ADVANCED GEOSCIENCE, INC.
Geology and Geophysics
Subsurface Exploration Non-Destructive Evaluation

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via. Email (4 pages + Attachments)

Haley & Aldrich, Inc.
3187 Red Hill Avenue
Suite 155
Costa Mesa, California 92626

Attention: Mr. Karl J. Neill
Senior Geologist

Re: **Summary Report**
Seismic Refraction Survey for Landslide Investigation
Vulcan Materials Company Soledad Development Site
Canyon Country, California

1.0 INTRODUCTION

This report summarizes the seismic refraction survey completed by Advanced Geoscience, Inc. at referenced site. This survey recorded the arrival times of seismic waves generated at the ground surface to prepare subsurface seismic velocity profiles for investigation of bedrock structure and rippability beneath the landslide.

The seismic refraction tomography data were recorded by Advanced Geoscience during a one-day field program completed on March 30, 2018. The data were recorded along two survey lines designated as Lines 1 and 2. Line 1 was positioned along a linear traverse set up above the road near the toe of the landslide. Line 2 was positioned along a shorter-length traverse positioned further upslope on the landslide (Figure 1). The seismic data recorded on these survey lines underwent computer processing to prepare 2D subsurface profiles showing seismic compressional-wave velocity layering in the upper 60 feet. The higher-velocity layering on these profiles was used to evaluate the structure of the bedrock surface.

The following sections of this report provide a summary of our field survey procedures and methods of data processing and evaluation. A concluding section discusses the results of this seismic velocity profiling and compares these estimated subsurface velocities to the range of rippabilty for various Caterpillar ripping equipment.

2.0 FIELD SURVEY

Advanced Geoscience mobilized a survey crew to the site to perform a one-day seismic refraction survey. Two survey lines designated as Lines 1 and 2 were set up across the toe area of the landslide along northwest-to-southeast traverses (Figure 1). Line 1 was positioned closer to the toe of the landslide, across the expected width of the slide area. Line 2 was positioned further upslope on the landslide along a shorter-length traverse set up on the much steeper slope.

The seismic data were recorded using a multi-channel Seistronix EX-6 data acquisition system. The recording system was connected to geophones (seismic motion detectors) positioned in the ground at 10 and 15-foot intervals along the survey lines. The geophones were 4-Hertz (lower-cutoff frequency), vertically-aligned velocity transducers.

Lines 1 was set up with 36 geophones spaced 10-feet apart to provide a total line length of 350 feet. Line 2 was set up with 12 geophones spaced 15-feet apart to provide a total line length of 165 feet.

The refraction data were recorded from seven to ten seismic energy “source points” positioned along each survey line. The source points started off the first geophone position and continued at 30 to 40-foot intervals between the geophone positions. The last source point was positioned off the last geophone position.

The seismic energy was generated using a 20-pound sledge hammer. The sledge hammer was used to make 3 to 5 impacts on a metal plate placed on the ground surface. At each source point, the recordings from these multiple impacts were summed (stacked) together to increase the amplitude of the seismic refraction wave arrivals.

The positions of Lines 1 and 2 were marked by stakes placed at the end points of the lines and various intermediate points along the lines. A measuring tape and Brunton pocket compass and transit were used to locate these survey lines on the topographic map shown in Figure 1.

3.0 DATA PROCESSING AND EVALUATION

The seismic data quality was very good. The field records from Lines 1 and 2 showed seismic wave arrivals from subsurface refraction events at all the geophone positions. Refraction wave arrivals from bedrock velocities exceeding 12,000 ft/sec were clearly visible on the field records.

The field records were input into the RAYFRACT seismic refraction tomography software developed by Intelligent Resources, Inc. (www.rayfract.com). RAYFRACT was used to generate seismic compressional-wave velocity profiles. This refraction tomography modeling procedure is generally more capable of imaging sharper lateral velocity variations due to bedrock structure than other refraction data modeling methods.

