GEOPHYSICAL SITE STUDY

SR147 - LAKE MEAD BLVD
MP CL9.67 TO CL14.23

MAY 2014

NEVADA DOT
GEOTECHNICAL ENGINEERING

MATERIALS DIVISION

STATE OF NEVADA

DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

GEOTECHNICAL SECTION

RIPPABILITY STUDY

SR147 LAKE MEAD BLVD SLOPE FLATTENING, SHOULDER WIDENING, AND SAFETY IMPROVEMENTS

NORTH LAS VEGAS TO LAKE MEAD NRA

MP CL 9.67 TO CL 14.23

E.A. 73711

MAY 2014

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TABLE OF CONTENTS

Disclaimer

The data and commentary provided in this report is for informational use only. The data presented herein is valid for only the locations where testing was performed. The statements made are professional opinions based on individual interpretation of the data. The actual conditions could vary significantly from reported values. This report is intended to be a general estimate for the typical type and condition of geological features in the project area. Variability in subsurface features, including rock type, state of weathering, and competency should be expected.

Limitation of Methods

Geophysical exploration methods should never be used as the sole and definitive source of information for rippability studies. Many variables can affect the rippability of a rock material including age, composition, competency, and jointing characteristics. Also, excavation equipment other than referenced may encounter different results, as ability to penetrate can be more important than seismic velocity. This information can be used to generally characterize the site and aid in expanded subsurface exploration techniques. Additional exploration including borings, core holes, or trench excavations could be used to provide further verification of the reported values. Geophysical data presented is valid for only the locations where testing was performed.

Picture 1: Looking North along SR147

1.0 Introduction:

Project Location and Purpose

The Nevada Department of Transportation has planned to make safety and operational improvements to State Route 147, Lake Mead Blvd, north of Las Vegas, in Clark County, Nevada. The project, to be contracted, seeks to flatten slopes, widen roadway shoulders, and perform additional safety and drainage improvements. The improvements are to be constructed from MP CL9.67 to CL14.23, along the rural portions of the roadway alignment. As part of these improvements, several protruding rock and soil slopes will need to be cut to allow for wider shoulders and shallower backslopes.

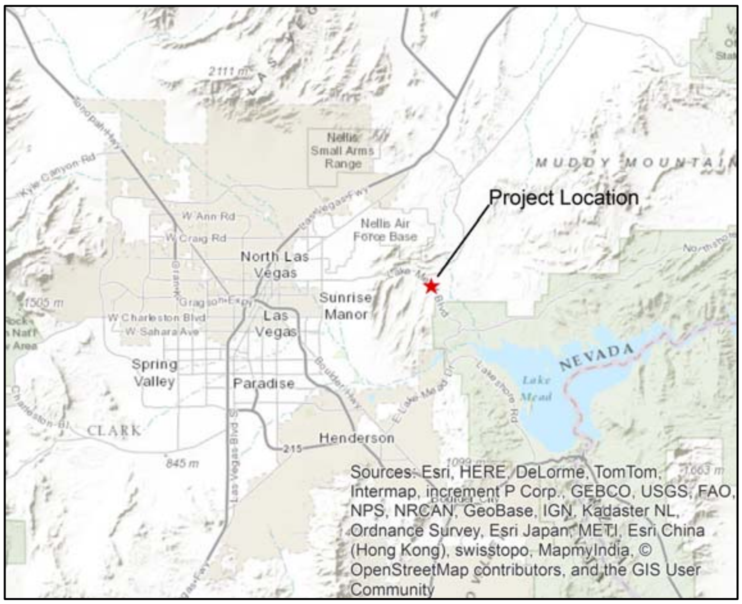


Figure 1: Map Showing Project Location (ESRI ArcMap, BaseMap-World Topographical)

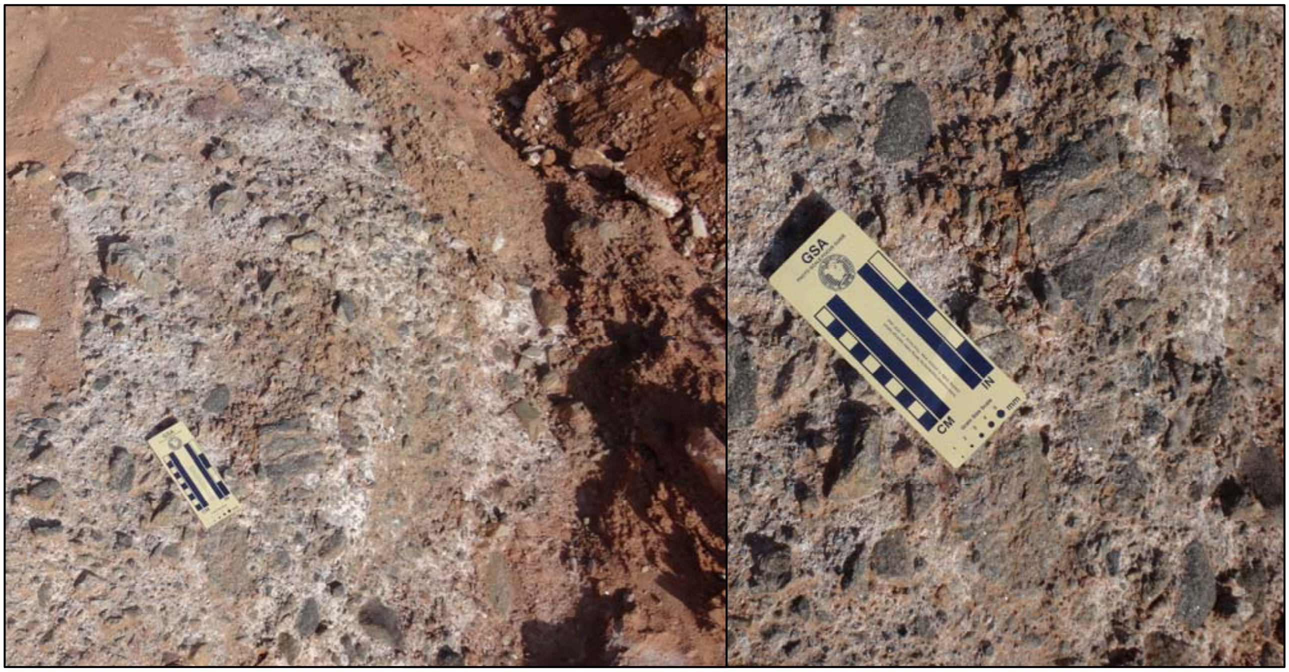
Project Investigation

The main purpose of this report is to characterize the rippability and provide earthwork factors for the rock slopes along the alignment to be improved. The local project geology consists of primarily sedimentary rock formations of varying age and composition, which will be discussed in more detail in the next section. This report will also summarize the results of a geophysical site study performed in the spring of 2014 and provide general interpretations of the collected data. During the geophysical survey, seismic data was collected at three different locations along the roadway alignment, utilizing both seismic refraction and ReMi ™ (Refraction Mictrotremor) methods. The locations were selected in an attempt to be the most representative of the different geological formations. The site geology, field exploration methods, and analysis and interpretations will be discussed in more detail later in the report.

Figure 2: Project Location (ESRI ArcMap, NAIP 2010 Imagery)

2.0 Site Geology:

The geologic information was obtained from United States Geological Survey (USGS) and Nevada Bureau of Mines and Geology (NBMG) geologic mapping. The project location and surrounding area is characterized by several different sedimentary bedrock formations and associated alluvial deposits. Seismic Line one is primarily mapped in geologic unit **Jas**-Eolian crossbedded sandstone (Jurassic), which is also referred to as the Aztec Sandstone formation. Seismic lines two and three are mapped in geologic unit **Ths**- Tuffaceous Sedimentary rocks (middle Miocene to upper Oligocene), also referred to as the Thumb Formation. Seismic Line four is mapped near the border between geologic units **JTRch** and **JRmt**, which are continentally derived siltstone and clay (Lower Jurassic and Upper Triassic) and marine siltstone, limestone, and conglomerate (Middle(?) and Lower Triassic), respectively. Both of these units are also referred to as the Chinle and Moenkopi Formations (Crafford, A.E.J., 2007). A geologic map, depicting the locations of the seismic lines as well as the various geologic units, is located in Appendix D.



Picture 2: Conglomerate materials near SR147 MP CL 13

3.0 Field Exploration Method:

The field exploration consisted of collecting geophysical data at three different locations along the alignment to be improved. The locations were selected in an attempt to be representative of the different geological formations in the area. Since bedrock and soil properties can vary greatly depending on the location(s) tested, caution should be used when utilizing the data. The equipment and procedures for each method will be described below.

<u>Equipment and Procedures</u>

General

Both methods, seismic refraction and ReMi^{TM}, are able to utilize the same basic equipment for data collection. The geophysical data is collected with a 220 ft long seismic array (line) cable with 12 available channels for geophones. The default geophone spacing on the cable is 20 ft on center when fully stretched. Twelve 10Hz vertical P-wave geophones are attached to the cable.

The data is recorded using a 24 channel DAQlink III Seismograph produced by Seismic Source. VibraScope software installed on a Windows based Dell "toughbook" is used to configure the seismograph for data acquisition as well as observe recorded records, pre-process seismic data, and save noise records for further analysis.

Individual geophones were located for display purposes using resource grade Global Positioning System (GPS) handheld unit (Trimble GeoXT). These coordinates were used to display the seismic line locations on the map and to calculate approximate stationing and offset. The horizontal accuracy is estimated to range from 1ft to 3ft with post processing. In the case where topographical elevation variation along the line exceeds 3% to 5% of total line length, relative geophone elevations and distances are recorded using a construction grade survey instrument. These measurements may or may not be tied into an existing benchmark, depending on project location and purpose.

Seismic Refraction

For this survey, geophone spacing was set at 20ft for all lines. Shot locations were located at 10ft offset from each end, as well as at Geophones 3, 6, and 9 for intermediate shots.

A 12lb sledge-hammer and metal striking plate were used to generate the "impulse" p-wave energy for the seismic refraction survey. The sledge hammer is equipped with a piezoelectric trigger, which starts the record at t=0 when the hammer impacts the steel plate. For seismic refraction, noise data was collected in 0.5 second recording periods with a .125ms sampling interval. The individual strike records are stored in SEG-2 format. Records are not stacked or modified until final processing. In general, 10 individual noise records (10 hammer strikes) are collected at each plate shot location along the line. The number of offset shots and their distances, as well as intermediate line shot locations are determined based on the inferred complexity of the subsurface and topographical variation along the line. The minimum is generally one offset shot off each end of the line and three intermediate locations.

ReMi™

For this survey, geophone spacing was set at 20ft for all lines.

Background (ambient) noise was used to generate seismic waves during the ReMi survey. Occasionally, light hammer strikes offset from the end of the seismic line were utilized to increase the high frequency energy during noise recordings. This process can aid interpretation of subsurface shear wave velocity at shallow depths. Occasionally, walking and other light disturbances can be used to increase the amplitude of noise energy over a variety of frequencies when working in quiet environments. Noise recordings for ReMi analysis were 30 second recording periods with a 2ms sampling interval. Each individual record is stored in SEG-Y format. In general, 10 individual recordings are made for each line. Individual records are not stacked or modified until final processing.

4.0 Analysis Methods and Data Interpretation:

The analysis and interpretation of the seismic data collected for this project was performed by a consultant, Optim of Reno, NV. The field exploration, data acquisition, location survey, and preliminary data verification was performed by NDOT. A short description of each process is described below:

Seismic Refraction

The seismic refraction data collected was analyzed using proprietary software, SeisOpt® @2D™ and SeisOpt® @Pro™ developed by Optim of Reno, NV. The analysis and interpretation of the data is a proprietary method owned and developed by Optim. The method uses a simulated annealing algorithm to invert for velocities within the subsurface from refraction picks. This method is based on Simulated Annealing Optimization (SA) and can be used to find optimum solutions to complex subsurface imaging problems in the geotechnical and energy industry (Optim Software, 2014).

The algorithm works by first discretizing the model space into grids. The geophone spacing determines the grid dimensions and these can be different in horizontal and vertical directions. The travel time picks and array geometry (shot and geophone locations, including elevation) are then read in and the algorithm samples thousands of models before settling on the one that best fits all the picks from all the shots equally well. In this process, velocity values for each grid point are determined thus allowing for lateral and vertical velocity variations and imaging of anomalous zones (Optim Software, 2014).

Additional technical details regarding the software or data analysis techniques can be obtained by visiting Optim's website, or contacting them directly.

ReMi ™ (Refraction Microtremor)

The noise data collected for ReMi analysis was analyzed using the proprietary software SeisOpt R ReMi™, developed by Optim of Reno, NV. The analysis and interpretation of the data is a proprietary method owned and developed by the University of Nevada, Reno. The process is currently licensed exclusively to Optim of Reno, NV (Optim Software, 2014).

The process uses ambient noise energy to produce surface wave data, more specifically Rayleigh waves. The Rayleigh wave noise data is converted from time domain to frequency domain using wavefield transformation techniques. This process produces a slowness-frequency spectral image. This image is used to select a "fundamental mode" dispersion curve that represents the minimum phase velocity of the Rayleigh wave energy (Optim Software,2014).

A forward modeling process is then used to produce a shear wave velocity profile that would create the given dispersion curve. This process can involve some individual interpretation and judgment. Other data, such as seismic refraction and soil boring logs can be used to further constrain the shear wave velocity model and improve the reliability of the interpretation. However, this methodology has been shown to produce accurate Vs_{100ft} (Average shear wave velocity in the upper 100ft) values as well as reasonable estimations of shear wave velocities of individual layers at depth.

5.0 Summary and Conclusions:

Rippability

Using the seismic refraction data collected, two-dimensional p-wave velocity models were created for each seismic line. The models for lines 2 and 3 were combined into one because the lines overlapped one another. These models show the variation in seismic velocity along the line as well as with depth. Although the cut depth is limited for the project, the full depth velocity model was provided.

