SOUTHERN CALIFORNIA GEOTECHNICAL
A California Corporation

August 18, 2014

Sares Regis Group
18802 Bardeen Avenue
Irvine, California 92612

Attention: Mr. Bob Klaewtanong
Senior Project Manager

Project No.: **14G174-1**

Subject: **Seismic Refraction Study**
Two Proposed Warehouse Buildings
Oleander Avenue and Nandina Avenue, West of Harvill Avenue
Unincorporated Riverside County, Perris Area, California

Reference: Geotechnical Feasibility Study, Commercial/Industrial Development, NWC Oleander Avenue and Decker Road, Riverside County, California, prepared by Southern California Geotechnical, Inc. (SCG), SCG Project No. 05G290-1, dated December 13, 2005.

Gentlemen:

In accordance with your request, we have conducted a seismic refraction study for the subject site. We are pleased to present this report summarizing the conclusions and recommendations developed from our investigation.

Site Conditions

The subject site is located on the south side of Nandina Avenue, approximately 700 feet west of the intersection of Nandina Avenue in an unincorporated area of Riverside County near Perris, California. The site is bounded to the north by Nandina Avenue, to the east by two commercial/industrial buildings, to the south by Oleander Avenue, and to the west by a vacant and undeveloped parcel.

The site is an irregular shaped parcel, approximately 97 acres in size. The site is currently vacant and undeveloped. Ground surface cover consists of exposed soil with sparse amounts of native grass and weed growth. Several irregular shaped outcrops of bedrock are visible throughout the subject site. These outcrops, at their highest points, extend to 5 to 8± feet above the ground surface.

Detailed topographic information was not available at the time of this report. However, based on visual observations made at the time of our investigation, topography within the subject area generally slopes downward to the east at an estimated gradient of 2 to 3± percent.

Proposed Development

The preliminary site plan for the proposed development was prepared by RGA. Based on this plan, the proposed development will consist of two new warehouse buildings with footprint areas of 1,016,240± ft^2 and 814,280± ft^2. Building A, the larger building, will be located in the northern half of the subject site and will be constructed in a cross dock configuration with docks along the north and south sides of the building. Building B, the smaller building, will be located in the south half of the subject site and will also be constructed in a cross dock configuration with loading docks along the north and south sides of the building. The buildings will be surrounded by asphaltic concrete pavements in the parking and drive lane areas and Portland cement concrete pavements in the loading dock areas. The proposed development is also expected to include limited areas of landscape planters and concrete flatwork.

Previous Studies

SCG previously performed a geotechnical investigation for the easterly adjacent site. As part of this investigation, we excavated a total of eight (8) test pits. The test pits were advanced with a track mounted excavator to depths up to 14± feet below the site grades. In addition, a seismic refraction survey was performed utilizing two (2) separate 230± feet long seismic lines. The geotechnical conditions at this site consisted of surficial alluvial soils and granitic bedrock. The upper portion of the bedrock was highly weathered and consisted of dense to very dense granodiorite with mafic inclusions. The underlying denser bedrock consisted of similar materials with a lesser degree of weathering.

Site Geology

The primary available reference applicable to the subject site is the Geologic Map of the Steele Peak Quadrangle, Riverside County, California, published by Santa Barbara Museum of Natural History, Dibblee T. W., 2003. A portion of this map indicating the location of the subject site is included herein as Plate 3 of this report. This map indicates that the subject site is underlain by granodiorite rocks of Cretaceous age (Map Symbol gdi). The granodiorite rocks are described as gray to light gray, massive granodiorite. Based on the bedrock outcrops that were identified during the seismic refraction survey, the on-site materials appear to be consistent with the geologic mapping.

Seismic Refraction Survey

A seismic refraction survey was performed at the subject site. The purpose of the seismic refraction survey was to define the excavation characteristics of the bedrock materials that underlie the subject site.

A brief summary of the methodology, field procedures, and the results of the seismic refraction survey are presented below. The complete results of the seismic refraction survey are presented in an appendix of this report.

Methodology

The seismic refraction method consists of measuring (at known points along the surface of the ground) the travel times of compressional waves generated by an impulsive energy source and can be used to estimate the layering, structure, and seismic acoustic velocities of subsurface horizons. Seismic waves travel down and through the soils and rocks, and when the wave encounters a contact between two earth materials having different velocities, some of the wave's energy travels along the contact at the velocity of the lower layer. The fundamental assumption is that each successively deeper layer has a velocity greater than the layer immediately above it. As the wave travels along the contact, some of the wave's energy is refracted toward the surface where it is detected by a series of motion-sensitive transducers (geophones). The arrival time of the seismic wave at the geophone locations can be related to the relative seismic velocities of the subsurface layers in feet per second (fps), which can then be used to aid in interpreting both the depth and type of materials encountered.

Field Procedures

Ten (10) 200-foot long seismic refraction survey lines (Seismic Line S-1 though S-10) were performed as shown on the Seismic Line Location Plan, enclosed as Plate 2 of this report. These lines were generally placed near the existing visible outcrops of bedrock. A 16-pound sledge-hammer was used as an energy source to produce the seismic waves and twenty-four, 14-Hz geophones (used to aid in filtering background noise from nearby vehicular traffic) spaced at eight-foot intervals were employed to detect both the direct and refracted waves. The seismic wave arrivals were digitally recorded in SEG-2 format on a Geometries StrataVisor™ NZXP model signal enhancement refraction seismograph. Seven shot points were utilized along the spread using forward, reverse, and several intermediate locations in order to obtain high resolution survey data for velocity analysis and depth modeling purposes. The data was acquired using a sampling rate of 0.0625 milliseconds having a record length of 0.07 seconds with no acquisition filters.

During acquisition, the seismograph provides both a hard copy and screen display of the seismic wave arrivals, of which are digitally recorded on the in-board seismograph computer. The data on the paper record and/or display screen were used to analyze the arrival time of the primary seismic "P"-waves at each geophone station, in the form of a wiggle trace, for quality control purposes in the field. Since the survey area was essentially flat, no topographic corrections were necessary.

Results and Conclusions

The field data obtained during the seismic refraction survey was processed and analyzed using two specialized computer programs, SIPWin, Rayfract, and Refractor. SIPWin provides average characteristics for several layers which are defined within the subsurface profile. Rayfract provides more discrete data that indicates the relative structure of the subsurface materials. Refactor evaluates the subsurface using layer assignments and this technique provides an approach for recognizing and compensating for hidden layers. In all of the cases, the results of the geophysical interpretation provide shear wave velocities can be evaluated using rippability charts published by Caterpillar and other grading equipment manufacturers. Typically, the Caterpillar rippability chart for a D-9 Single Shank Ripper is utilized when evaluating the excavation characteristics of bedrock. This table is presented below:

Granitic Rock Velocity (feet/second±)	Rippability
<6,800	Rippable
6,800 – 8,000	Moderately Rippable
>8,000	Non-Rippable

In general, the geophysical survey identified three major subsurface layers with respect to seismic velocities. These layers are depicted graphically in Appendix A of the geophysical report, which has been included as an appendix of this report. Velocity Layer V-1, ranges from 1,577 to 2,260 feet/second, and is considered to represent the alluvial deposits. Velocity Layer V-1 was encountered at the ground surface within the seismic lines. Velocity Layer V-2, ranges from 3,514 to 5,012 feet/second and is considered to represent the weathered granodiorite bedrock or older alluvial sediments. Velocity Layer V-2 was encountered at depths ranging from 1 to 15± feet within the seismic lines. Velocity Layer V-3, ranges from 8,743 to 16,858 feet/second, and is considered to represent relatively unweathered, granodiorite bedrock. Velocity Layer V-3 was encountered at depths ranging from 7 to 62± feet within the seismic lines.

Conclusions and Recommendations

Based on the results of the geophysical survey, the granodiorite bedrock, which is represented by Velocity Layer V-3, is considered non-rippable based on the Caterpillar rippability chart. Therefore, blasting should be expected in any areas where these materials will need to be excavated. It is recommended that the full text of the seismic refraction survey be reviewed for more complete information.

Closure

We sincerely appreciate the opportunity to be of continued service on this project. If we may be of further assistance in any manner, please contact our office.

Respectfully Submitted,

SOUTHERN CALIFORNIA GEOTECHNICAL, INC.

PROFESSIONAL GEOLOGIST DARYL R. KAS No. 2467 CERTIFIED ENGINEERING GEOLOGIST STATE OF CALIFORNIA

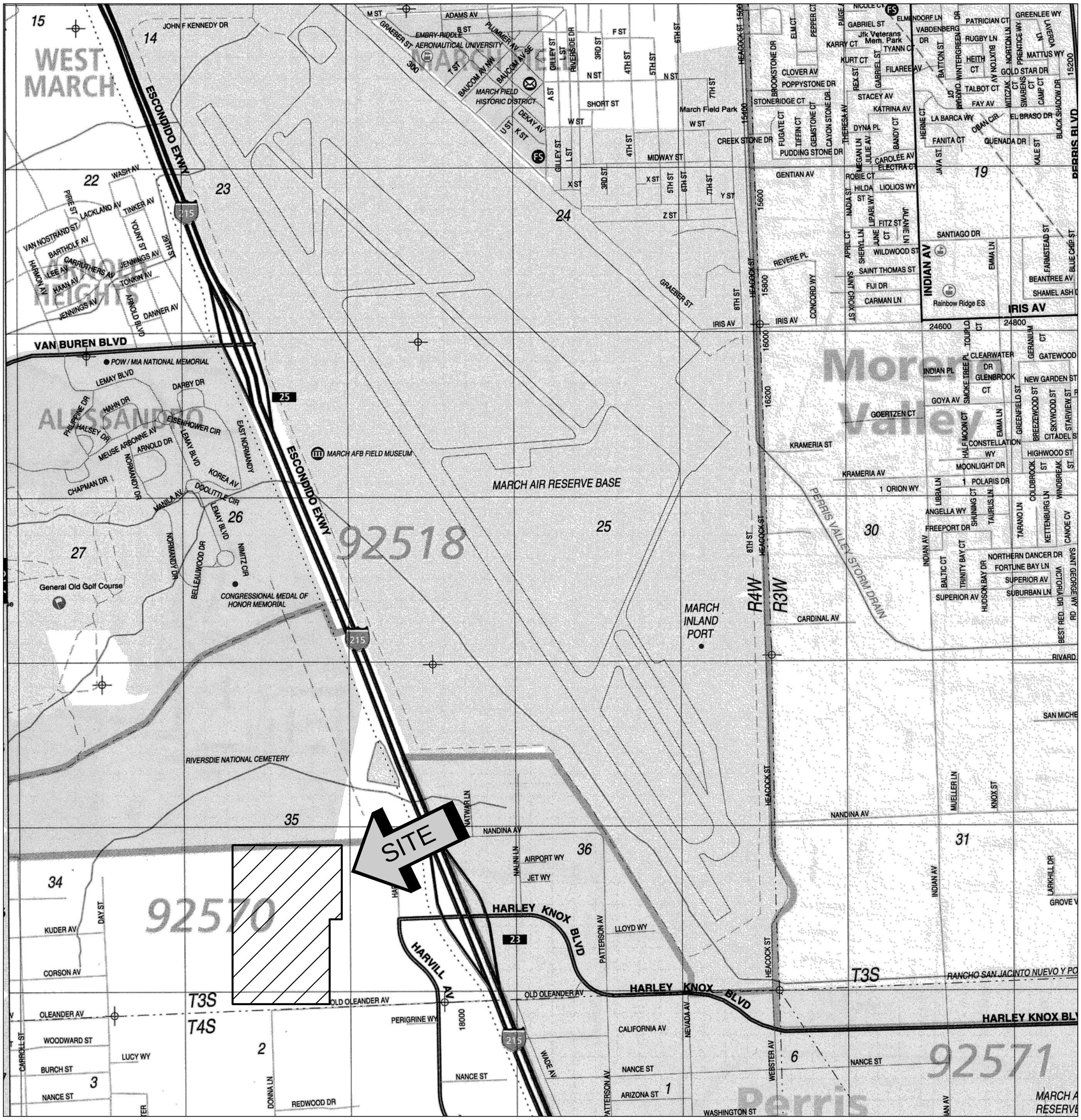
Daryl R. Kas, CEG 2467
Project Geologist

John A. Seminara, GE 2294
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER JOHN A. SEMINARA No. 2294 GEOTECHNICAL STATE OF CALIFORNIA

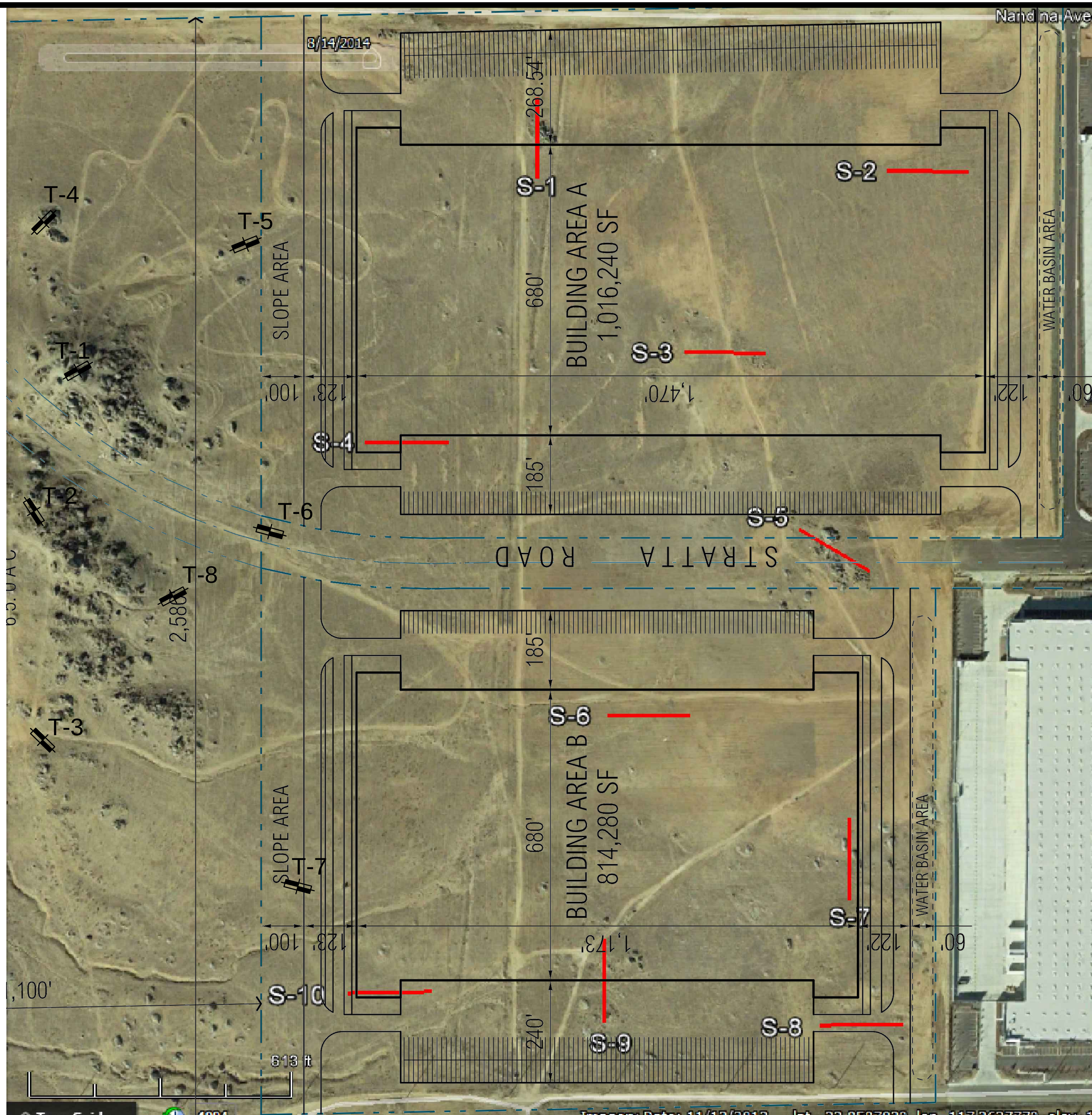
Enclosures: Plate 1 – Site Location Map
Plate 2 – Seismic Line Location Plan
Plate 3 – Geologic Map
Trench Logs (from previous SCG Report No. 05G290-1)
Seismic Refraction Survey

Distribution: (2) Addressee



SOURCE: RIVERSIDE COUNTY
THOMAS GUIDE, 2013

SITE LOCATION MAP	
TWO PROPOSED WAREHOUSE BUILDINGS	
RIVERSIDE COUNTY, CALIFORNIA	
SCALE: 1" = 2400'	SoCalGeo SOUTHERN CALIFORNIA GEOTECHNICAL
DRAWN: KVC CHKD: JAS	
SCG PROJECT 14G174-1	
PLATE 1	



NORTH
SoCalGeo

GEOTECHNICAL LEGEND

- APPROXIMATE SEISMIC LINE LOCATION
- PREVIOUS TRENCH LOCATION (SCG PROJECT NO. 05G290-1)

0 250 500

NOTE: BASE MAP OBTAINED FROM GOOGLE EARTH

SEISMIC LINE LOCATION PLAN

TWO PROPOSED COMMERCIAL BUILDINGS

RIVERSIDE COUNTY, CALIFORNIA

SCALE: 1" = 250'	SoCalGeo SOUTHERN CALIFORNIA GEOTECHNICAL
DRAWN: DRK CHKD: JAS	
SCG PROJECT 14G174-1	
PLATE 2	

LEGEND

af

Qa

SURFICIAL SEDIMENTS

Alluvial sediments, unconsolidated, undissected

af *Artificial fill at construction site of March Airforce base in northeast area and at 2 sites over buried Colorado River aqueduct near Cajalco Road in north area*

Qa *Alluvial sand and clay of valley areas, covered with gray clay soil*

Qoa

OLDER SURFICIAL SEDIMENTS

Slightly indurated, much dissected alluvial sediments

Qoa *Alluvial sand, commonly pebbly, light reddish brown, arkosic, includes alluvial fan gravel at base of hill terranes*

— *UNCONFORMITY* —

Tcg

Tcrr

Ts

TERRESTRIAL SEDIMENTARY DEPOSITS

Indurated, massively bedded, form erosional remnants of once more extensive alluvial stream-laid deposits at or near west border of quadrangle; age, Tertiary, probably Pliocene or late Miocene

Tcg *Conglomerate of Lake Mathews area (Morton, 2001), of granitic cobbles in light gray coarse grained sandstone matrix*

Tcrr *Conglomerate of red rhyolitic cobbles in coarse grained sandstone matrix, exposed at west border of quadrangle and beyond into Lake Mathews area*

Ts *Mudstone and minor conglomerate and sandstone of Lake Mathews Formation (Morton, 2001)*

— *UNCONFORMITY* —

p gr

grd qdi qdu hdg qdc grb

PLUTONIC ROCKS

Mostly medium grained holocrystalline plutonic rocks of Peninsular Range batholith of Cretaceous age; includes post – plutonic granitic dike rocks of variable grain size, also of Cretaceous age

p *Pegmatite dike rocks, leucocratic, very coarse grained; of quartz, alkali feldspar biotite and mica; dikes as wide as 2 m, forms dike swarm in quartz diorite in central west area, and scattered dikes elsewhere*

gr *Granitic dike rocks, leucocratic, tan – white, fine to medium grained, massive; of quartz, alkali feldspars, and minor biotite; form scattered dikes, some large, intrusive into quartz diorite (**qdi**)*

grd *Granodiorite, ranging to quartz monzonite in north area; includes Woodson Mountain Granodiorite of Larsen 1948; Steele Valley Pluton of Dudley 1935, and Arroyo del Toro Pluton of Morton, 2001,) in southwest area; leucocratic, tan-white, massive, homogeneous, of quartz, alkali feldspars and minor biotite*

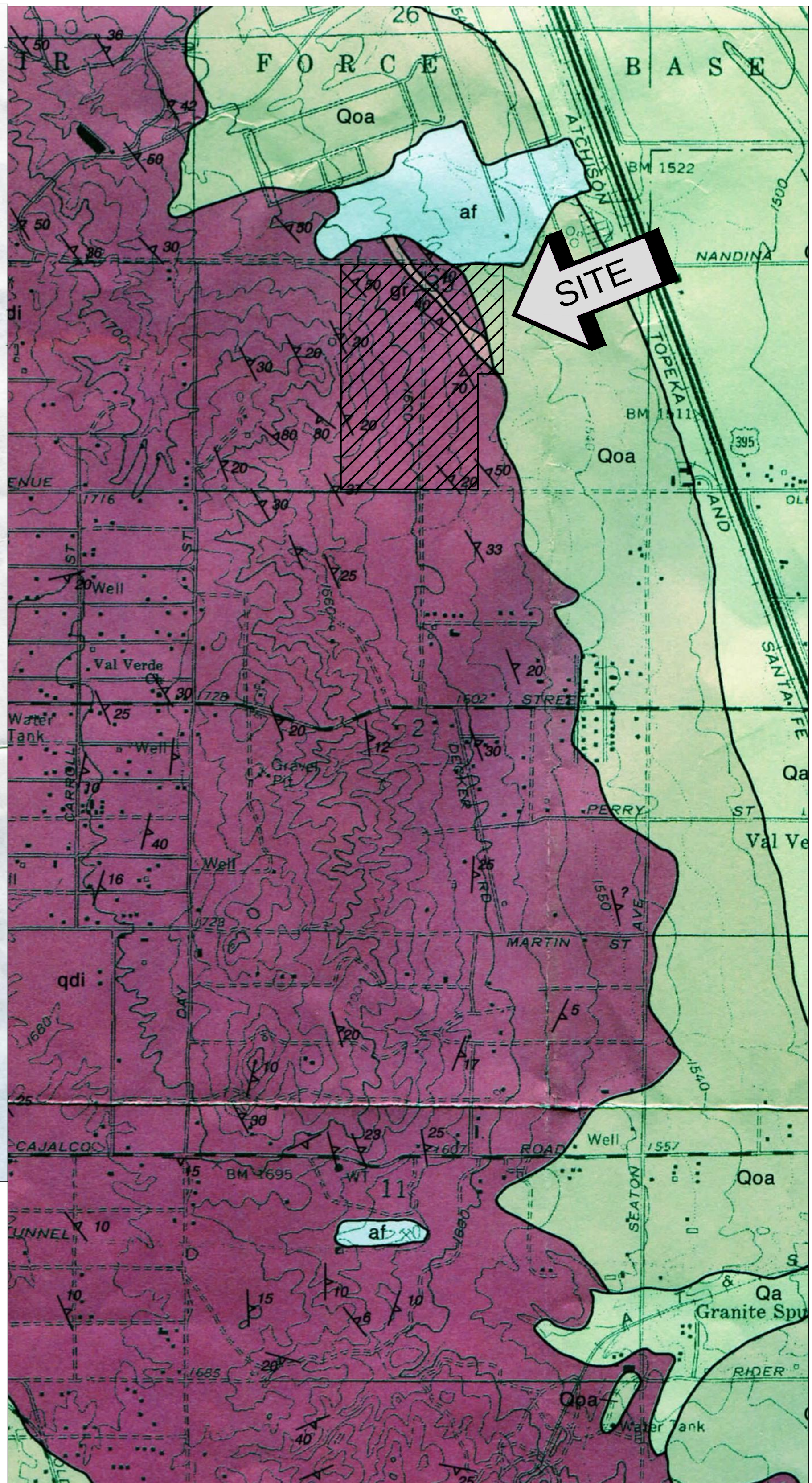
qdi *Quartz diorite (includes Perris quartz diorite of Dudley, 1935, renamed Vat Verde Tonalite by Osborn, 1939, included in Bonsal Tonalite of Larsen, 1948, and Val Verde Tonalite by Morton and Cox, 2001, in east area: gray to light gray, massive to more commonly gneissoid, composed mostly of sodic plagioclase feldspar and the remainder of quartz, biotite and hornblende, and very minor potassic feldspar, contains few to abundant dark gray discoid inclusions; (xenoliths) oriented parallel to gneissoid structure of rock; radiometric age 105.7 MA, Ar 40/Ar 39 age of hornblende, 100 MA, biotite 95 MA, and potassic feldspar 85.5 MA (Morton 2001)*

qdu *Quartz diorite, similar to qdi but massive, contains hypersthene, few equant (non-discoid inclusions; radiometric age of zircon 112.9 and 113.6 MA (Morton, 2001)*

hdg *Hornblende gabbro, included in San Marcos Gabbro by Larsen, 1948, gray-black, weathers brown, medium to coarse grained, massive, of hornblende and calcic plagioclase feldspar, some hornblende anhedra, very large, poikilitic*

qdc *Quartz diorite, cataclastic, gray, homogeneous but very gneissoid due to parallel orientation of biotite, composition about same as **qdi** but richer in biotite and hornblende; gneissoid structure due in part to thin cataclastic or mylonitic laminae; rock sheared at depth in a metamorphic environment, part of Santa Rosa shear zone; contacts with adjacent rocks (**qdi** and **ms**) gradational, difficult to map*

grb *"Black granite", hyperthene monzogranite of Morton 2001, nearly black, weathers dark brown, massive, composed of quartz, alkali feldspar, biotite, hornblende, hyperthene and clinopyroxene, exposed in one area north of Steele Valley, formerly quarried as "black granite" building stone; radiometric age of zircon 109 and 106 MA, Ar 40/Ar39 of biotite 104.5 MA and potassic feldspar 99.3 MA (Morton 2001)*



