Lighten Up … Your Blasting Results
Signature Hole Analysis for Minimizing Community Perception of Blasting

QUARRY ACADEMY

Agenda

- What is Signature Hole Analysis (SHA)?
- How it works
- What it can do
- What it can’t do
- How to collect data
- How to analyze data
- Troubleshooting

QUARRY ACADEMY

What Is SHA

- **Allows for modeling seismic effects of any blast design**
  - ✓ **Site specific**
  - ✓ **Sensitive to changes in shot designs**
- **Can determine optimum firing sequences for minimizing off site impact**
  - ✓ **Reduced low frequency amplitude**
  - ✓ **Reinforce high frequency spectra**
- **Can determine optimum shot geometry**
  - ✓ **Number of holes/row**
  - ✓ **Number of rows**

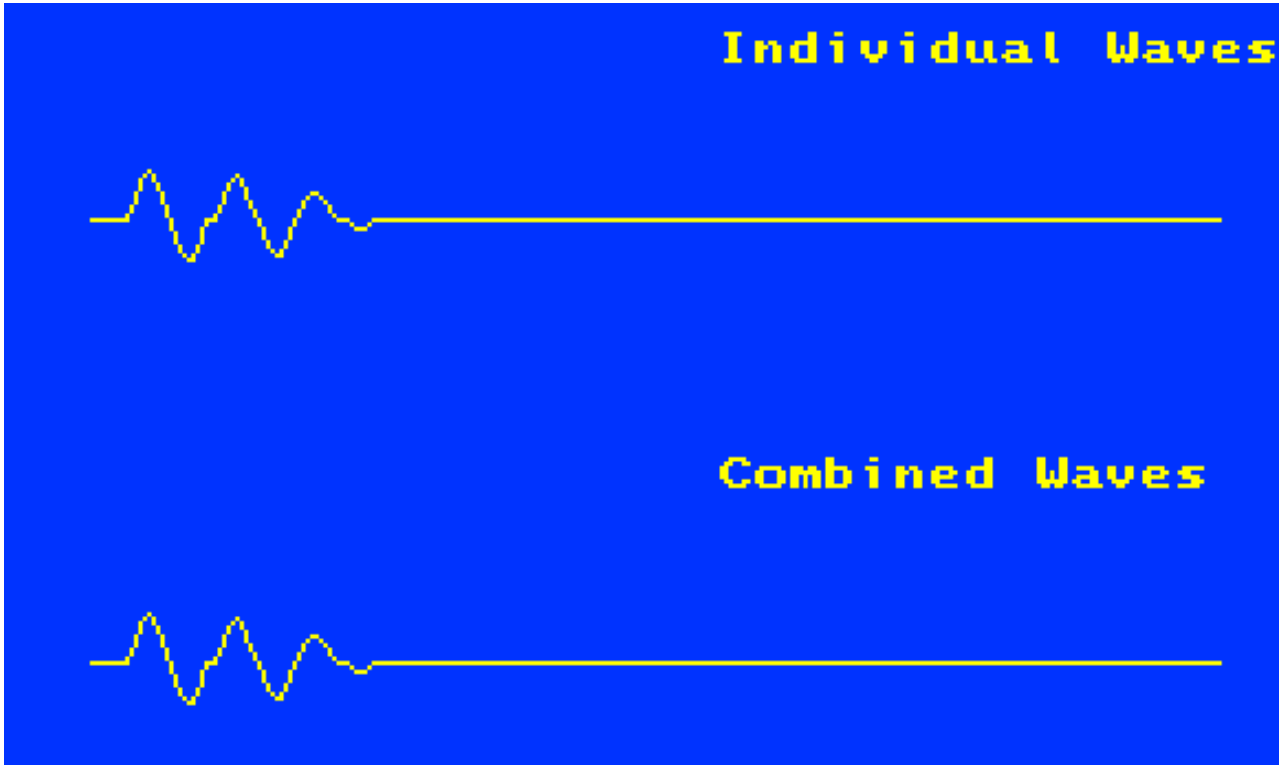
QUARRY ACADEMY

How SHA Works

- **Uses superpositioning of waves**
  - ✓ **Waves can be added together**
  - ✓ **Relative position to each dictates the resulting, complex waves**
- **Done by digitizing seismic data**
- **Digitized wave data is summed to represent multiple hole detonations**
- **Critical for use with electronic detonators**