Using ReMi ™ data analysis, one dimensional average shear wave velocity profiles were provided for each line. Although these models are traditionally used for site classifications, they can also be used to compliment some of the weaknesses in seismic refraction method. Layer velocity reversals, with lower velocity layers underlying higher velocity layers, and other features may be hidden during refraction, but can be identified using ReMi™ methods.

The criterion for estimating rippability of the cut slopes was based on the Seismic (P- Wave) Velocity vs. Rippability developed by the California Department of Transportation (CALTRANS) (Leeds, 2001). These values are based on unpublished Caltrans data for a Caterpillar D9G series bulldozer with a single-tooth ripper (CALTRANS, 2011).

Seismic Velocity (P-wave) (Feet/Second)	**Rippability**
<3400	Easily Ripped
3400-4900	Moderately Difficult
4900-6500	Difficult ripping/Light Blasting
>6500	Blasting Required

Table 1: CALTRANS Rippability Recommendations

The recorded maximum p-wave velocities, at the maximum depth of the proposed cut, for each line, are shown below. These values are reported to provide clarification to the range shown on the 2-D seismic wave velocity models shown in Appendix A. Full tables of numerical values at each depth and distance along the line are available on request, but are not provided in this report.

Seismic Line #	Maximum Seismic Velocity @ Max Depth of Cut	Caltrans Rippability Criteria
Seismic Line #1	5300 ft/s	Difficult Ripping/Light Blasting
Seismic Line #2 & Seismic Line #3	5600 ft/s	Difficult Ripping/Light Blasting
Seismic Line #4	5350 ft/s	Difficult Ripping/Light Blasting

Table 2: Recorded P-wave velocities at maximum proposed cut depth.

Based on the seismic velocities observed, difficult to rip materials may be encountered. In certain cases, some light blasting may be required depending on the processes used and equipment available. Velocity models and cross sections can be found in the Appendix B and Appendix E respectively.

Earthwork Factors

Earthwork factors, or Shrink/Swell factors, were estimated based on the geologic formation and seismic velocities recorded. The average site seismic velocity was calculated by averaging all individual layer velocities recorded from the top to the bottom of the proposed cut depth, for each line. This value was then used to estimate the mean seismic velocity to be expected throughout the project. Variability is to be expected and the selected value was only used to predict the volume swell of the excavated materials. Empirical correlations developed by CALTRANS were used to select a predicted swell value. Based on this data, the estimated swell will be approximately 5%. The site velocity table and the Shrink/Swell prediction charts used can be found in Appendix F.

6.0 References

1. California Department of Transportation (CALTRANS), "Seismic Refraction Survey, Route 299, North Fork Curve Project", 02-TRI-299 PM36.6/36.8, September 6, 2011. Accessed from http://www.dot.ca.gov/hq/esc/oe/project_ads_addenda/02/02-3E8204/pdf/02-3e8204IH.pdf

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4. Castor, S.B, Faulds, J.E., Rowland, S.M., dePolo, C.M., 2000, Geologic Map of the Frenchman Mountain Quadrangle,1:24,000 Scale, Nevada Bureau of Mine and Geology Map 127.

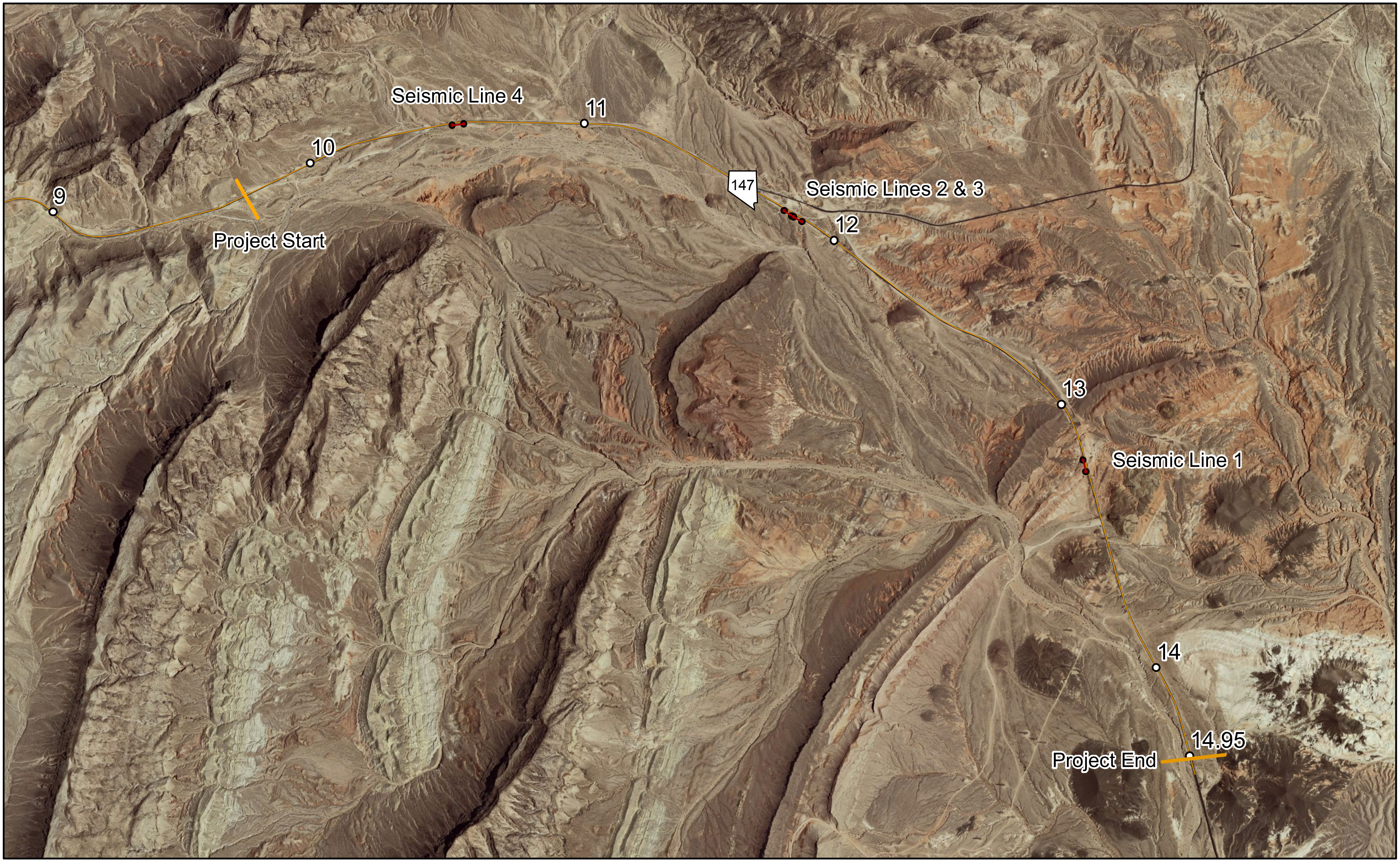
5. ESRI et al., World Topographical Map, Retrieved from http://goto.arcgisonline.com/maps/World_Topo_Map

6. Google Maps. (2011) [Lake Mead Blvd.][Street Map Imagery] Retrieved from- https://maps.google.com/maps?q=lake+mead+blvd+las+vegas&ie=UTF-8&hq=&hnear=0x80c8c1ce6d325ce5:0x7918d72bd9256f5,Las+Vegas,+NV&gl=us&ei=LA5pU-n_IYSDogTk7YKwAw&sqi=2&ved=0CCUQ8gEwAA

7. Optim Software. (2014) Retrieved from- http://www.optimsoftware.com/ Accessed on 05/12/2014.

8. Stephens, E., 1978, Calculating Earthwork Factors using Seismic Velocities, California Department of Transportation (CALTRANS) Report Number FHWA-CA-TL-78-23. Retrieved from- http://www.dot.ca.gov/hq/research/researchreports/1978-1980/78-23.pdf

APPENDIX A



N

Start/End Seismic Line

Milepost

0 1,320 2,640 3,960 Feet

Safety Improvements, Flatten Slopes, Widen Shoulders
SR147 Lake Mead Blvd

1:30,000

THIS MAP IS FOR DISPLAY PURPOSES ONLY.
MAP COMPILED FROM BEST AVAILABLE DATA SOURCES.
NOT ALL FEATURES PORTRAYED DUE TO SCALE.

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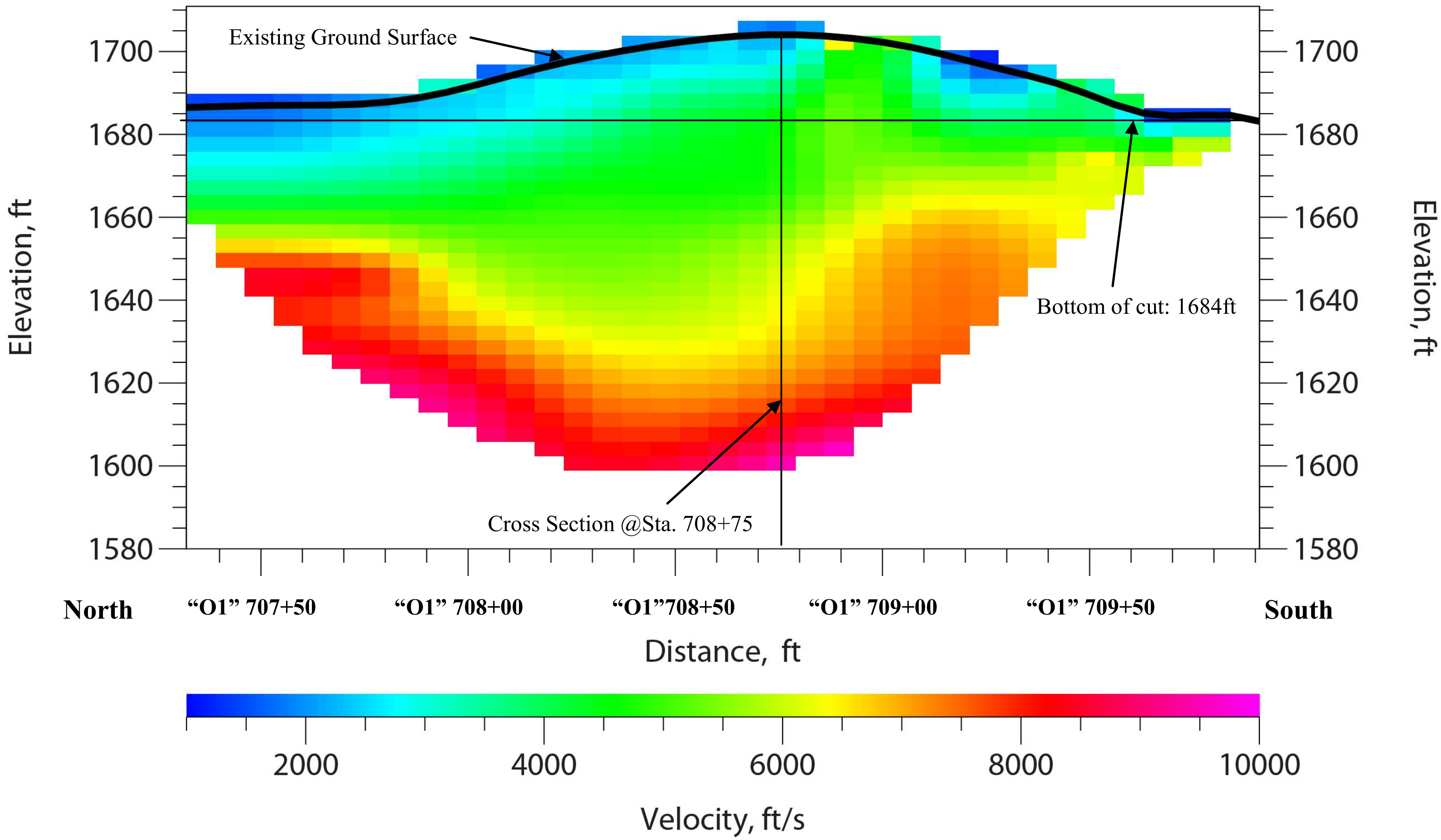
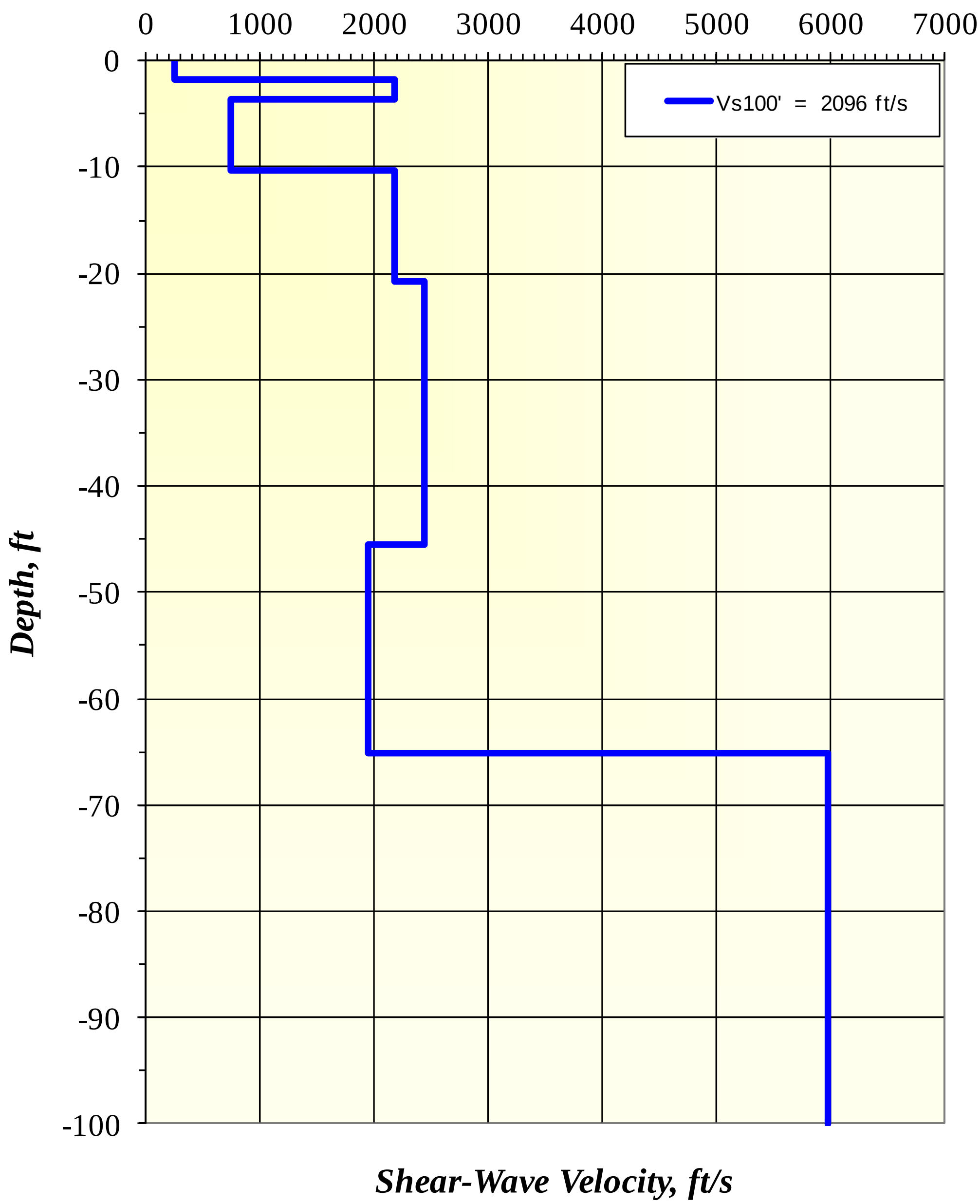
APPENDIX B



