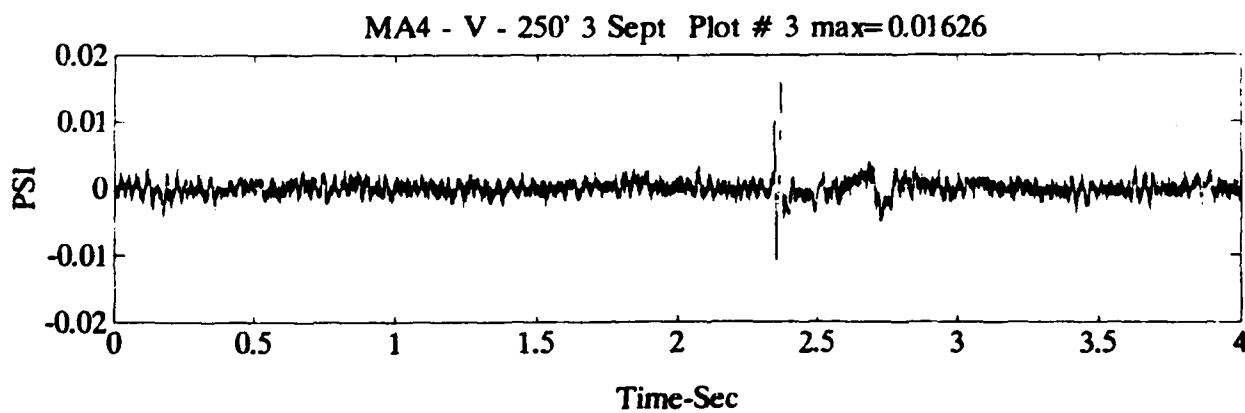
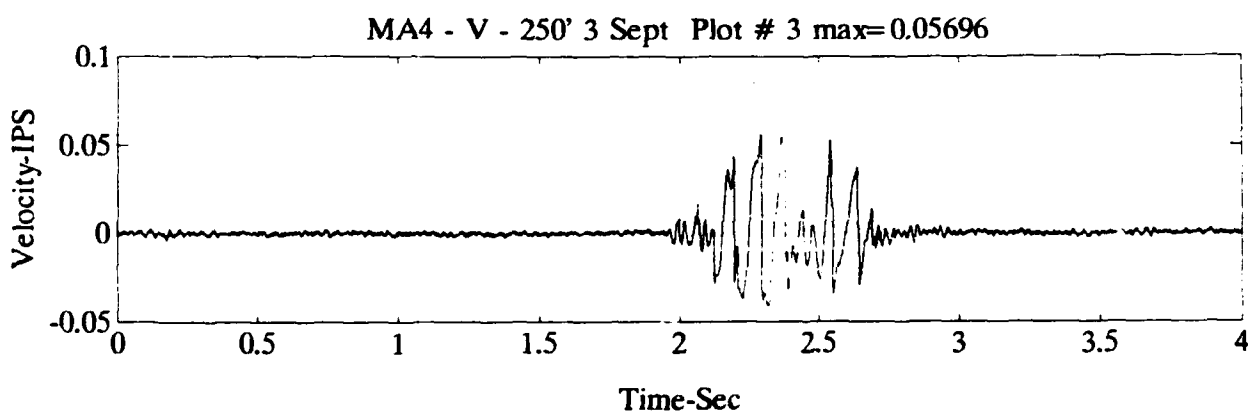
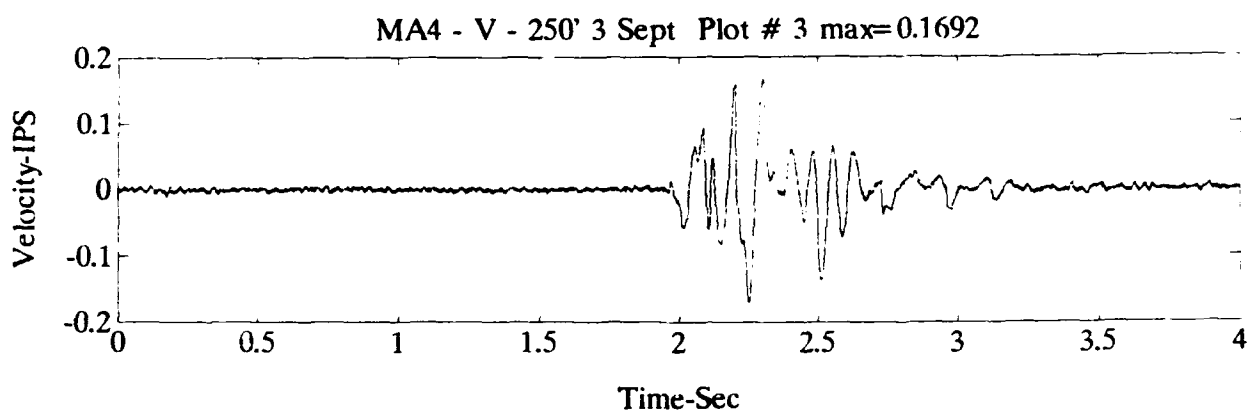
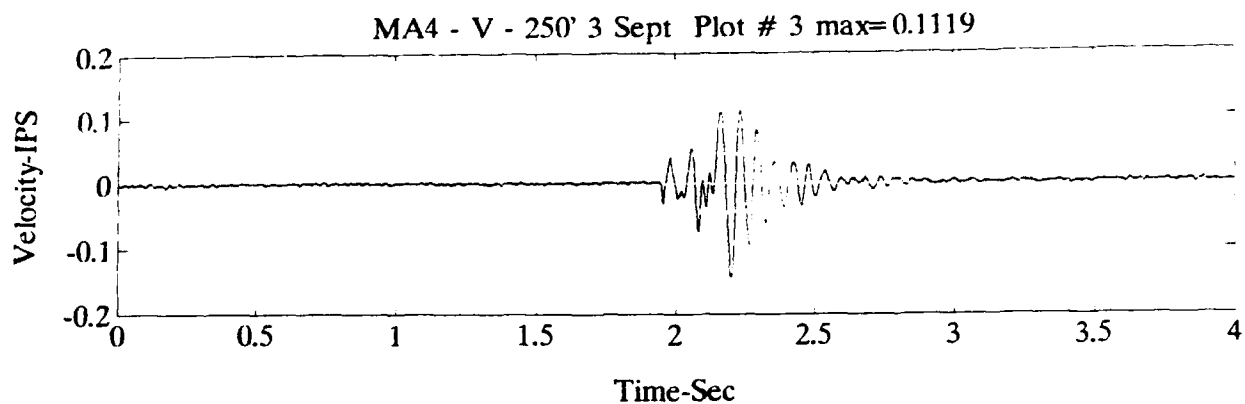


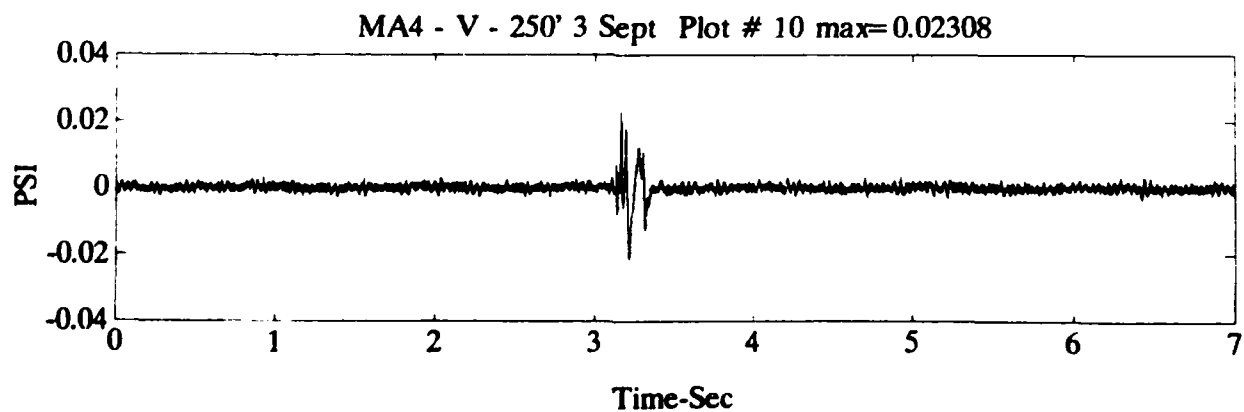
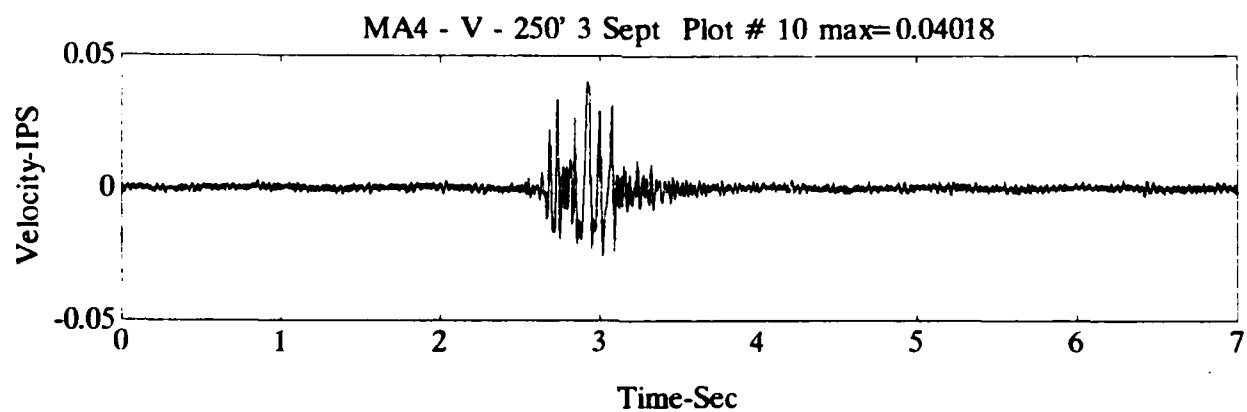
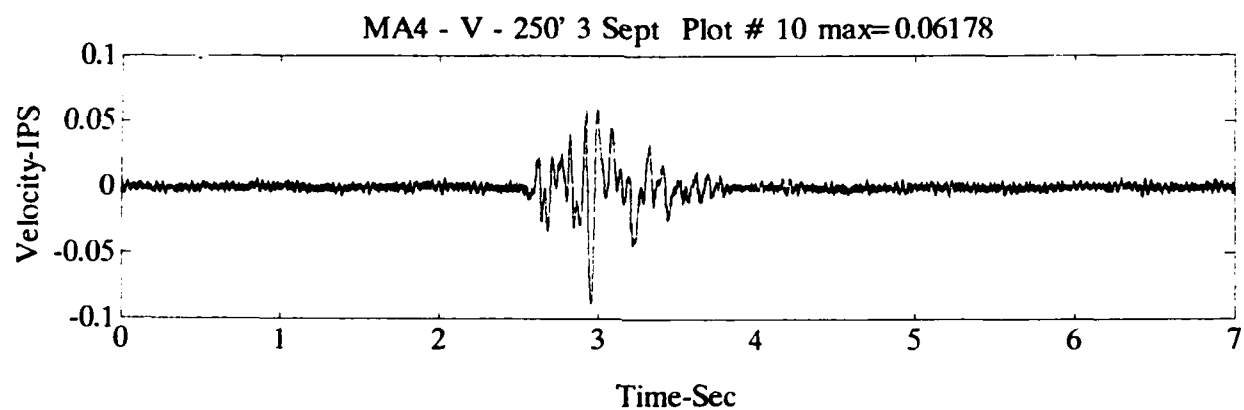
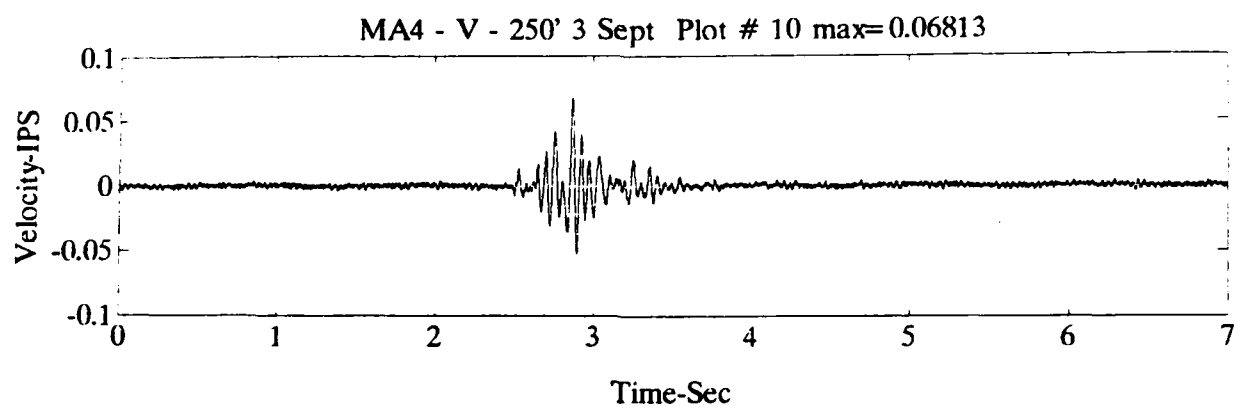


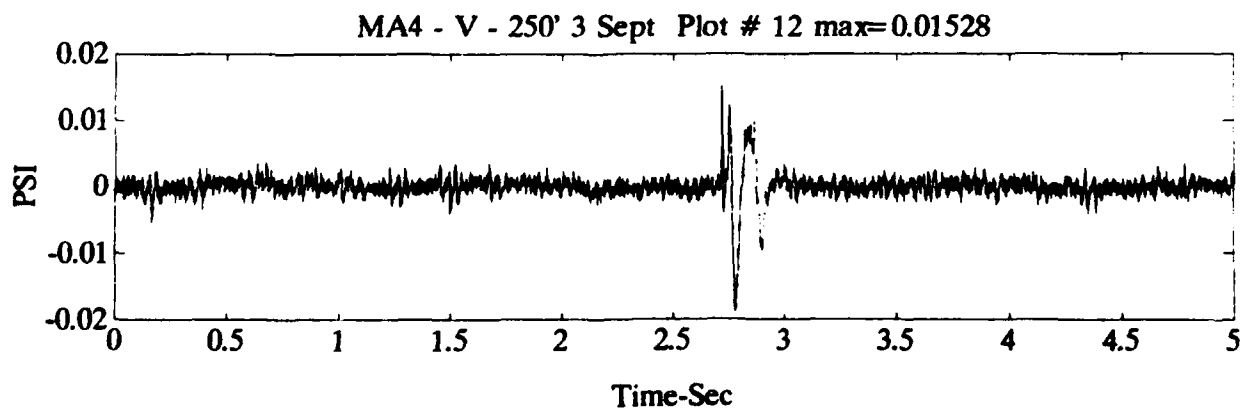
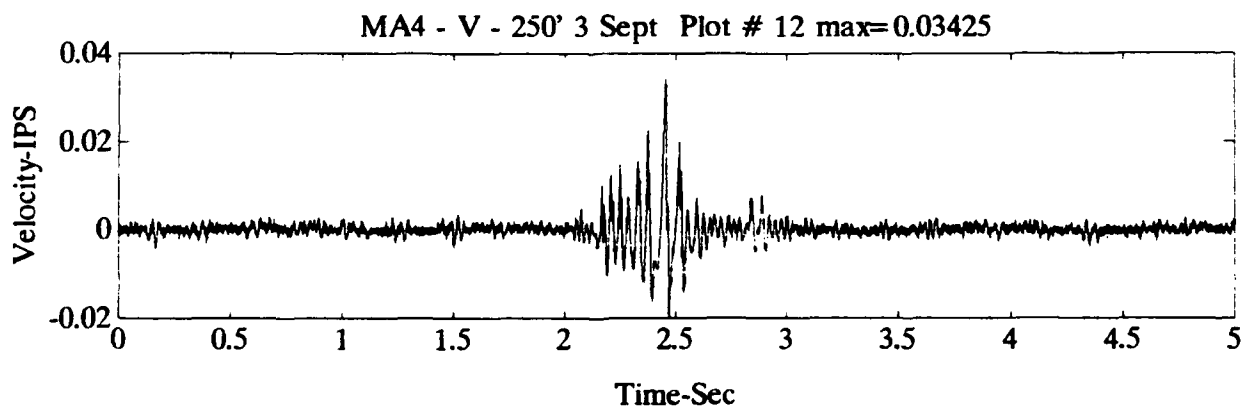
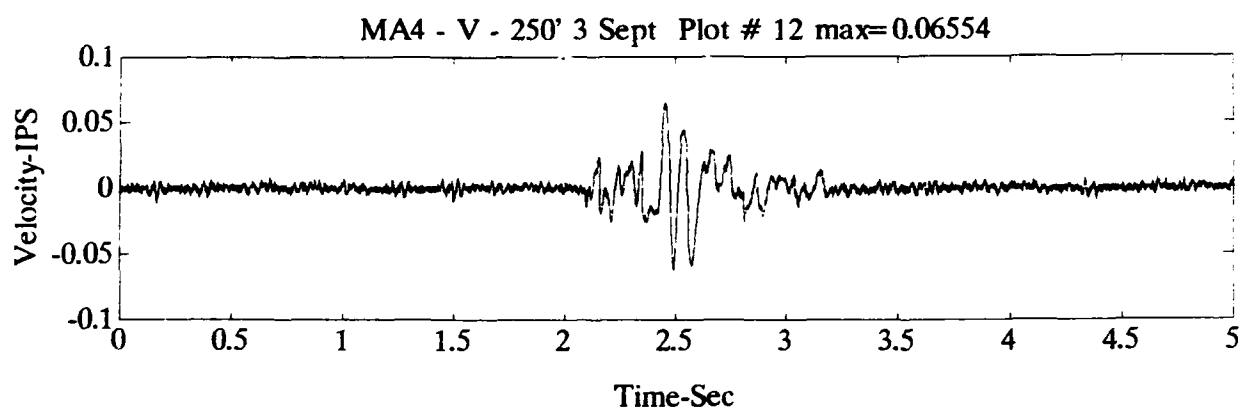
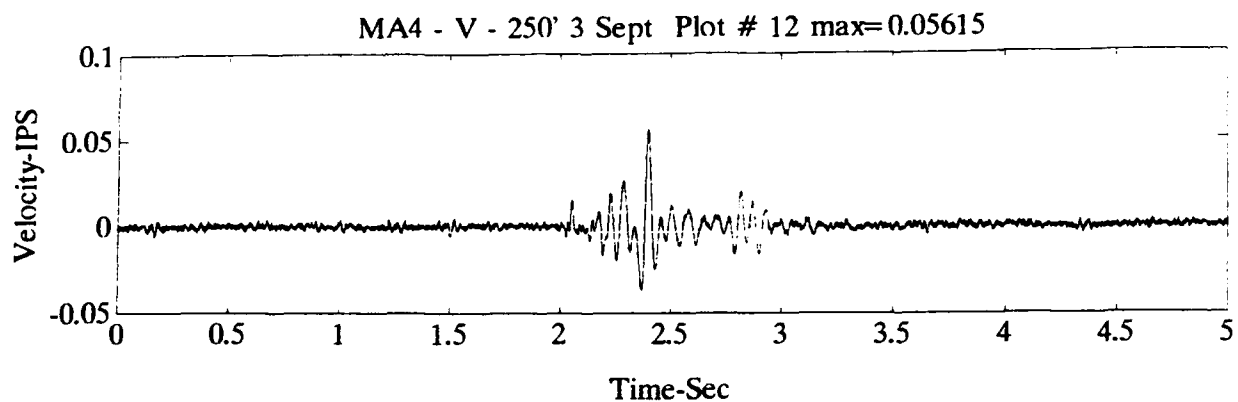


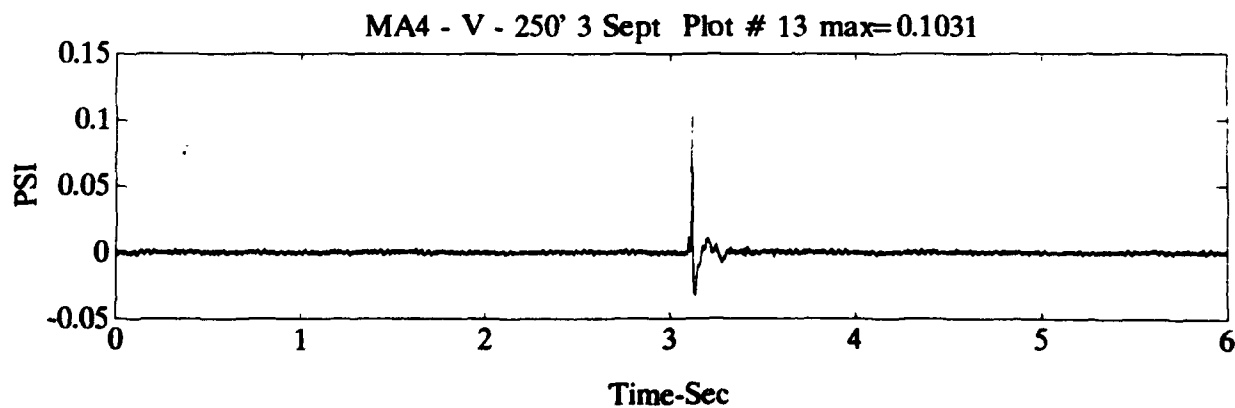
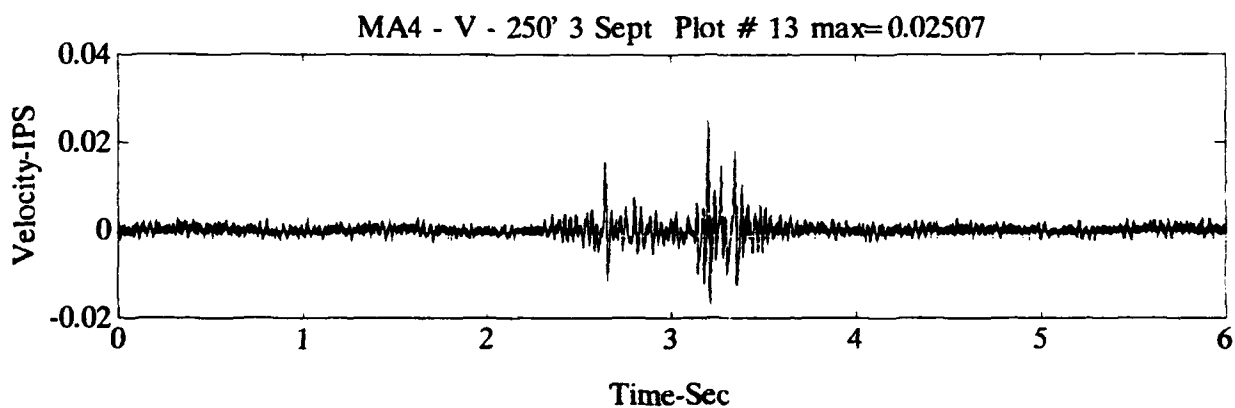
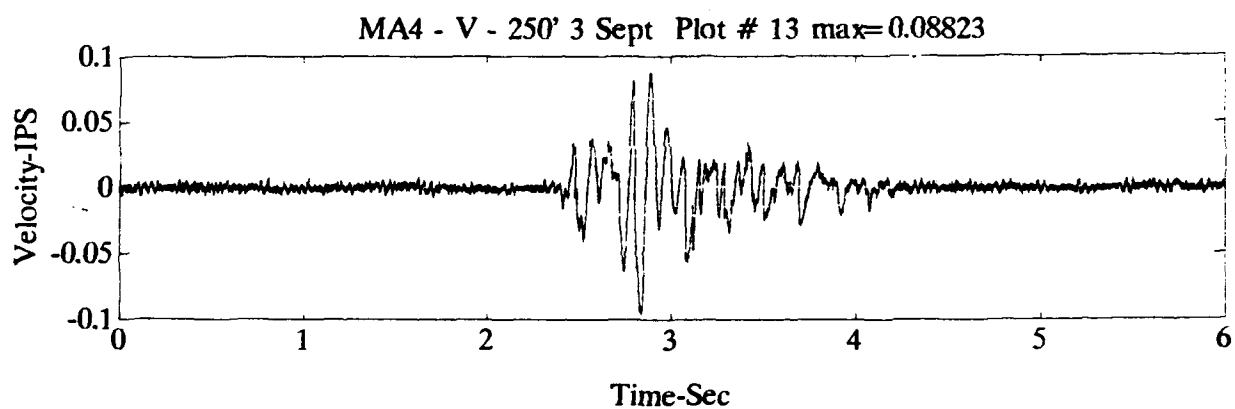
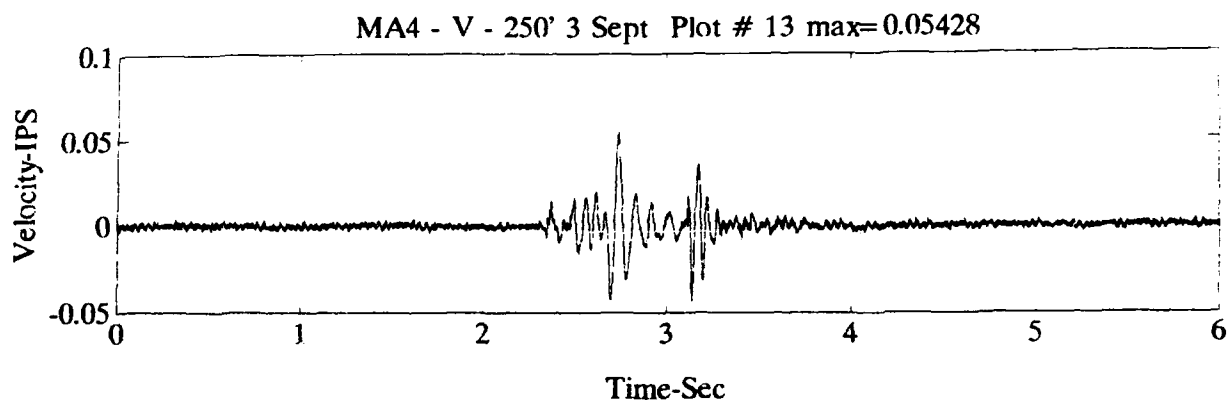


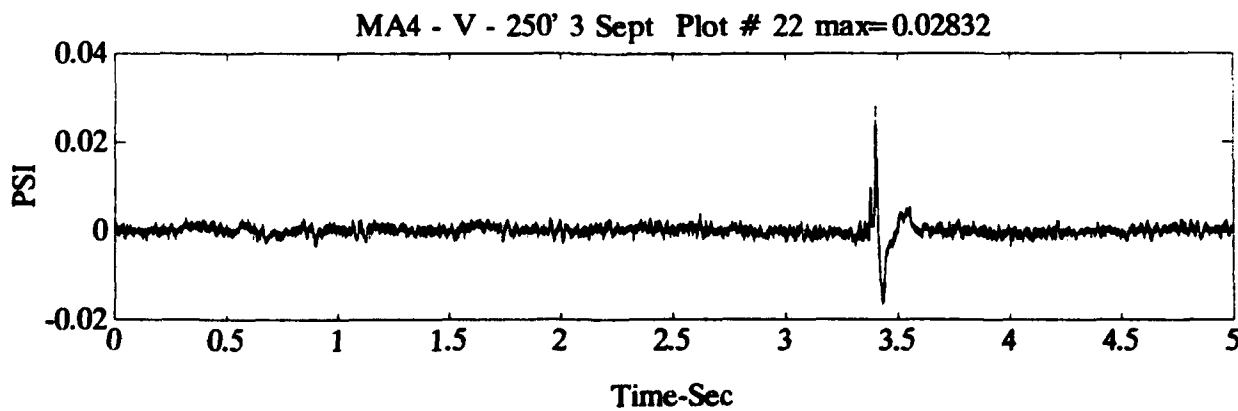
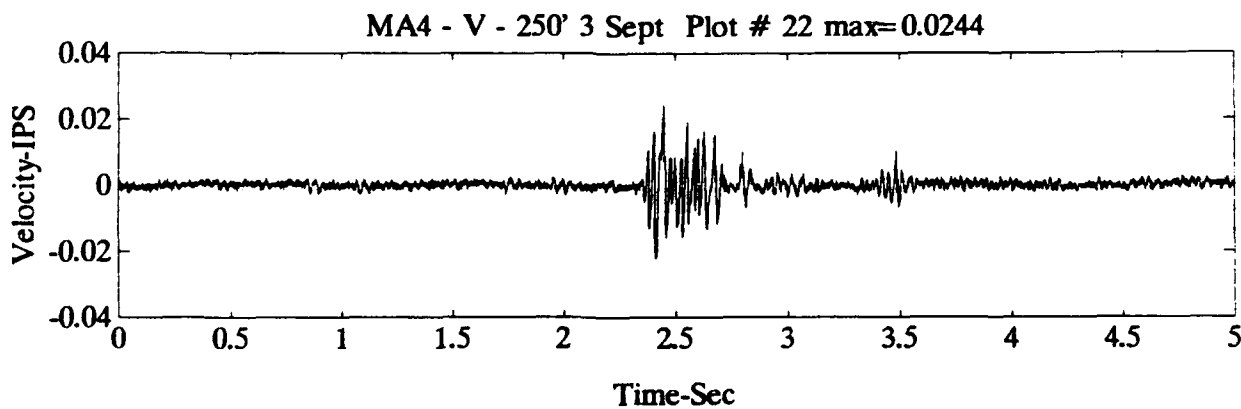
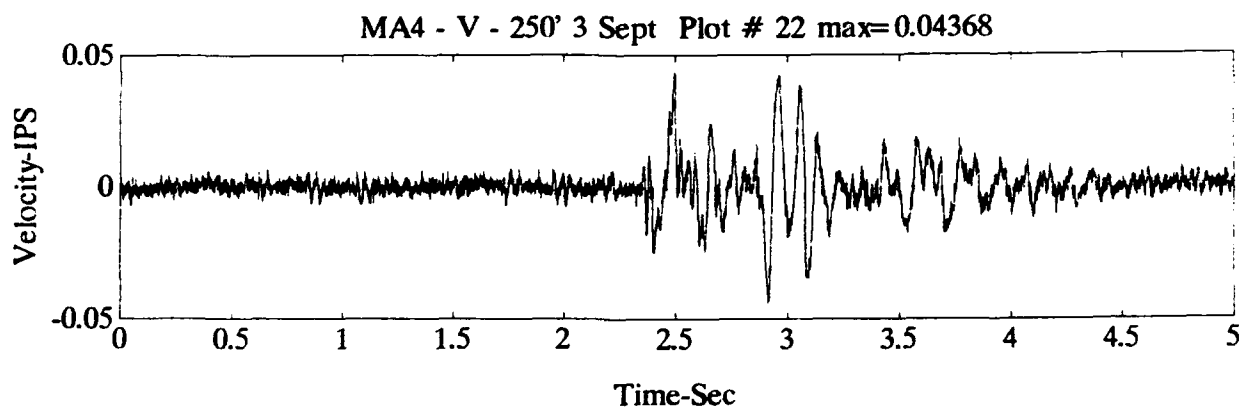
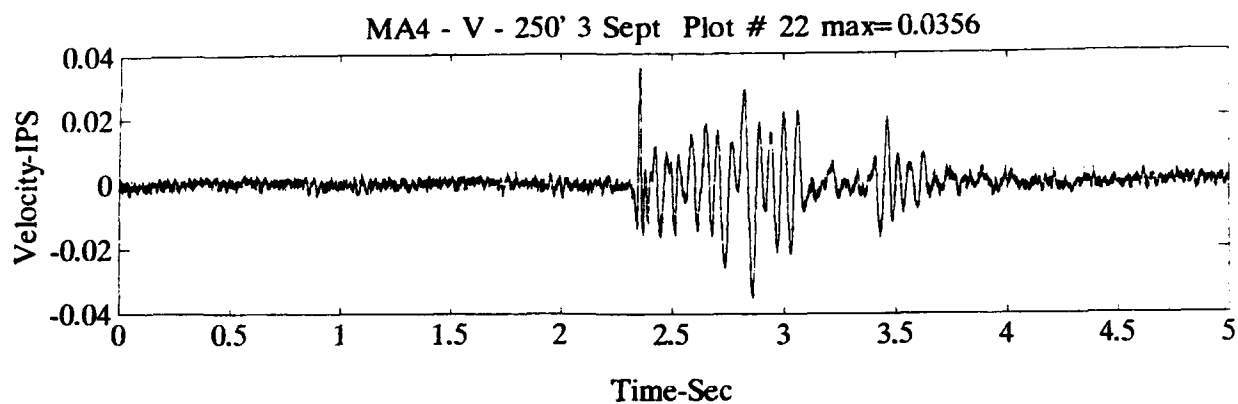
B21

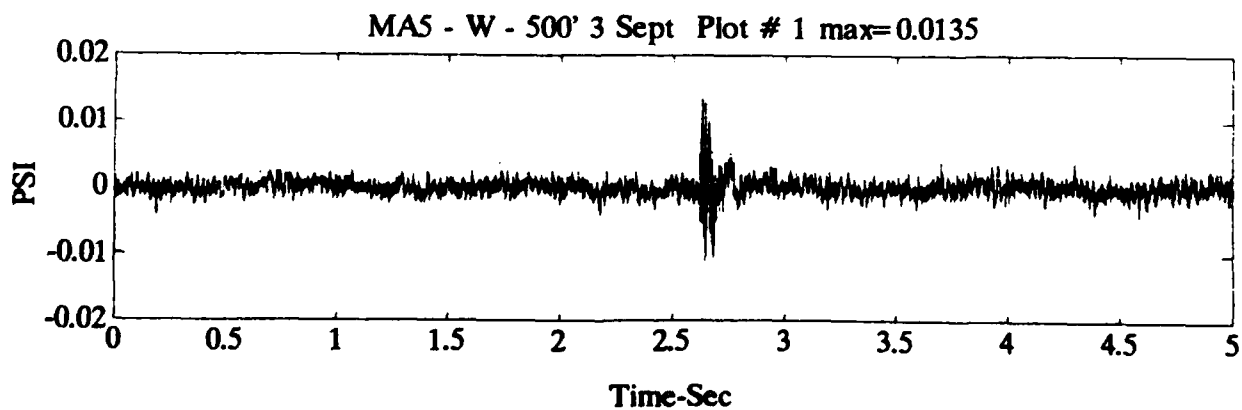
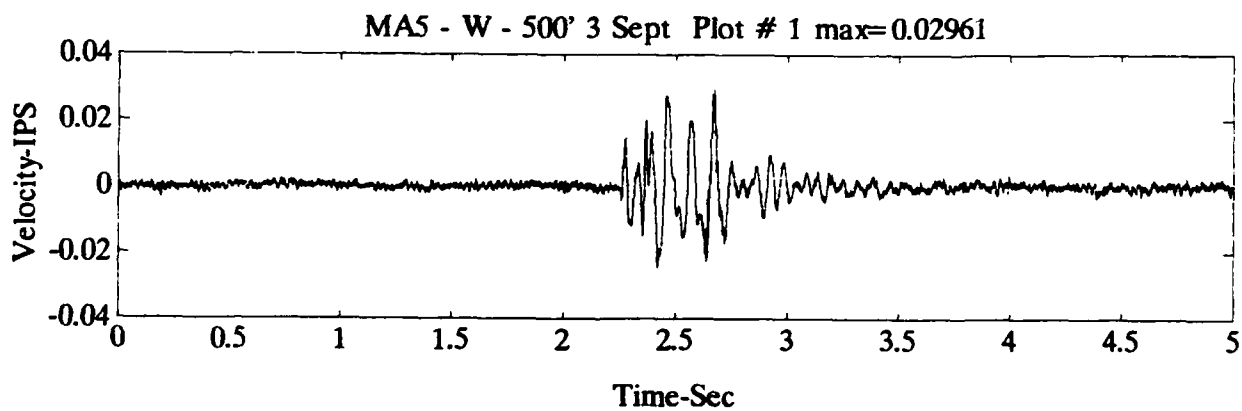
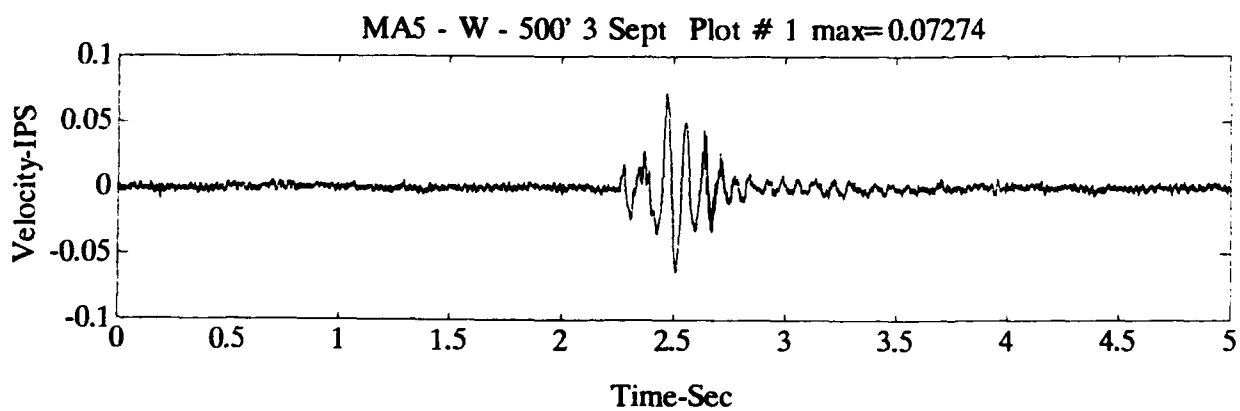
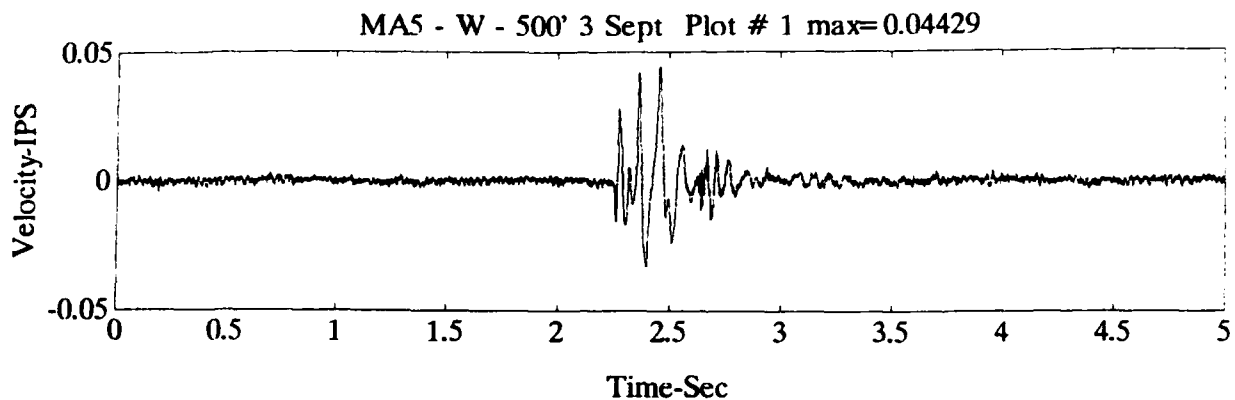


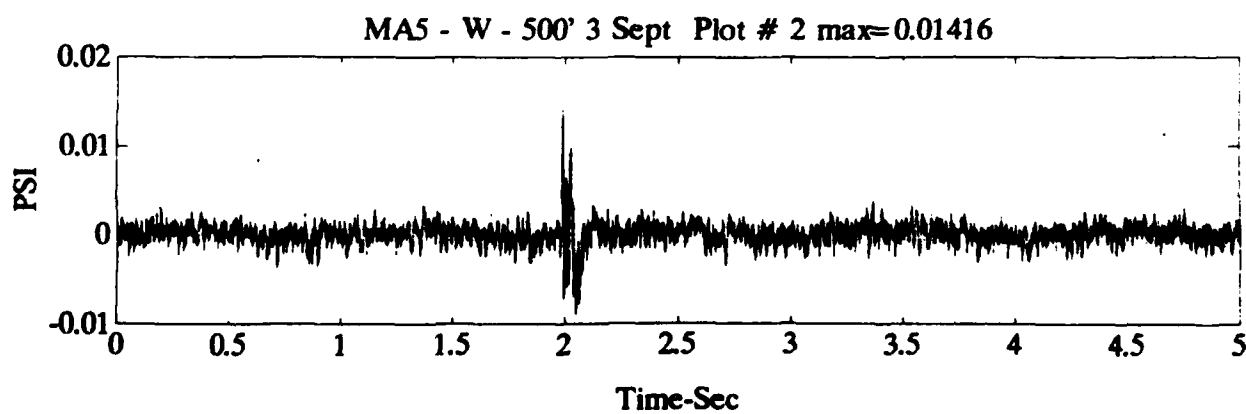
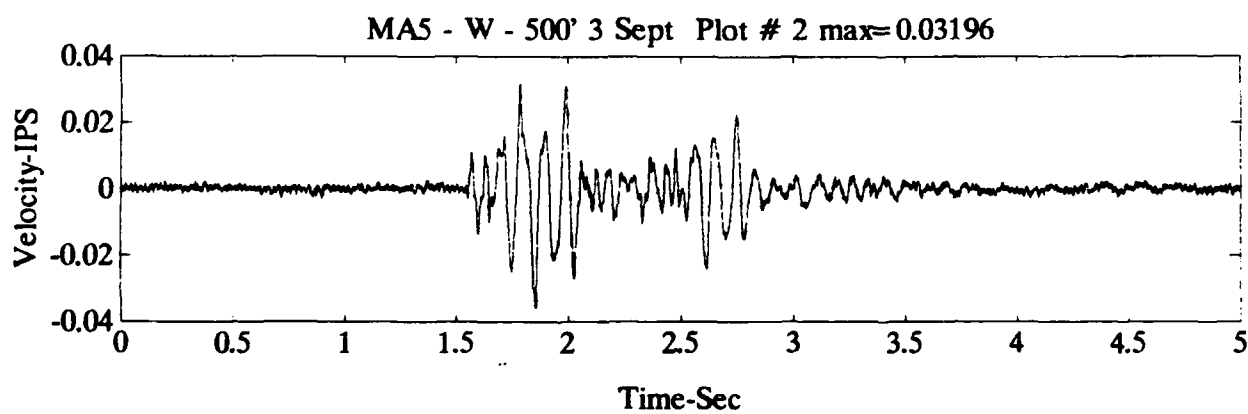
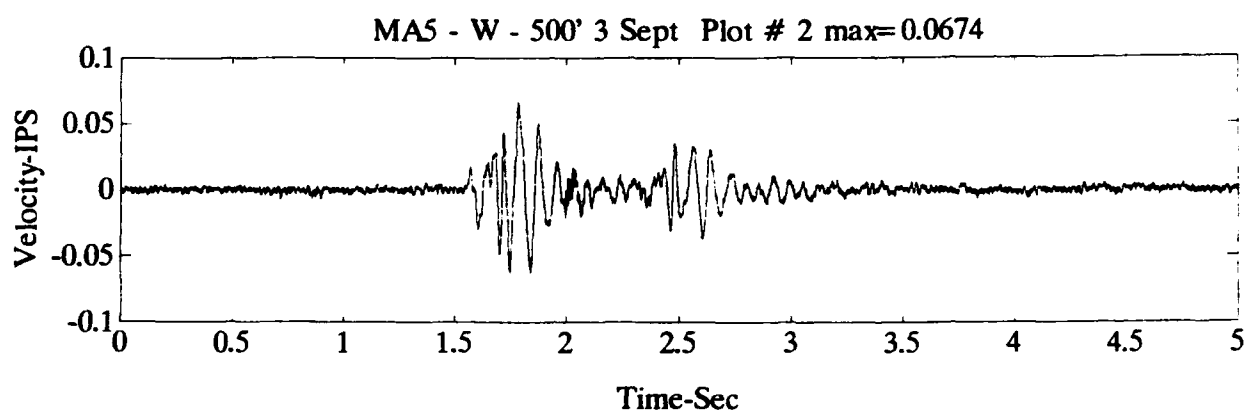
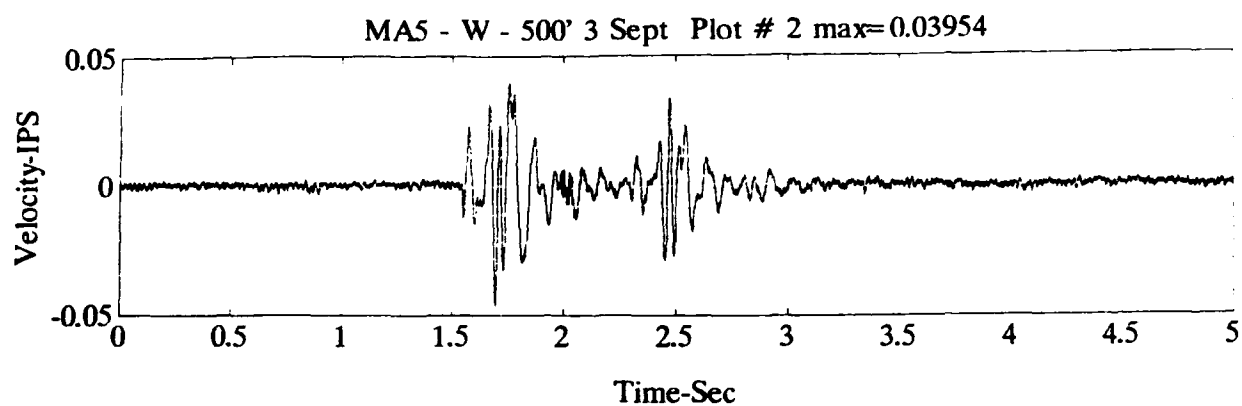


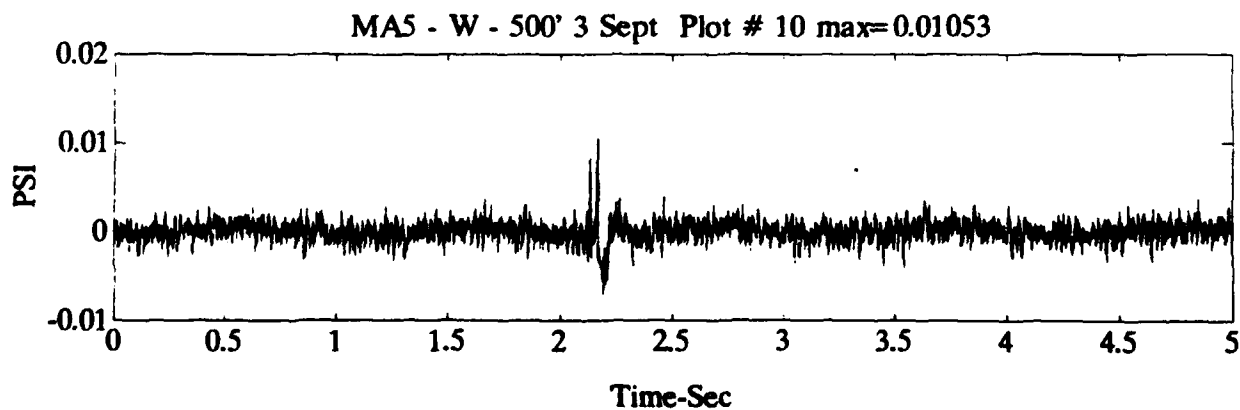
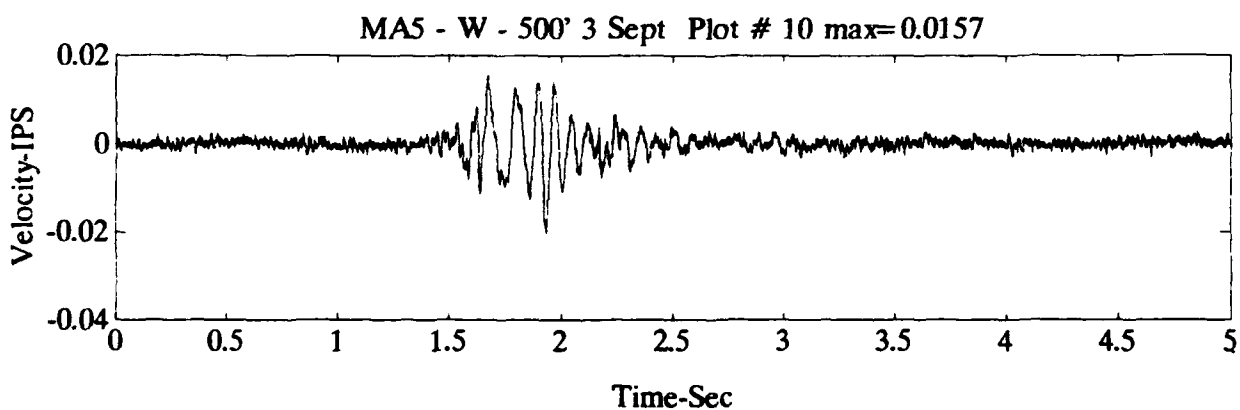
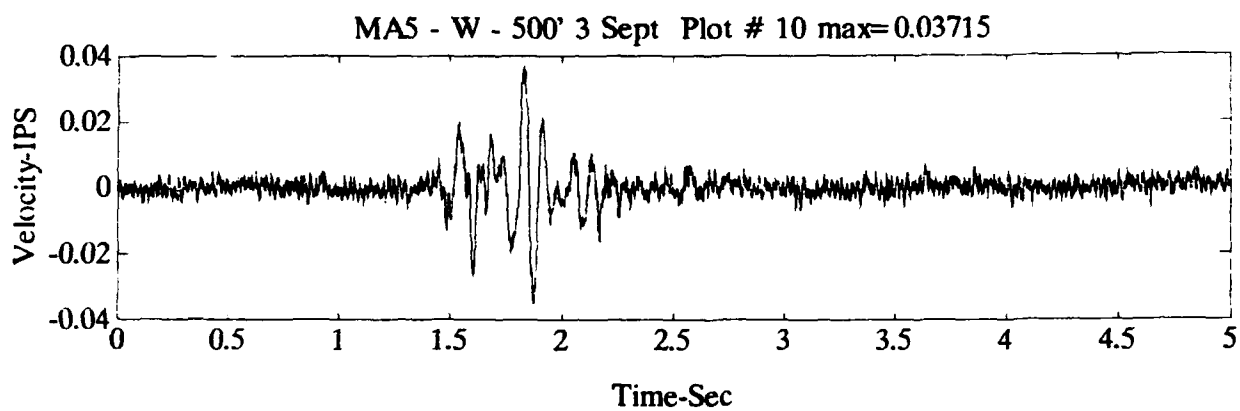
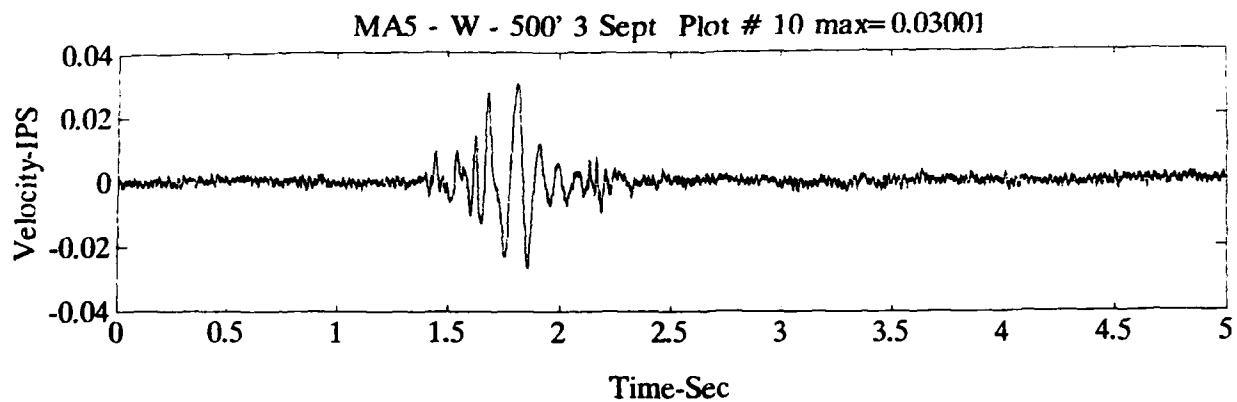