SOURCE: "GEOLOGIC MAP OF THE STEELE PEAK 7.5' QUADRANGLE, RIVERSIDE COUNTIY, CALIFORNIA" DIBBLEE, 2003

GEOLOGIC MAP	
TWO PROPOSED WAREHOUSE BUILDINGS	
RIVERSIDE COUNTY, CALIFORNIA	
SCALE: 1" = 2000'	SOUTHERN CALIFORNIA GEOTECHNICAL
DRAWN: DRK CHKD: JAS	
SCG PROJECT 14G174-1	
PLATE 3	

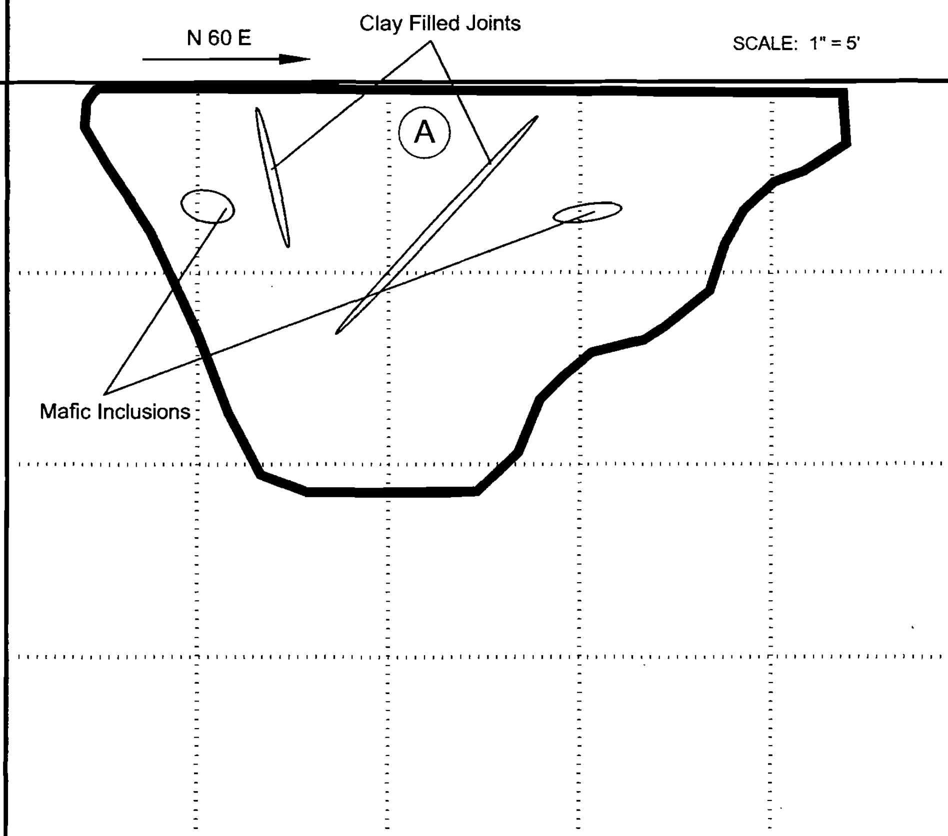
Southern California Geotechnical

TRENCH NO.
T-1

JOB NO.: 05G290	EQUIPMENT USED: Excavator	WATER DEPTH: None
PROJECT: Commercial/Industrial Development	LOGGED BY: Daryl Kas	SEEPAGE DEPTH: Dry
LOCATION: Perris, CA	ORIENTATION: N 60 E	READINGS TAKEN: at Completion
DATE: 12/7/2005	ELEVATION: 1699	

DEPTH	SAMPLE	DRY DENSITY (PCF)	MOISTURE (%)	EARTH MATERIALS DESCRIPTION
	b			A: BEDROCK: Gray Quartz Diorite, phaneritic, friable, joints, weathered, some Iron oxide staining, mafic inclusions, very dense-dry
5				Joints: N55W, 30S N30W, 80N
	b			
10	b			
				Trench Terminated at 10½' due to very dense bedrock
15				

GRAPHIC REPRESENTATION



KEY TO SAMPLE TYPES:
B - BULK SAMPLE (DISTURBED)
R - RING SAMPLE 2-1/2" DIAMETER
(RELATIVELY UNDISTURBED)

TRENCH LOG

PLATE B-1

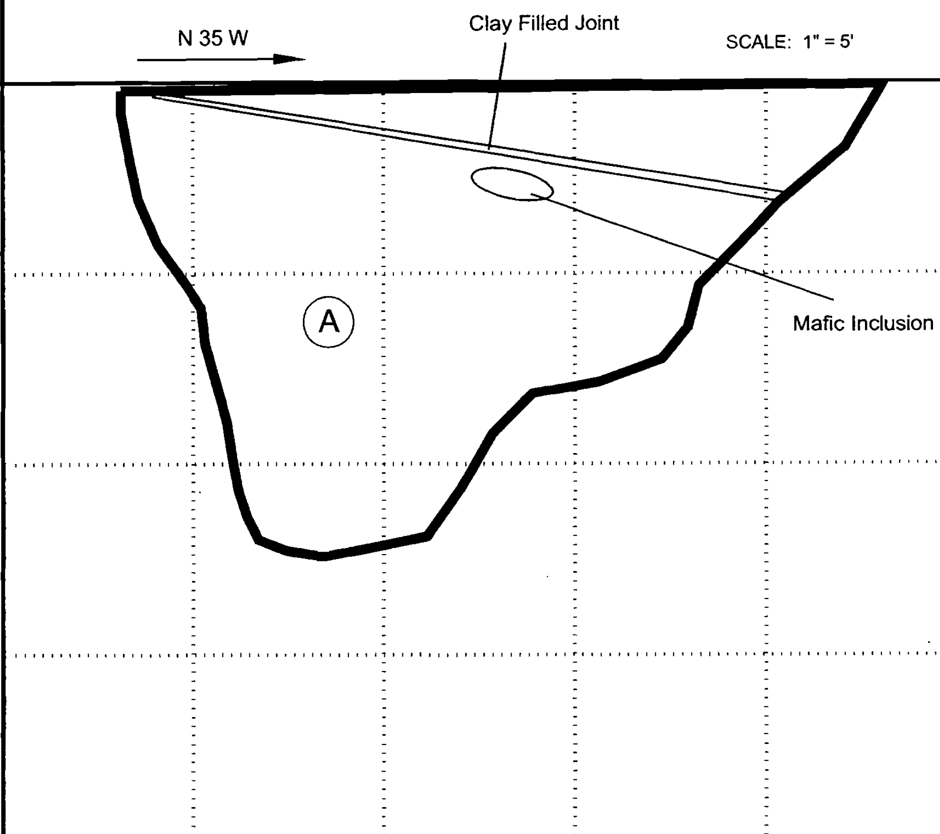
Southern California Geotechnical

TRENCH NO. T-2

JOB NO.: 05G290	EQUIPMENT USED: Excavator	WATER DEPTH: None
PROJECT: Commercial/Industrial Development	LOGGED BY: Daryl Kas	SEEPAGE DEPTH: Dry
LOCATION: Perris, CA	ORIENTATION: N 35 W	READINGS TAKEN: at Completion
DATE: 12/7/2005	ELEVATION: 1715	

DEPTH	SAMPLE	DRY DENSITY (PCF)	MOISTURE (%)	EARTH MATERIALS DESCRIPTION
	b			A: BEDROCK: Brown to Gray Brown Quartz Diorite, phaneritic, friable, clay filled joints, weathered, Iron oxide staining, mafic inclusions, very dense-dry
	b			@ 4 feet, becomes less weathered
5				Joint: N45W, 25NE
	b			
10	b			
				Trench Terminated at 12' due to very dense bedrock
15				

GRAPHIC REPRESENTATION



KEY TO SAMPLE TYPES:
B - BULK SAMPLE (DISTURBED)
R - RING SAMPLE 2-1/2" DIAMETER (RELATIVELY UNDISTURBED)

TRENCH LOG

PLATE B-2

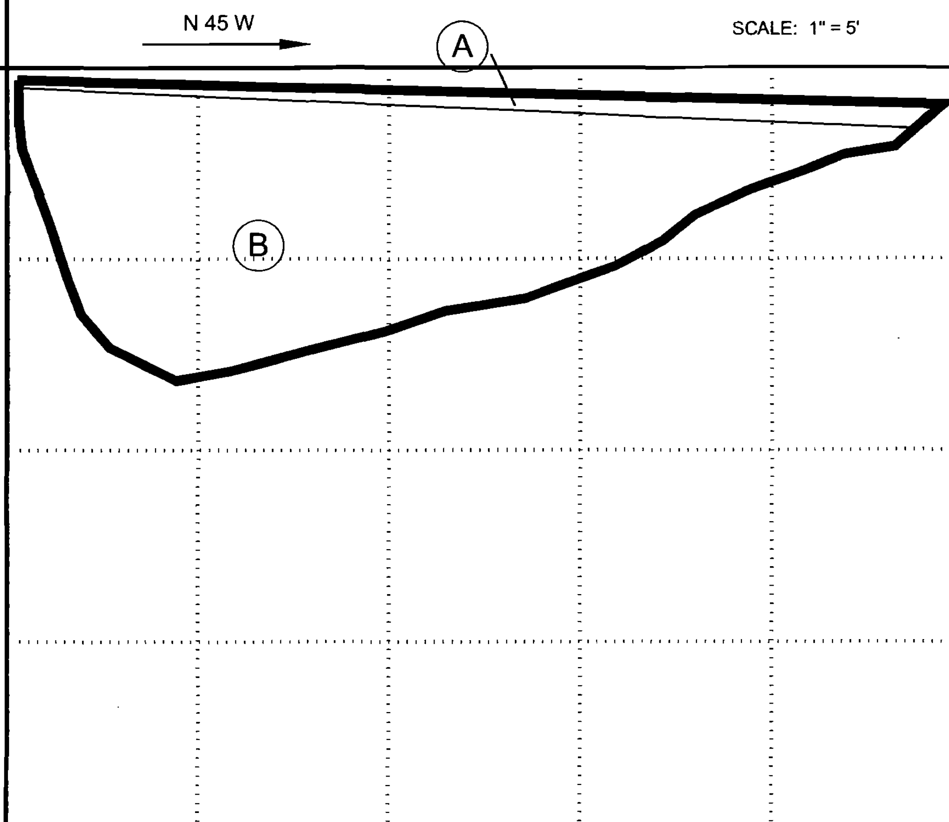
Southern California Geotechnical

TRENCH NO.
T-3

JOB NO.: 05G290	EQUIPMENT USED: Excavator	WATER DEPTH: None
PROJECT: Commercial/Industrial Development	LOGGED BY: Daryl Kas	SEEPAGE DEPTH: Dry
LOCATION: Perris, CA	ORIENTATION: N 45 W	READINGS TAKEN: at Completion
DATE: 12/7/2005	ELEVATION: 1681	

DEPTH	SAMPLE	DRY DENSITY (PCF)	MOISTURE (%)	EARTH MATERIALS DESCRIPTION
	b b b			A: ALLUVIUM: Brown Silty fine Sand, loose-dry B: BEDROCK: Orange Brown Quartz Diorite, phaneritic, friable, very weathered, abundant Iron oxide staining, dense to very dense-dry @ 2½ feet, becomes less weathered, some Iron oxide staining
5				
				Trench Terminated at 7½'
10				
15				

GRAPHIC REPRESENTATION



KEY TO SAMPLE TYPES:
B - BULK SAMPLE (DISTURBED)
R - RING SAMPLE 2-1/2" DIAMETER
(RELATIVELY UNDISTURBED)

TRENCH LOG

PLATE B-3

Southern California Geotechnical

TRENCH NO. T-4

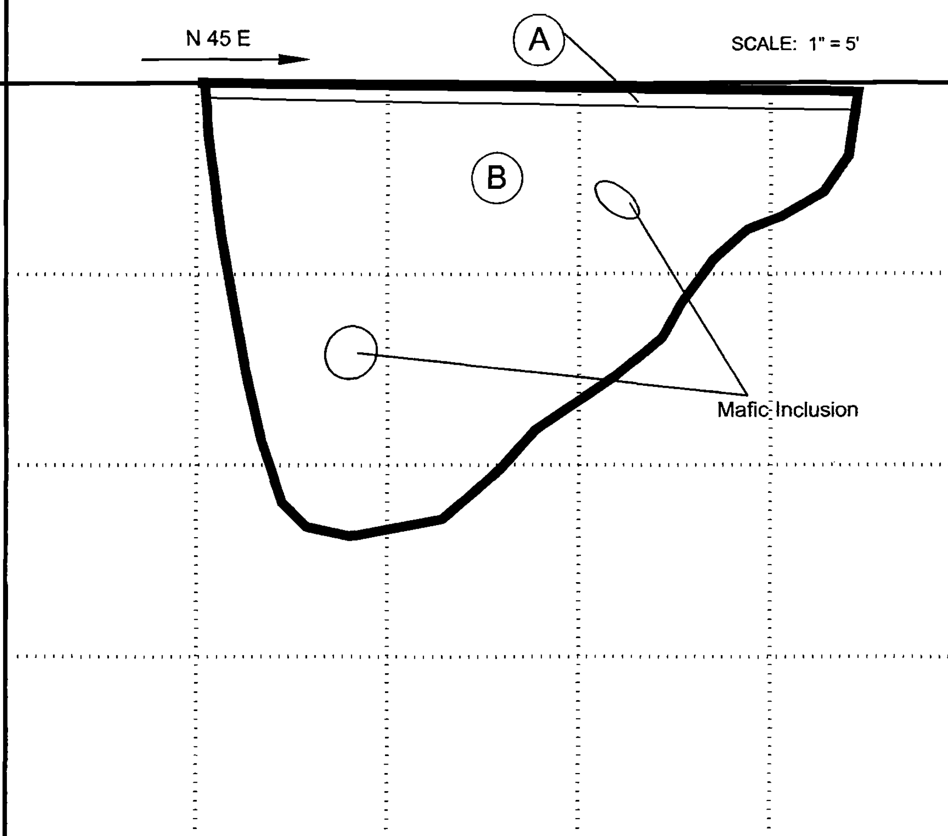
JOB NO.: 05G290
PROJECT: Commercial/Industrial Development
LOCATION: Perris, CA
DATE: 12/7/2005

EQUIPMENT USED: Excavator
LOGGED BY: Daryl Kas
ORIENTATION: N 45 E
ELEVATION: 1651

WATER DEPTH: None
SEEPAGE DEPTH: Dry
READINGS TAKEN: at Completion

DEPTH	SAMPLE	DRY DENSITY (PCF)	MOISTURE (%)	EARTH MATERIALS DESCRIPTION
	b			A: ALLUVIUM: Brown Silty fine Sand, loose-dry
	b			B: BEDROCK: Orange Brown to Gray Brown Quartz Diorite, phaneritic, friable, very weathered, some Iron oxide staining, mafic inclusions, very dense-dry
5				@ 2 feet, becomes less weathered, less Iron oxide staining
10				
	b			Trench Terminated at 11½' due to very dense bedrock
15				

GRAPHIC REPRESENTATION



KEY TO SAMPLE TYPES:
B - BULK SAMPLE (DISTURBED)
R - RING SAMPLE 2-1/2" DIAMETER (RELATIVELY UNDISTURBED)

TRENCH LOG

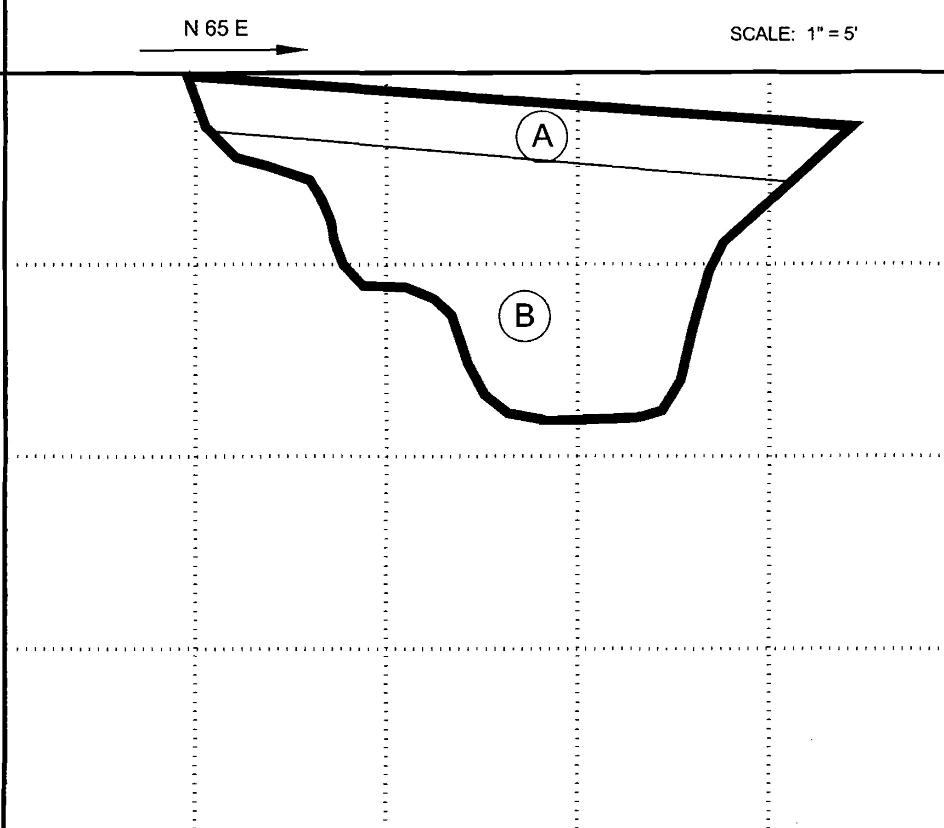
Southern California Geotechnical

TRENCH NO. T-5

JOB NO.: 05G290	EQUIPMENT USED: Excavator	WATER DEPTH: None
PROJECT: Commercial/Industrial Development	LOGGED BY: Daryl Kas	SEEPAGE DEPTH: Dry
LOCATION: Perris, CA	ORIENTATION: N 65 E	READINGS TAKEN: at Completion
DATE: 12/7/2005	ELEVATION: 1613	

DEPTH	SAMPLE	DRY DENSITY (PCF)	MOISTURE (%)	EARTH MATERIALS DESCRIPTION
	b			A: ALLUVIUM: Brown Silty fine to medium Sand, loose to medium dense-dry
	b			B: BEDROCK: Orange Brown to Gray Quartz Diorite, phaneritic, friable, weathered, abundant Iron oxide staining, mafic inclusion, very dense-dry
5	b			@ 3 feet, becomes less weathered
	b			
10				Trench Terminated at 9' due to very dense bedrock
15				

GRAPHIC REPRESENTATION



KEY TO SAMPLE TYPES:
B - BULK SAMPLE (DISTURBED)
R - RING SAMPLE 2-1/2" DIAMETER (RELATIVELY UNDISTURBED)

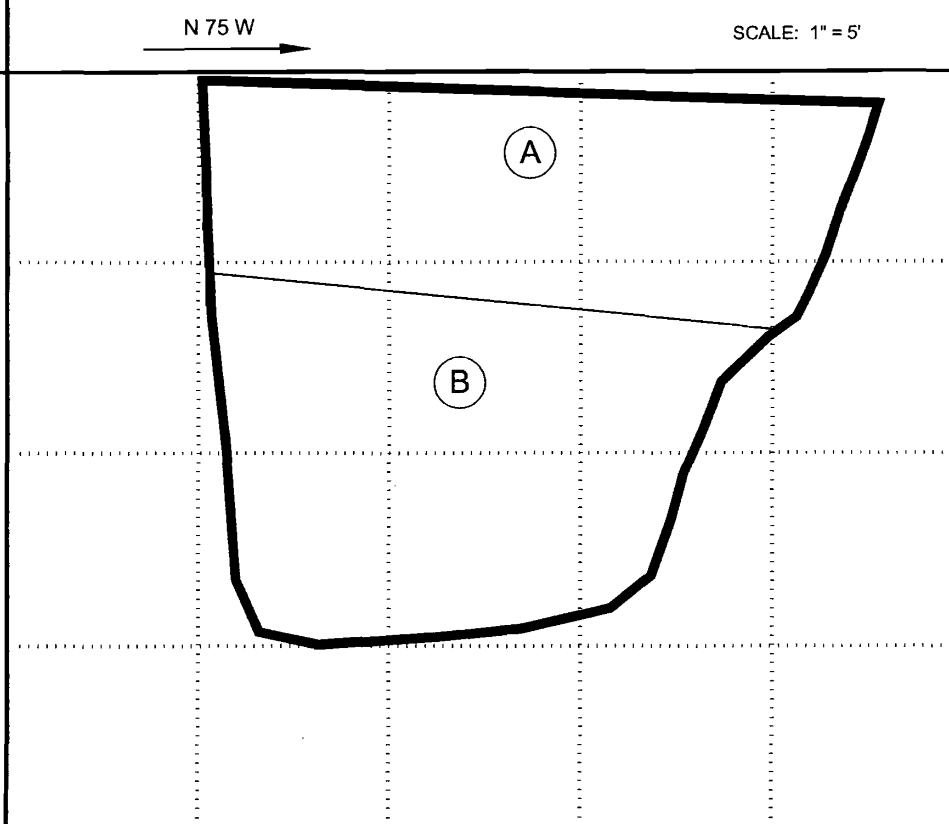
Southern California Geotechnical

TRENCH NO. T-6

JOB NO.: 05G290	EQUIPMENT USED: Excavator	WATER DEPTH: None
PROJECT: Commercial/Industrial Development	LOGGED BY: Daryl Kas	SEEPAGE DEPTH: Dry
LOCATION: Perris, CA	ORIENTATION: N 75 W	READINGS TAKEN: at Completion
DATE: 12/7/2005	ELEVATION: 1627	

DEPTH	SAMPLE	DRY DENSITY (PCF)	MOISTURE (%)	EARTH MATERIALS DESCRIPTION
0–5	b (~1'), b (~5')			A: ALLUVIUM: Brown Clayey fine to medium Sand, dense-dry
5–14	b (~12'), b (~13.5')			B: BEDROCK: Orange Brown to Gray Quartz Diorite, phaneritic, friable, weathered, Iron oxide staining, very dense-dry
14				Trench Terminated at 14' due to very dense bedrock

GRAPHIC REPRESENTATION



KEY TO SAMPLE TYPES:
B - BULK SAMPLE (DISTURBED)
R - RING SAMPLE 2-1/2" DIAMETER (RELATIVELY UNDISTURBED)

