

ROCK CUT SLOPE STABILITY ANALYSIS

PROPOSED CUSTOM HILLSIDE RESIDENCE

APN 169-04-007

7550 NORTH HUMMINGBIRD LANE
PARADISE VALLEY, ARIZONA 85253

Prepared for:

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Project 25998

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THE SCOPE OF WORK FOR THIS REPORT MIRRORS THAT OF THE PROPOSAL AND IS AS FOLLOWS:

- 1) TWO (2) SEPARATE COMPLETE GEOMETRIES OF THE SLOPE WILL BE DRAWN. THE GEOMETRIES WILL INCLUDE THE TOE, ASPERITIES ALONG THE SLOPE FACE, SLOPE ANGLE, CHARACTER OF CREST, AND MEASUREMENT OF THE NATURAL UP SLOPE TERRAIN
- 2) SOIL AND ROCK TYPES ALONG THE GEOMETRY WILL BE EXAMINED, VERIFIED, AND PRESENTED ON REPRESENTATIVE CROSS SECTION
- 3) GEOLOGIC MEASUREMENTS OF DISCONTINUITIES WITHIN THE ROCK MASS WILL BE MADE. THESE WILL FOCUS ON FRACTURES AND FOLIATION ORIENTATION
- 4) BASED ON THE ABOVE, A KINEMATIC-LIKE ANALYSIS WILL BE PREFORMED SUING METHODOLOGIES CREATED BY MARKLAND. THESE ANALYSIS WILL DETERMINE THE POTENTIAL FOR PLANAR, WEDGE, AND TOPPLING FAILURES
- 5) A DETAILED DETERMINISTIC SLOPE STABILITY ANALYSIS WILL BE COMPLETED USING COMPUTER SOFTWARE KNOWN AS SLIDE

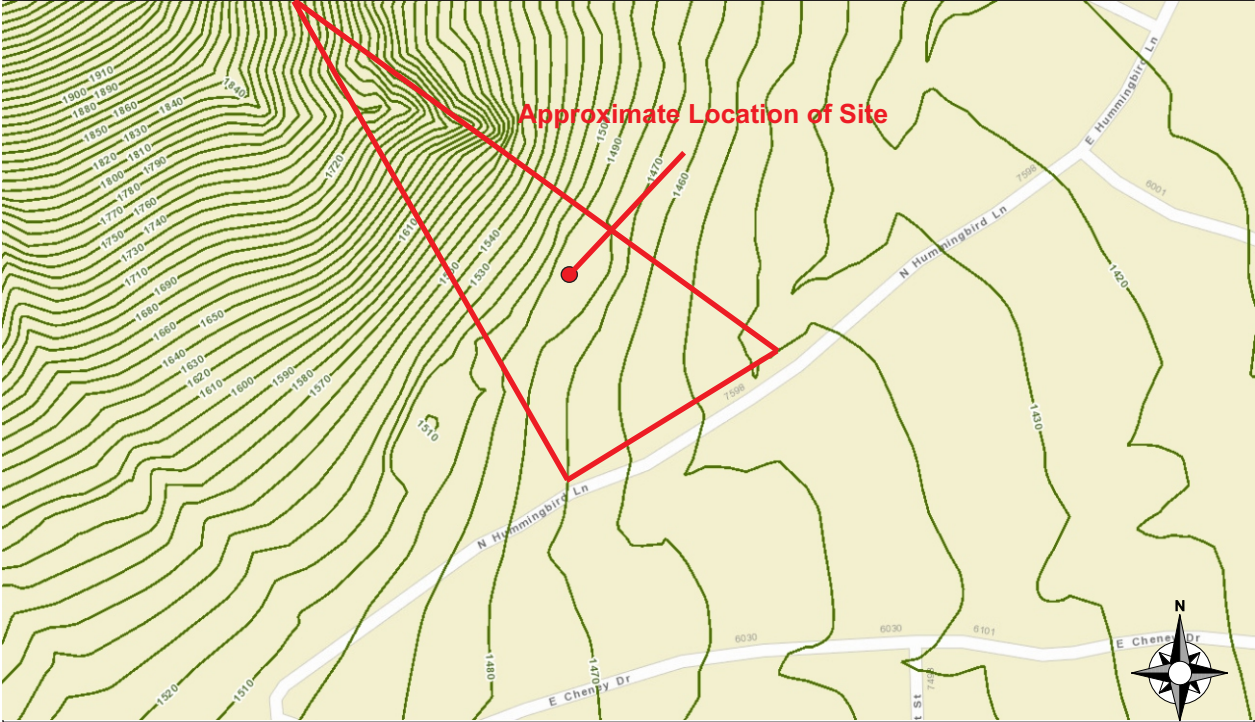
- 6) SEVERAL FAILURE MODES AND LOADS (INCLUDING SEISMIC SHAKING) WILL BE USED TO ARRIVE AT THE LOWEST FACTOR OF SAFETY FOR THE EXISTING SLOPE SECTIONS. FACTORS OF SAFETY LESS THAN 1.5 WILL BE OF CONCERN
- 7) BECAUSE OF THE ANALYSIS, ANY SLOPE SECTION WITH A FACTOR OF SAFETY LESS THAN 1.5 WILL BE ASSIGNED A REMEDIAL ACTION MEASURE, RESULTING FROM EXHAUSTIVE COMPUTER MODELING TO ENSURE STABILITY
- 8) PHOTOGRAPHS AND DISCUSSION OF THE ROCK SLOPE ANALYZED
- 9) REMEDIAL RECOMMENDATIONS (IF NECESSARY) UTILIZING:
 - ROCK ANCHORS
 - RETAINING WALLS
 - MESH AND GROUT
 - COMBINATION OF THE ABOVE