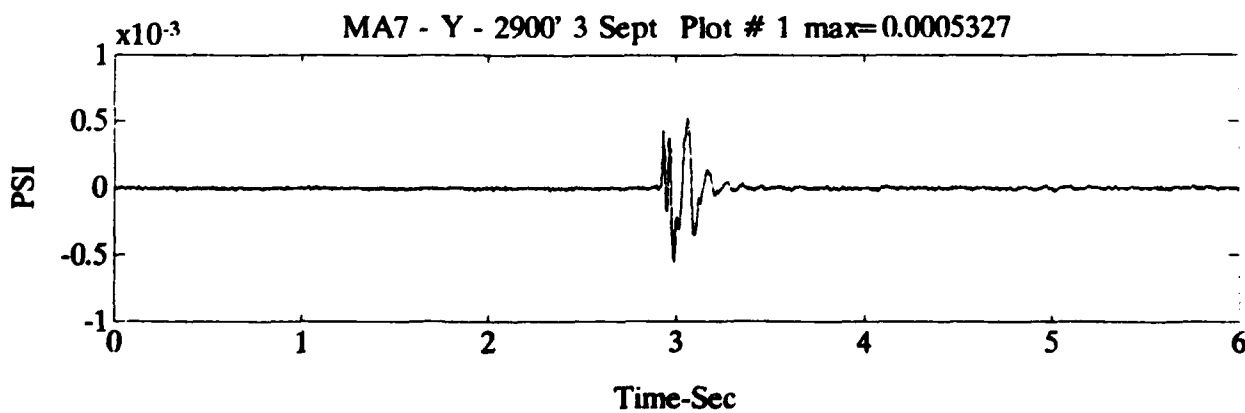
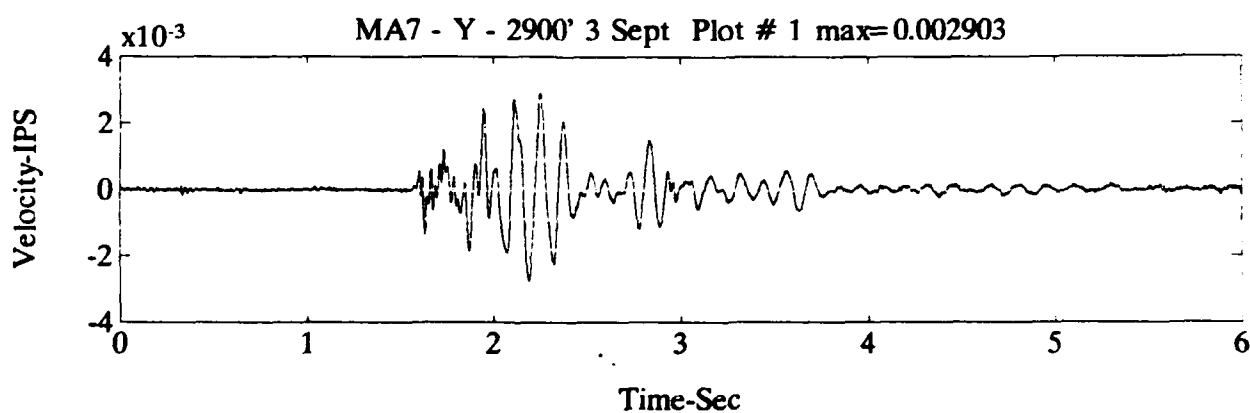
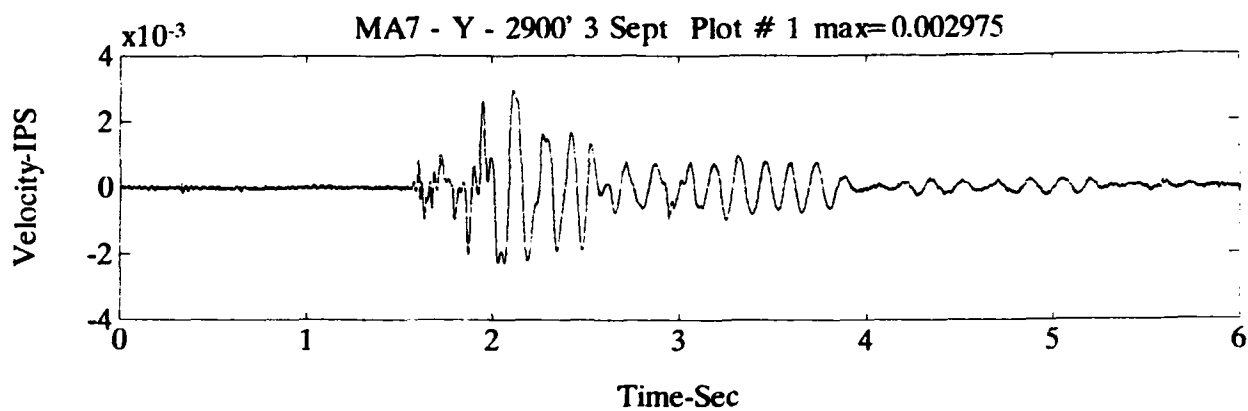
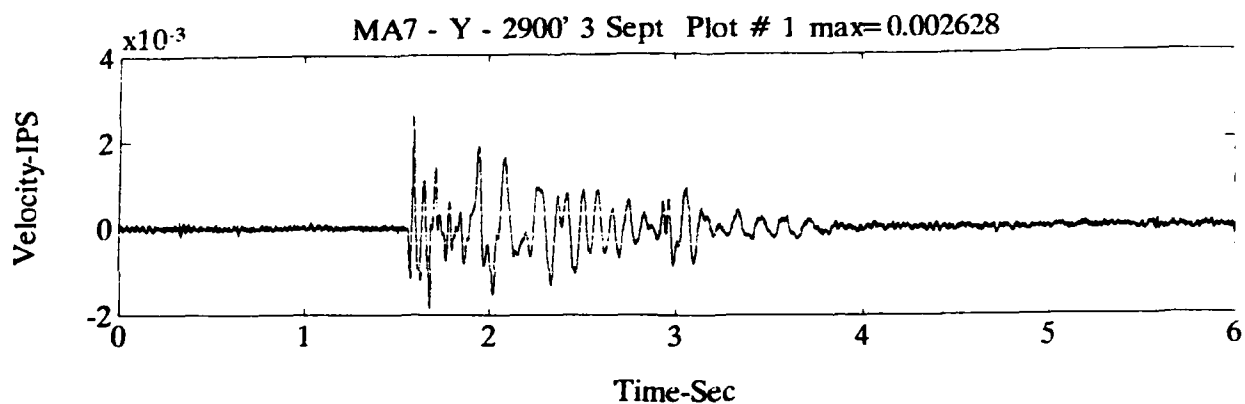


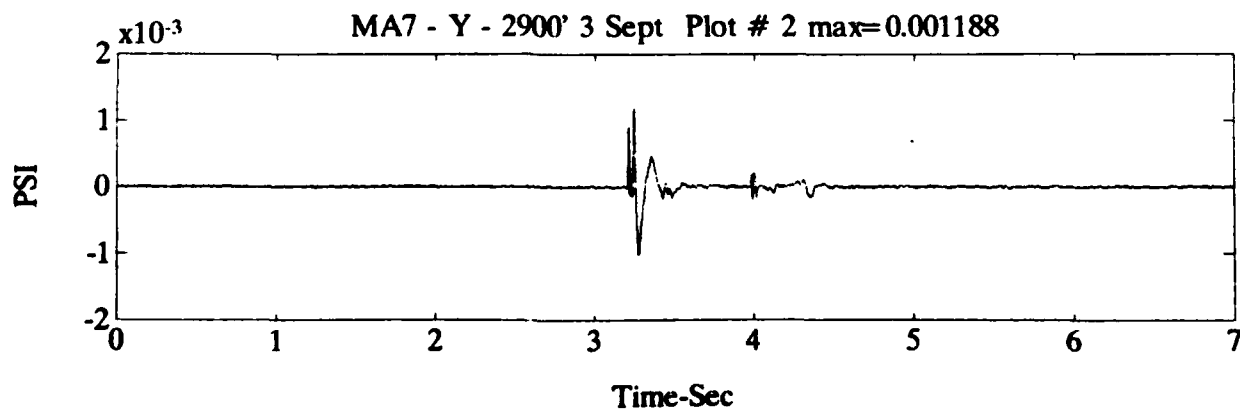
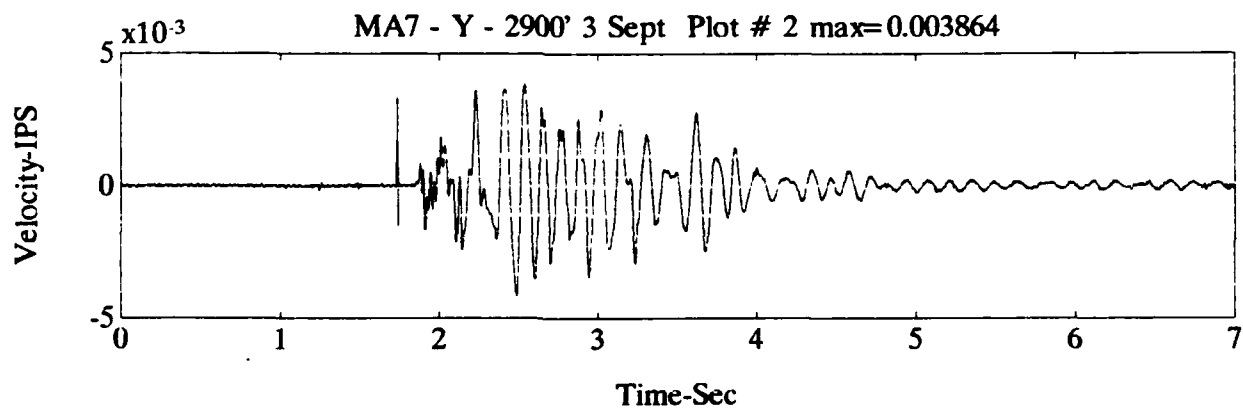
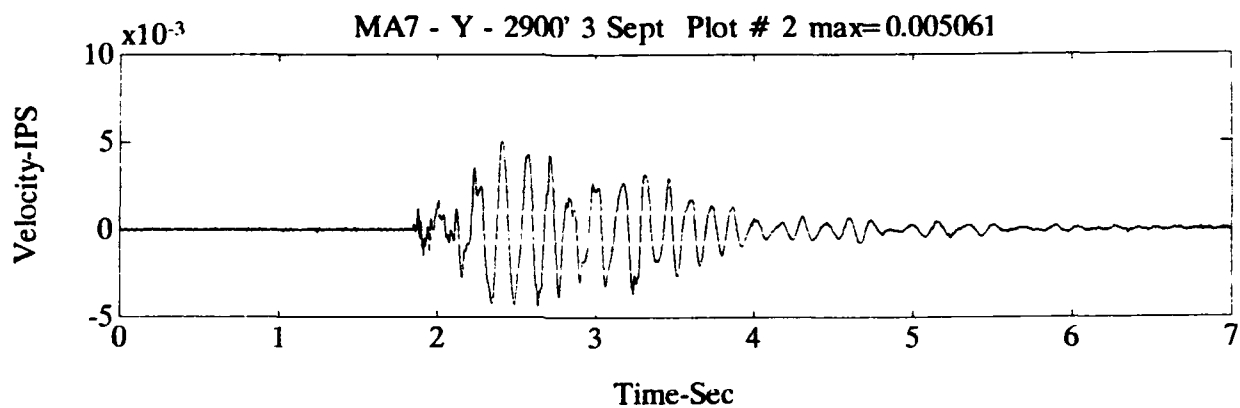
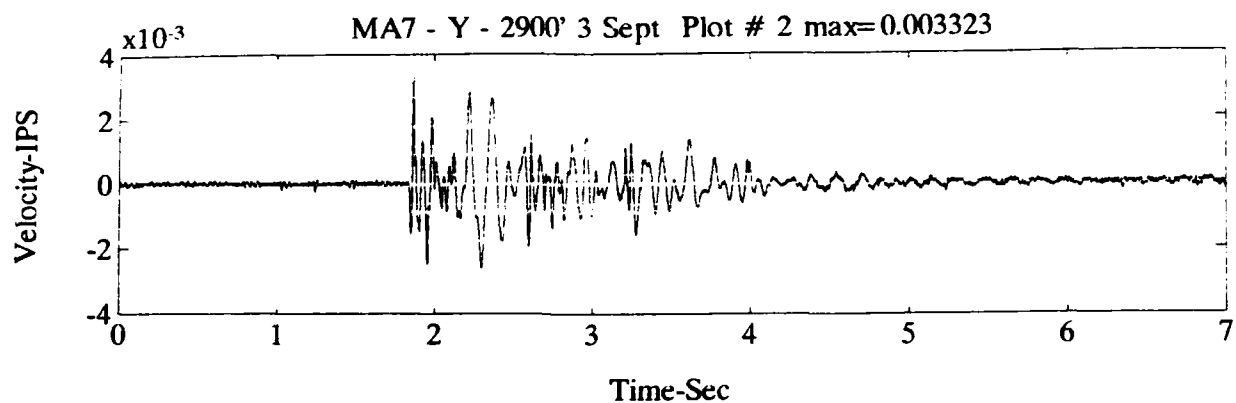


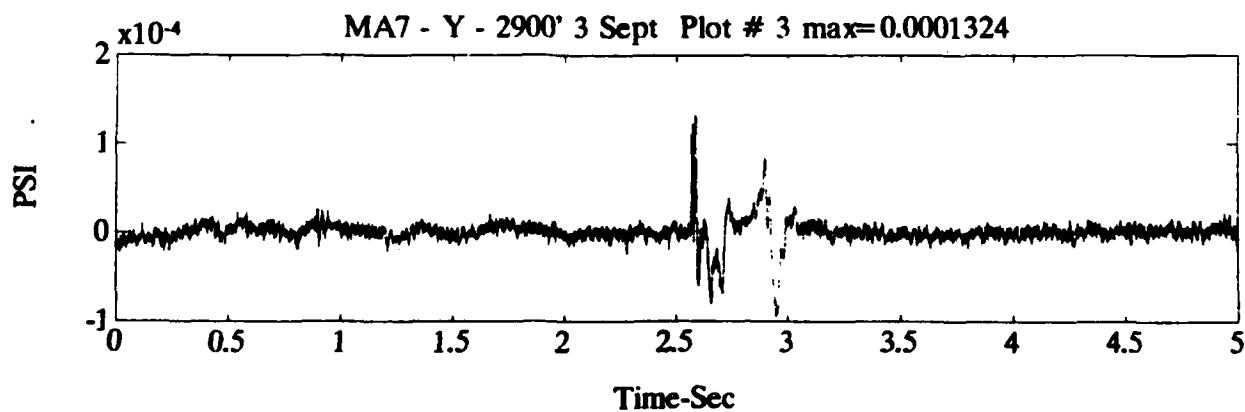
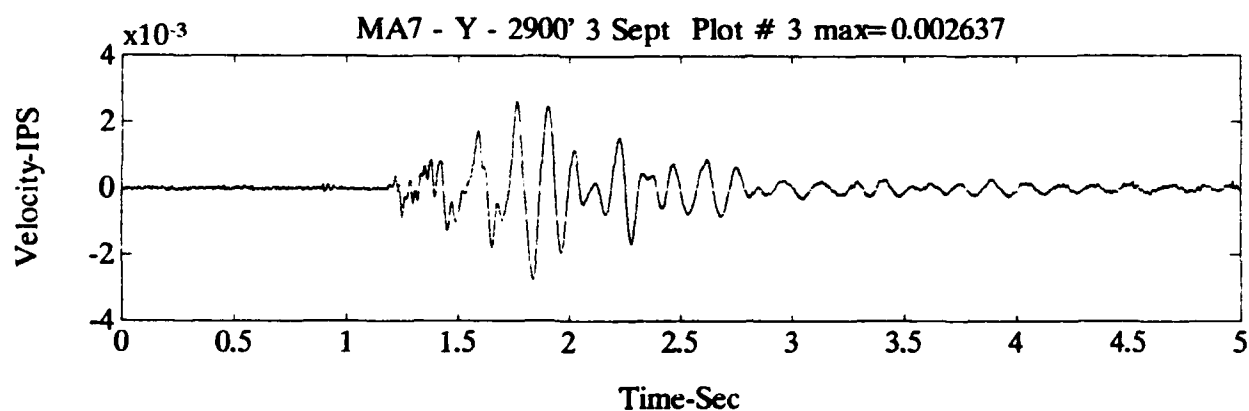
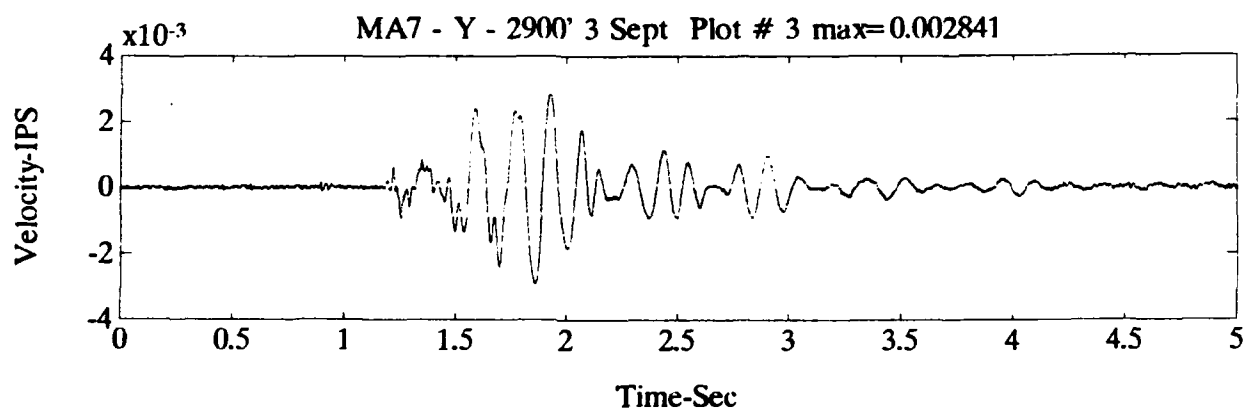
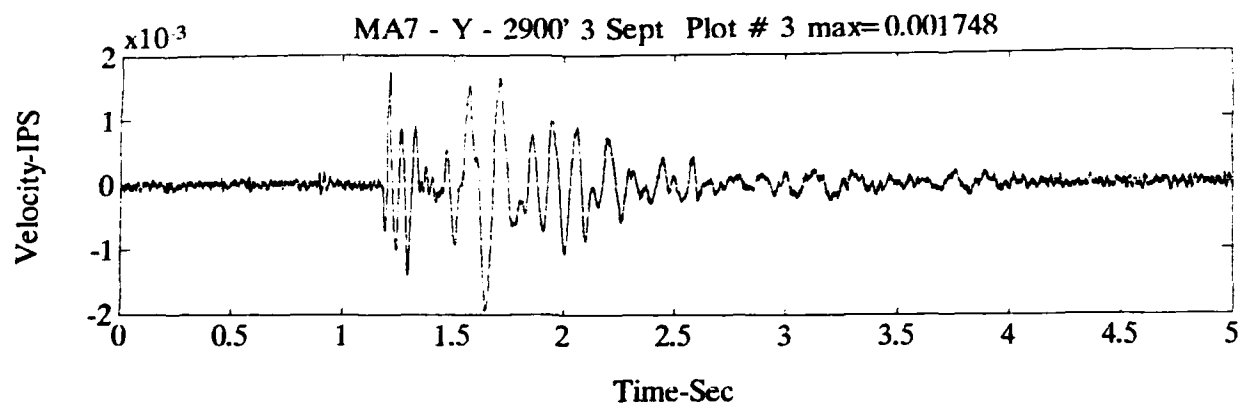


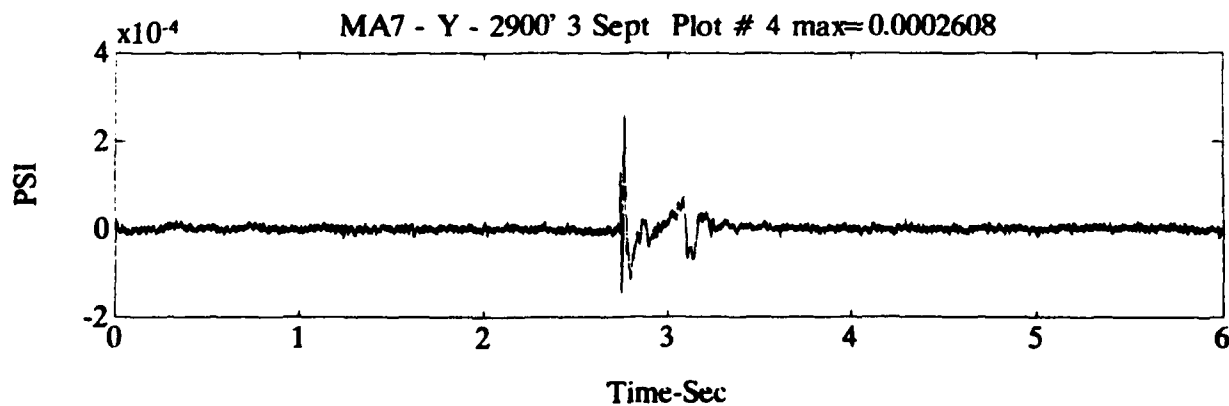
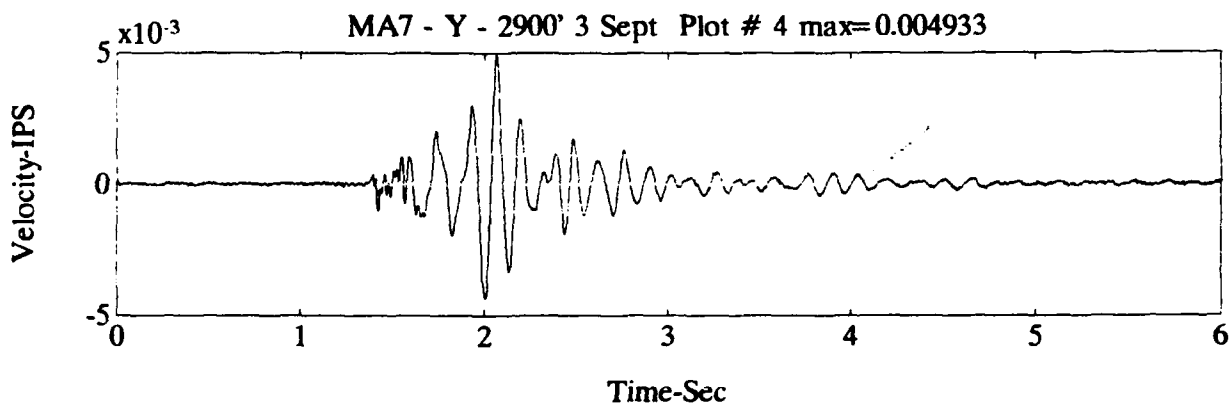
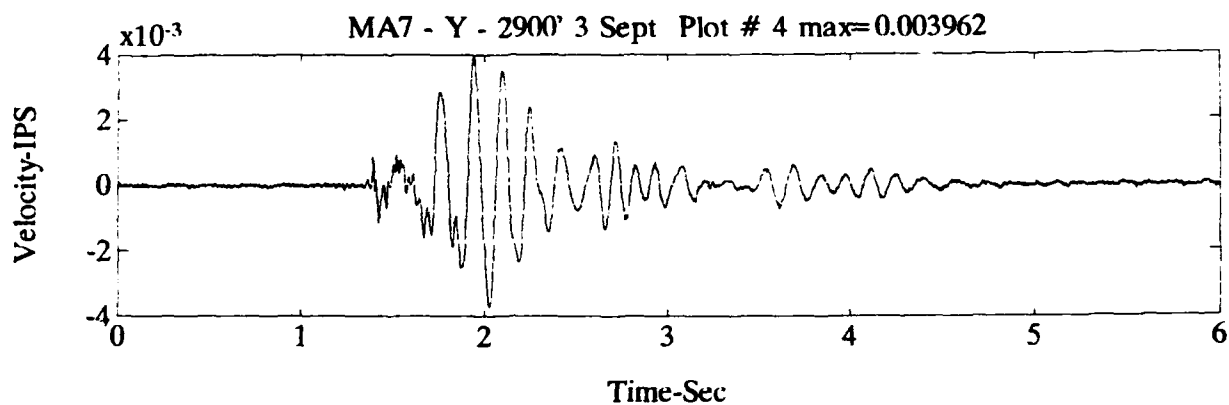
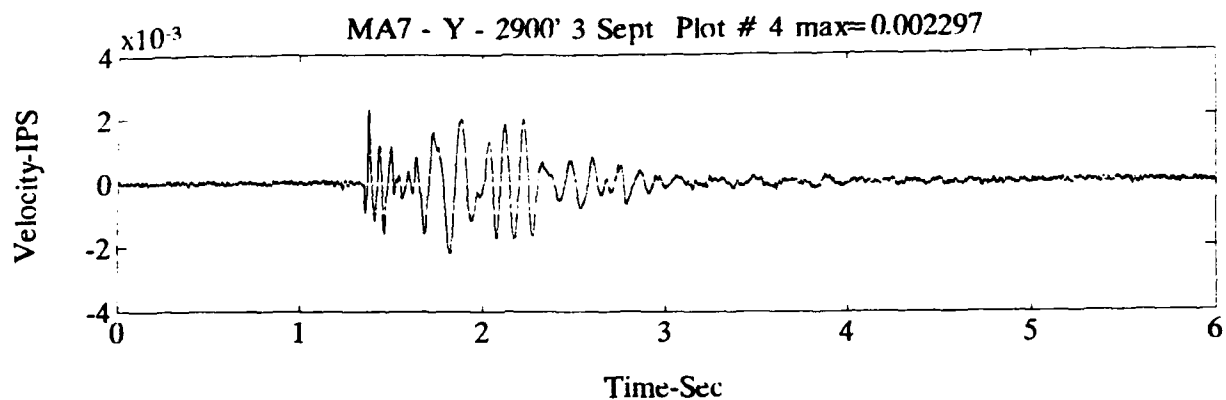


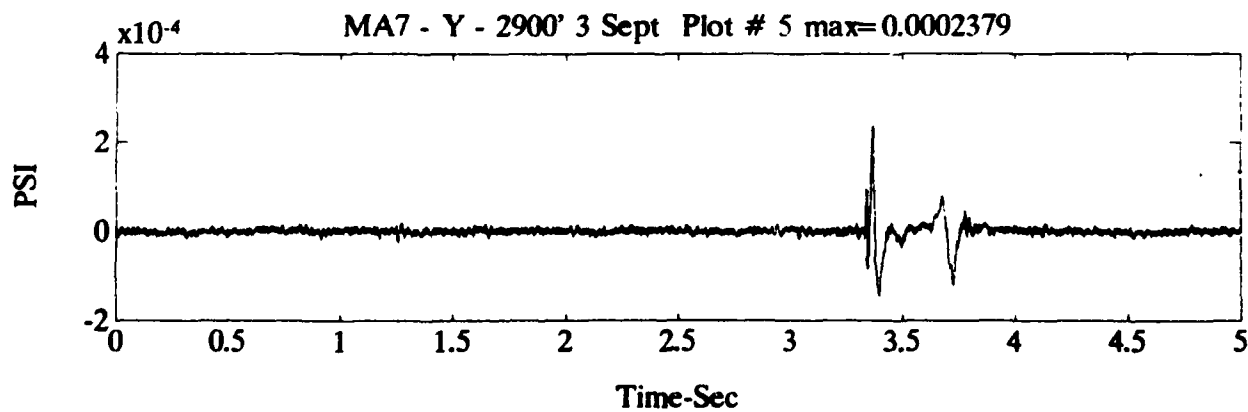
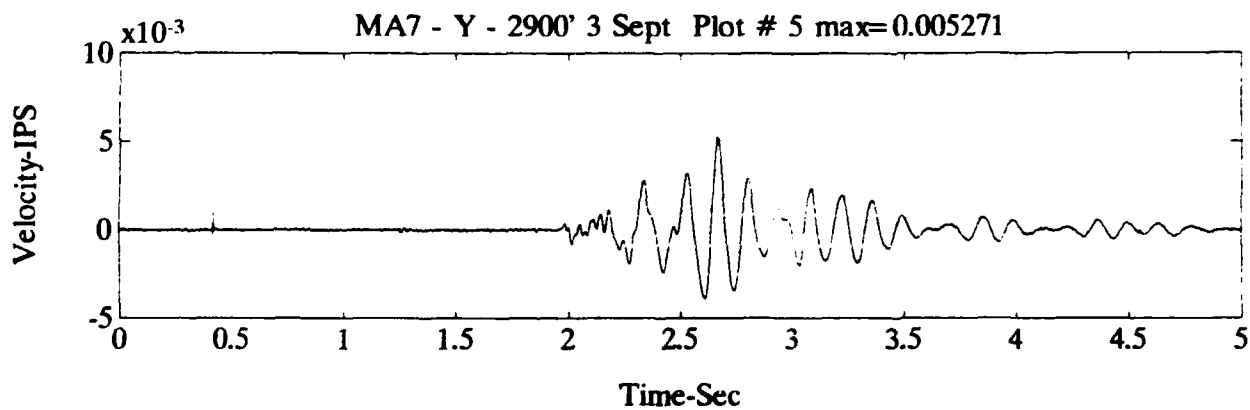
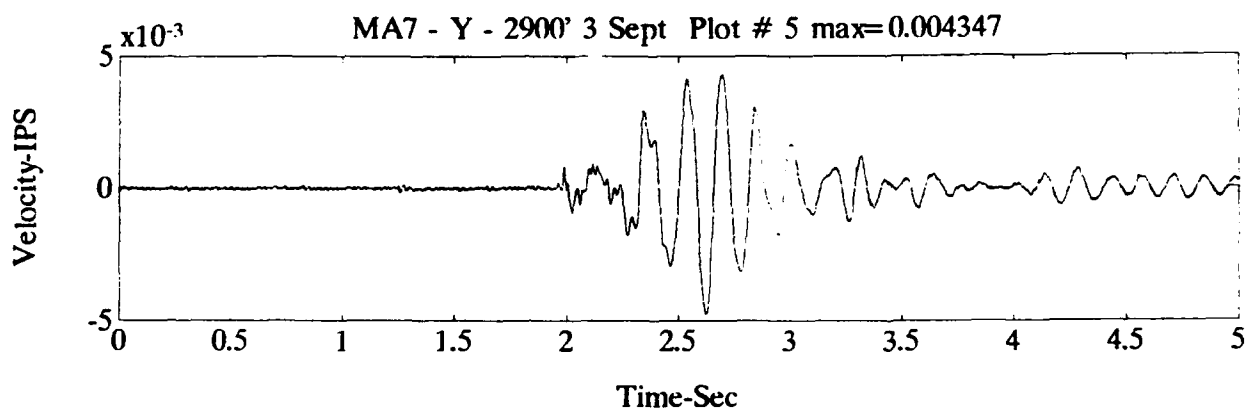
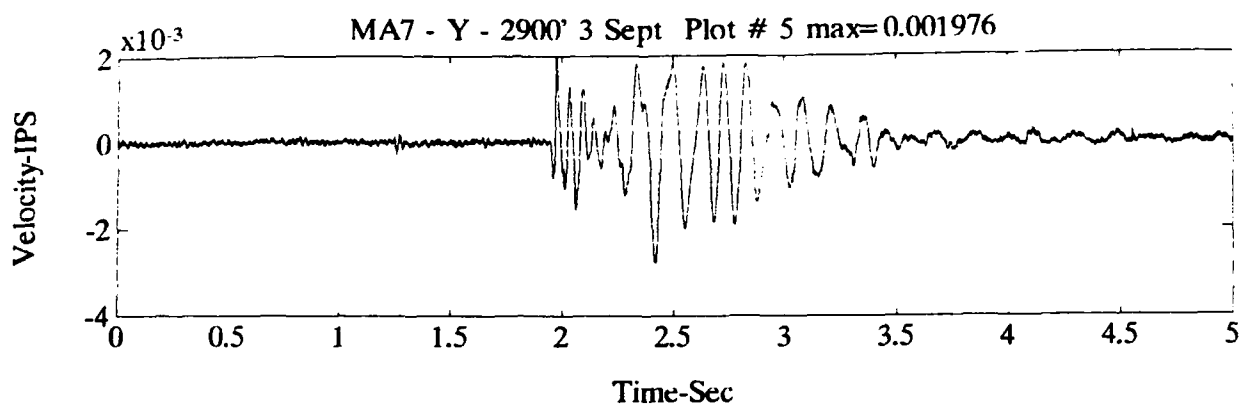


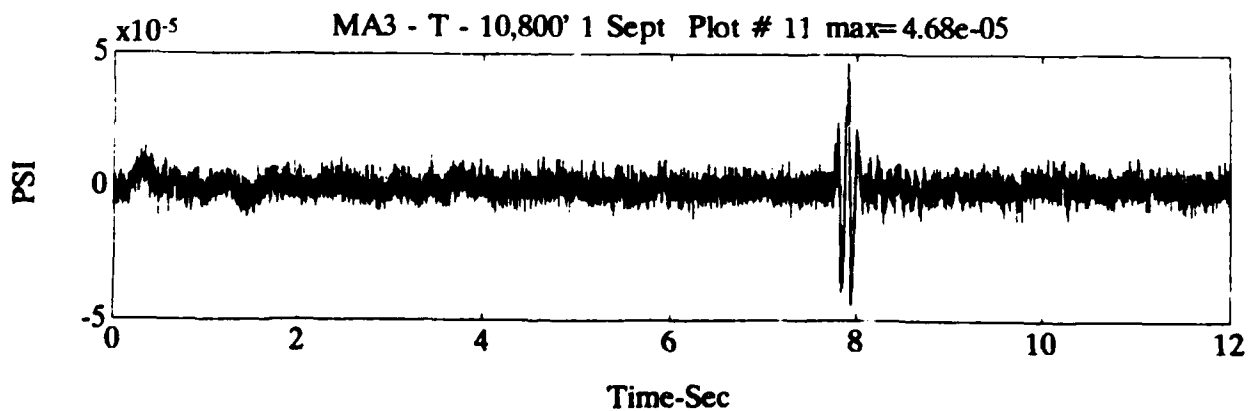
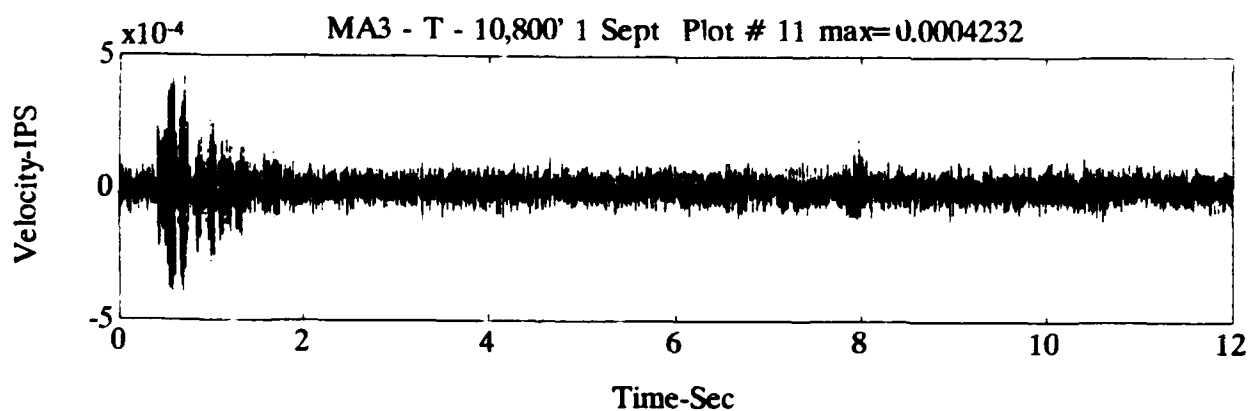
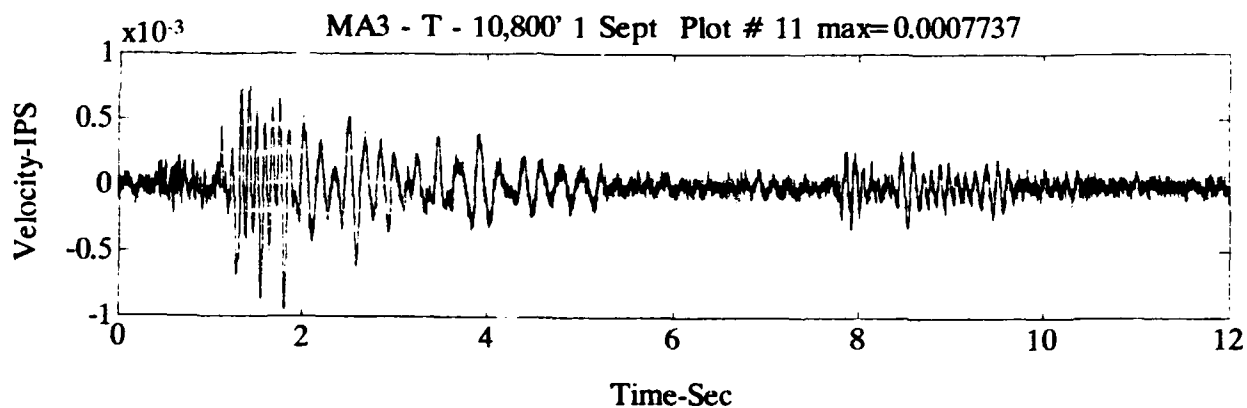
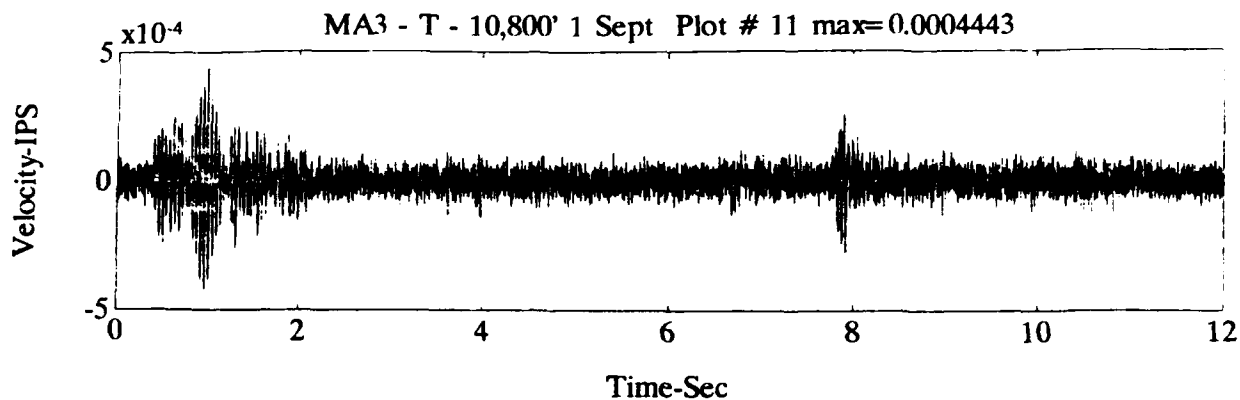


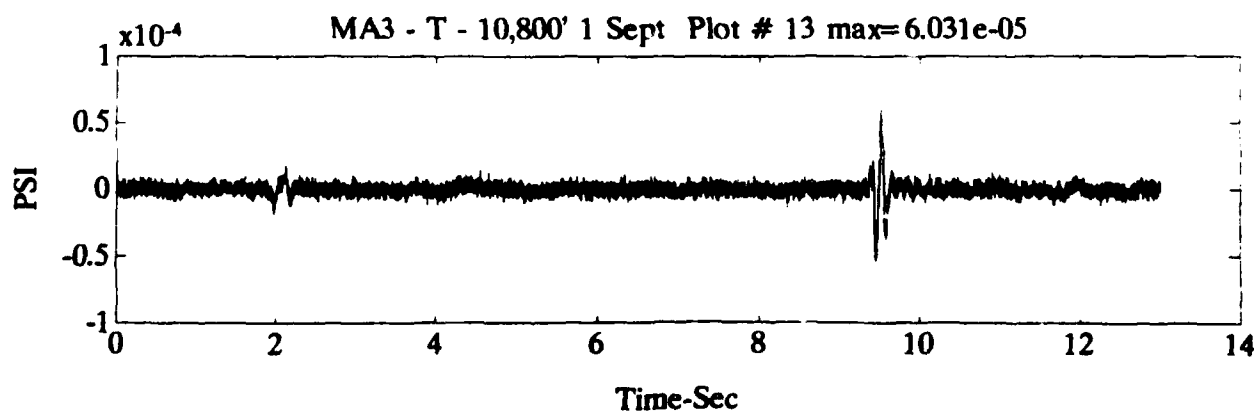
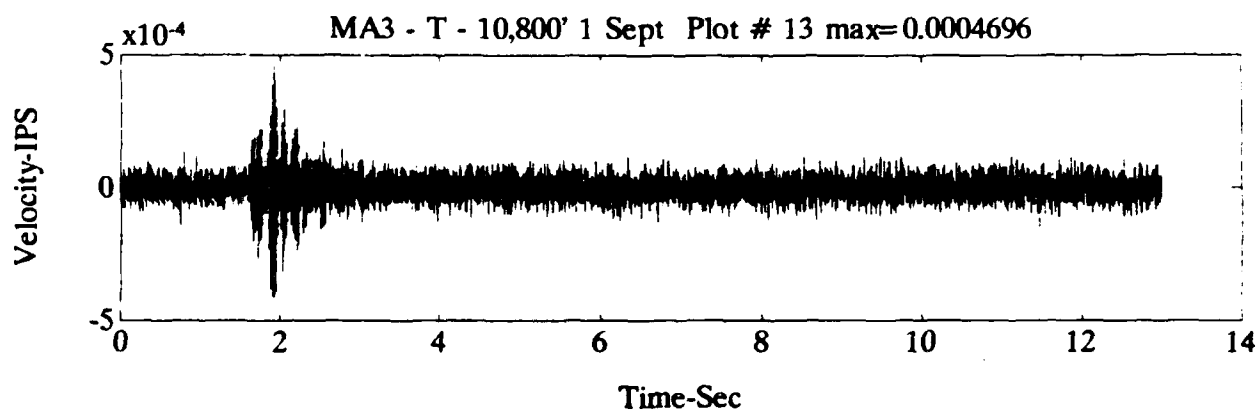
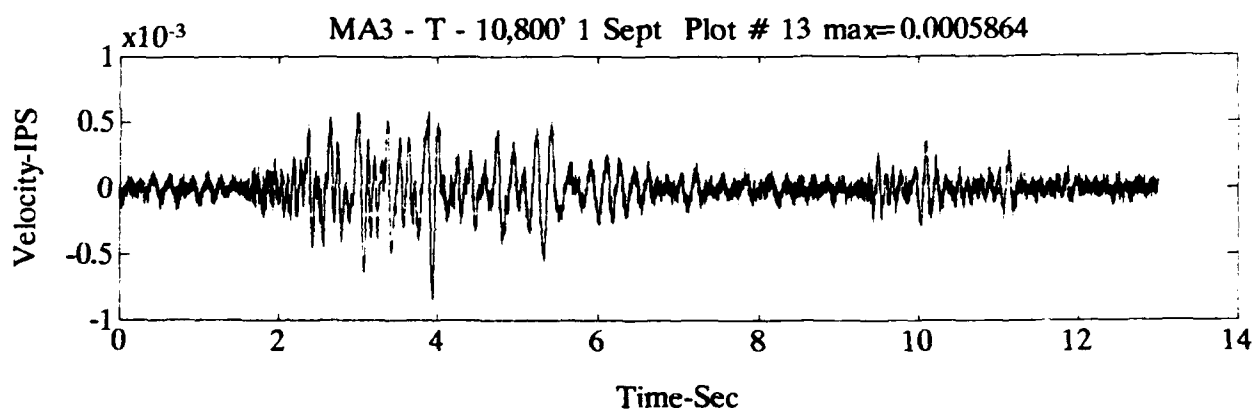
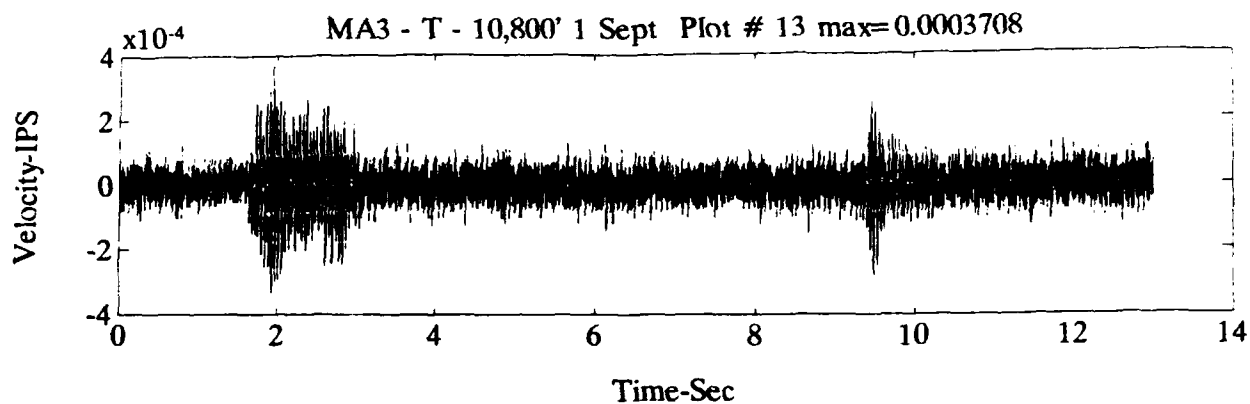


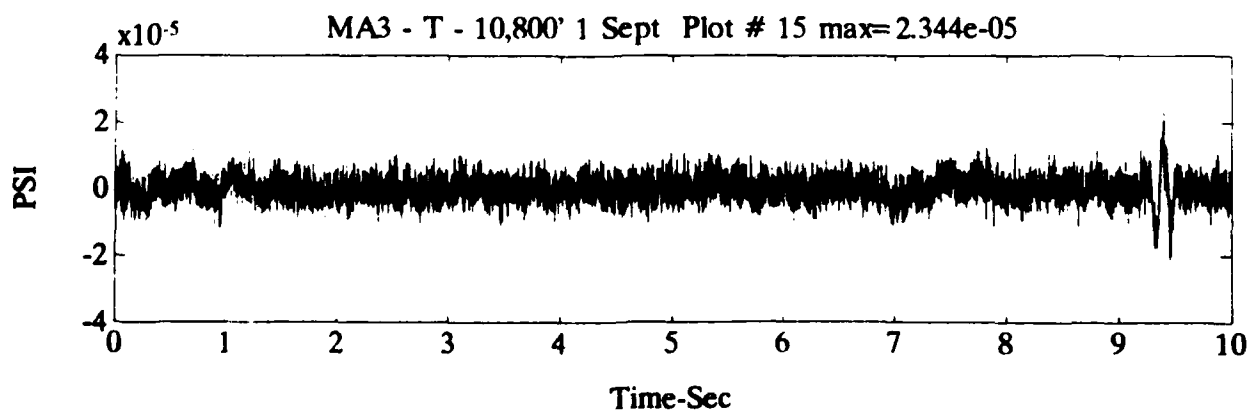
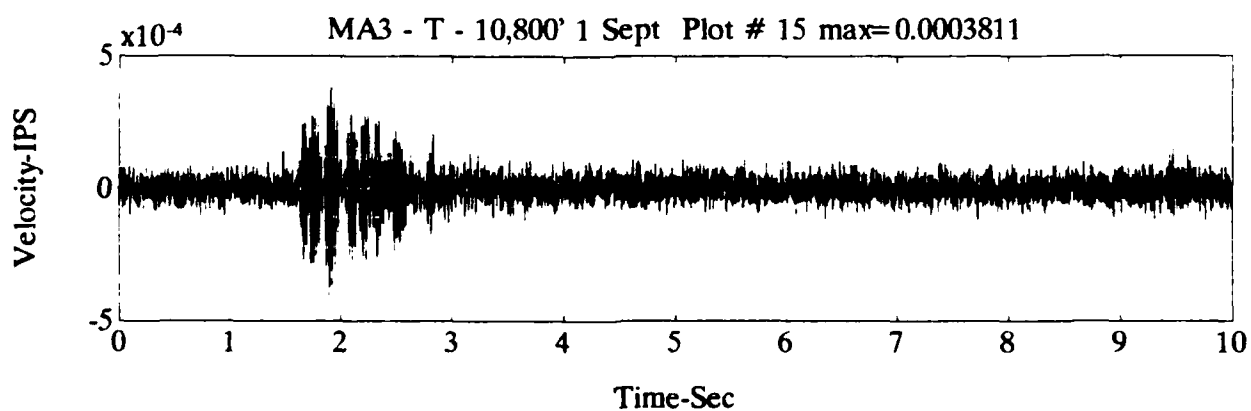
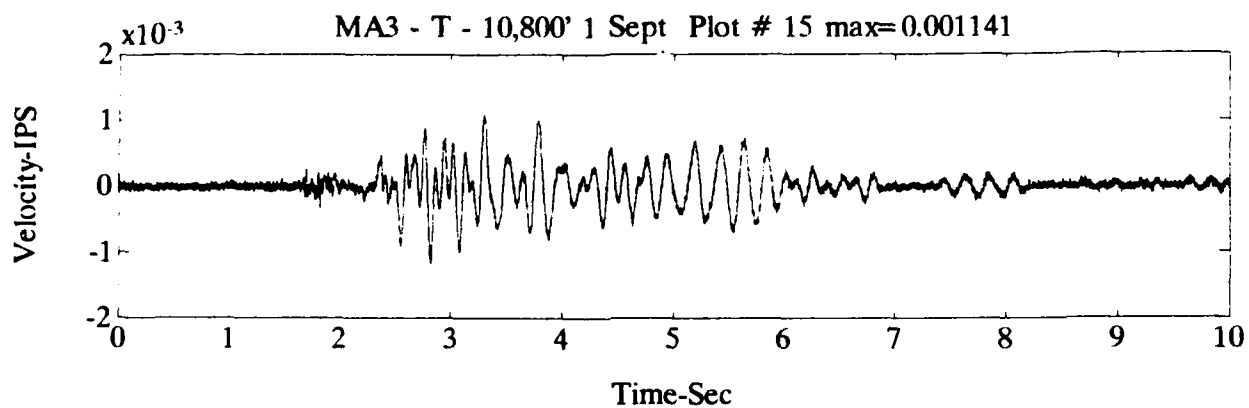
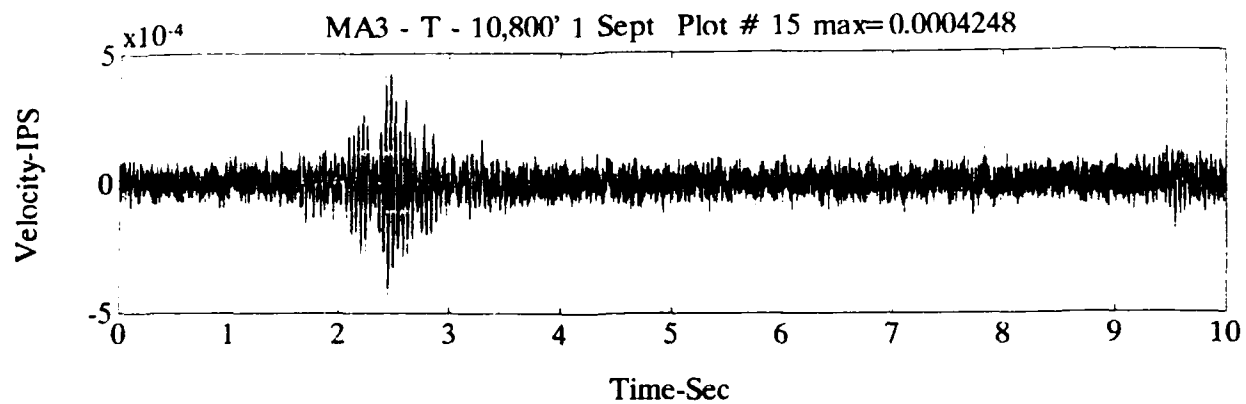