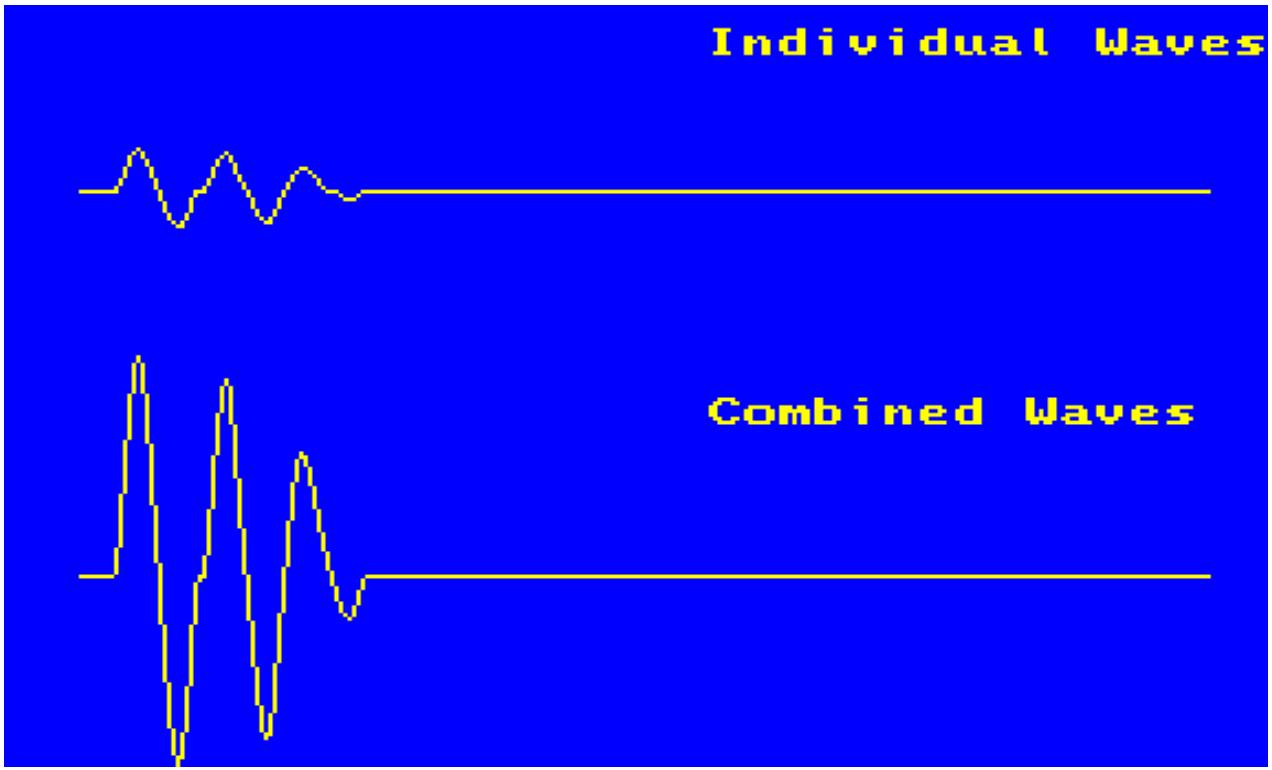
QUARRY ACADEMY

Linear Superpositioning



QUARRY ACADEMY

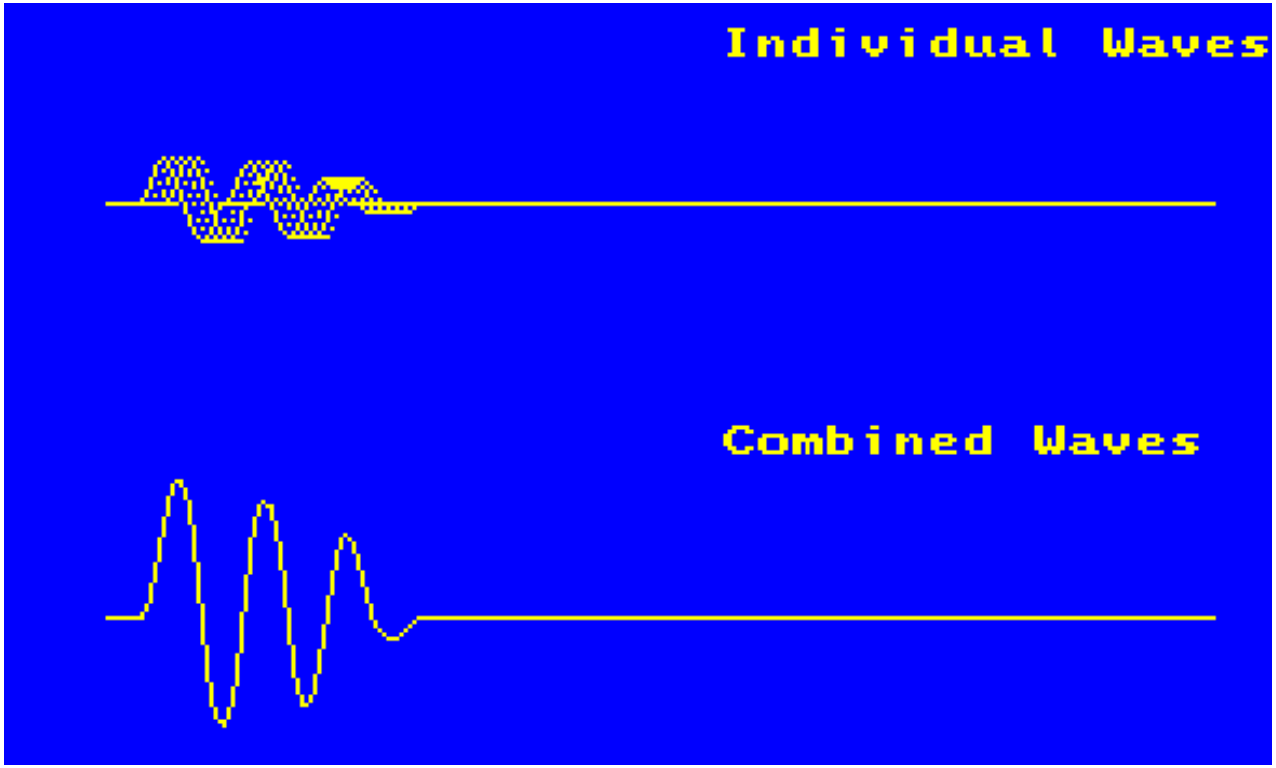
Linear Superpositioning



No delay

QUARRY ACADEMY

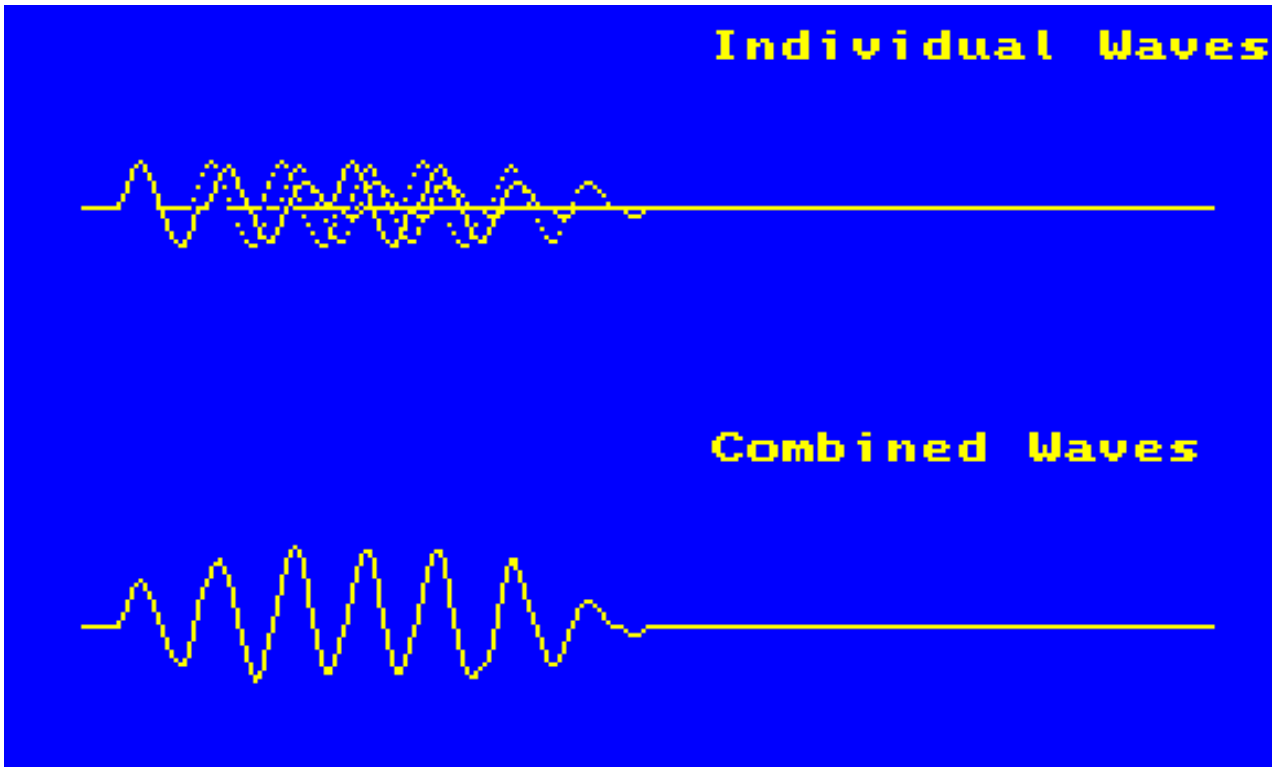
Linear Superpositioning



8 ms delay

QUARRY ACADEMY

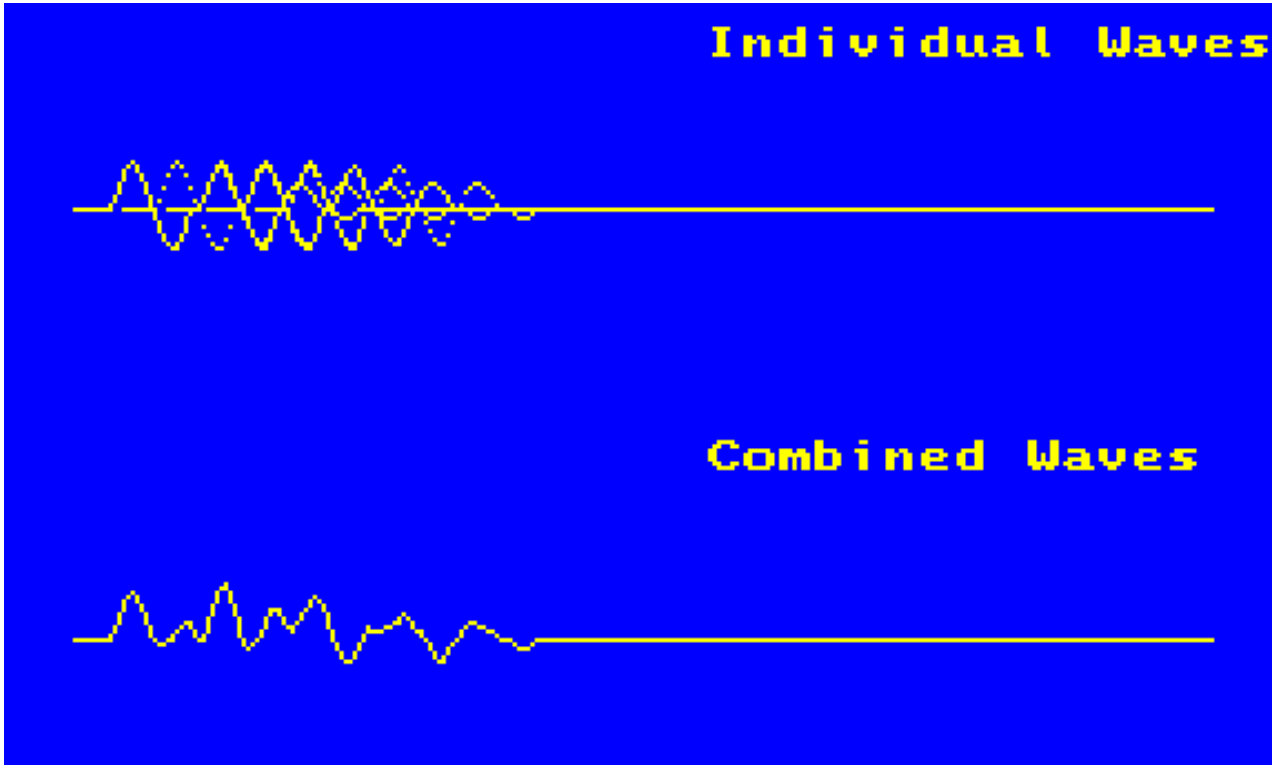
Linear Superpositioning



67 ms delay

QUARRY ACADEMY

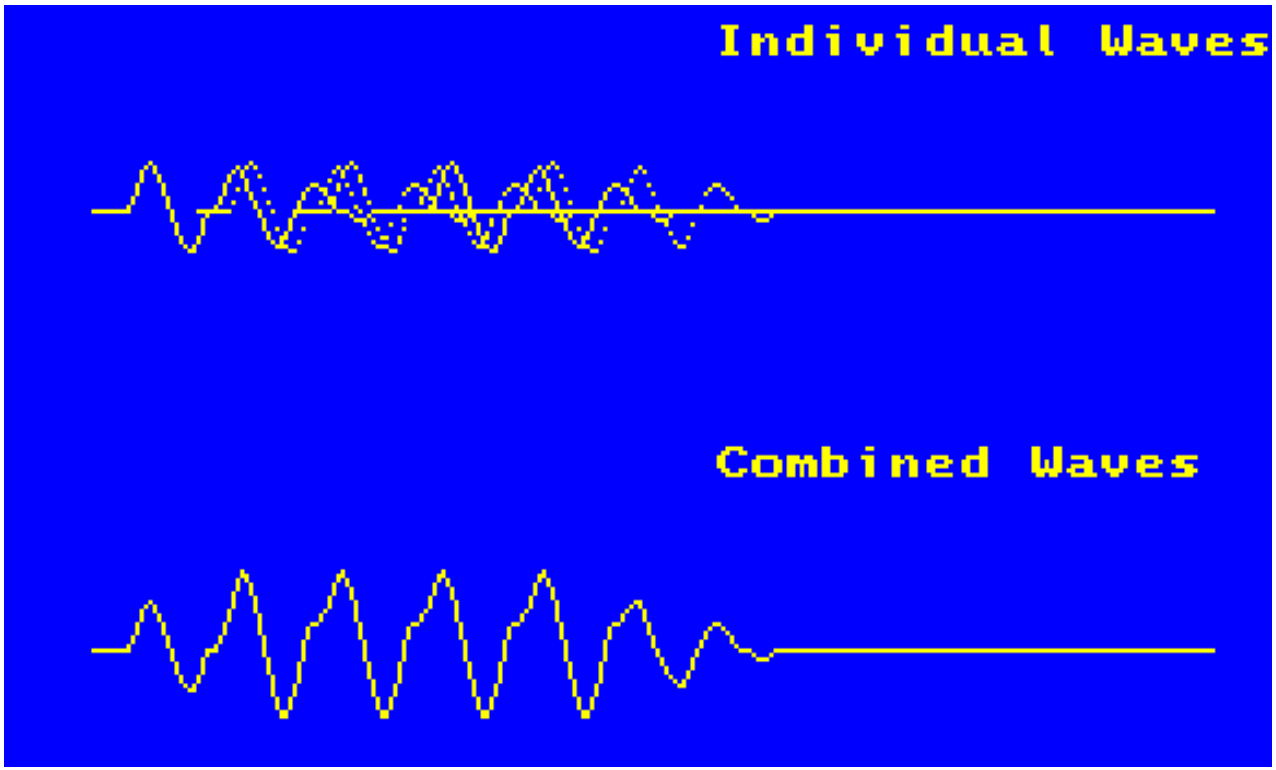
Linear Superpositioning



42 ms delay

QUARRY ACADEMY

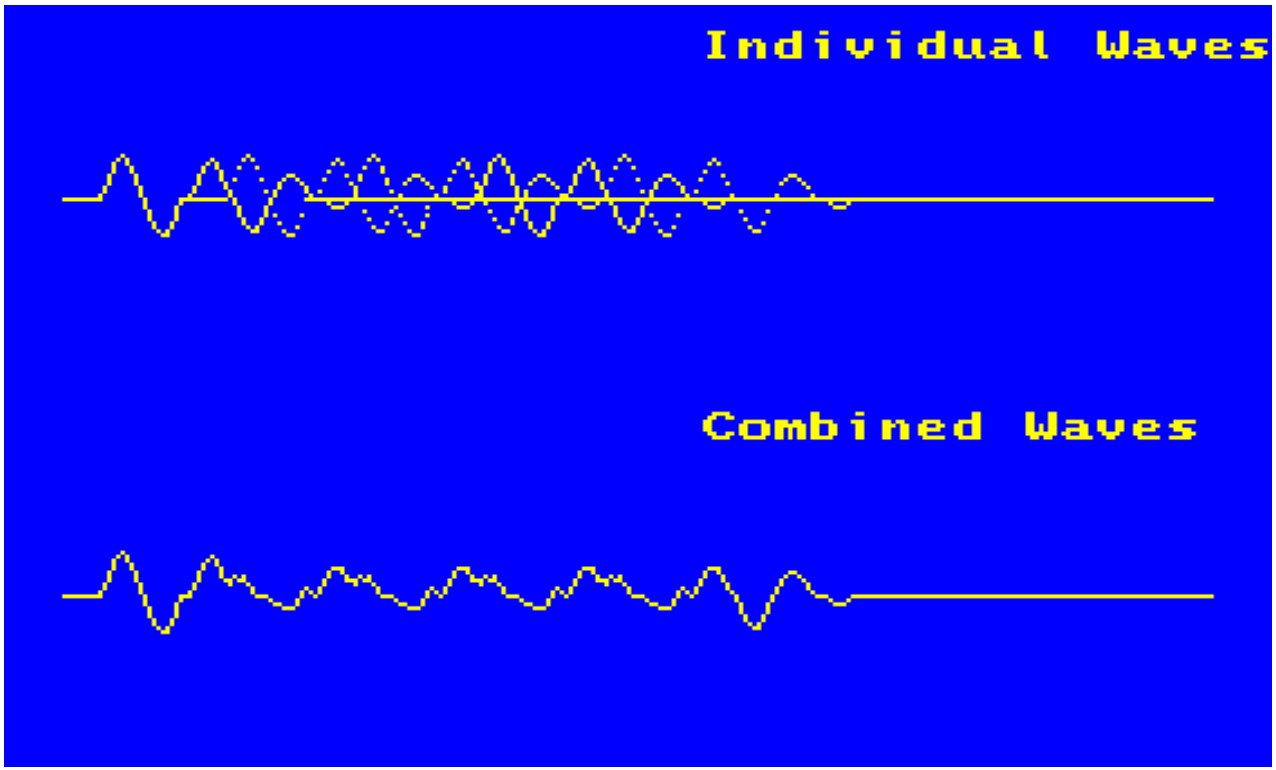
Linear Superpositioning



92 ms delay

QUARRY ACADEMY

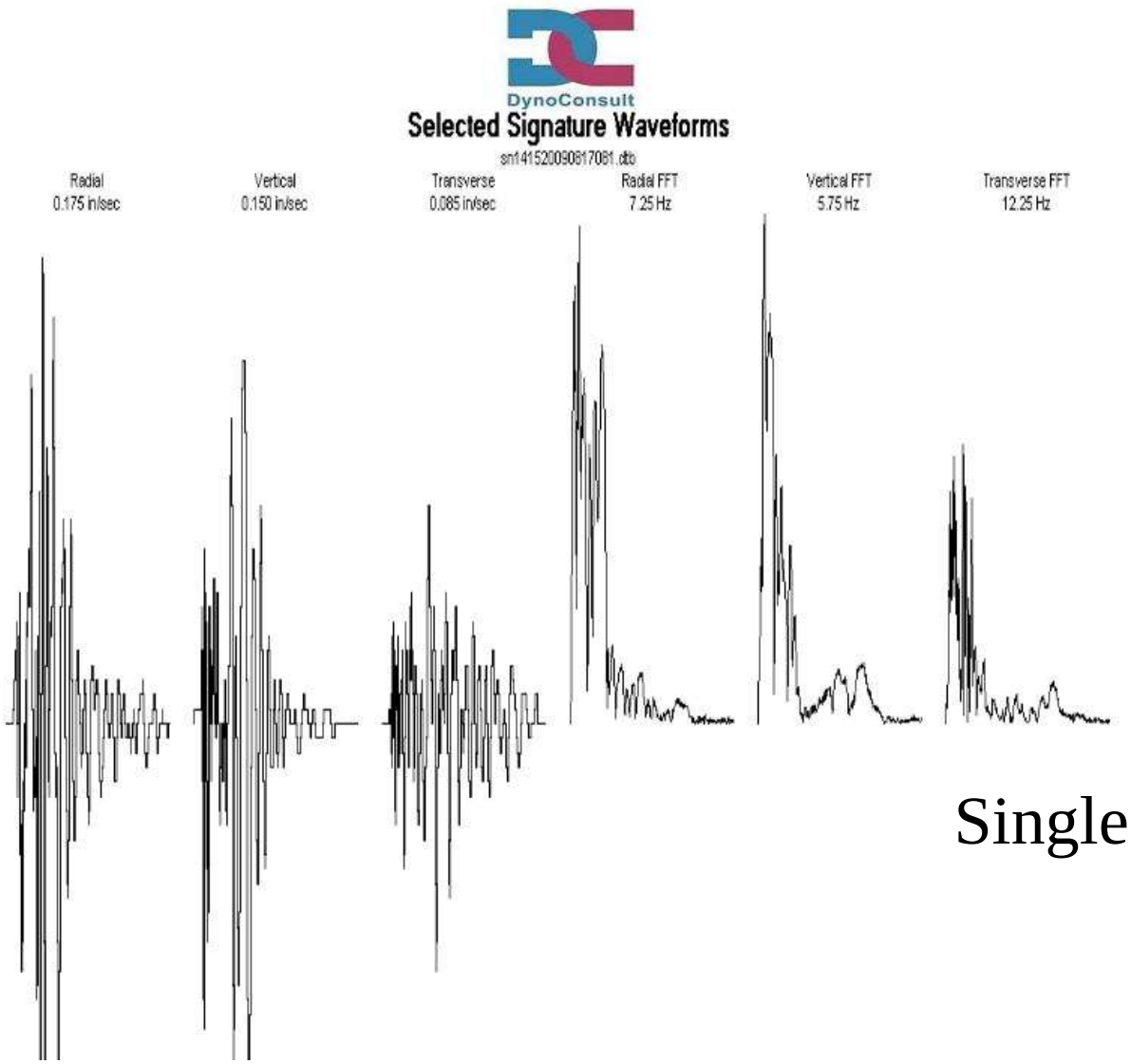
Linear Superpositioning



115 ms delay

QUARRY ACADEMY

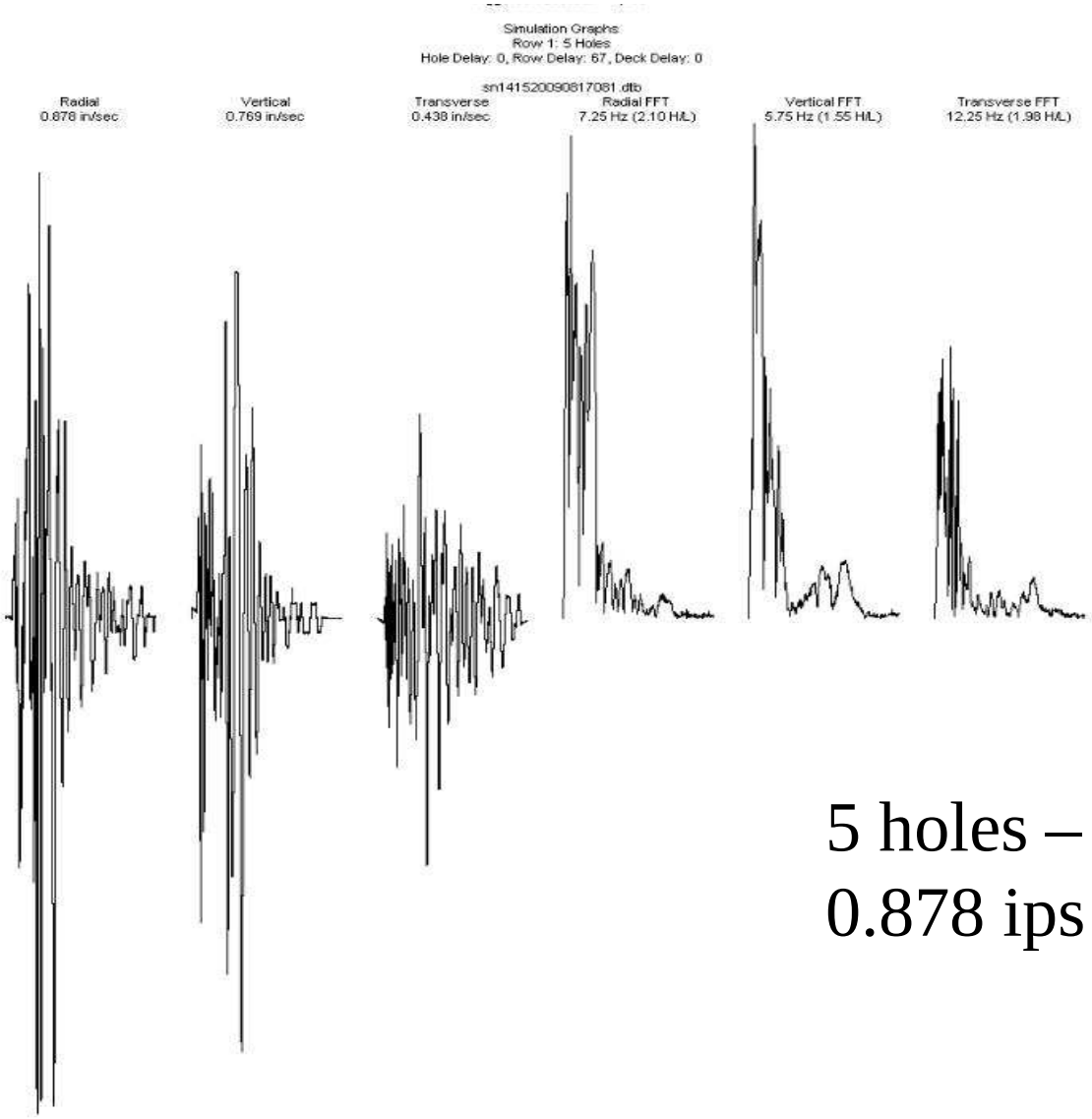
Linear Superpositioning



Single hole – 0.175ips

QUARRY ACADEMY

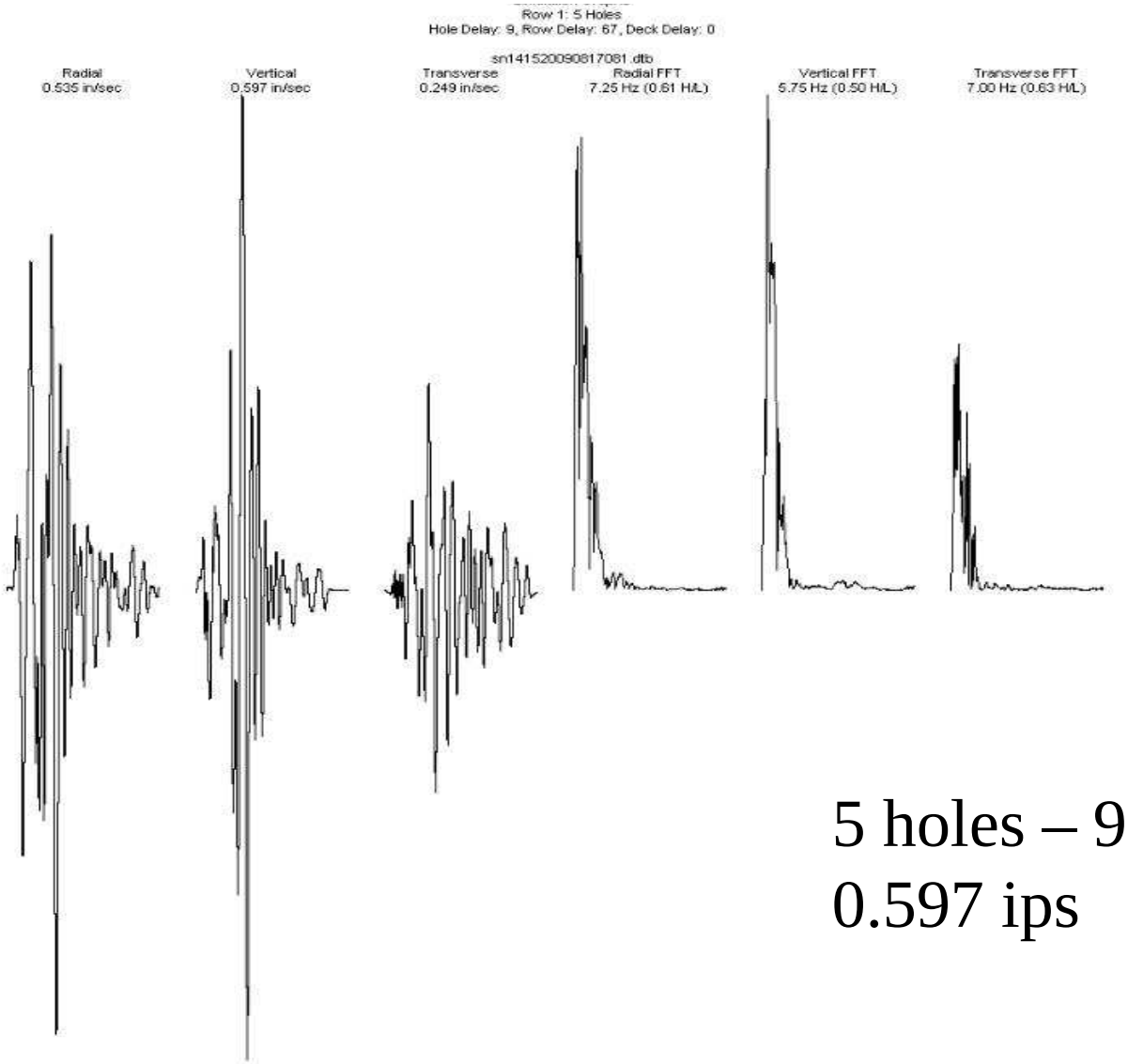
Linear Superpositioning



5 holes – 0 delay
0.878 ips

QUARRY ACADEMY

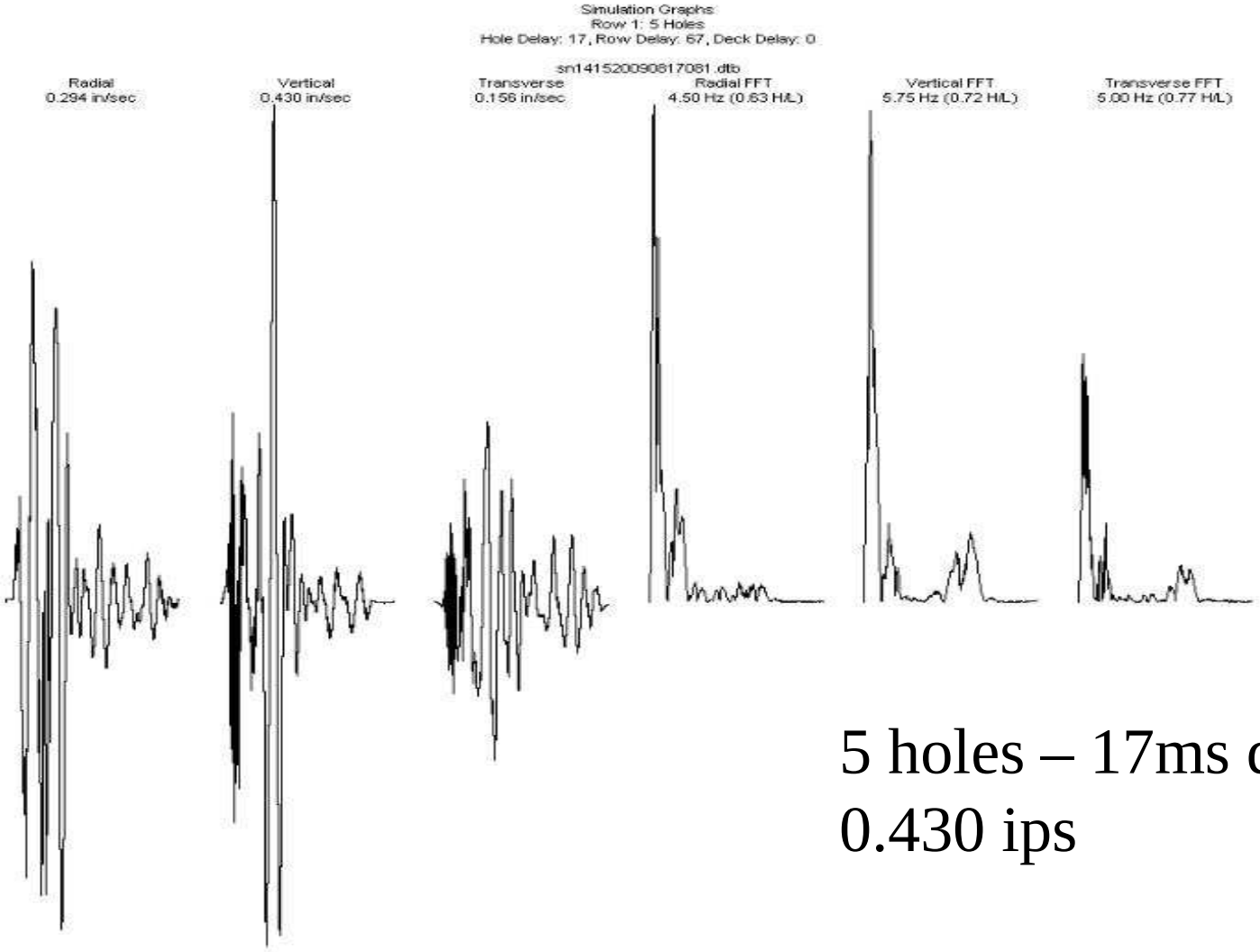
Linear Superpositioning



5 holes – 9ms delay
0.597 ips

QUARRY ACADEMY

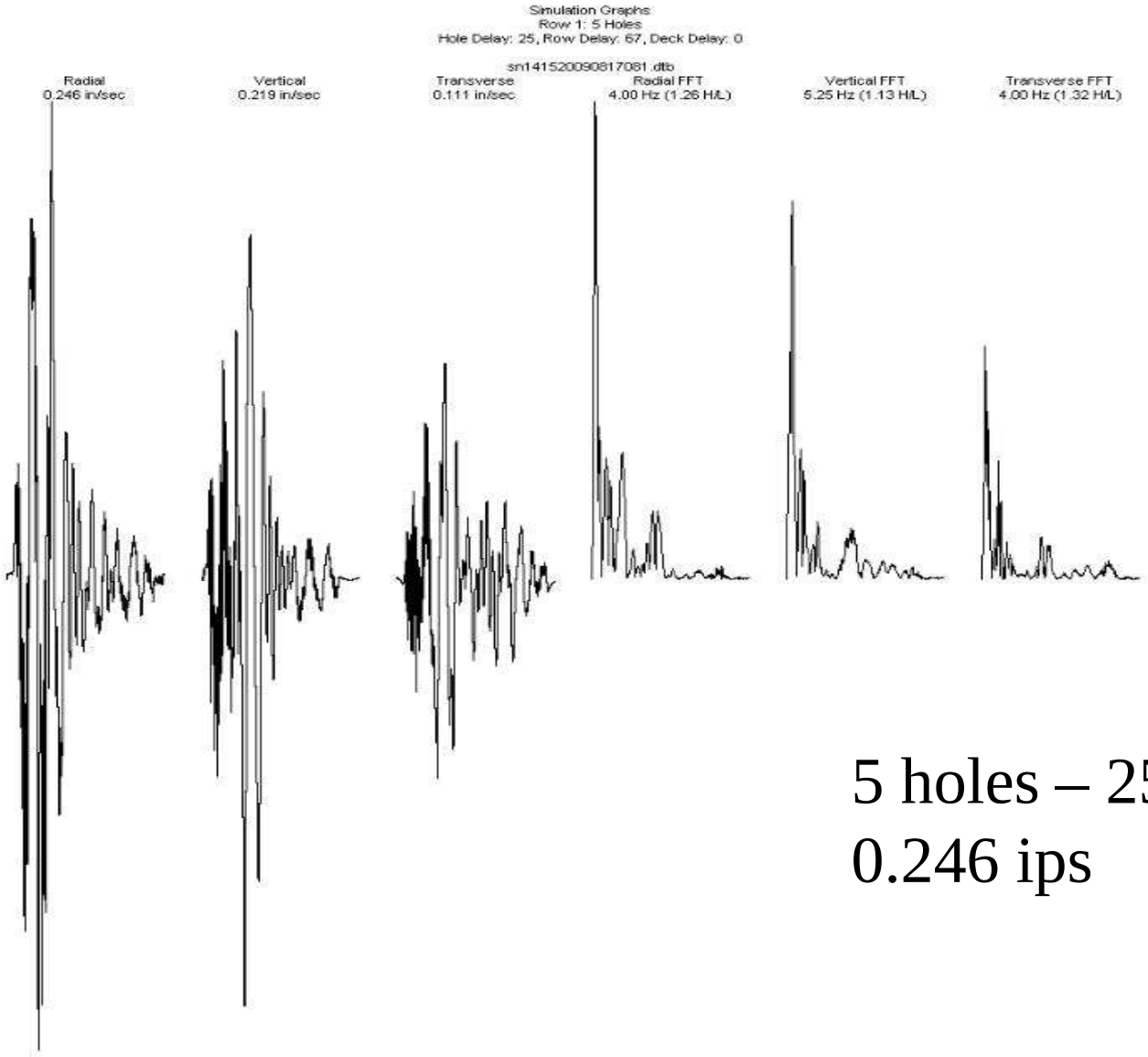
Linear Superpositioning



5 holes – 17ms delay
0.430 ips

QUARRY ACADEMY

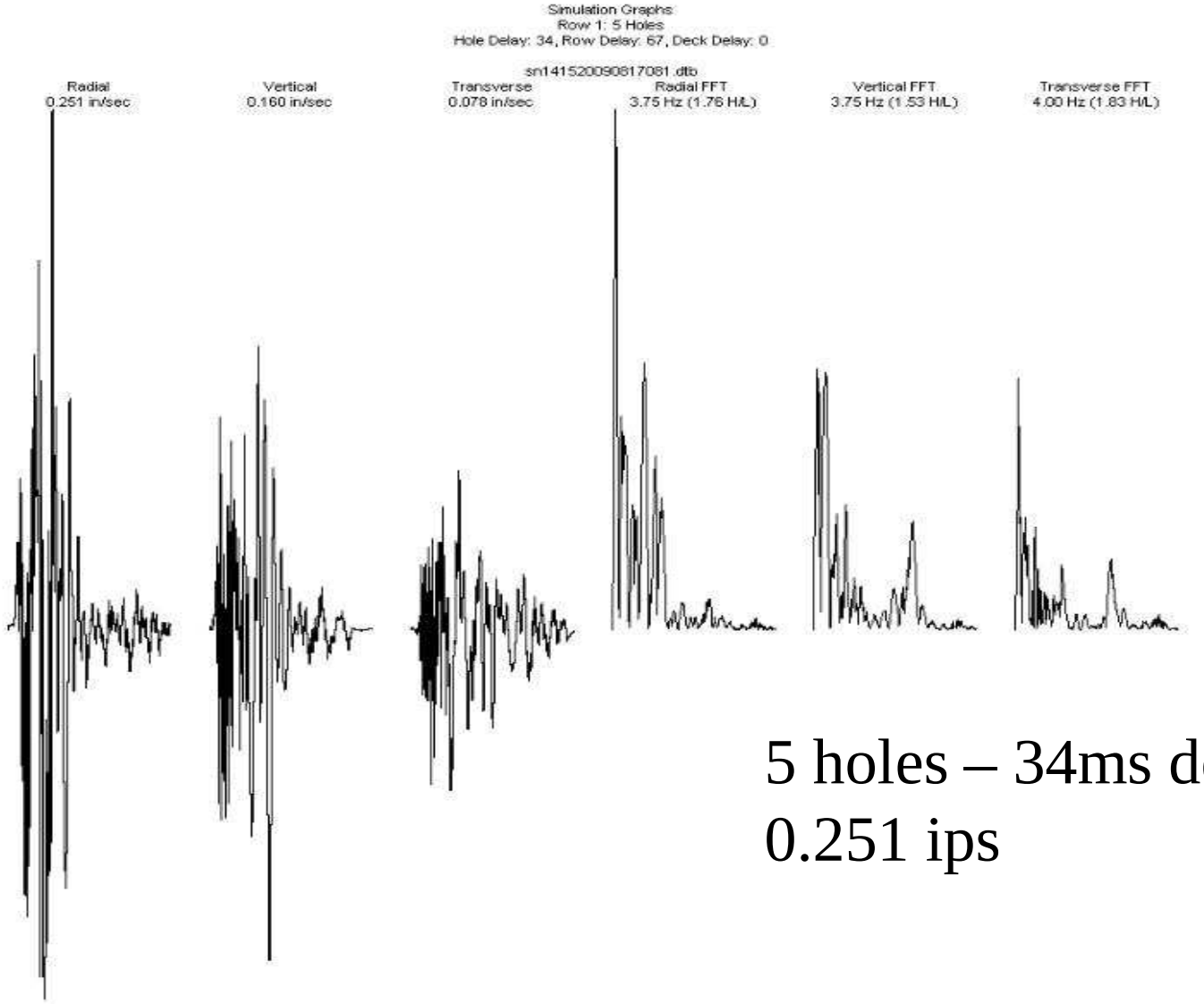
Linear Superpositioning



5 holes – 25ms delay
0.246 ips

QUARRY ACADEMY

Linear Superpositioning



5 holes – 34ms delay
0.251 ips

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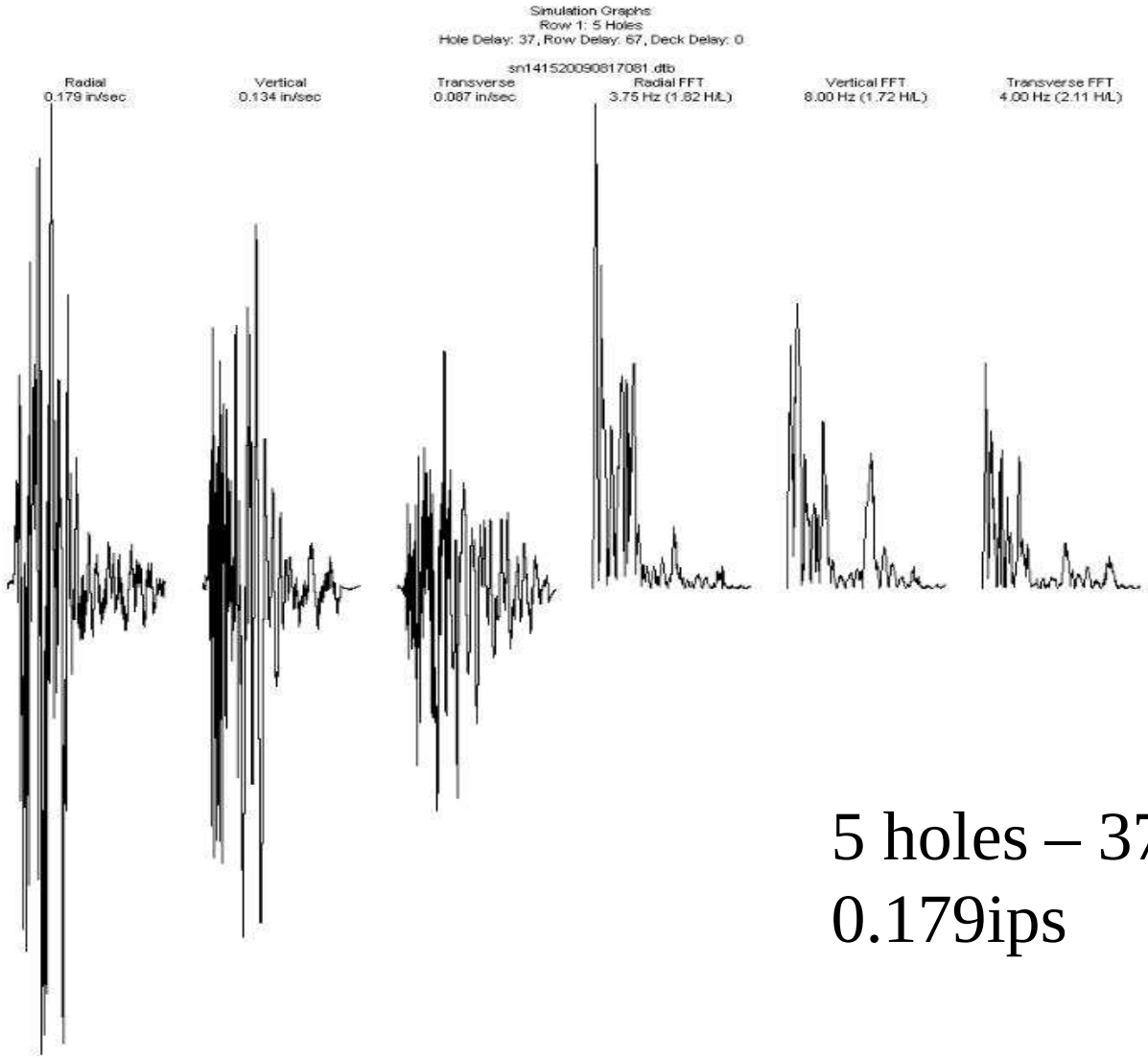
Linear Superpositioning

Hole	R	V	T	RHz	VHz	THz