Data Provided By:
NDOT Geotechnical Section
Andrew Lawrence P.E.
Date: 4/28/2014

73711 Lake Mead Blvd.
Seismic Line #1: P-Wave Velocity
Offset 40' Rt. from Existing Roadway CL

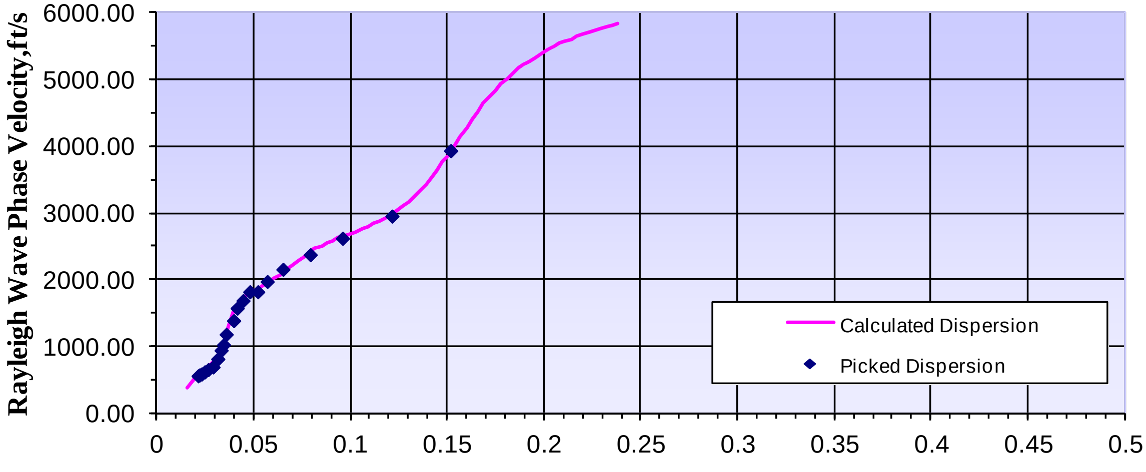
Seismic Line 1: ReMi Vs Model



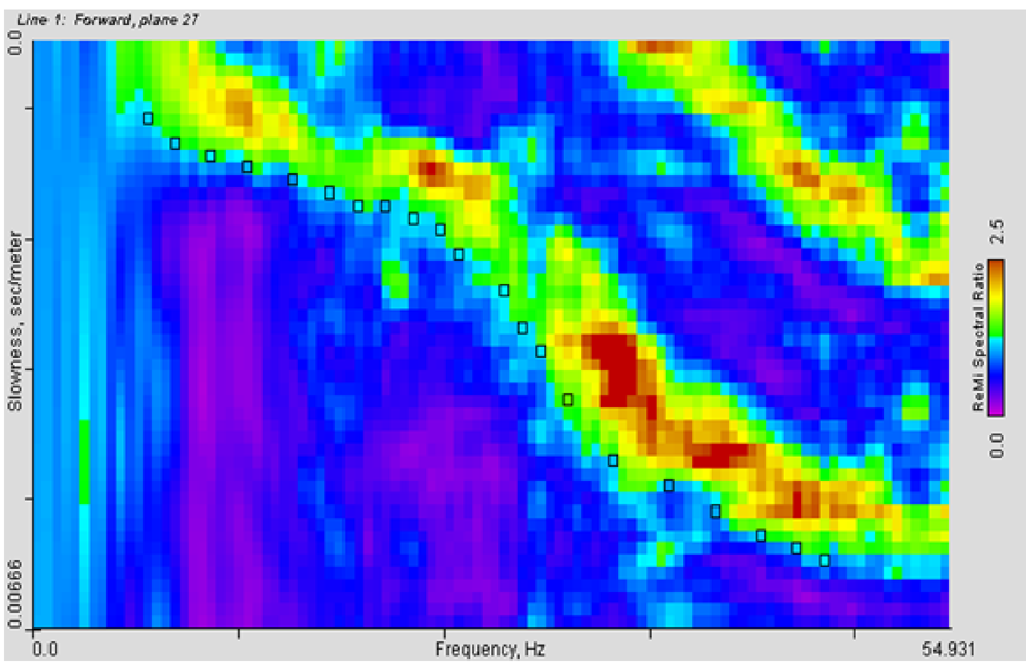
NEVADA DOT GEOTECHNICAL ENGINEERING	**73711 Lake Mead Blvd.** **Seismic Line #1: 1D Average S-Wave Velocity** **Offset 40’ Rt. From Existing Roadway CL**

Sesimic Line 1: ReMi Analysis Supportive Illustration

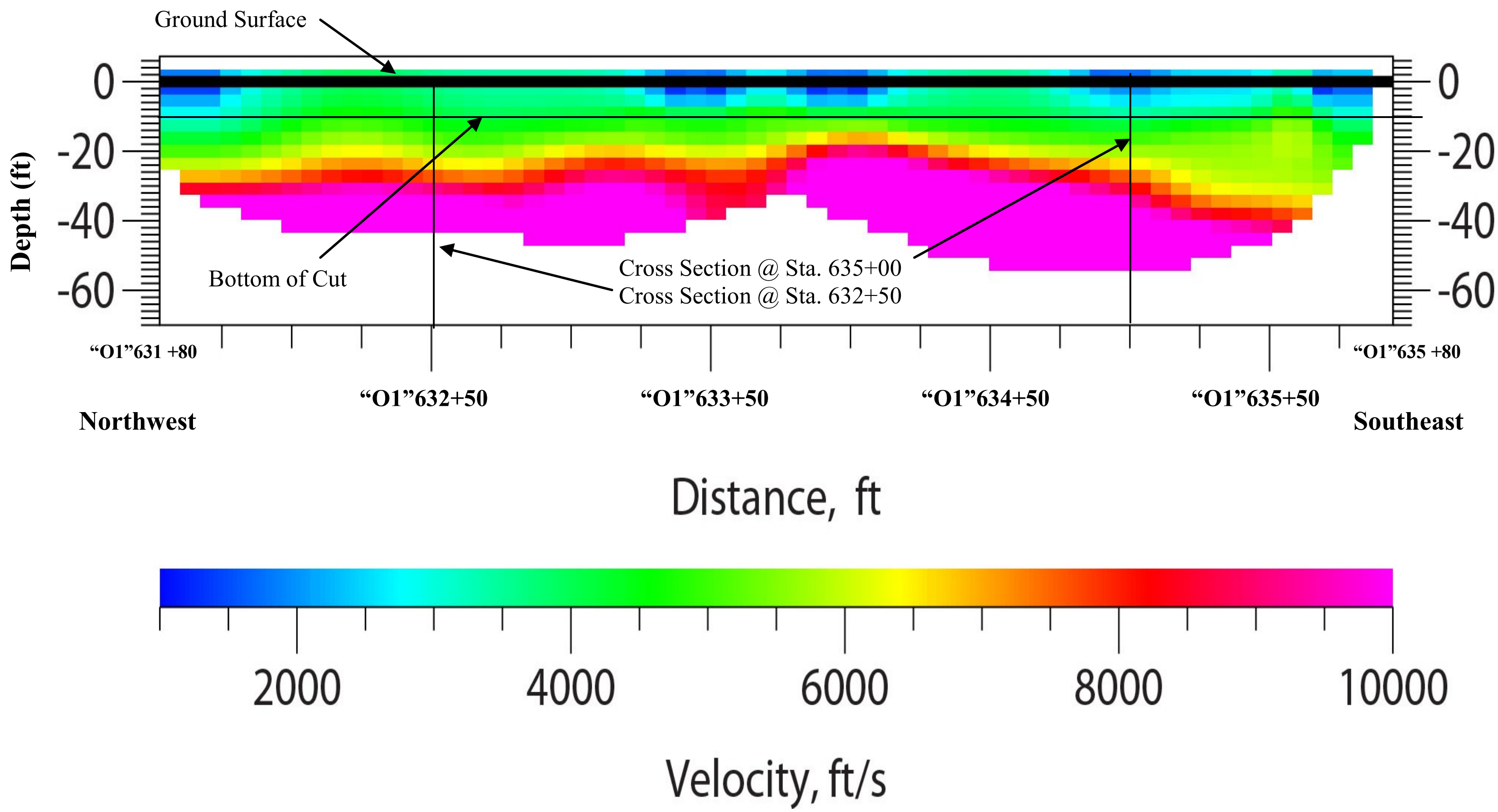
Dispersion Curve Showing Picks and Fit



p-f Image with Dispersion Modeling Picks

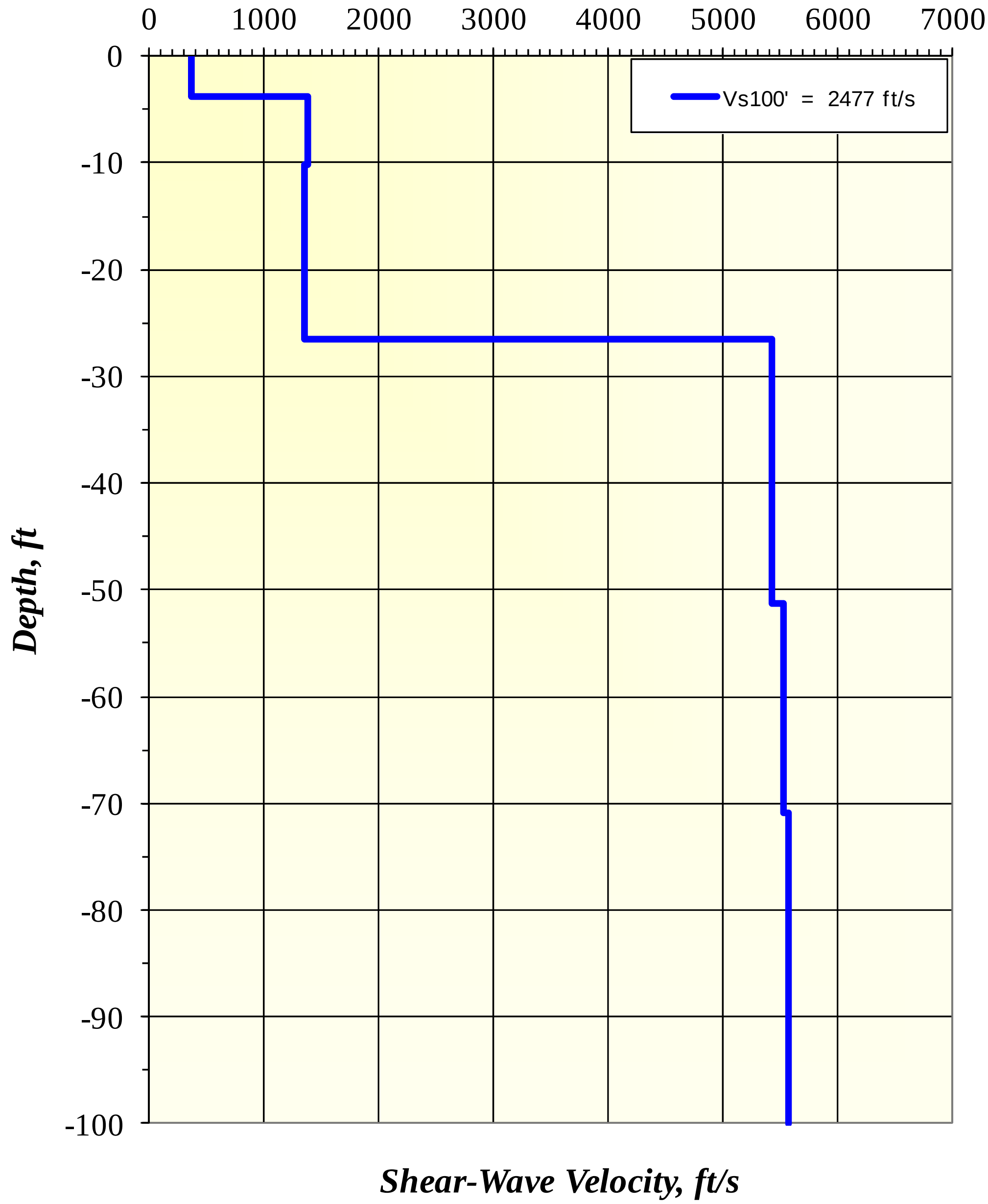


73711 Lake Mead Blvd.
Seismic Line #1:
ReMi Spectral Image and Dispersion Picks



NEVADA DOT GEOTECHNICAL ENGINEERING	Data Provided By: NDOT Geotechnical Section Andrew Lawrence P.E. Date: 4/28/2014	**73711 Lake Mead Blvd. Seismic Line #2 & #3: P-Wave Velocity Offset 50' Rt. from Existing Roadway CL**