TRENCH LOG

Southern California Geotechnical

TRENCH NO. T-7

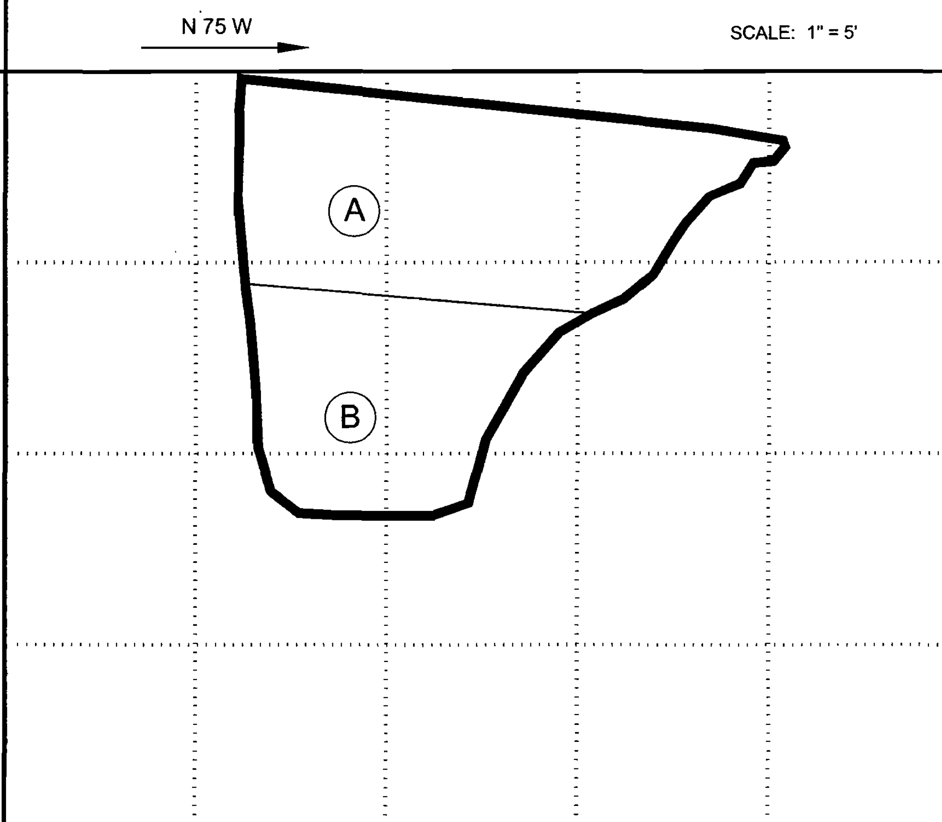
JOB NO.: 05G290
PROJECT: Commercial/Industrial Development
LOCATION: Perris, CA
DATE: 12/7/2005

EQUIPMENT USED: Excavator
LOGGED BY: Daryl Kas
ORIENTATION: N 75 W
ELEVATION: 1620

WATER DEPTH: None
SEEPAGE DEPTH: Dry
READINGS TAKEN: at Completion

DEPTH	SAMPLE	DRY DENSITY (PCF)	MOISTURE (%)	EARTH MATERIALS DESCRIPTION
	b			A: ALLUVIUM: Brown Clayey fine to medium Sand, medium dense-dry to damp
5	b			B: BEDROCK: Brown Quartz Diorite, phaneritic, friable,very weathered, some Iron oxide staining, very dense-dry
	b			
10				Trench Terminated at 10' due to very dense bedrock
15				

GRAPHIC REPRESENTATION



KEY TO SAMPLE TYPES:
B - BULK SAMPLE (DISTURBED)
R - RING SAMPLE 2-1/2" DIAMETER
(RELATIVELY UNDISTURBED)

TRENCH LOG

PLATE B-7

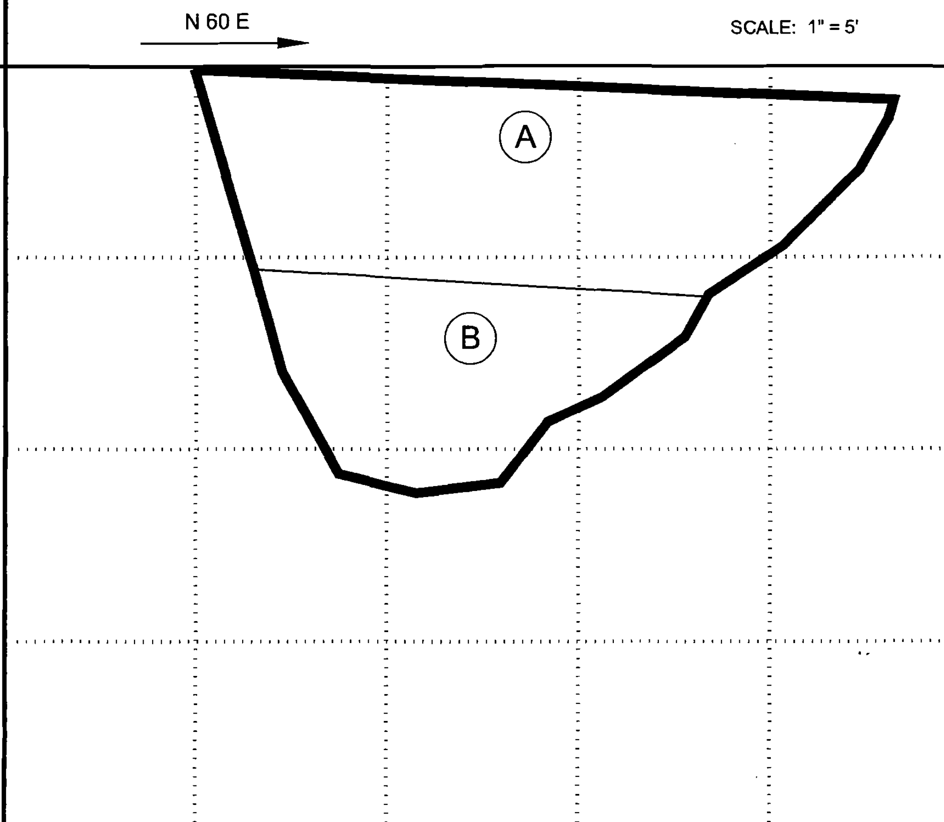
Southern California Geotechnical

TRENCH NO.
T-8

JOB NO.: 05G290	EQUIPMENT USED: Excavator	WATER DEPTH: None
PROJECT: Commercial/Industrial Development	LOGGED BY: Daryl Kas	SEEPAGE DEPTH: Dry
LOCATION: Perris, CA	ORIENTATION: N 60 E	READINGS TAKEN: at Completion
DATE: 12/7/2005	ELEVATION: 1665	

DEPTH	SAMPLE	DRY DENSITY (PCF)	MOISTURE (%)	EARTH MATERIALS DESCRIPTION
				A: ALLUVIUM: Brown fine to medium Sand, trace Clay, medium dense-damp
	b			B: BEDROCK: Brown to Gray Brown Quartz Diorite, phaneritic, friable, weathered, some Iron oxide staining, very dense-dry
5				
10				
	b			
				Trench Terminated at 12'
15				

GRAPHIC REPRESENTATION



KEY TO SAMPLE TYPES:
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R - RING SAMPLE 2-1/2" DIAMETER
(RELATIVELY UNDISTURBED)

TRENCH LOG

PLATE B-8

SEISMIC REFRACTION SURVEY

TWO PROPOSED WAREHOUSE BUILDINGS PROJECT

PERRIS, RIVERSIDE COUNTY, CALIFORNIA

Project No. 142733-1

August 13, 2014

Prepared for:

Southern California Geotechnical, Inc.
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Consulting Engineering Geology & Geophysics

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Southern California Geotechnical, Inc.
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Yorba Linda, California 92887

Attention: Mr. Daryl R. Kas, Project Geologist

Regarding: Seismic Refraction Survey
Two Proposed Warehouse Buildings Project
Perris, Riverside County, California
SCG Project No. 14G174-1

INTRODUCTION

As requested, this firm has performed a geophysical survey using the seismic refraction method for the above-referenced site. The purpose of this investigation was to assess the general seismic velocity characteristics of the underlying earth materials and to evaluate whether high velocity earth materials (non-rippable) are present which could possibly indicate areas of potential excavation difficulties, and also to aid in evaluating the subsurface structure and seismic velocity distribution. The local earth materials that surficially mantle the site have been mapped by Morton (2003) to consist of very old alluvial fan deposits (early Pleistocene age) comprised of well-indurated sand deposits, directly underlain by Cretaceous age granitic rocks (locally referred to as the Val Verde tonalite) consisting of a gray-weathering, relatively homogeneous, massive to well-foliated, medium- to coarse-grained, biotite hornblende tonalite.

As requested, the locations of the seismic survey lines have been approximated on a captured Google™ Earth image (Google™ Earth, 2013) which is presented as the Seismic Line Location Map, Plate 1. As authorized by you, the following services were performed during this study:

- ***Review of available published and unpublished geologic/geophysical data in our files pertinent to the site.***
- ***Performing a geophysical survey by a State of California licensed Professional Geophysicist; to include ten seismic refraction traverses.***
- ***Preparation of this report, presenting our findings and conclusions with respect to the bedrock velocity characteristics and the expected excavation potentials.***

Accompanying Map and Appendices

Plate 1 - Seismic Line Location Map
Appendix A - Layer Velocity Models
Appendix B - Refraction Tomographic Models
Appendix C - Excavation Considerations
Appendix D - References

SEISMIC REFRACTION SURVEY

Methodology

The seismic refraction method consists of measuring (at known points along the surface of the ground) the travel times of compressional waves generated by an impulsive energy source and can be used to estimate the layering, structure, and seismic acoustic velocities of subsurface horizons. Seismic waves travel down and through the soils and rocks, and when the wave encounters a contact between two earth materials having different velocities, some of the wave's energy travels along the contact at the velocity of the lower layer. The fundamental assumption is that each successively deeper layer has a velocity greater than the layer immediately above it. As the wave travels along the contact, some of the wave's energy is refracted toward the surface where it is detected by a series of motion-sensitive transducers (geophones). The arrival time of the seismic wave at the geophone locations can be related to the relative seismic velocities of the subsurface layers in feet per second (fps), which can then be used to aid in interpreting both the depth and type of materials encountered.

Field Procedures

Ten 200-foot long seismic refraction survey lines (Seismic Lines S-1 through S-10) were performed along representative areas as delineated by your firm. The traverses were located in the field by use of GPS coordinates and Google™ Earth (2013) imagery. Twenty-four 14-Hertz geophones spaced at eight-foot intervals were employed on each line to detect both the direct and refracted waves, with a 16-pound sledge-hammer being used as the energy source to produce the seismic waves. The seismic wave arrivals were digitally recorded in SEG-2 format on a Geometrics StrataVisor™ NZXP model signal enhancement refraction seismograph. Seven shot points were utilized along each spread using forward, reverse, and several intermediate locations in order to obtain high resolution survey data for velocity analysis and depth modeling purposes. The data was acquired using a sampling rate of 0.0625 milliseconds having a record length of 0.07 seconds with no acquisition filters. During acquisition, the seismograph displays the seismic wave arrivals on the computer screen which were used to analyze the arrival time of the primary seismic “P”-waves at each geophone station, in the form of a wiggle trace for quality control purposes in the field. Each geophone and seismic shot location was surveyed using a hand level and ruler for relative topographic correction, with “0” representing the lowest point along the survey line.

Data Processing

All of the recorded seismic data was subsequently transferred to our office computer for further processing, analyzing, and printing purposes, using the computer programs **SIPwin** (**S**eismic Refraction **I**nterpretation **P**rogram for **Win**dows) developed by Rimrock Geophysics, Inc. (2004); **Refractor** (Geogiga, 2001-2013); and **Rayfract™** (Intelligent Resources, Inc., 1996-2014). All of the computer programs perform their analysis using exactly the same input data which includes the first-arrival “P”-waves and survey line geometry.

- **SIPwin** is a ray-trace modeling program that evaluates the subsurface using layer assignments based on time-distance curves and is better suited for layered media, using the "Seismic Refraction Modeling by Computer" method (Scott, 1973). The first step in the modeling procedure is to compute layer velocities by least-squares techniques. Then the program uses the delay-time method to estimate depths to the top of layer-2. A forward modeling routine traces rays from the shot points to each geophone that received a first-arrival ray refracted along the top of layer-2. The travel time of each such ray is compared with the travel time recorded in the field by the seismic system. The program then adjusts the layer-2 depths so as to minimize discrepancies between the computed ray-trace travel times and the first arrival times picked from the seismic waveform record. The process of ray tracing and model adjustment is repeated a total of six times to improve the accuracy of depths to the top of layer-2. This first-arrival picks were then used to generate the Layer Velocity Models using the **SIPwin** computer program, which presents the subsurface velocities as individual layers and are presented within Appendix A for reference. In addition, the associated Time-Distance Plot for the survey lines which shows the individual data picks of the first "P-wave" arrival times, also appears in Appendix A.

- **Refractor** is seismic refraction software that also evaluates the subsurface using layer assignments utilizing interactive and interchangeable analytical methods that include the Delay-Time method, the ABC method, and the Generalized Reciprocal Method (GRM). These methods are used for defining irregular non-planar refractors and are briefly described below. The <u>Delay-Time</u> method will measure the delay time depth to a refractor beneath each geophone rather than at shot points. Delay-time is the time spent by a wave to travel up or down through the layer (slant path) compared to the time the wave would spend if traveling along the projection of the slant path on the refractor. The <u>ABC</u> (intercept time) method makes use of critically refracted rays converging on a common surface position. This method involves using three surface to surface travel times between three geophones and the velocity of the first layer in an equation to calculate depth under the central geophone and is applied to all other geophones on the survey line. The <u>GRM</u> method is a technique for delineating undulating refractors at any depth from in-line seismic refraction data consisting of forward and reverse travel-times and is capable of resolving dips of up to 20% and does not over-smooth or average the subsurface refracting layers. In addition, the technique provides an approach for recognizing and compensating for hidden layer conditions.

- **Rayfract™** is seismic refraction tomography software that models subsurface refraction, transmission, and diffraction of acoustic waves which generally indicates the relative structure and velocity distribution of the subsurface using first break energy propagation modeling. An initial 1D gradient model is created using the DeltatV method (Gebrande and Miller, 1985) which gives a good initial fit between modeled and picked first breaks. The DeltatV method is a turning-ray inversion method which delivers continuous depth vs. velocity profiles for all profile stations. These profiles consist of horizontal inline offset, depth, and velocity triples. The method handles real-life geological conditions such as velocity gradients, linear increasing of velocity with depth, velocity inversions, pinched-out layers and outcrops, and faults and local velocity anomalies. This initial model is then refined automatically with a true 2D WET (Wavepath Eikonal Traveltime) tomographic inversion (Schuster and Quintus-Bosz, 1993).

WET tomography models multiple signal propagation paths contributing to one first break, whereas conventional ray tracing tomography is limited to the modeling of just one ray per first break. This computer program performs the analysis by using the same first-arrival P-wave times and survey line geometry that were generated during the layer velocity model analyses. The associated Refraction Tomographic Models which display the subsurface earth material velocity structure, is represented by the velocity contours (isobars displayed in feet/second), supplemented with the color-coded velocity shading for visual reference, and are presented within Appendix B.

The combined use of these computer programs provided a more thorough and comprehensive analysis of the subsurface structure and velocity characteristics. Each computer program has a specific purpose based on the objective of the analysis being performed. **SIPwin** and **Refractor** were primarily used for detecting generalized subsurface velocity layers providing “weighted average velocities.” The processed seismic data of these two programs were compared and averaged to provide a final composite layer velocity model which provided a more thorough representation of the subsurface. **Rayfract™** provided tomographic velocity and structural imaging that is very conducive to detecting strong lateral velocity characteristics such as imaging corestones, dikes, and other subsurface structural characteristics.

SUMMARY OF GEOPHYSICAL INTERPRETATION

To begin our discussion, it is important to consider that the seismic velocities obtained within bedrock materials are influenced by the nature and character of the localized major structural discontinuities (foliation, fracturing, relic bedding, etc.), creating anisotropic conditions. Anisotropy (direction-dependent properties of materials) can be caused by “micro-cracks,” jointing, foliation, layered or inter-bedded rocks with unequal layer stiffness, small-scale lithologic changes, etc (Barton, 2007). Velocity anisotropy complicates interpretation and it should be noted that the seismic velocities obtained during this survey may have been influenced by the nature and character of any localized structural discontinuities within the bedrock underlying the subject site. Generally, it is expected that higher (truer) velocities will be obtained when the seismic waves propagate along direction (strike) of the dominant structure, with a damping effect when the seismic waves travel in a perpendicular direction. Such variable directions can result in velocity differentials of between 2% to 40% depending upon the degree of the structural fabric (i.e., weakly-moderately-strongly foliated, respectively). Therefore, the seismic velocities obtained during our field study and as discussed below, should be considered *minimum* velocities at this time.

The first method described below used for data analysis is the traditional layer method (**SIPwin** and **Refractor**). Using this method, it should be understood that the data obtained represents an average of seismic velocities within any given layer. For example, high seismic velocity boulders, dikes, or other local lithologic inconsistencies, may be isolated within a low velocity matrix, thus yielding an average medium velocity for that layer. Therefore, in any given layer, a range of velocities could be anticipated, which can also result in a wide range of excavation characteristics. In general, the site where locally surveyed was noted to be characterized by three major subsurface layers with respect to seismic velocities. The following layer summaries have been prepared using the **SIPwin** and **Refractor** analysis, with the representative Layer Velocity Models presented within Appendix A along with their respective Time-Distance Plots.

- **Velocity Layer V1**:

  This uppermost velocity layer (V1) is most likely comprised of topsoil, colluvium, older alluvial sediments, and/or completely-weathered and fractured bedrock materials. This layer has an average weighted velocity of 1,577 to 2,260 fps, which is typical for these types of unconsolidated surficial earth materials.

- **Velocity Layer V2**:

  The second layer (V2) yielded a seismic velocity range of 3,514 to 5,012 fps, which is typical for highly-weathered bedrock materials. This velocity range may indicate the presence of homogeneous weathered bedrock with a relatively wide spaced joint/fracture system and/or the possibility of buried relatively-fresher boulders within a very-highly decomposed bedrock matrix. Additionally, the presence of older alluvial sediments, such as mapped by Morton (2001), may also be locally present based upon the degree of sediment induration.

- **Velocity Layer V3**:

  The third layer (V3) indicates the presence of slightly-weathered granitic bedrock, having a seismic velocity range of 8,743 to 16,858 fps. These higher velocities signify the decreasing effect of weathering as a function of depth and could indicate the presence of abundant widely-scattered buried fresh large crystalline boulders in highly-weathered matrix, or possibly a relatively fresher crystalline, slightly-weathered bedrock matrix, that has a wide-spaced fracture system.

Using **Rayfract™**, tomographic models were also prepared for comparative purposes to better illustrate the general structure and velocity distribution of the subsurface, as presented within Appendix B. Although no discrete velocity layers or boundaries are created, these models generally resemble the corresponding overall average layer velocities as presented within Appendix A. In general, the seismic velocity of the bedrock and/or alluvial deposits gradually increases with depth, with numerous strong lateral velocity differentials suggesting the presence of buried corestones and/or dike structures. The colors representing the velocity gradients have been standardized on all of the models for comparative purposes.

GENERALIZED RIPPABILITY CHARACTERISTICS OF BEDROCK

A summary of the generalized rippability characteristics of bedrock based on a compilation of rippability performance charts prepared by Caterpillar, Inc. (2004), Caltrans (Stephens, 1978), and Santi (2006), has been provided to aid in evaluating potential excavation difficulties with respect to the seismic velocities obtained along the local areas surveyed. These seismic velocity ranges and rippability potentials have been tabulated below for reference.

TABLE 1- CATERPILLAR RIPPABILITY CHART (D9 Ripper)

Granitic Rock Velocity	Rippability
< 6,800	Rippable
6,800 – 8,000	Moderately Rippable
> 8,000	Non-Rippable

Additionally, we have provided the Caltrans Rippability Chart as presented below within Table 2 for comparison. These values are from published Caltrans studies (Stephens, 1978) that are based on their experience which are more conservative than Caterpillar's rippability charts. It should be noted that the type of bedrock was not indicated.

TABLE 2- STANDARD CALTRANS RIPPABILITY CHART

Velocity (feet/sec ±)	Rippability
< 3,500	Easily Ripped
3,500 – 5,000	Moderately Difficult
5,000 – 6,600	Difficult Ripping / Light Blasting
> 6,600	Blasting Required

Table 3 is partially modified from the "Engineering Behavior from Weathering Grade" as presented by Santi (2006), which also provides velocity ranges with respect to rippability potentials, along with other rock engineering properties that may be pertinent.

TABLE 3- SUMMARY OF ROCK ENGINEERING PROPERTIES

ENGINEERING PROPERTY:	Slightly Weathered	Moderately Weathered	Highly Weathered	Completely Weathered
Excavatability	Blasting necessary	Blasting to rippable	Generally rippable	Rippable
Slope Stability	½ :1 to 1:1 (H:V)	1:1 (H:V)	1:1 to 1.5:1 (H:V)	1.5:1 to 2:1 (H:V)
Schmidt Hammer Value	51 – 56	37 – 48	12 – 21	5 – 20
Seismic Velocity (fps)	8,200 – 13,125	5,000 – 10,000	3,300 – 6,600	1,650 – 3,300

Additionally, as presented below on Figure 1, the Caterpillar D9R Ripper Performance Chart (Caterpillar, 2012) has been provided for reference.

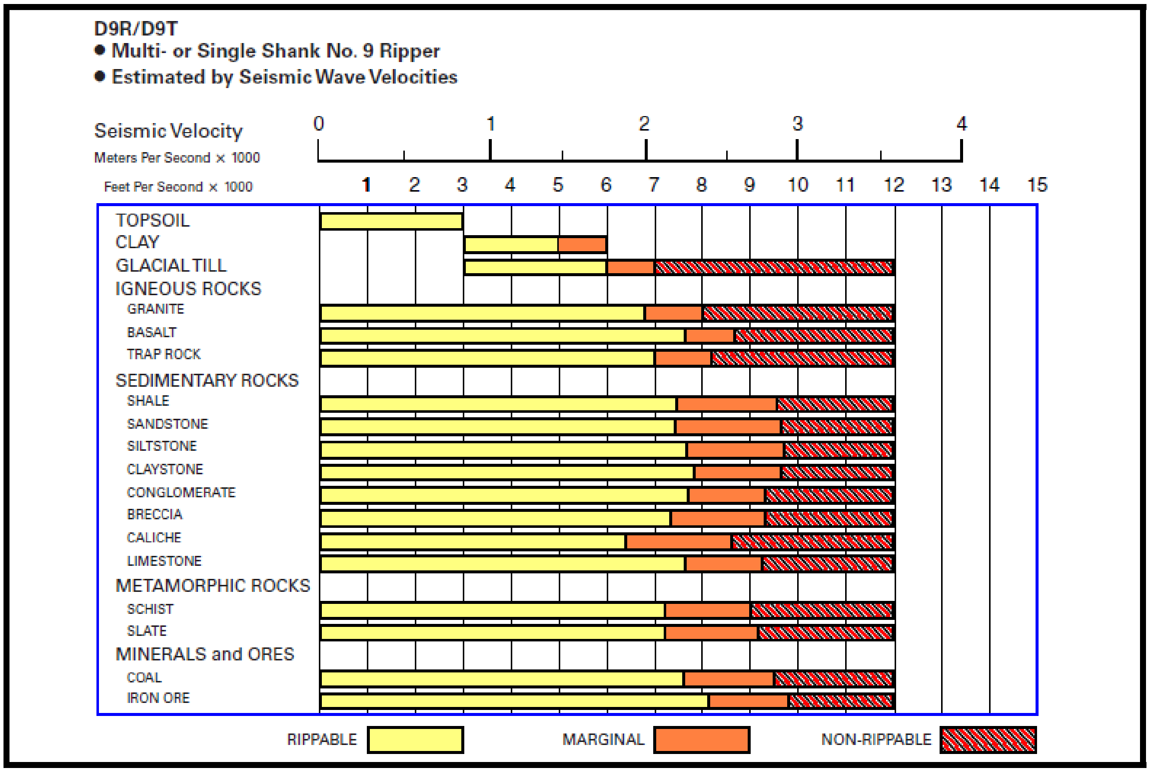


FIGURE 1- Caterpillar D9R Ripper Performance Chart

For purposes of the discussion in this report with respect to the expected bedrock rippability characteristics, we are assuming that a D9R/D9T dozer will be used as a minimum, such as illustrated above. Smaller excavating equipment will most likely result in slower production rates and possible refusal within relatively lower velocity bedrock materials. It should be noted that the decision for blasting of bedrock materials for facilitating the excavation process is sometimes made based upon economic production reasons and not solely on the rippability (velocity/hardness) characteristics of the bedrock.

A summary of the generalized rippability characteristics of granitic bedrock has been provided to aid in evaluating potential excavation difficulties with respect to the seismic velocities obtained along the local area surveyed. The velocity ranges described below are approximate and assume typical, good-working, heavy excavation equipment, such as single shank D9R dozer, such as described by Caterpillar, Inc. (2000 and 2012); however, different excavating equipment (i.e., trenching equipment) <u>may not</u> correlate well with these velocity ranges. Trenching operations which utilize large excavator-type equipment within granitic bedrock materials, typically encounter very difficult to non-productable conditions where seismic velocities are generally greater than 4,000± fps, and less for smaller backhoe-type equipment.