37	0.179	0.134	0.087	3.75	8	4
38	0.181	0.143	0.089	3.75	7.75	3.75
39	0.202	0.158	0.098	22.75	7.75	3.75
36	0.207	0.143	0.087	3.75	8	4
29	0.225	0.175	0.096	4	5.25	4
28	0.227	0.172	0.101	4	5.25	4
27	0.228	0.167	0.107	4	5.25	4
35	0.229	0.155	0.083	3.75	9.25	4
40	0.23	0.176	0.105	22.75	24	3.75
26	0.231	0.19	0.11	4	5.25	4
32	0.238	0.174	0.081	4	5	4
30	0.242	0.176	0.091	4	5.25	4
31	0.245	0.177	0.085	4	5	4
25	0.246	0.219	0.111	4	5.25	4
33	0.25	0.168	0.081	3.75	5	4
34	0.251	0.16	0.078	3.75	3.75	4
41	0.261	0.194	0.111	22.5	24	7
24	0.263	0.245	0.127	4	5.25	4
23	0.275	0.269	0.14	4	5.25	4
22	0.28	0.29	0.151	4	5.5	4
42	0.299	0.207	0.114	22.5	21.75	7
21	0.281	0.305	0.159	4	5.5	4

Linear Superpositioning



5 holes – 37ms delay
0.179ips

QUARRY ACADEMY

What SHA Can Do

- Eliminate “train wreck” delay choices
- Assist in meeting regulatory limits
- Reduce structure response in neighboring structures
  - ✓ Reduce human perception of event
  - ✓ Reduce complaints
  - ✓ Minimize risk of litigation
- Assist in blast program development
  - ✓ Project effects for different shot sizes

QUARRY ACADEMY

WHAT SHA Cannot Do

- **Predict actual ppv values**
- **“Shift” energy to higher frequencies**
- **Take into account confinement or other blast variables**

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Other Effects of SHA

- **By optimizing for use of electronic detonators…**
  - ✓ **Reduce oversize (axial priming)**
  - ✓ **Improve overall fragmentation**