OBLIQUE AERIAL PHOTOGRAPH



OBLIQUE AERIAL PHOTOGRAPH OF THE SITE, SHOWING THE CURRENT SITE CONDITIONS. THE EXISTING CUT SLOPE IS LOCATED ALONG THE WEST SIDE OF THE SITE SHOWN IN THE AERIAL PHOTOGRAPH (OUTLINED IN RED).

TOPOGRAPHIC MAP OF SITE



IT MUST BE NOTED THAT THIS REPORT AND THE RECOMMENDATIONS CONTAINED HEREIN ARE PREDICATED ON THREE REPORTS SERVING IN CONGRESS; 1) THIS REPORT, 2) THE GEOTECHNICAL INVESTIGATION REPORT DATED JULY 30, 2018, AND 3) THE BOULDER STABILITY EVALUATION REPORT DATED JULY 30, 2018. THIS REPORT IS, THEREFORE, A PORTION OF THE OVERALL STUDY OF THE SITE. BECAUSE OF THE UNIQUENESS OF EACH REPORT, THE CONTENTS ARE CONSTRAINED TO SEPARATE SUBMITTALS. NOTWITHSTANDING, ALL THREE REPORTS WILL WORK TOGETHER. ALL THREE REPORTS ARE IDENTIFIED BY THE PROJECT NUMBER 25998.



OBLIQUE AERIAL PHOTOGRAPH AND TOPOGRAPHIC MAP		
DATE: 7/30/18		REVIEWED BY: JEFFERY D. VANN, MS PE D.GE F. ASCE
PROPOSED CUSTOM HILLSIDE RESIDENCE APN 106-04-007 7550 NORTH HUMMINGBIRD LANE PARADISE VALLEY, ARIZONA		
PROJECT 25998		



GENERAL INFORMATION:
1) SLOPE HEIGHT (MAX): 16 FEET
2) GENERAL STRIKE: 10 DEGREES
3) MAX DIP: 80 DEGREES
4) DIP RANGE: 65-80 DEGREES
5) SLOPE STRUCTURE: HEAVILY BROKEN
ROCK MASS

MAIN SLOPE:
NORTH-NORTHEAST TO SOUTH-
SOUTHWEST TRENDING CUT SLOPE;
EAST-SOUTHEAST DIPPING;
WEST SIDE OF PROPOSED BUILD AREA

SITE PLAN		
DATE: 7/30/18		REVIEWED BY: JEFFERY D. VANN, MS PE D.GE F. ASCE
PROPOSED CUSTOM HILLSIDE RESIDENCE APN 169-04-007 7550 NORTH HUMMINGBIRD LANE PARADISE VALLEY, ARIZONA		
PROJECT 25998		