- **<u>Rippable Condition (0 - 4,000 ft/sec)</u>**:

  This velocity range indicates rippable materials which may consist of alluvial-type deposits and decomposed granitic bedrock, with random hardrock floaters. These materials typically break down into silty sands (depending on parent lithologic materials), whereas floaters will require special disposal. Some areas containing numerous hardrock floaters may present utility trench problems. Large floaters exposed at or near finished grade may present problems for footing or infrastructure trenching.

- **<u>Marginally Rippable Condition (4,000 - 7,000 ft/sec)</u>**:

  This range of seismic velocities indicates materials which may consist of moderately weathered bedrock and/or large areas of fresh bedrock materials separated by weathered fractured zones. These bedrock materials are generally rippable with difficulty by a Caterpillar D9R or equivalent. Excavations may produce material that will partially break down into a coarse, silty to clean sand, with a high percentage of very coarse sand to pebble-sized material depending on the parent bedrock lithology. Less fractured or weathered materials will probably require blasting to facilitate removal.

- **<u>Non-Rippable Condition (7,000 ft/sec or greater)</u>**:

  This velocity range includes non-rippable material consisting primarily of moderately fractured bedrock at lower velocities and only slightly fractured or unfractured rock at higher velocities. Materials in this velocity range may be marginally rippable, depending upon the degree of fracturing and the skill and experience of the operator. Tooth penetration is often the key to ripping success, regardless of seismic velocity. If the fractures and joints do not allow tooth penetration, the material may not be ripped effectively; however, pre-blasting or "popping" may induce sufficient fracturing to permit tooth entry. In their natural state, materials with these velocities are generally not desirable for building pad grade, due to difficulty in footing and utility trench excavation. Blasting will most likely produce oversized material, requiring special disposal.

GEOLOGIC & EARTHWORK CONSIDERATIONS

To evaluate whether a particular bedrock material can be ripped or excavated, this geophysical survey should be used in conjunction with the geologic and/or geotechnical report and/or information gathered for the subject project which may describe the physical properties of the bedrock. The physical characteristics of bedrock materials that favor ripping generally include the presence of fractures, faults, and other structural discontinuities, weathering effects, brittleness or crystalline structure, stratification or lamination, large grain size, moisture permeated clay, and low compressive strength. If the bedrock is foliated and/or fractured at depth, this structure could aid in excavation production.

Unfavorable bedrock conditions can include such characteristics as massive and homogeneous formations, non-crystalline structure, absence of planes of weakness, fine-grained materials, and formations of clay origin where moisture makes the material plastic. Use of these physical bedrock conditions along with the subsurface velocity characteristics as presented within this report should aid in properly evaluating the type of equipment that will be necessary and the production levels that can be anticipated for this project. A summary of excavation considerations is included within Appendix C in order to provide you with a better understanding of the complexities of excavation in bedrock materials. These concepts should be understood so that proper planning and excavation techniques can be employed by the selected grading contractor.

SUMMARY OF FINDINGS AND CONCLUSIONS

The raw field data was considered to be of good quality which minor amounts of ambient “noise” that was introduced during our survey, most likely from the nearby vehicular along the 215 Freeway, local air traffic, and also truck traffic from the adjacent warehouse buildings to the west. Analysis of the data and picking of the primary “P”-wave arrivals was performed with little difficulty, with only minor interpolation of data being necessary. Based on the results of our comparative seismic analyses of the computer programs **SIPwin**, **Refractor**, and **Rayfract™**, the seismic refraction survey line models appear to generally coincide with one another, with some minor variances due to the methods that these programs process and integrate the input data. The anticipated excavation potentials of the velocity layers encountered locally during our survey are as follows:

- **Velocity Layer V1**:

  No excavating difficulties are expected to be encountered within the uppermost, low-velocity layer V1 (average weighted velocity of 1,577 to 2,260 fps) and should excavate with conventional ripping. This layer is expected to be comprised of topsoil, colluvium, older alluvial sediments, and/or completely-weathered and fractured bedrock materials. Localized boulders should be anticipated based on surficial exposures, which may require more significant excavation techniques.

- **Velocity Layer V2**:

  The second layer V2 (average weighted velocity of 3,514 to 5,012 fps) is believed to consist of highly weathered granitic bedrock (within higher end of velocity range) and/or possibly older alluvial sediments (within lower end of velocity range). Using the rock classifications as presented within Tables 1 through 3, seismic wave velocities of less than 6,800± fps are generally noted to be within the threshold for conventional ripping. Isolated floaters (i.e., boulders, corestones, etc.) should be expected to be present within this layer and could produce somewhat difficult conditions locally. Placement of infrastructure within this velocity layer may require some breaking and/or light blasting to obtain desired grade.

- **Velocity Layer V3**:

  The third layer V3 is believed to consist of slightly-weathered bedrock. Very hard excavation difficulties within this deeper velocity layer (average weighted velocity range of 8,743 to 16,858 fps) are anticipated. This layer may consist of relatively fresher homogeneous bedrock, or may contain higher velocity scattered boulders, dikes, and other lithologic variables, within a relatively lower velocity bedrock matrix. Continuous blasting will most likely be required within this velocity layer to achieve desired grade, including any infrastructure.

The ray sampling coverage of the subsurface seismic waves that were acquired during the processing of the tomographic models appeared to be of very good quality which was verified by having a Root Mean Square Error (RMS) of 0.7 to 1.9 percent (see lower right-hand corner of each model). The RMS error (misfit between picked and modeled first break times) is automatically calculated during the processing routine, with a value of less than 2.0% being preferred, of which all of the models obtained. Based on the tomographic models and typical excavation characteristics observed within granitic bedrock of the southern California region, anticipation of gradual increasing hardness with depth should be anticipated during grading. Significant lateral velocity variations will most likely be encountered across the predominance of the site generally due to the presence of buried corestones and/or dikes such as imaged in some of the tomographic refraction modes and as also expressed as scattered outcrops across the subject site.

CLOSURE

The field geophysical survey was performed by the undersigned on August 6 and 7, 2014 using "state of the art" geophysical equipment and techniques along the selected portions of the subject study area as directed by you. The seismic data was further evaluated using recently developed tomographic inversion techniques to provide a more thorough analysis and understanding of the subsurface structural conditions. It should be noted that our data was obtained along only ten specific locations therefore other areas in the local vicinity beyond the limits of our seismic lines may contain different velocity layers and depths not encountered during our field survey. Additional survey traverses may be necessary to further evaluate the excavation characteristics across other portions of the site where cut grading will be proposed.

In summary, the results of this seismic refraction survey are to be considered as an aid to assessing the rippability and excavation potentials of the bedrock locally. This information should be carefully reviewed by the grading contractor and representative “test” excavations with the proposed type of excavation equipment for the proposed construction should be considered, so that they may be correlated with the data presented within this report. Estimates of layer velocity boundaries as presented in this report are generally considered to be within 10± percent of the total depth of the contact.

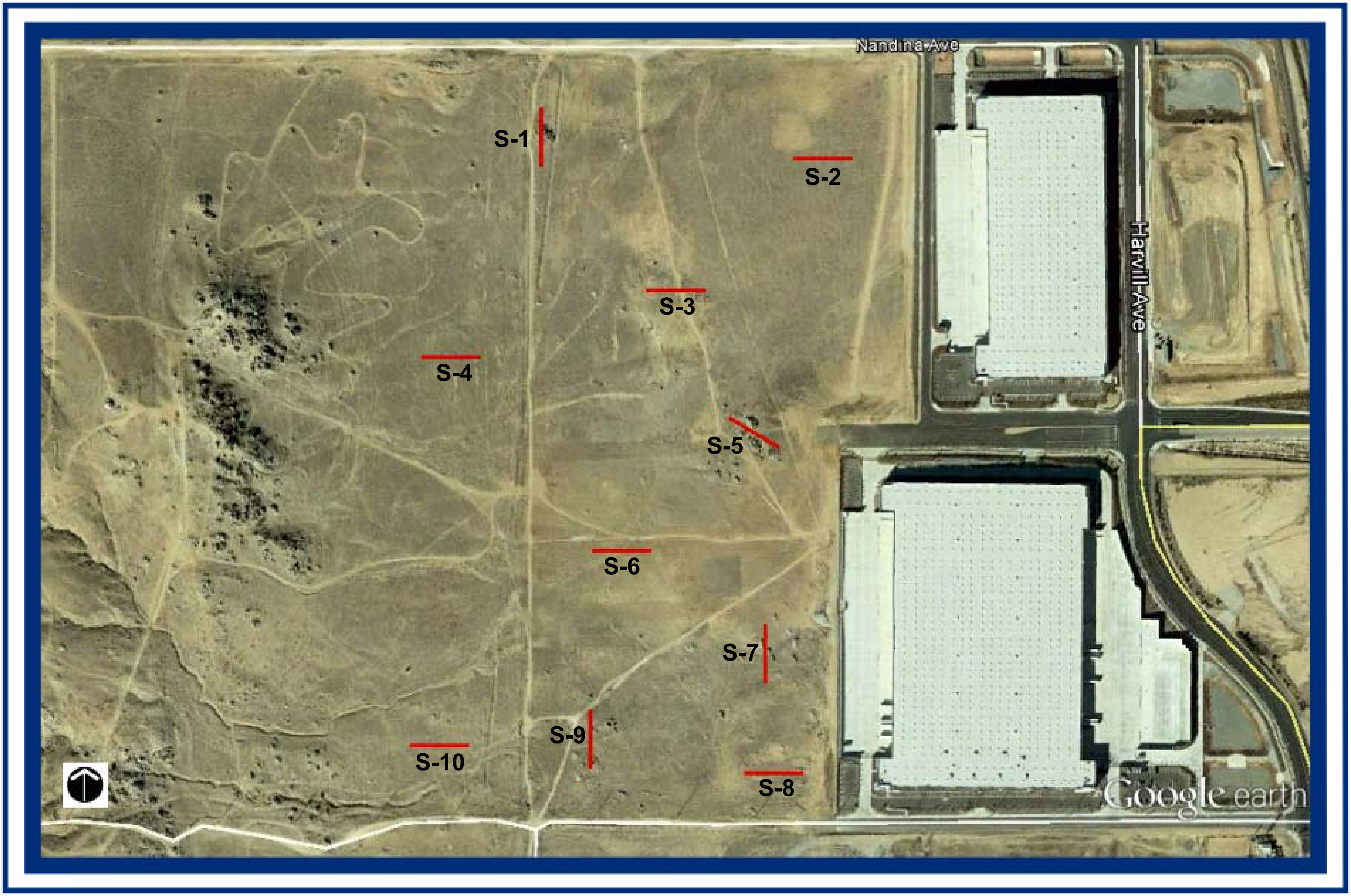
It is important to understand that the fundamental limitation for seismic refraction surveys is known as nonuniqueness, wherein a specific seismic refraction data set does not provide sufficient information to determine a single "true" earth model. Therefore, the interpretation of any seismic data set uses "best-fit" approximations along with the geologic models that appear to be most reasonable for the local area being surveyed. Client should also understand that when using the theoretical geophysical principles and techniques discussed in this report, sources of error are possible in both the data obtained and in the interpretation and that the results of this survey may not represent actual subsurface conditions. These are all factors beyond **Terra Geosciences** control and no guarantees as to the results of this survey can be made. We make no warranty, either expressed or implied.

This opportunity to be of service is sincerely appreciated. If you should have any questions regarding this report or do not understand the limitations of this study or the data and results that are presented, please do not hesitate to contact our office at your earliest convenience.

Respectfully submitted,
TERRA GEOSCIENCES

Donn C. Schwartzkopf
Principal Geophysicist
PGP 1002

SEISMIC LINE LOCATION MAP



PROJECT NO. 142733-1

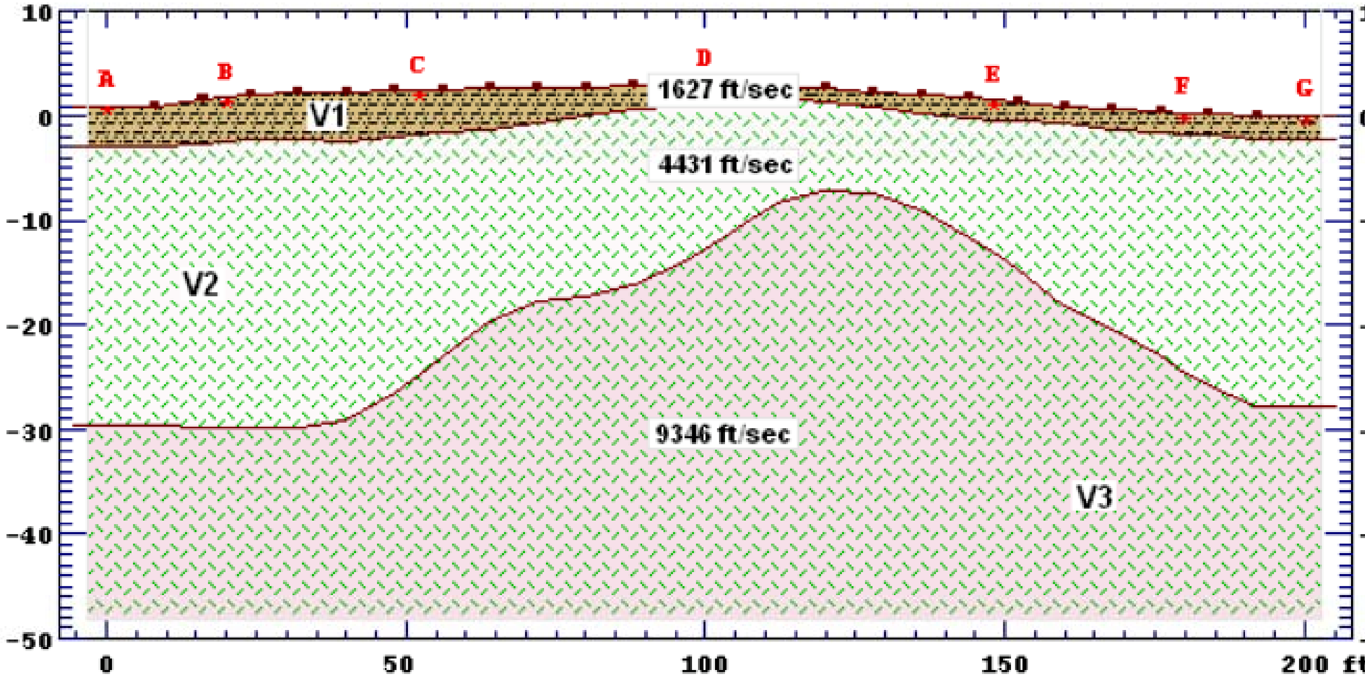
PLATE 1

APPENDIX A

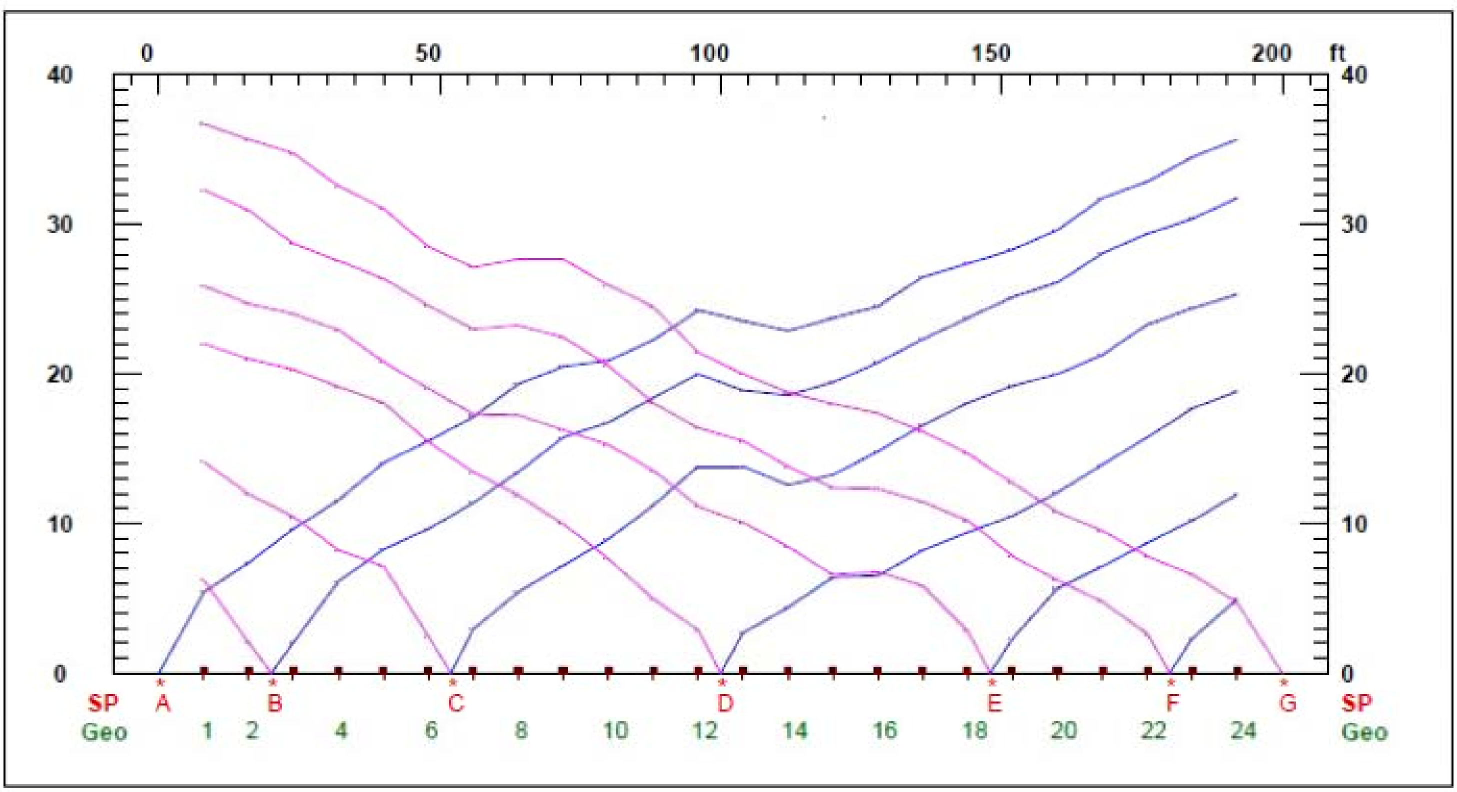
LAYER VELOCITY MODELS

SEISMIC LINE S-1
< South - North >

LAYER VELOCITY MODEL



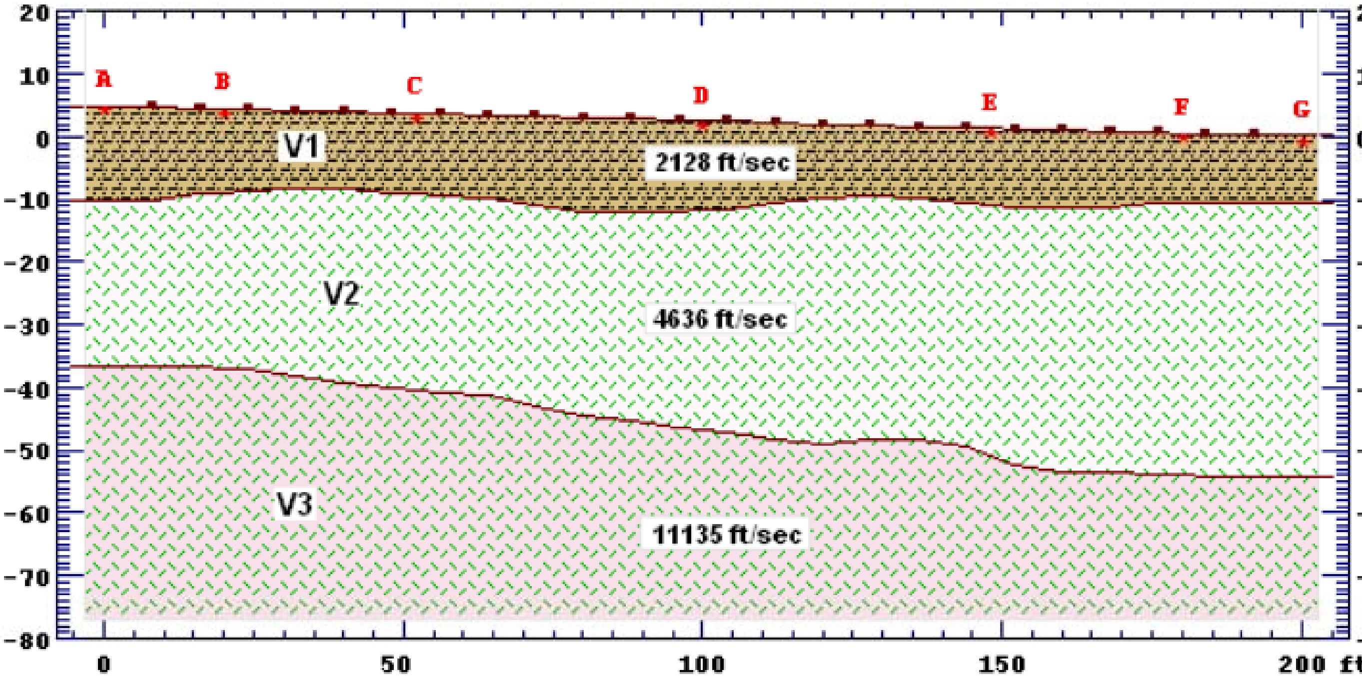
TIME-DISTANCE PLOT



SEISMIC LINE S-2

< West - East >

LAYER VELOCITY MODEL



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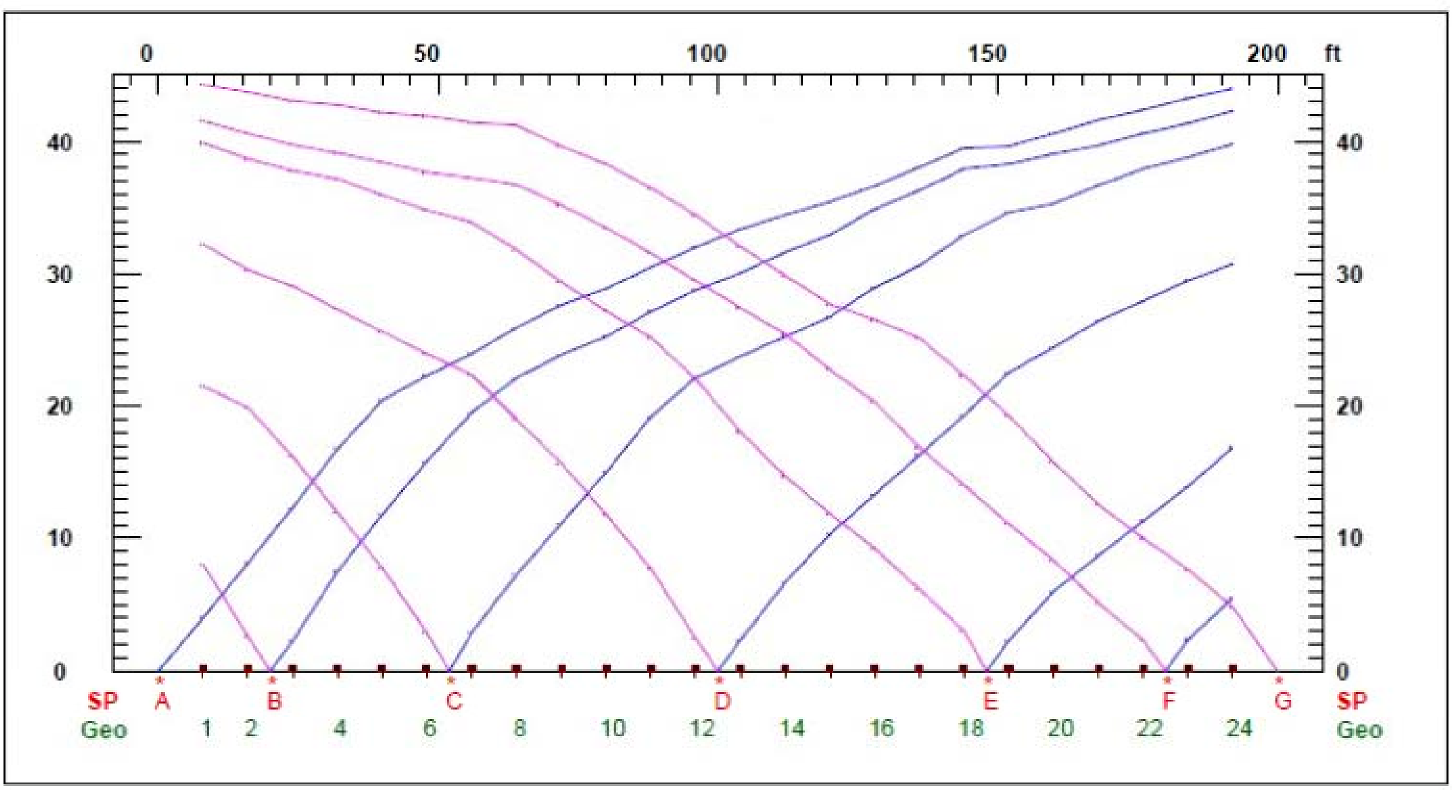
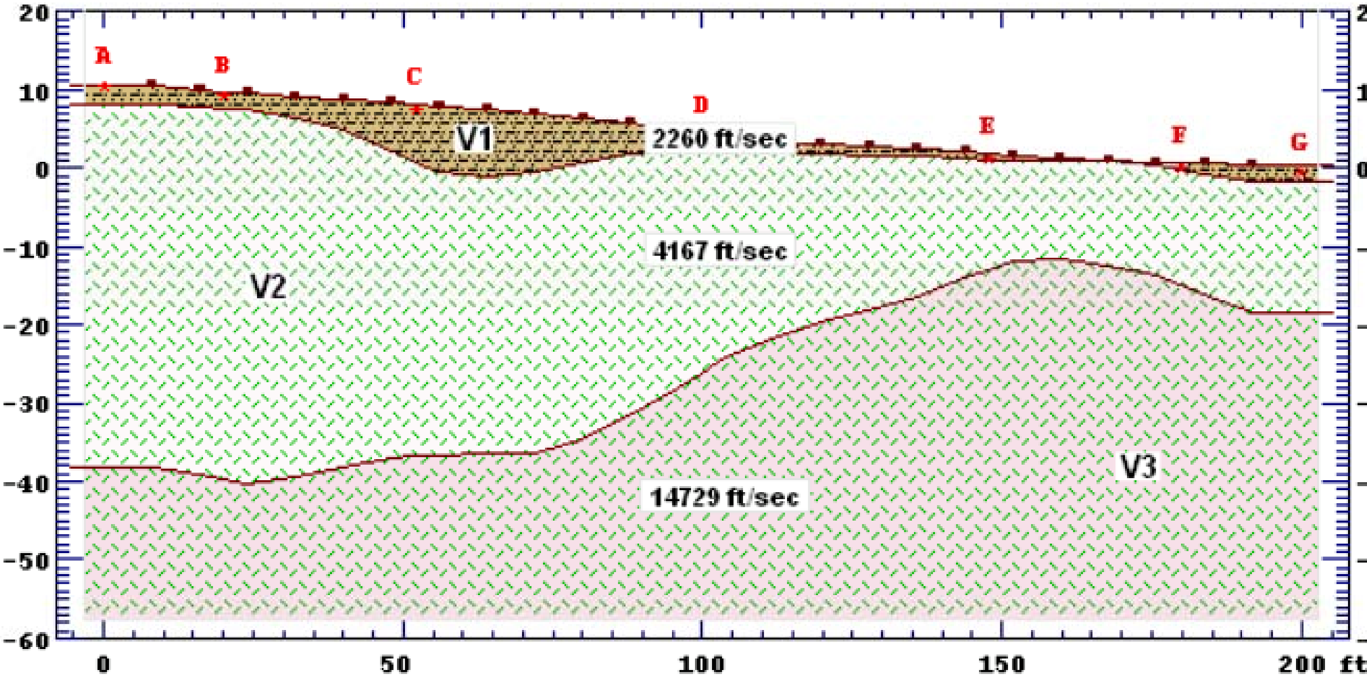