  - ✓ **Customize muckpile profile**
  - ✓ **Enhance crusher throughput**
  - ✓ **Improve cycle times**
- **Allows you to use your loading equipment for alternative chores…**

QUARRY ACADEMY

The SHA Process

- Determine current and future mining areas of concern
- Identify critical and/or regulatory structures of interest
- Develop test hole program
- Determine seismic arrays
- Document locations
  - ✓ Test holes
  - ✓ Seismographs
- Load and shoot test holes
- Process raw seismic data
- Analyze shot designs

QUARRY ACADEMY

Determine Hole Locations

- Orientation of benches
- Changes in rock characterization
- Prominent localized geologic conditions
- Significant changes in elevation

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ACADEMY

QUARRY ACADEMY

QUARRY ACADEMY

QUARRY ACADEMY

Determine Seismograph Locations

- **Criterion**
  - ✓ **Regulatory interest**
  - ✓ **Complaint interest**
  - ✓ **Distance from test holes**
  - ✓ **Orientation relative to test holes**
- **Create array if needed**
  - ✓ **Near field – guaranteed data**
  - ✓ **Mid field – probably “good” data**
  - ✓ **Far Field – closest to structure that will trigger unit**

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Document Locations

- Use GPS to record test hole locations
- Use GPS to record seismograph locations
- Critical to keep data straight

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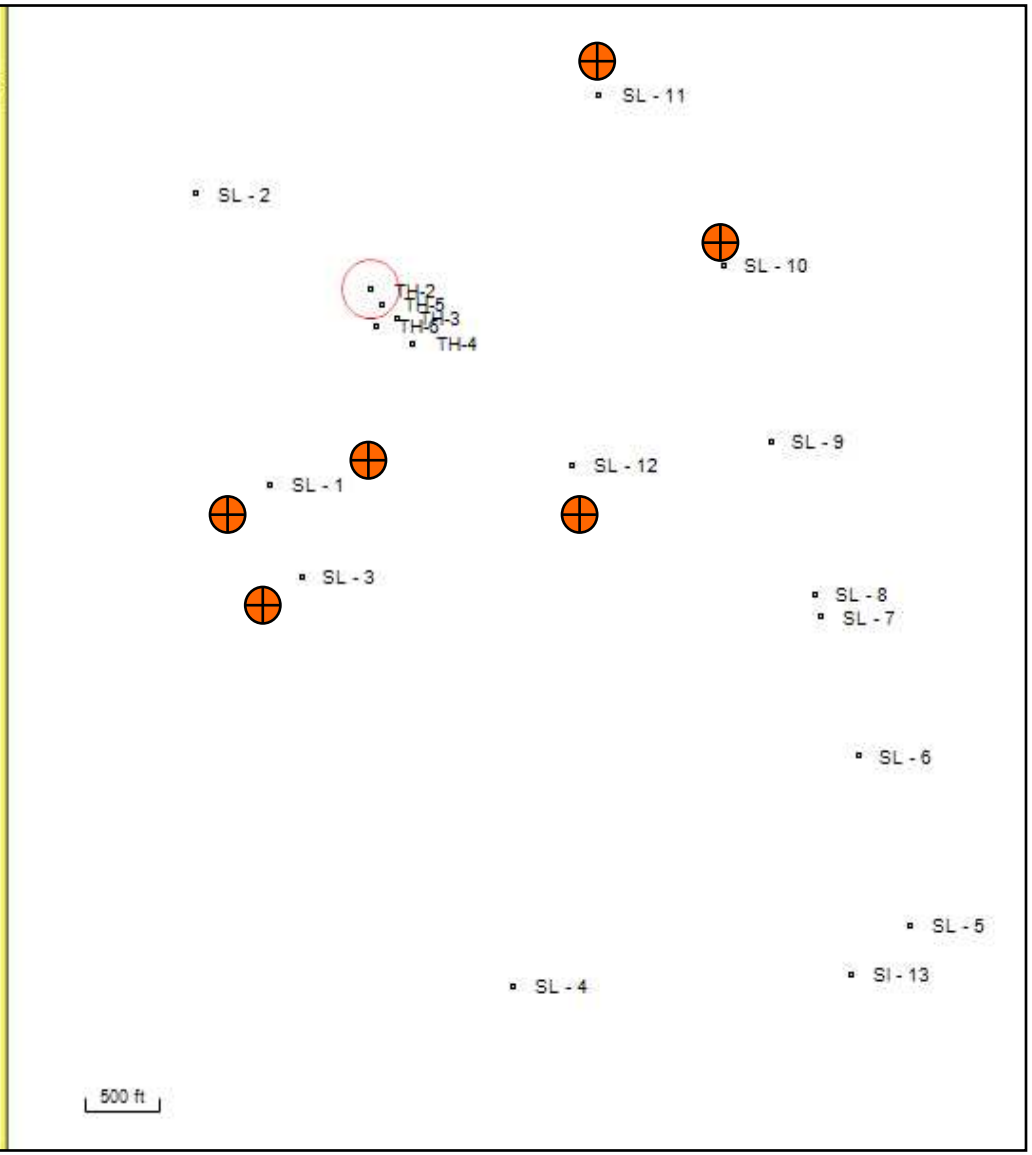
Waypoints