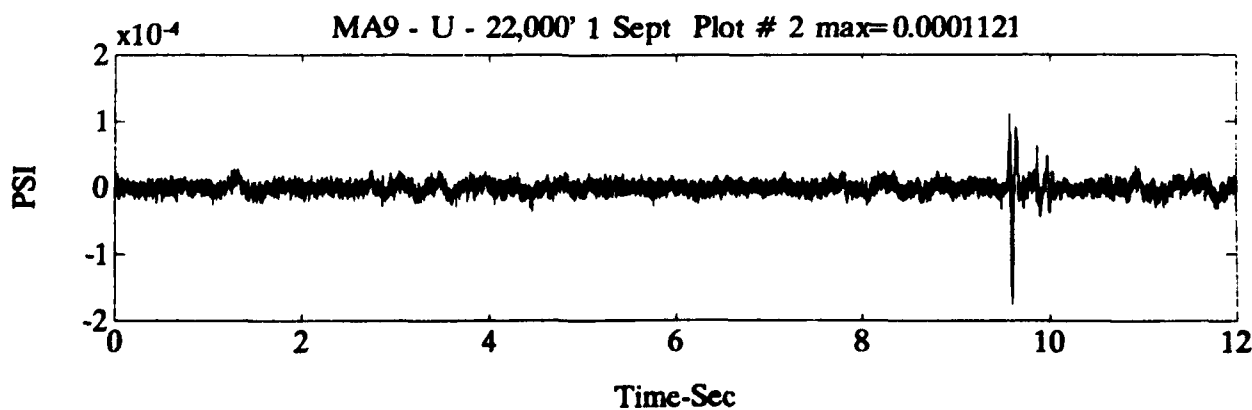
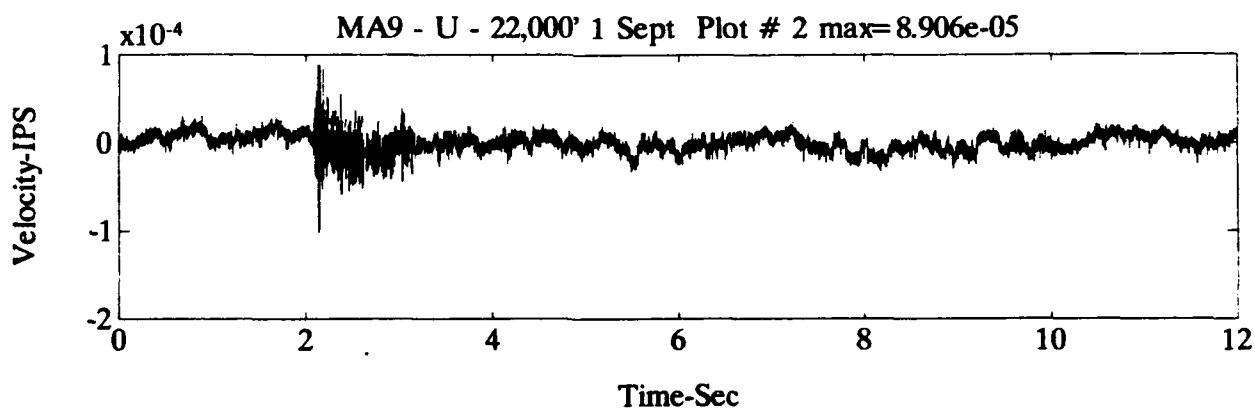
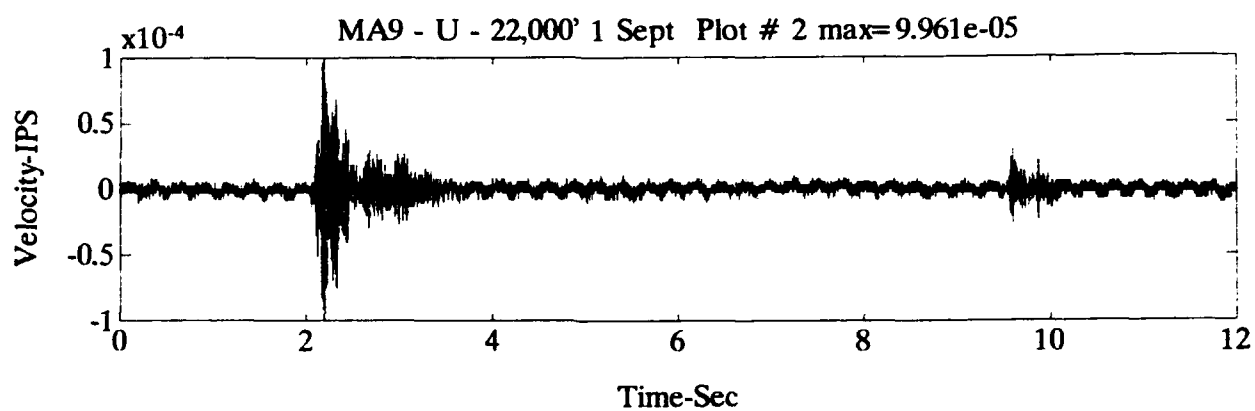
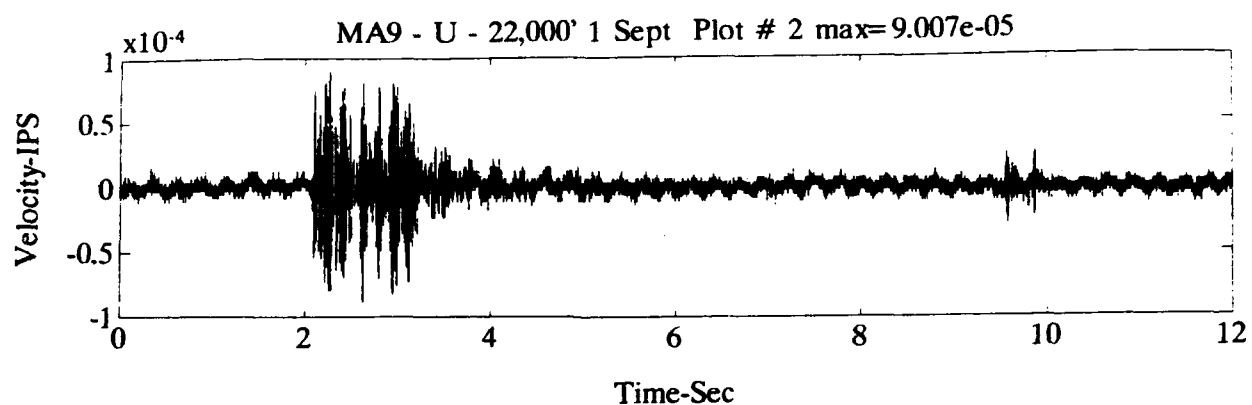


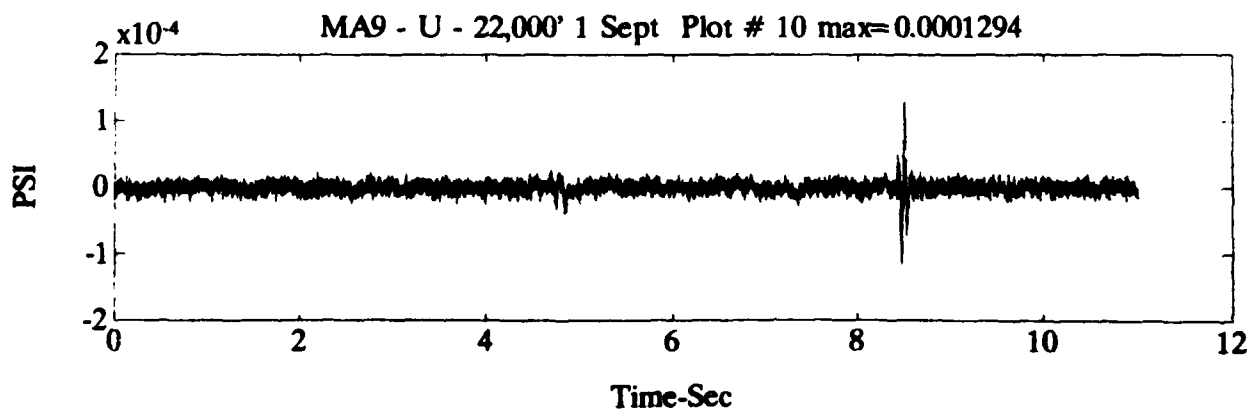
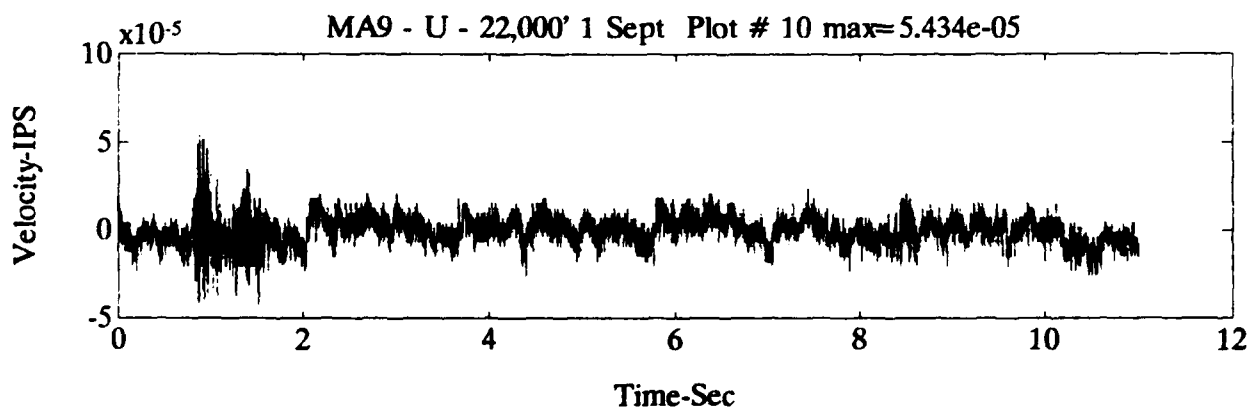
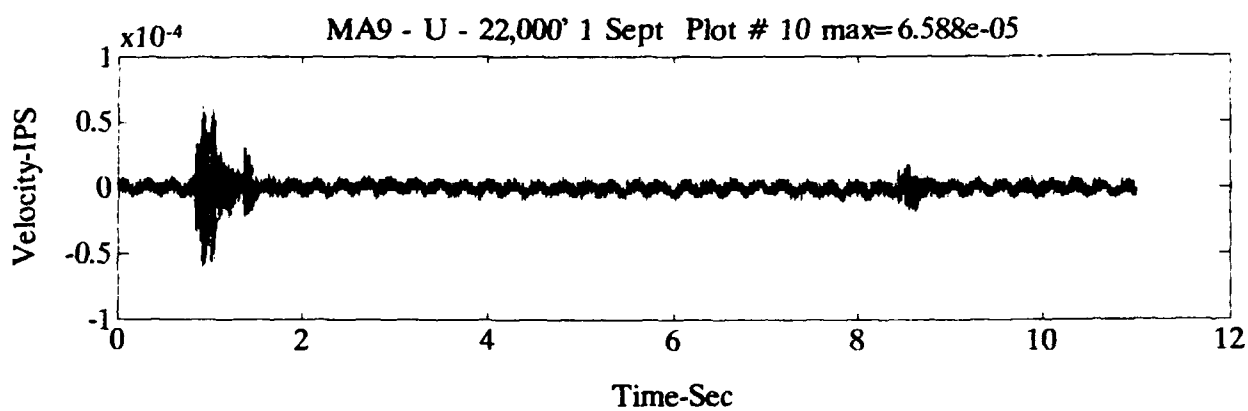
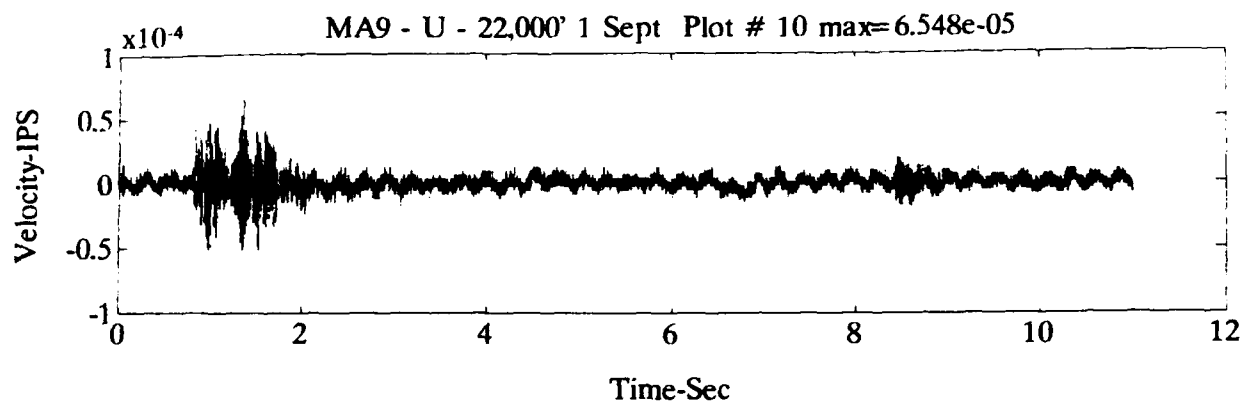


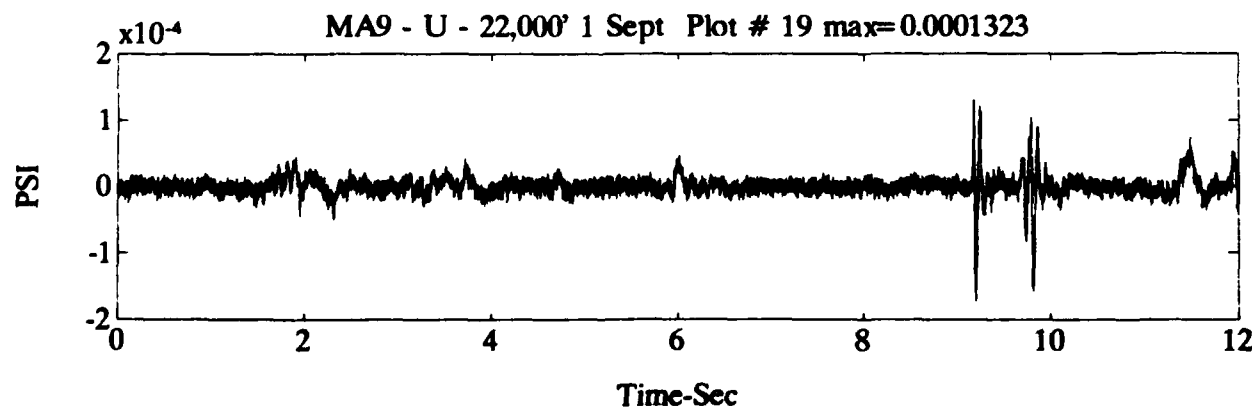
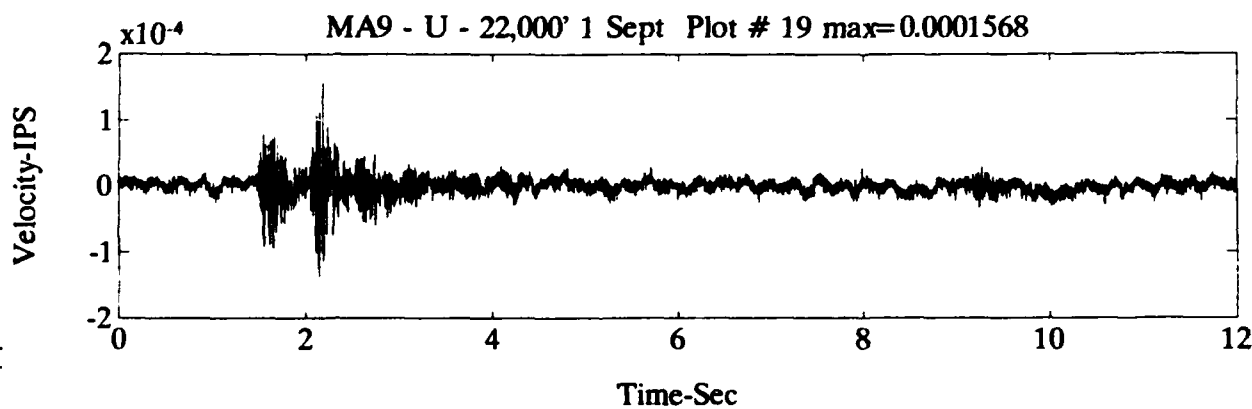
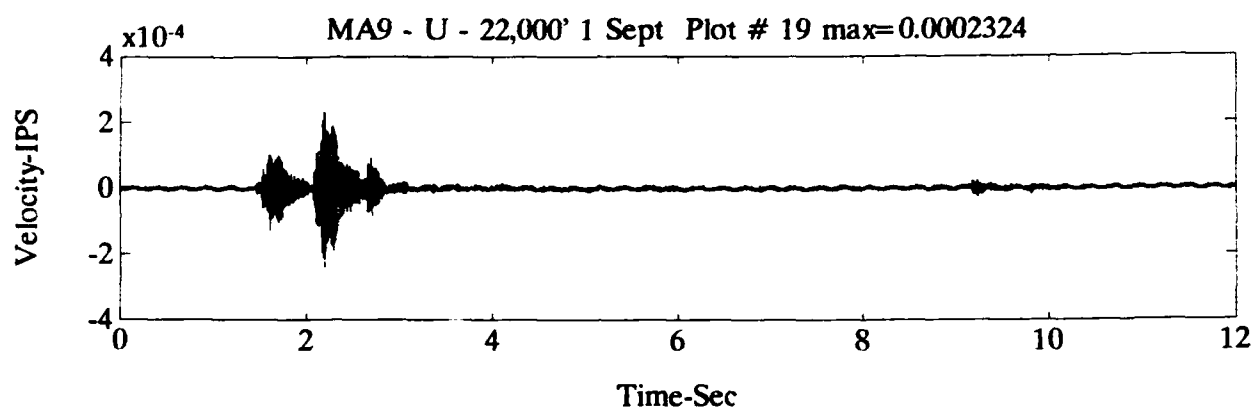
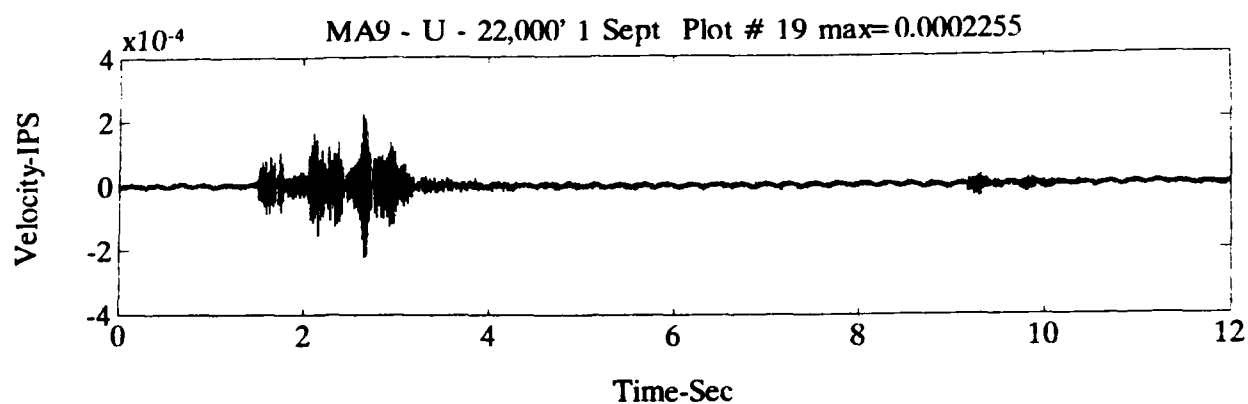








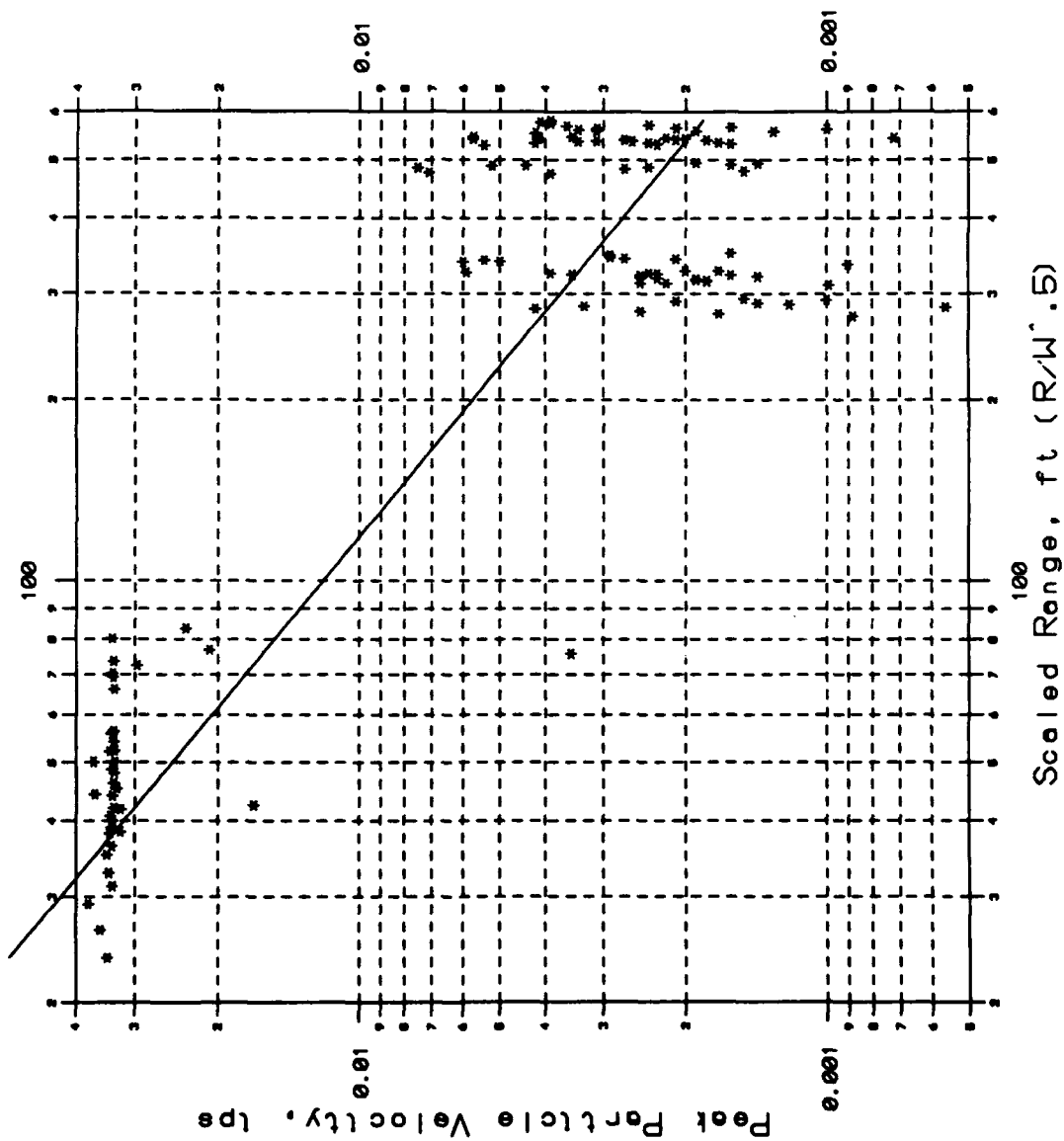




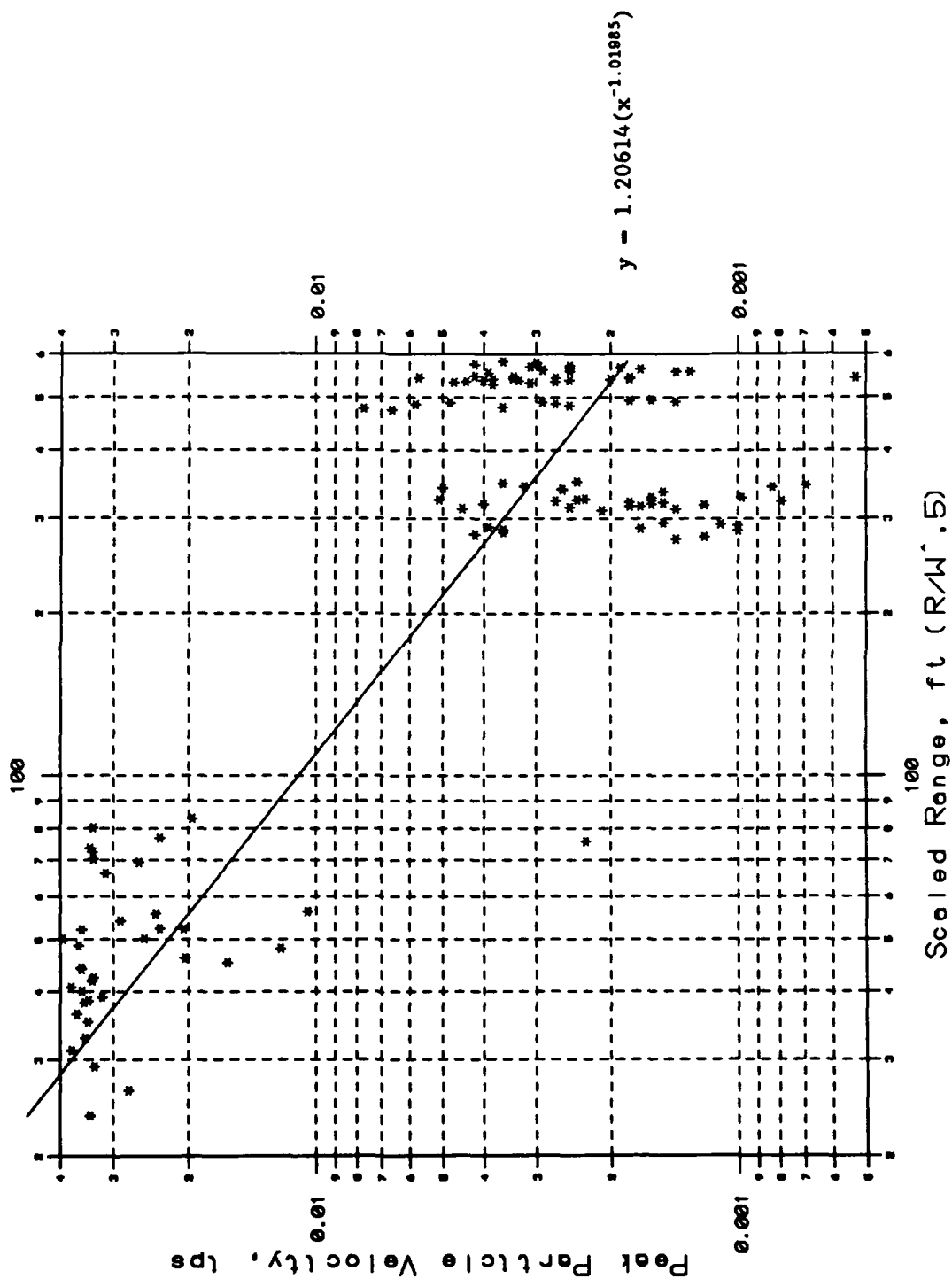
**Appendix C: Plots of Peak Particle Velocities and Air**

**Air Overpressures Versus Scaled Range**

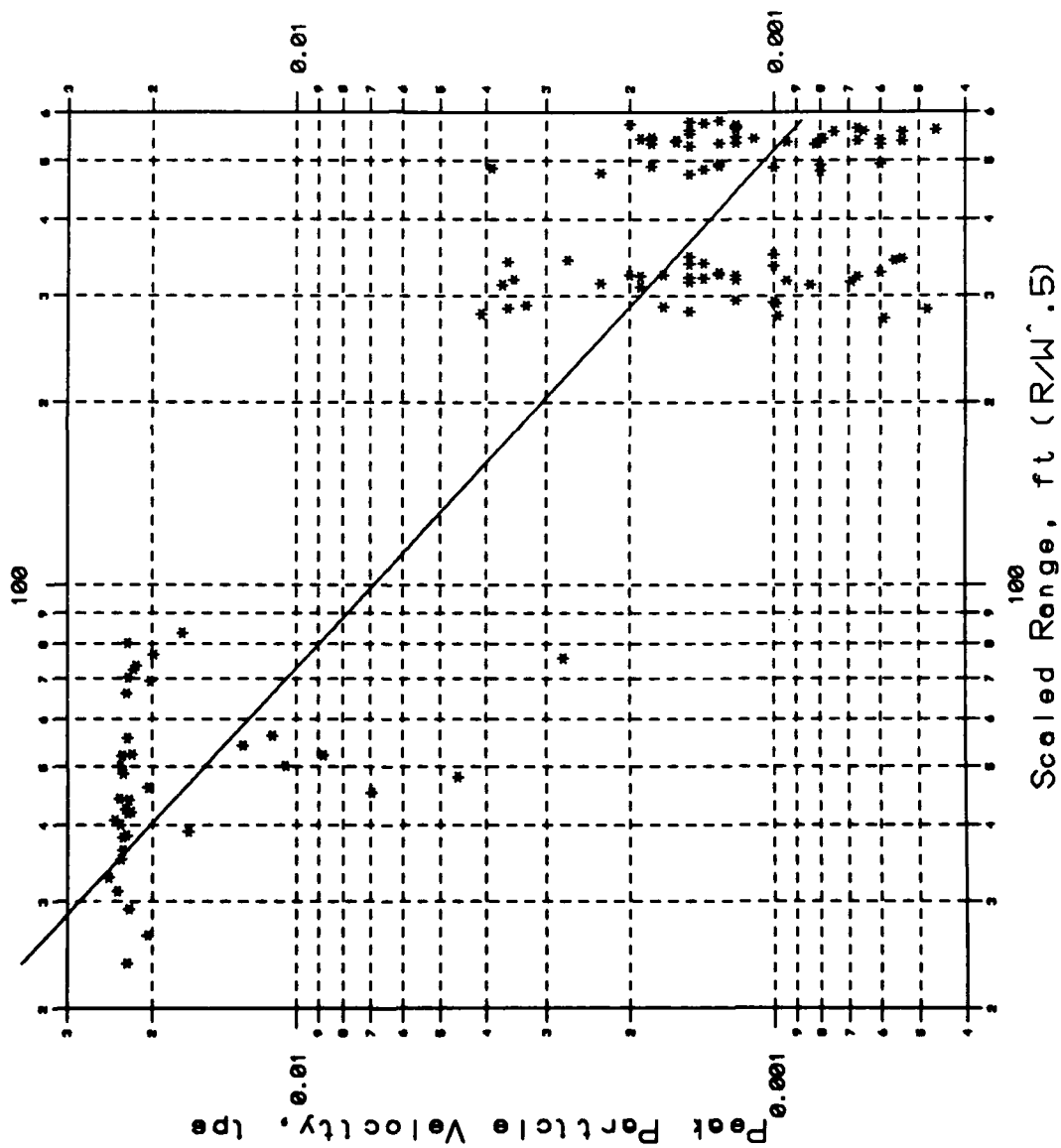
28 Aug Vert



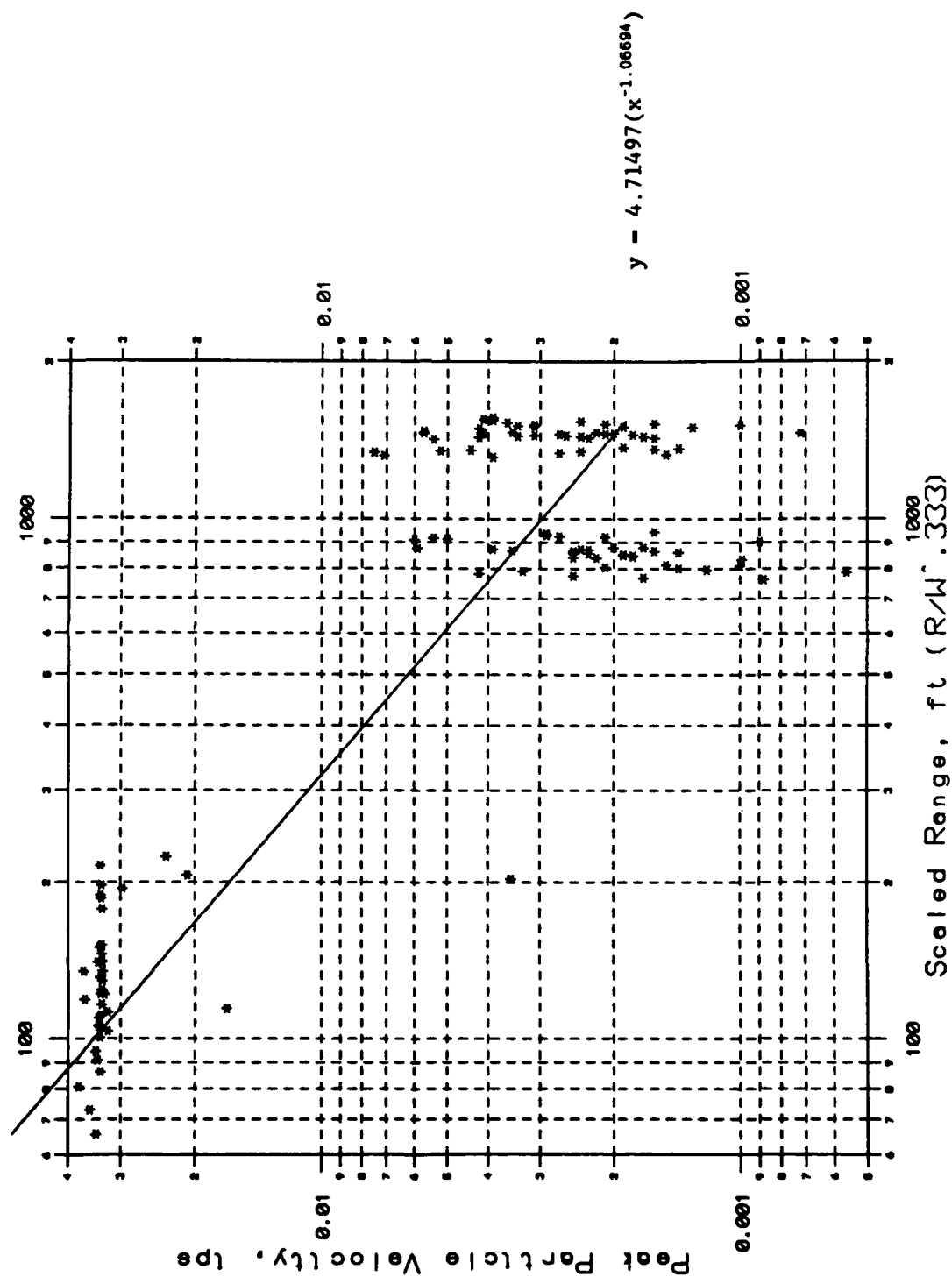
28 Aug Rad (a)