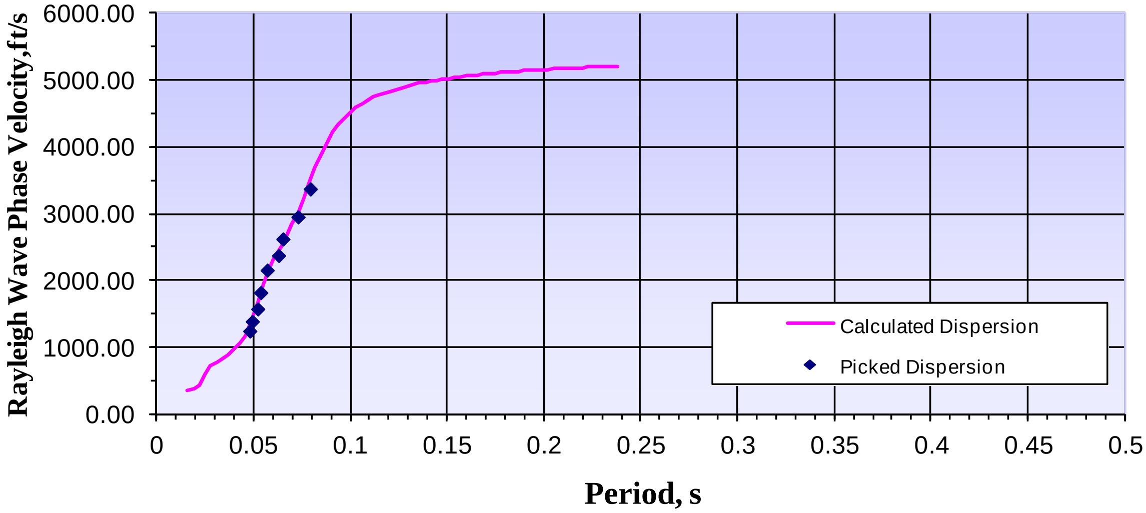
Seismic Line 2: ReMi Vs Model



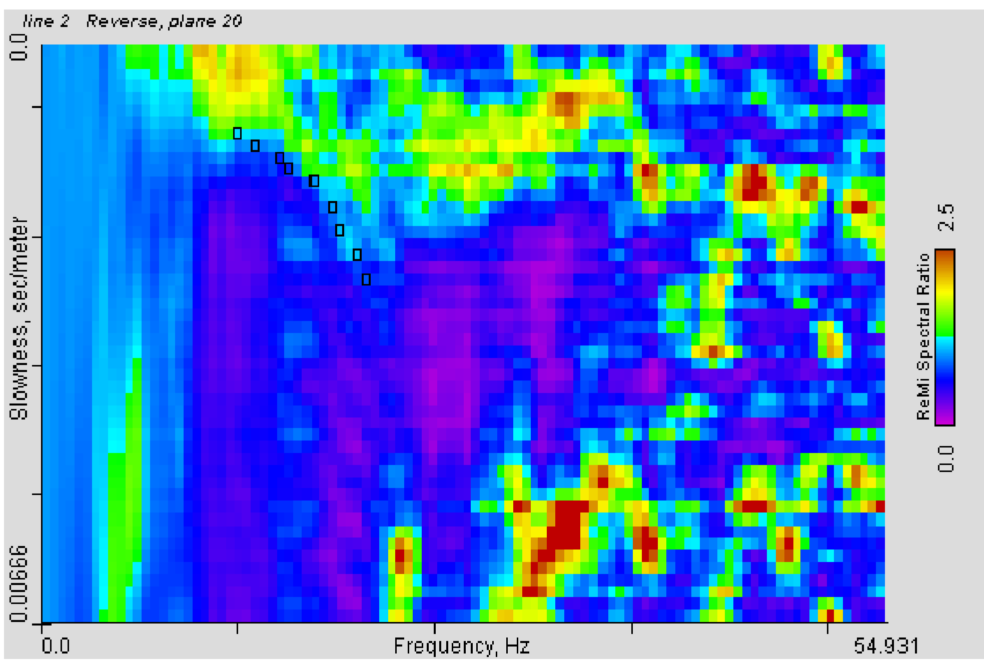
73711 Lake Mead Blvd.
Seismic Line #2: 1D Average S-Wave Velocity
Offset 50' Rt. From Existing Roadway CL

Seismic Line 2: ReMi Analysis Supportive Illustration

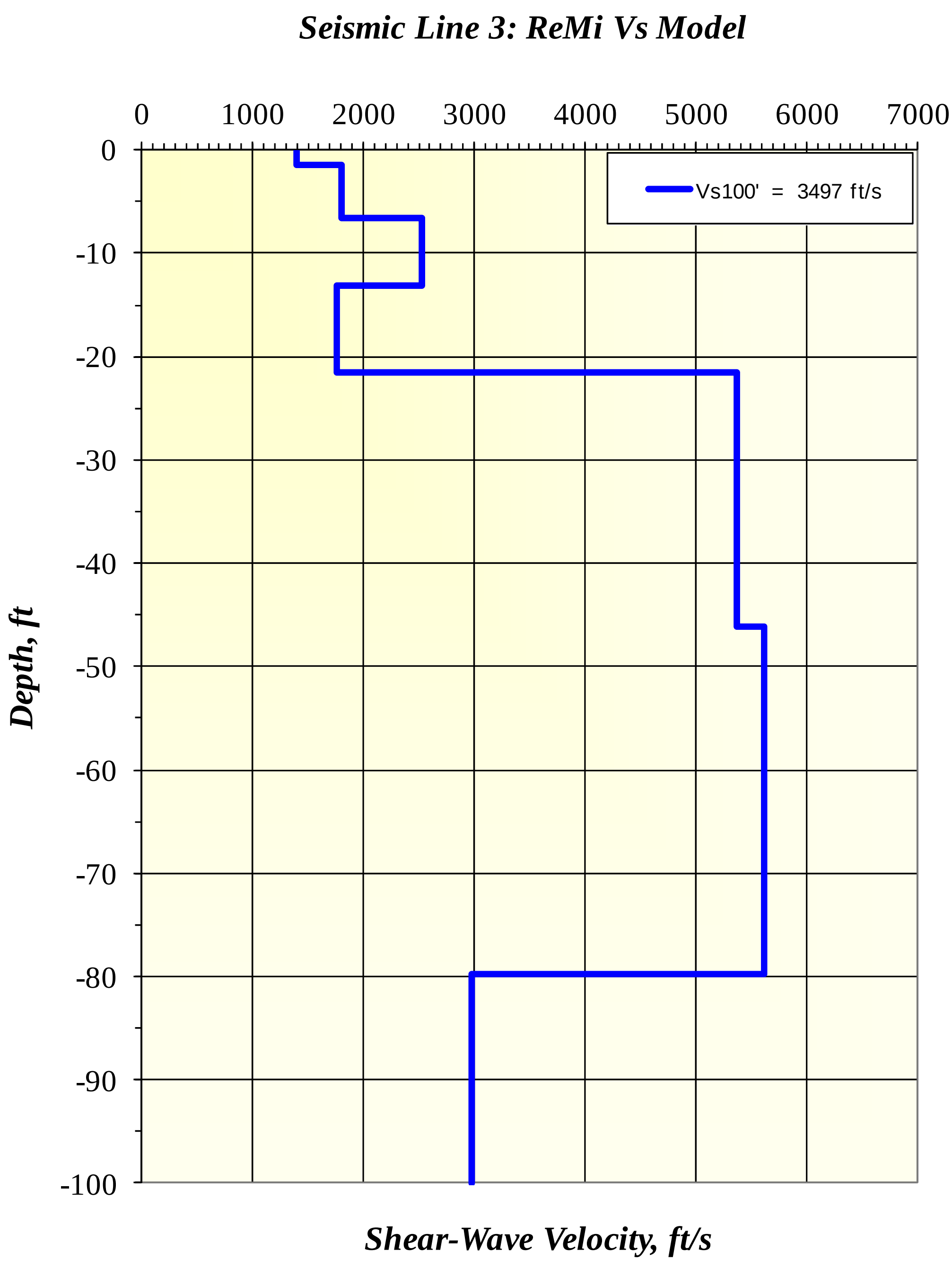
Dispersion Curve Showing Picks and Fit



p-f Image with Dispersion Modeling Picks



NEVADA DOT GEOTECHNICAL ENGINEERING	**73711 Lake Mead Blvd.** **Seismic Line #2:** **ReMi Spectral Image and Dispersion Picks**

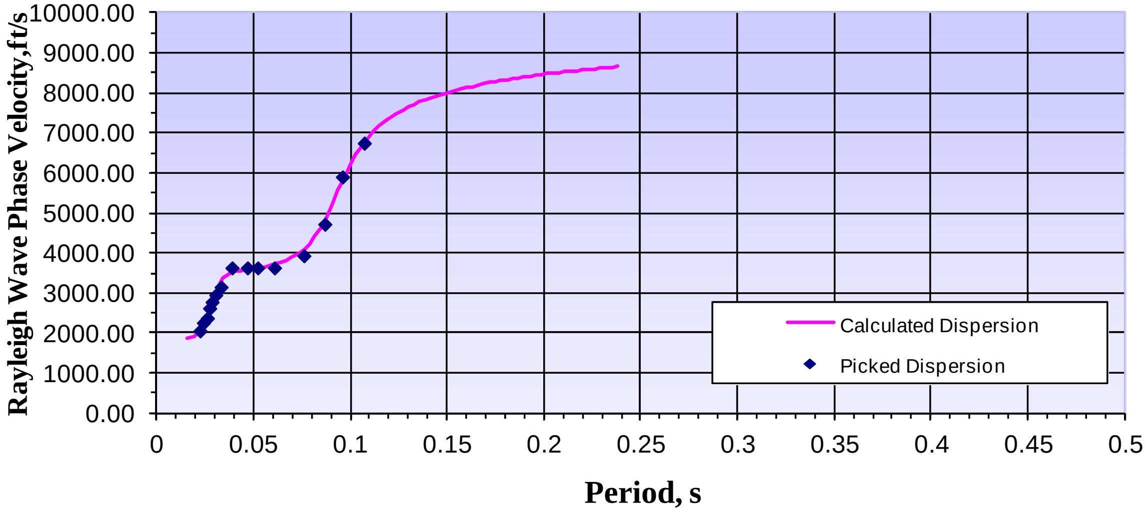


NEVADA DOT GEOTECHNICAL ENGINEERING

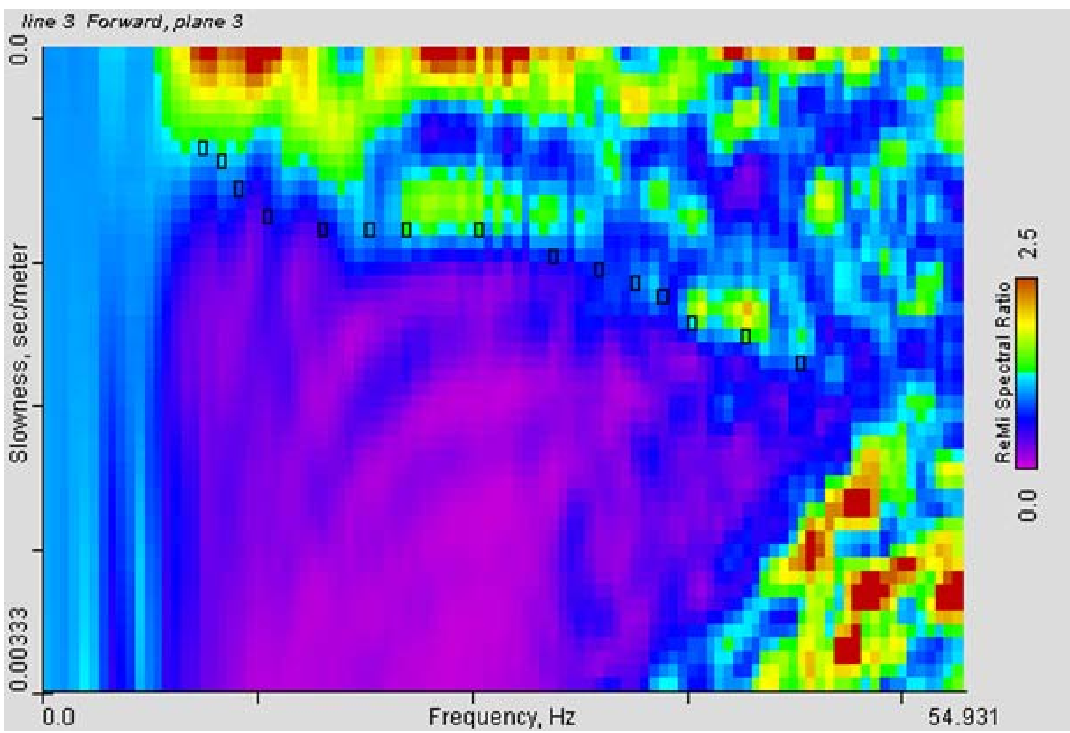
73711 Lake Mead Blvd.
Seismic Line #3: 1D Average S-Wave Velocity
Offset 50’ Rt. From Existing Roadway CL