RAYFRACT was first used to graphically pick first arrival times ("first breaks") for refracted waves traveling through the surface layer and into deeper higher-velocity layers. These time-distance data were used together with the geophone positioning and elevations to conduct refraction tomography imaging of the subsurface seismic velocity layering. RAYFRACT first used the 1D turning ray-based method to generate an initial 1D velocity-depth model. This initial model was then refined to produce a closer fit to the arrival time data using the Wavepath Eikonal Traveltime (WET) tomographic inversion method with 45 iterations with a maximum velocity 6,000 m/sec. The best-fit velocity-depth models were then gridded and color contoured with SURFER (written by Golden Software, Inc.) to show estimated vertical and lateral velocity variations.

Figure 2 shows the resulting seismic compressional-wave velocity profiles for Lines 1 and 2.

4.0 DISCUSION OF RESULTS

The seismic velocity profiles for Lines 1 and 2 in Figure 2 both show similar higher velocity structures indicating the "intact bedrock surface" beneath the landslide. The 8,000+ ft/sec velocity layering just above elevation 1,810 feet is consistent on both profiles and indicates the start of this higher velocity bedrock surface. The lower-velocity layering above this surface indicates coarse-grained landslide colluvium ranging to large boulder size deposits. The 8,000+ ft/sec velocity layering represents the upper surface of the harder Precambrian Anorthosite mapped in this area. (Reference: Geologic Atlas, Los Angeles Sheet 1:250,000 scale map, California Department of Conservation).

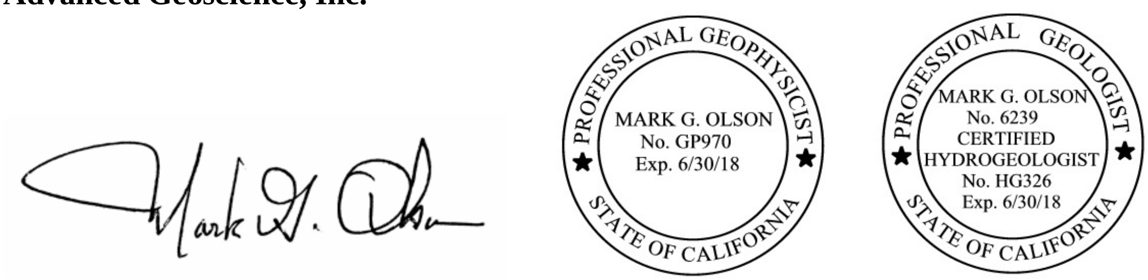
The elevation profiles for this interpreted "intact bedrock surface" beneath Lines 1 and 2 show the thickness of landslide deposits increases further upslope beneath Line 2. The projection of this Line 2 bedrock surface elevation upslope to the landslide head scarp could provide an estimation of the volume of landslide material. However, one additional seismic refraction survey line recorded further up slope could help make this estimation more accurate.

Figure 2 also displays the seismic velocity ranges for the rippability of basalt bedrock estimated based on the graphs in the Caterpillar Handbook of Ripping, 12th Edition (Caterpillar, Inc., 2000). These velocity ranges are shown superimposed on the color scale for the compressional-wave velocity profiles for Lines 1 and 2. Based on these graphs most of the bedrock material a few feet below the "intact bedrock surface" is not rippable for the Caterpillar D8R through D11R grading equipment.

Advanced Geoscience appreciates this opportunity to be of service to Haley & Aldrich and the Vulcan Materials Company. If you have any questions or additional requests concerning this seismic refraction survey please contact the undersigned.