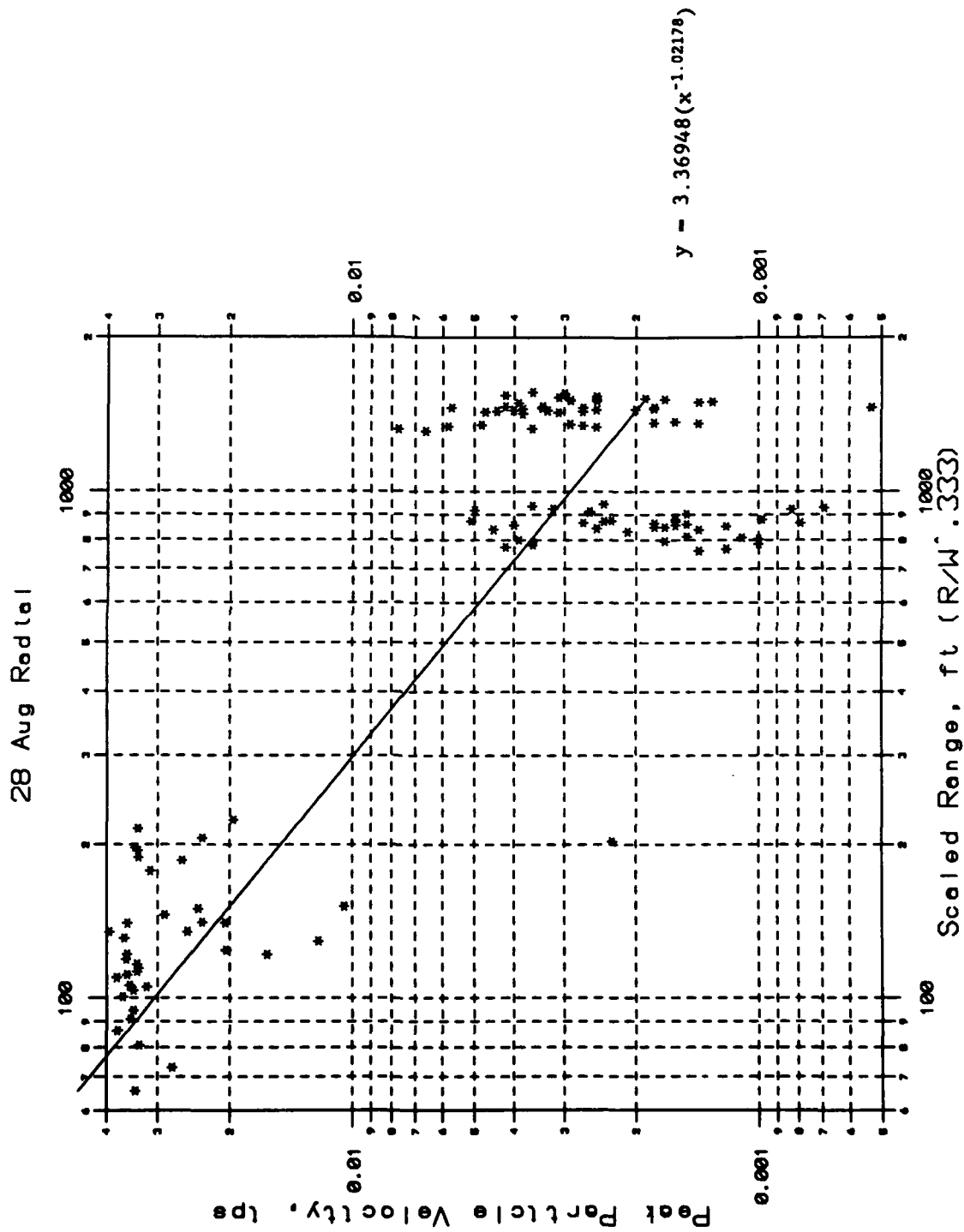


28 Aug Transverse

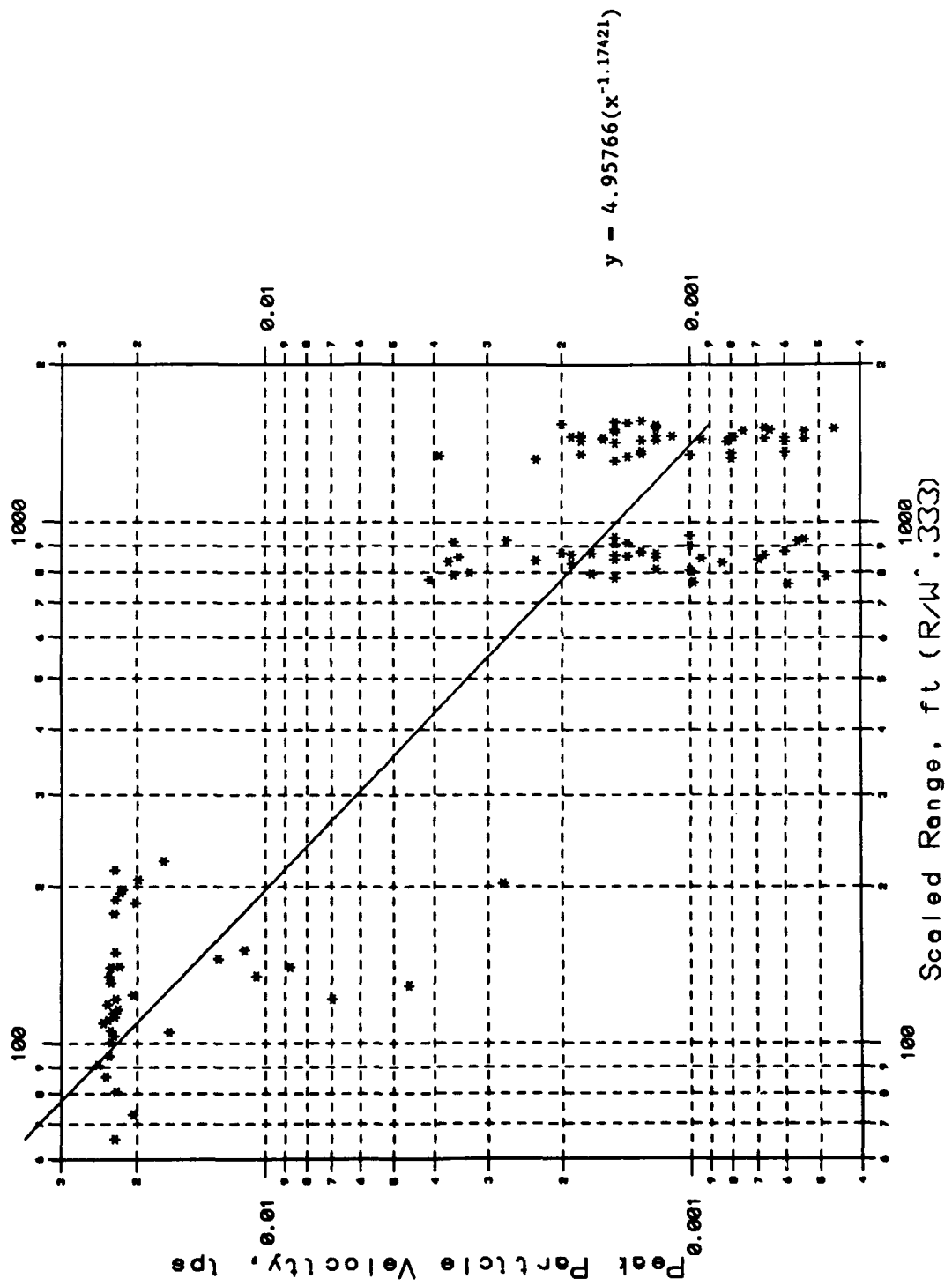


28 Aug Vertical

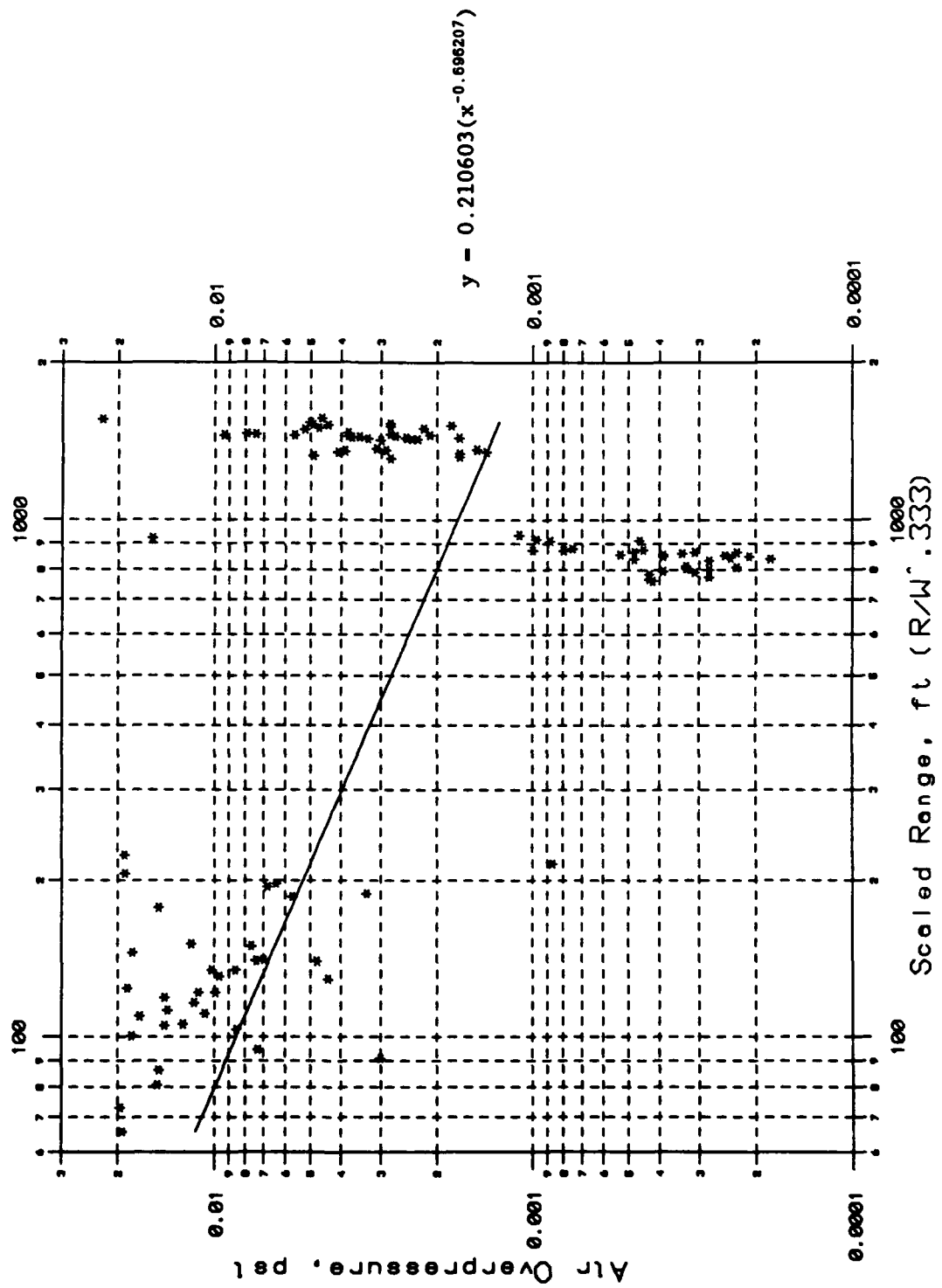


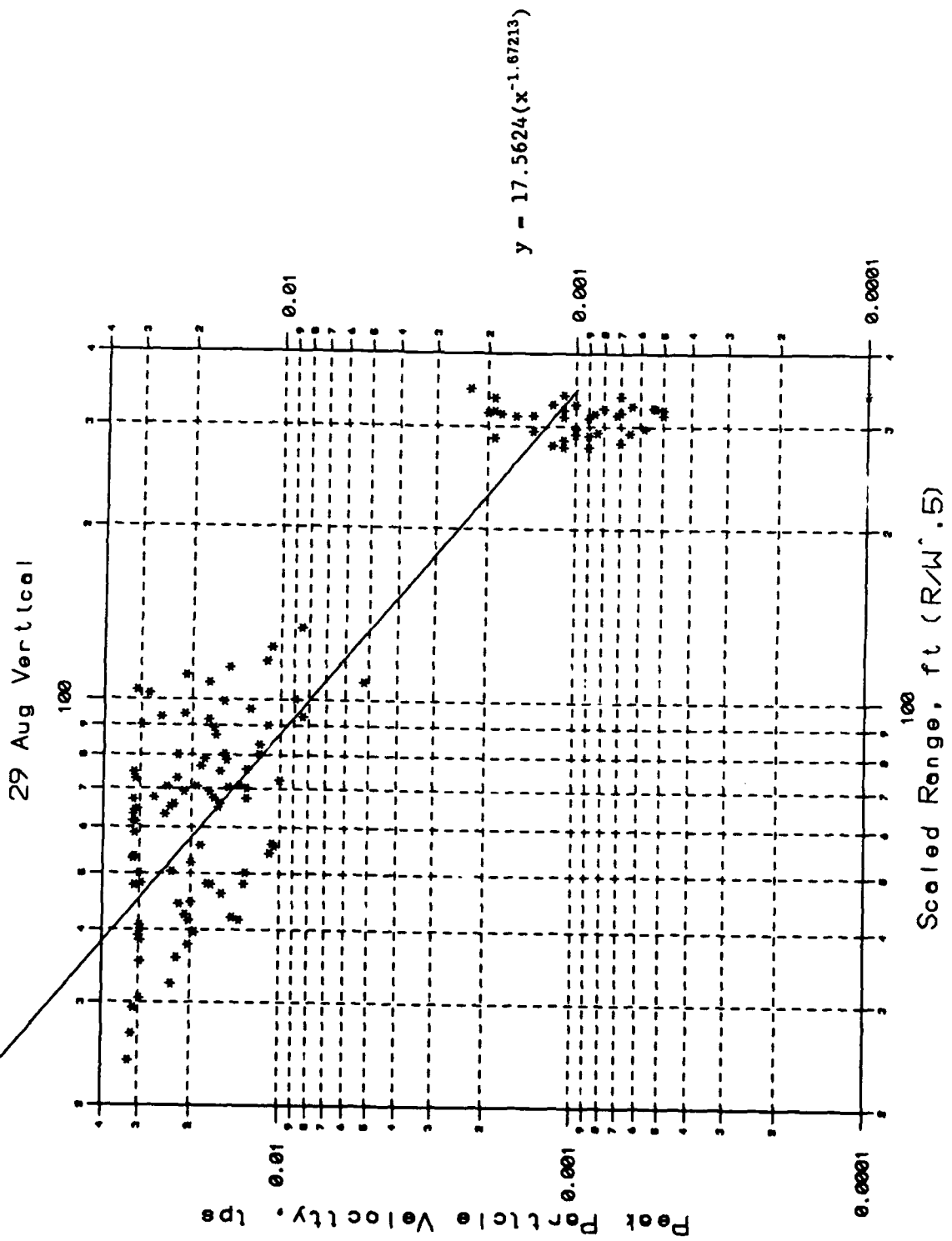


28 Aug Transverse

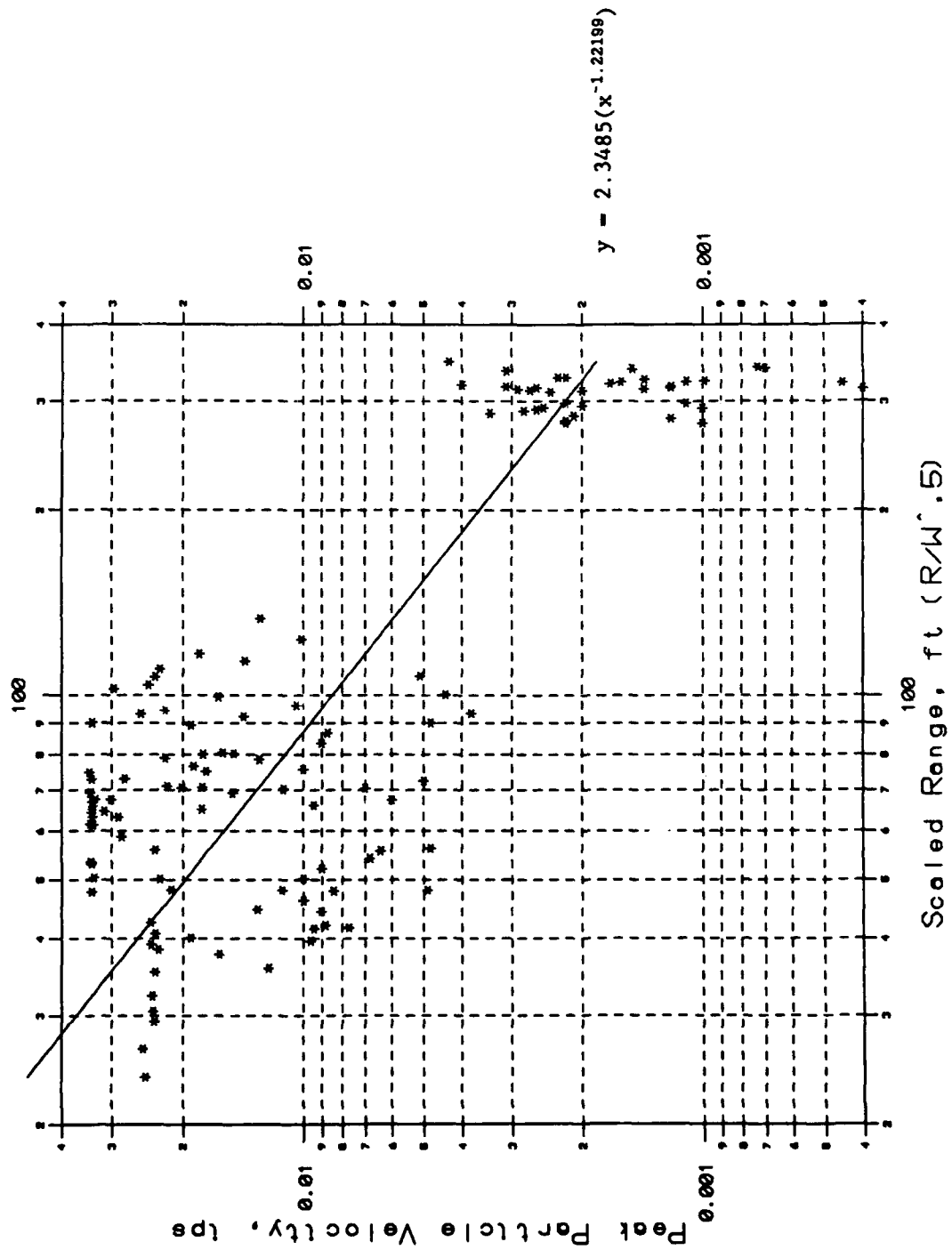


28 Aug Atr

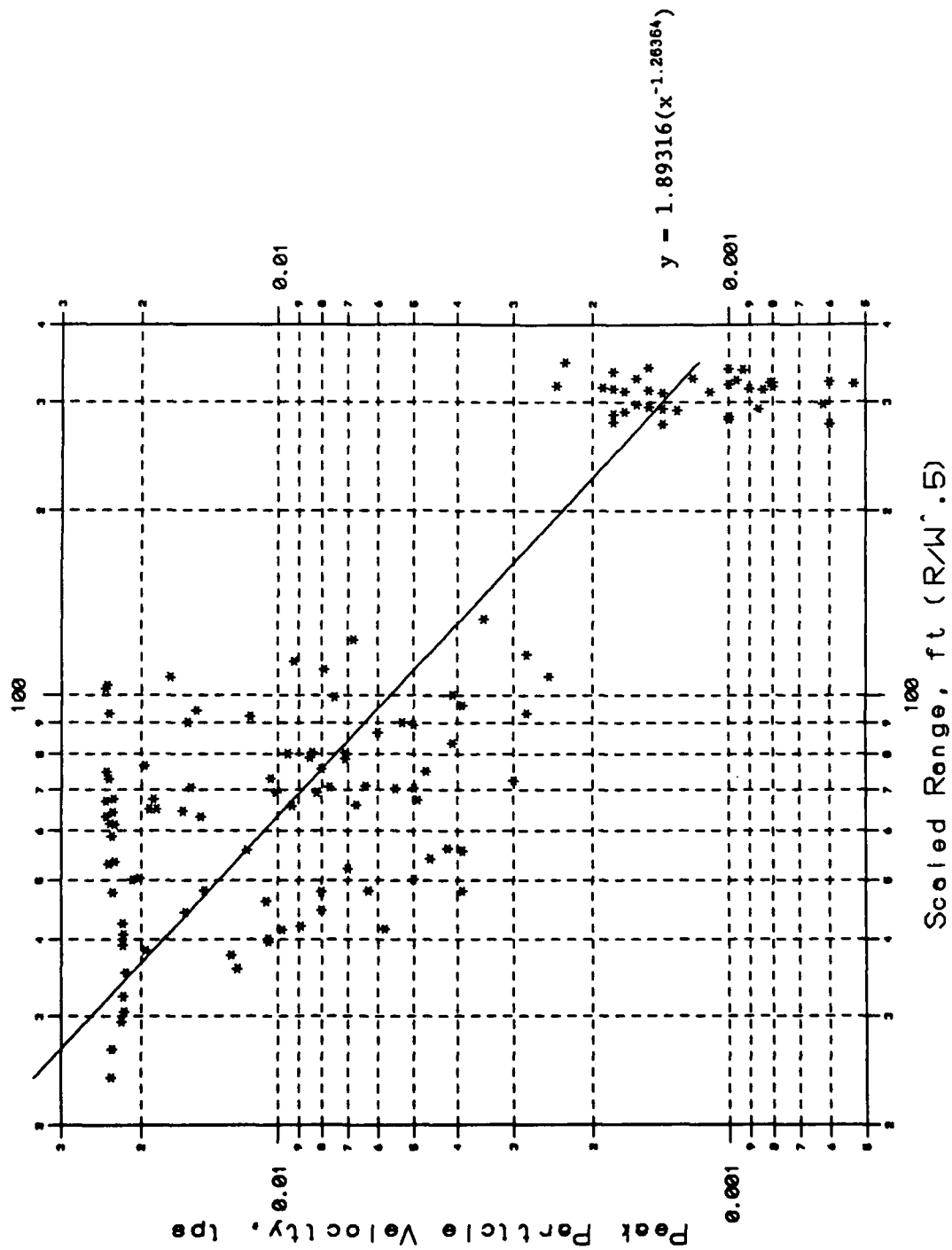


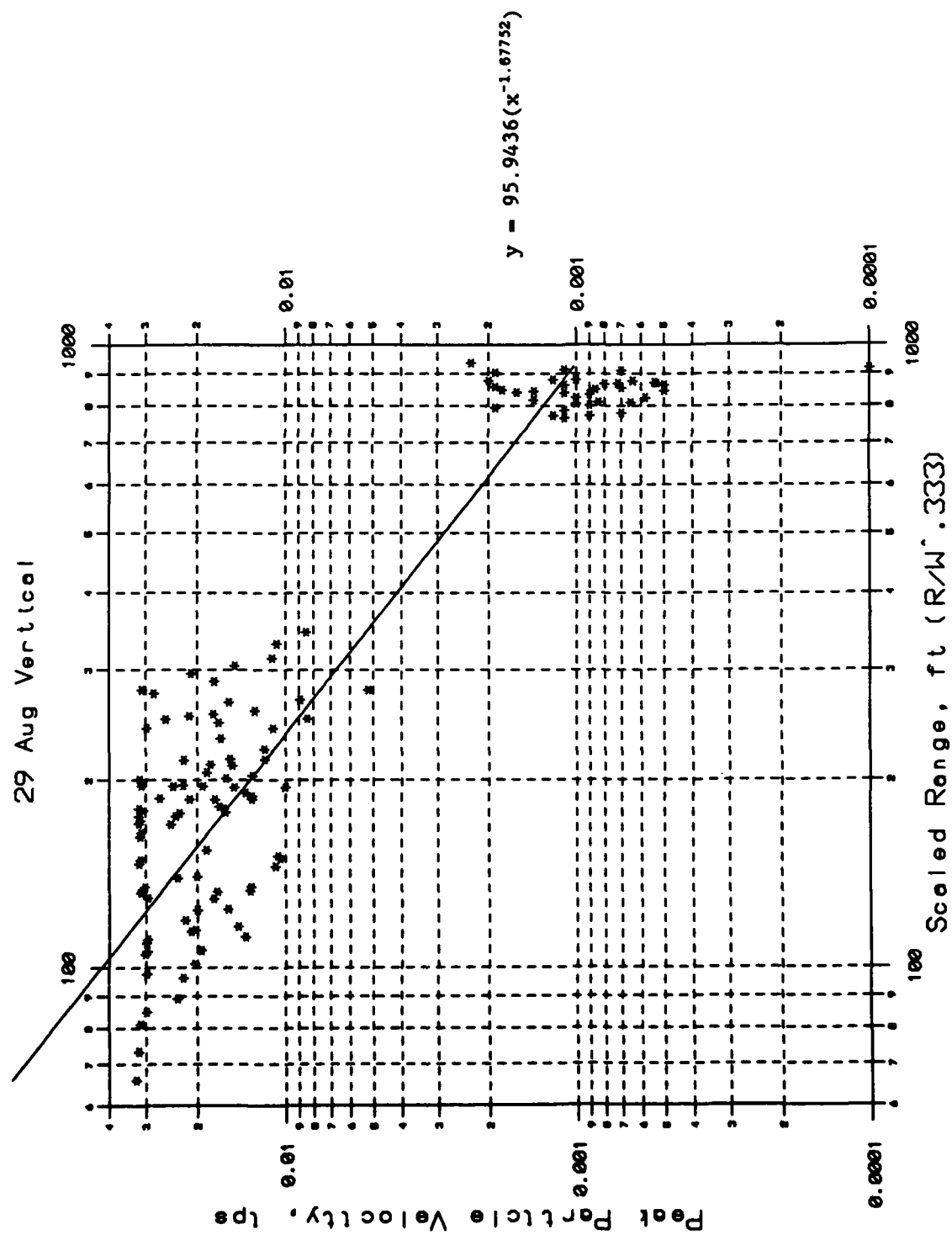


29 Aug Rad (al)

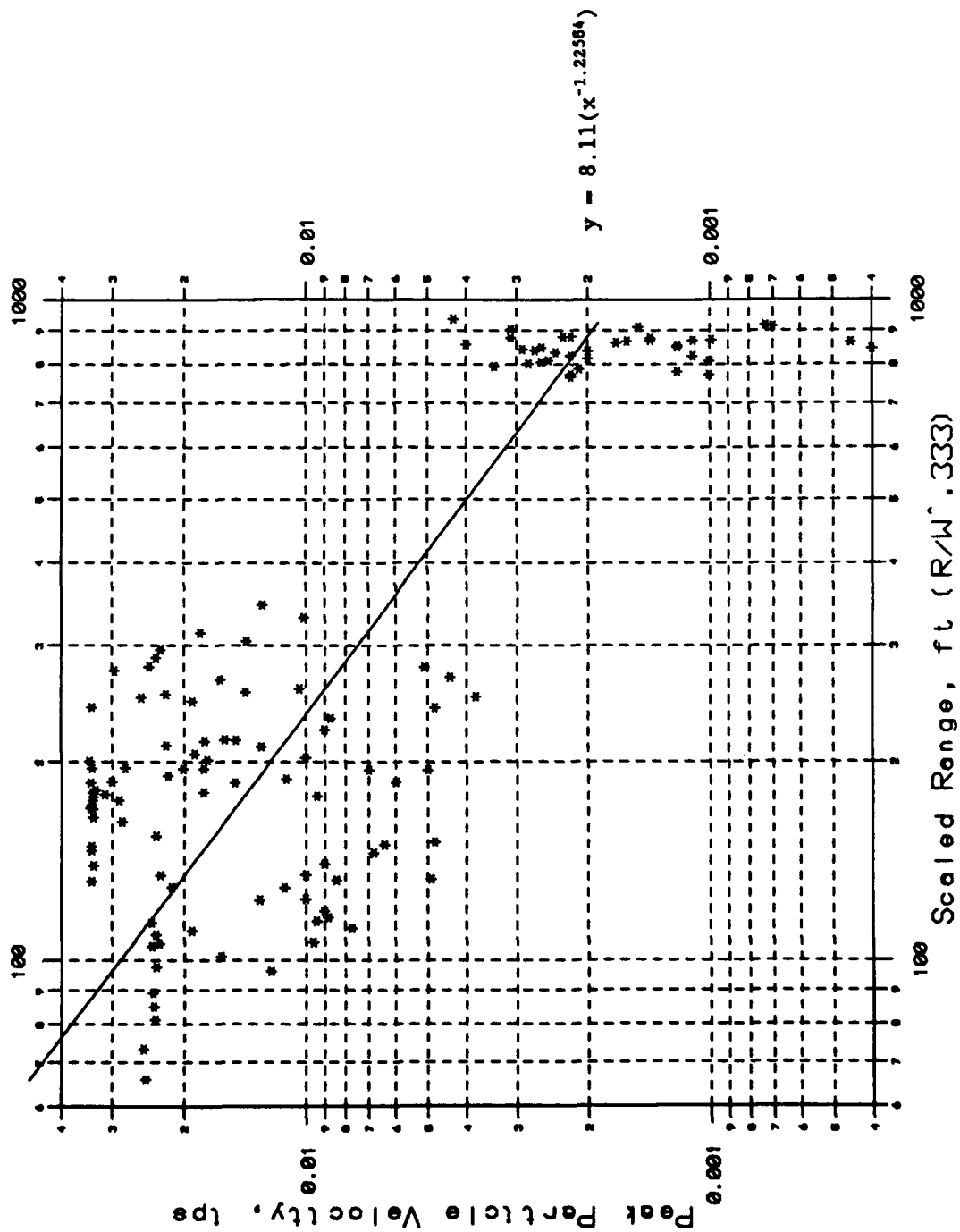


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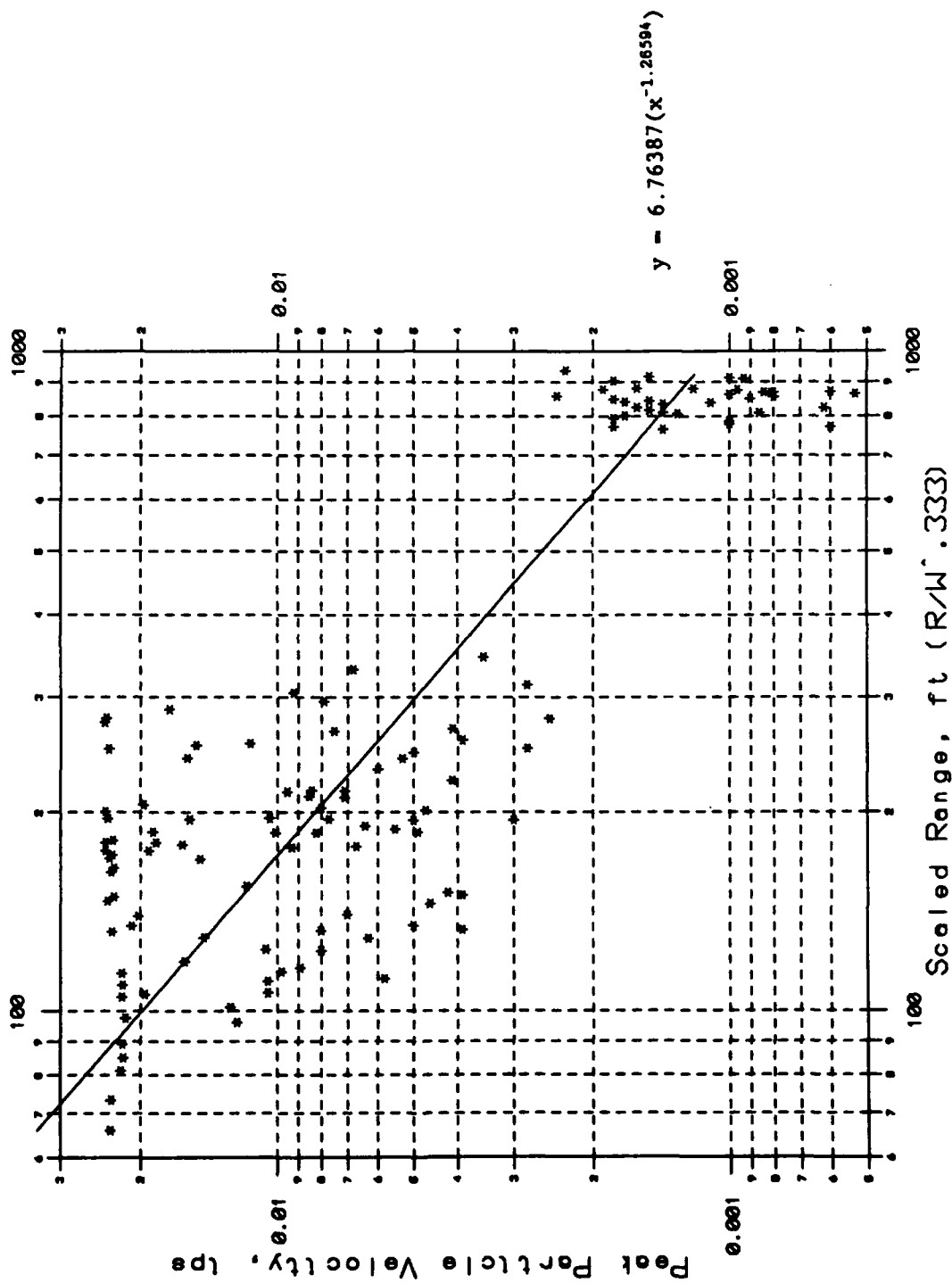




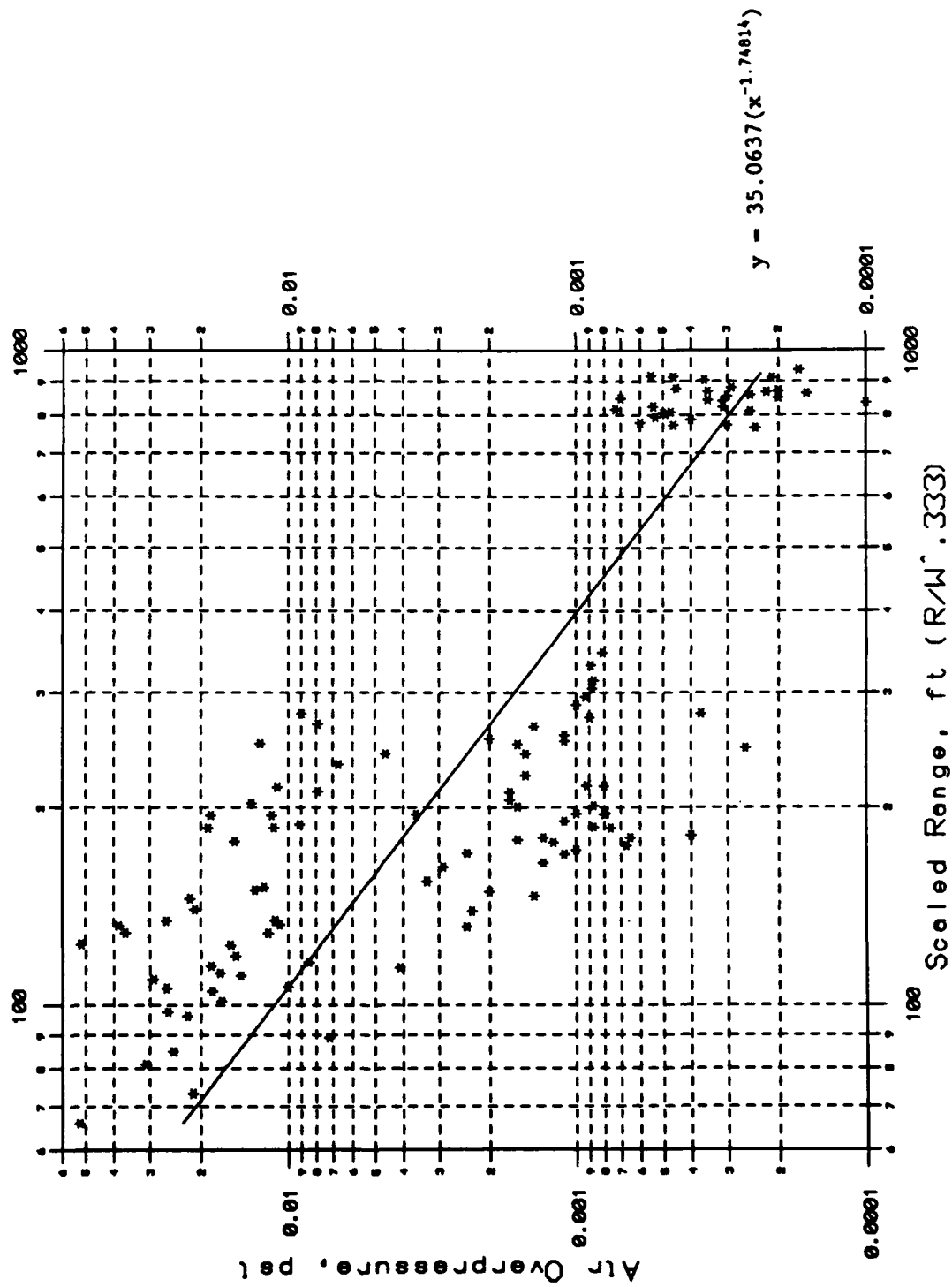
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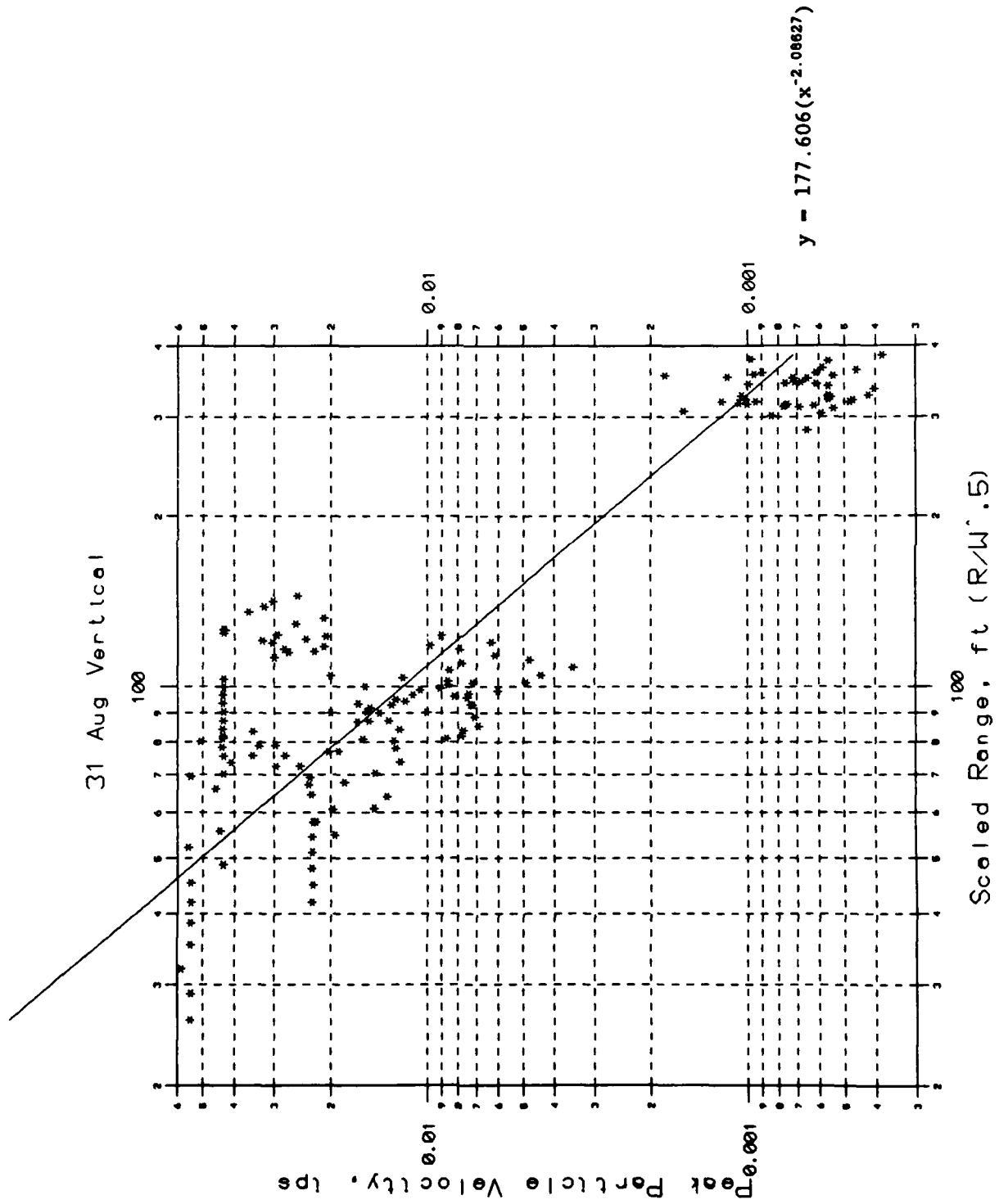


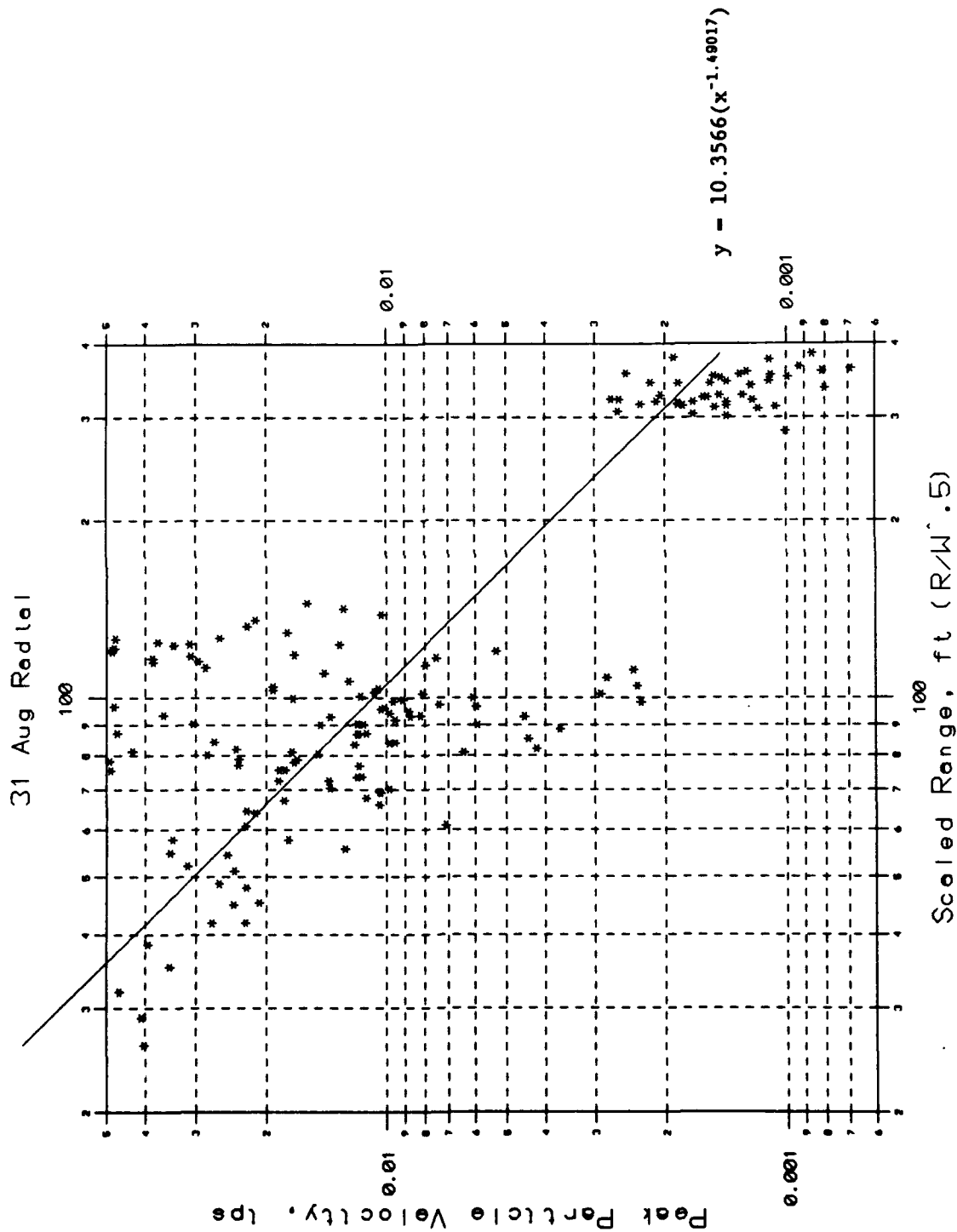
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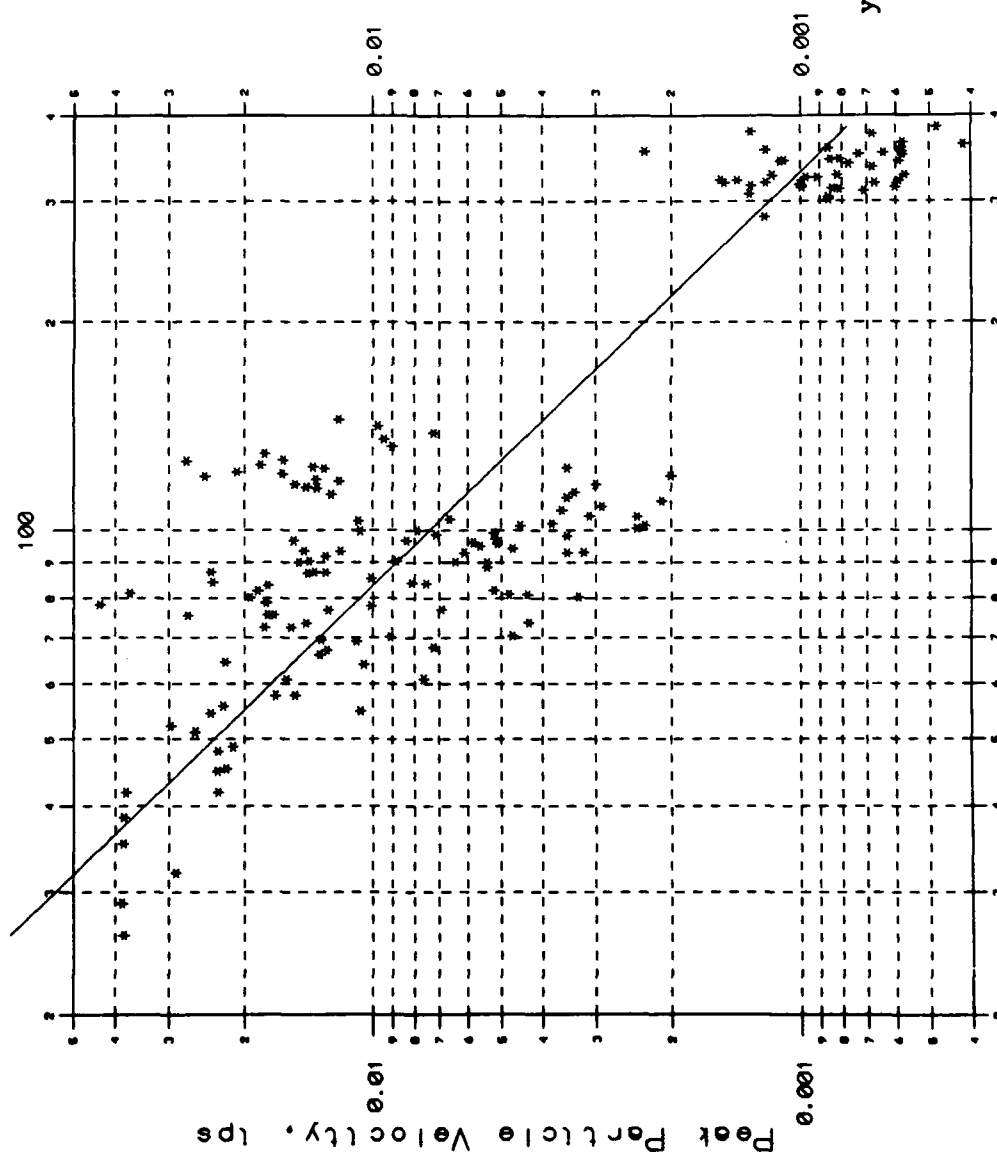
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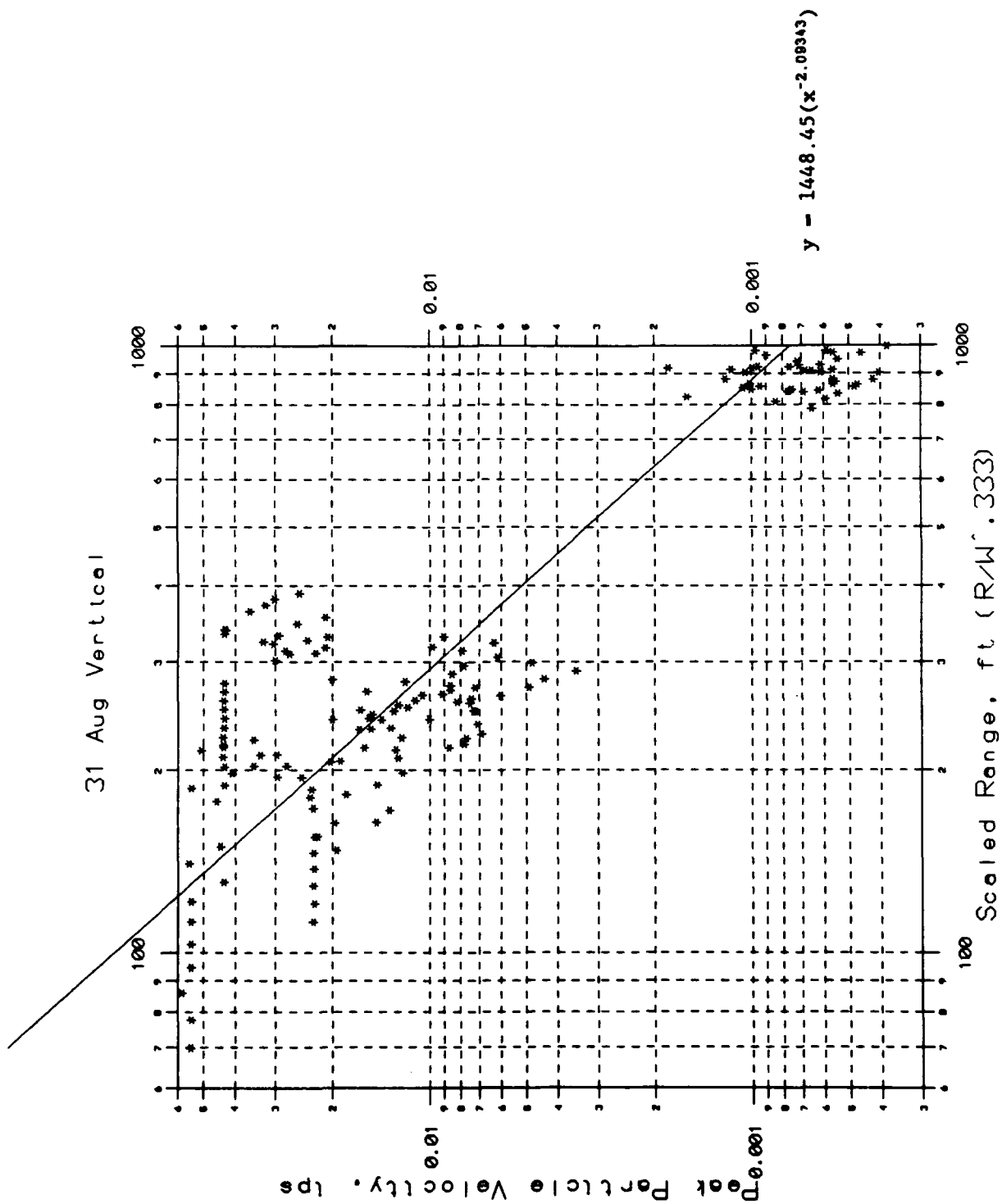


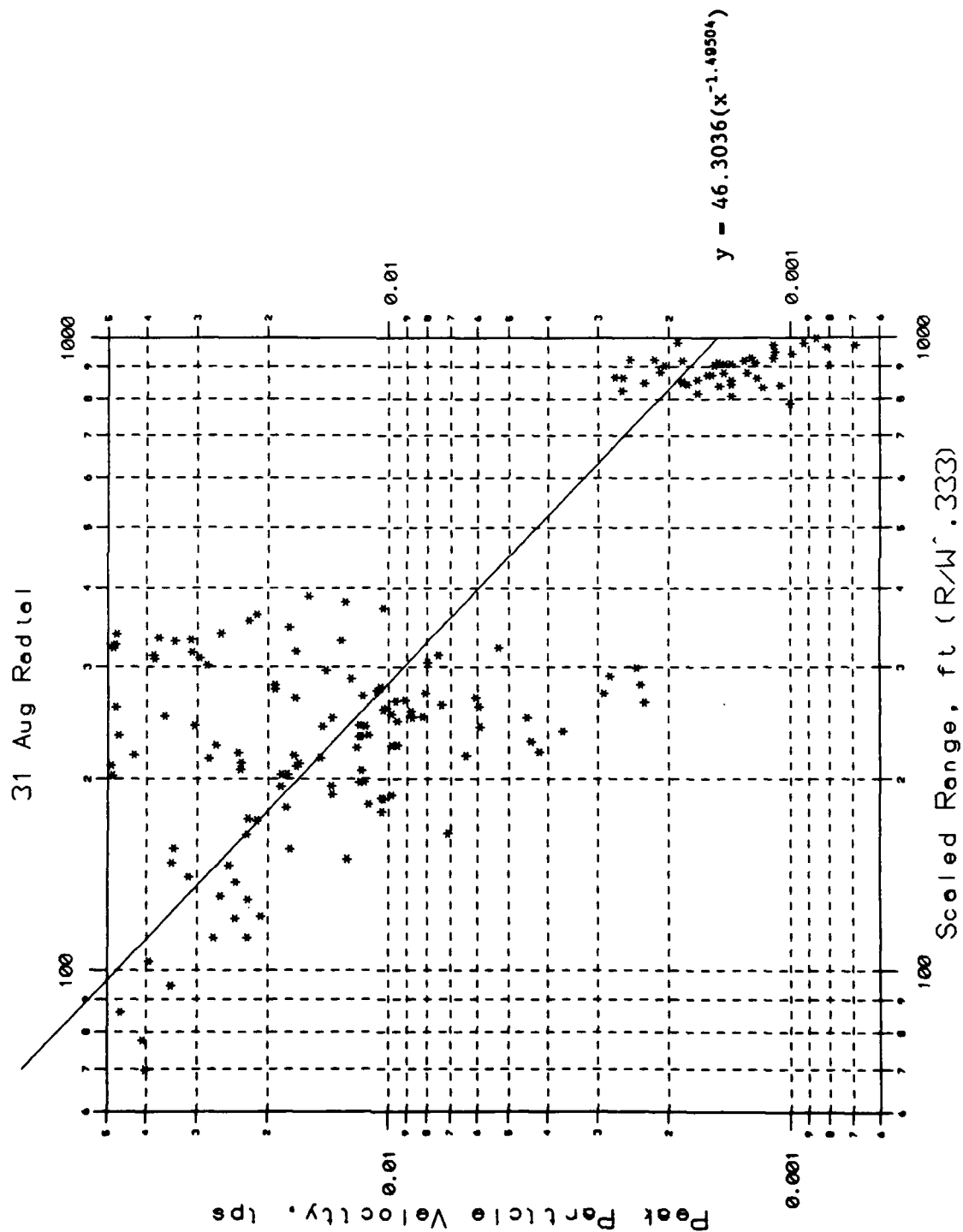




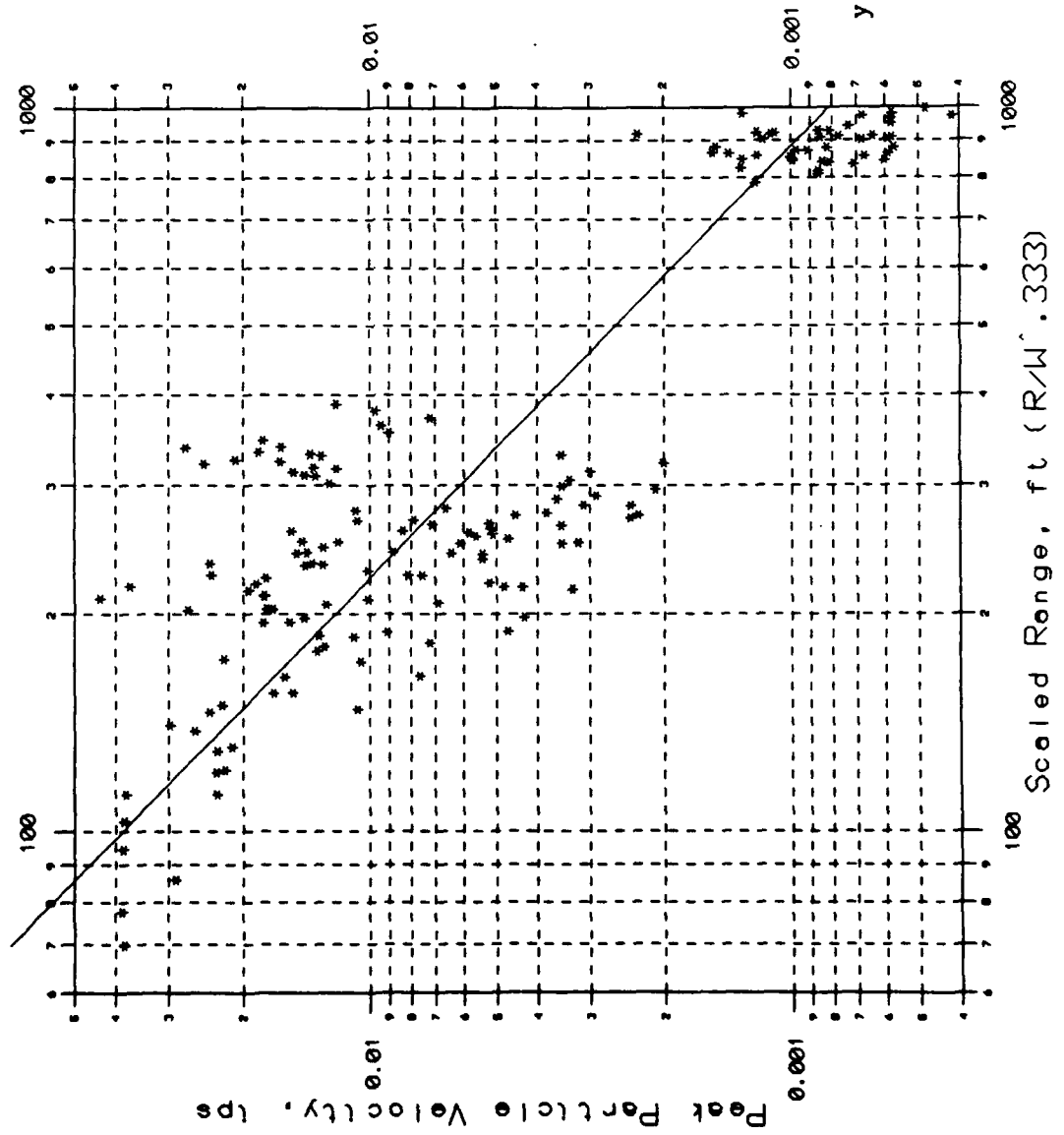
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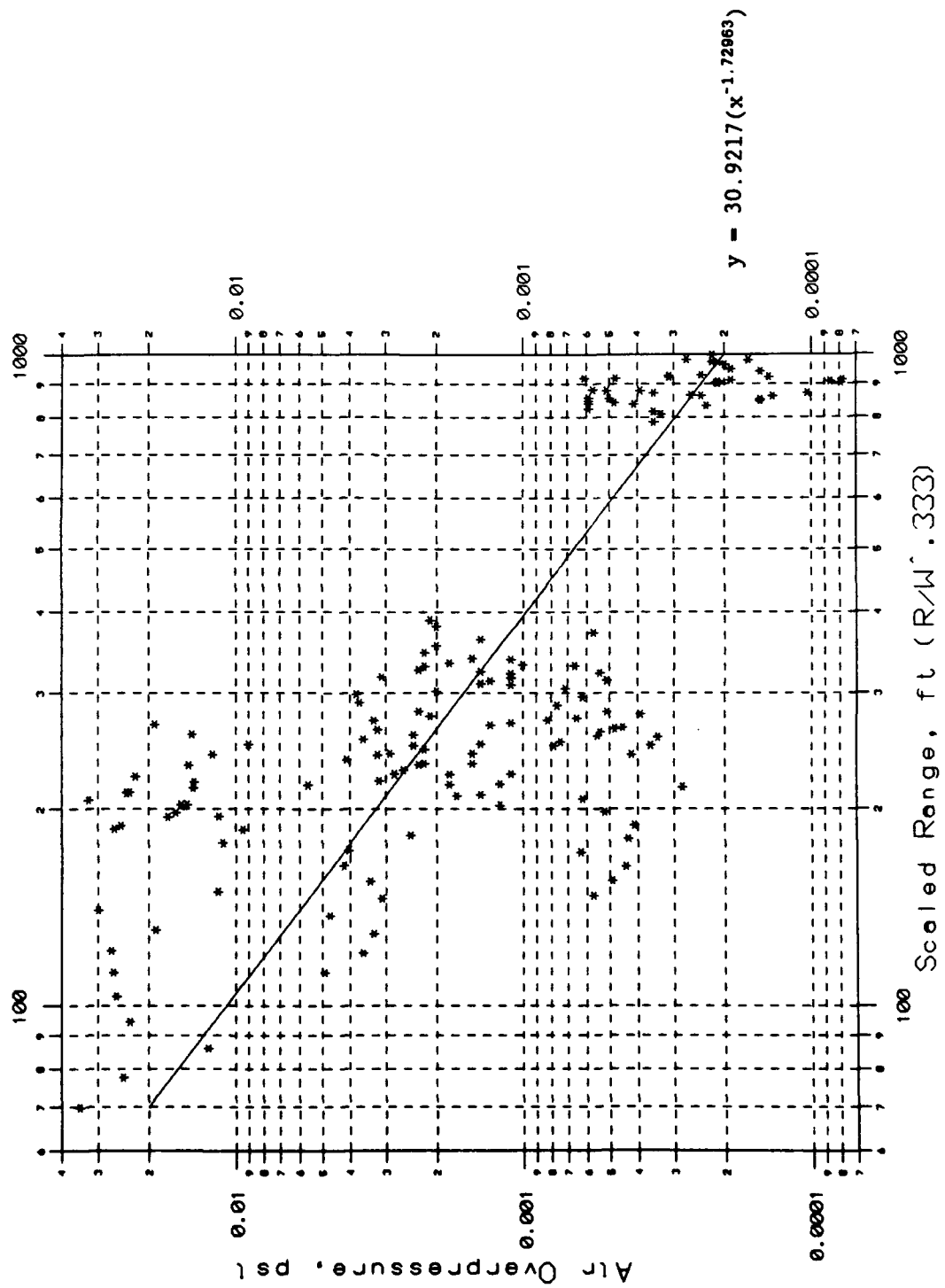