Seismic Line 3: ReMi Analysis Supportive Illustration

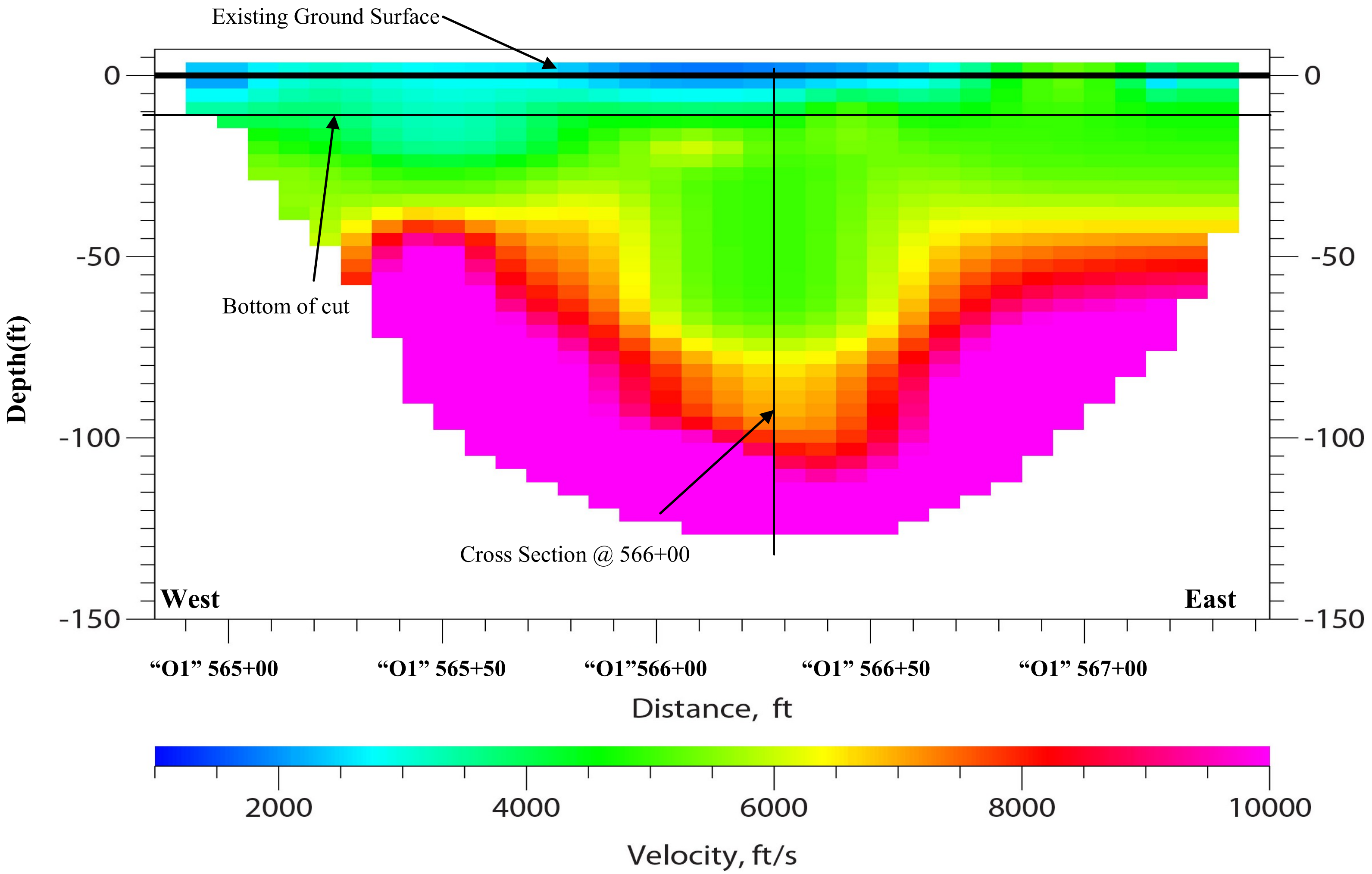
Dispersion Curve Showing Picks and Fit



p-f Image with Dispersion Modeling Picks

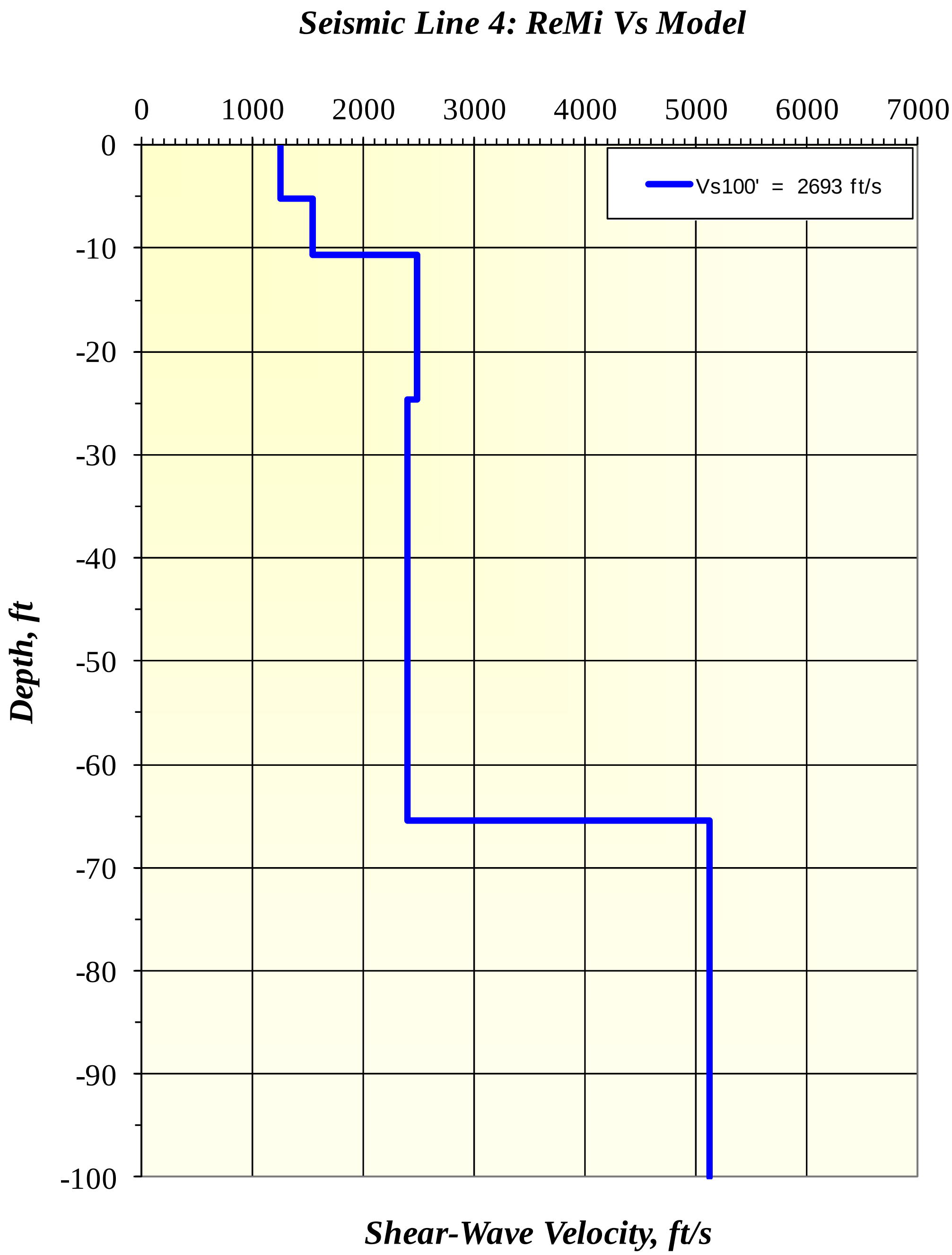


NEVADA DOT GEOTECHNICAL ENGINEERING	**73711 Lake Mead Blvd. Seismic Line #3: ReMi Spectral Image and Dispersion Picks**



Data Provided By:
NDOT Geotechnical Section
Andrew Lawrence P.E.
Date: 4/28/2014

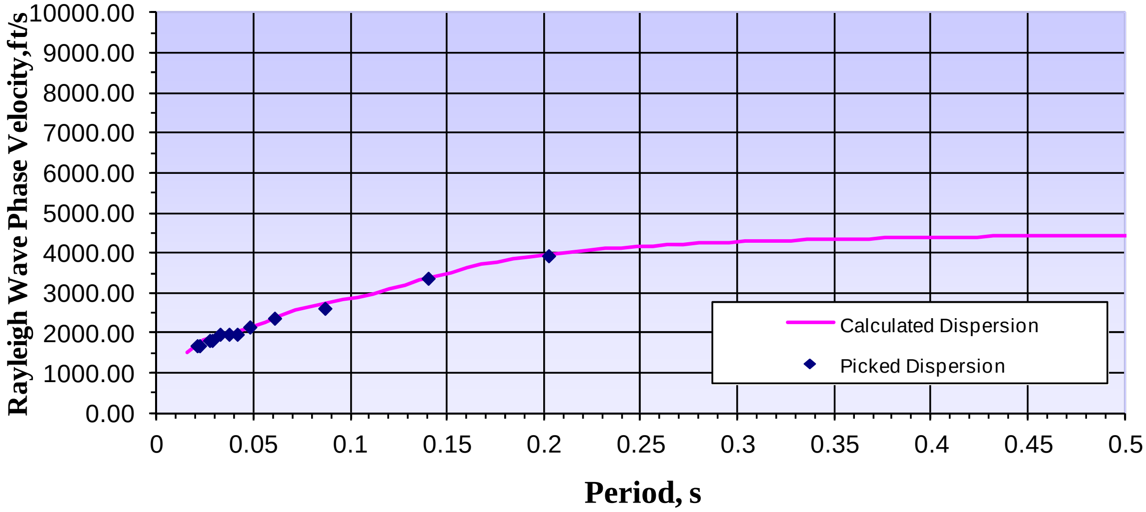
73711 Lake Mead Blvd.
Seismic Line #4: P-Wave Velocity
Offset 40' Rt. from Existing Roadway CL



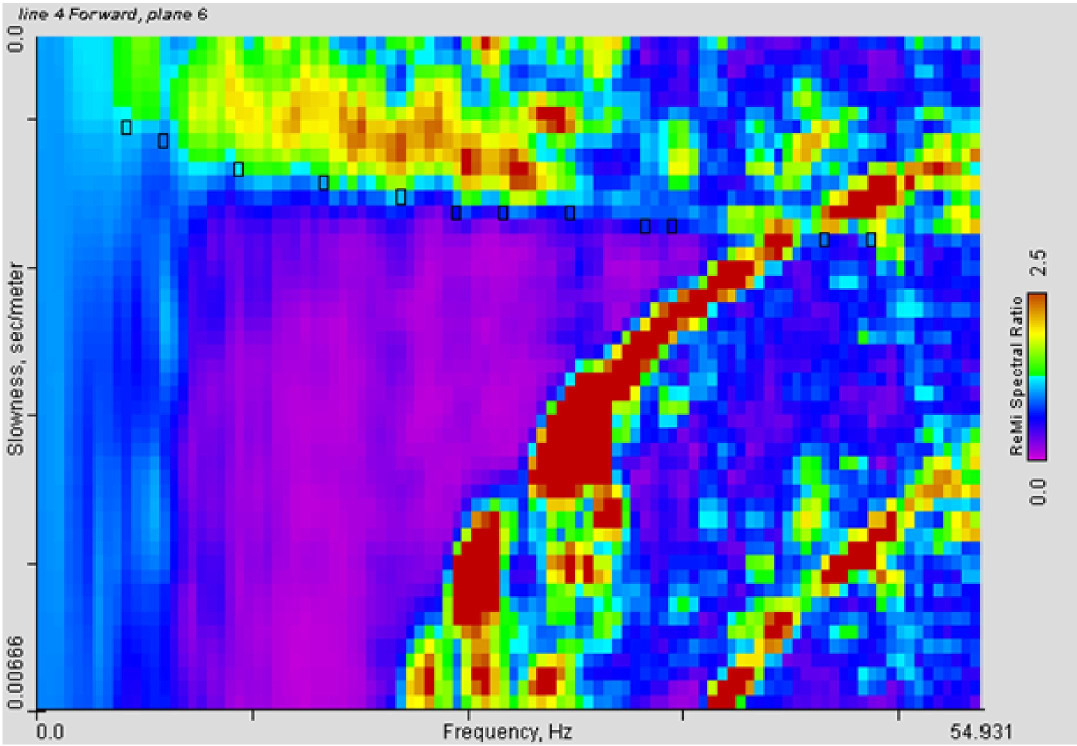
73711 Lake Mead Blvd.
Seismic Line #4: 1D Average S-Wave Velocity
Offset 40' Rt. From Existing Roadway CL

Seismic Line 4: ReMi Analysis Supportive Illustration

Dispersion Curve Showing Picks and Fit



p-f Image with Dispersion Modeling Picks



NEVADA DOT GEOTECHNICAL ENGINEERING	**73711 Lake Mead Blvd.** **Seismic Line #4:** **ReMi Spectral Image and Dispersion Picks**

APPENDIX C

<u>Seismic Line Description:</u>

Seismic Line #1, running parallel to the roadway, offset 40ft Rt. from SR147 centerline.
Station "O1" 707+50 to "O1" 709+50.

Image obtained from Google Maps Imagery

NEVADA DOT
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73711 Lake Mead Blvd.
Geophysical Survey
NDOT Geotechnical Section (028)

Seismic Line Description:

Seismic Lines #2 and #3, running parallel to the roadway, offset 50ft Rt. from SR147 centerline.
Station “O1” 631+80 to “O1” 635+80.