Label	Type	Description	Distance to Active Po
TH-6	Hole	Top Bench - west	231.95 ft
TH-5	Hole	Level 1 - west	120.75 ft
TH-4	Hole	Level 2 - south	448.11 ft
TH-3	Hole	Level 2 - west	251.70 ft
TH-2	Hole	Level 5 - west	0 ft
SL - 9	Seismogram	55 Vintage Rd	2849.43 ft
SL - 8	Seismograph	76 Vintage Rd	3559.73 ft
SL - 7	Seismograph	78 Vintage Rd	3681.10 ft
SL - 6	Seismograph	Farm @ 102 Vintage Rd	4443.27 ft
SL - 5	Seismograph	Wils Residence, Vintage Rd	5475.36 ft
SL - 4	Seismograph	788 Strausburg Rd - farm drive	4615.93 ft
SL - 3	Seismograph	92-96 McIlvane Rd driveway	1918.05 ft
SL - 2	Seismograph	34 McIlvane Rd	1324.02 ft
SI - 13	Seismograph	829 Strasburg Rd	5481.66 ft
SL - 12	Seismograph	54 Vintage Rd	1758.91 ft
SL - 11	Seismograph	Hess Mills Parking lot	1977.79 ft
SL - 10	Seismograph	27 Vintage Rd	2358.69 ft
SL - 1	Seismograph	Smith Residence McIlvane Rd	1438.98 ft



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Load test holes

- Nominal burden
- Nominal depth
- Nominal hole diameter
- Nominal subdrill
- Nominal explosive loading
- Single initiation source

QUARRY ACADEMY

Deploy Seismographs

- **Insure good coupling of geophones**
  - ✓ **Buried**
  - ✓ **Spiked and sandbagged**
  - ✓ **Never use spikes only!!!!**
- **Synchronize internal clocks**
  - ✓ **Aids in assigning event data to specific shots**
  - ✓ **All shots might not trigger all seismographs**
- **Set trigger levels to 0.05 ips**

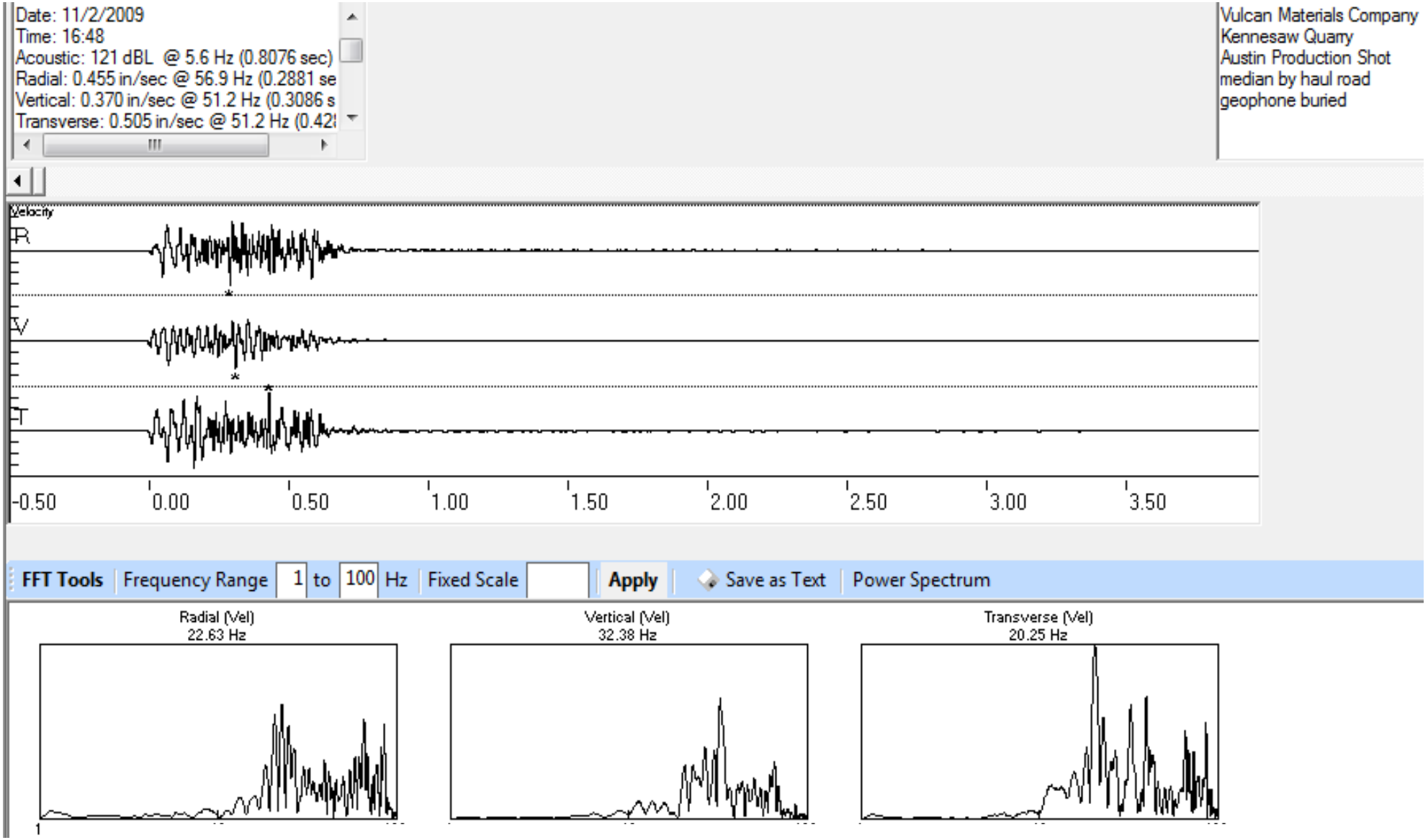
QUARRY ACADEMY

Setup Basics

- Date and time correct
- Adequate recording duration for air blast capture
  - ✓ Rule of thumb - 1 second per 1,000 ft of distance from shot
- Location of unit
- Proper coupling of geophone critical
  - ✓ Correct amplitude values
  - ✓ Correct frequency spectra