SEISMIC LINE S-3
< West - East >

LAYER VELOCITY MODEL



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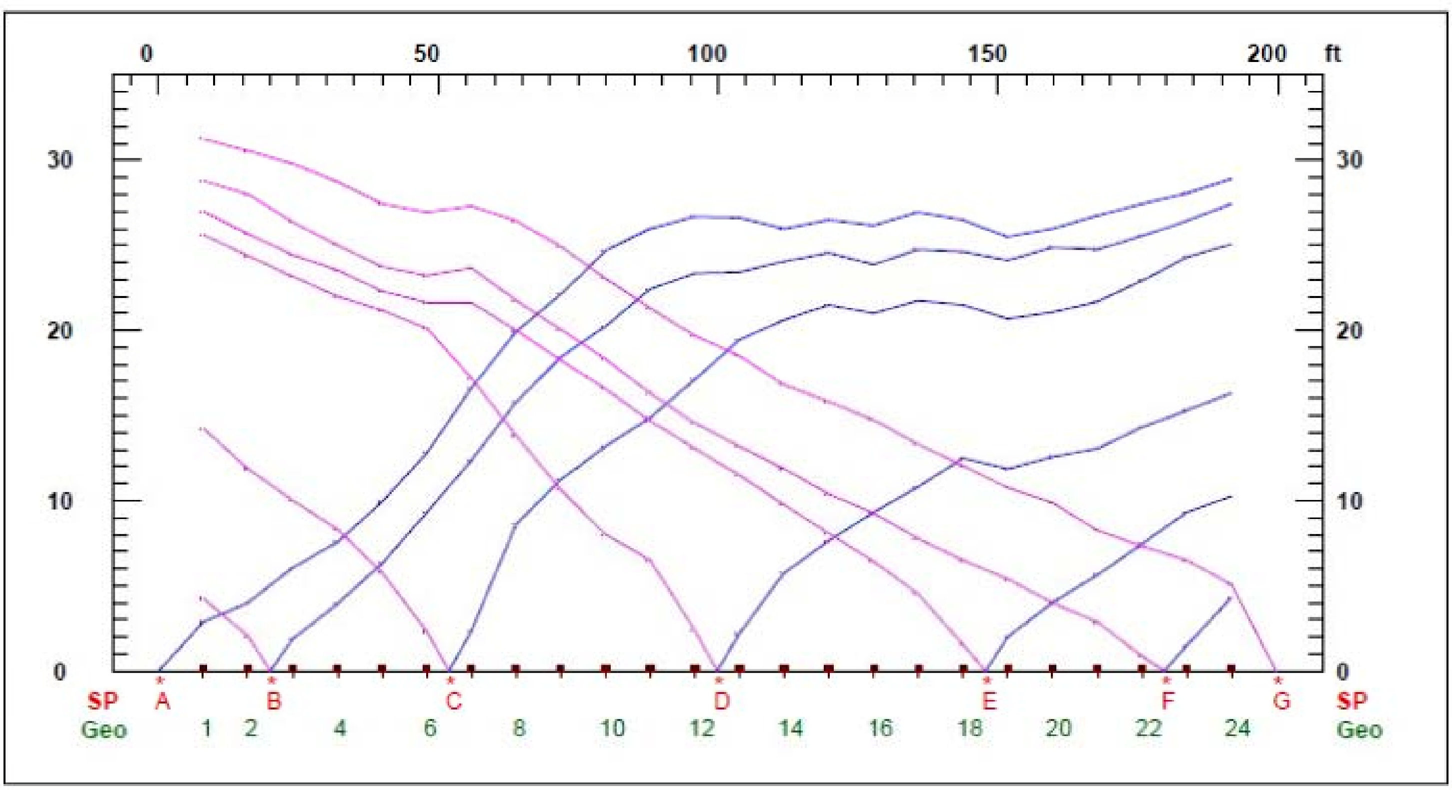
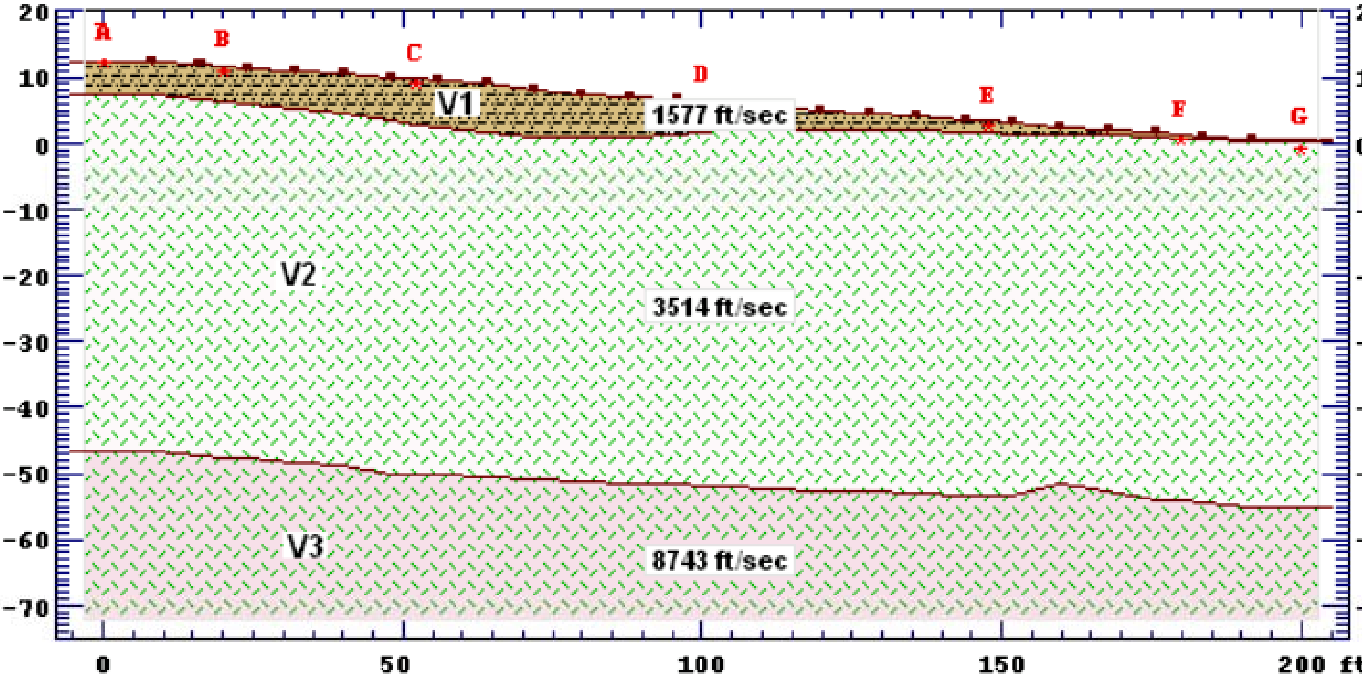


SEISMIC LINE S-4

< West - East >

LAYER VELOCITY MODEL



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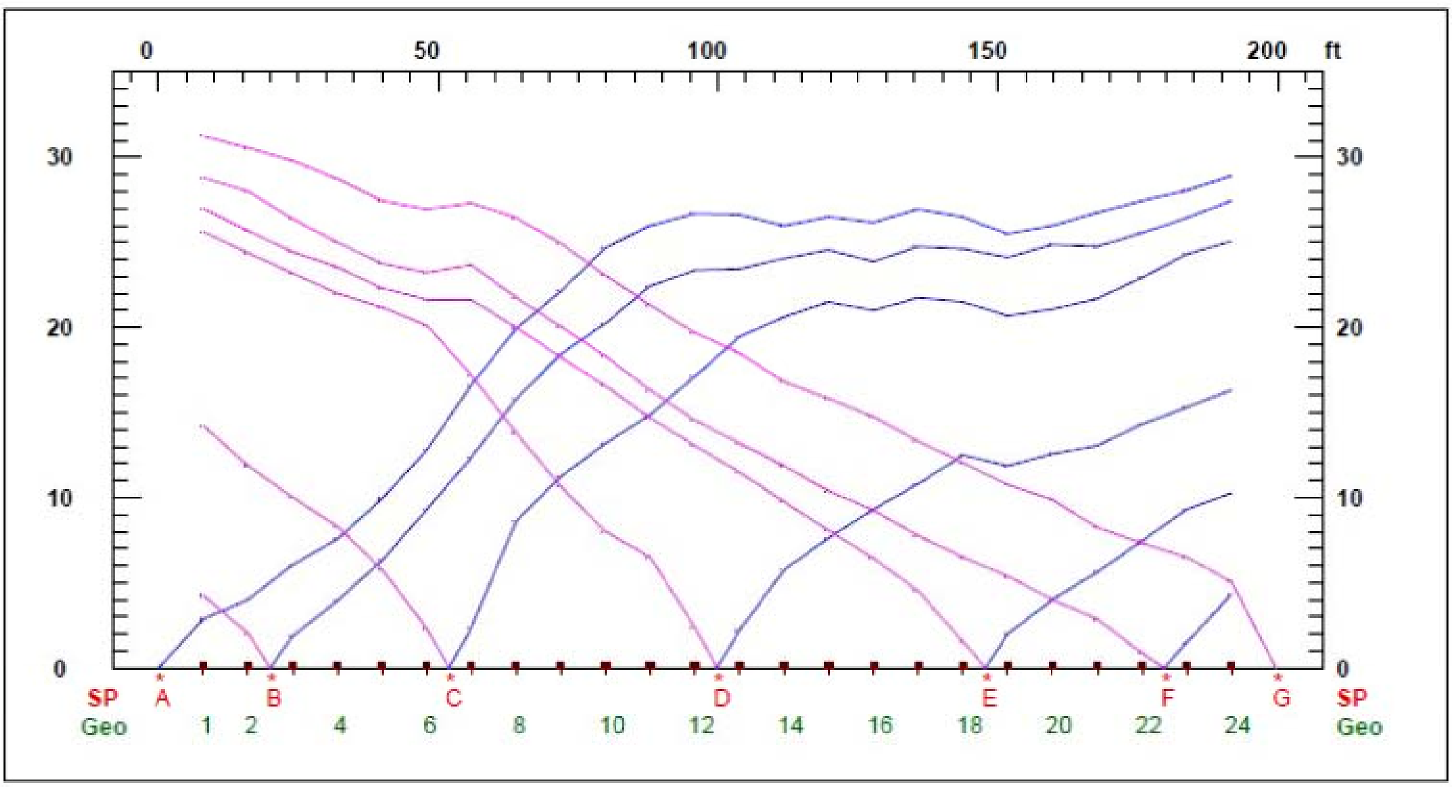
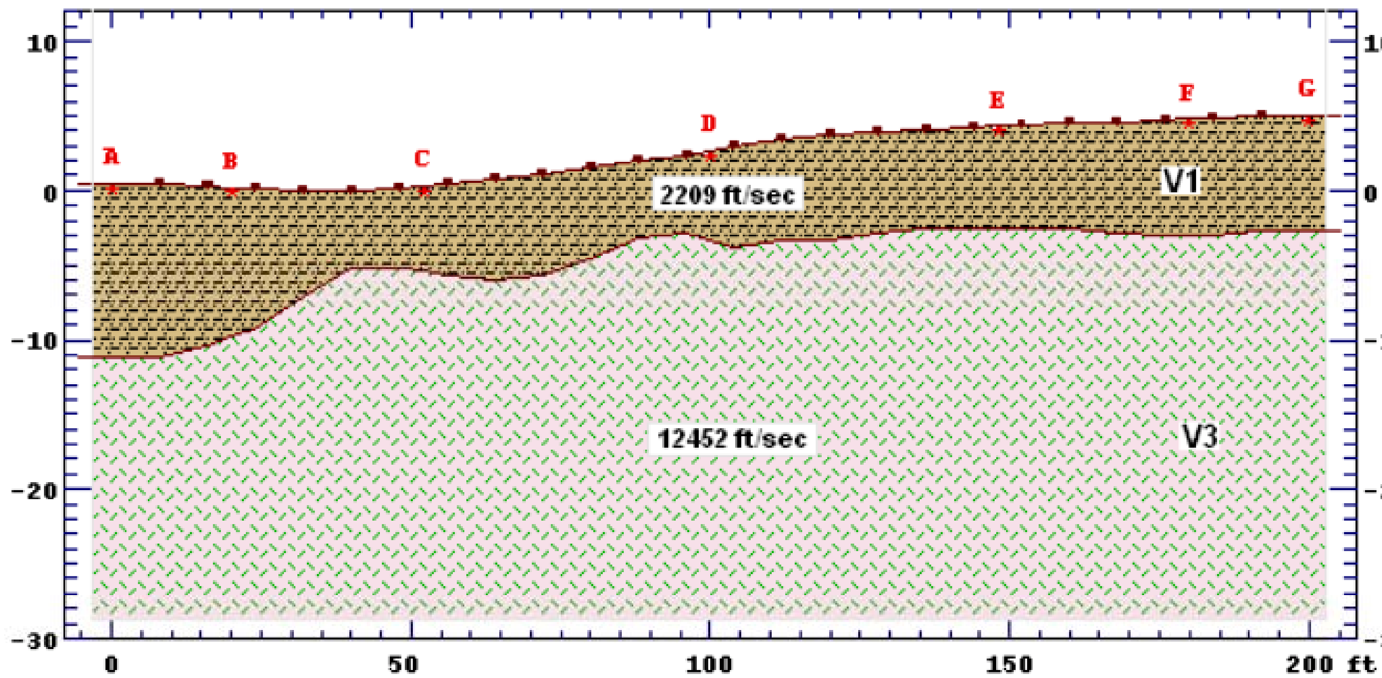


SEISMIC LINE S-5

South 60° East >

LAYER VELOCITY MODEL



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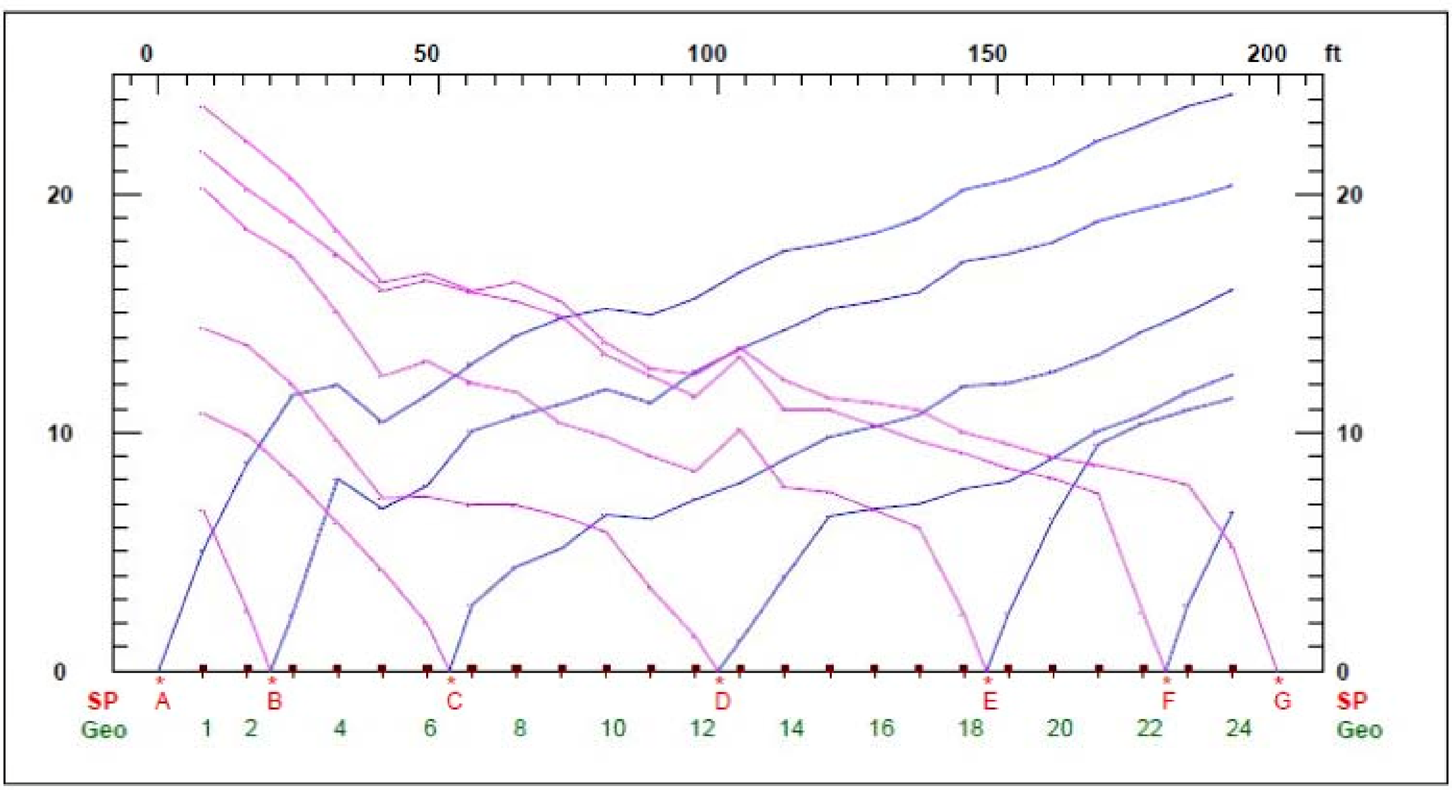
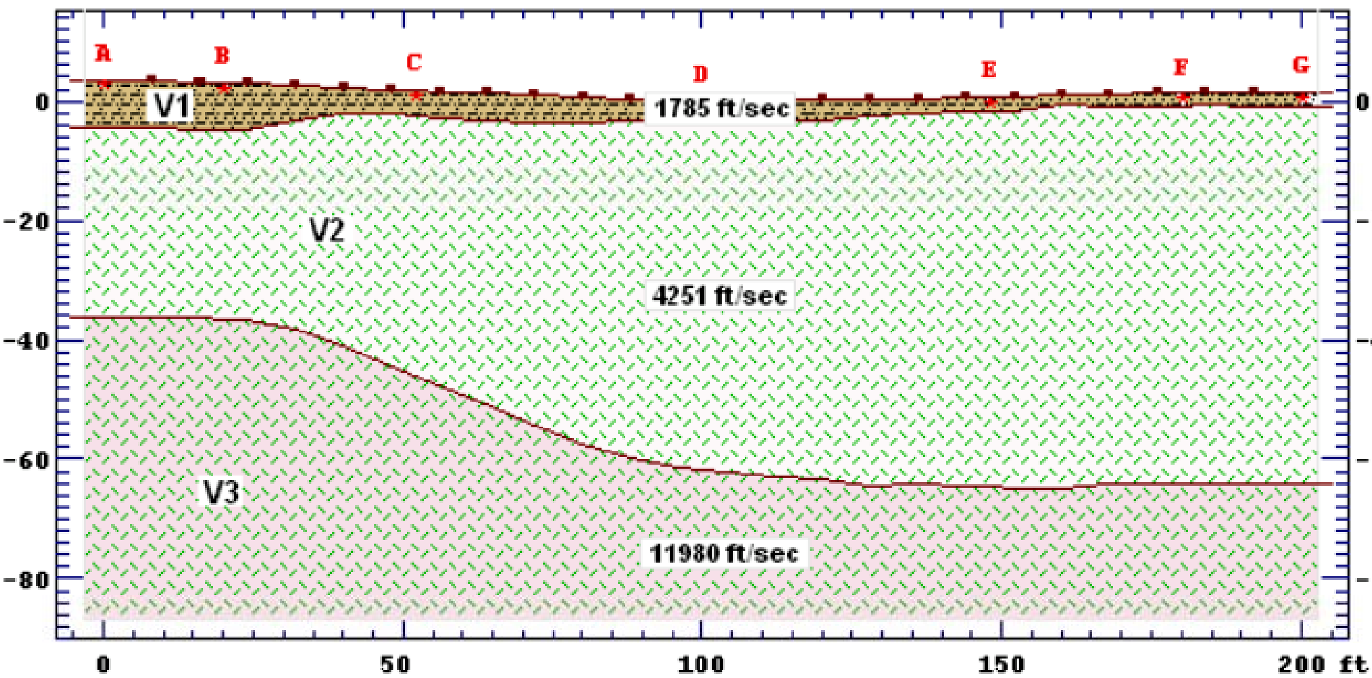