Sincerely,

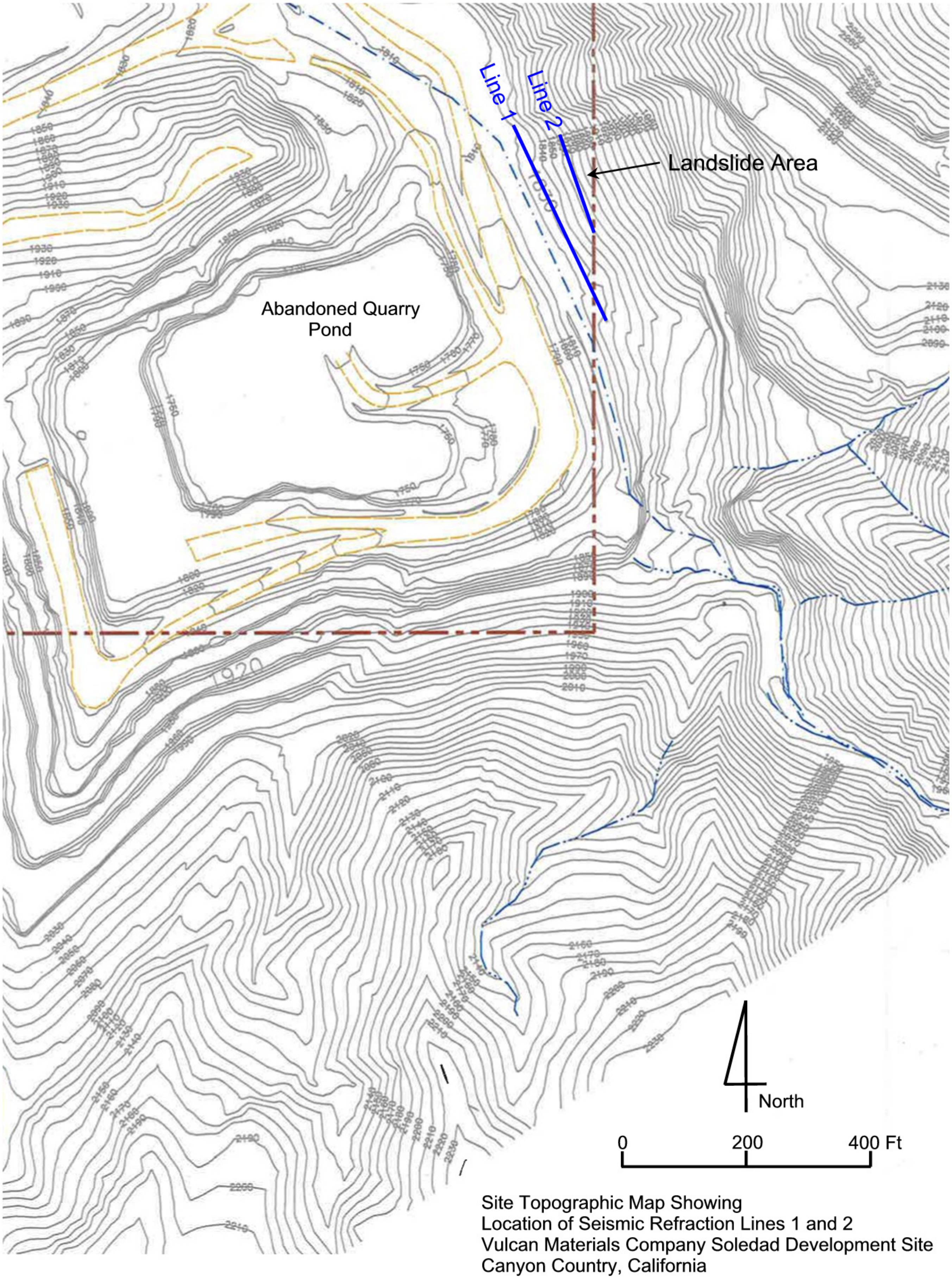
Advanced Geoscience, Inc.