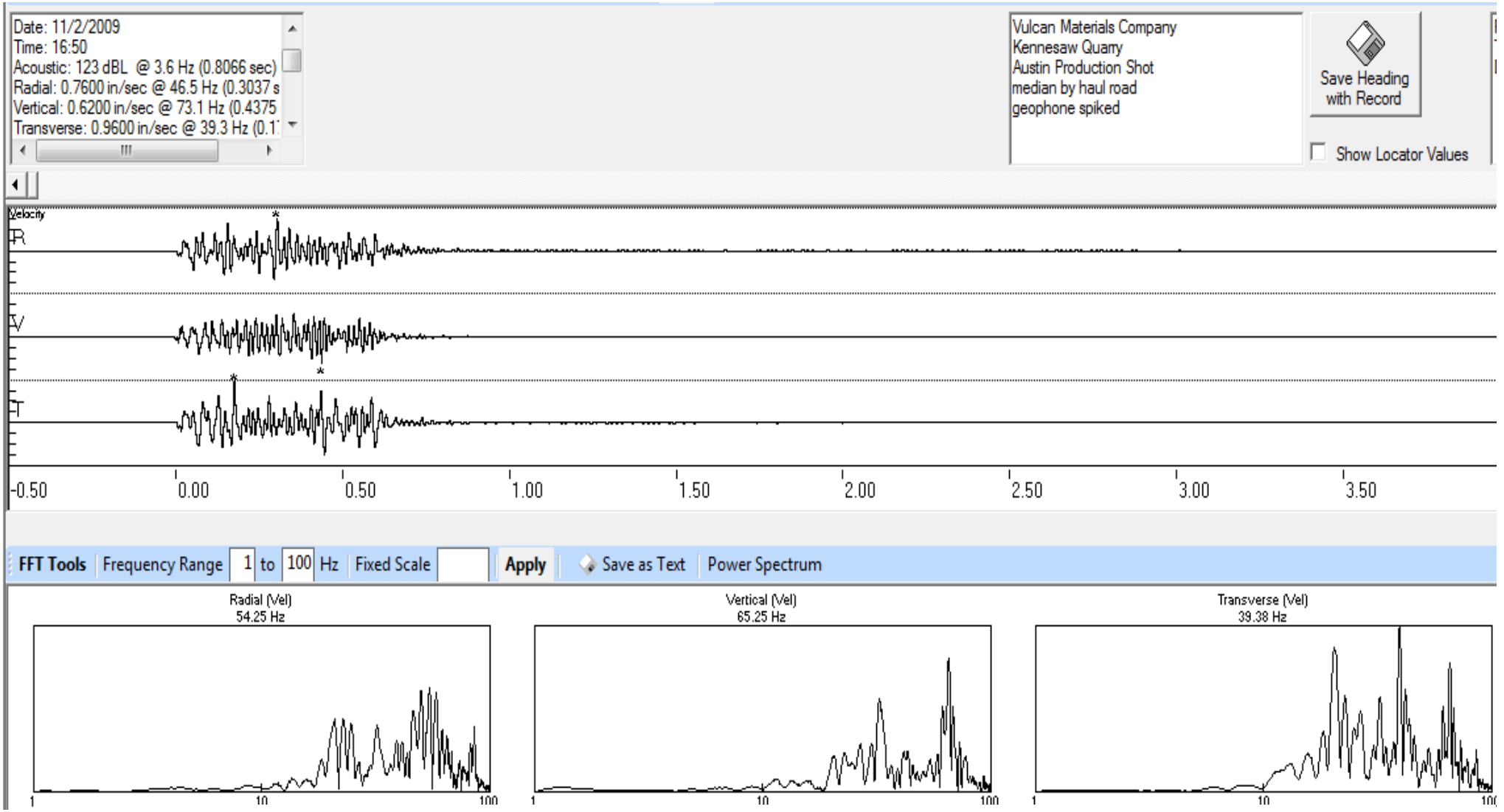
QUARRY ACADEMY

Production Shot – Geophone Buried



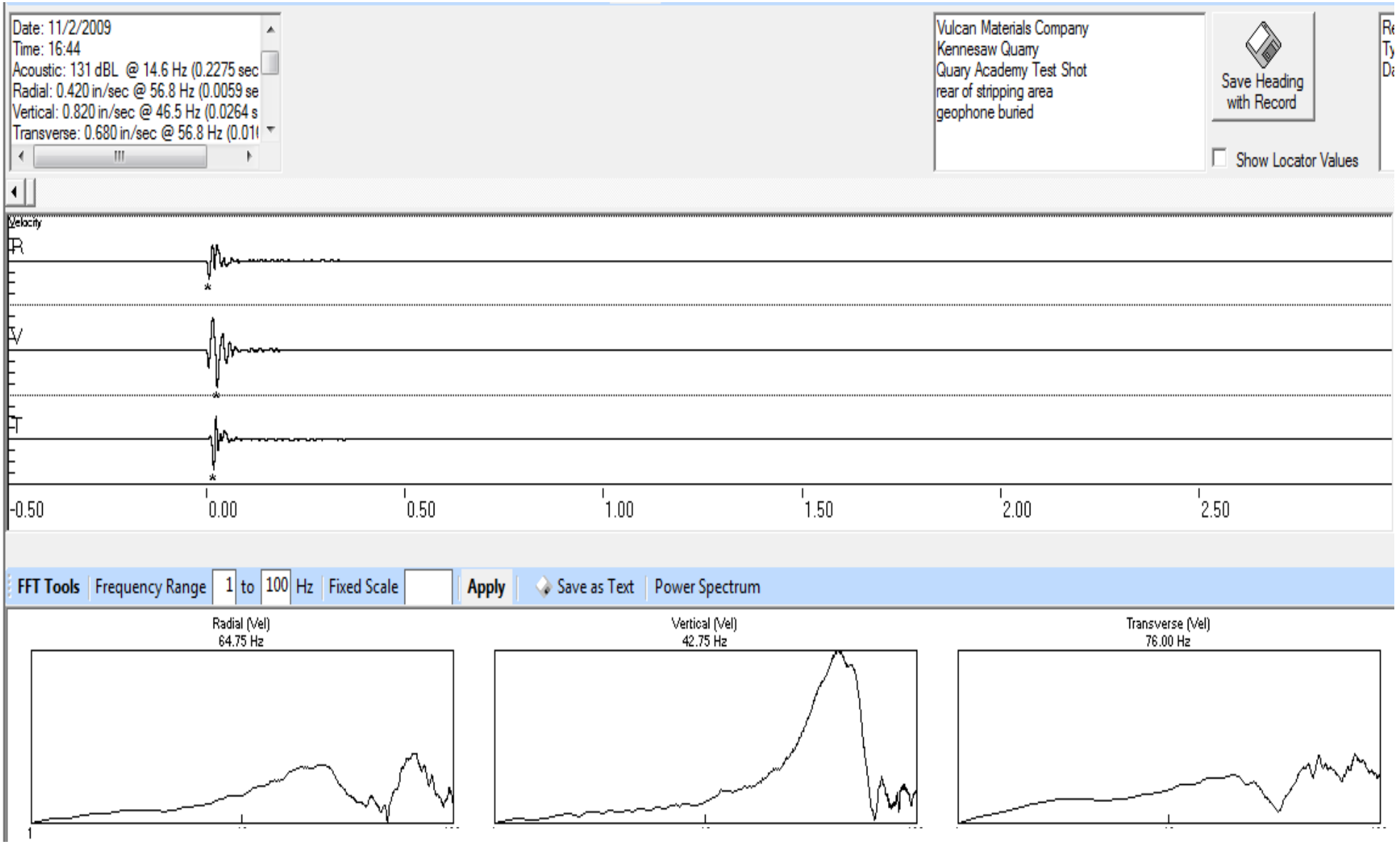
QUARRY ACADEMY

Production Shot – Geophone Spiked



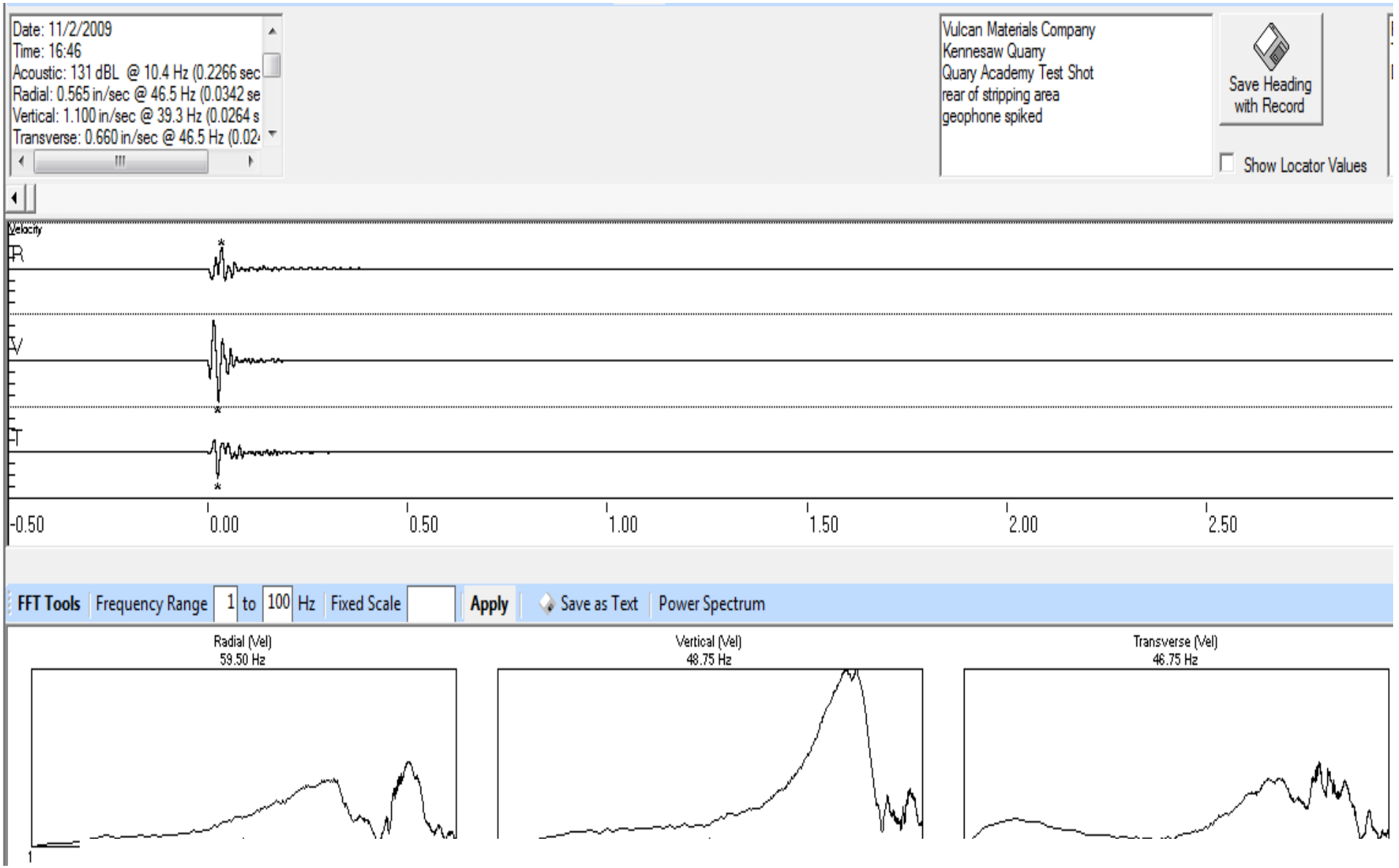
QUARRY ACADEMY

Test Hole – Geophone Buried



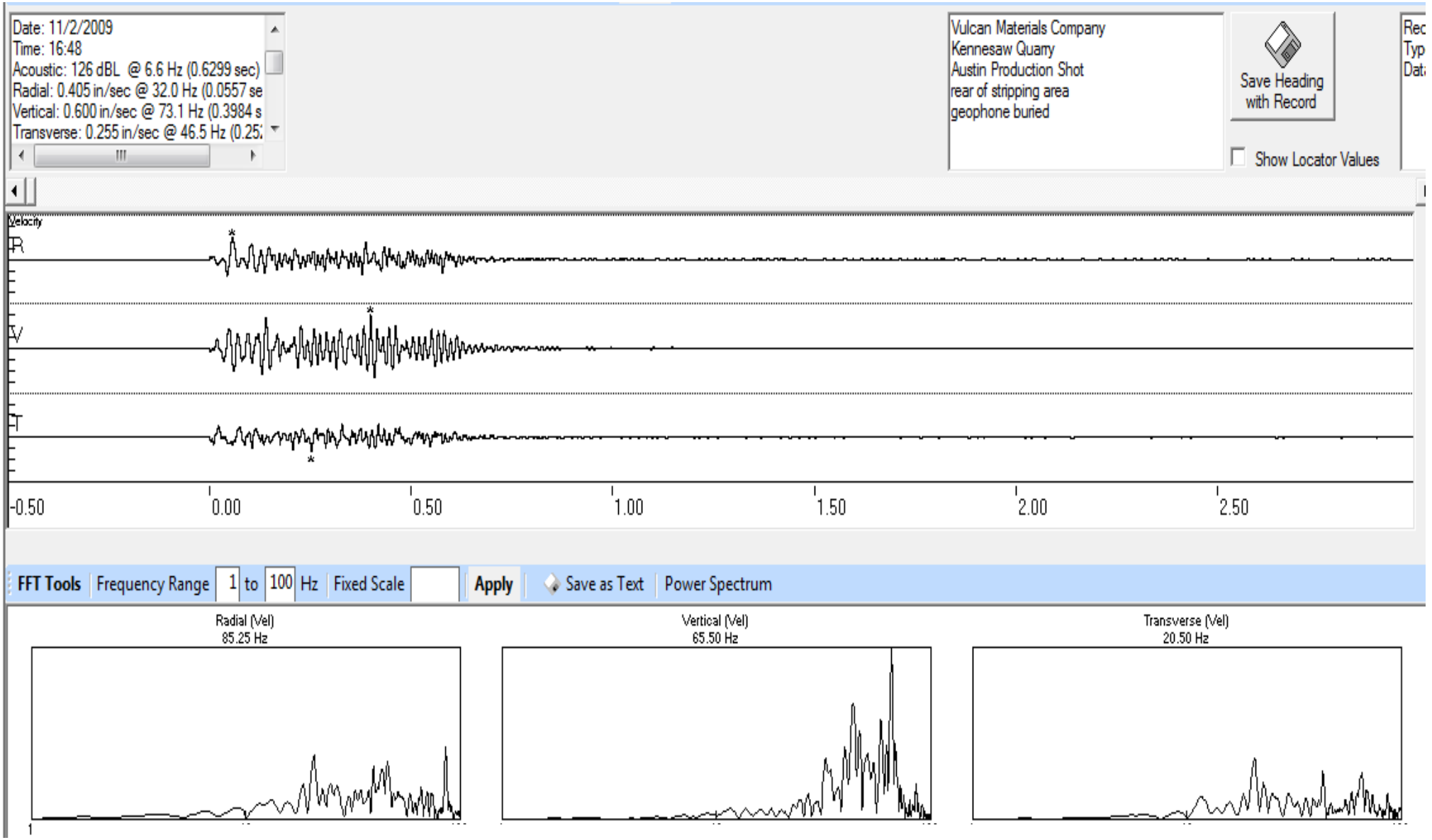
QUARRY ACADEMY

Test Hole – Geophone Spiked



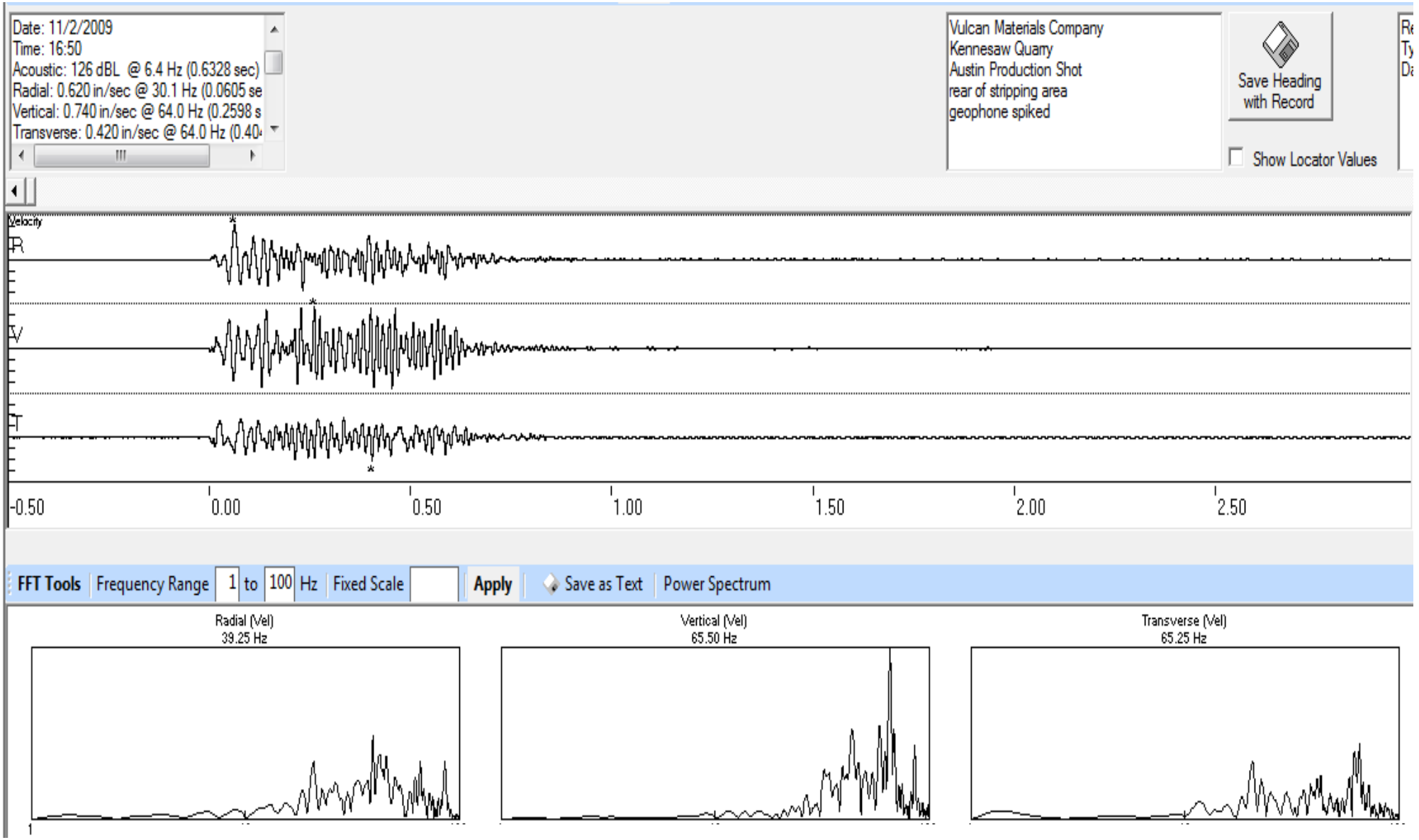
QUARRY ACADEMY

Production Shot – Geophone Buried



QUARRY ACADEMY

Production Shot – Geophone Spiked



QUARRY ACADEMY

Summary

Shot	coupling	PPV	Hz - R	Hz – V	Hz - T
production	buried	0.51	23	33	20
production	spiked	0.96	54	65	39
Test hole	buried	0.82	65	43	76
Test hole	spiked	1.10	59	49	46
production	buried	0.60	85	66	21
production	spiked	0.74	39	66	66