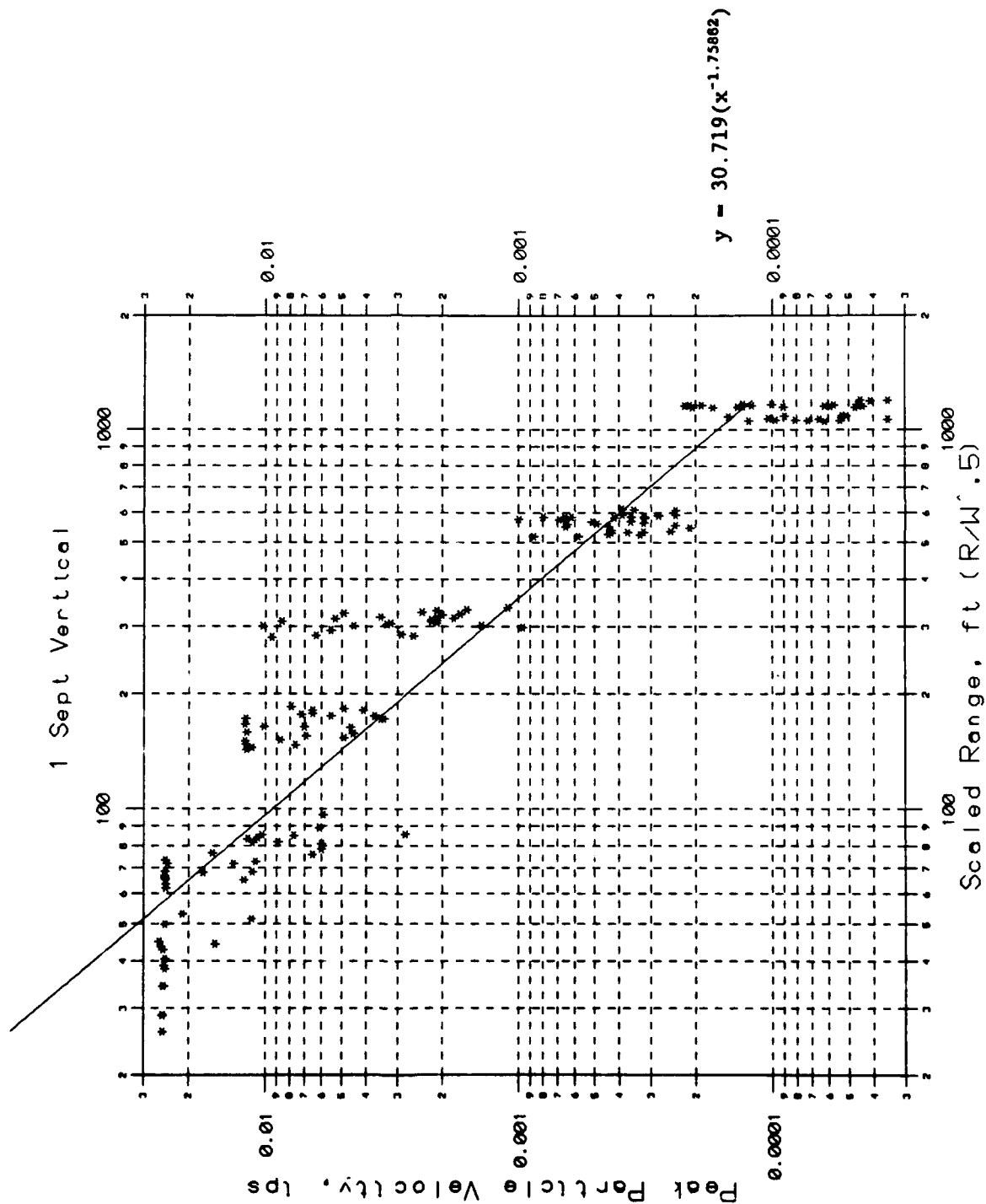


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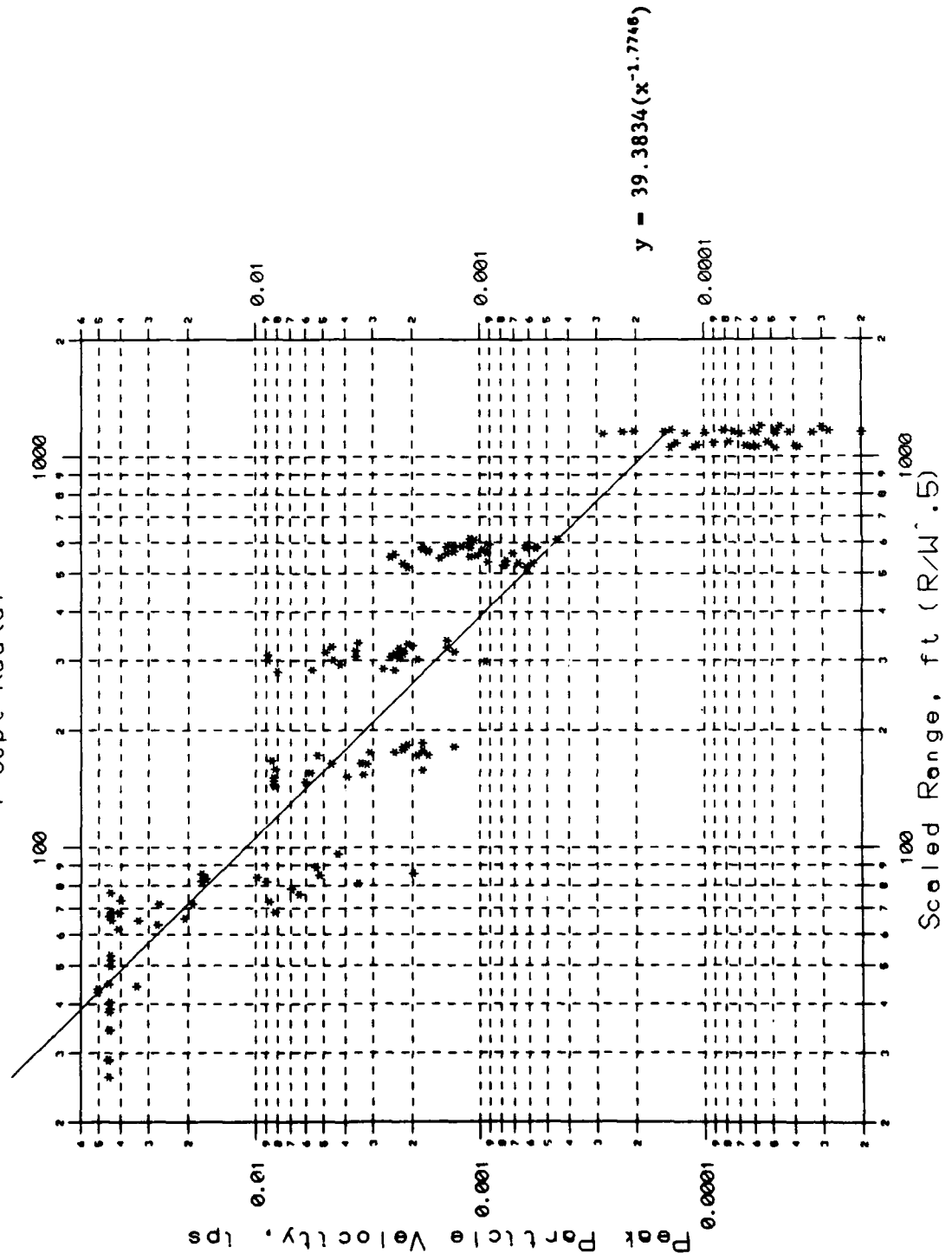


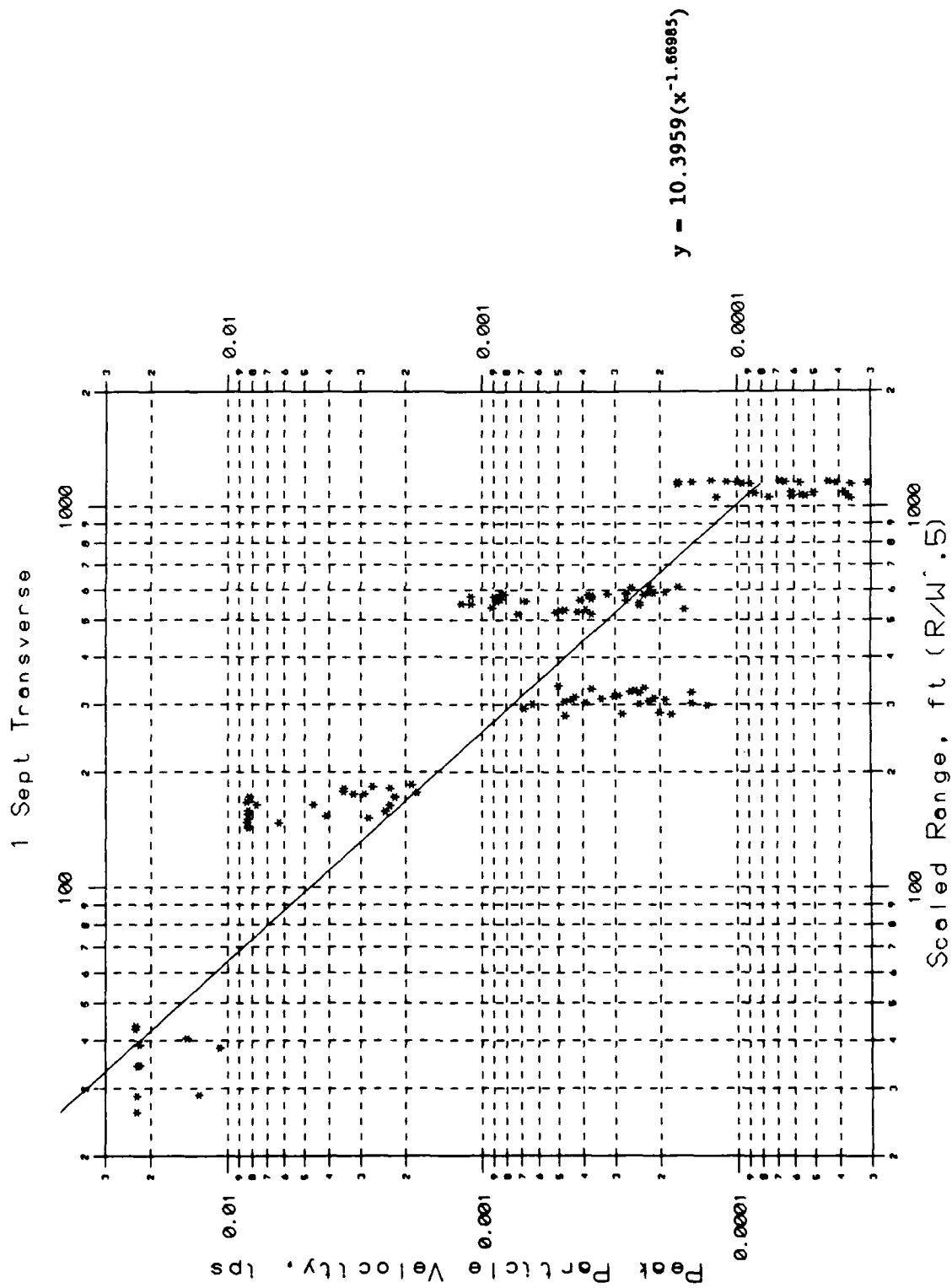
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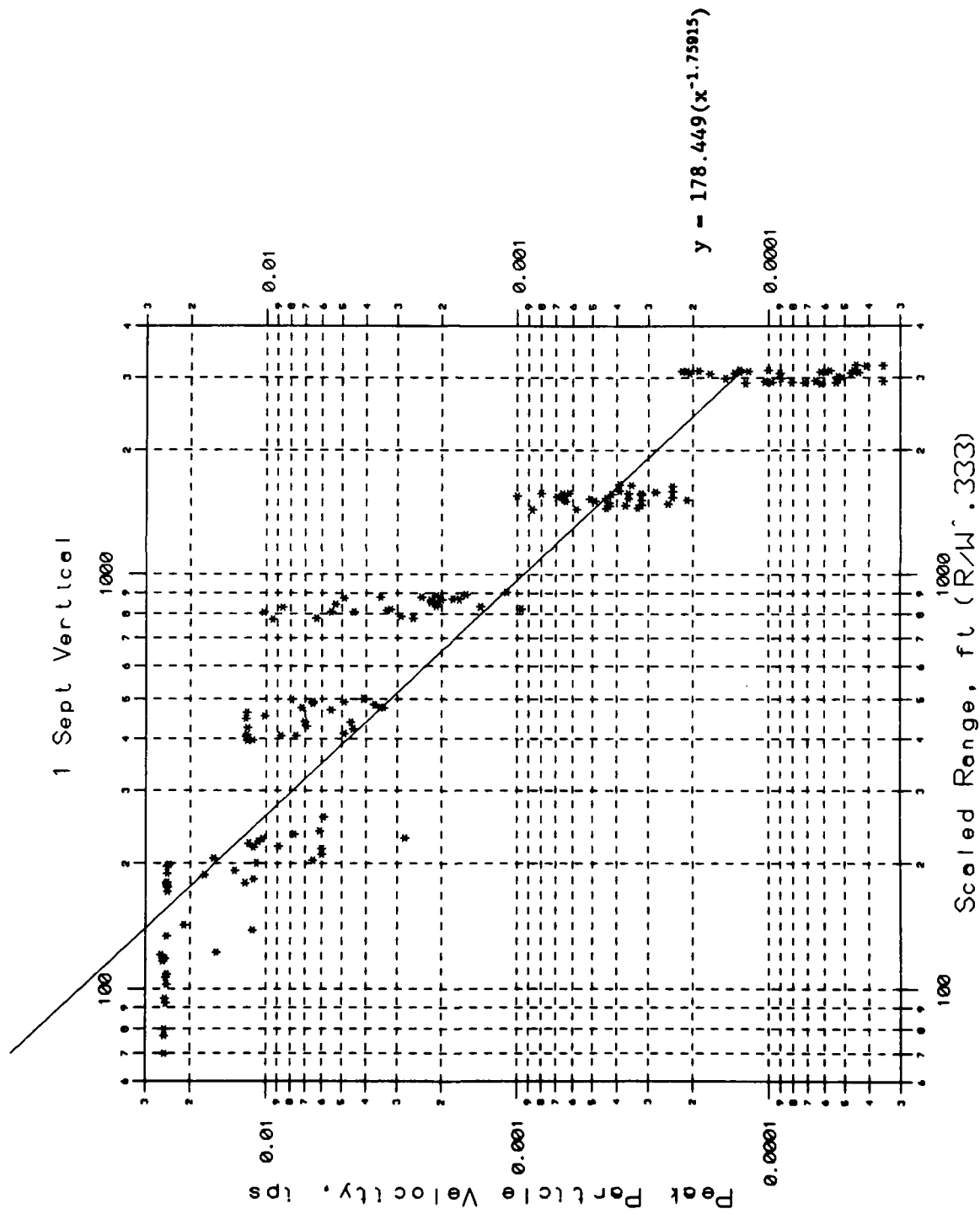


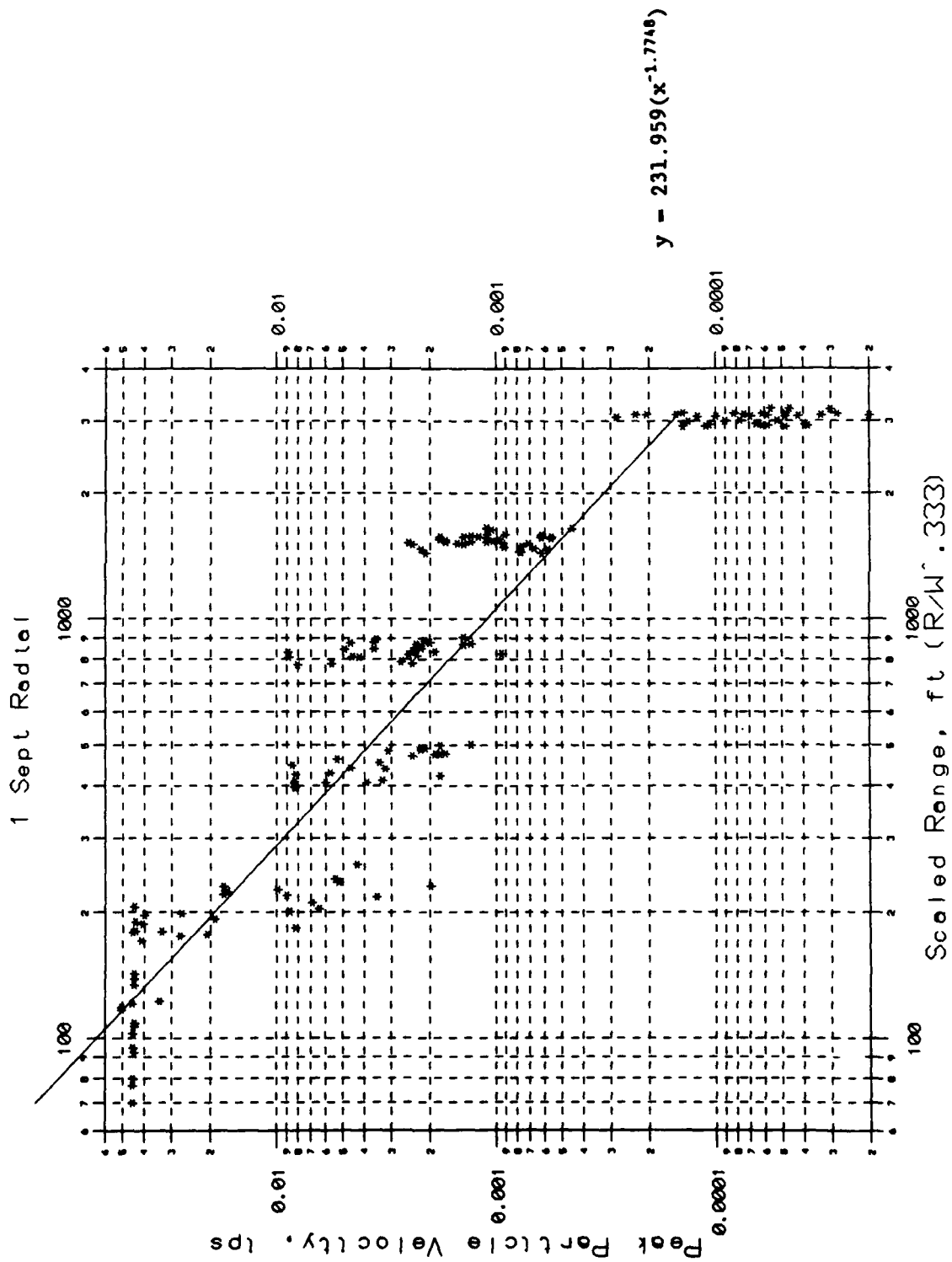


1 Sept Rod 101

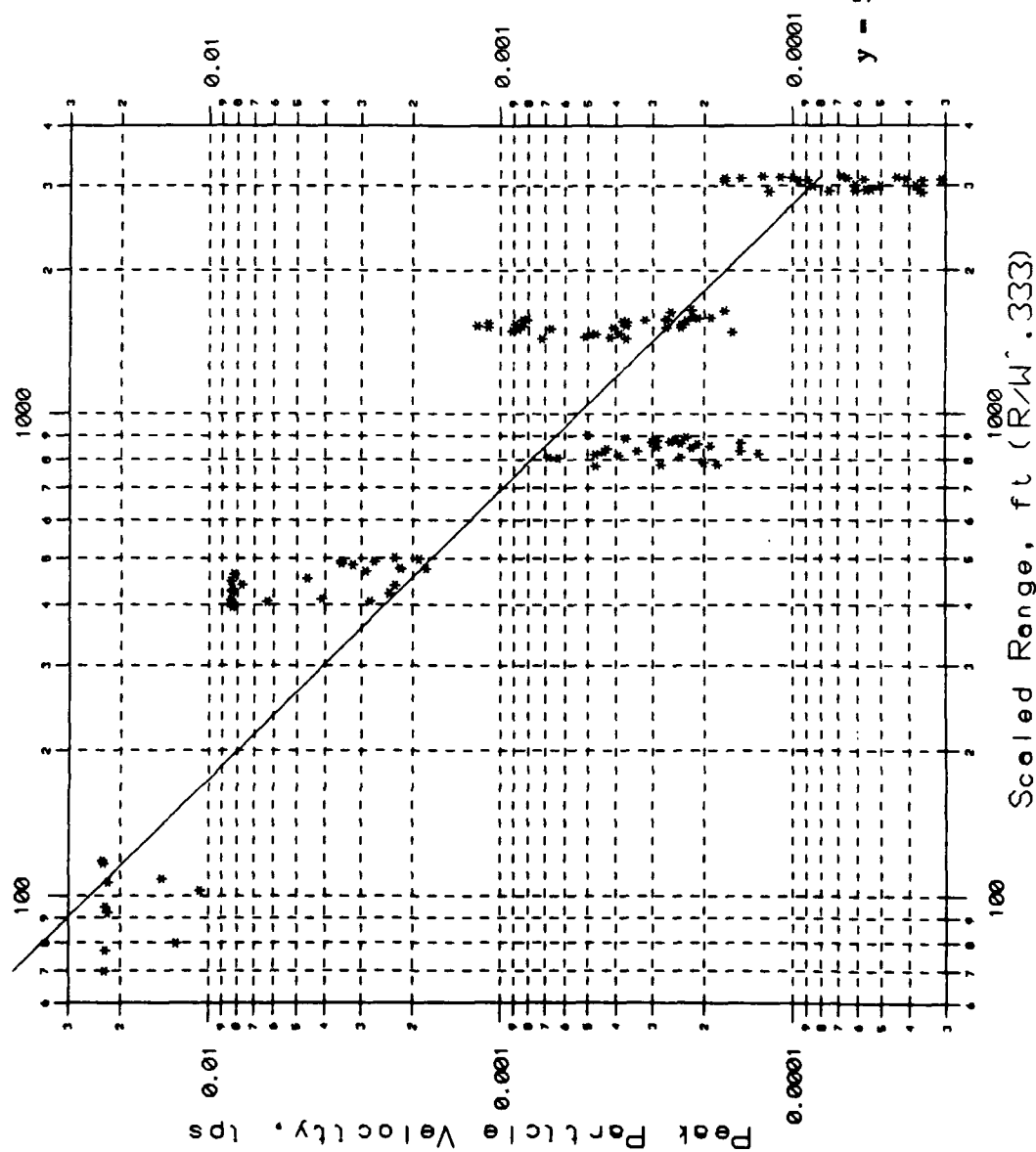




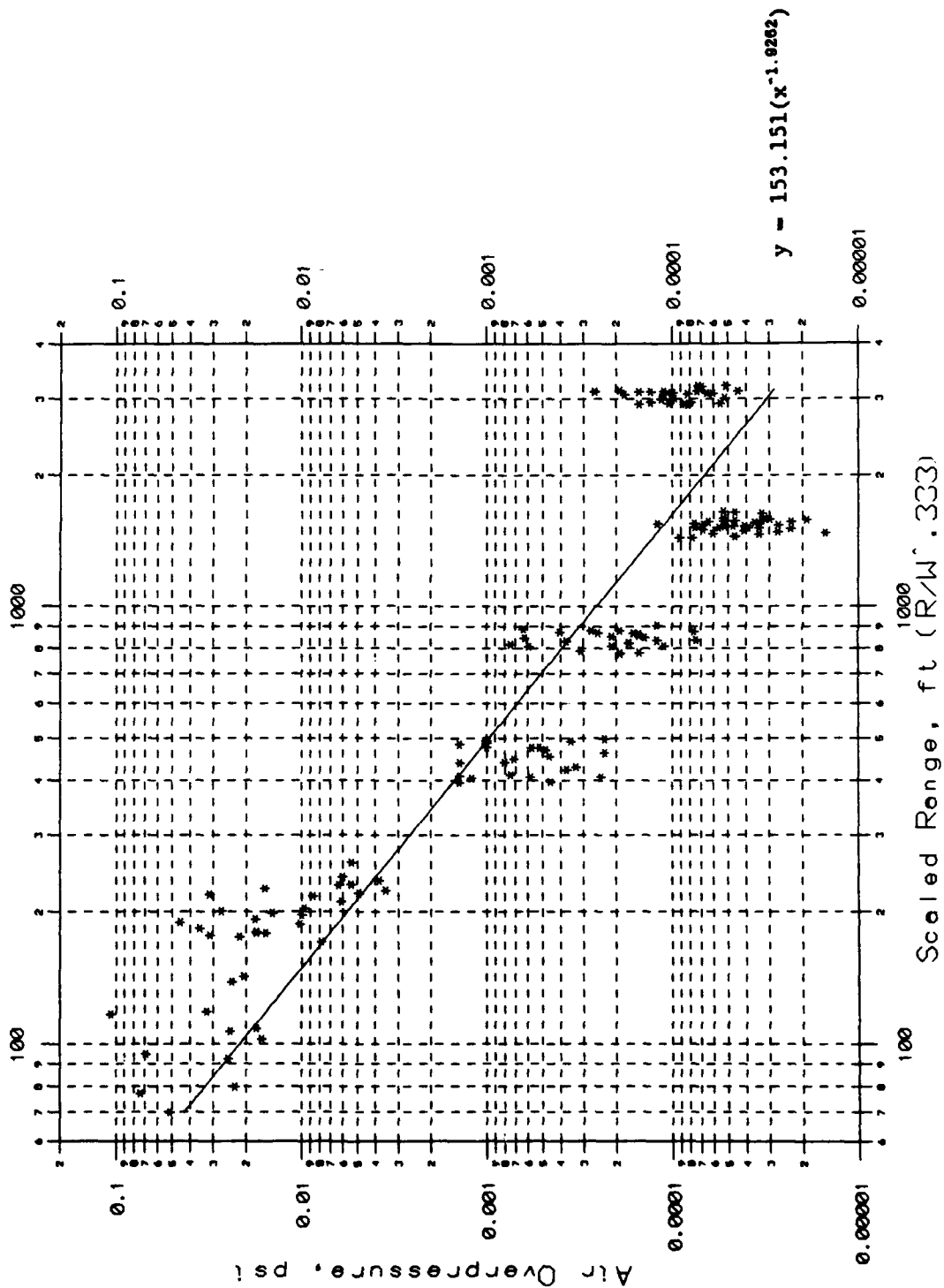


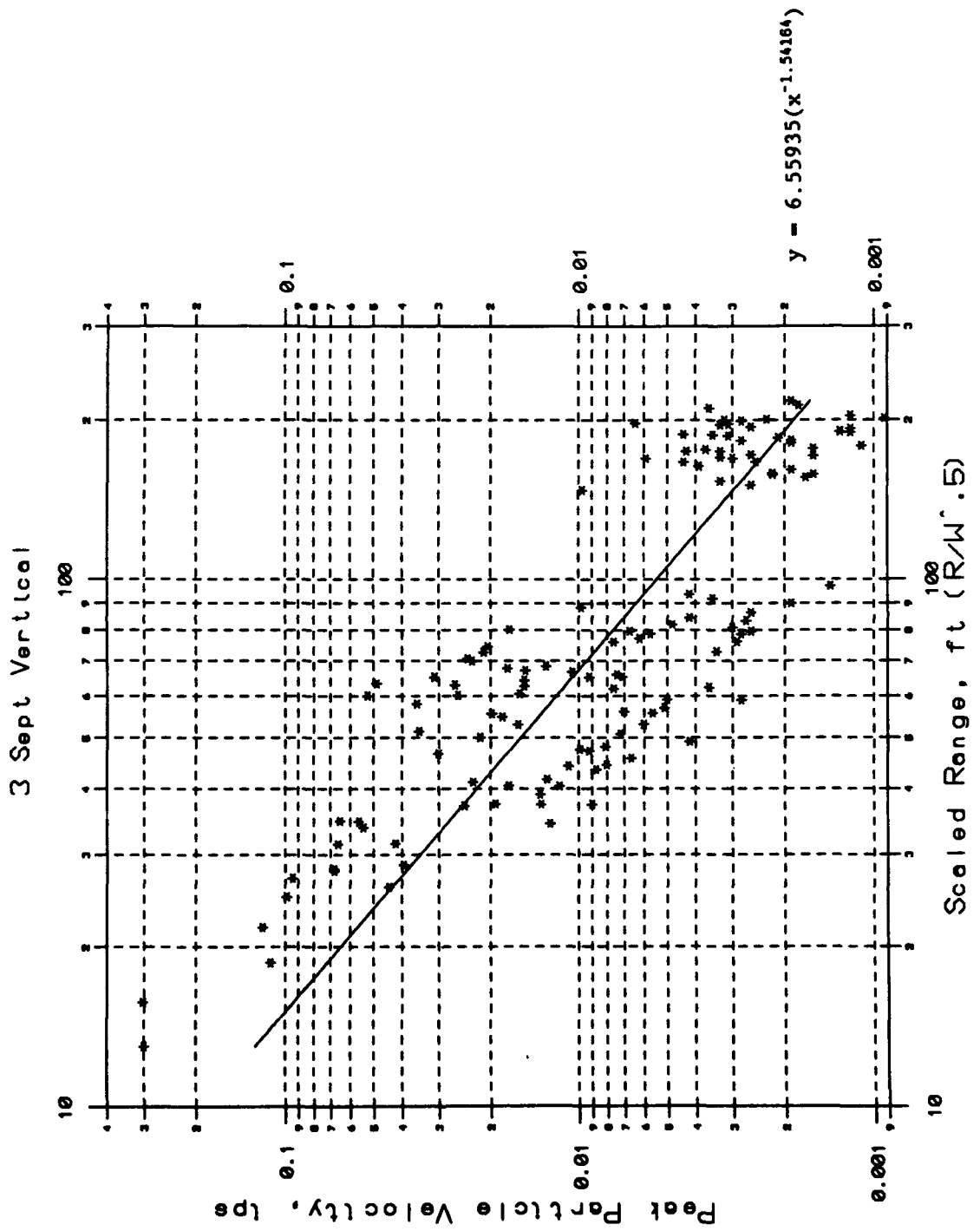


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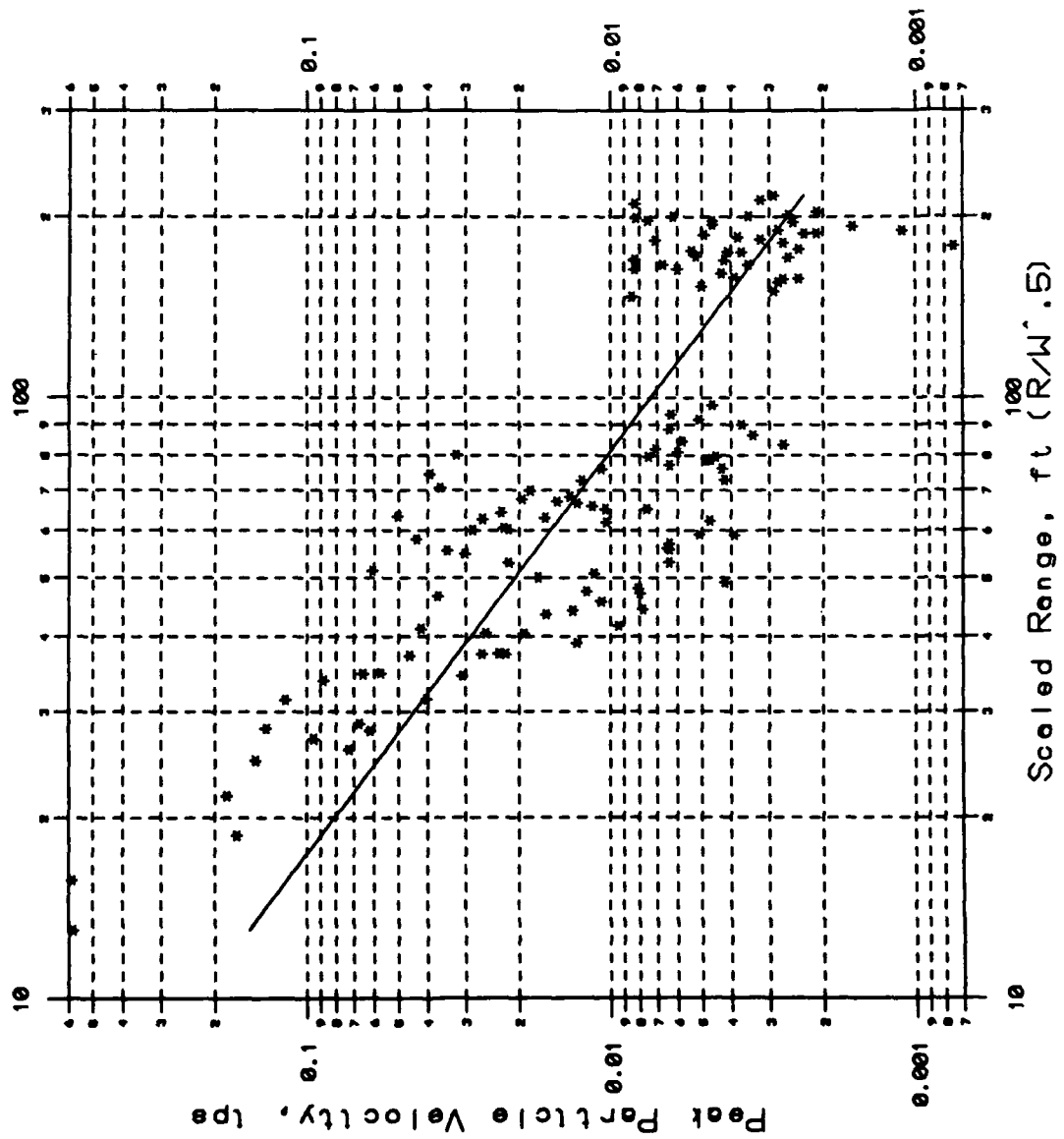


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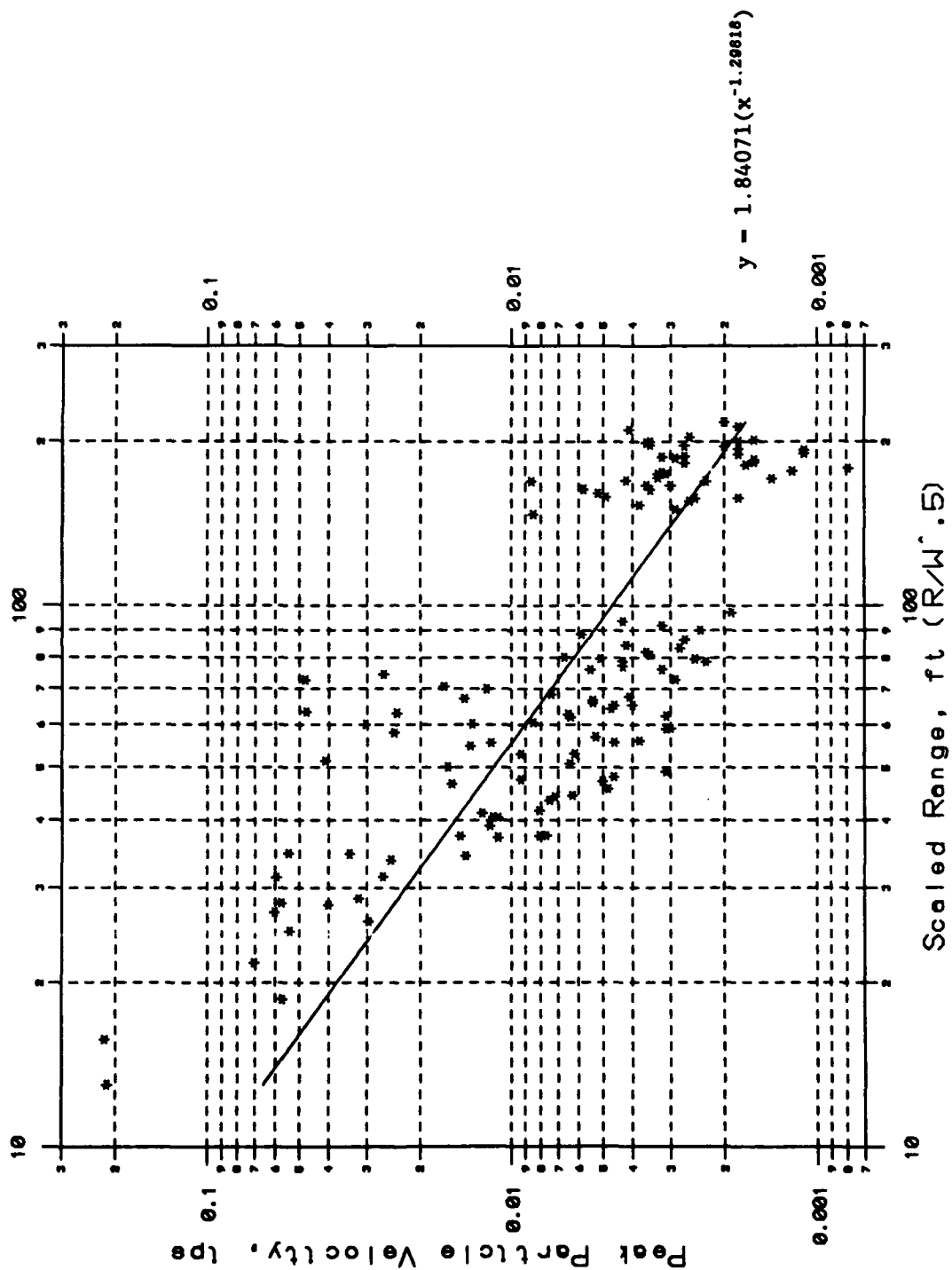




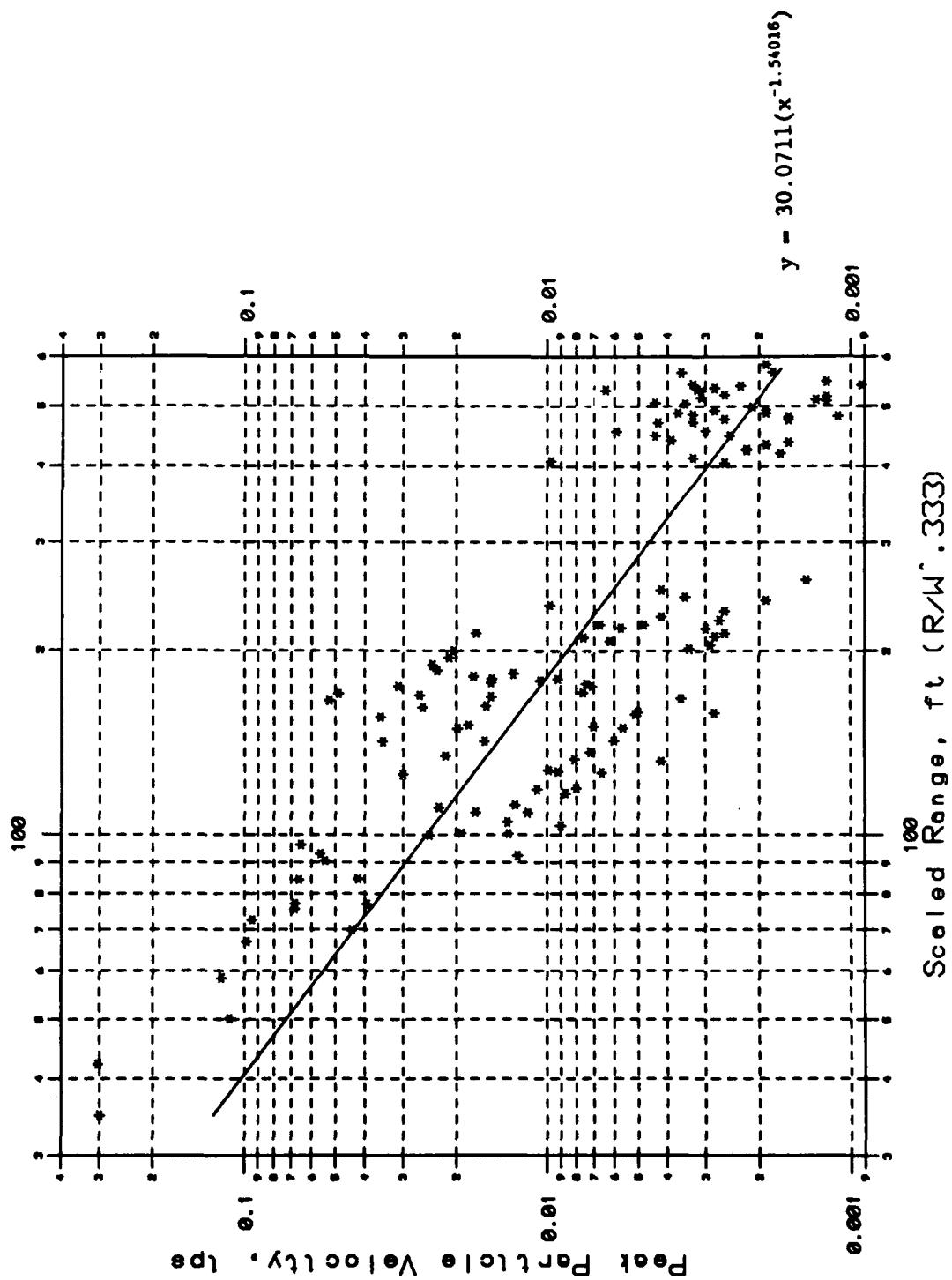
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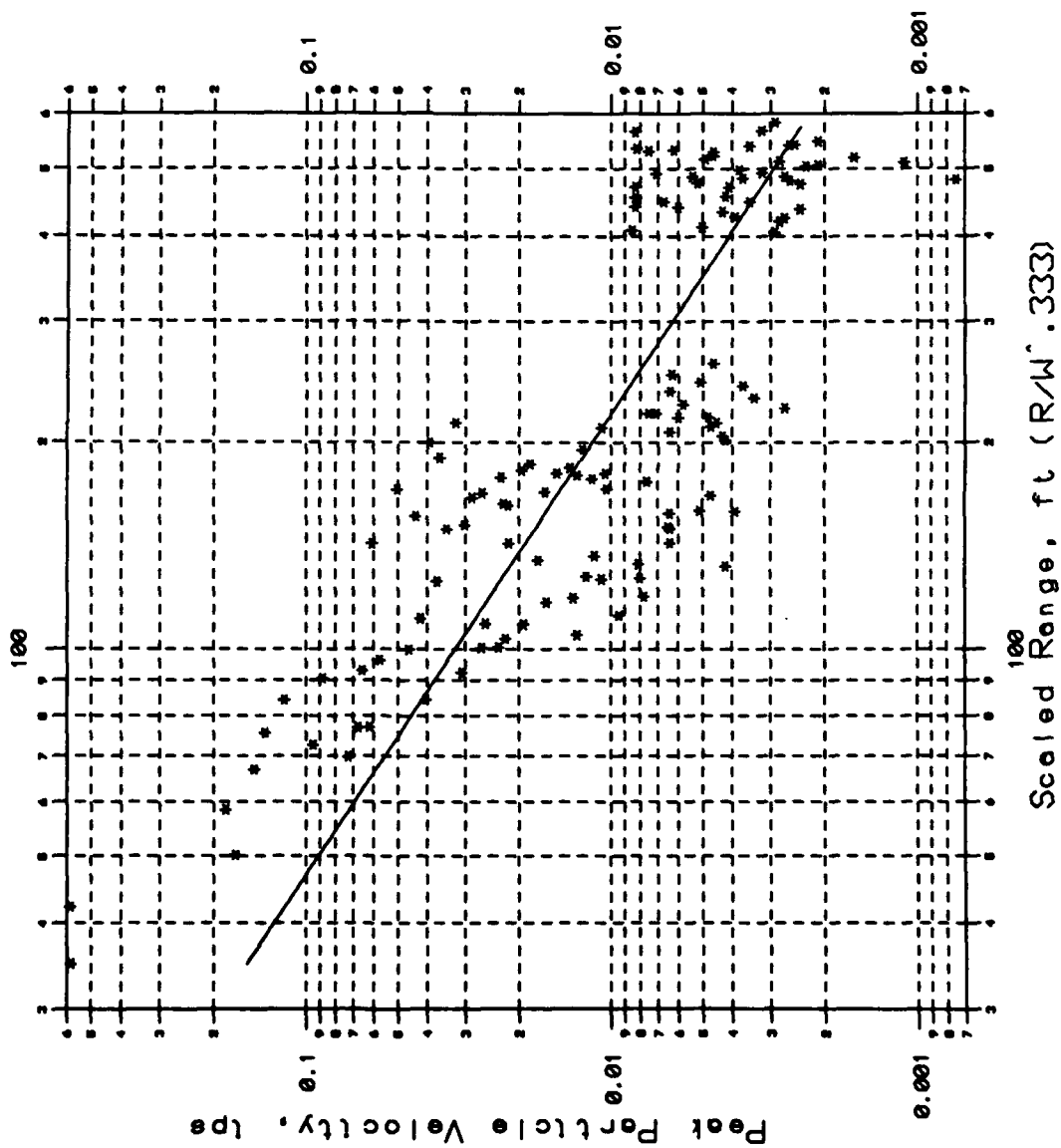
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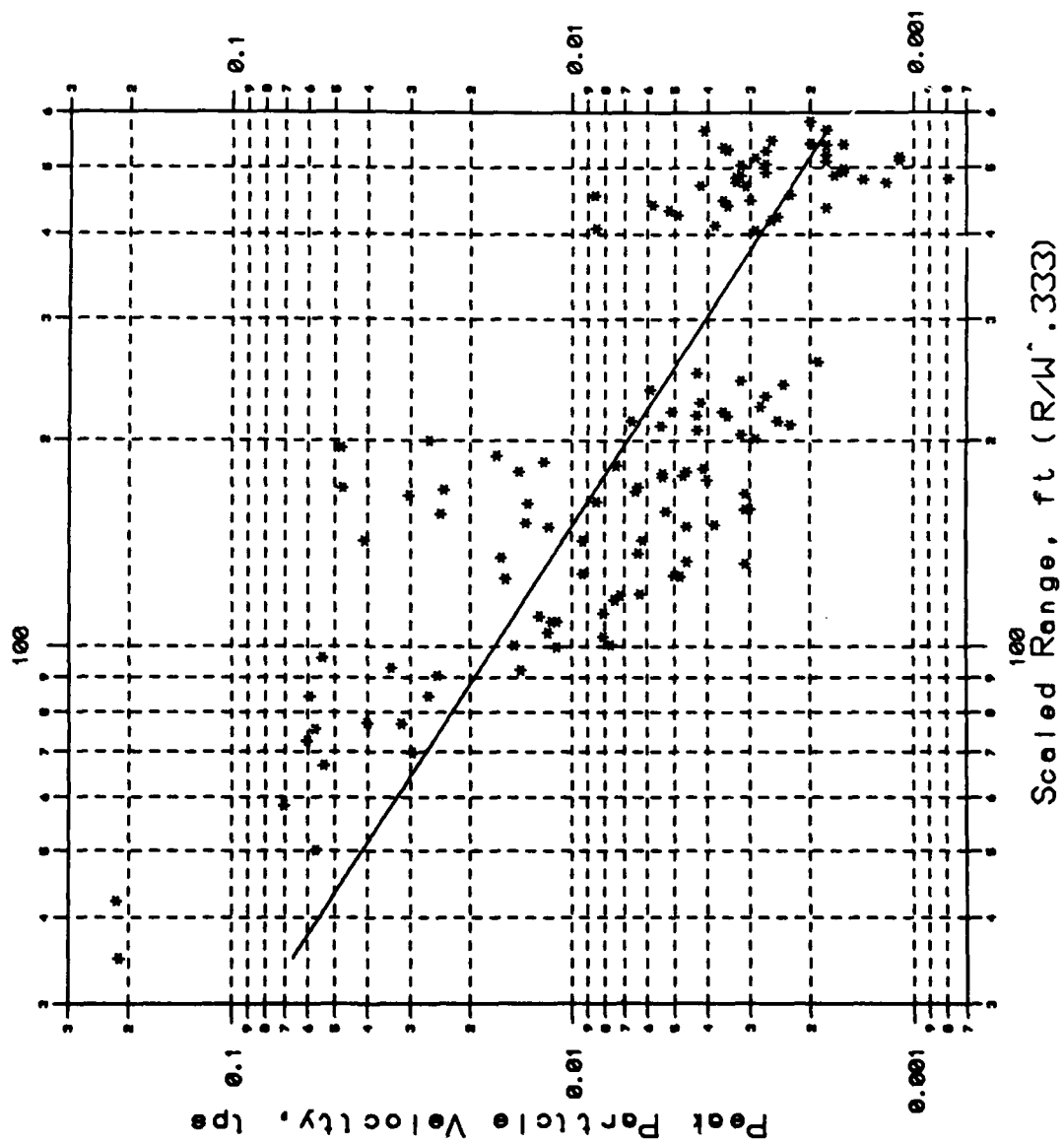
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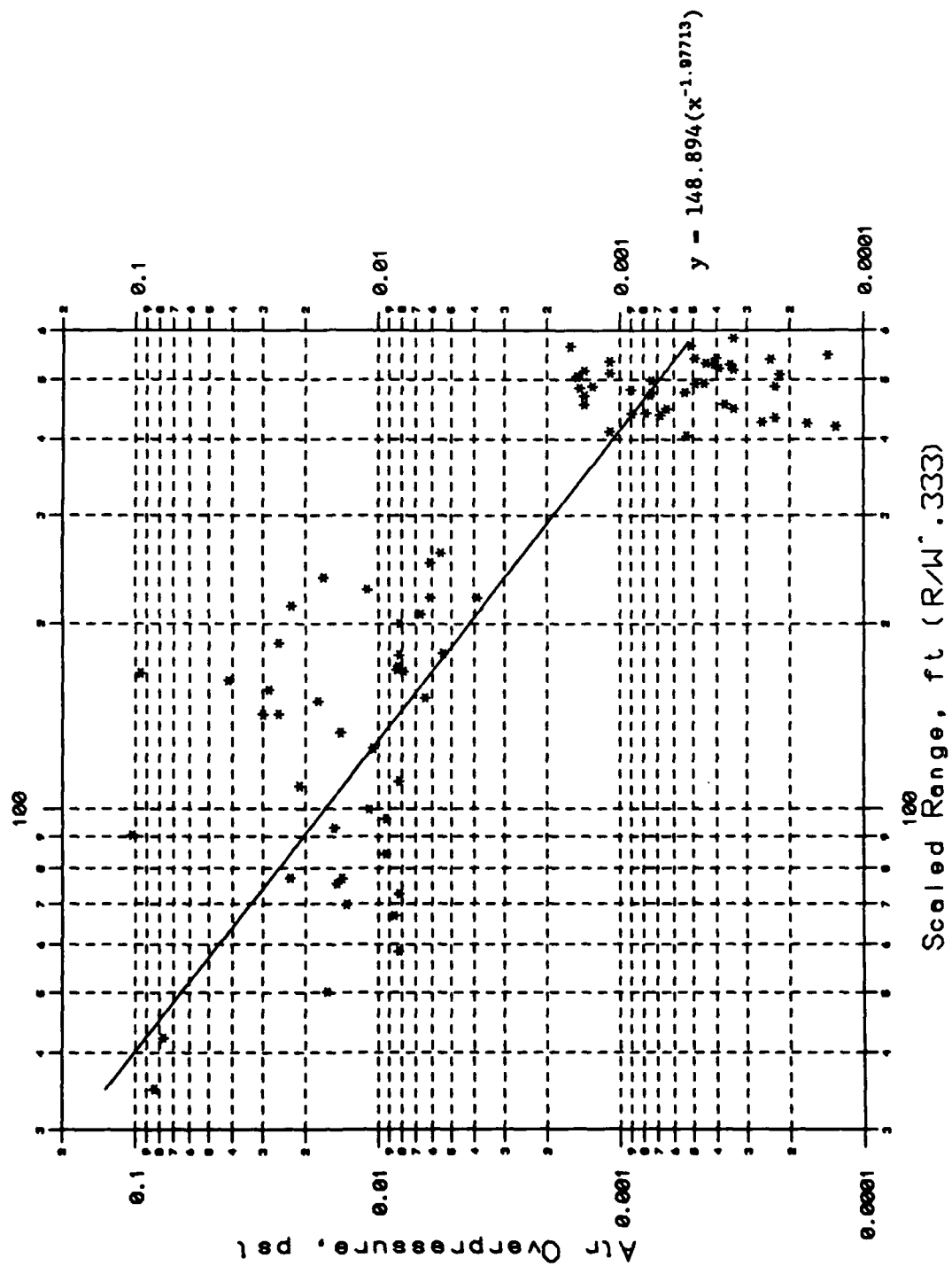
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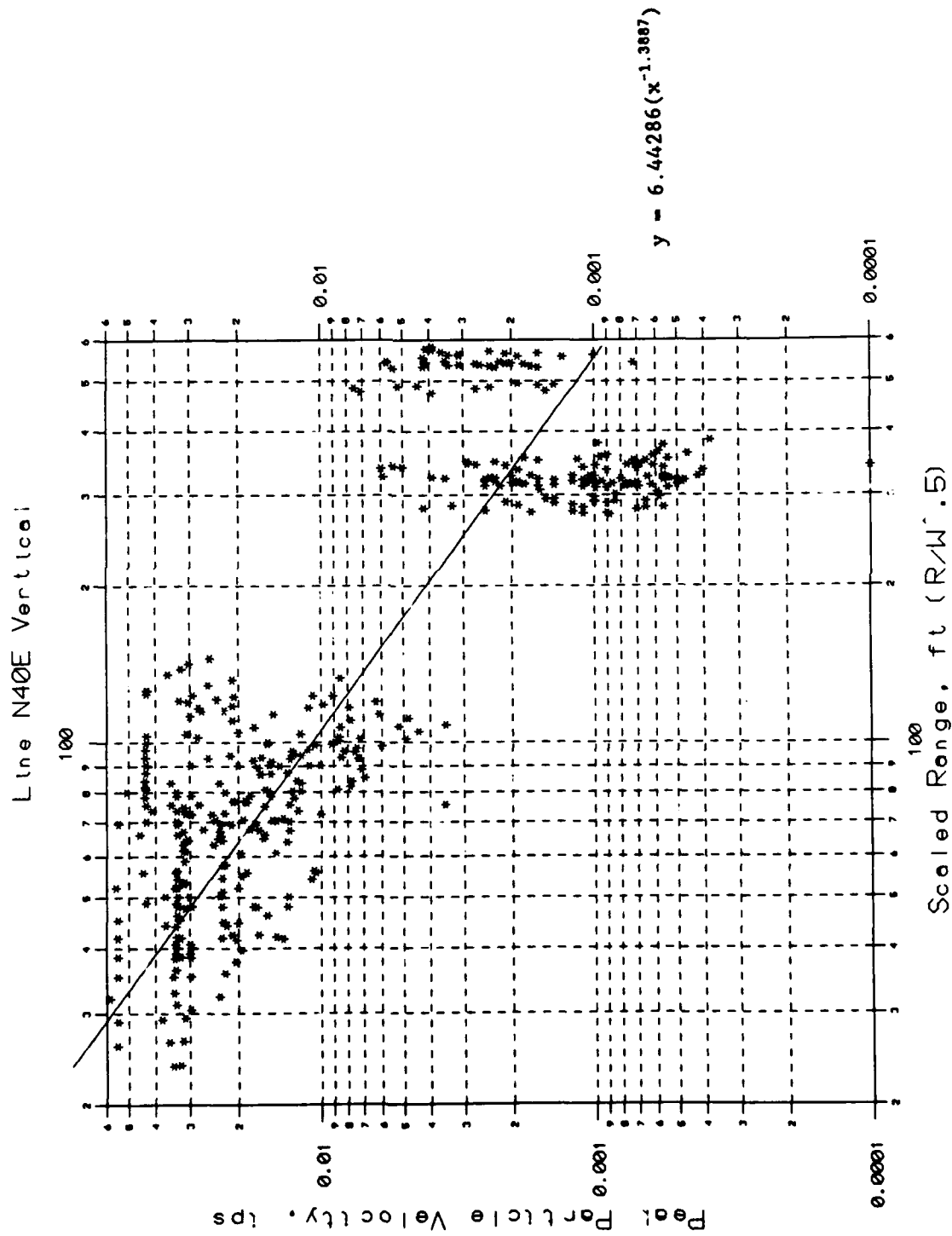