Image obtained from Google Maps Imagery

NEVADA DOT GEOTECHNICAL ENGINEERING

73711 Lake Mead Blvd.
Geophysical Survey
NDOT Geotechnical Section (028)

Seismic Line Description:

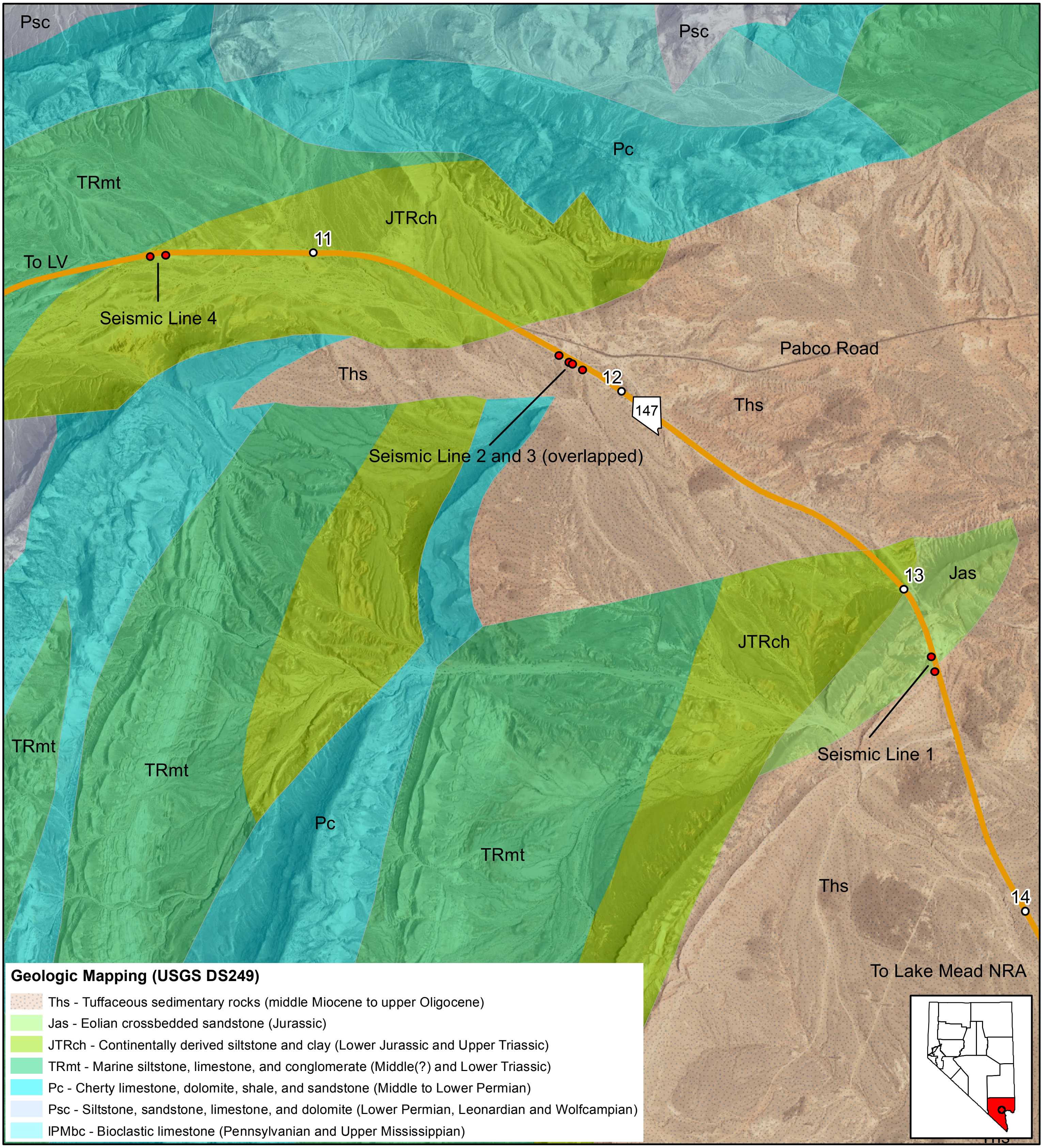
Seismic Line #4, running parallel to the roadway, offset 40ft Rt. from SR147 centerline.
Station “O1” 565+00 to “O1” 567+00.

Image obtained from Google Maps Imagery

NEVADA DOT GEOTECHNICAL ENGINEERING

73711 Lake Mead Blvd.
Geophysical Survey
NDOT Geotechnical Section (028)

APPENDIX D



N

State Route 147 (Lake Mead Blvd)

Milepost Location

Start/End of Seismic Line

0 1,320 2,640 3,960 Feet

THIS MAP IS FOR DISPLAY PURPOSES ONLY.
MAP COMPILED FROM BEST AVAILABLE DATA SOURCES.
NOT ALL FEATURES PORTRAYED DUE TO SCALE.

Rippability Study 73711 Lake Mead Blvd. Geologic Mapping (USGS)

1:24,000

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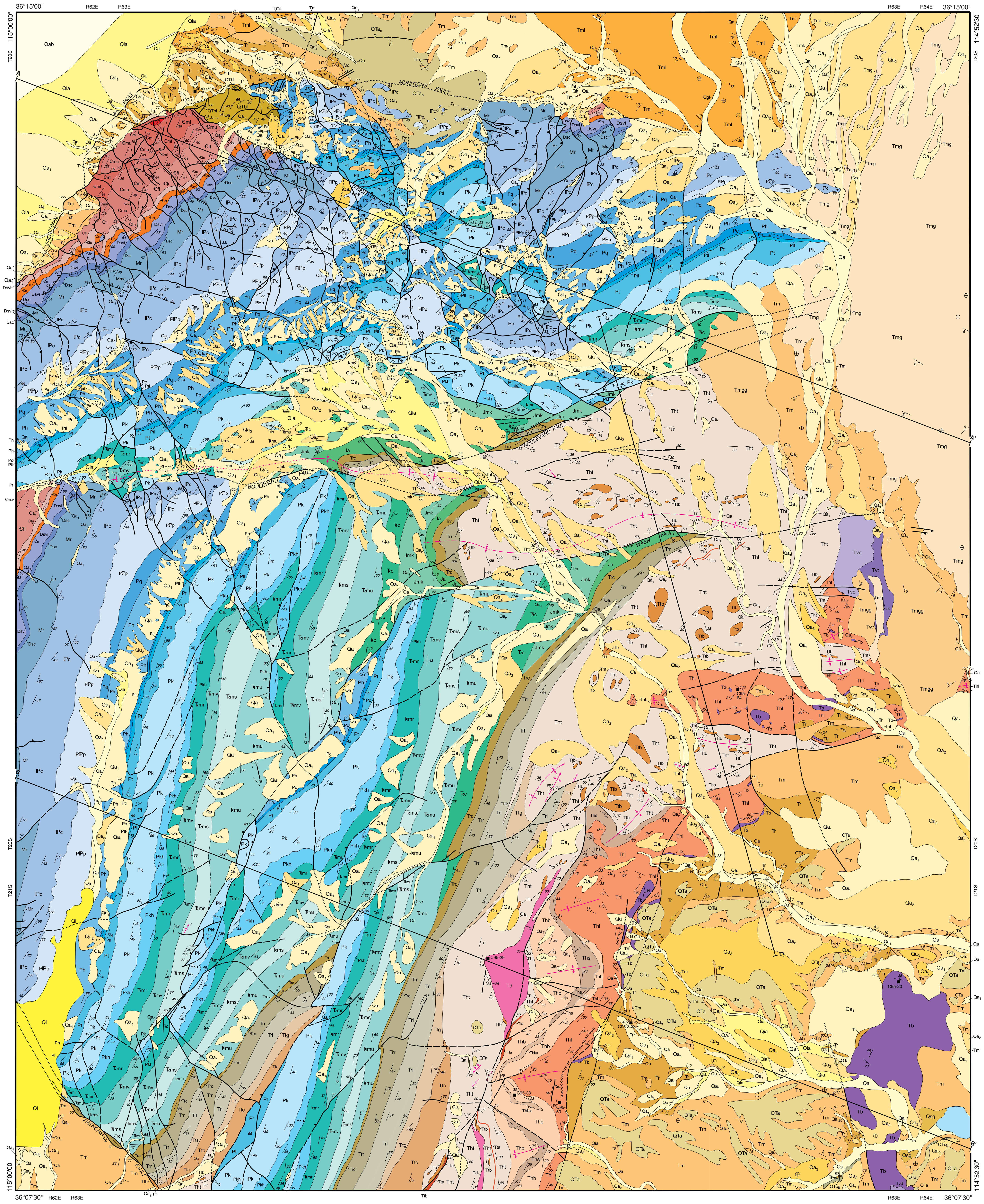
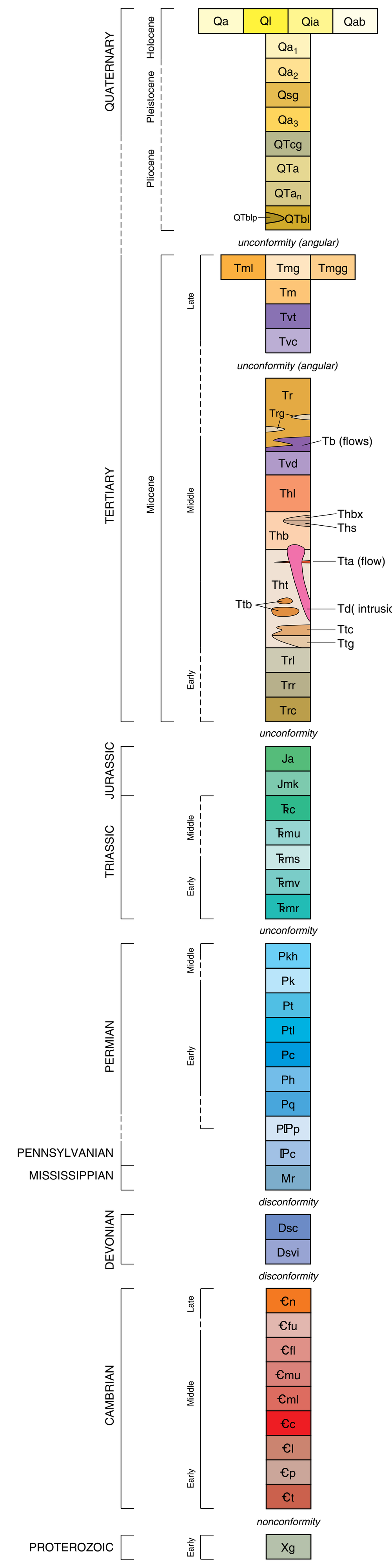




- Qa Active alluvium
- Ql Landfill
- Qia Intermittently active alluvium
- Qab Basin alluvium of Las Vegas Valley
- Qa_1 Young stream-terrace and fan-terrace alluvium
- Qa_2 Intermediate stream-terrace and fan-terrace alluvium
- Qsg Intermediate alluvium of Las Vegas Wash
- Qa_3 Older stream-terrace and fan-terrace alluvium
- QTcg Older cemented conglomerate of Las Vegas Wash
- QTa Older alluvium and lag gravels
- QTa_n Older alluvium of Nellis basin
- QTbl Limestone megabreccia, IPc and Mr clasts; PIPp clasts (QTblp)

Muddy Creek Formation
- Tml Limestone
- Tmg Gypsum
- Tmgg Gypsiferous gravel
- Tm Sandstone, siltstone, and conglomerate

Volcanics of Callville Mesa
- Tvt Tuffaceous siltstone
- Tvc Mafic flows and cinders

- Tr Red sandstone; gypsum (Trg)
- Tb Basalt
- Tvd Dacite flow rock
- Td Intrusive porphyry

Horse Spring Formation
- Thl Lovell Wash Member
- Thb Bitter Ridge Limestone Member; volcanic breccia (Thbx); sandstone (Ths)

Thumb Member
- Tht Sandstone, siltstone, and conglomerate
- Tta Intermediate or mafic volcanic rock
- Ttb Breccia with Proterozoic detritus
- Ttc Conglomerate
- Ttg Gypsum-rich sequence

Rainbow Gardens Member
- Trl Resistant limestone unit
- Trr Sandstone, conglomerate, and limestone unit
- Trc Resistant basal conglomerate

- Ja Aztec Sandstone
- Jmk Moenave and Kayenta Formation equivalents
- Ŧc Chinle Formation

Moenkopi Formation
- Ŧmu Upper redbed unit
- Ŧms Schnabkaib Member
- Ŧmv Virgin Member
- Ŧmr Lower redbed unit

Kaibab Formation
- Pkh Harrisburg Member
- Pk Kaibab cherty limestone

Toroweap Formation
- Pt Upper unit
- Ptl Lower unit

- Pc Coconino Sandstone
- Ph Hermit Formation
- Pq Queantoweap Sandstone
- PIPp Pakoon Formation
- IPc Callville Limestone
- Mr Redwall Limestone

Sultan Formation
- Dsc Crystal Pass Member
- Dsvi Valentine and Ironside Members

- €n Nopah Formation

Frenchman Mountain Dolomite
- €fu Upper part
- €fl Lower part

Muav Limestone
- €mu Upper part
- €ml Lower part

- €c Chisholm Shale
- €l Lyndon Limestone
- €p Pioche Shale
- €t Tapeats Sandstone
- Xg Early Proterozoic gneiss

Lithologic contact Dashed where inferred or approximately located due to poor exposures.

Moderately to steeply dipping normal fault showing dip Ball on downthrown side; arrow near dip symbol shows trend of striae on fault surface; dashed where inferred or approximately located due to poor exposures; dotted where concealed; queried where uncertain.