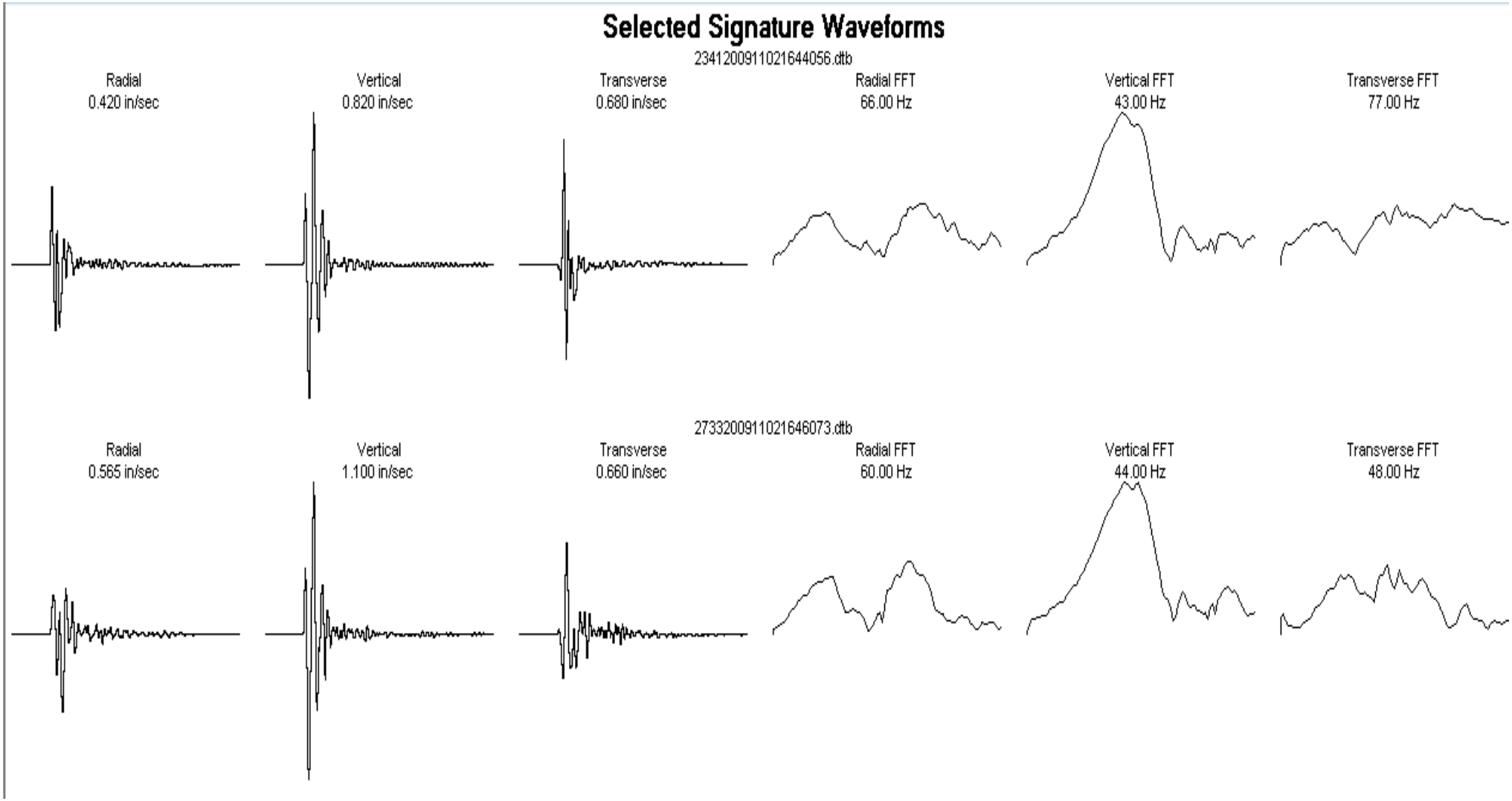
QUARRY ACADEMY

Signature Hole Analysis

- **Shape of waveform provides essence of geophysical properties of site**
- **Incorrect data will result in timing sequences designed for geophone response, not geology**

QUARRY ACADEMY

SHA – Buried vs Spiked



QUARRY ACADEMY

Fire Signature Holes

- Determine order of firing
- Shoot from bottom of pit to top
- If possible, separate detonations by several minutes
- Record shot times

QUARRY ACADEMY

Process data for analysis

- **Download data asap**
- **Check waveforms for conformity**
- **Place all needed data in headings and save with event**
  - ✓ **Test hole number or location**
  - ✓ **Seismograph location**

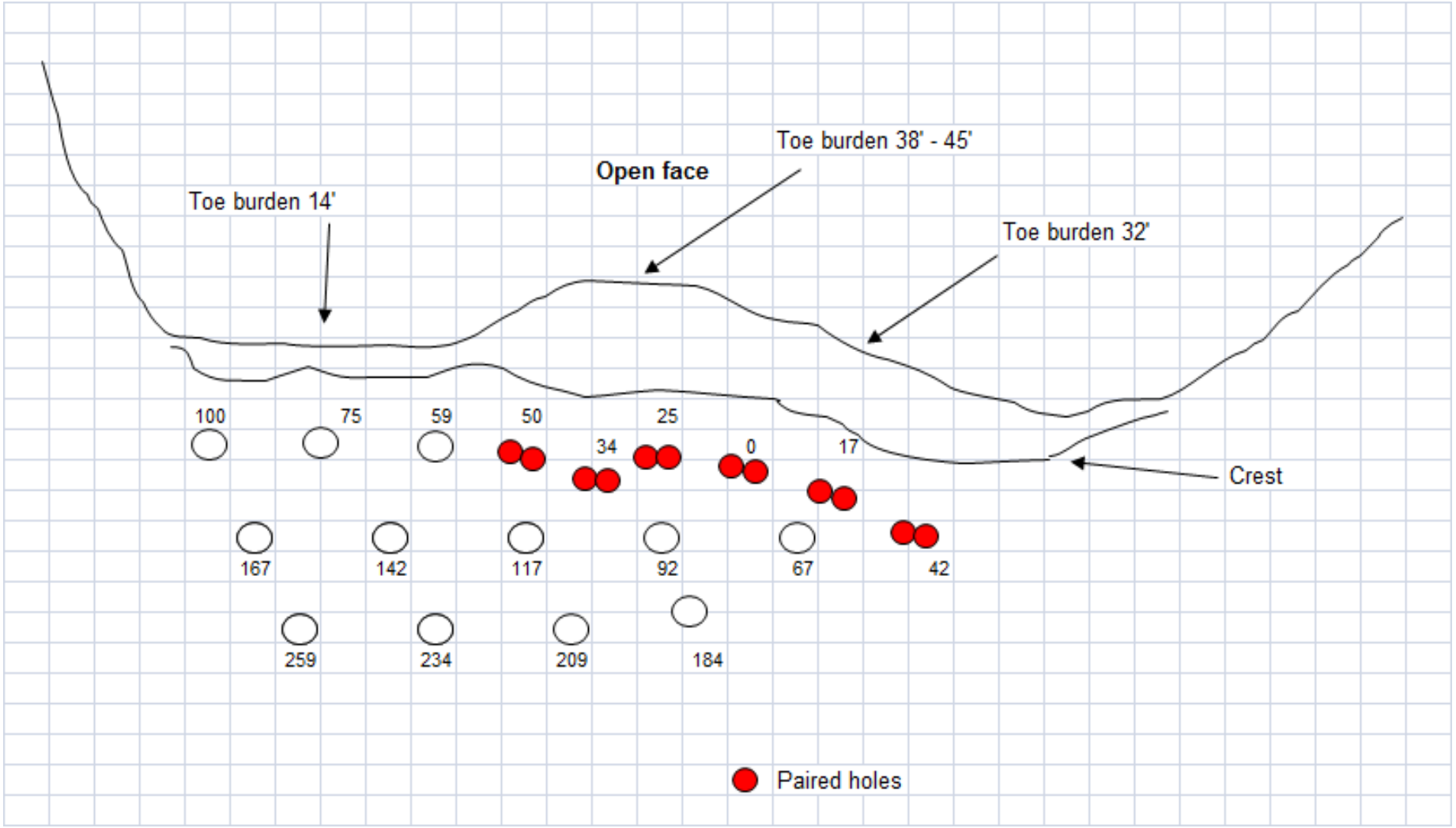
QUARRY ACADEMY

Analyze for shot

- **Limitations of software**
  - ✓ **Single inter hole delay**
  - ✓ **Single inter row delay**
  - ✓ **Variable holes per row**
- **Must determine order of initiation to define holes and rows**
- **V-cut shots are problematic**
  - ✓ **Must maintain inter hole timing**
  - ✓ **Results in doubled actual delay between holes on each side of shot**