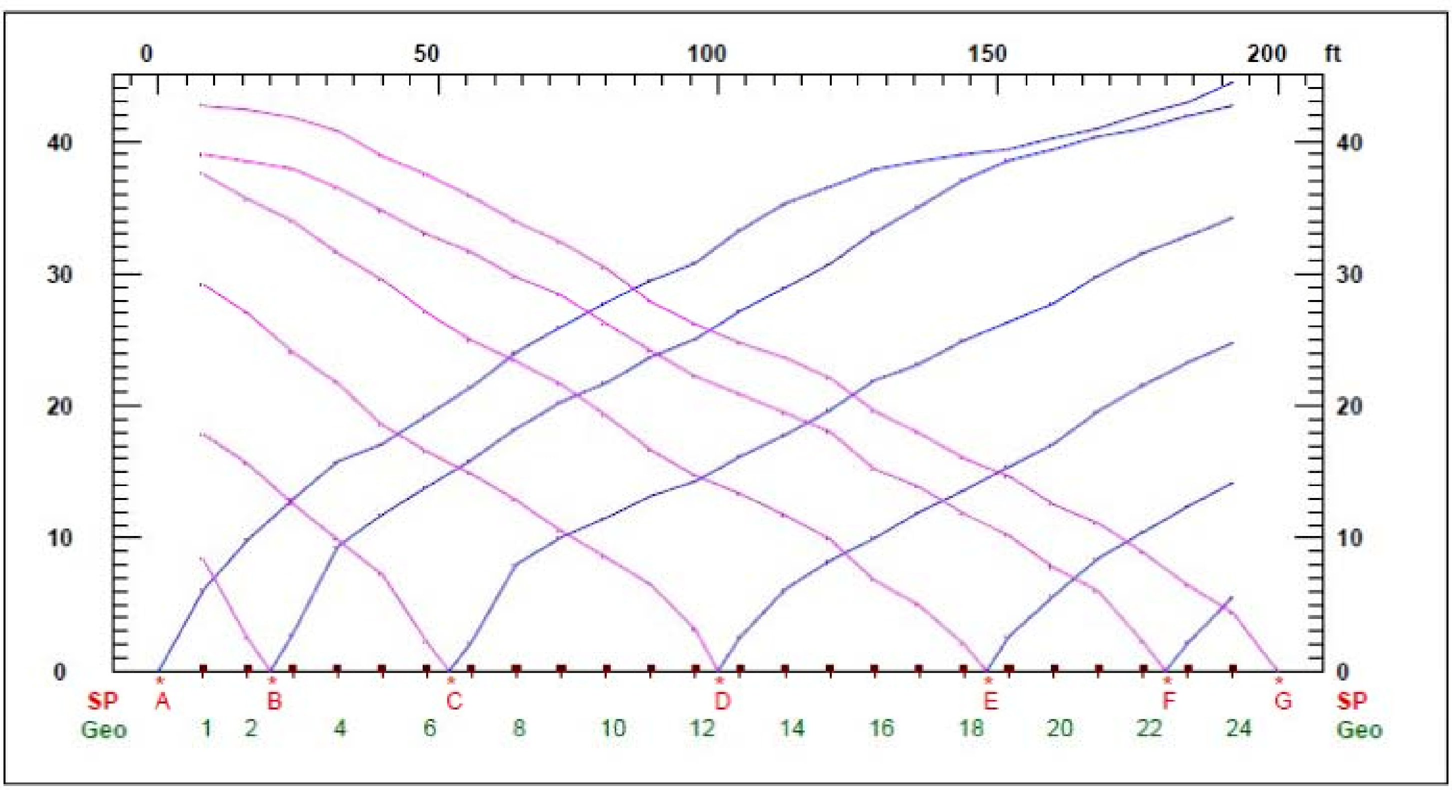
SEISMIC LINE S-6

< West - East >

LAYER VELOCITY MODEL



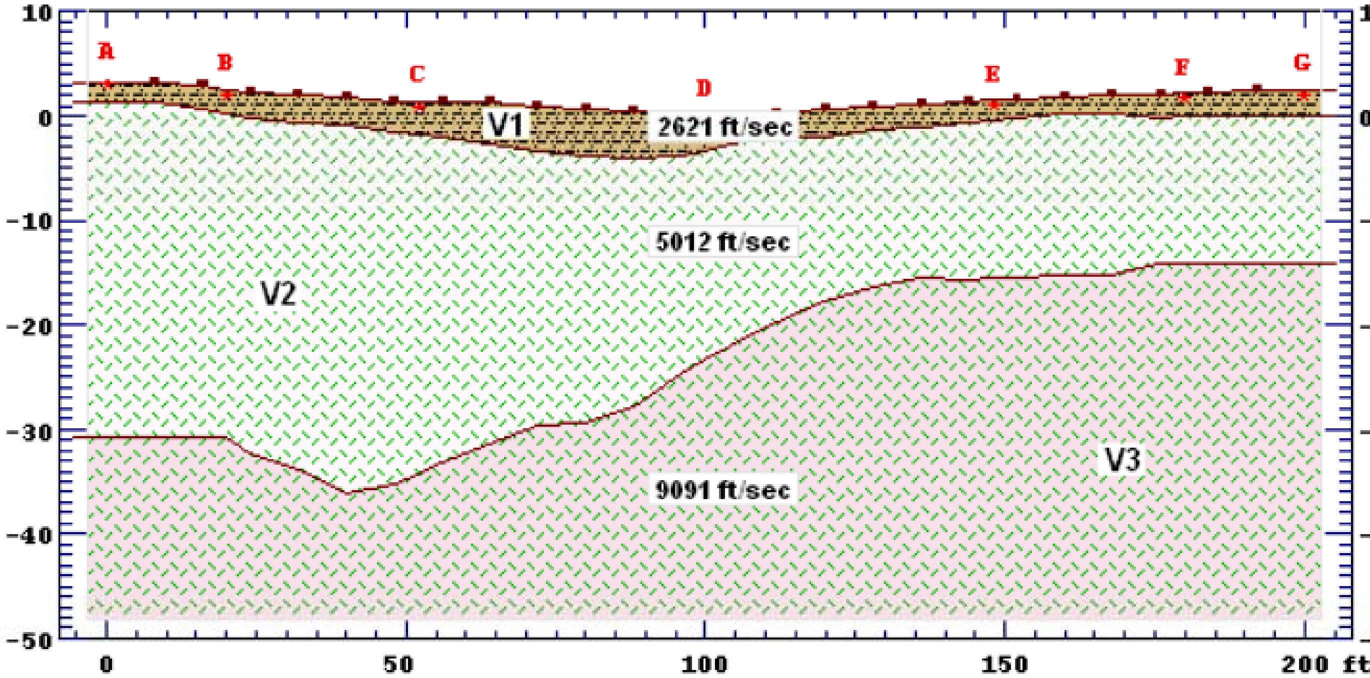
TIME-DISTANCE PLOT



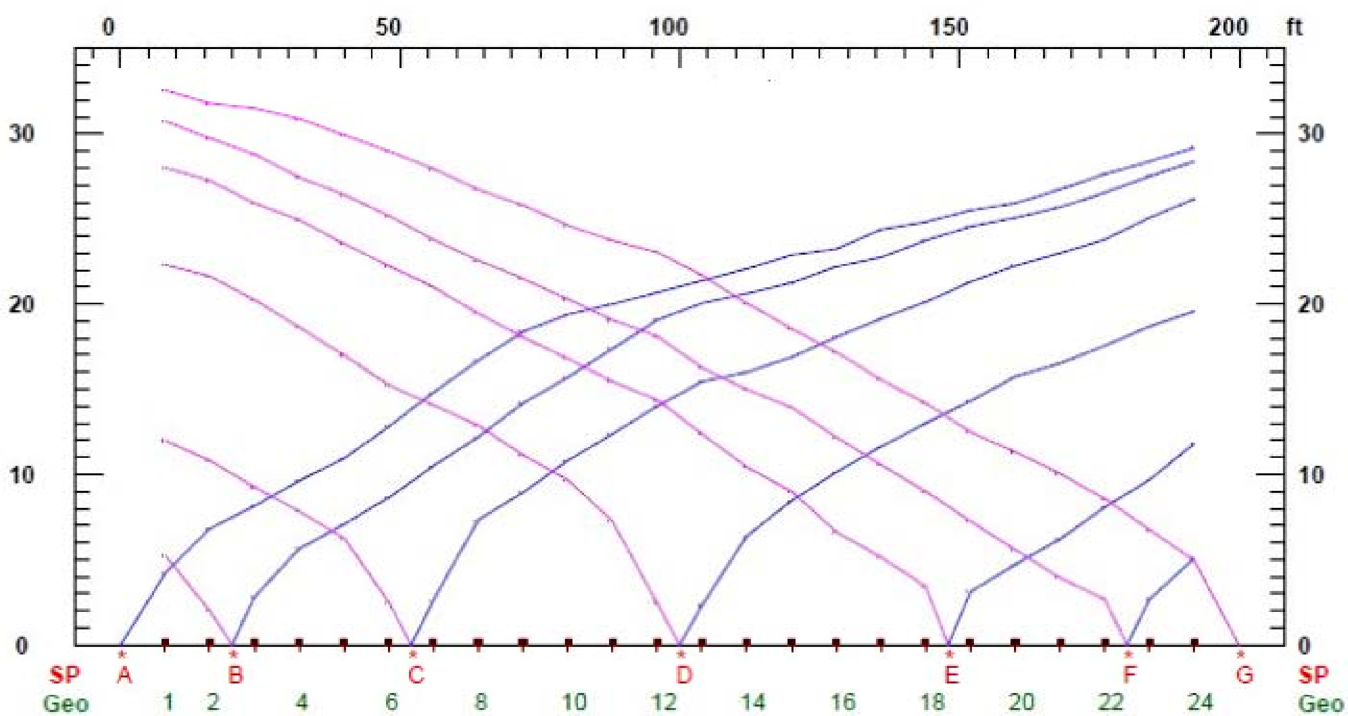
SEISMIC LINE S-7

< South - North >

LAYER VELOCITY MODEL



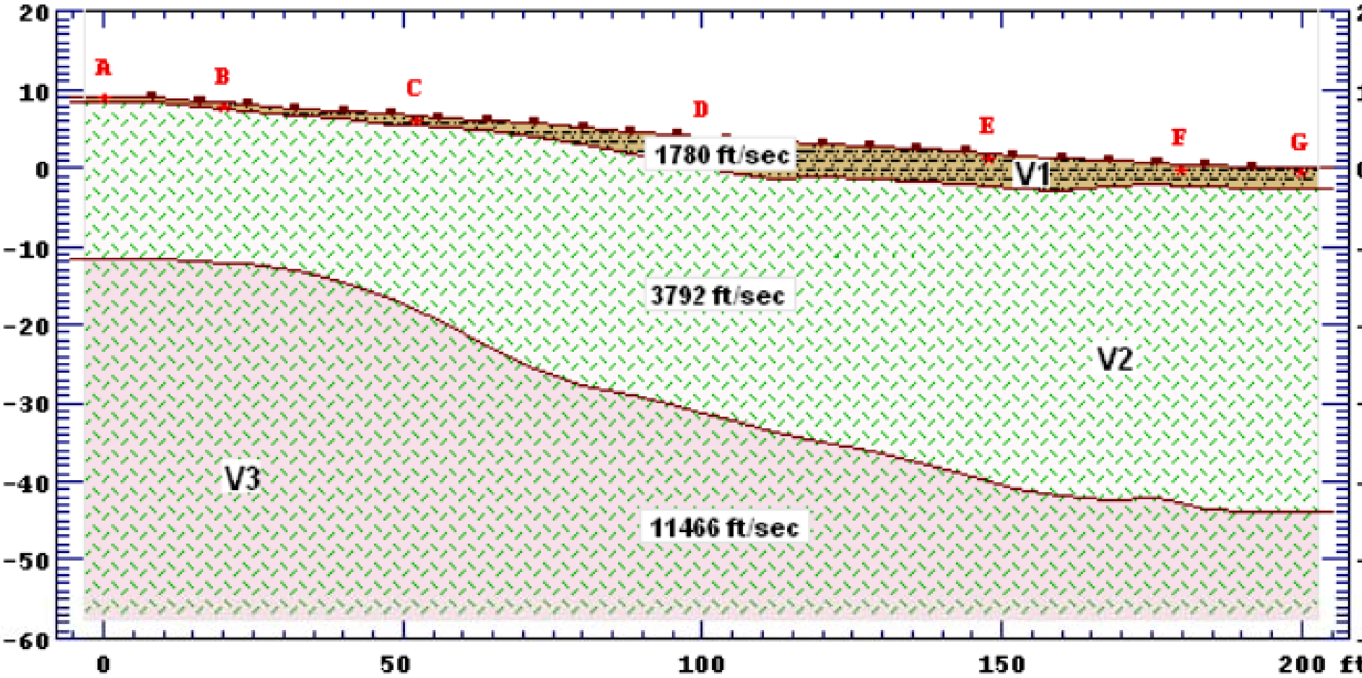
TIME-DISTANCE PLOT



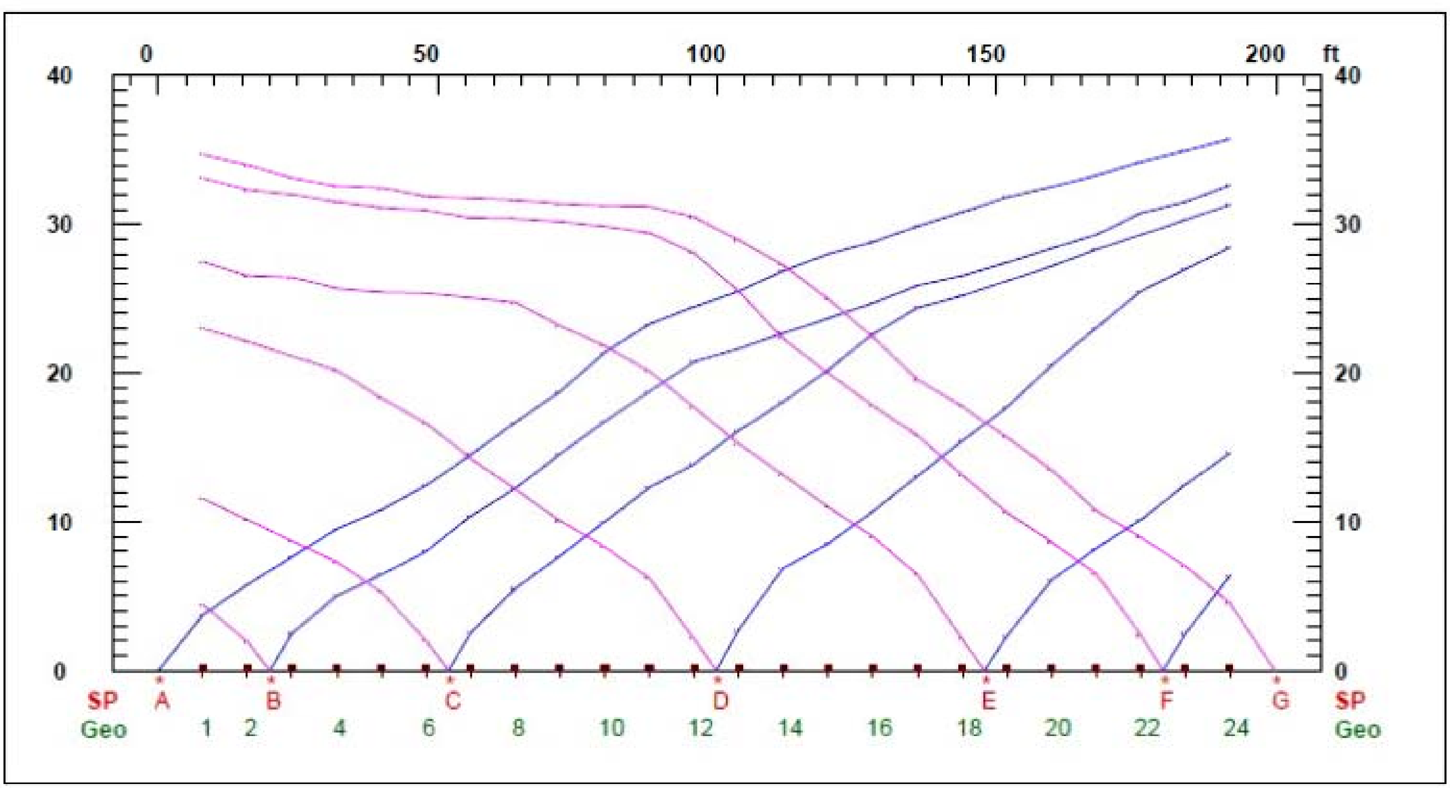
SEISMIC LINE S-8

< West - East >

LAYER VELOCITY MODEL



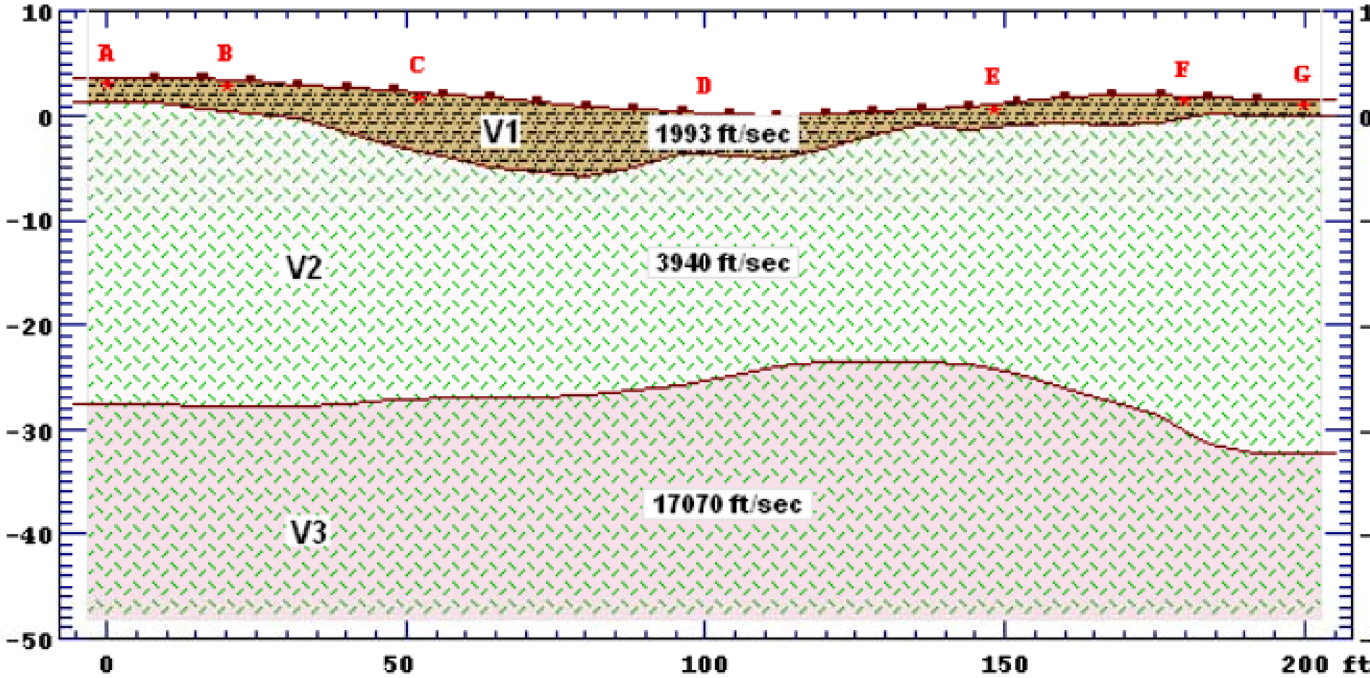
TIME-DISTANCE PLOT



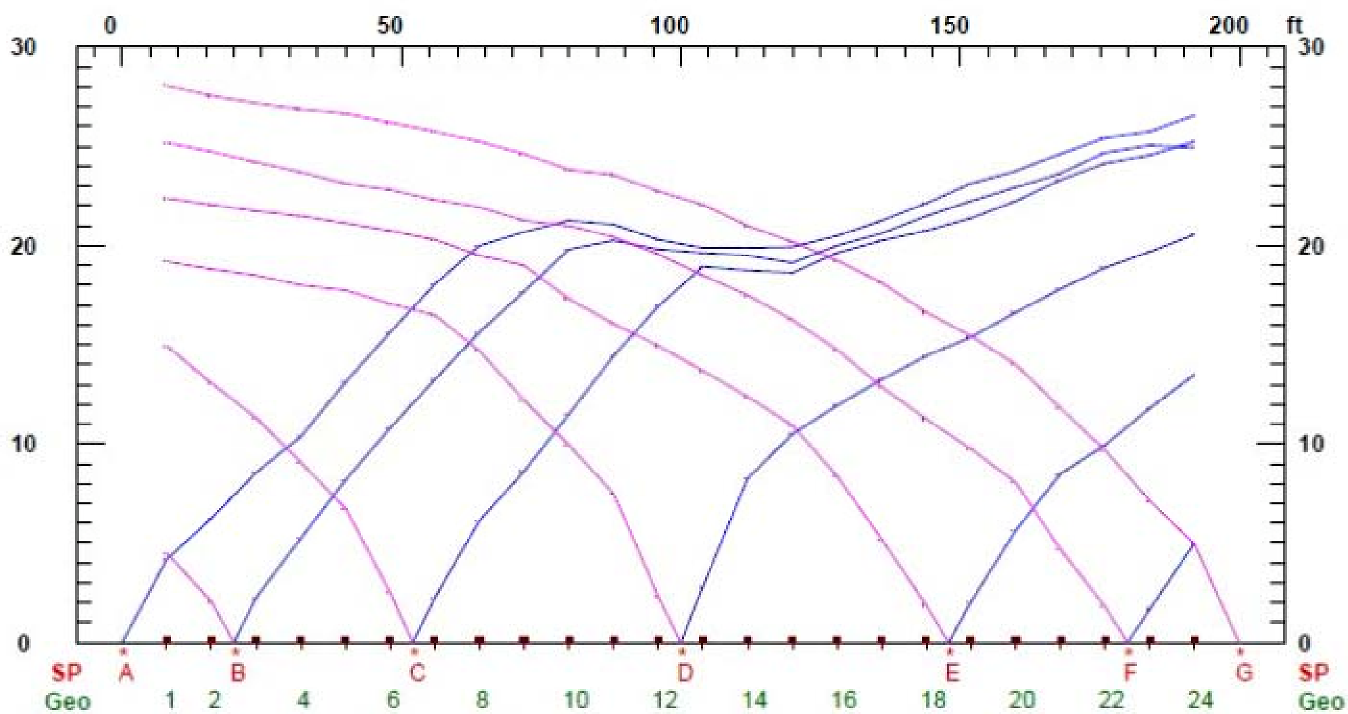
SEISMIC LINE S-9

< South - North >

LAYER VELOCITY MODEL



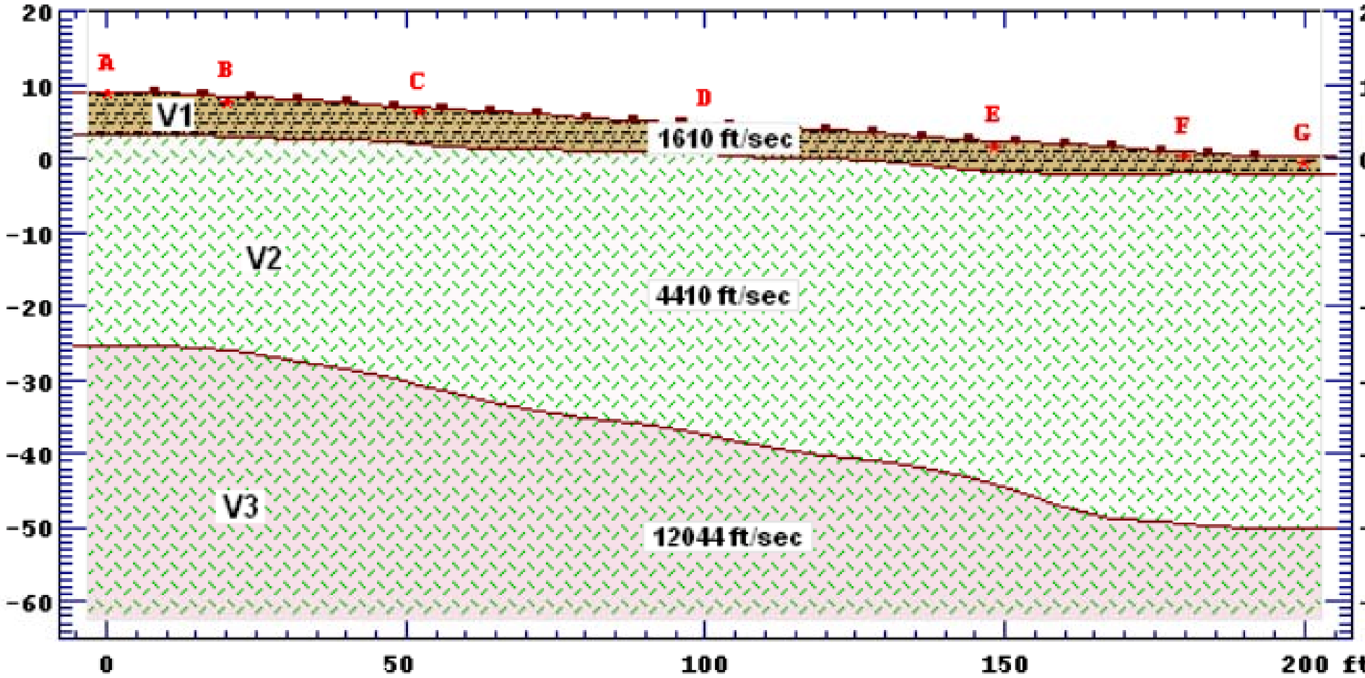
TIME-DISTANCE PLOT



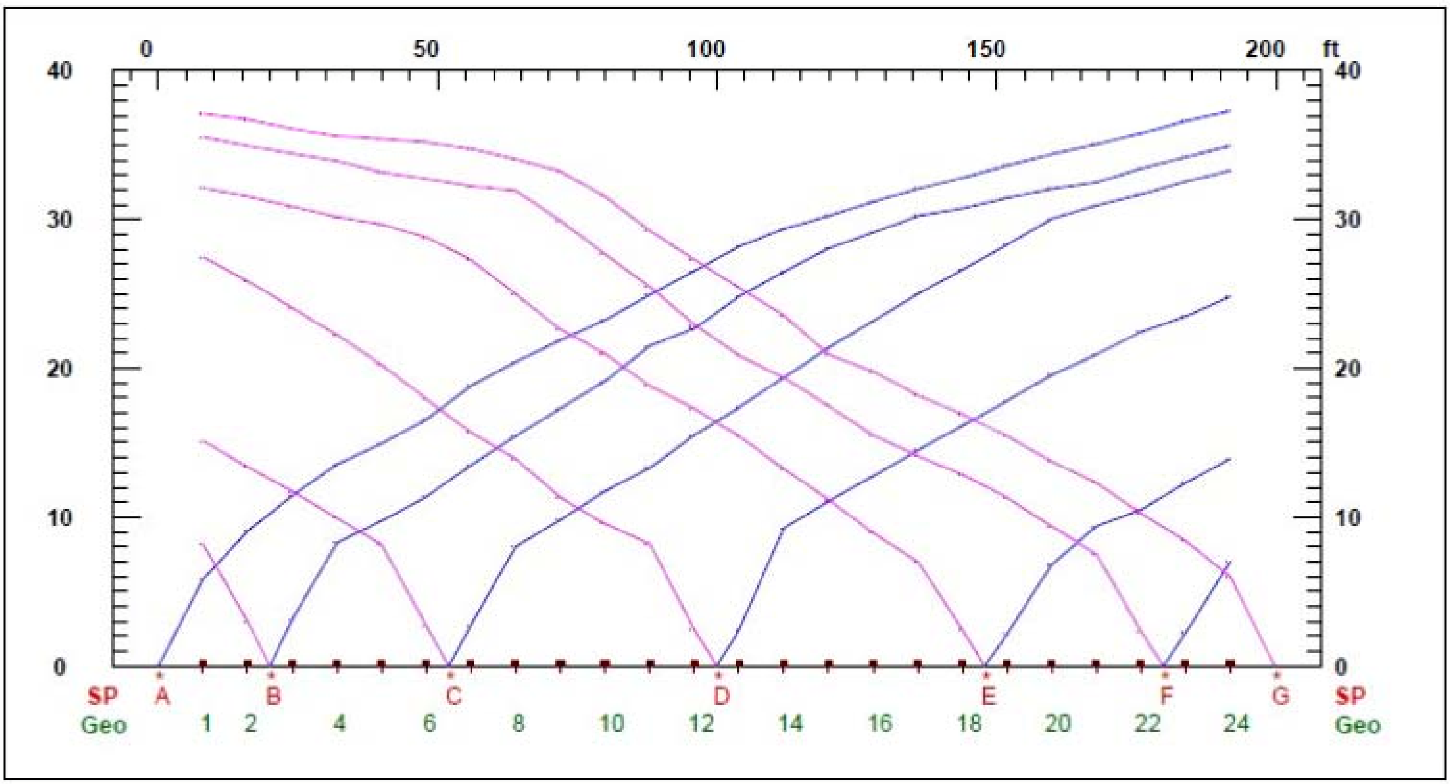
SEISMIC LINE S-10

< West - East >

LAYER VELOCITY MODEL



TIME-DISTANCE PLOT