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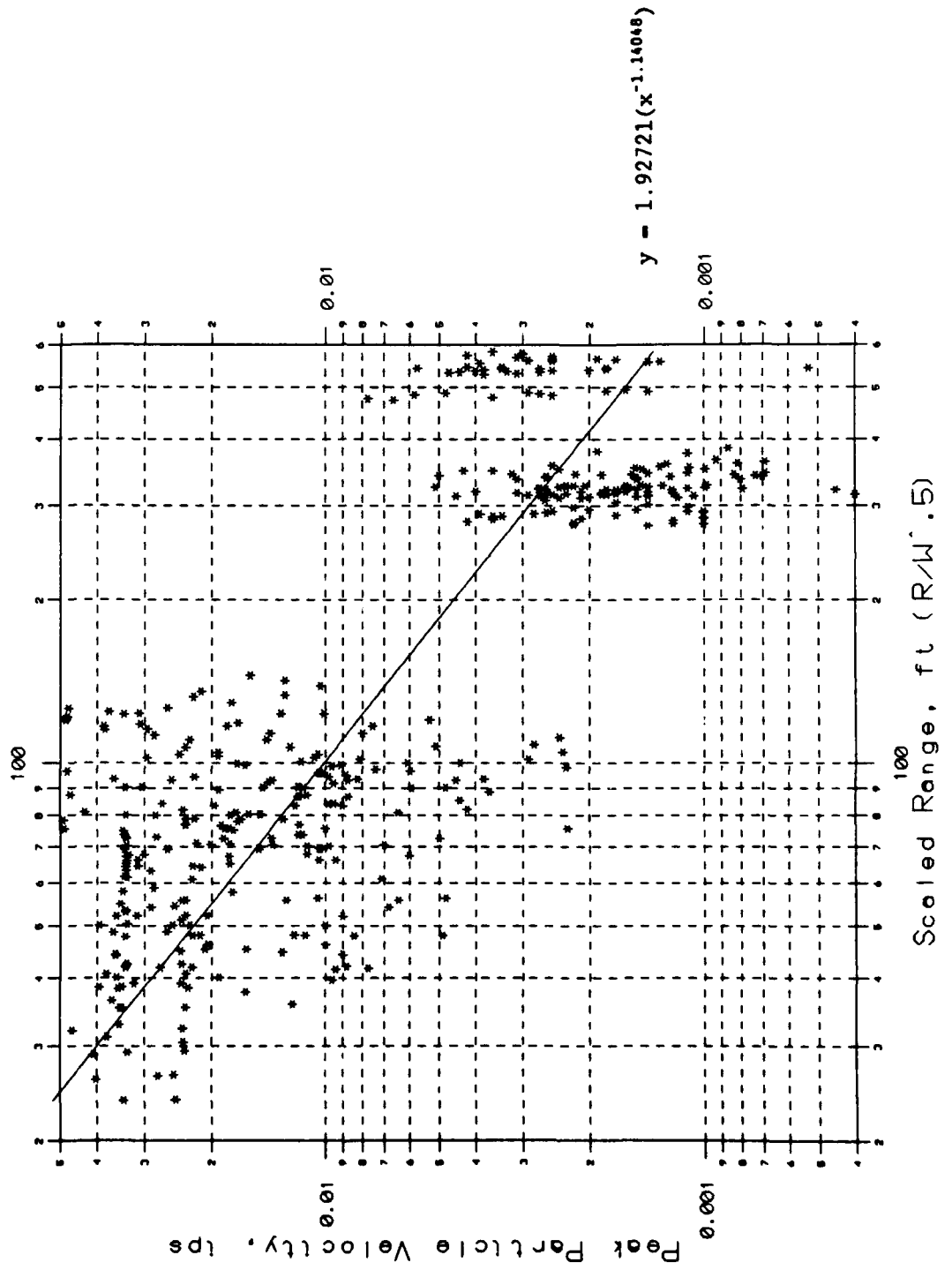


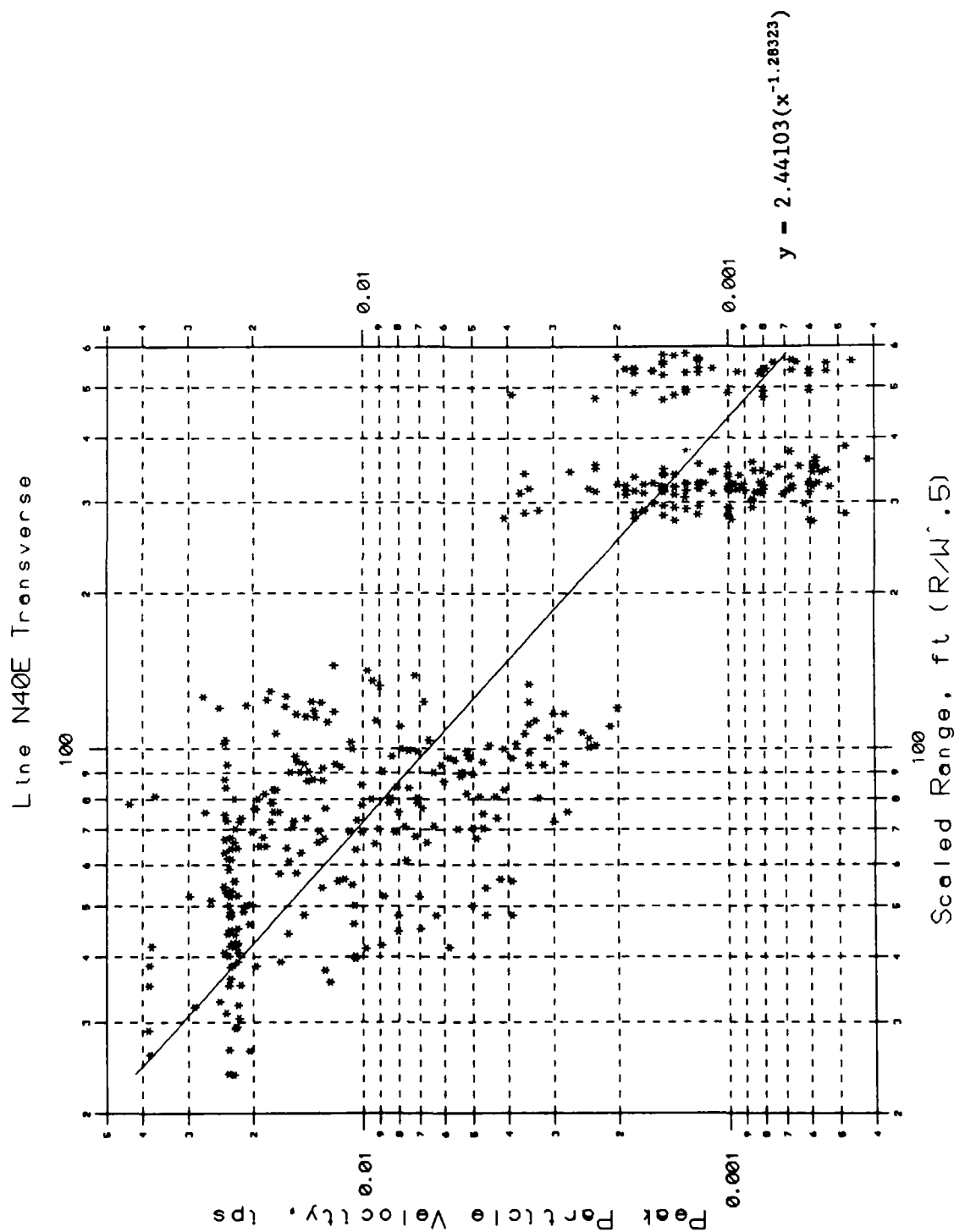
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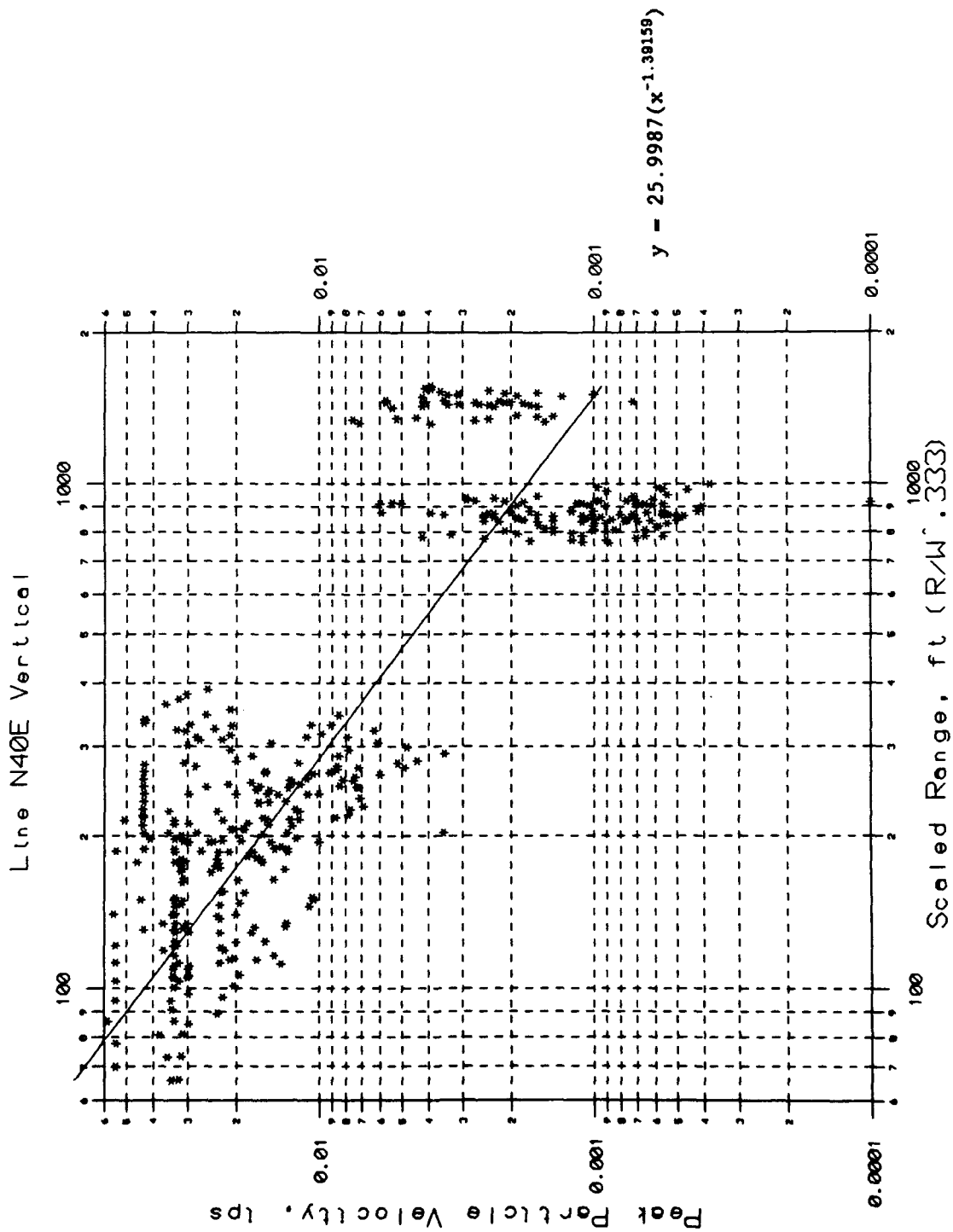




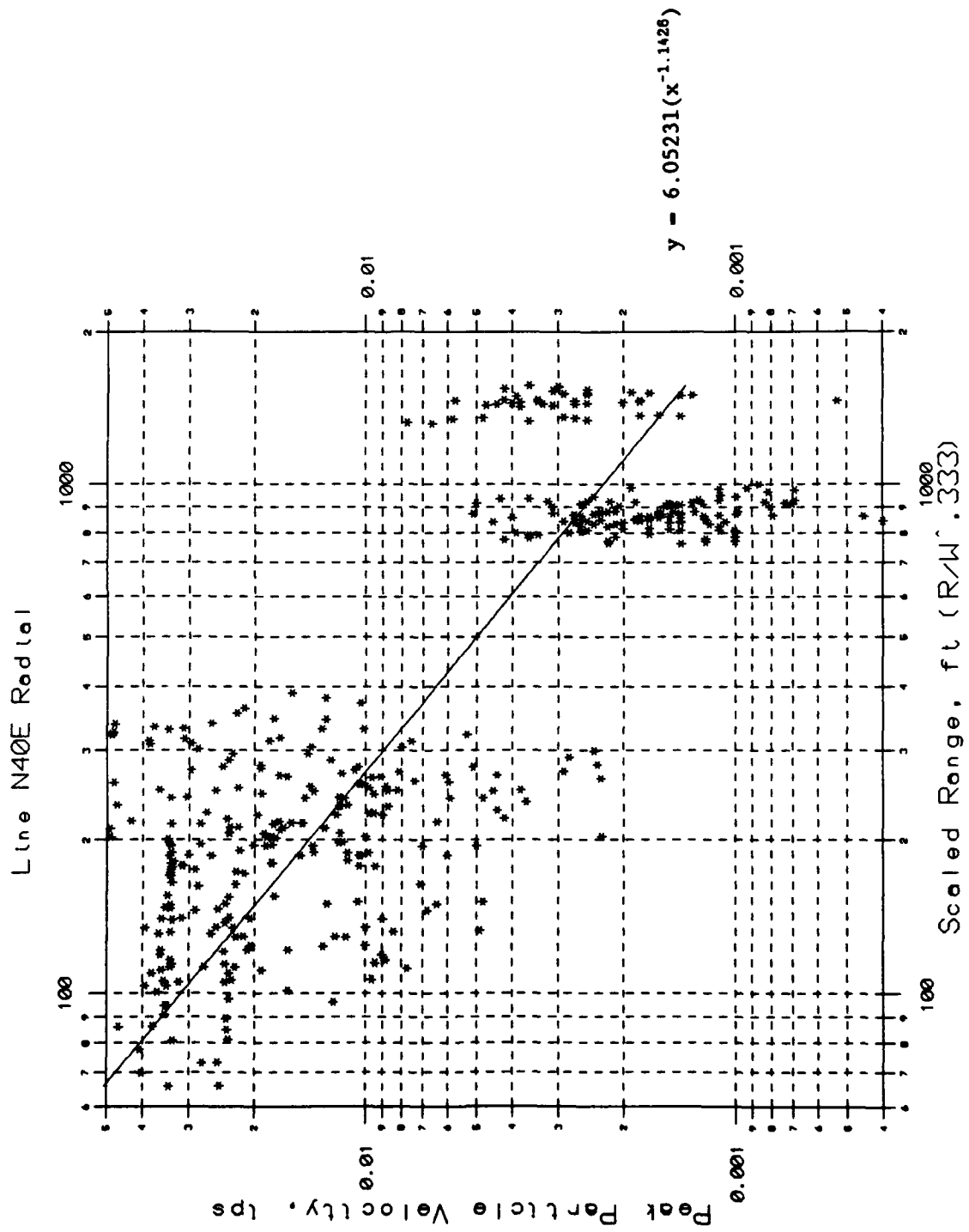
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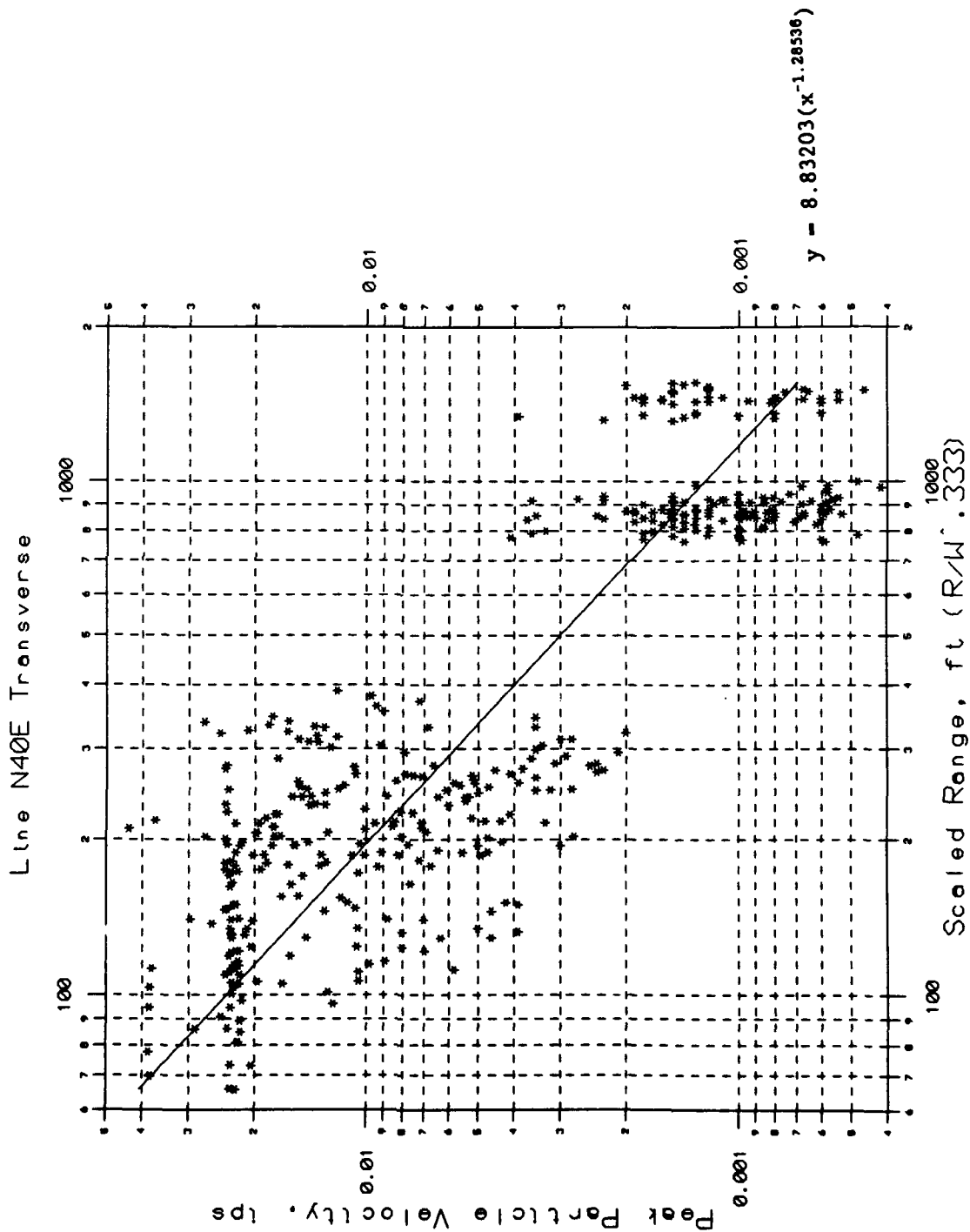




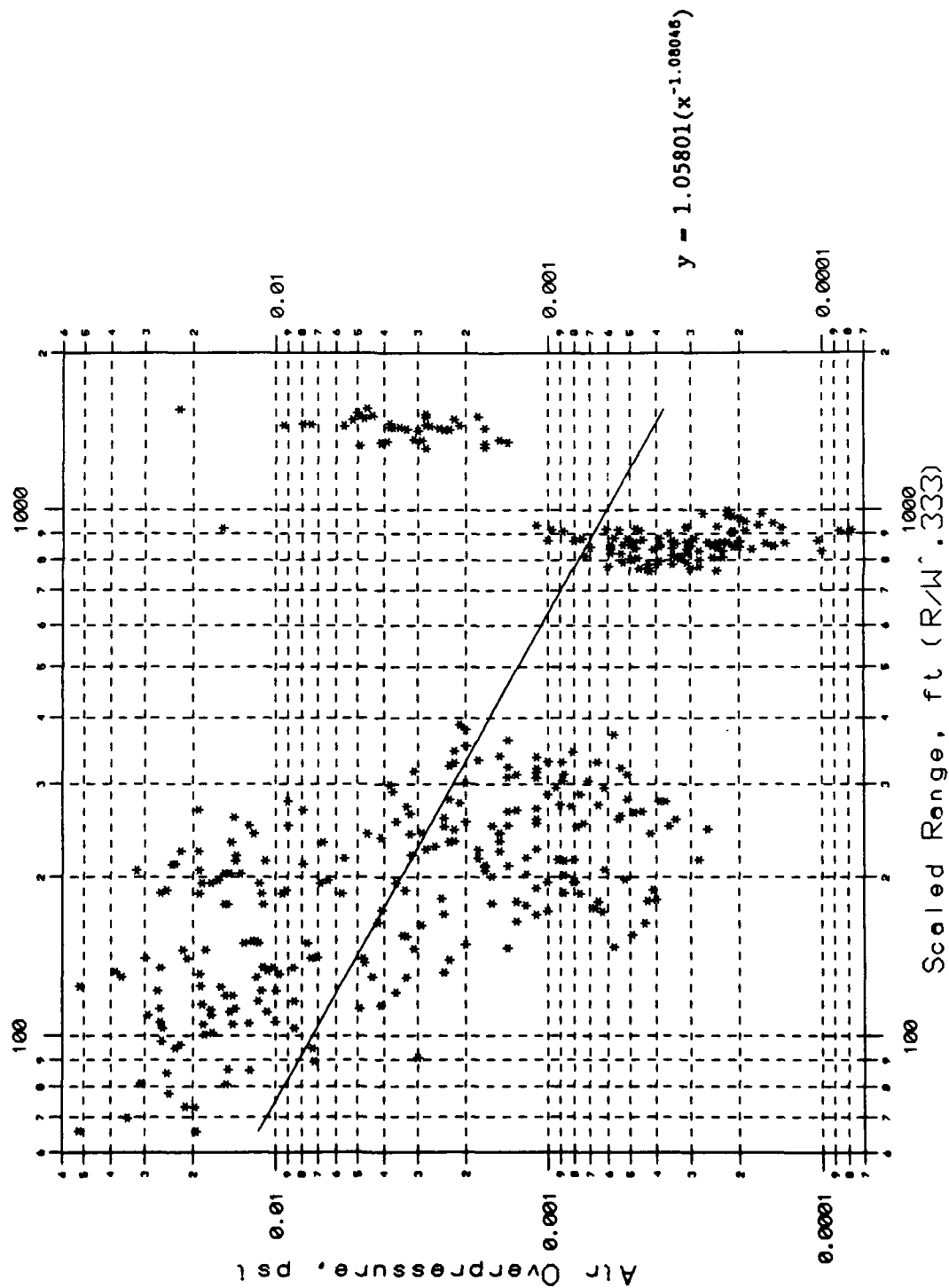


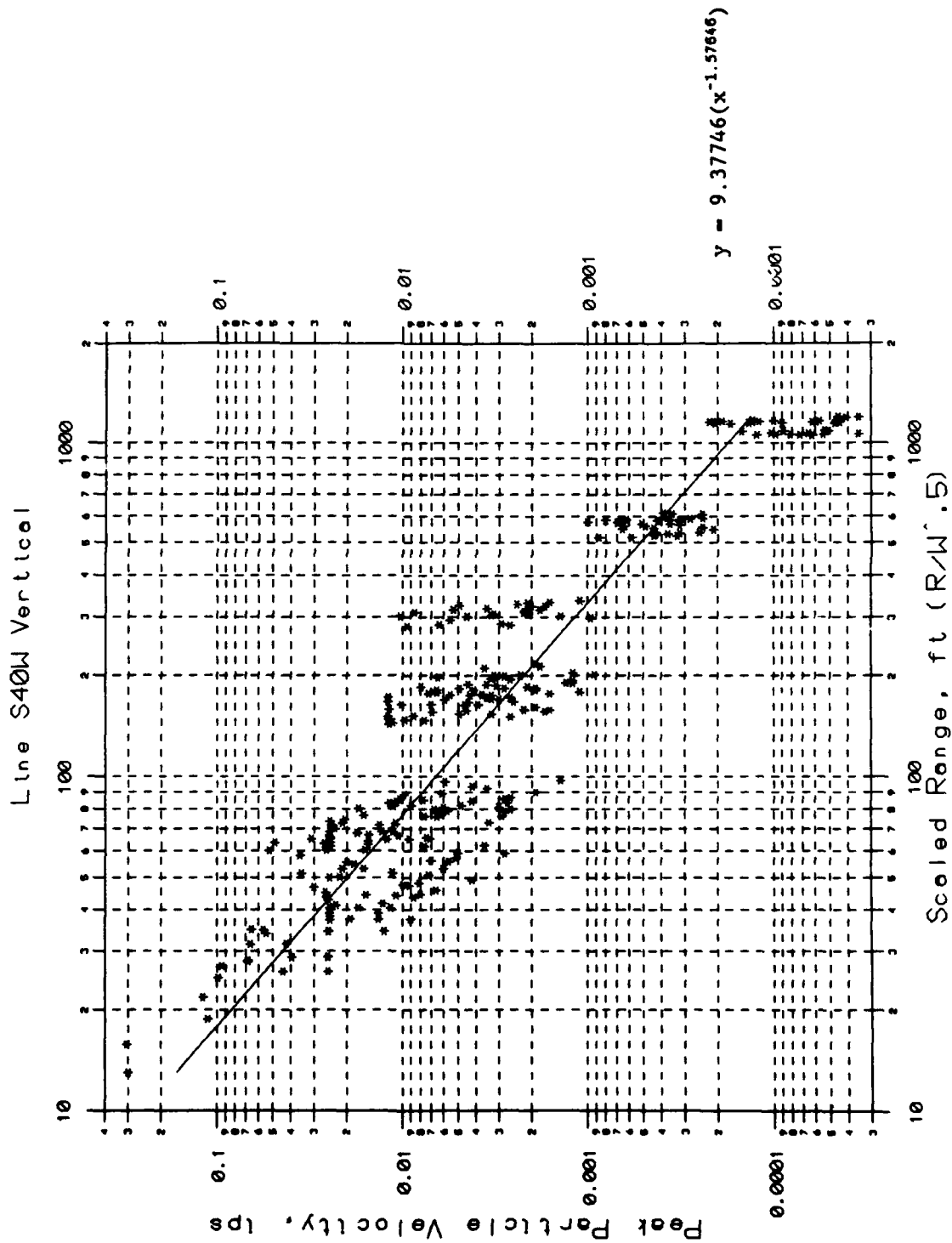
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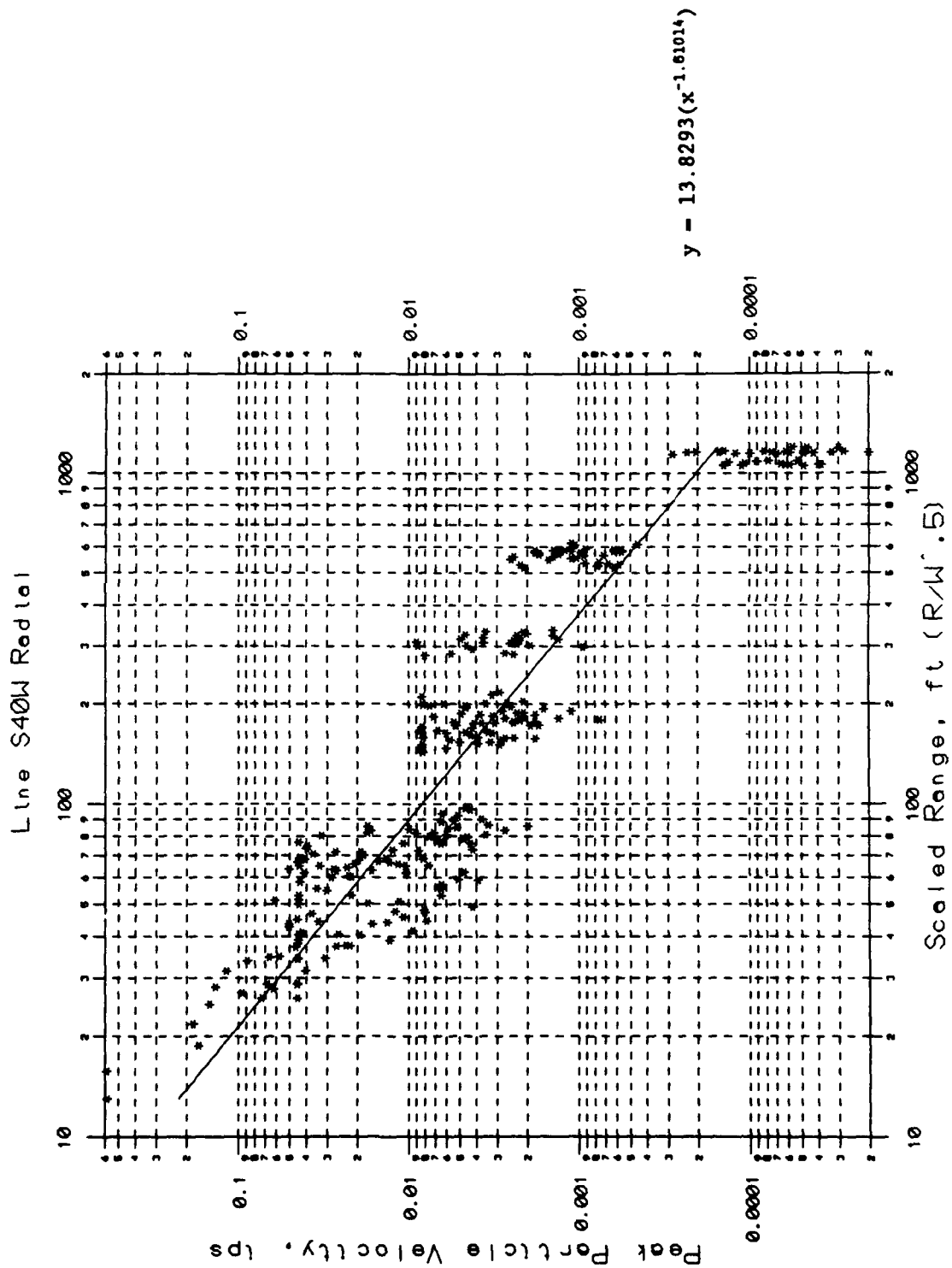




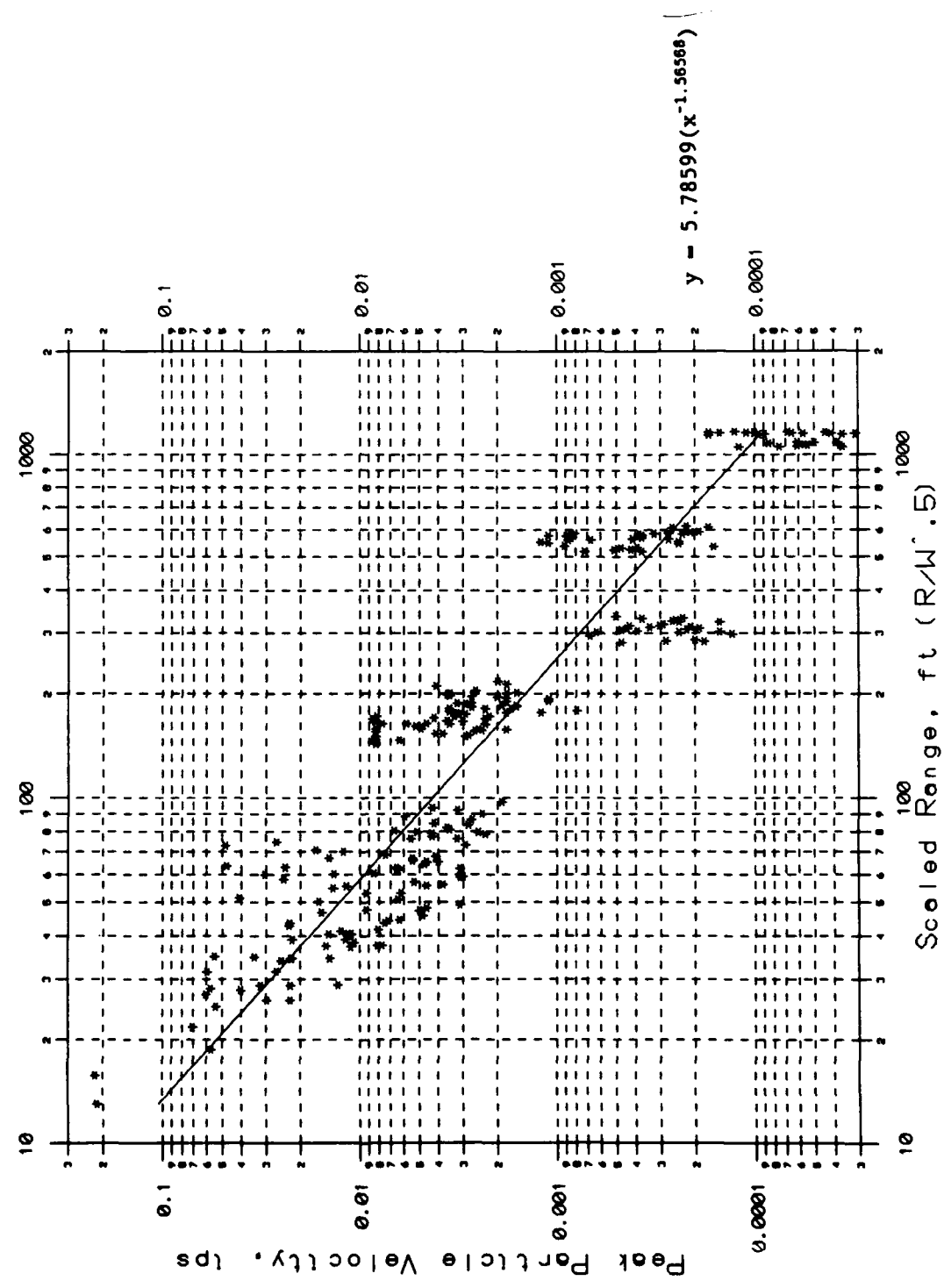
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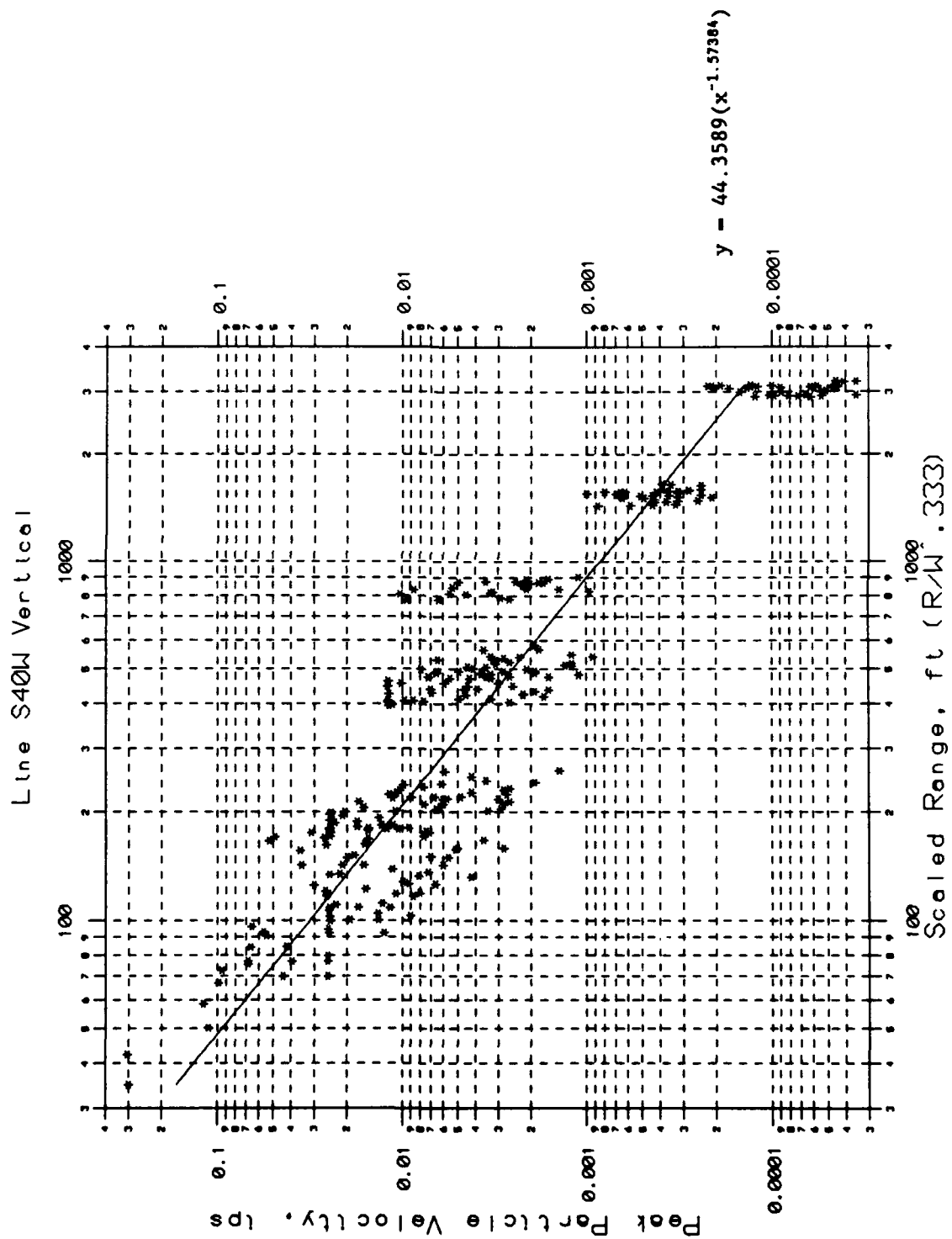


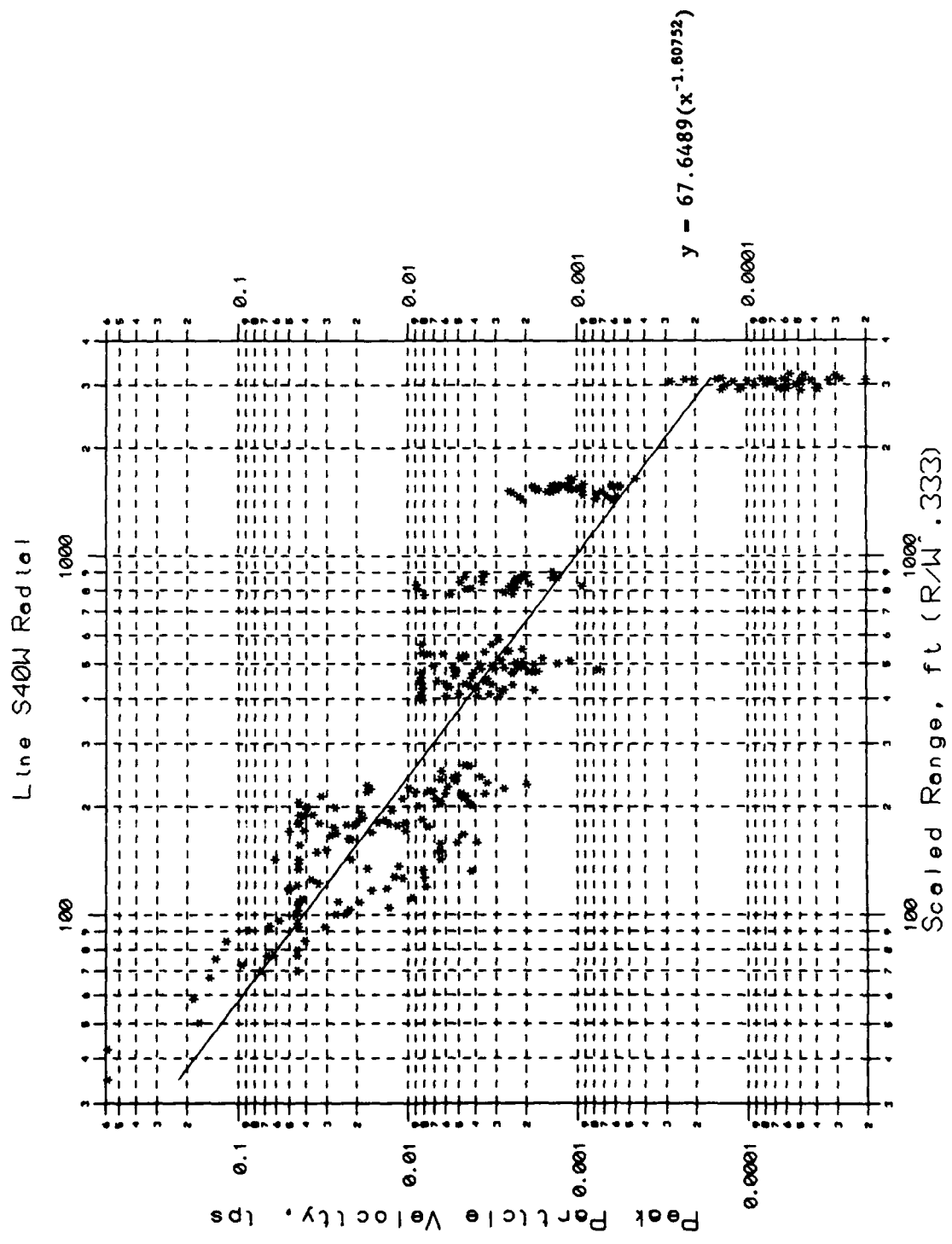


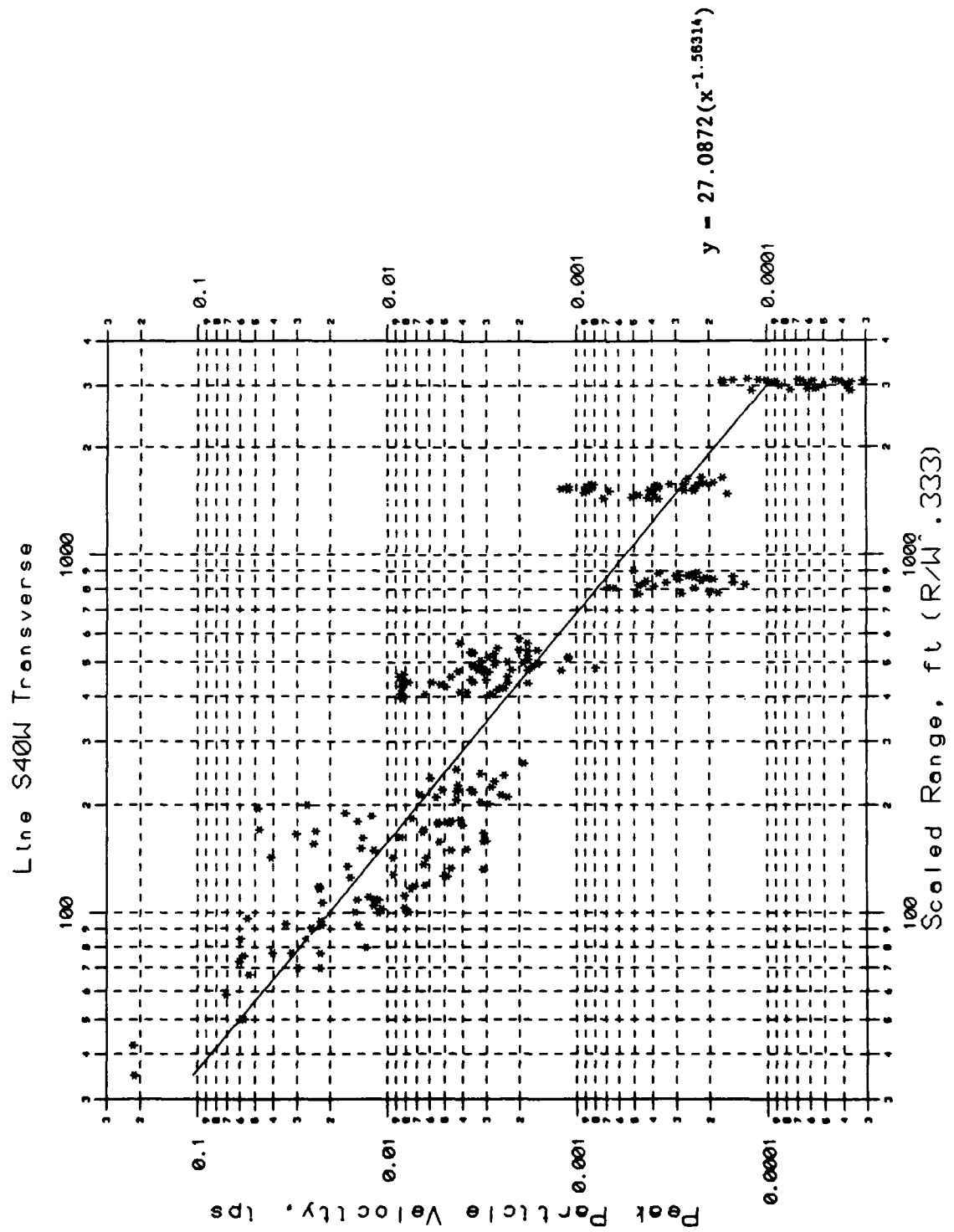


Line S40W Transverse

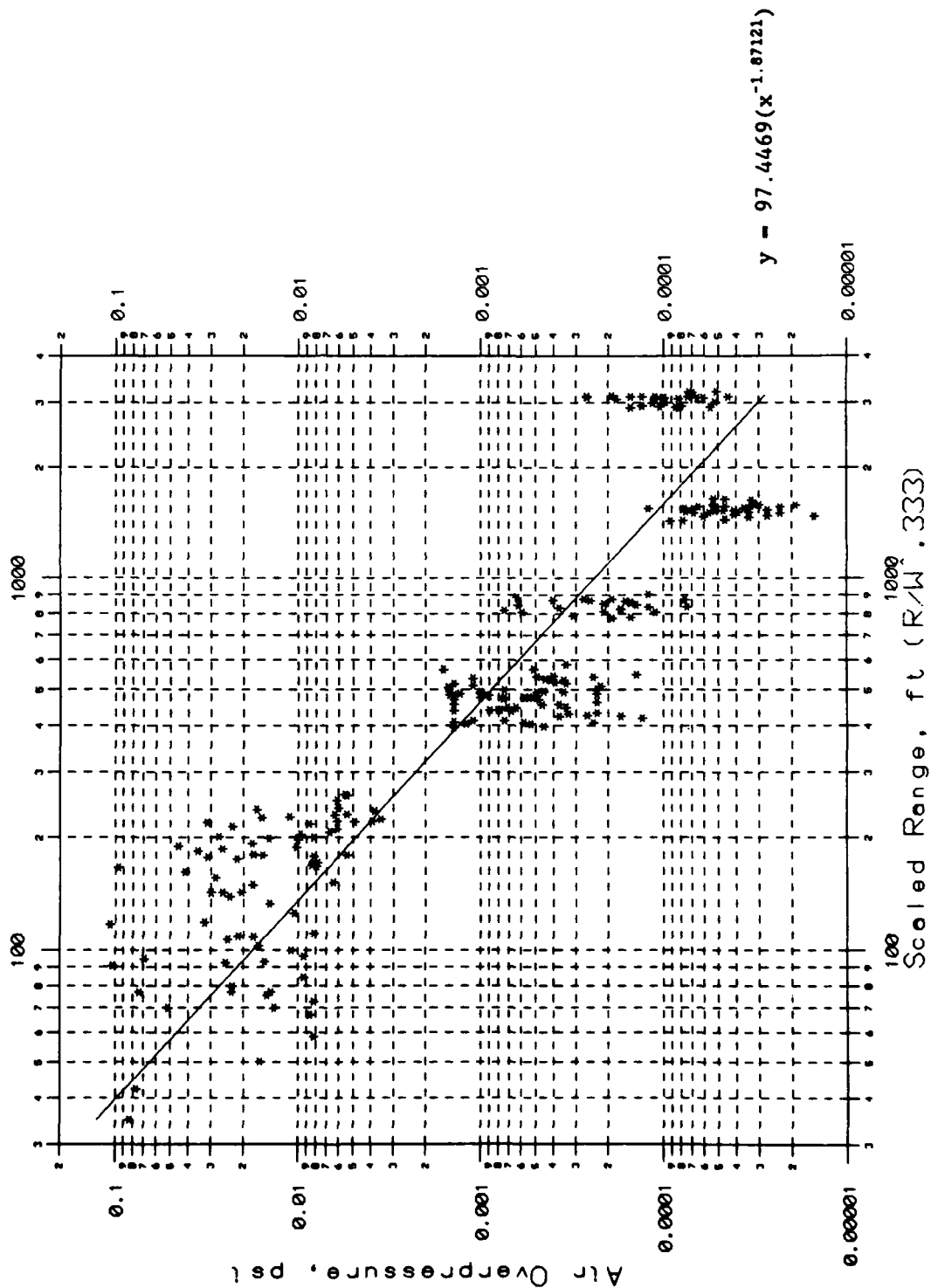




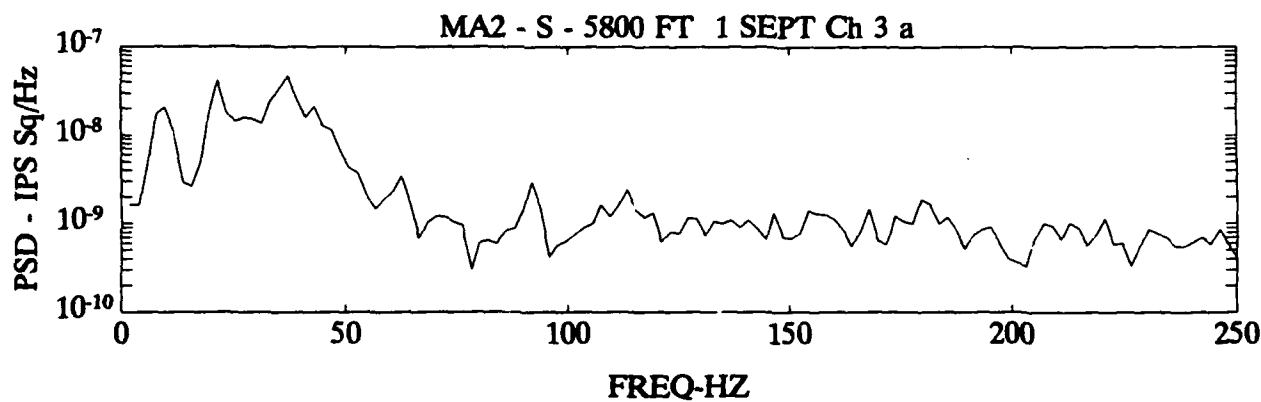
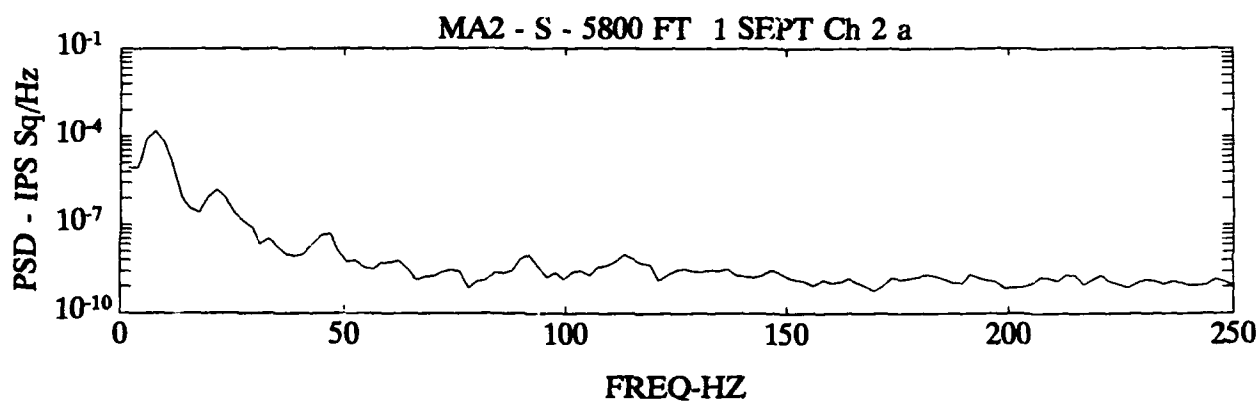
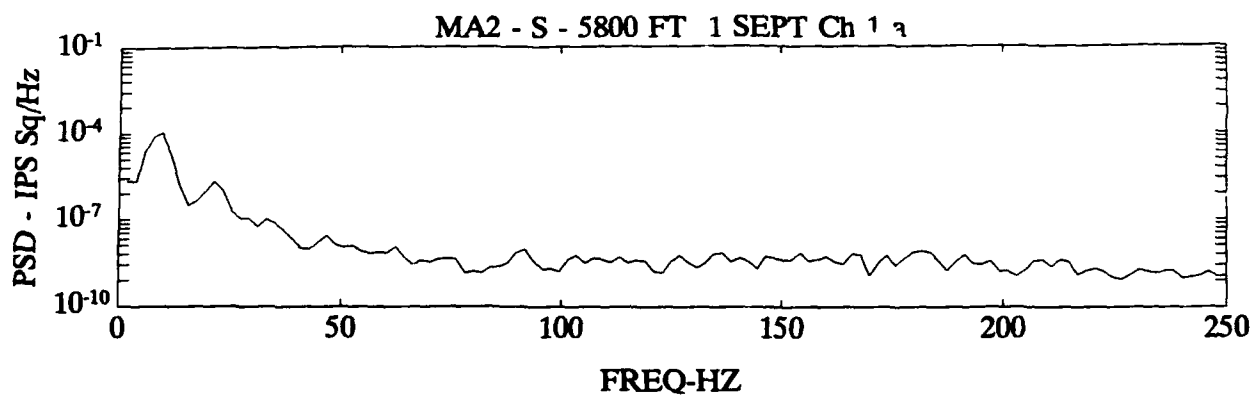