Gently dipping normal fault showing dip Hachures on downthrown side; arrow near dip symbol shows trend of striae on fault surface; dashed where inferred or approximately located due to poor exposures; dotted where concealed.

Reverse fault showing dip Teeth on hanging wall; arrow near dip symbol shows trend of striae on fault surface; dashed where inferred or approximately located due to poor exposures; dotted where concealed.

Mainly strike-slip fault Arrows on either side of fault indicate sense of strike separation; arrow near dip symbol shows trend of striae on fault surface; dashed where inferred or approximately located due to poor exposures; dotted where concealed. In cross section, T indicates movement toward profile; A indicates movement away from profile.

Syncline Dashed where inferred or approximately located due to poor exposures, dotted where concealed.

Anticline Dashed where inferred or approximately located due to poor exposures, dotted where concealed.

Tufa with silica in the Lovell Wash Member of the Horse Spring Formation.

Strike and dip of inclined bedding

Horizontal bedding

Minor anticline showing bearing and plunge of hingeline

Overturned syncline

C95-38 **Sample locality for $^{40}Ar/^{39}Ar$ geochronologic age determination**

See accompanying text for explanation of units, figures, references, and a discussion of the geology of the Frenchman Mountain Quadrangle.

Scale 1:24,000

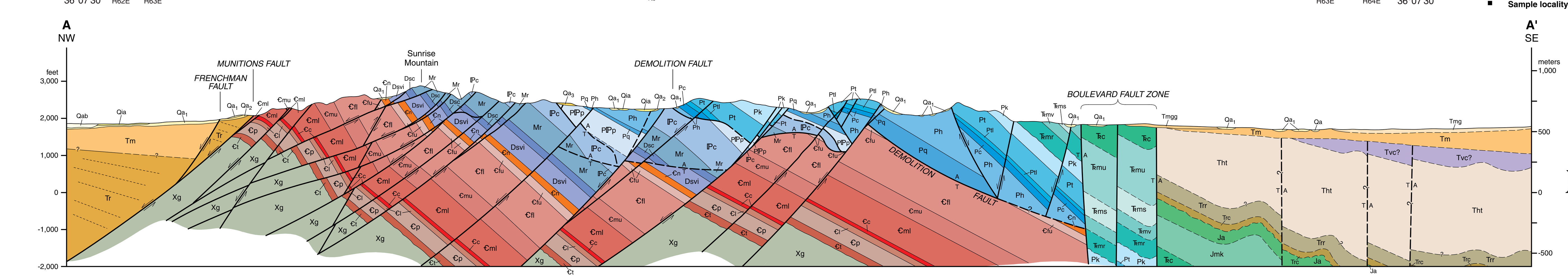
0 0.5 1 kilometer

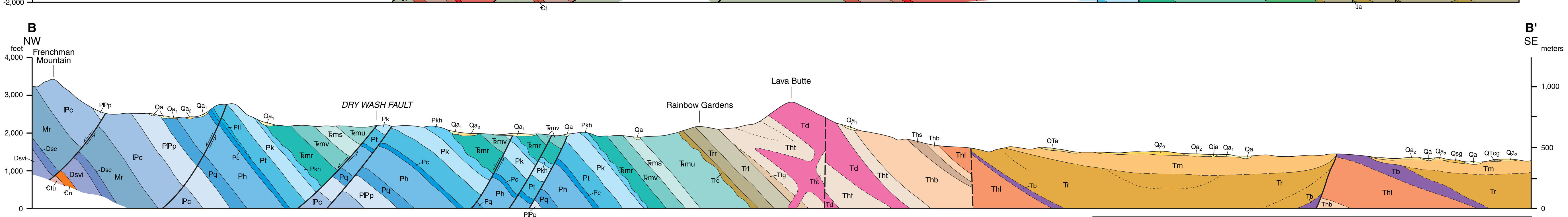
0 0.5 1 mile

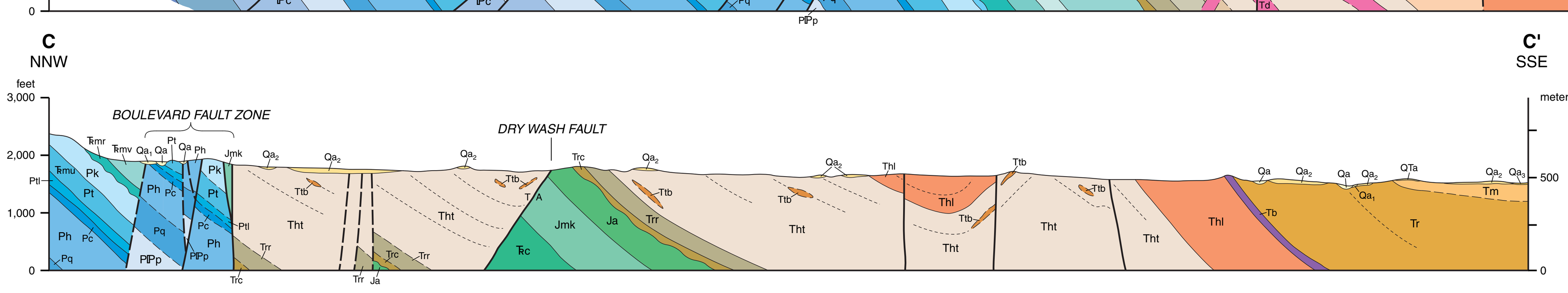
0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 40 FEET

Base map: U.S. Geological Survey Frenchman Mountain 7.5' Quadrangle, 1983







GEOLOGIC MAP OF THE FRENCHMAN MOUNTAIN QUADRANGLE, CLARK COUNTY, NEVADA

Stephen B. Castor,
James E. Faulds,
Stephen M. Rowland,
and Craig M. dePolo

2000

Field work performed from 1995 through 2000.

Office Review: R. Ernie Anderson, USGS, Denver; Robert G. Bohannon, USGS, Menlo Park; Alan R. Ramelli, NBMG, Reno

Field Review: R. Ernie Anderson, USGS, Denver; L. Sue Beard, USGS, Flagstaff; Robert G. Bohannon, USGS, Menlo Park

First edition, first printing 2000; printed by Bear Industries, Sparks, NV
Edited by Dick Meeuwig; cartography by Robert Chaney and Susan Tingley

Partial funding for this research was provided by the STATEMAP Program of the U.S. Geological Survey (grant numbers 1434-94-A-1242 and 1434-HQ-97-AG-01766). In addition, the Las Vegas office of the U.S. Geological Survey is acknowledged for providing vehicular support during part of this study, for which we thank Gary Dixon. The U.S. National Park Service at the Lake Mead National Recreation Area kindly provided housing at Callville Bay during mapping of the north half of the quadrangle, for which we thank Kent Turner and Darlene Carnes. Colonel S.A. Arrington, Captain R.J. Brown, and Sergeant Votaw of the U.S. Air Force are thanked for providing access to Nellis Air Force Base. The views and conclusions contained in this document are, however, those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

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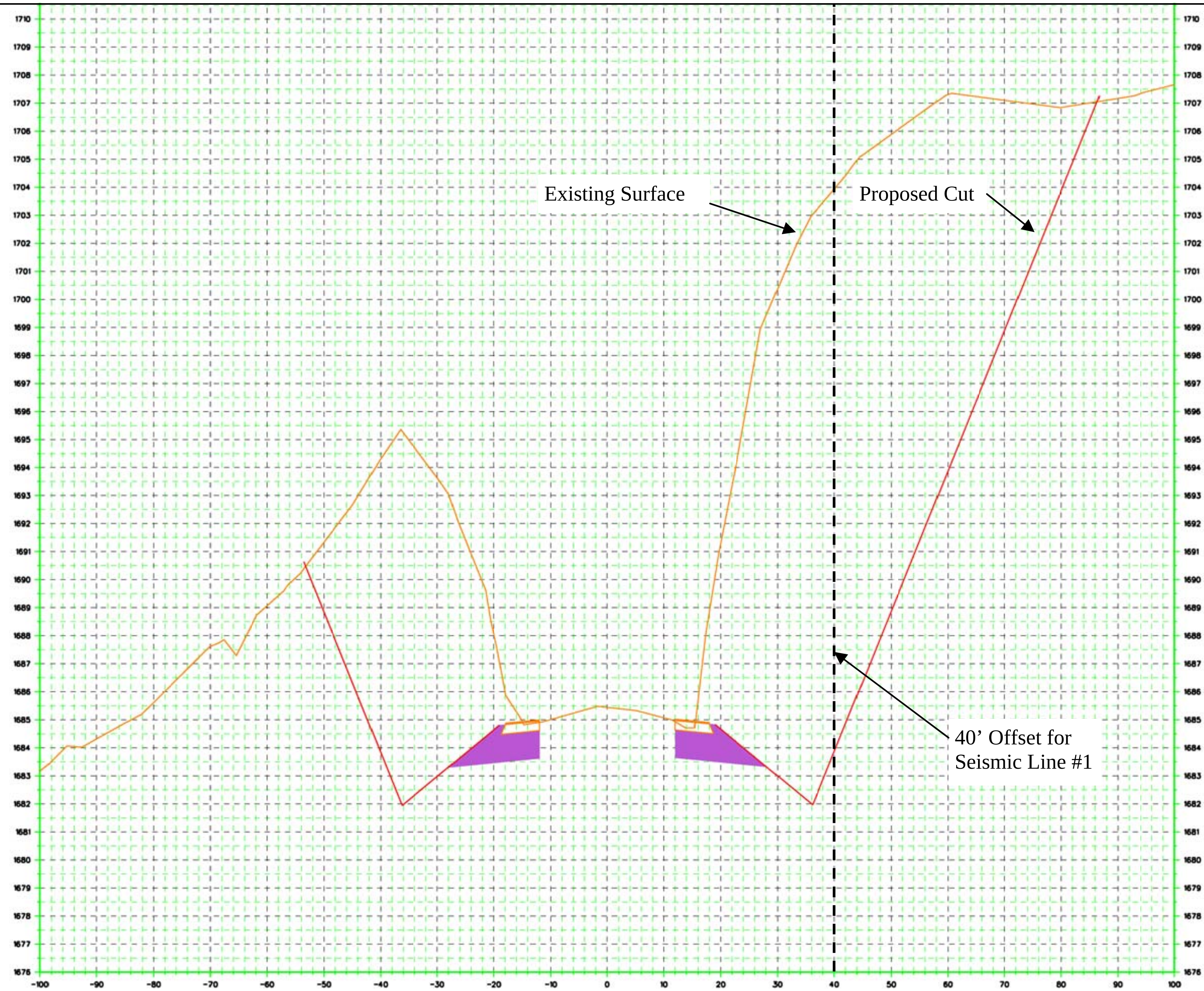
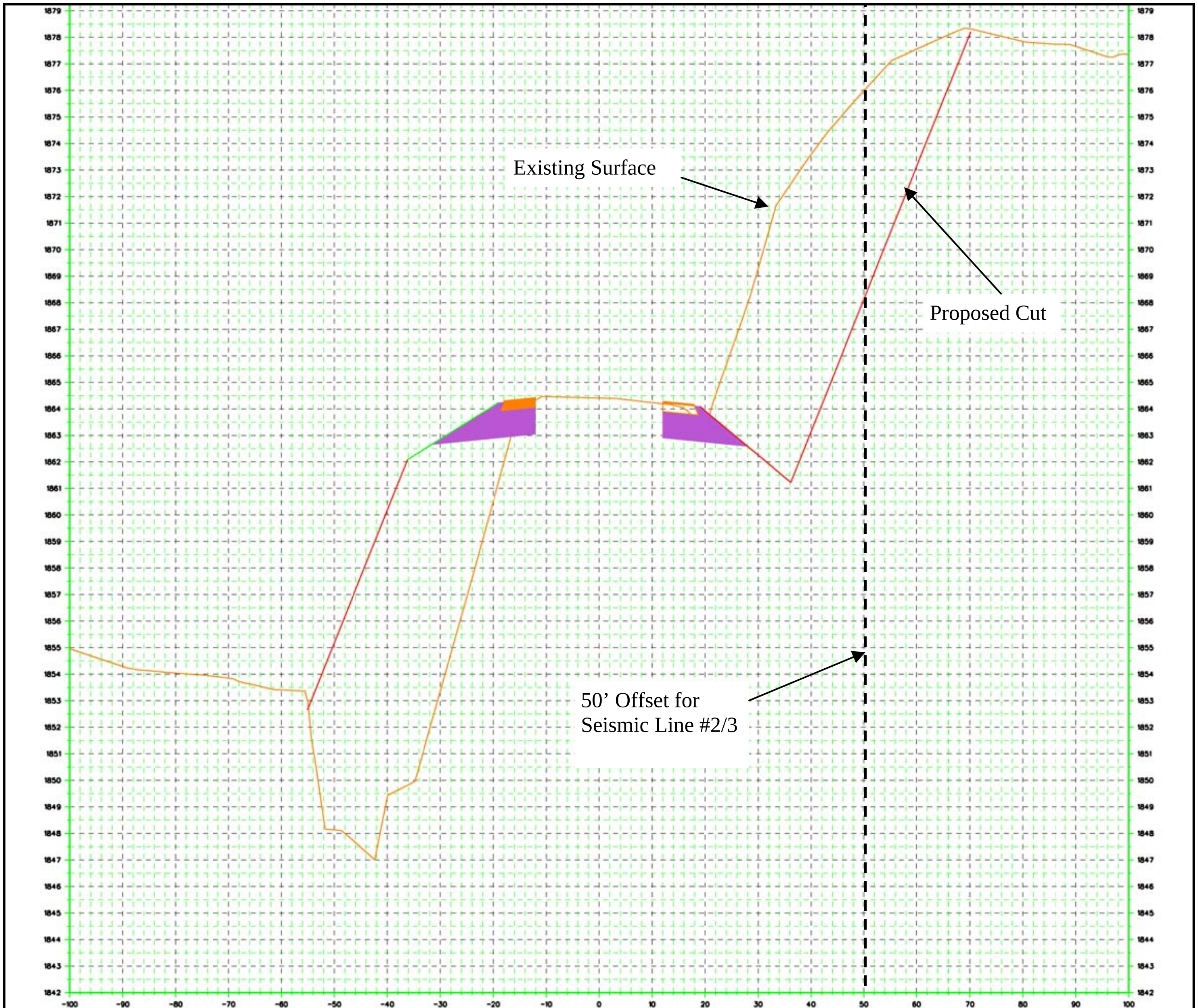
APPENDIX E