Mark G. Olson, PGp, PG, CHG
Principal Geophysicist

Attachments:

Figure 1	Site Map Showing Locations of Lines 1 and 2
Figure 2	Seismic Refraction Velocity Profiles for Lines 1 and 2

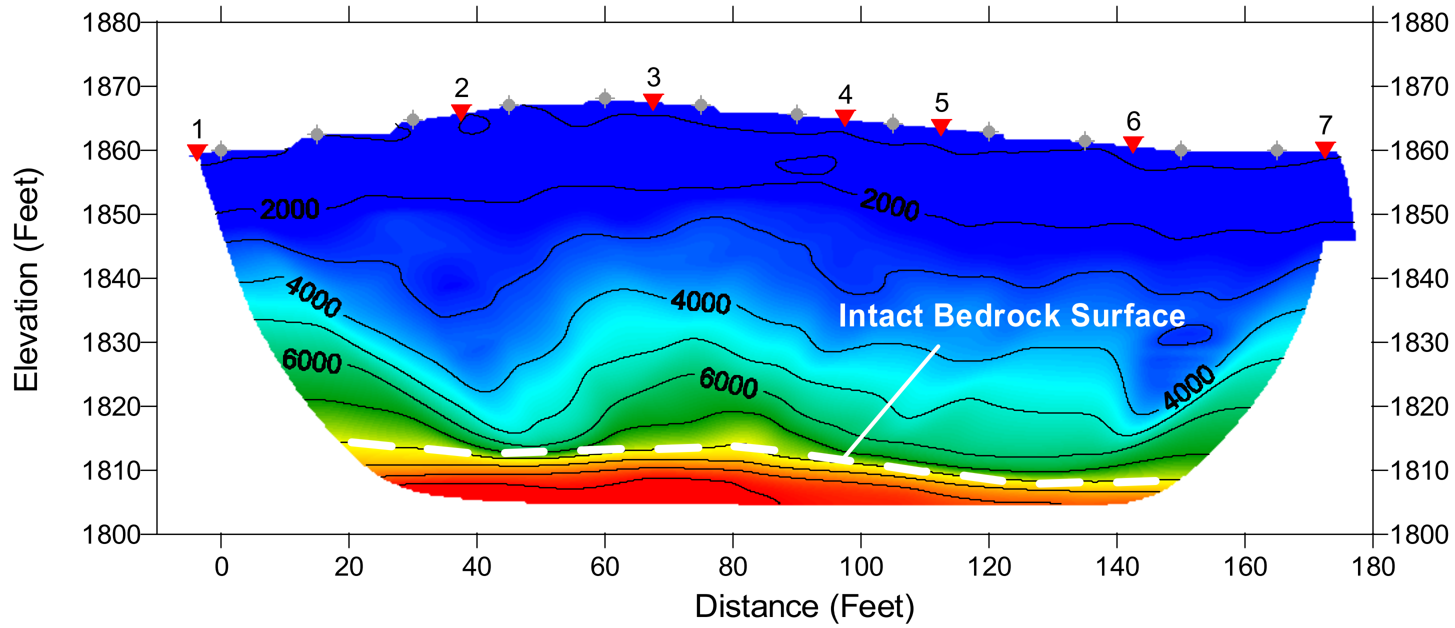


Site Topographic Map Showing
Location of Seismic Refraction Lines 1 and 2
Vulcan Materials Company Soledad Development Site
Canyon Country, California

Topographic Map From Vulcan Materials Co.
DWG No. SOLEDAD-2009 Conceptual Mass Grading

Figure 1
ADVANCED GEOSCIENCE, INC.