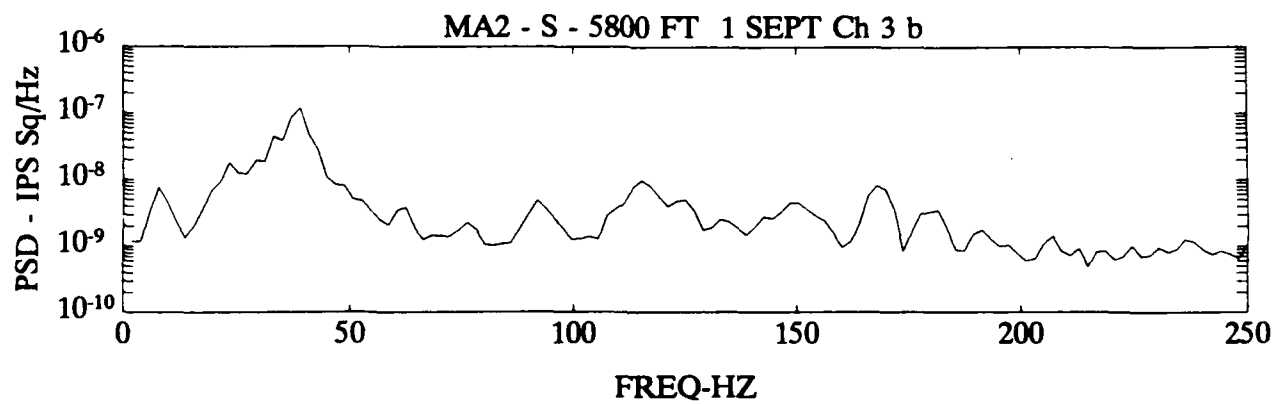
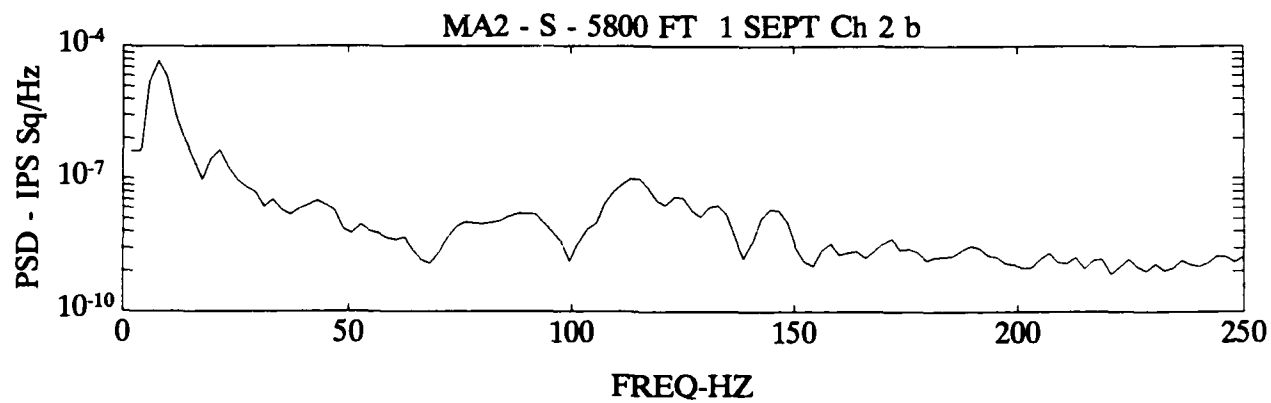
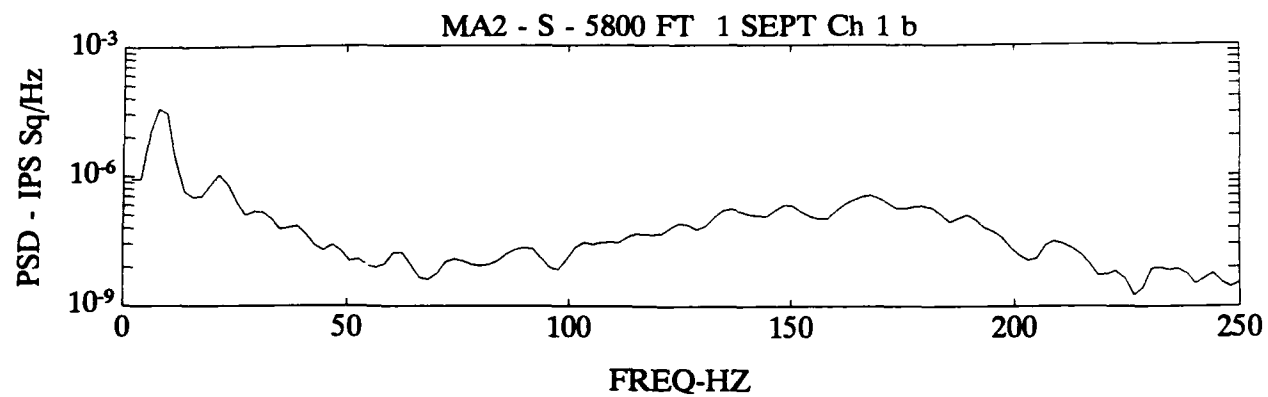


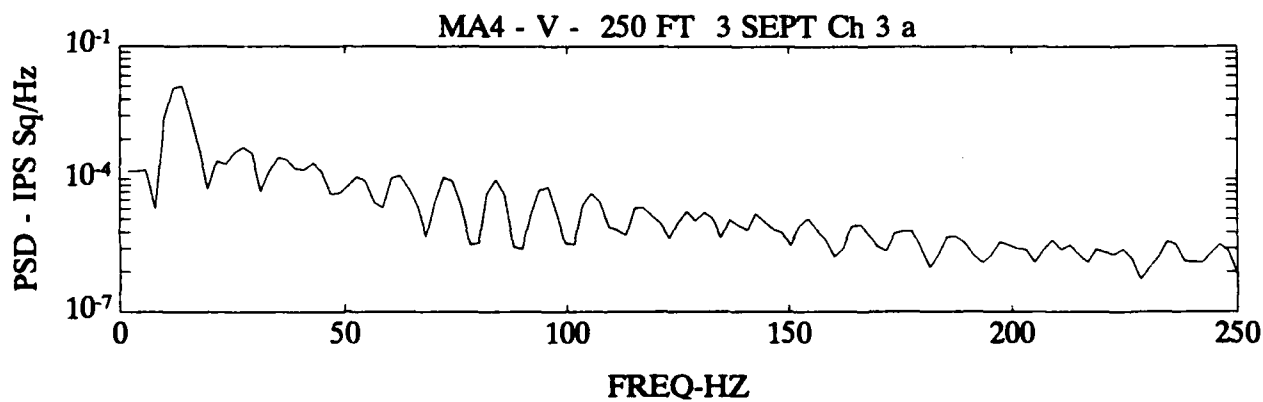
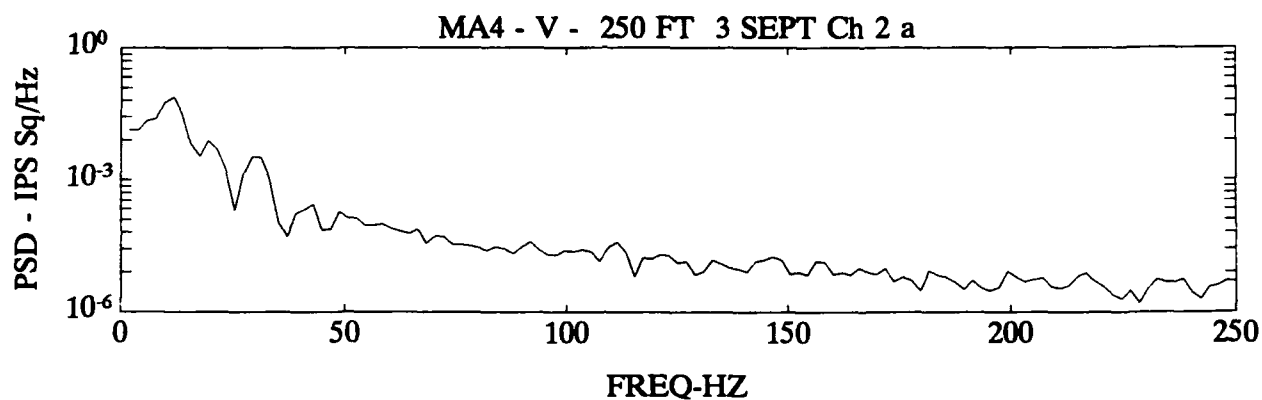
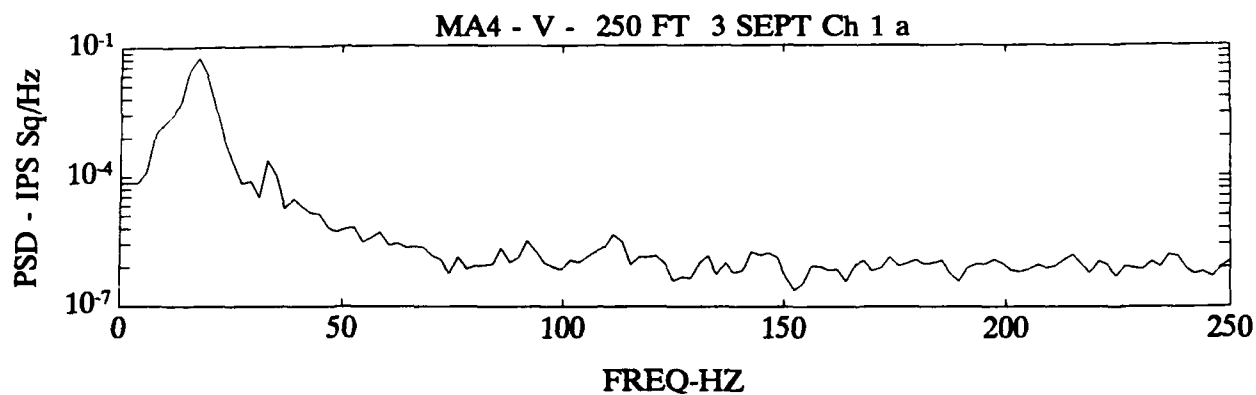
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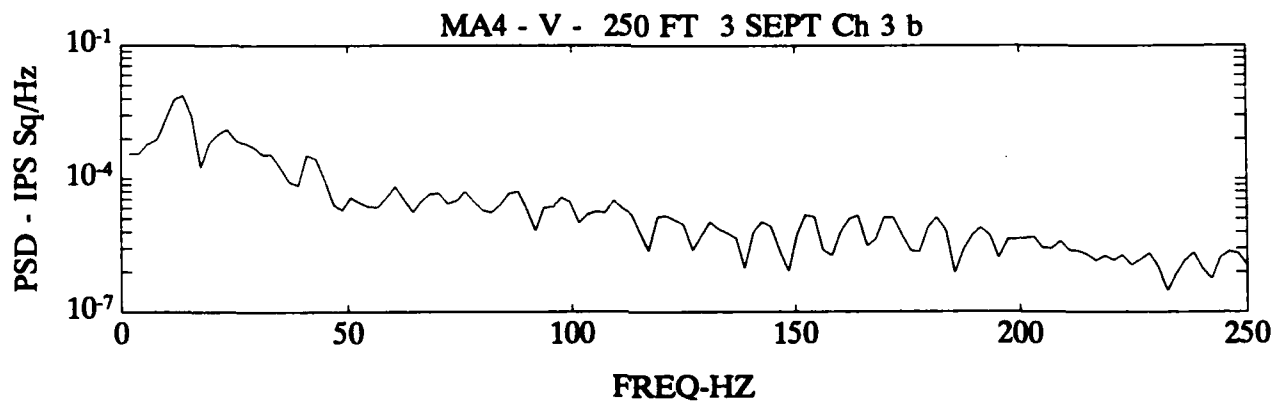
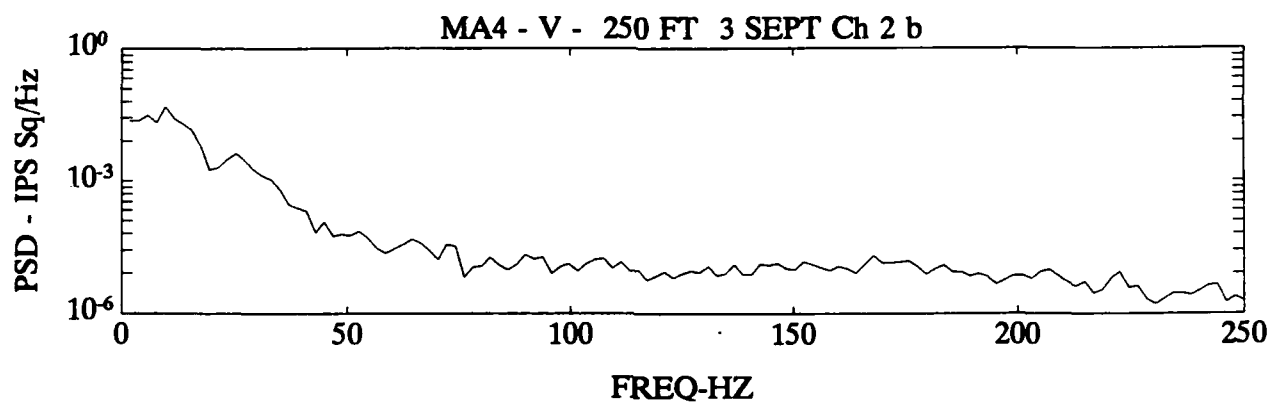
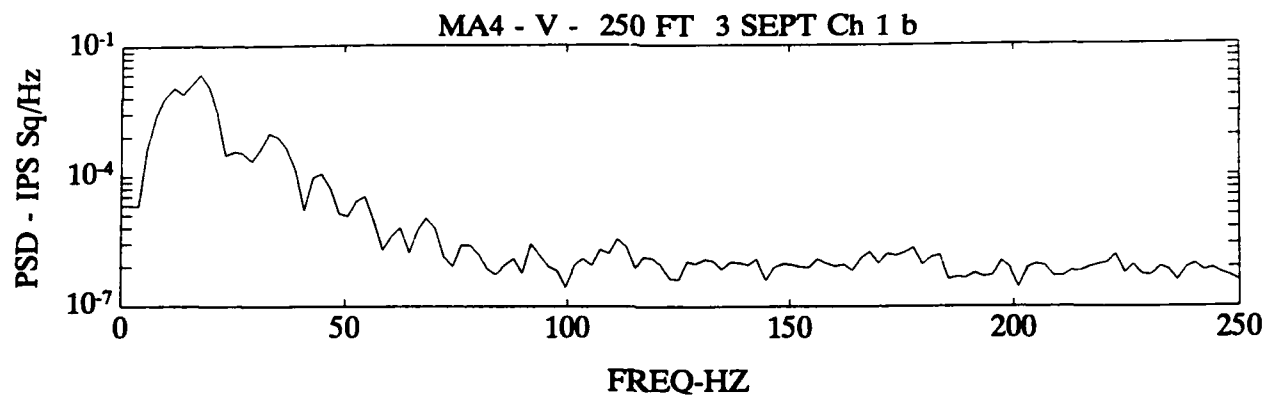


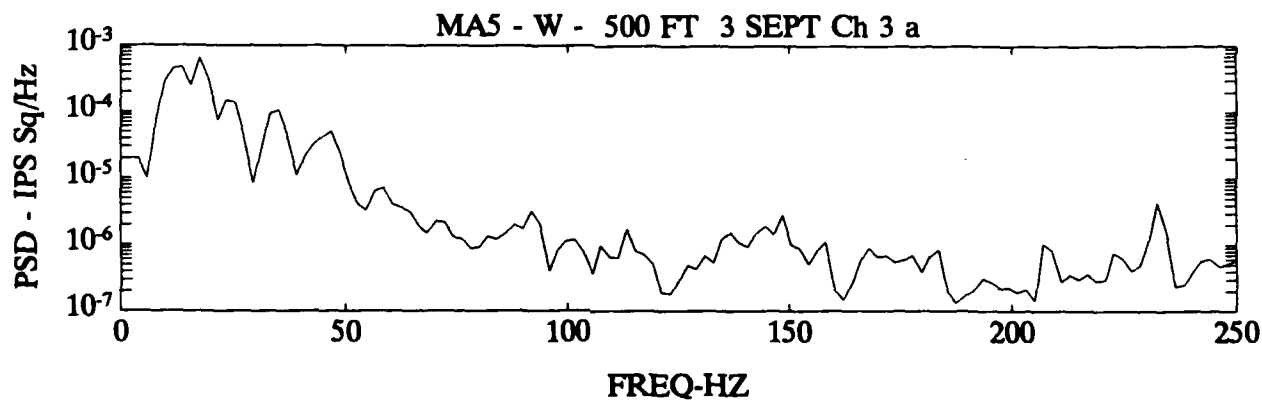
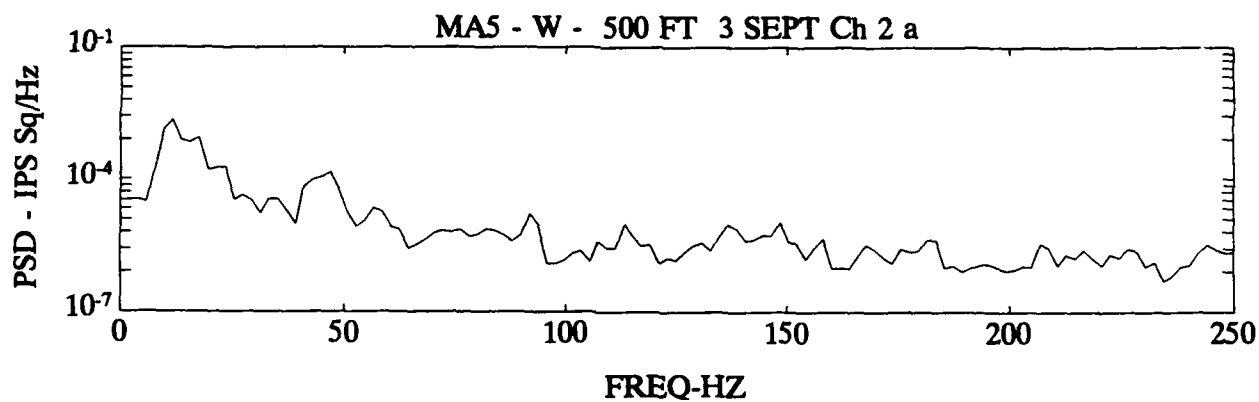
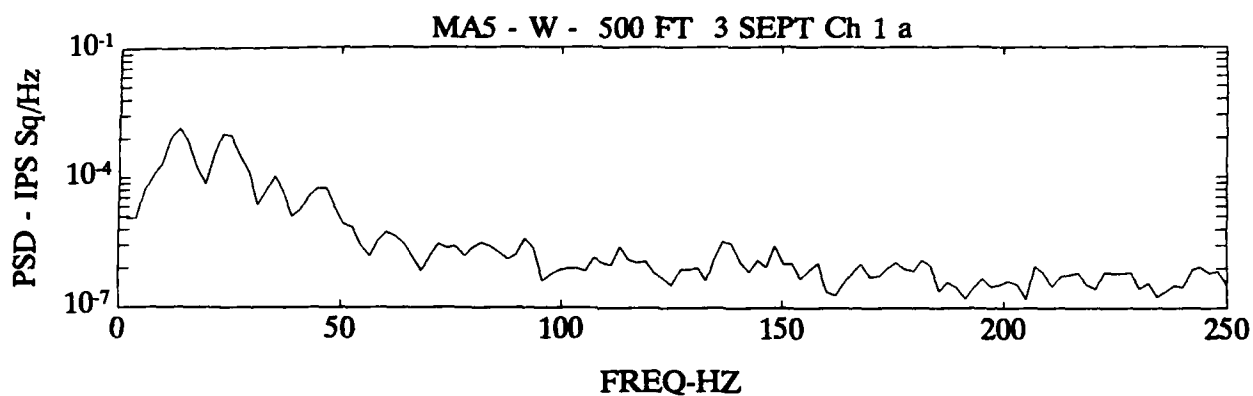
Appendix D: Selected Power Spectral Density Plots

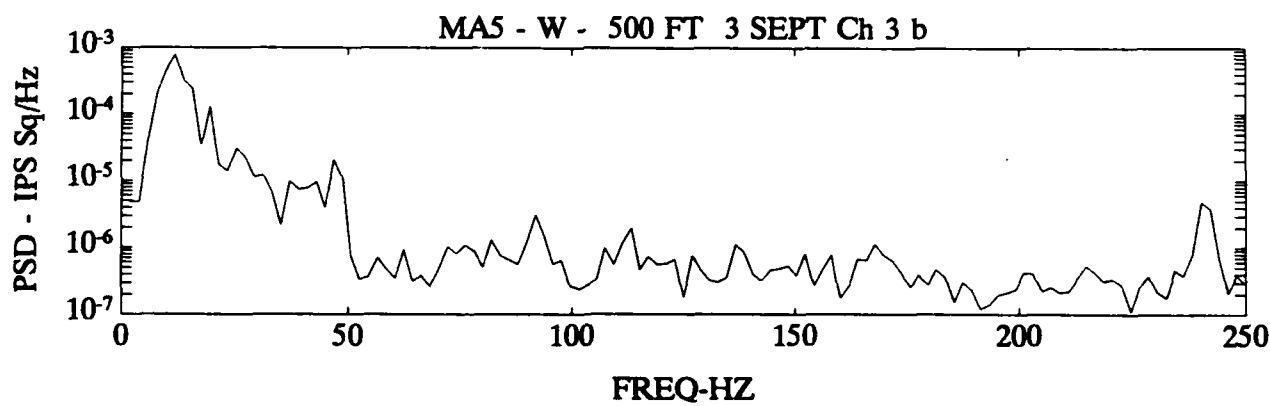
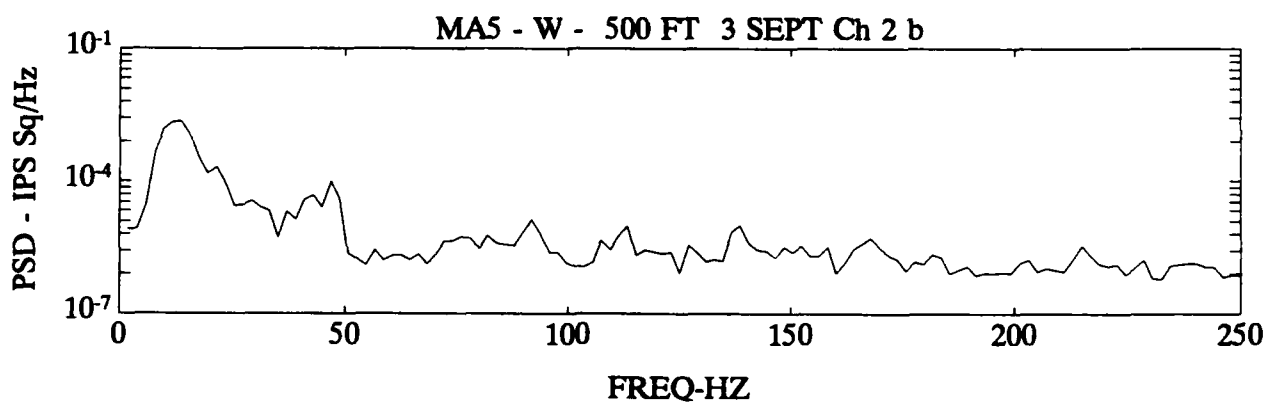
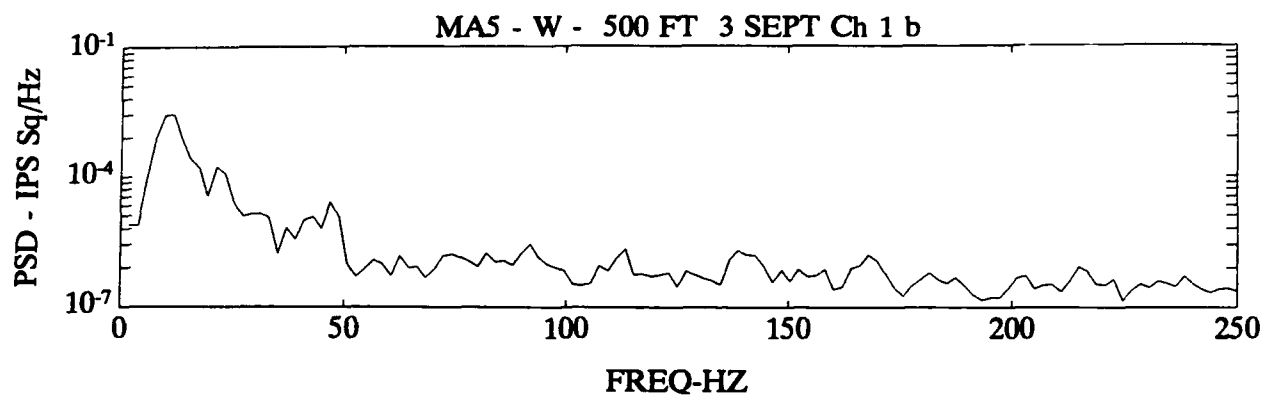


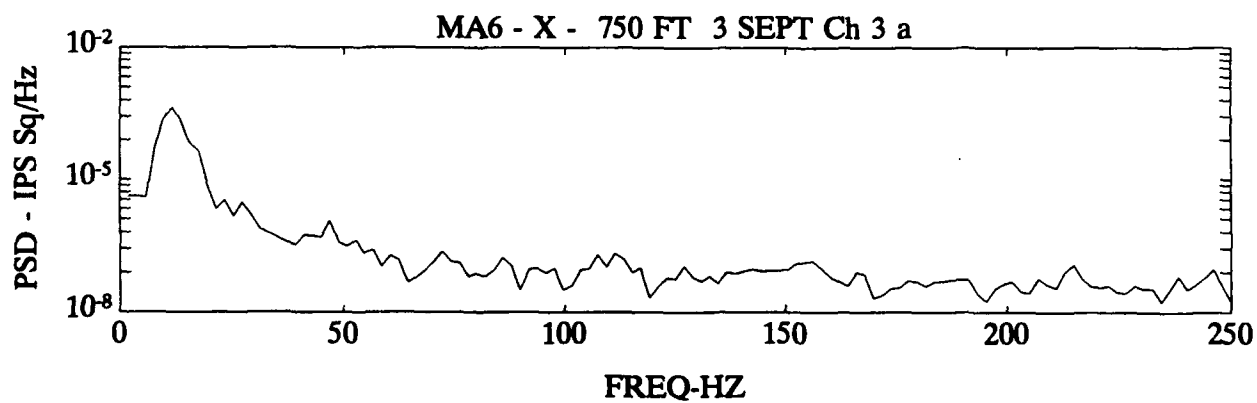
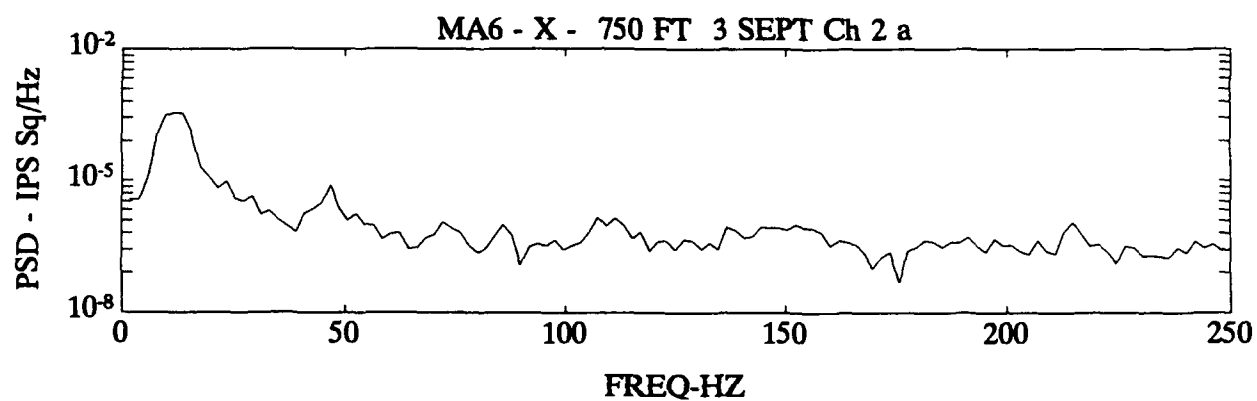
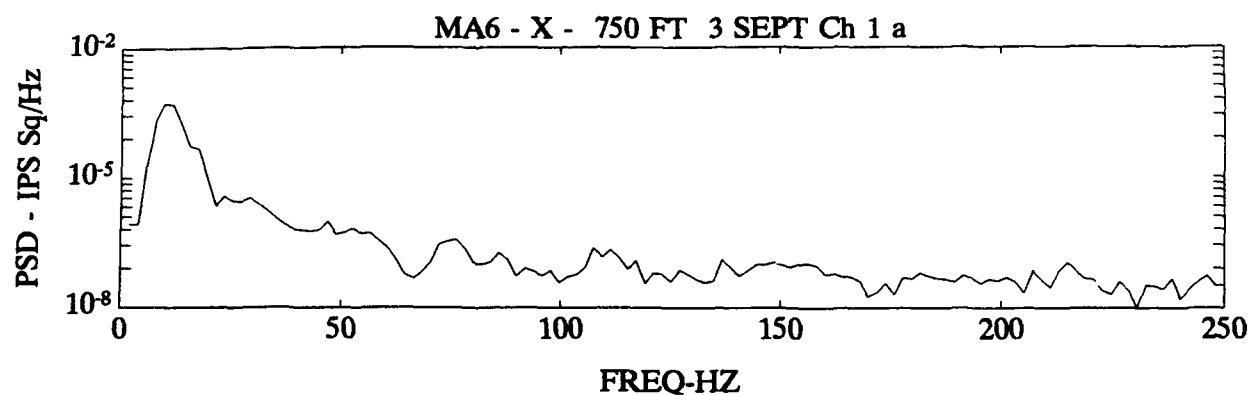


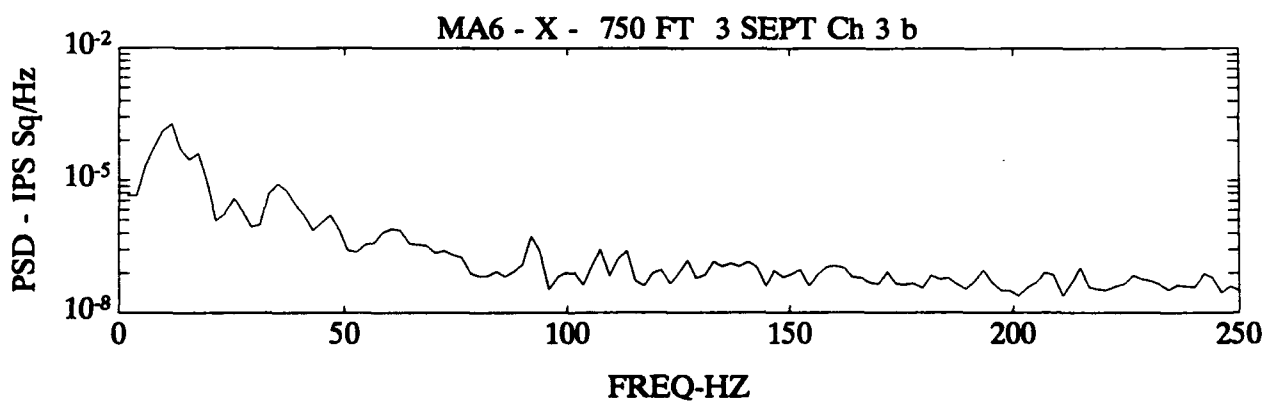
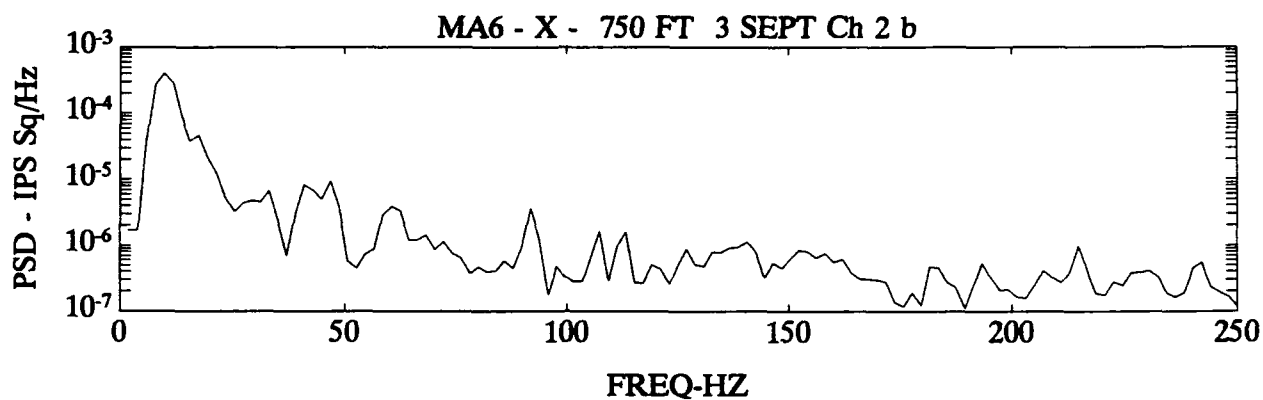
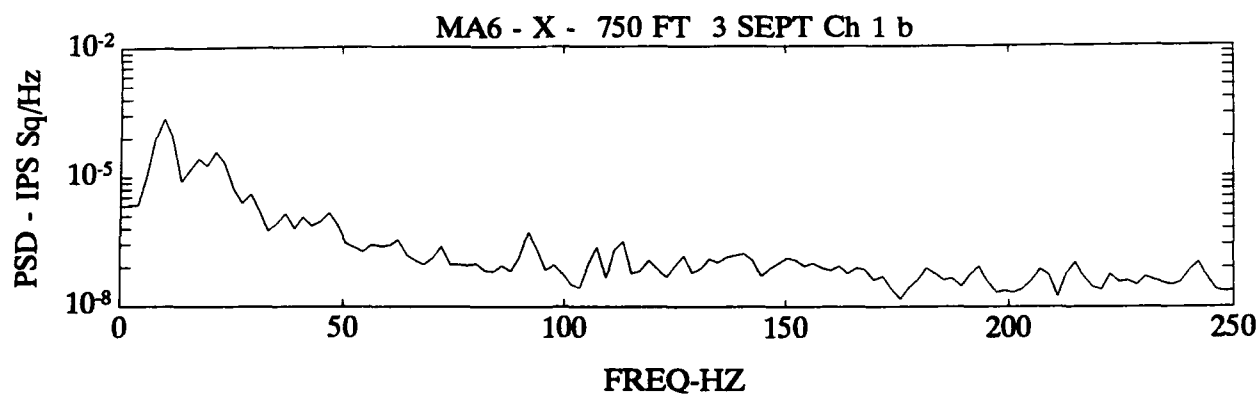


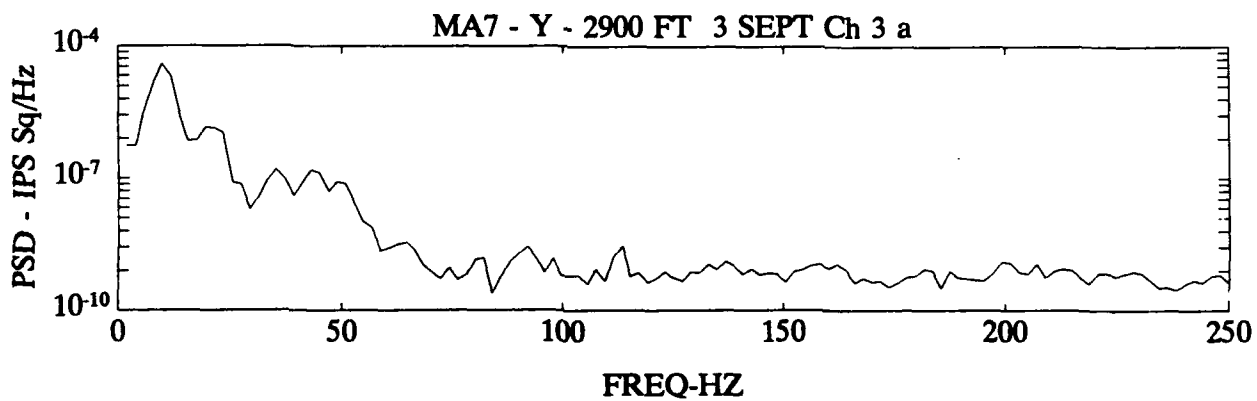
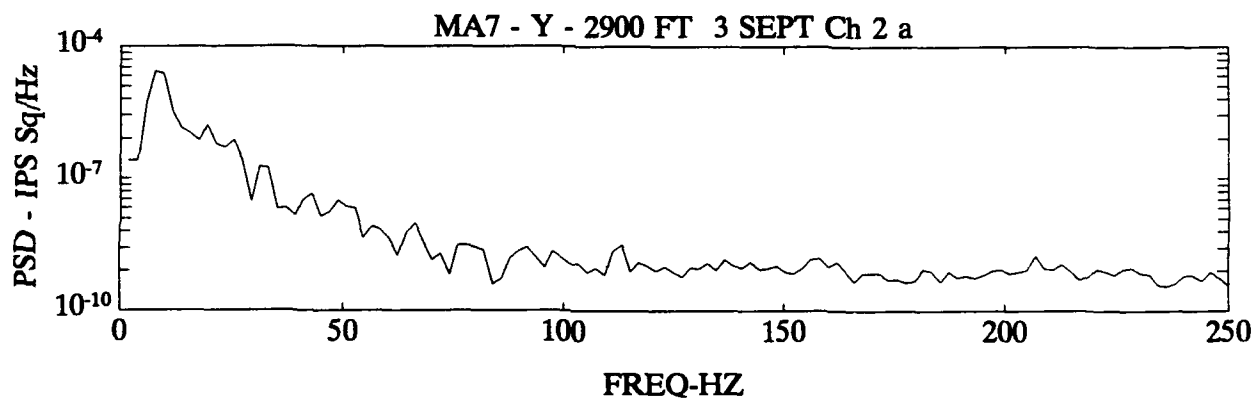
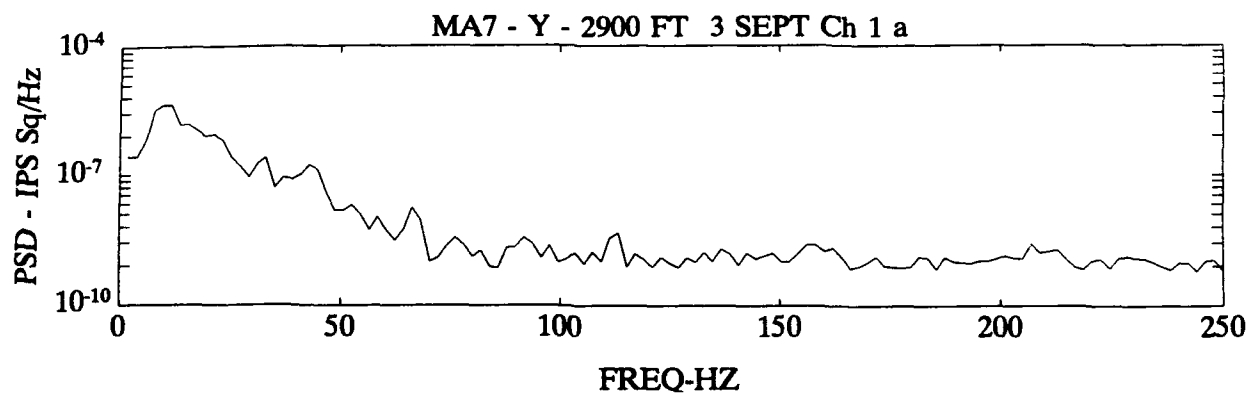


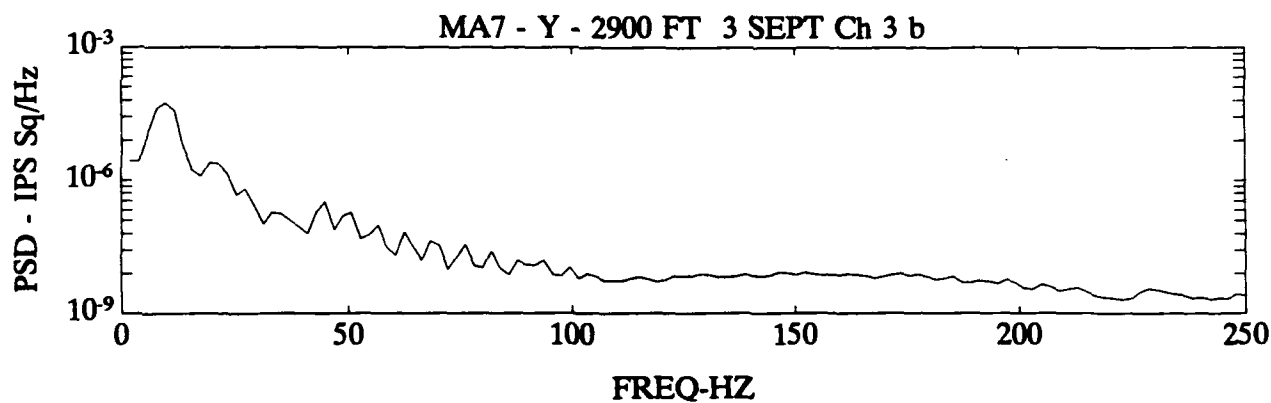
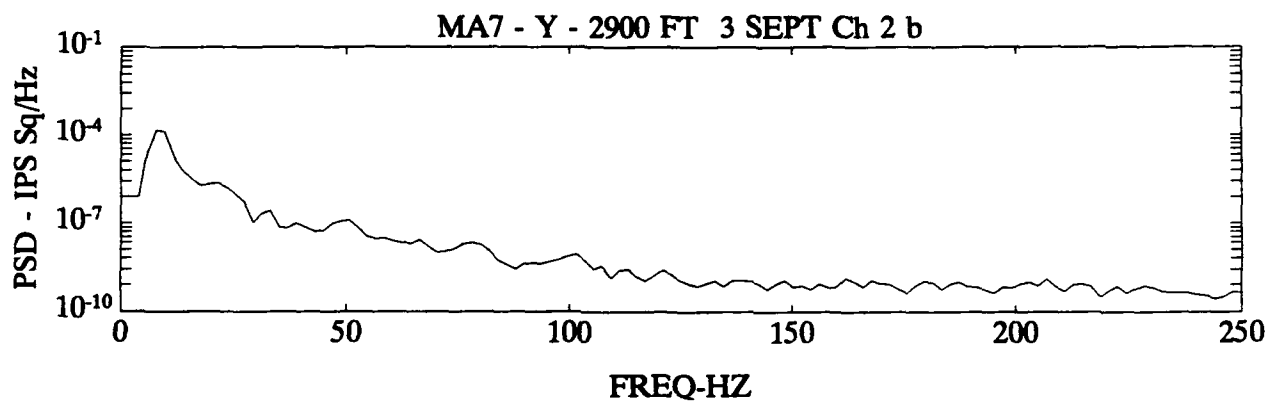
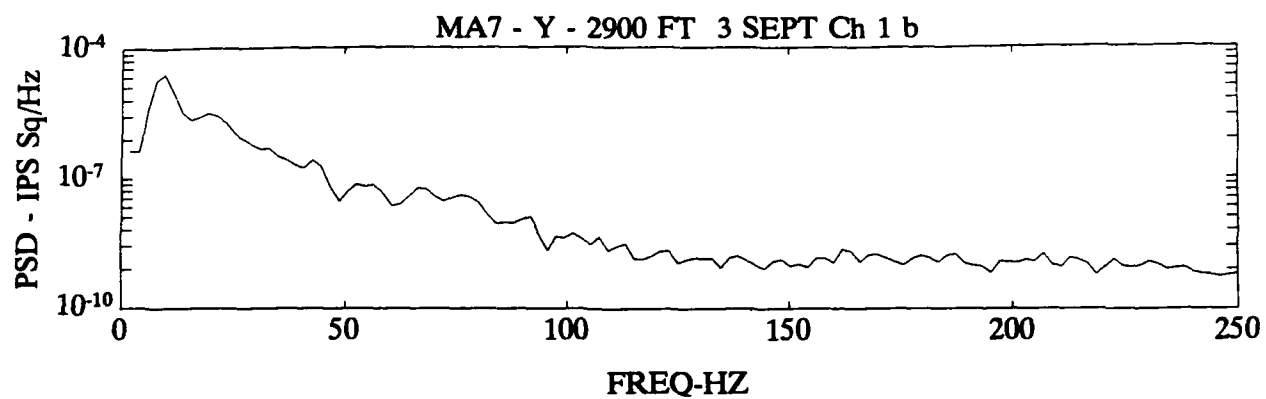