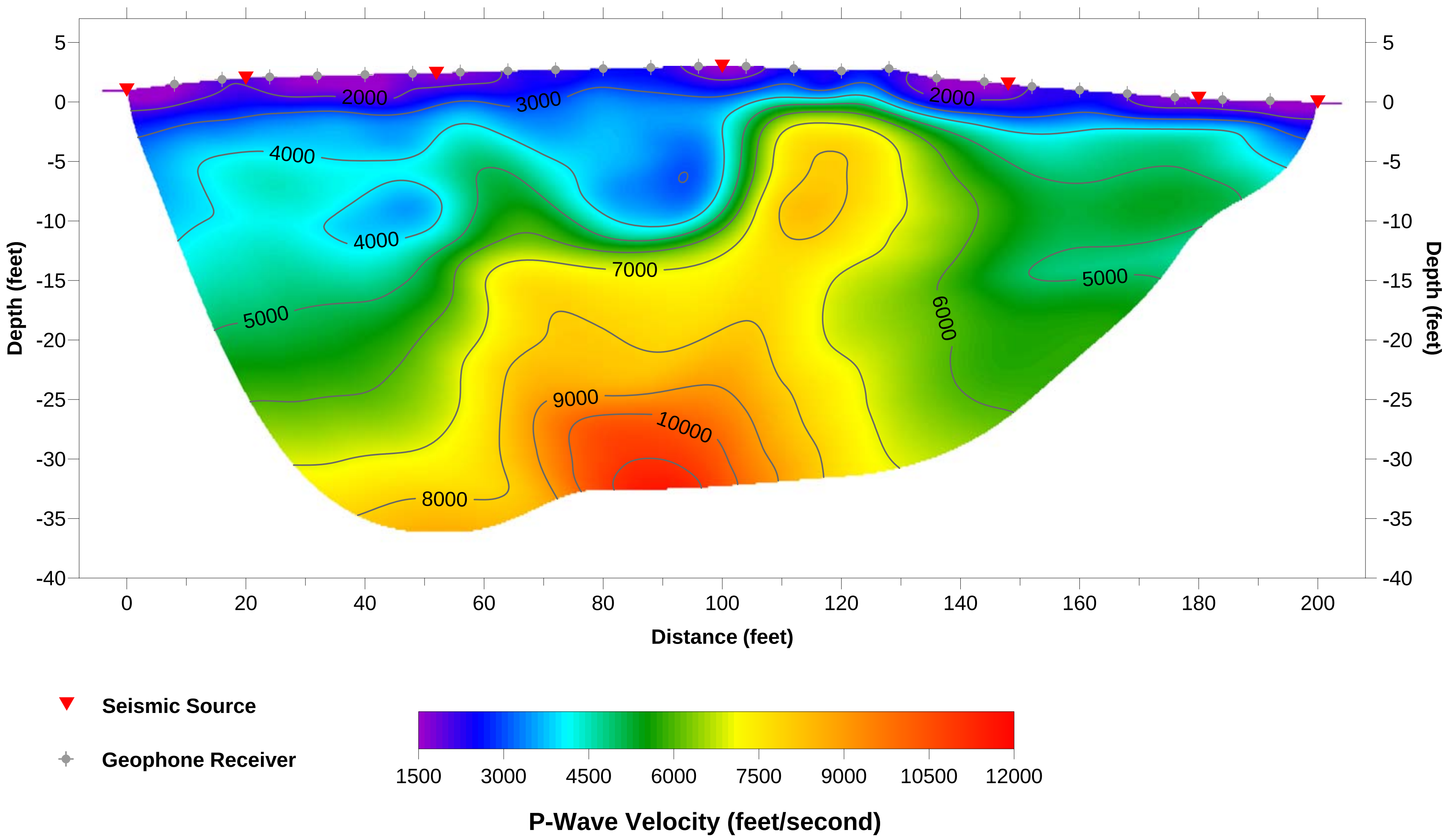
APPENDIX B

REFRACTION TOMOGRAPHIC MODELS

SEISMIC LINE S-1

← South - North →

REFRACTION TOMOGRAPHIC MODEL



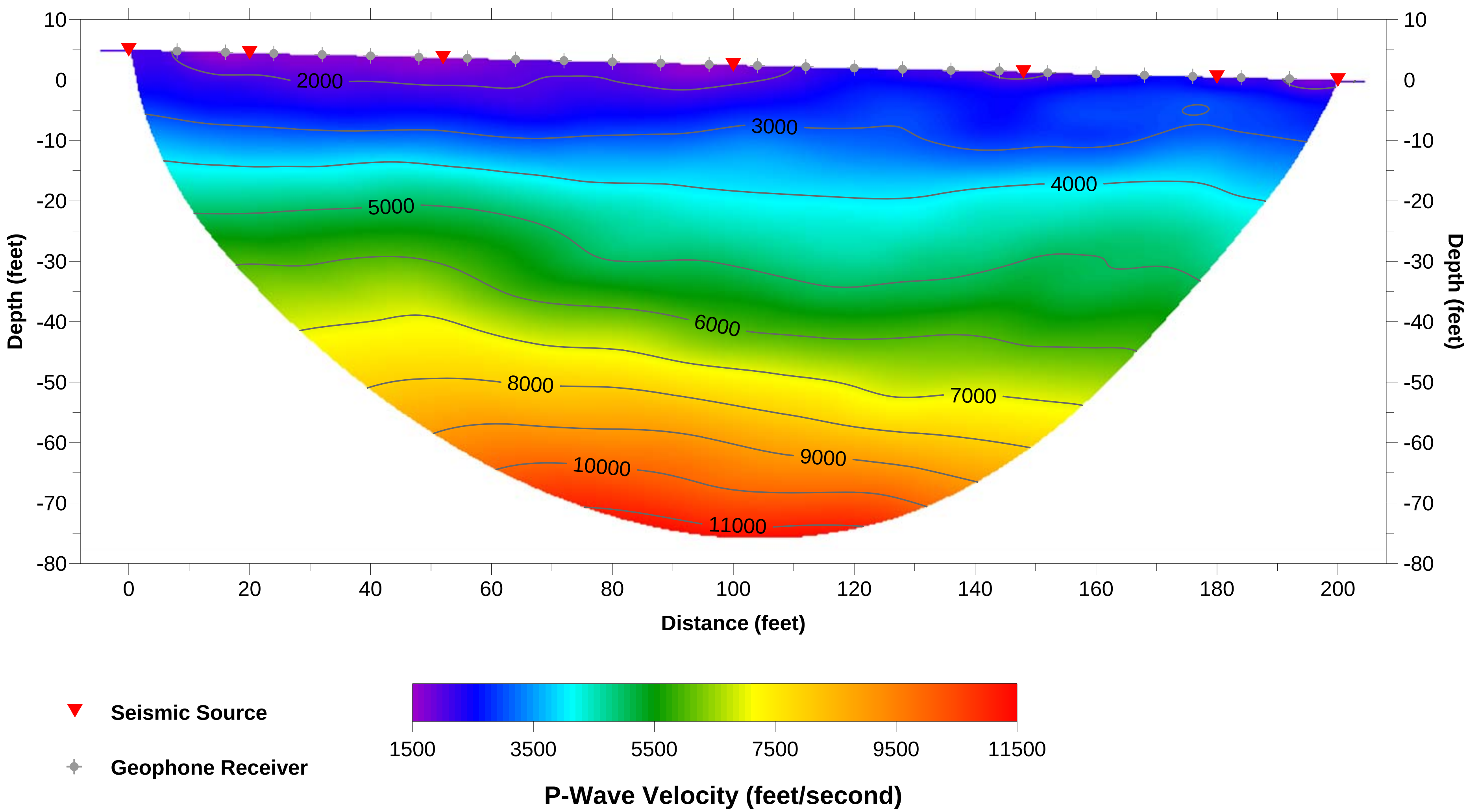
NOTE: Vertical Exaggeration 2X

RMS error 1.2 %, Rayfract Version 3.31

SEISMIC LINE S-2

← West - East →

REFRACTION TOMOGRAPHIC MODEL



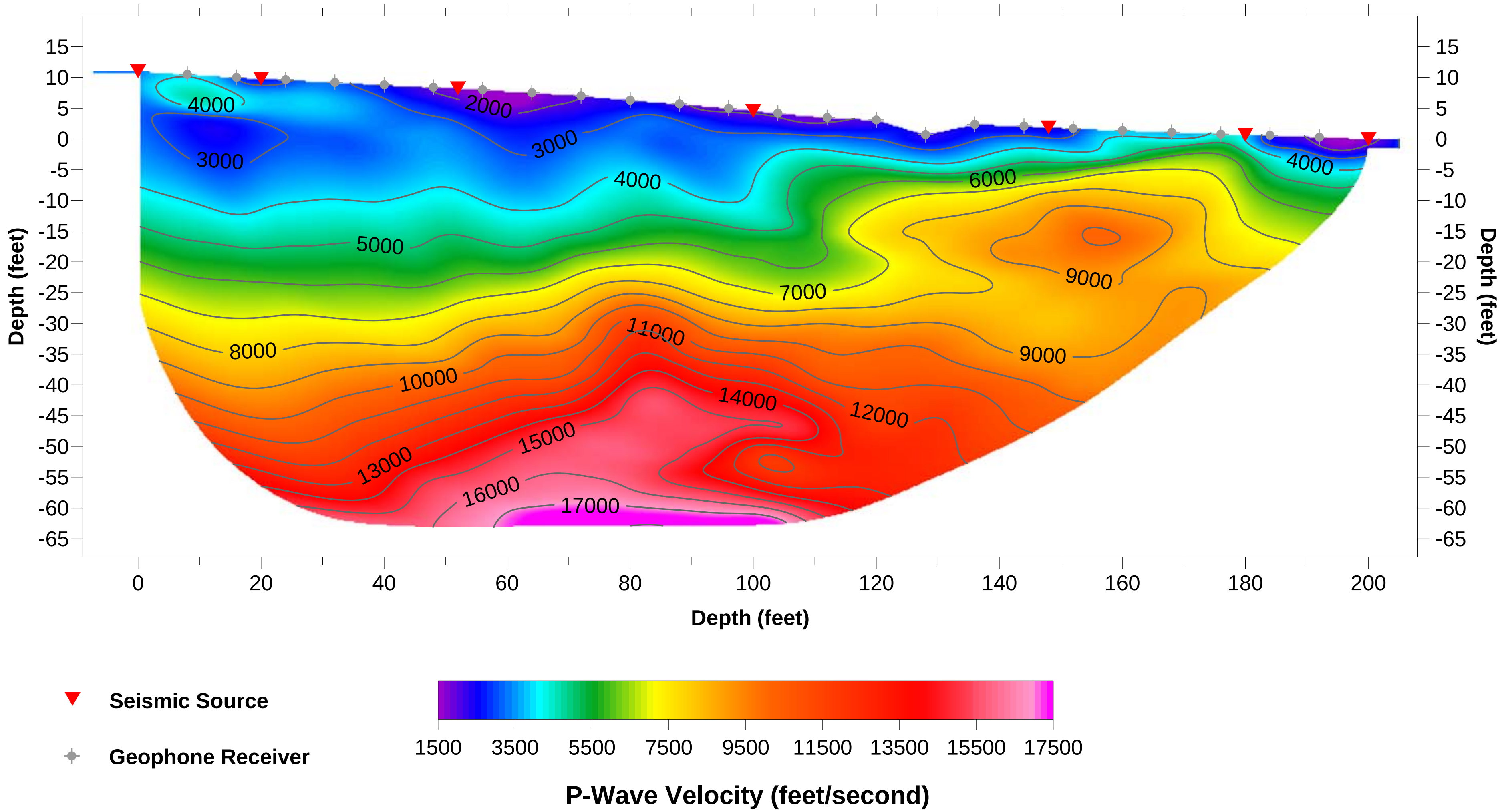
SCALE: 1" = 25' (Horizontal & Vertical)

RMS error 0.7 %, Rayfract Version 3.31

SEISMIC LINE S-3

← West - East →

REFRACTION TOMOGRAPHIC MODEL



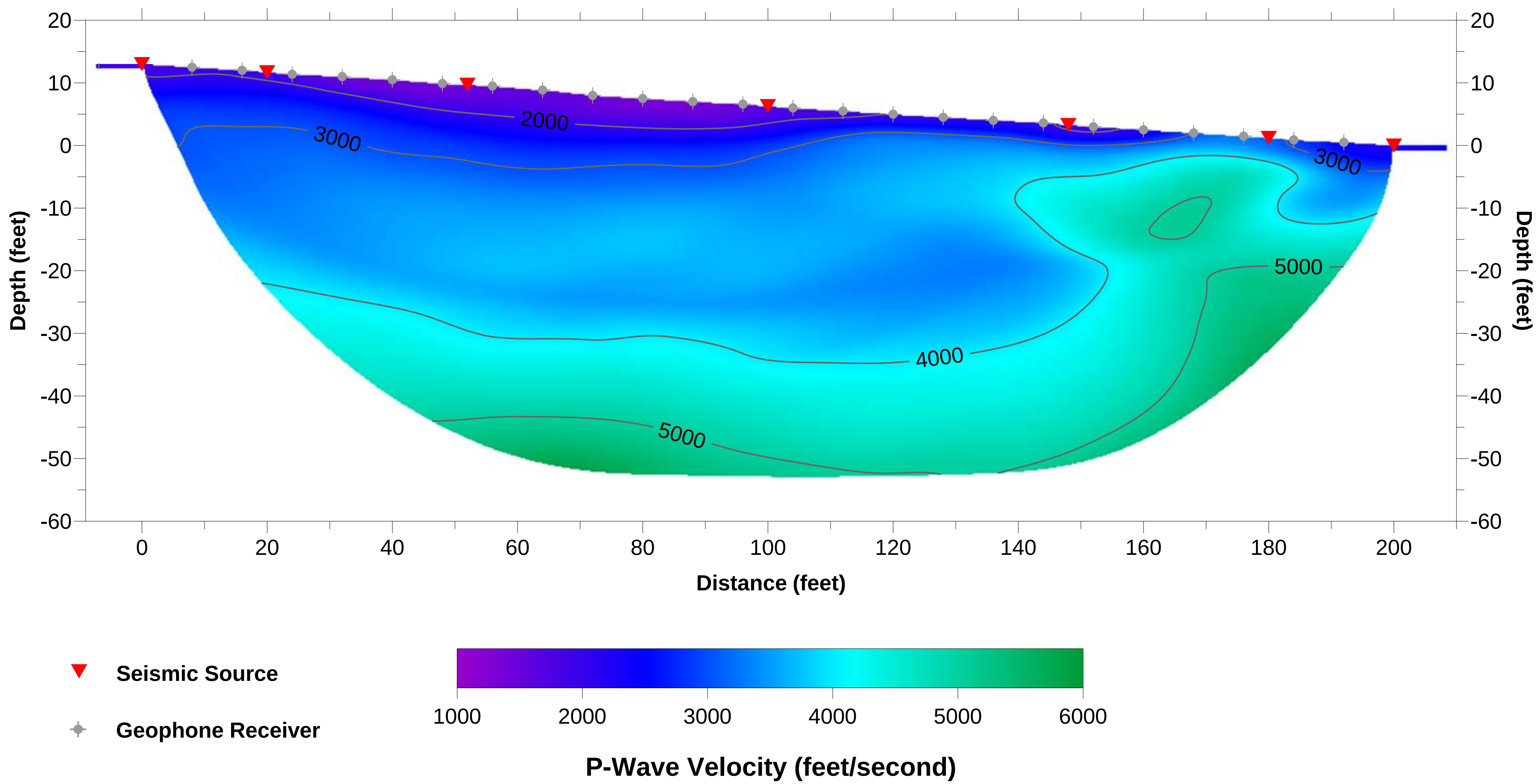
SCALE: 1" = 25' (Horizontal & Vertical)

RMS error 1.6 %, Rayfract Version 3.31

SEISMIC LINE S-4

← West - East →

REFRACTION TOMOGRAPHIC MODEL

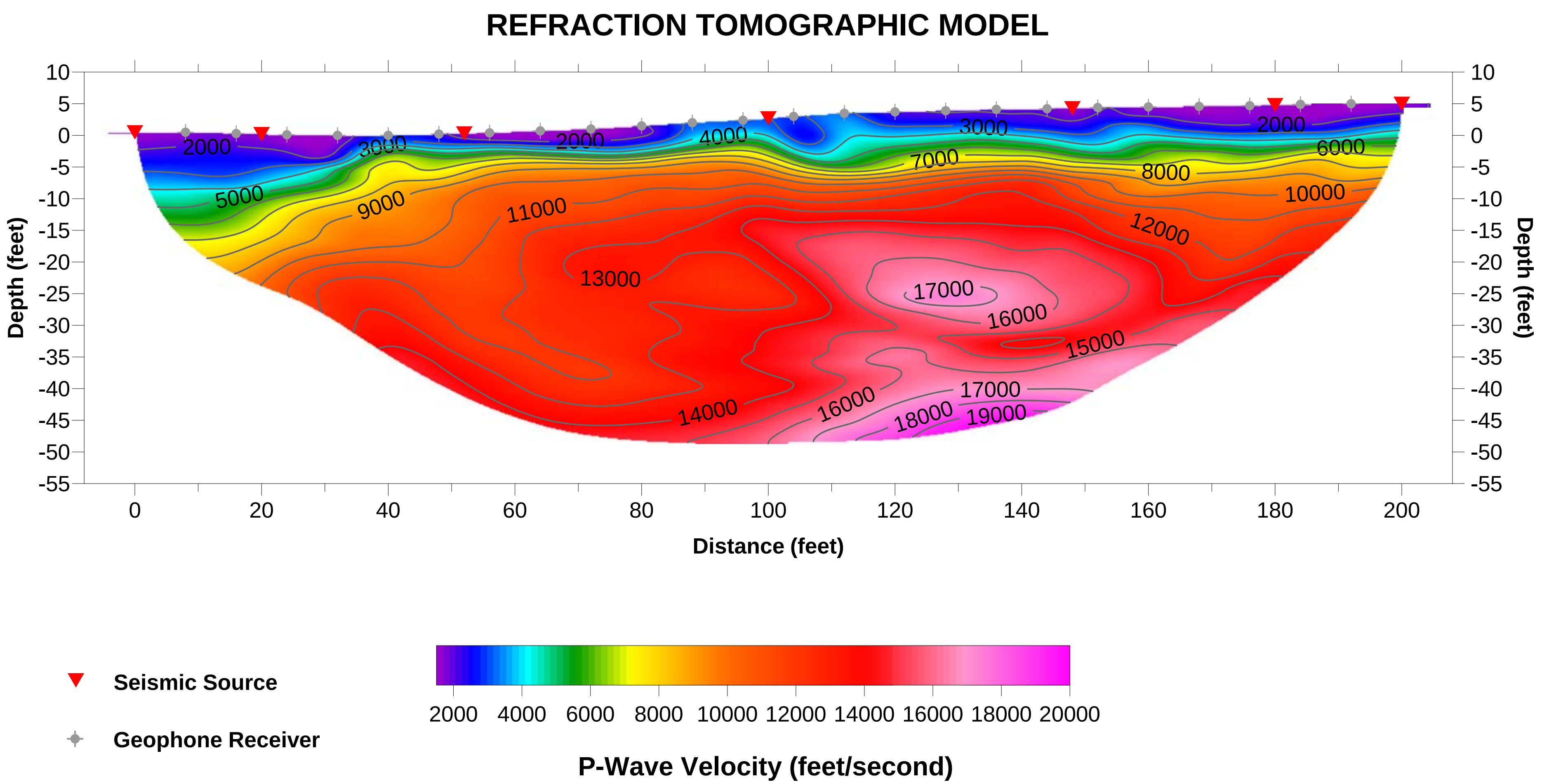


SCALE: 1" = 25' (Horizontal & Vertical)