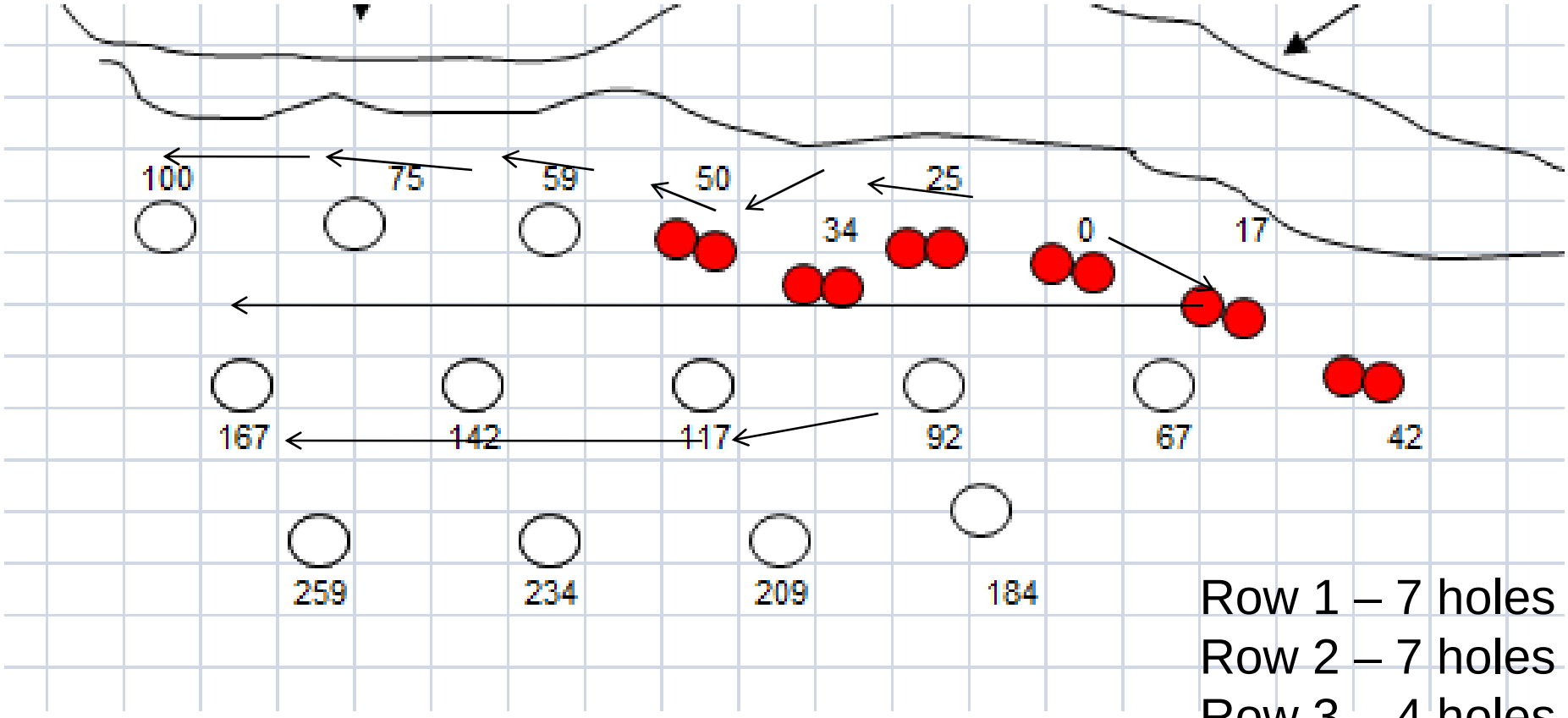
QUARRY ACADEMY

Defining Rows



QUARRY ACADEMY

Defining Rows



Row 1 – 7 holes
Row 2 – 7 holes
Row 3 – 4 holes

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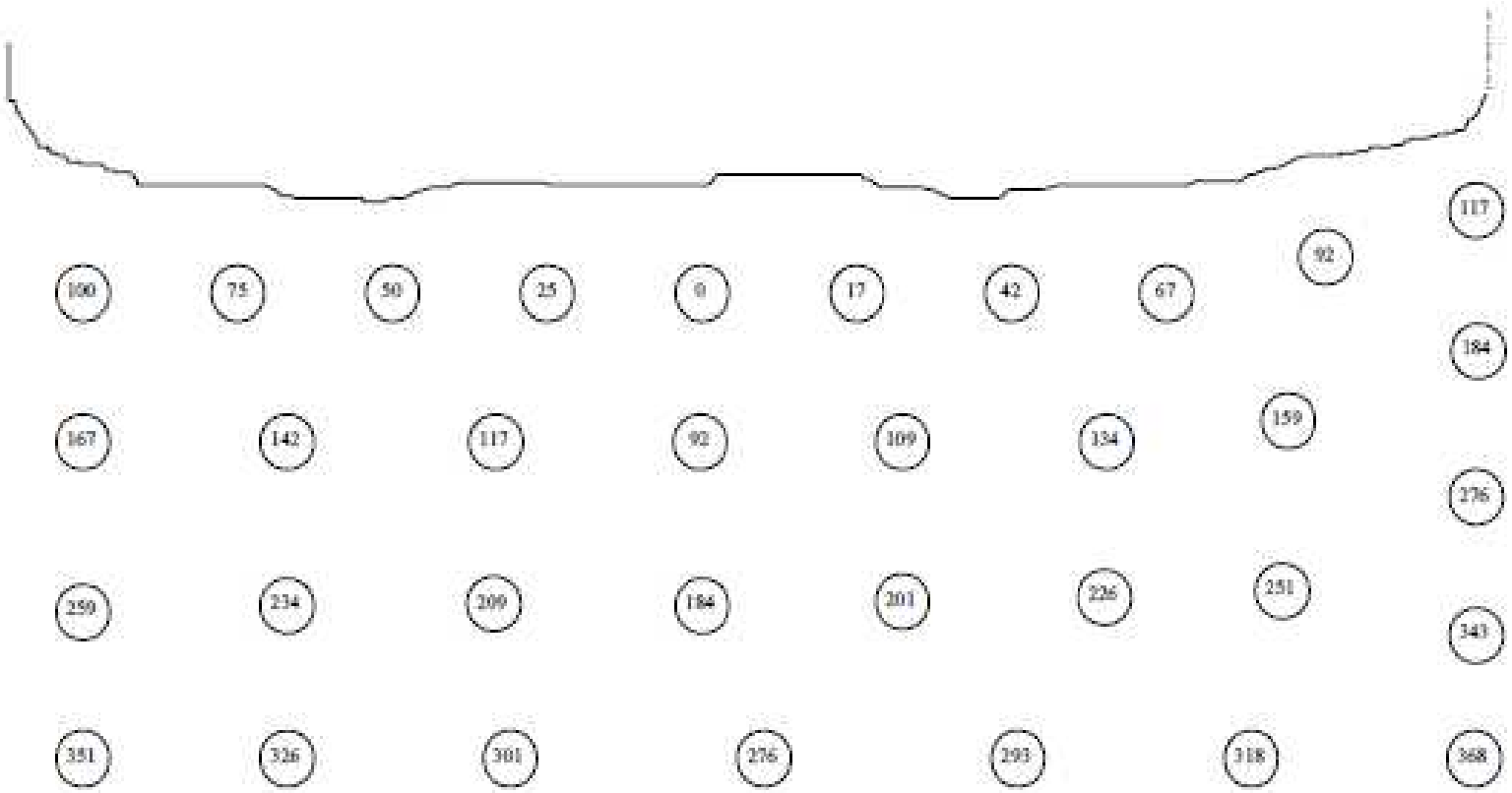
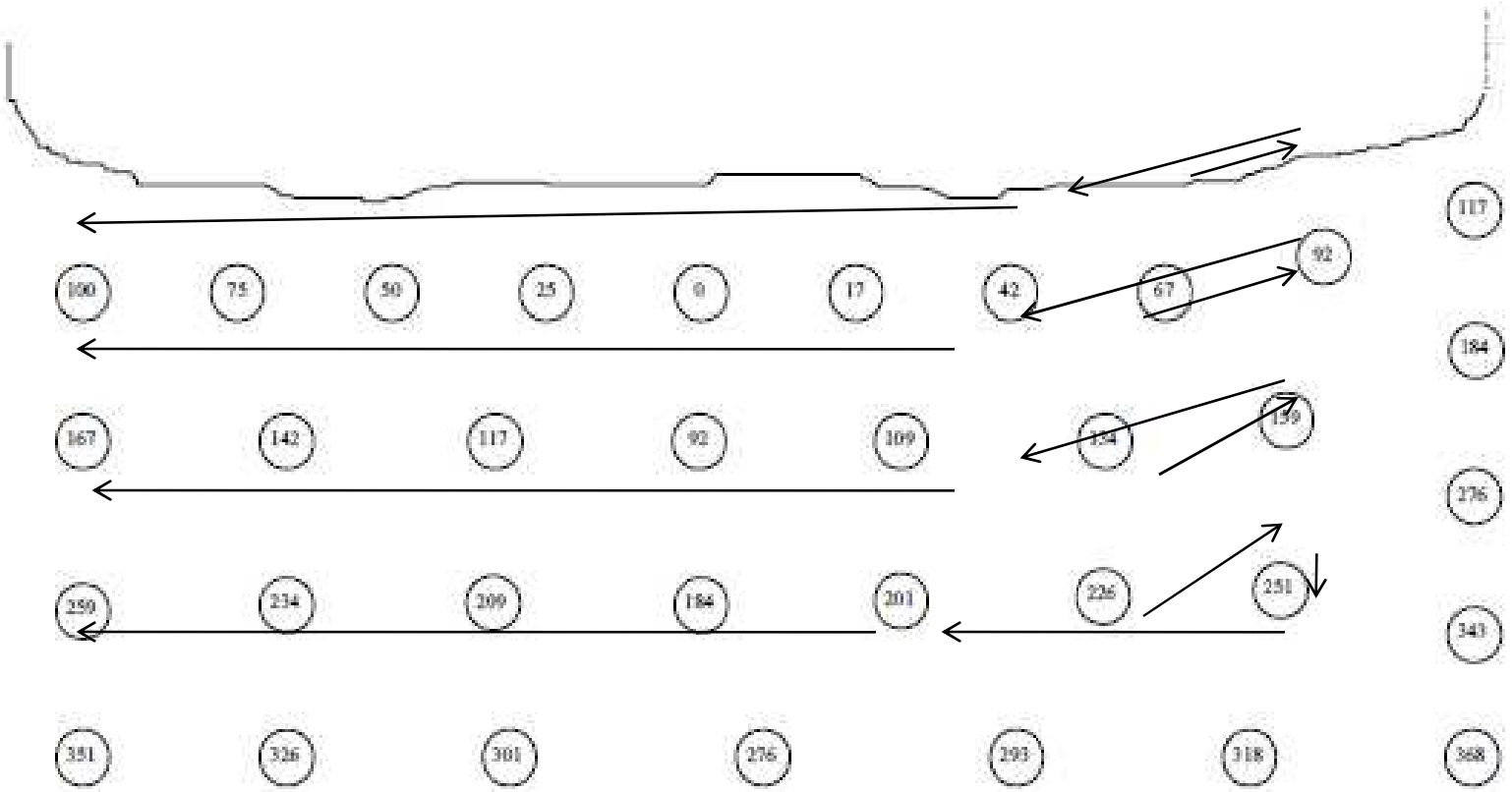
Defining Rows



QUARRY ACADEMY

Defining Rows



QUARRY ACADEMY

Run analysis

- With electronic detonators, optimum sequences can change shot by shot
- With properly set up data, analysis for each shot is possible
- Removes need to maintain exact shot pattern to be effective
- Using correct data file, run analysis for shot specific design

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First Mission (easy)……..

New Memo | Reply | Forward | Delete | Folder | Send | Send and File | Copy into | Tools

Glenn Barton <gbarton@borencompanies.com>
11/03/2010 08:16 AM

To: "tony.sheffield@am.dynonobel.com" <tony.sheffield@am.dynonobel.com>
cc: Stuart Brasher <stuart.brashear@am.dynonobel.com>
Subject: Delay

Good morning

Can you recommend a delay pattern that will allow one hole per delay at the coal mine? Up to 9 rows across the pit and 20 holes down the face. I know from a ppv standpoint it does not matter. Current levels below 0.15. From lawyer and jury point of view one hole sounds better even with electronics.

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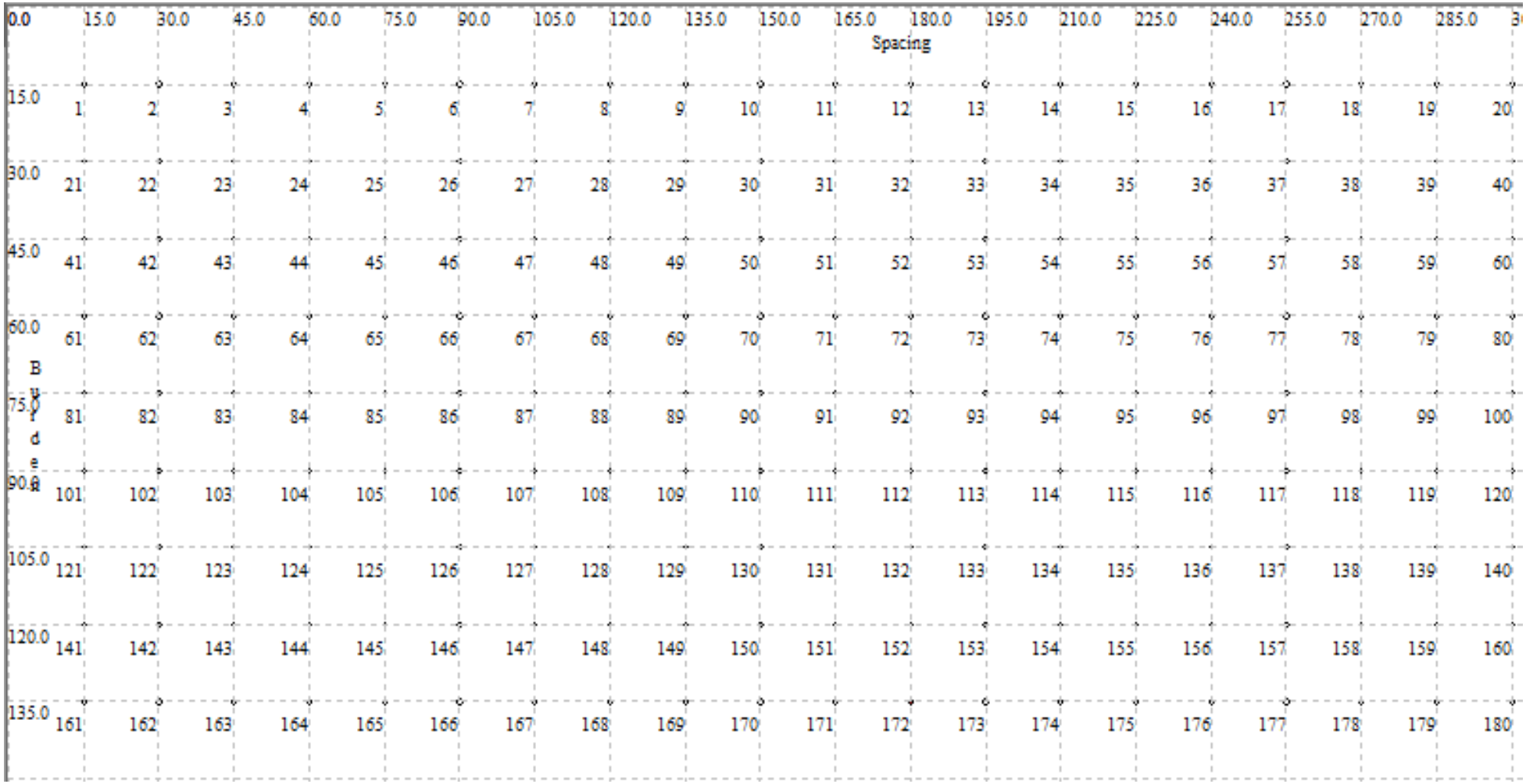
Shot Geometry



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Second Mission (harder)

New Memo | Reply | Forward | Delete | Folder | Send | Send and File | Copy into | Tools

Shawn Sullivan
11/04/2010 11:05 AM
OPERATIONS

To: Stuart Brashear/DNA/AM/DynoInd@DynoInd
cc: Dave Beckwith/DNA/AM/DynoInd@DynoInd
Subject: Eats Kingston

Stuart

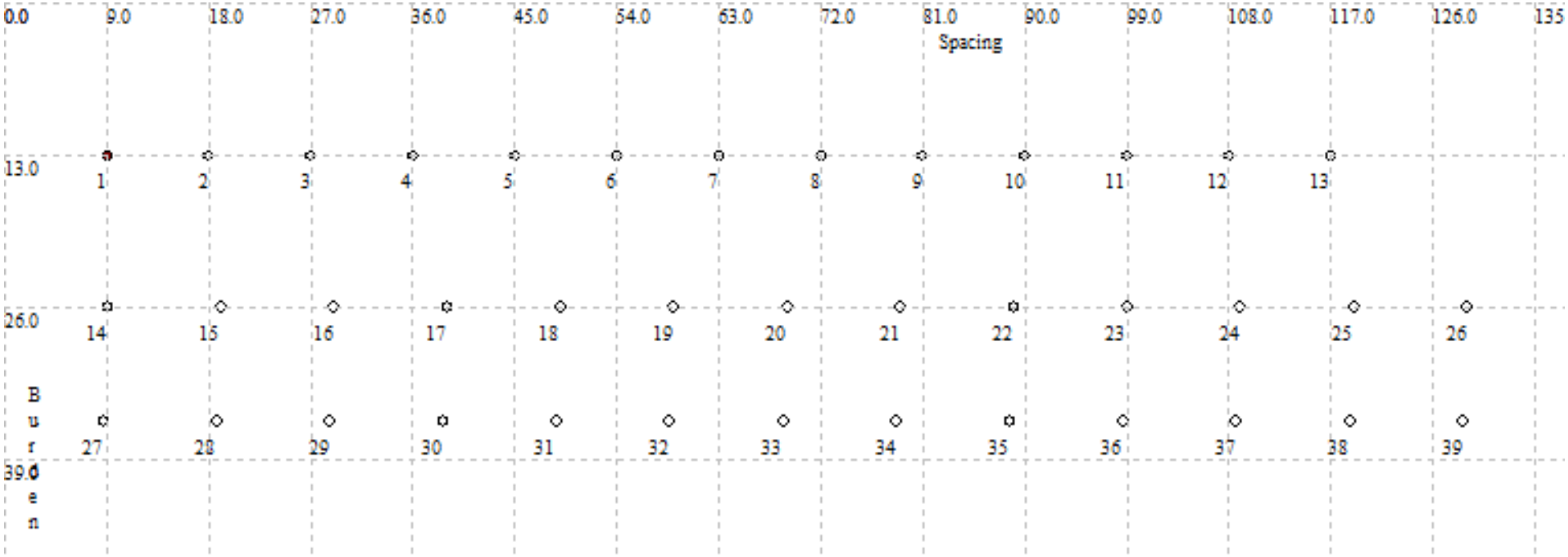
I have a shot tomorrow on the plant side lower East wall, three rows thirteen holes per row 13 x 9 front row and 10 x 10 back rows. There is an open corner, however I will be opening on the fourth hole in due to the screen towers being directly off the open end.

Best regards,
Shawn R. Sullivan
Site Manager

Dyno Nobel Inc.
Northeast Region, Dyno Nobel Inc, PO Box 117 South Bethlehem, NY 12161 USA
Office: 518 767 0233/ Fax: 518 767 0251/ Mobile: 518 225 1735
mailto: shawn.sullivan@am.dynonobel.com
http://www.dynonobel.com

QUARRY ACADEMY

Shot Geometry



QUARRY ACADEMY

Troubleshooting

- Are you using the correct signature waveform ?
- Do you have the right design ?
  - ✓ Holes per row
  - ✓ Rows
- Has something changed at the quarry ?
  - ✓ Distance to seismograph
  - ✓ Geology between shots and seismograph
- Are sound blasting practices still being employed ??

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www.quarryacademy.com

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