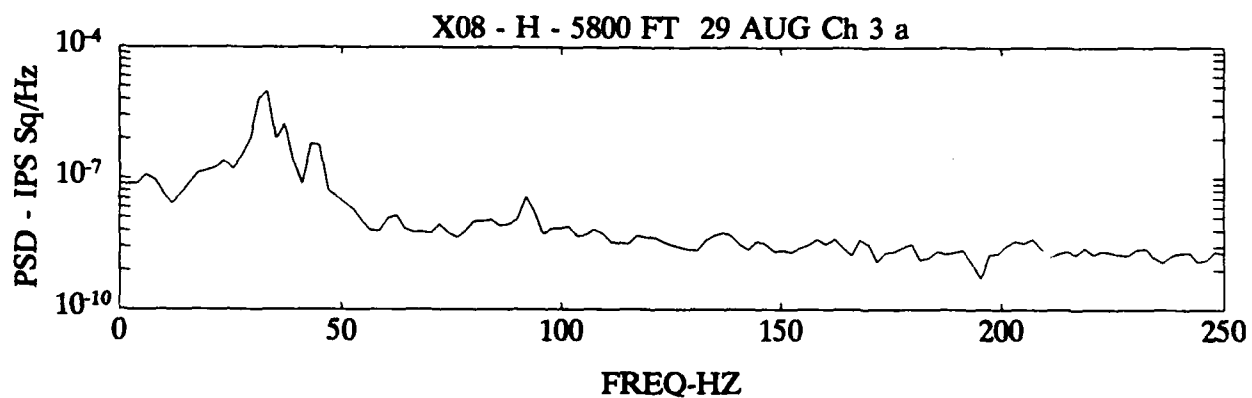
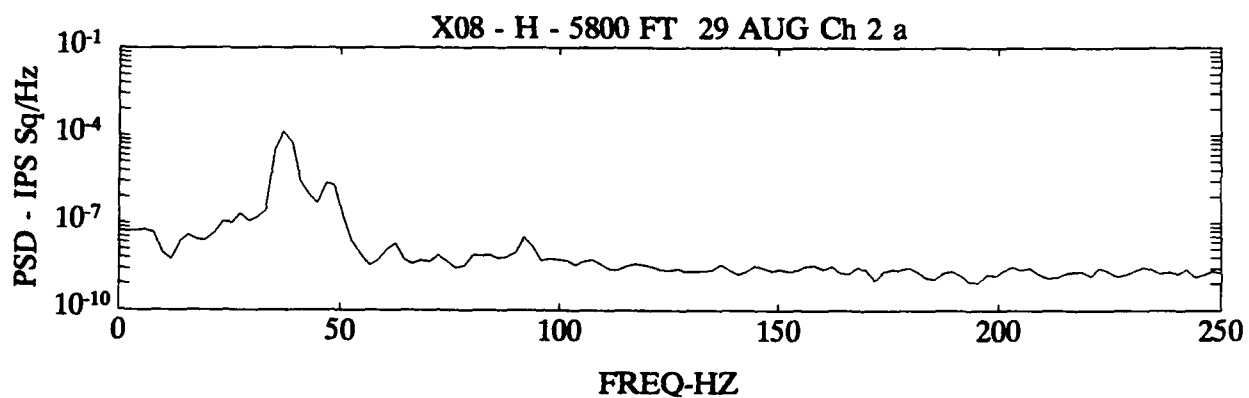
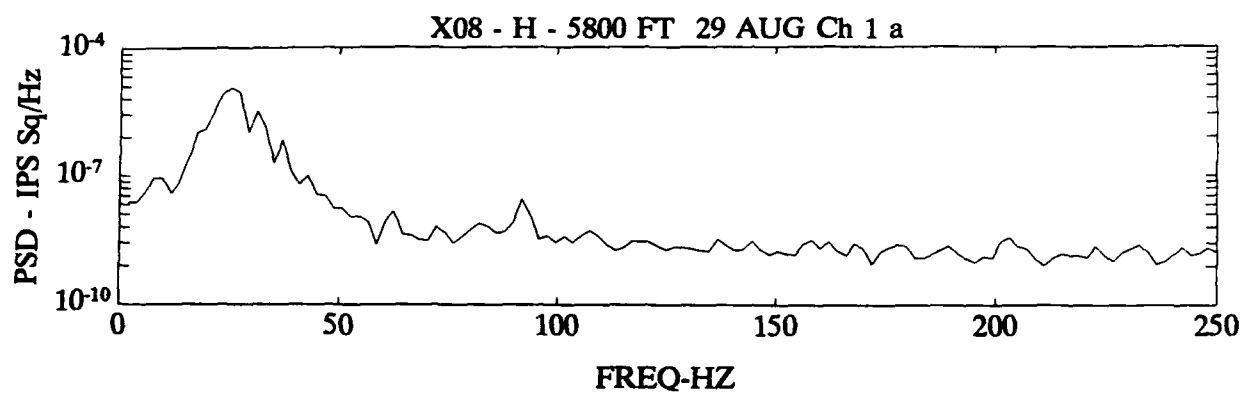


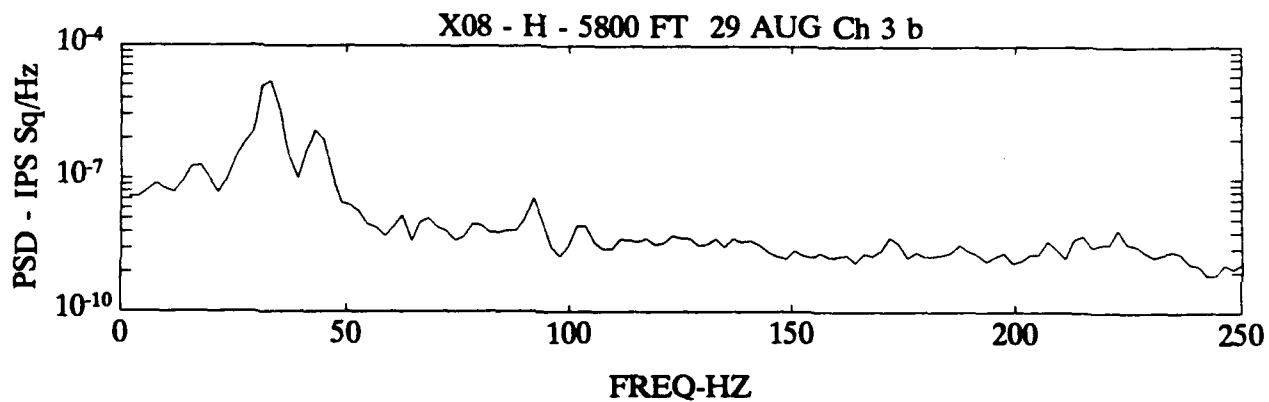
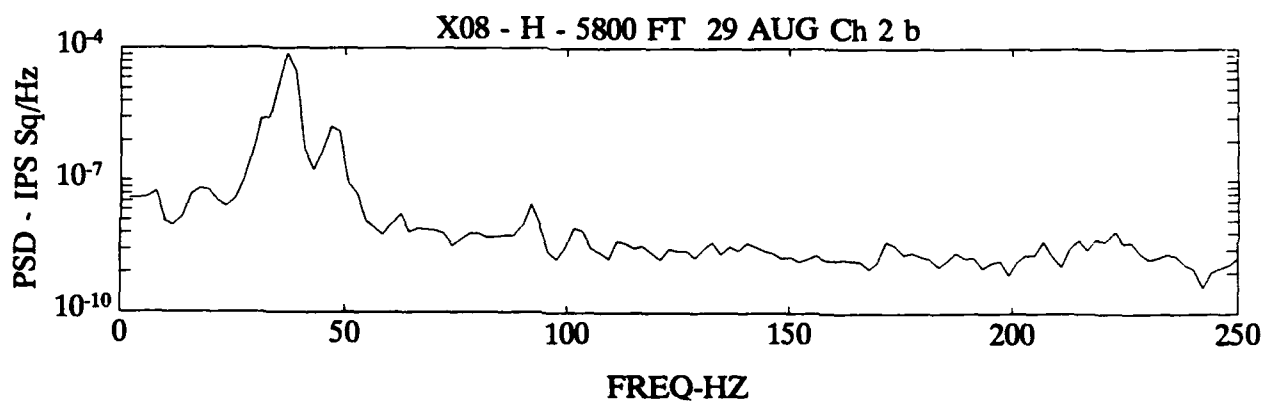
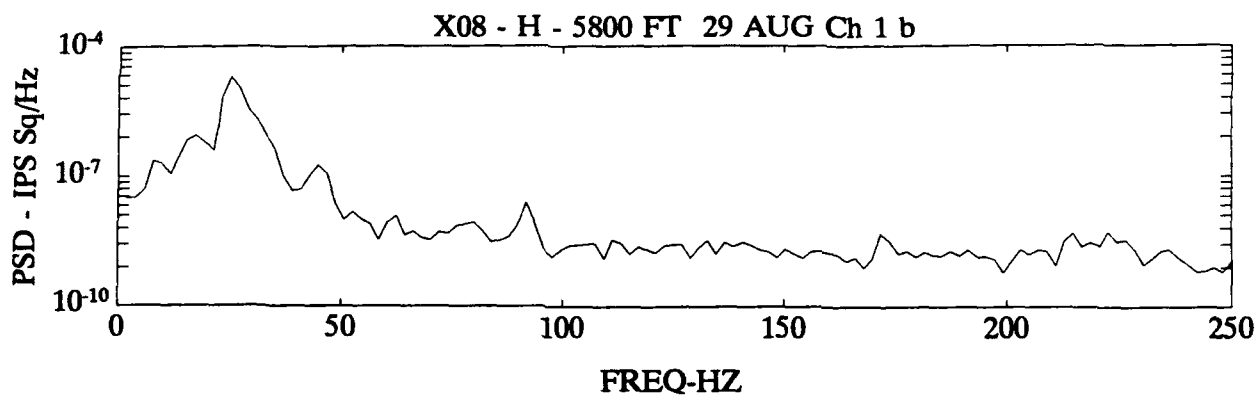


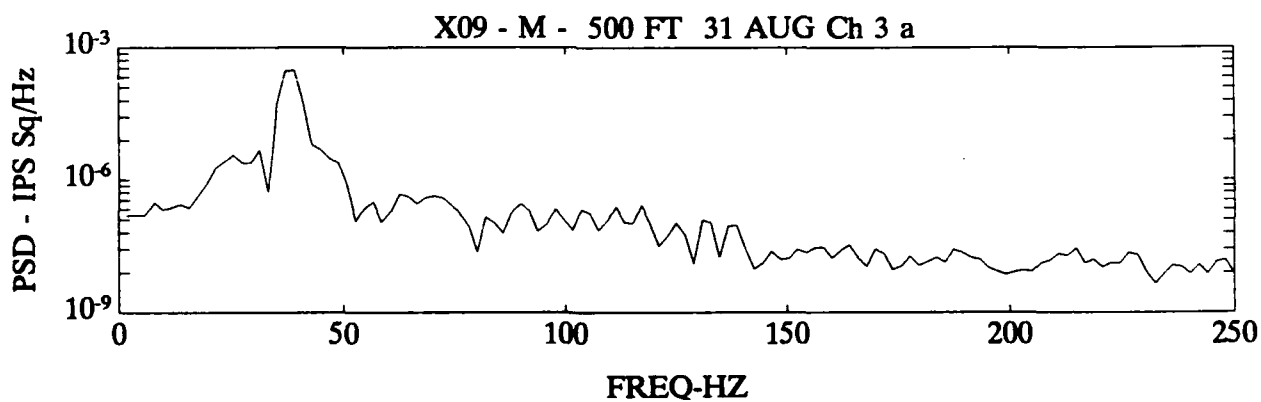
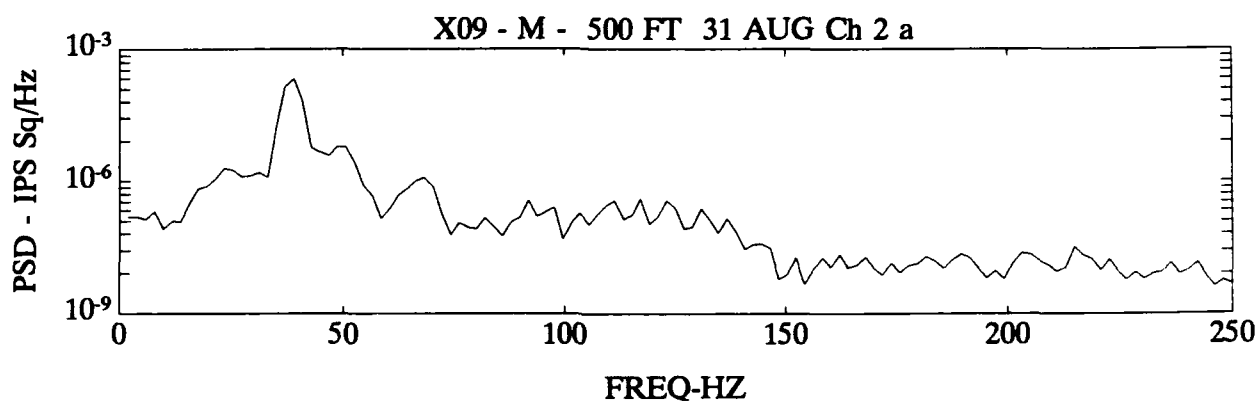
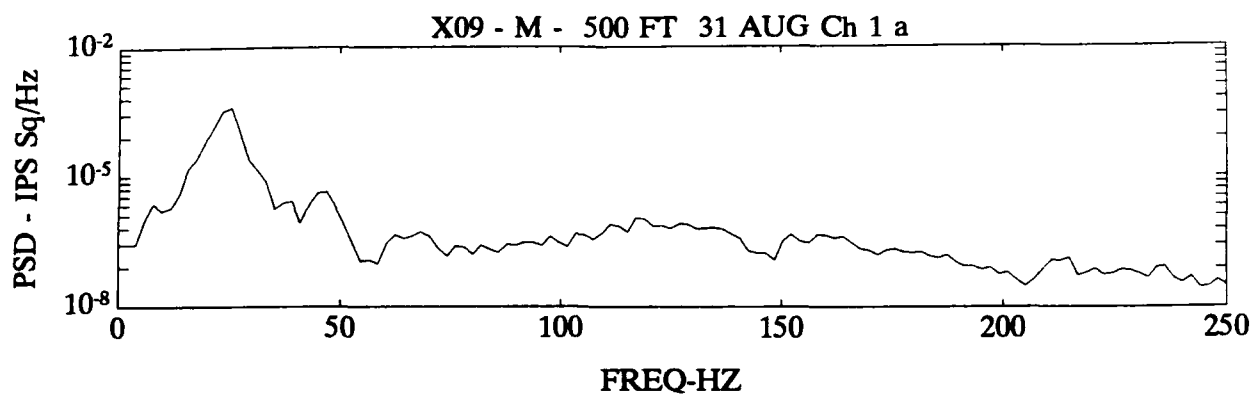


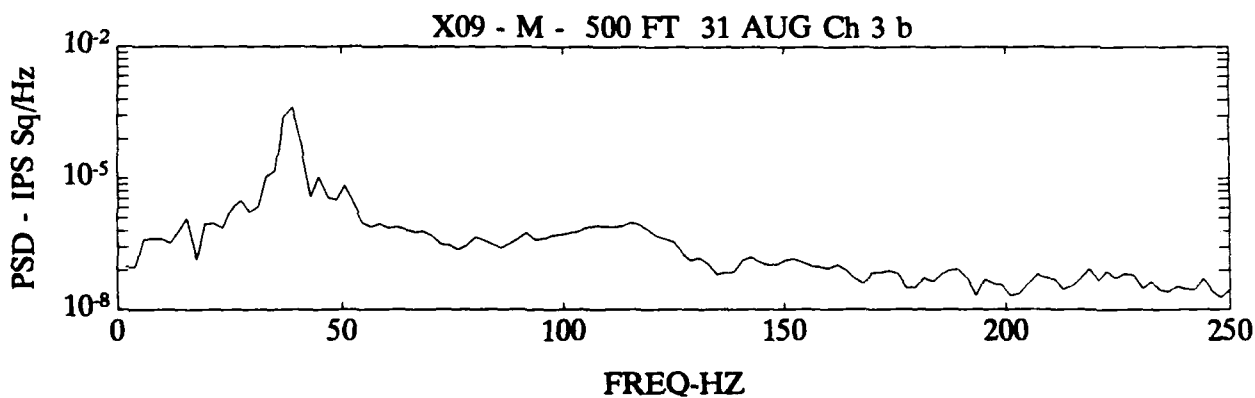
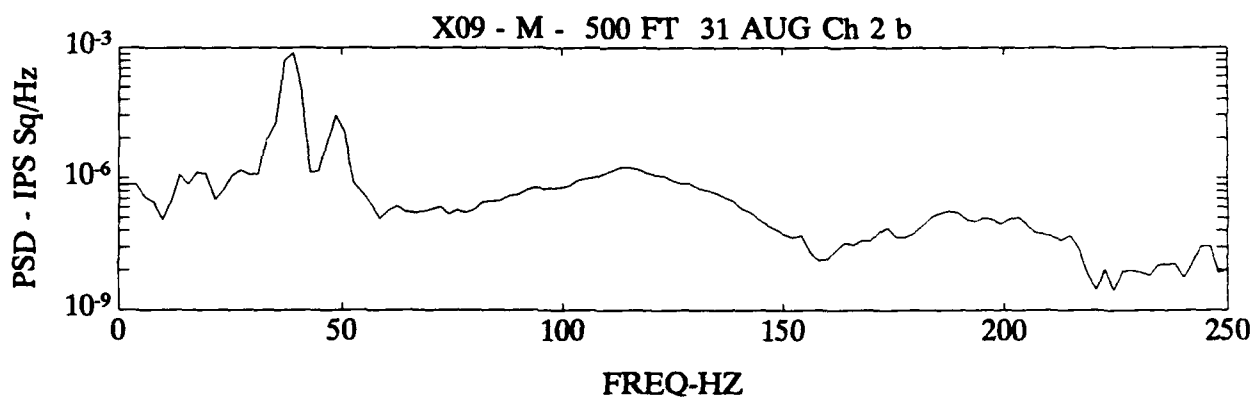
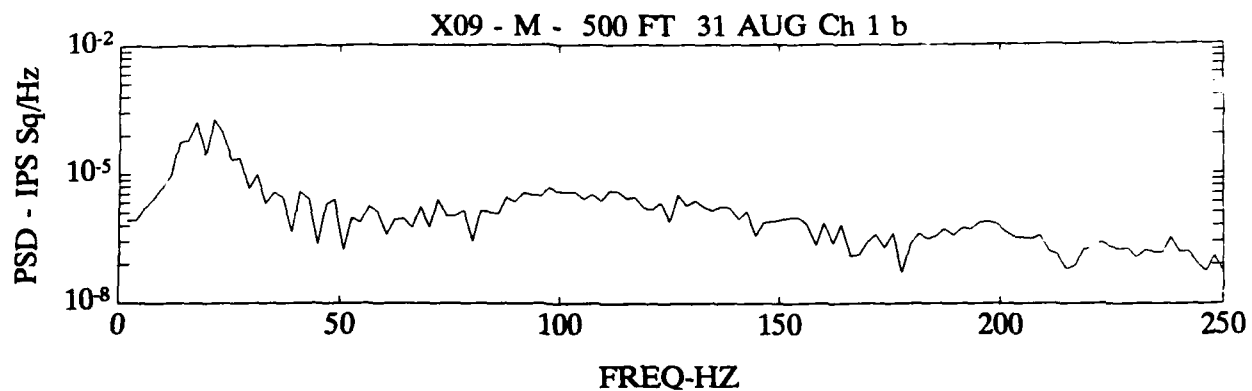


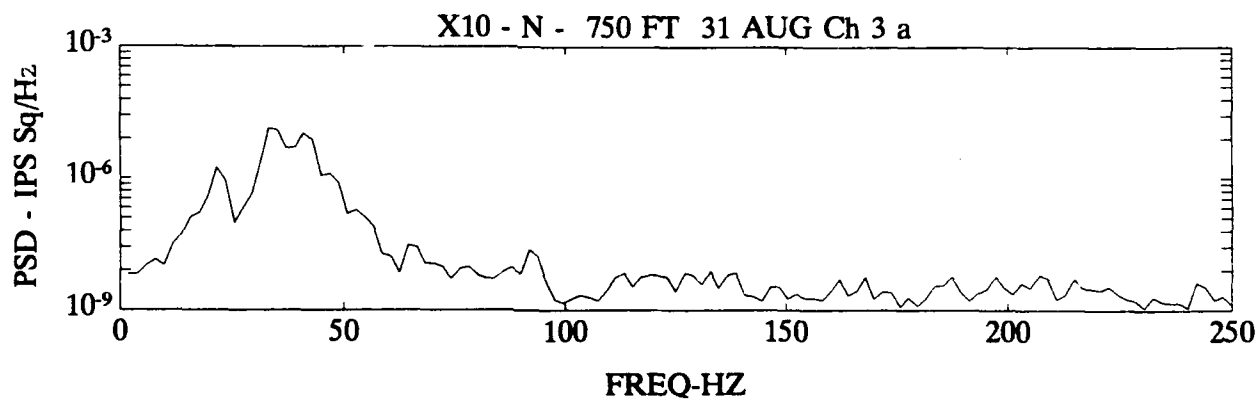
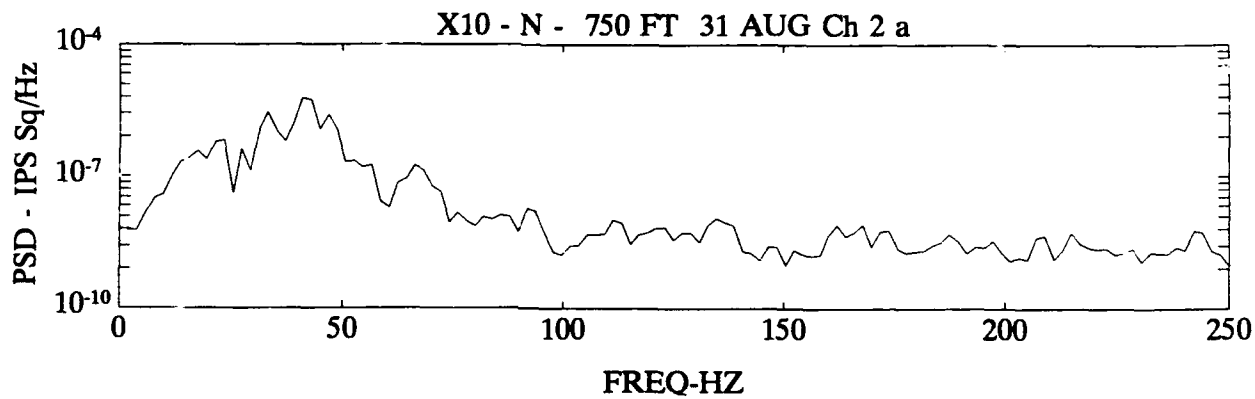
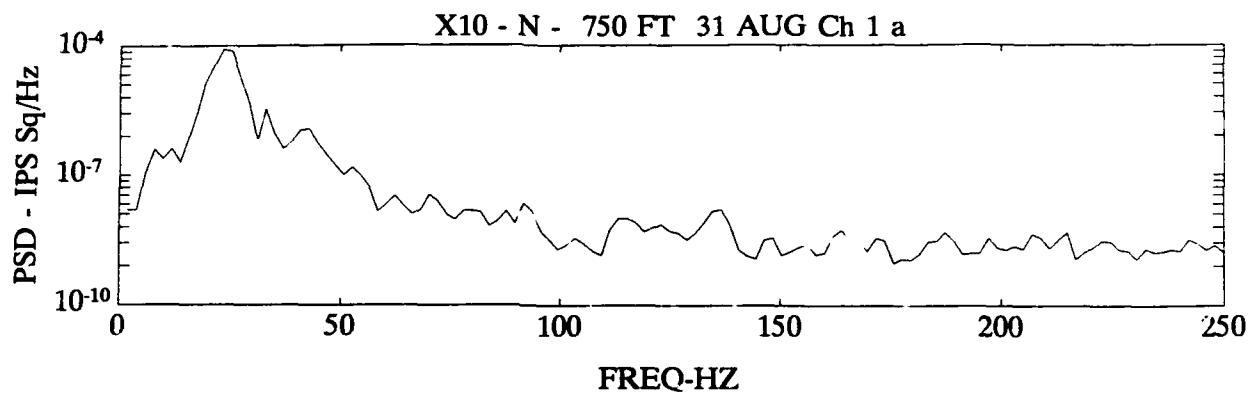


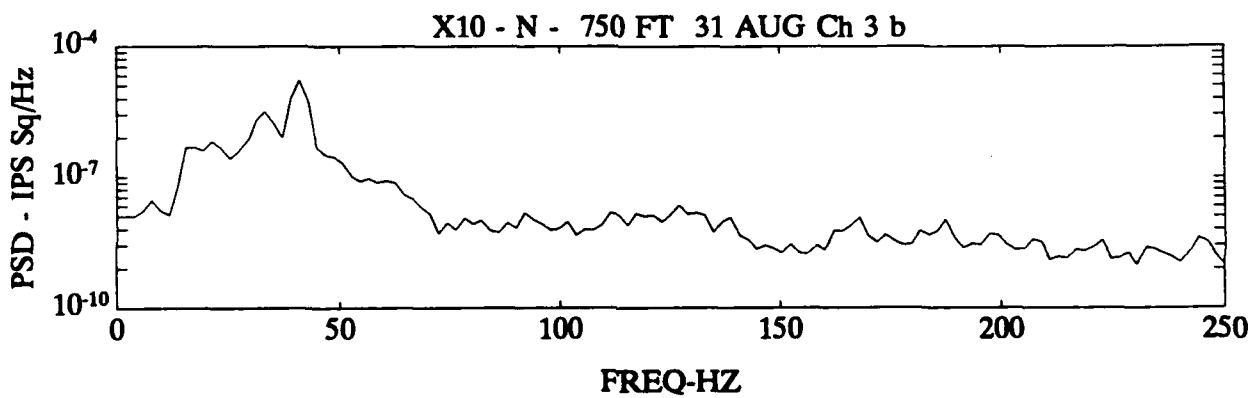
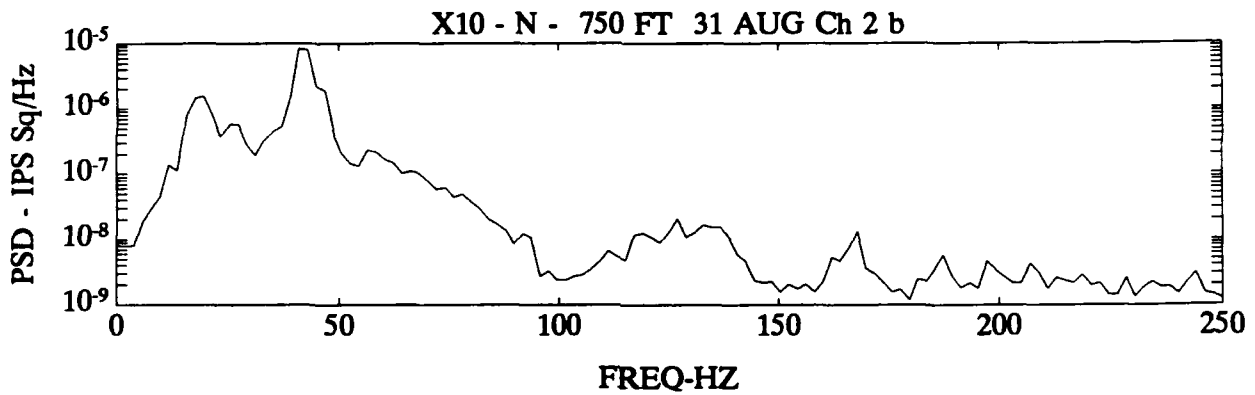
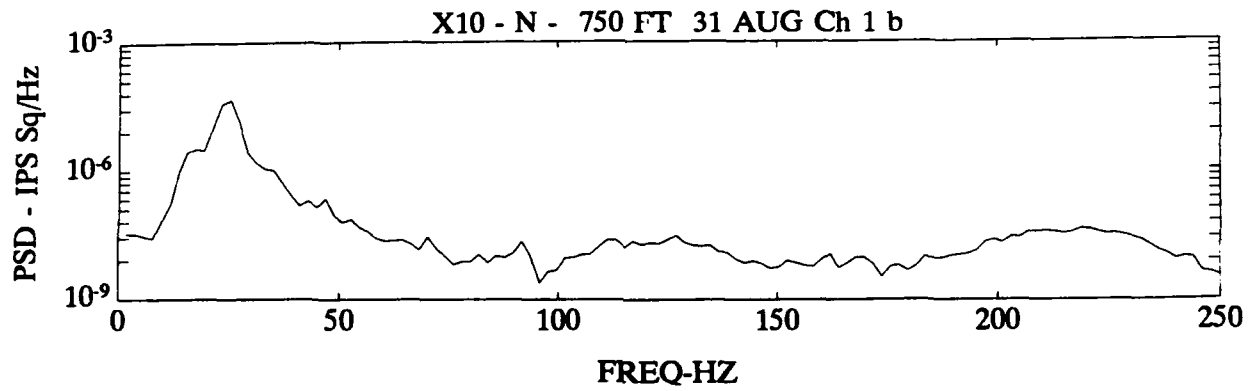


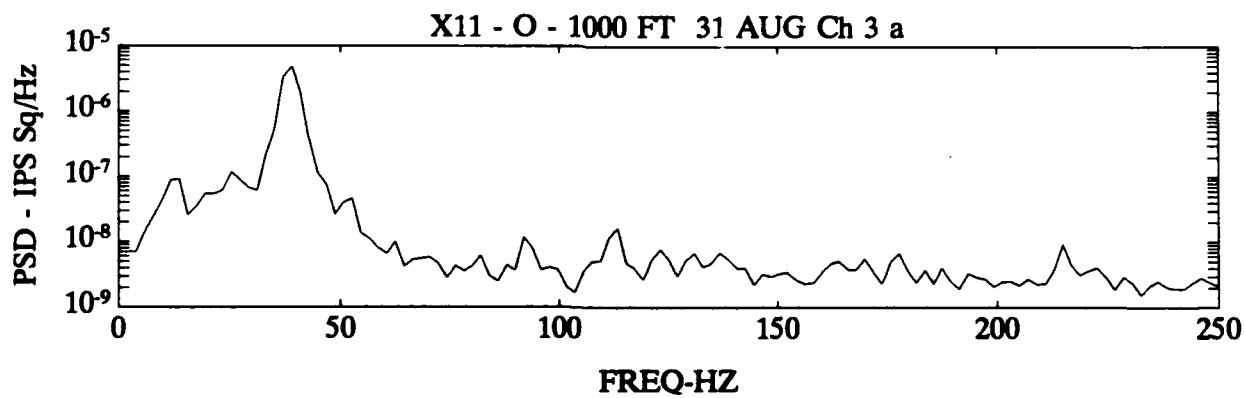
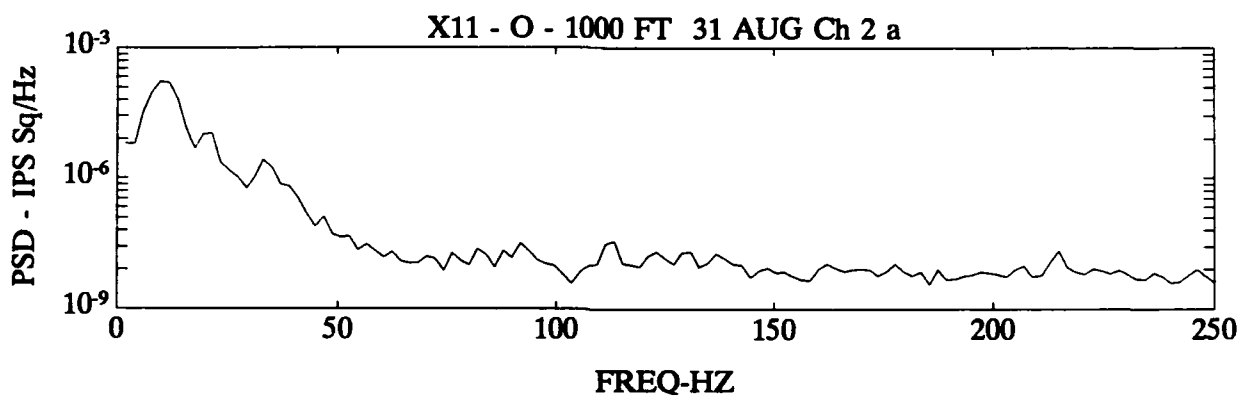
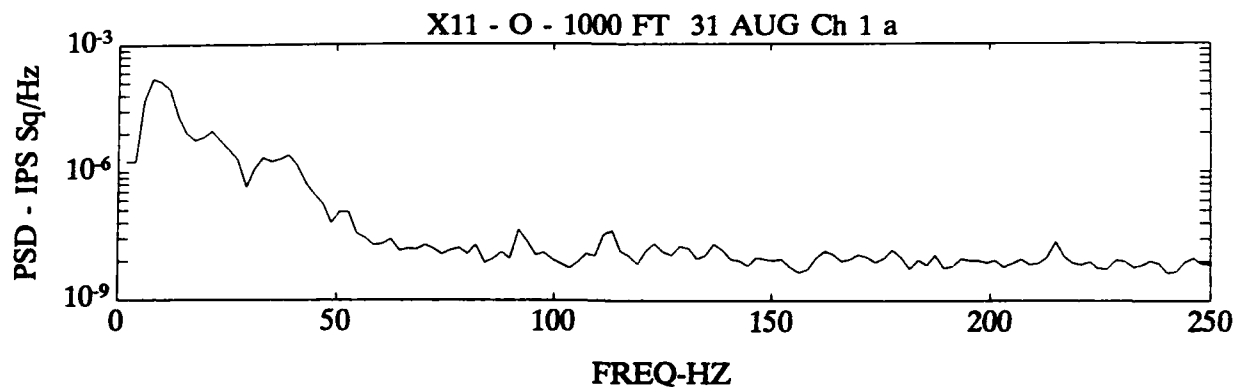


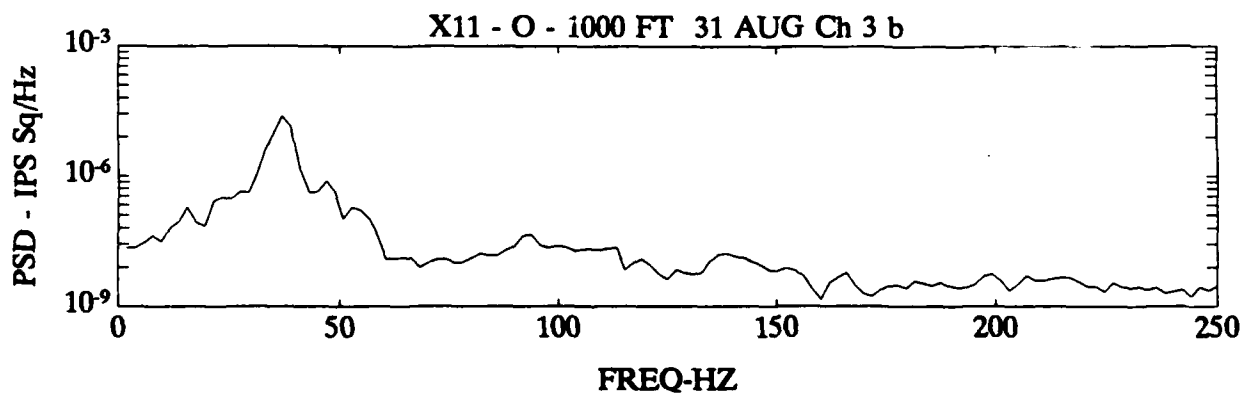
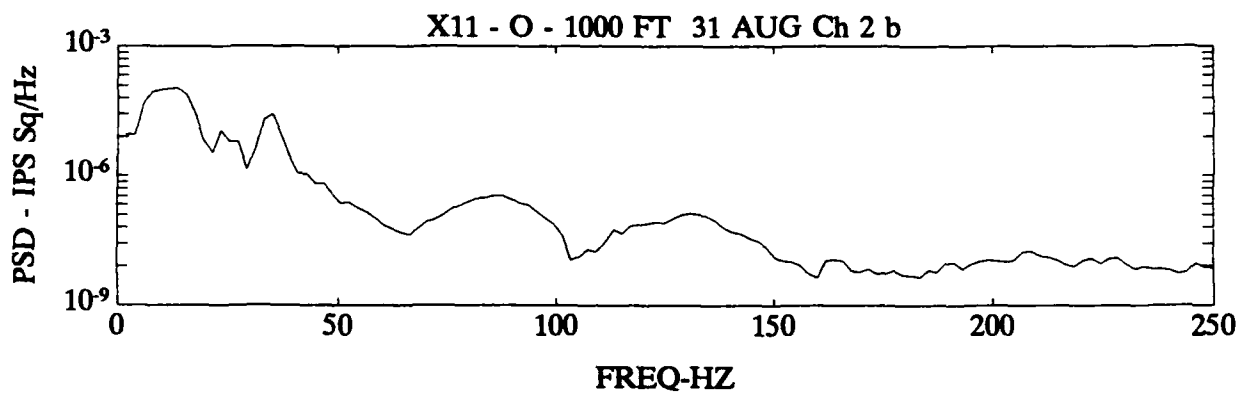
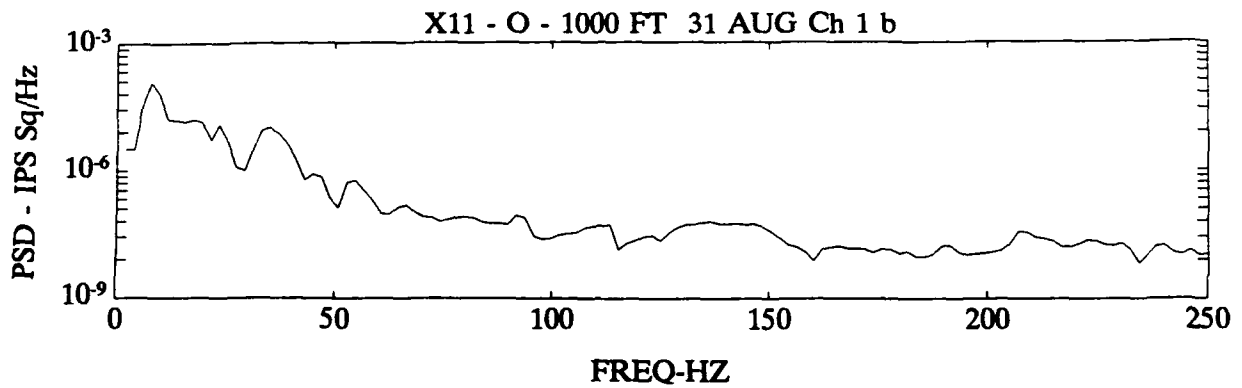


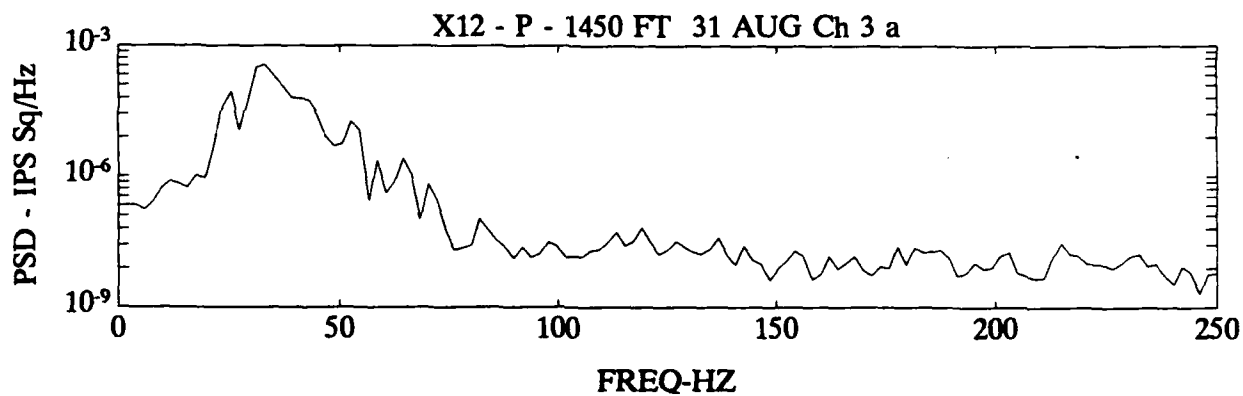
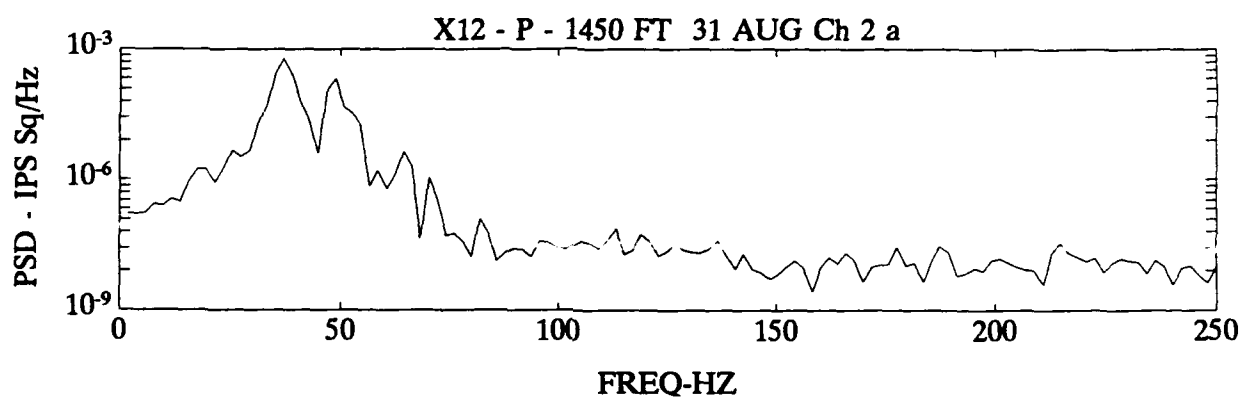
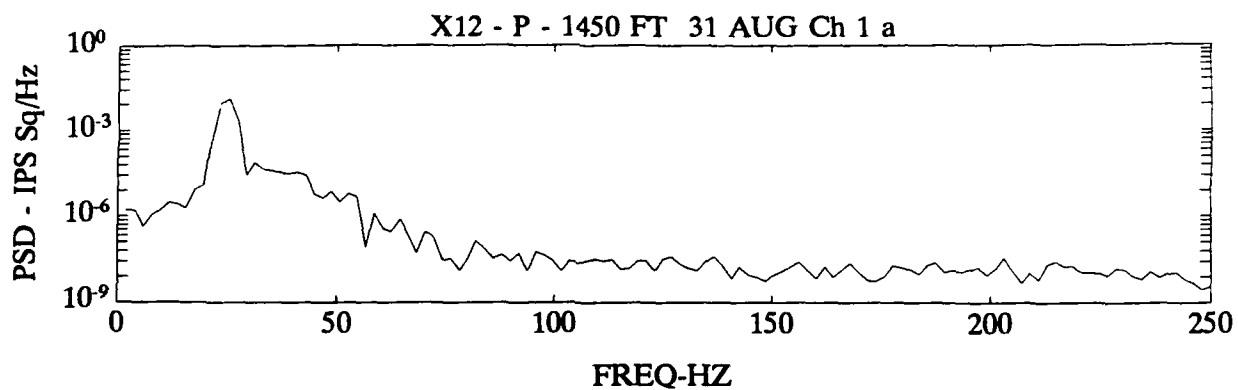


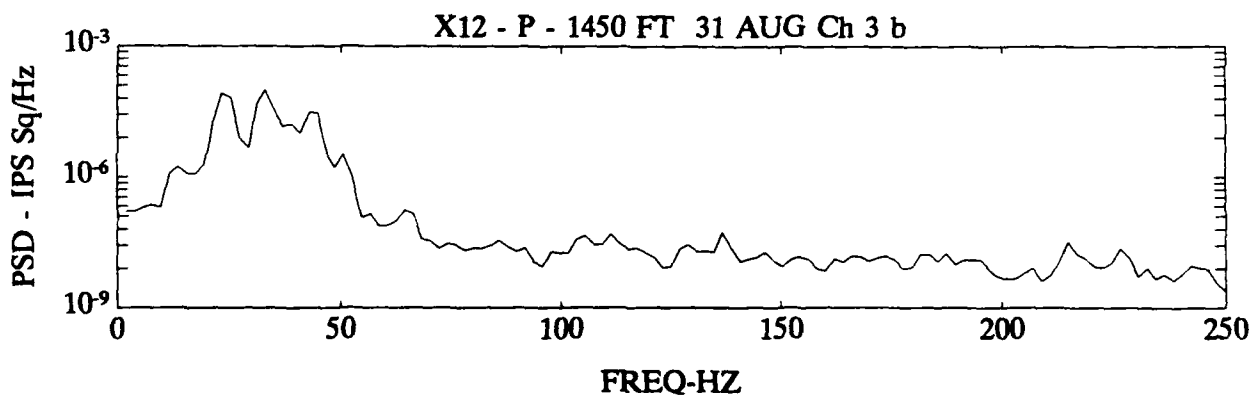
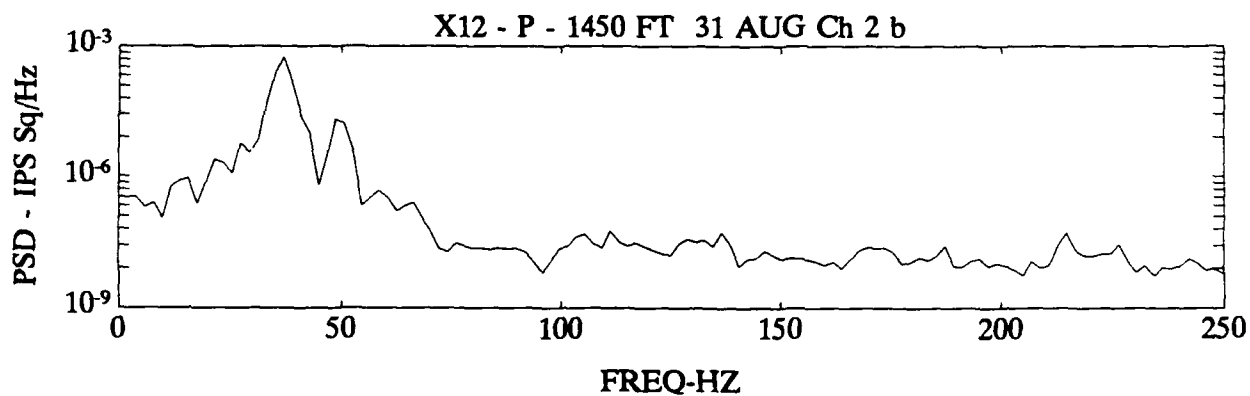
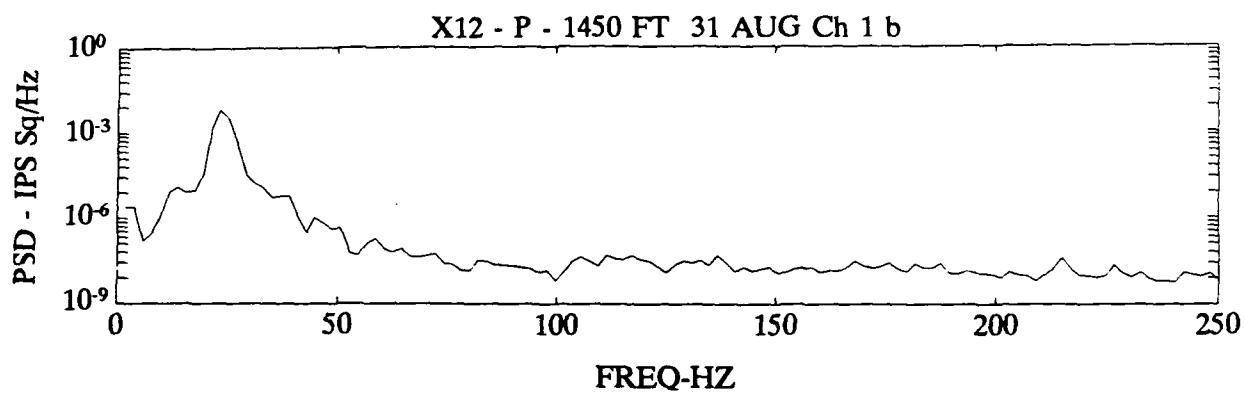












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| 13. ABSTRACT (Maximum 200 words)<br><br><p>This report provides documentation for and presents an analysis of a seismic attenuation and air overpressure study at the Naval Surface Warfare Center, Crane, Indiana. The investigation consisted of measuring peak particle velocities and peak air overpressures along two radials (N40°E and S40°W). Each radial consisted of four to five monitoring stations recording vertical, radial, and transverse ground motions in addition to air overpressures. Data were recorded from 24 August through 5 September 1992, with 3084 time histories being recorded. From the data, ground motion and air overpressure attenuation curves were developed from which predictions could be made given the size of the explosion and the distance from the explosion.</p> <p>Based on the results obtained, the following attenuation curves are proposed.</p> <p style="text-align: right;">(Continued)</p> |                                                          |                                                                                |                                    |                            |
| 14. SUBJECT TERMS<br>Air overpressure<br>Ground motions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                          | Peak particle velocity<br>Regression                                           |                                    | 15. NUMBER OF PAGES<br>195 |
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13. Continued.

Ground motion predictions

$$y_{95\%} = 28.69 (x^{-1.43})$$

y = peak particle velocity, ips

x = scaled range, ft

distance from shot divided by square root of shot weight

Air overpressure predictions

$$y_{95\%} = 65.74 (x^{-1.51})$$

y = peak particle velocity, psi

x = scaled range, ft

distance from shot divided by cubic root of shot weight