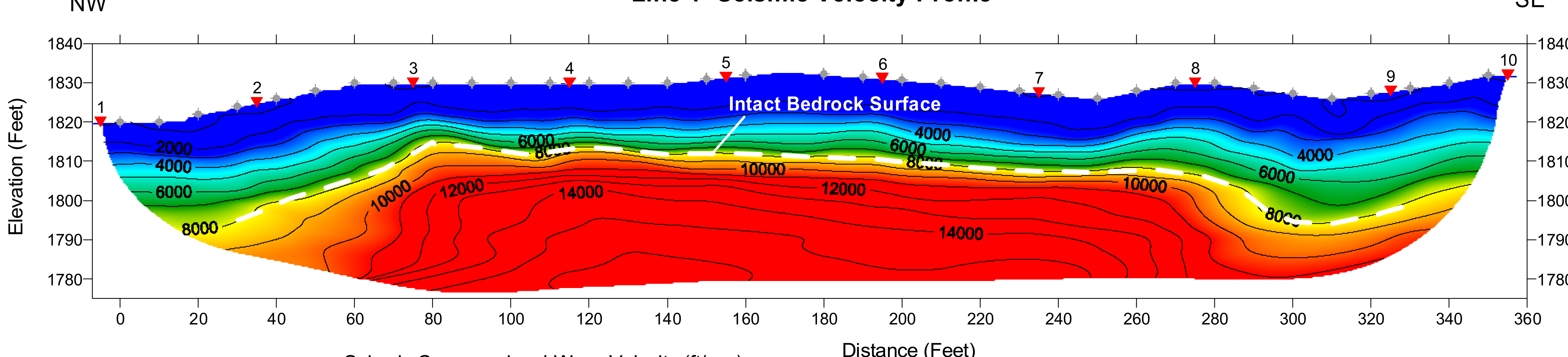
Line 2- Seismic Velocity Profile



Horizontal and Vertical Scale 1 inch= 30 feet

Based on RAYFRACT Seismic Refraction Tomography
Initial 1D Gradient Model + 45 WET Iterations with Vmax=6,000 m/sec

Line 1- Seismic Velocity Profile

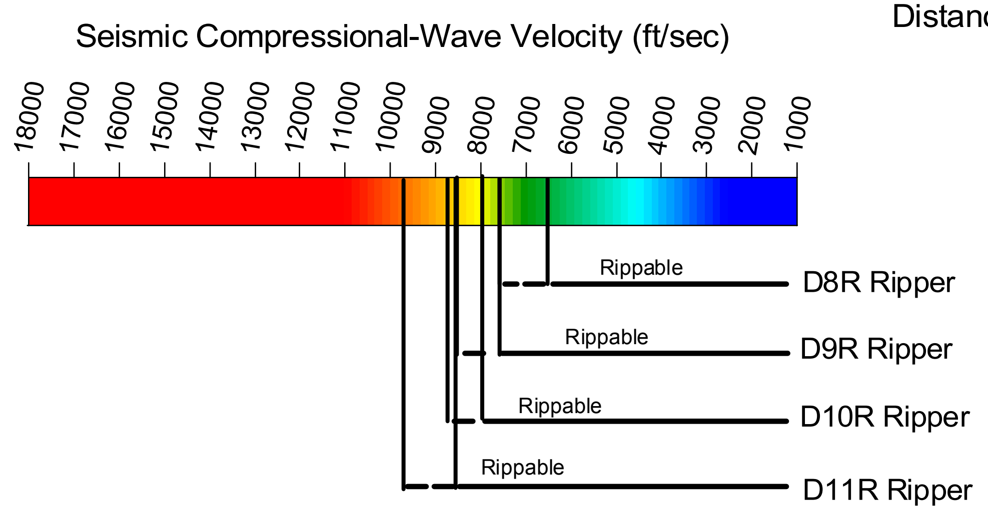


Estimated Rippability for Caterpillar Equipment
From Caterpillar Inc. Handbook of Ripping
12th Edition, Feb. 2000

Rippable

Marginal Rippability

Based on Seismic Velocity Range for Rippability of
Basalt Rock Type on Caterpillar Charts
For Precambrian Anorthosites Mapped in Area



Seismic Refraction Subsurface Velocity Profiles
Across Landslide Area at Vulcan Materials Company
Soledad Development Site
Canyon Country, California

Figure 2
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