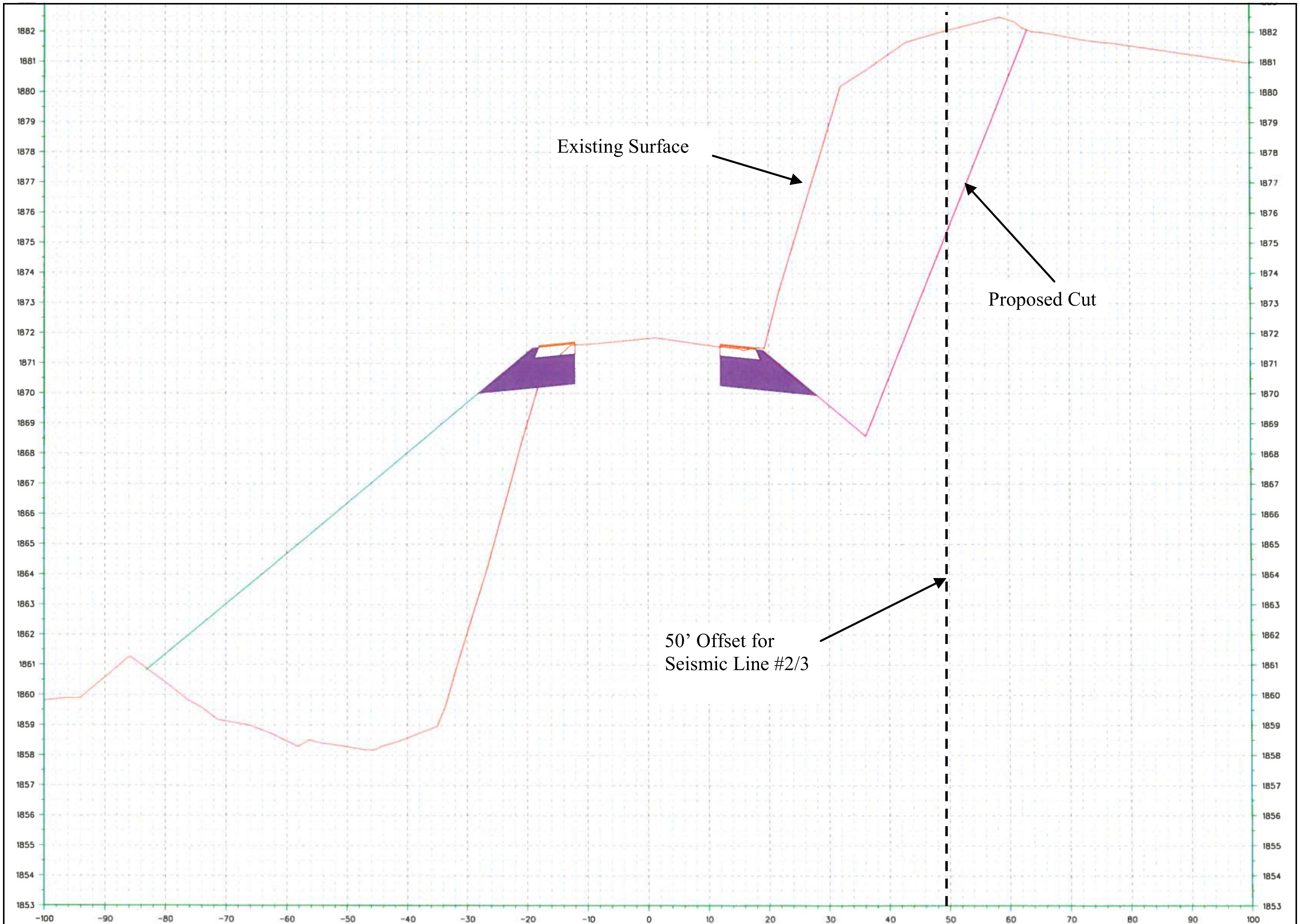
Data Provided By:
NDOT Geotechnical Section
Andrew Lawrence P.E.
Date: 4/28/2014

73711 Lake Mead Blvd.
Seismic Line #1:
Cross Section @ “O1” 708+75.00



Data Provided By:
NDOT Geotechnical Section
Andrew Lawrence P.E.
Date: 4/28/2014

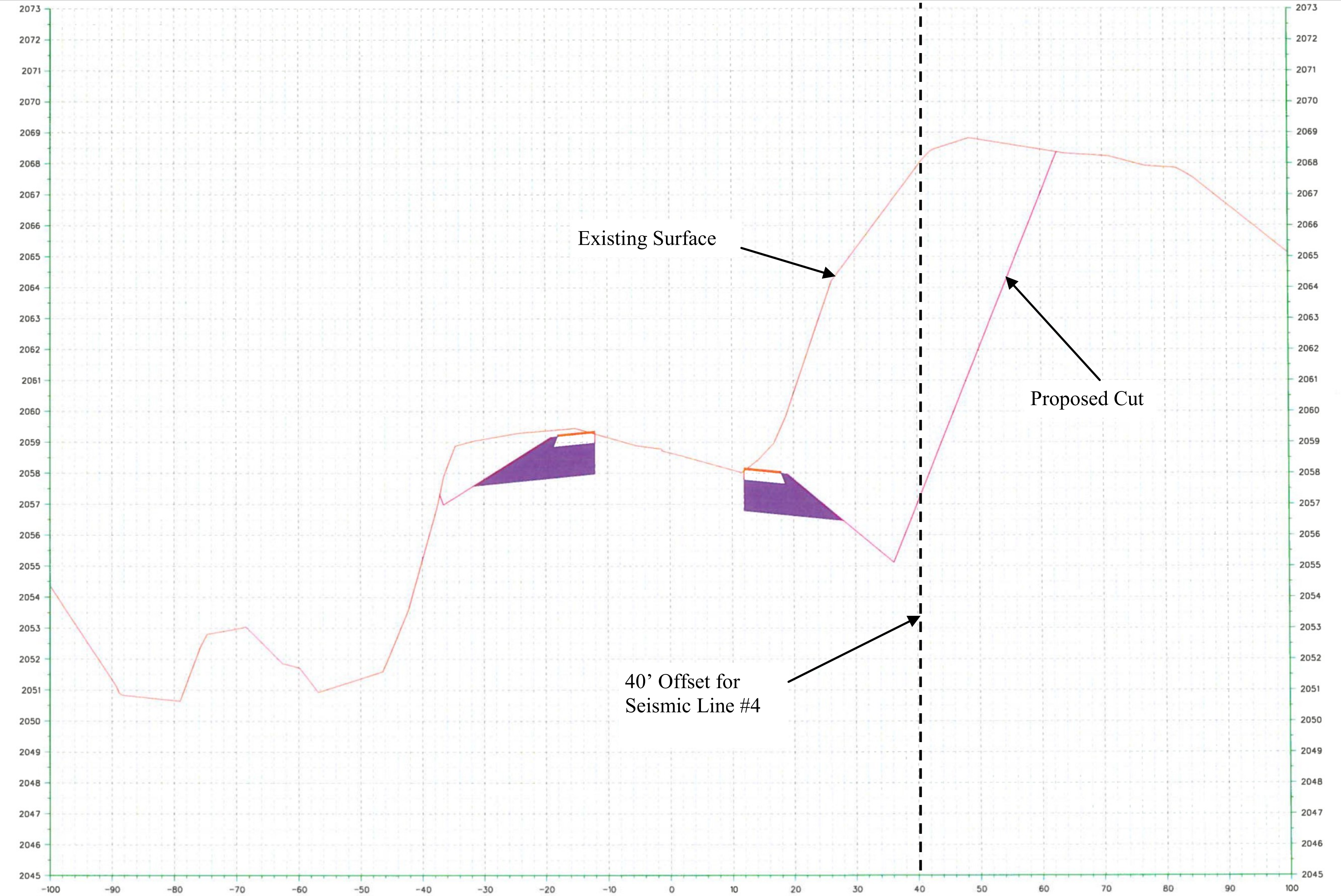
73711 Lake Mead Blvd.
Seismic Line #2/3:
Cross Section @ “O1” 635+00.00



NEVADA DOT GEOTECHNICAL ENGINEERING

Data Provided By:
NDOT Geotechnical Section
Andrew Lawrence P.E.
Date: 4/28/2014

73711 Lake Mead Blvd.
Seismic Line #2/3:
Cross Section @ "O1" 632+50.00

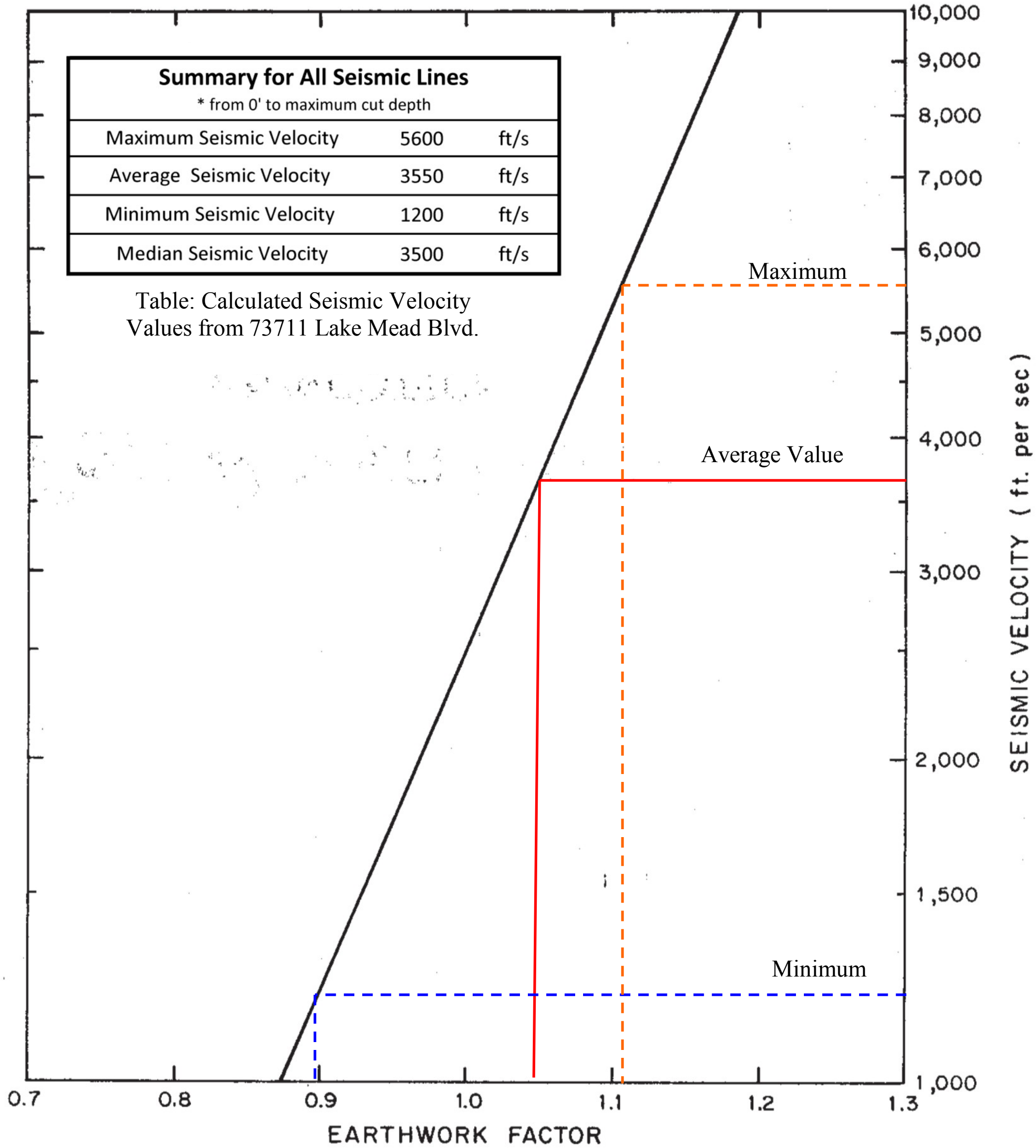


Data Provided By:
NDOT Geotechnical Section
Andrew Lawrence P.E.
Date: 4/28/2014

73711 Lake Mead Blvd.
Seismic Line #4:
Cross Section @ "O1" 566+00.00

APPENDIX F

RELATIONSHIP BETWEEN SEISMIC VELOCITIES AND EARTHWORK FACTORS FOR SOME SEDIMENTARY ROCKS



Summary for All Seismic Lines
* from 0' to maximum cut depth

Maximum Seismic Velocity	5600	ft/s
Average Seismic Velocity	3550	ft/s
Minimum Seismic Velocity	1200	ft/s
Median Seismic Velocity	3500	ft/s

Table: Calculated Seismic Velocity Values from 73711 Lake Mead Blvd.

FIGURE 7

31

Figure Obtained from "Relationships between Seismic Velocities and Earthwork factors for some Sedimentary Rocks." Stevens, E. 1978, CALTRANS.

NEVADA DOT GEOTECHNICAL ENGINEERING

73711 Lake Mead Blvd.
"Relationship Between Seismic Velocities and Earthwork Factors for Some Sedimentary Rocks"