RMS error 1.3 %, Rayfract Version 3.31

SEISMIC LINE S-5

South 60° East →



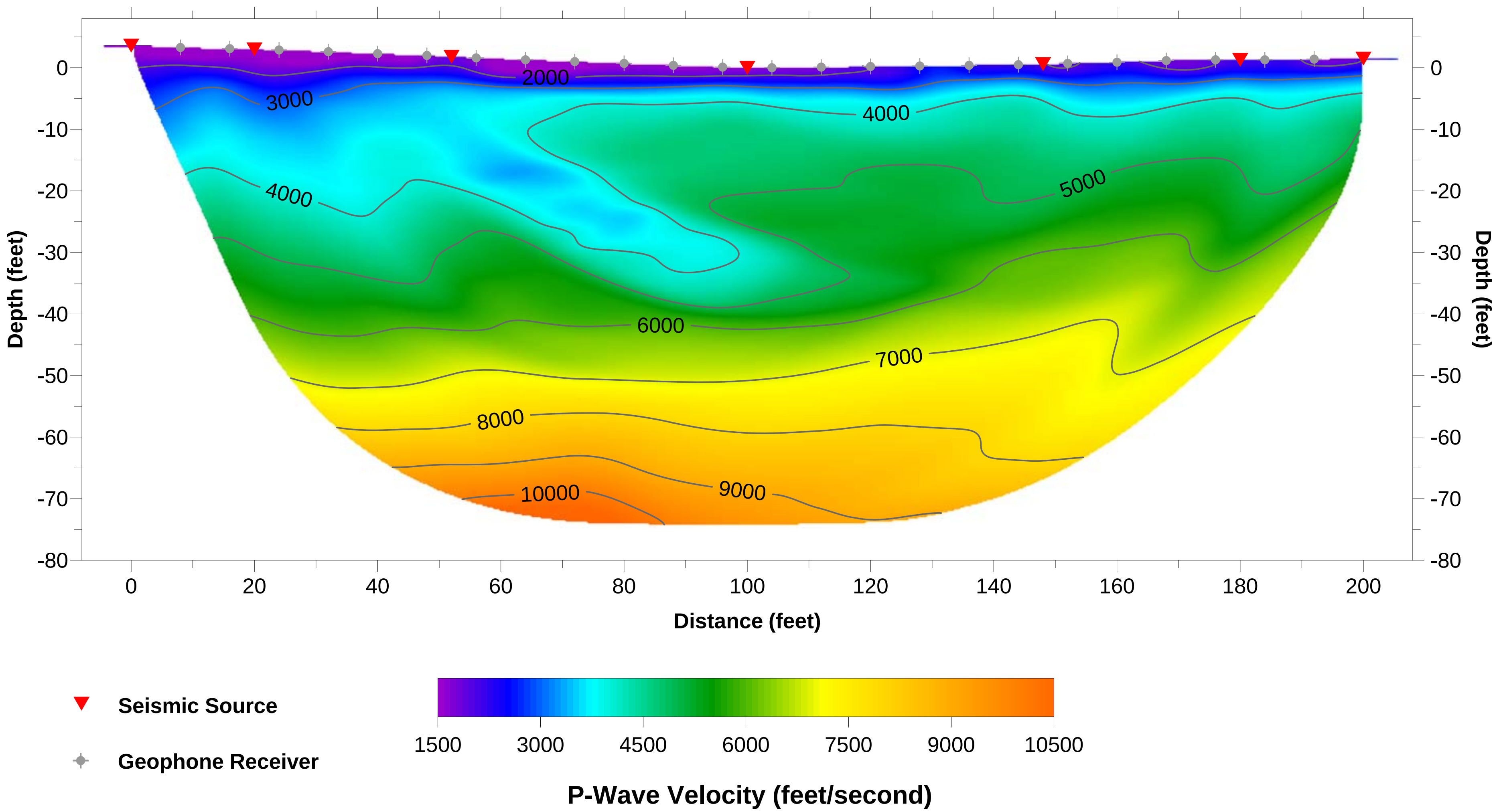
SCALE: 1" = 25' (Horizontal & Vertical)

RMS error 1.9 %, Rayfract Version 3.31

SEISMIC LINE S-6

← West - East →

REFRACTION TOMOGRAPHIC MODEL

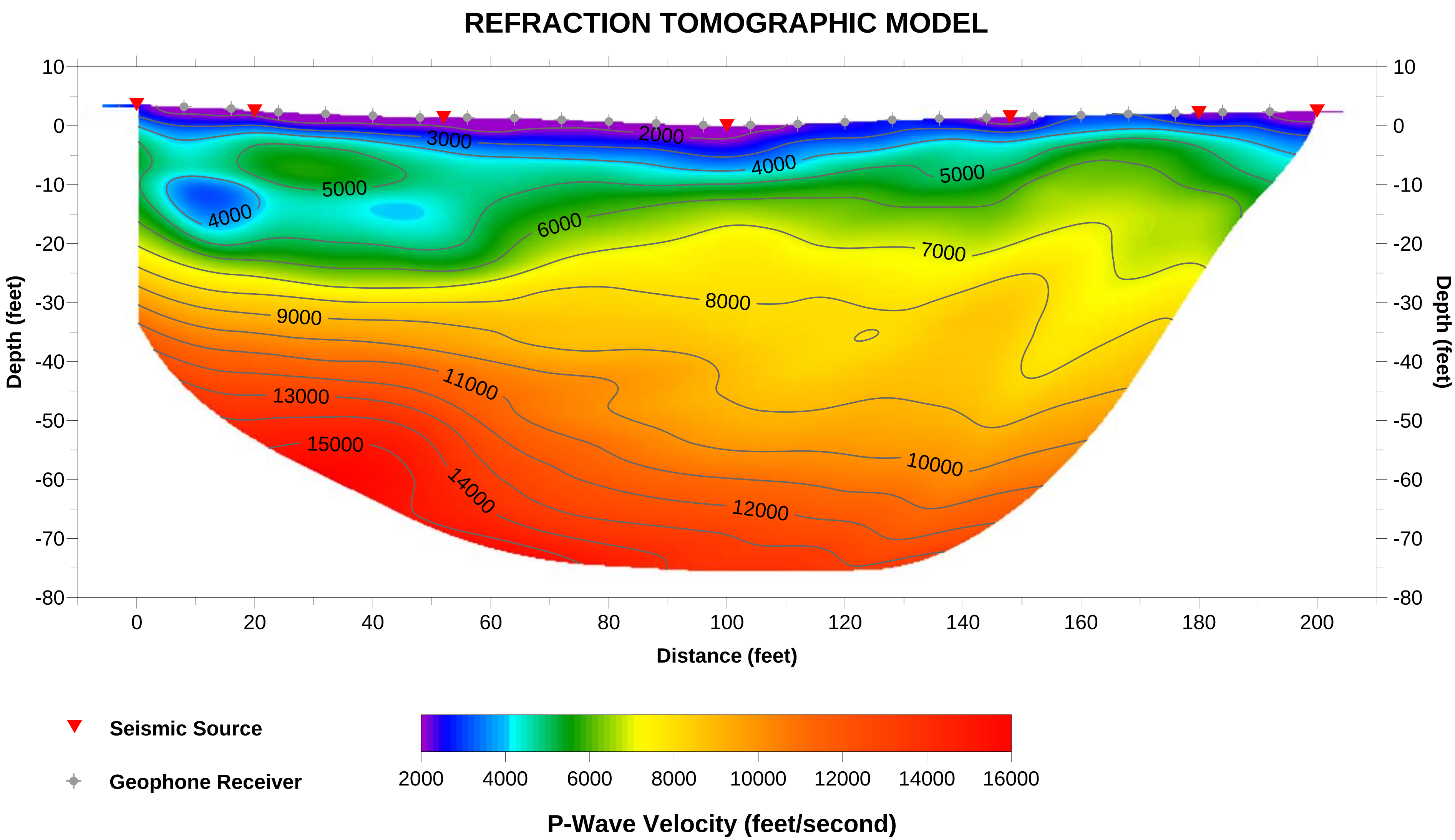


SCALE: 1" = 25' (Horizontal & Vertical)

RMS error 1.2 %, Rayfract Version 3.31

SEISMIC LINE S-7

← South - North →



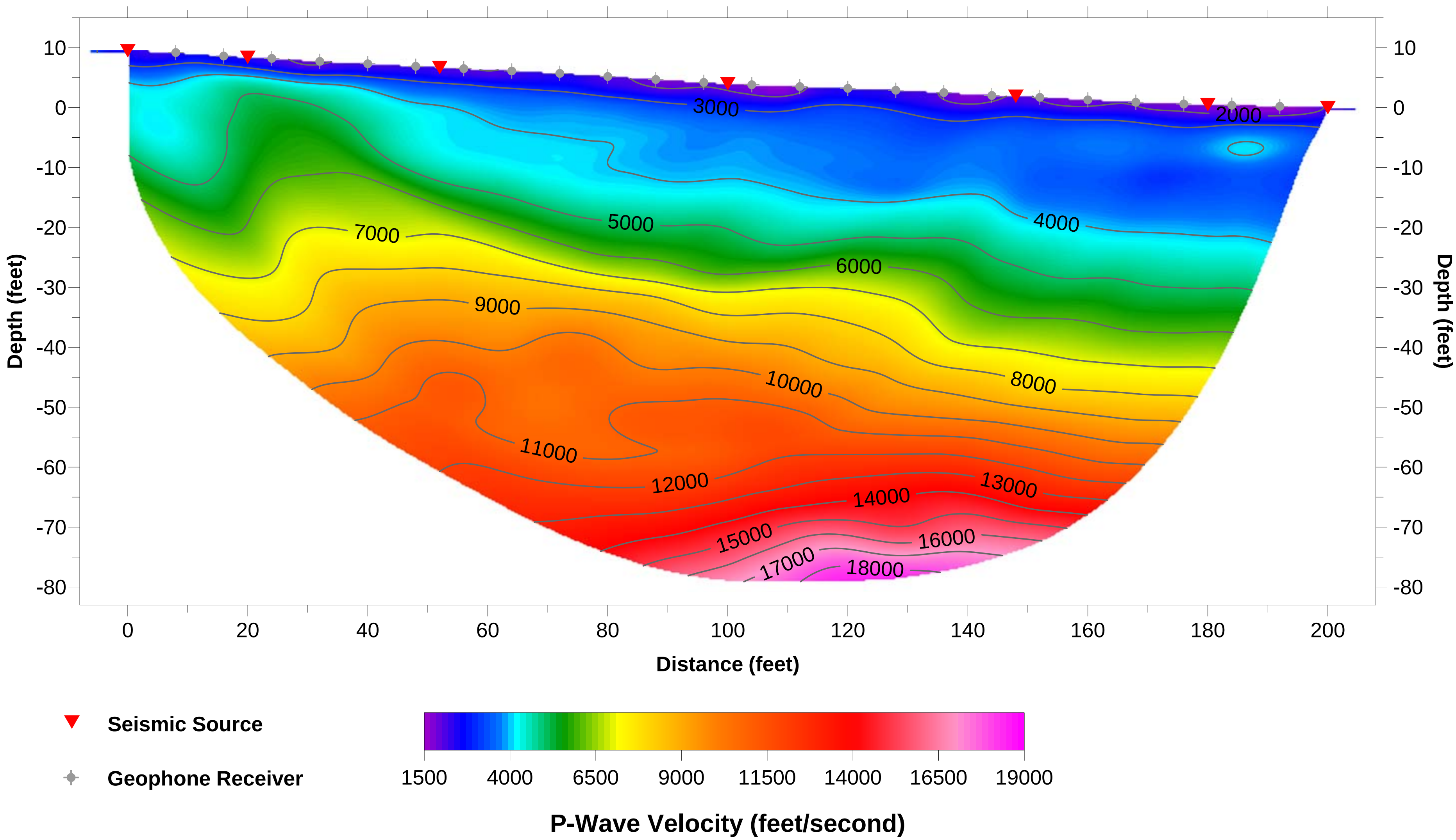
SCALE: 1" = 25' (Horizontal & Vertical)

RMS error 1.4 %, Rayfract Version 3.31

SEISMIC LINE S-8

← West - East →

REFRACTION TOMOGRAPHIC MODEL



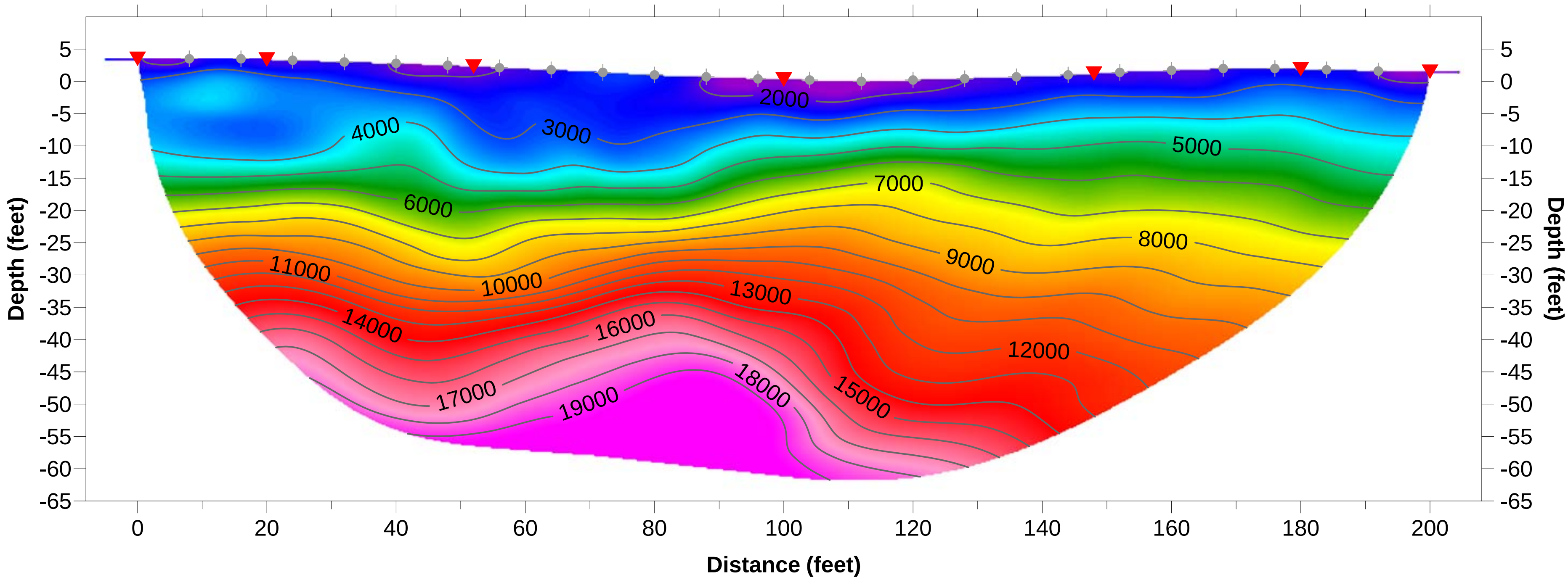
SCALE: 1" = 25' (Horizontal & Vertical)

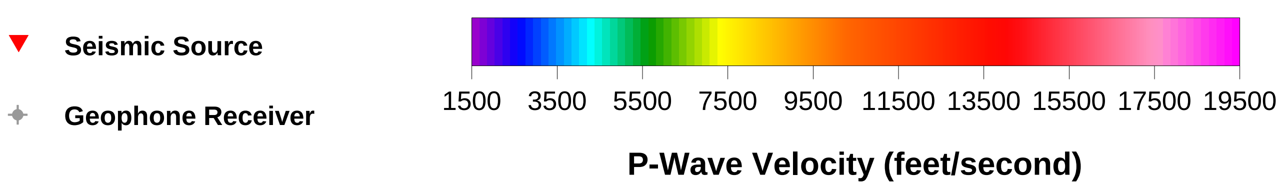
RMS error 1.1 %, Rayfract Version 3.31

SEISMIC LINE S-9

← South - North →

REFRACTION TOMOGRAPHIC MODEL





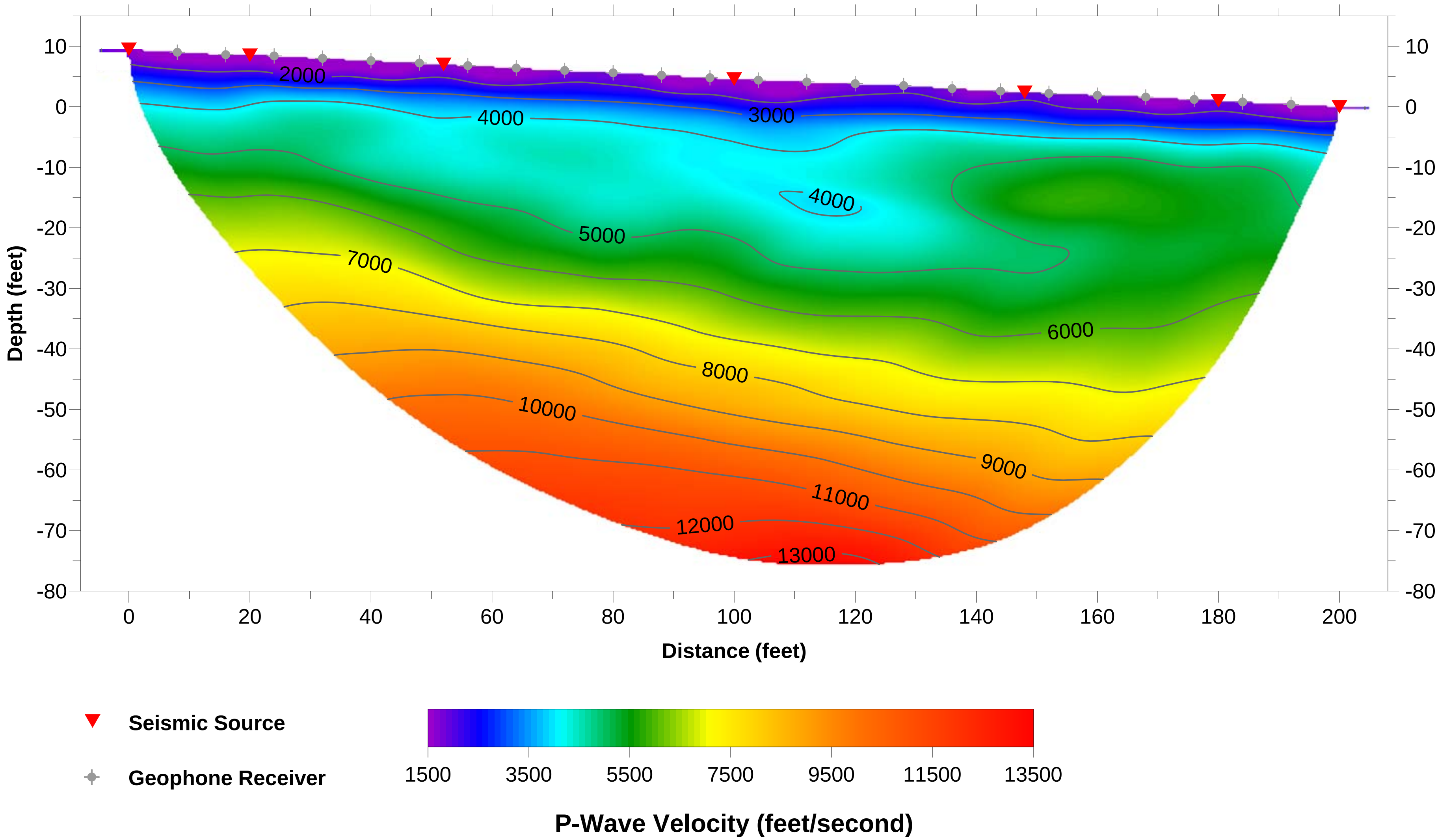
SCALE: 1" = 25' (Horizontal & Vertical)

RMS error 1.3 %, Rayfract Version 3.31

SEISMIC LINE S-10

← West - East →

REFRACTION TOMOGRAPHIC MODEL



SCALE: 1" = 25' (Horizontal & Vertical)

RMS error 1.0 %, Rayfract Version 3.31

APPENDIX C

EXCAVATION CONSIDERATIONS

EXCAVATION CONSIDERATIONS

These excavation considerations have been included to provide the client with a brief overall summary of the general complexity of hard bedrock excavation. It is considered the clients responsibility to insure that the grading contractor they select is both properly licensed and qualified, with experience in hard-bedrock ripping processes. To evaluate whether a particular bedrock material can be ripped, this geophysical survey should be used in conjunction with the geologic or geotechnical report prepared for the project which describes the physical properties of the bedrock. The physical characteristics of bedrock materials that favor ripping generally include the presence of fractures, faults and other structural discontinuities, weathering effects, brittleness or crystalline structure, stratification of lamination, large grain size, moisture permeated clay, and low compressive strength. Unfavorable conditions can include such characteristics as massive and homogeneous formations, non-crystalline structure, absence of planes of weakness, fine-grained materials, and formations of clay origin where moisture makes the material plastic.

When assessing the potential rippability of the underlying bedrock of a given site, the above geologic characteristics along with the estimated seismic velocities can then be used to evaluate what type of equipment may be appropriate for the proposed grading. When selecting the proper ripping equipment there are three primary factors to consider, which are:

- ***Down Pressure available at the tip, which determines the ripper penetration that can be attained and maintained,***
- ***Tractor flywheel horsepower, which determines whether the tractor can advance the tip, and,***
- ***Tractor gross-weight, which determines whether the tractor will have sufficient traction to use the horsepower.***

In addition to selecting the appropriate tractor, selection of the proper ripper design is also important. There are basically three designs, being radial, parallelogram, and adjustable parallelogram, of which the contractor should be aware of when selecting the appropriate design to be used for the project. The penetration depth will depend upon the down-pressure and penetration angle, as well as the length of the shank tips (short, intermediate, and long).

Also important in the excavation process is the ripping technique used as well as the skill of the individual tractor operator. These techniques include the use of one or more ripping teeth, up- and down-hill ripping, and the direction of ripping with respect to the geologic structure of the bedrock locally. The use of two tractors (one to push the first tractor-ripper) can extend the range of materials that can be ripped. The second tractor can also be used to supply additional down-pressure on the ripper. Consideration of light blasting can also facilitate the ripper penetration and reduce the cost of moving highly consolidated rock formations.

All of the combined factors above should be considered by both the client and the grading contractor, to insure that the proper selection of equipment and ripping techniques are used for the proposed grading.

APPENDIX D

REFERENCES

REFERENCES

American Society for Testing and Materials, Intl. (ASTM), 2000, Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation, Designation D 5777-00, 13 pp.

Barton, N., 2007, Rock Quality, Seismic Velocity, Attenuation and Anisotropy, Taylor & Francis Group Publishers, 729 pp.

California State Board for Geologists and Geophysicists, Department of Consumer Affairs, 1998, Guidelines for Geophysical Reports for Environmental and Engineering Geology, 5 pp.

Caterpillar, Inc., 2000, Handbook of Ripping, Twelfth Edition, Caterpillar, Inc., Peoria, Illinois, 31 pp.

Caterpillar, Inc., 2012, Caterpillar Performance Handbook, Edition 42, Caterpillar, Inc., Peoria, Illinois, 1598 pp.

Geometrics, Inc., 2004, StrataVisor™ NZXP Operation Manual, Revision B, San Jose, California, 234 pp.

Geogiga Technology Corp., 2001-2013, Geogiga Seismic Pro Refractor Software Program, Version 7.31, http://www.geogiga.com/.

Geogiga Technology Corp., 2013, Geogiga Refractor 7.3 User Guide, 59 pp.

Intelligent Resources, Inc., 1991-2014, Rayfract™ Seismic Refraction Tomography Software, Version 3.31, http://rayfract.com/.

Morton, D.M., 2001, Geologic Map of the Steele Peak 7.5-Minute Quadrangle, Riverside County, California, U.S.G.S. Open File Report 01-449, Scale 1:24,000.

Rimrock Geophysics, Inc., 1995, User Manuals for Computer Programs SIP Shell, SIPIK, SIPIN, SIPEDIT, and SIPT2.

Rimrock Geophysics, Inc., 2004, **SIPwin**, **S**eismic **R**efraction **I**nterpretation **P**rogram for **Win**dows, Version 2.78, User Manual 78 pp.

Santi, P.M., 2006, Field Methods for Characterizing Weak Rock for Engineering, *in*, Environmental & Engineering Geoscience, Volume XII, No. 1, February 2006, pp. 1-11.

Scott, James H., 1973, Seismic Refraction Modeling by Computer, *in* Geophysics, Volume 38, No. 2, pp. 271-284.

Schuster, G. T. and Quintus-Bosz, A., (1993), Wavepath Eikonal Traveltime Inversion: Theory, *in*, *Geophysics*, Vol. 58, No. 9, September, pp. 1314-1323.

Stephens, E., 1978, Calculating Earthwork Factors Using Seismic Velocities, California Department of Transportation Report No. FHWA-CA-TL-78-23, 63 pp.