1) FOLIATION OF CUT SLOPE

2) HEAVILY BROKEN ROCK MASS



FACING NORTH



FACING WEST

3) CONJUGATE FRACTURE SET 1
4) CONJUGATE FRACTURE SET 2

5) APPROXIMATE SLOPE ANGLE OF 80 DEGREES

6) APPROXIMATE SLOPE ANGLE OF 65 DEGREES



FACING NORTH



FACING WEST

7) APPROXIMATE SLOPE ANGLE OF 65 DEGREES



MAIN SLOPE PHOTOGRAPHS

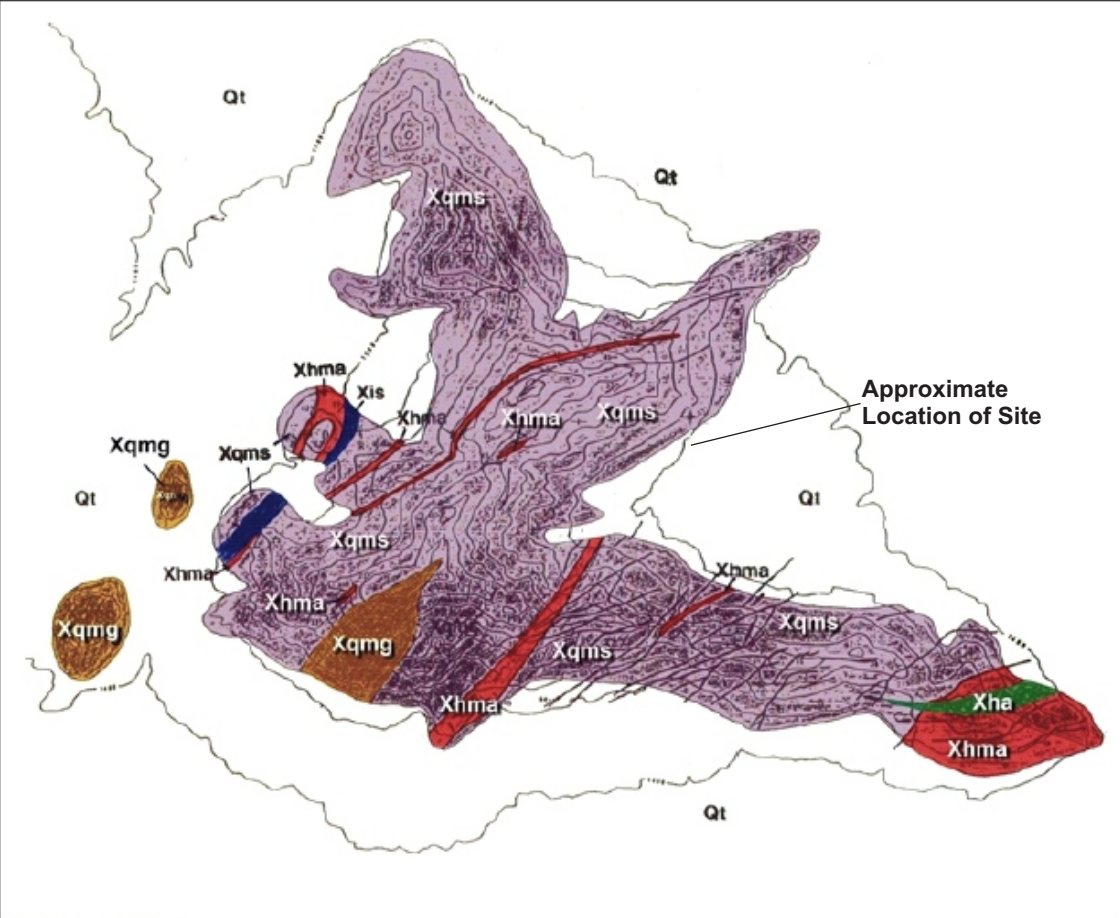
DATE: 7/30/18

REVIEWED BY:
JEFFERY D. VANN, MS PE D.G.E. F. ASCE

PROPOSED CUSTOM HILLSIDE RESIDENCE
APN 169-04-007
7550 NORTH HUMMINGBIRD LANE
PARADISE VALLEY, ARIZONA

PROJECT 25998



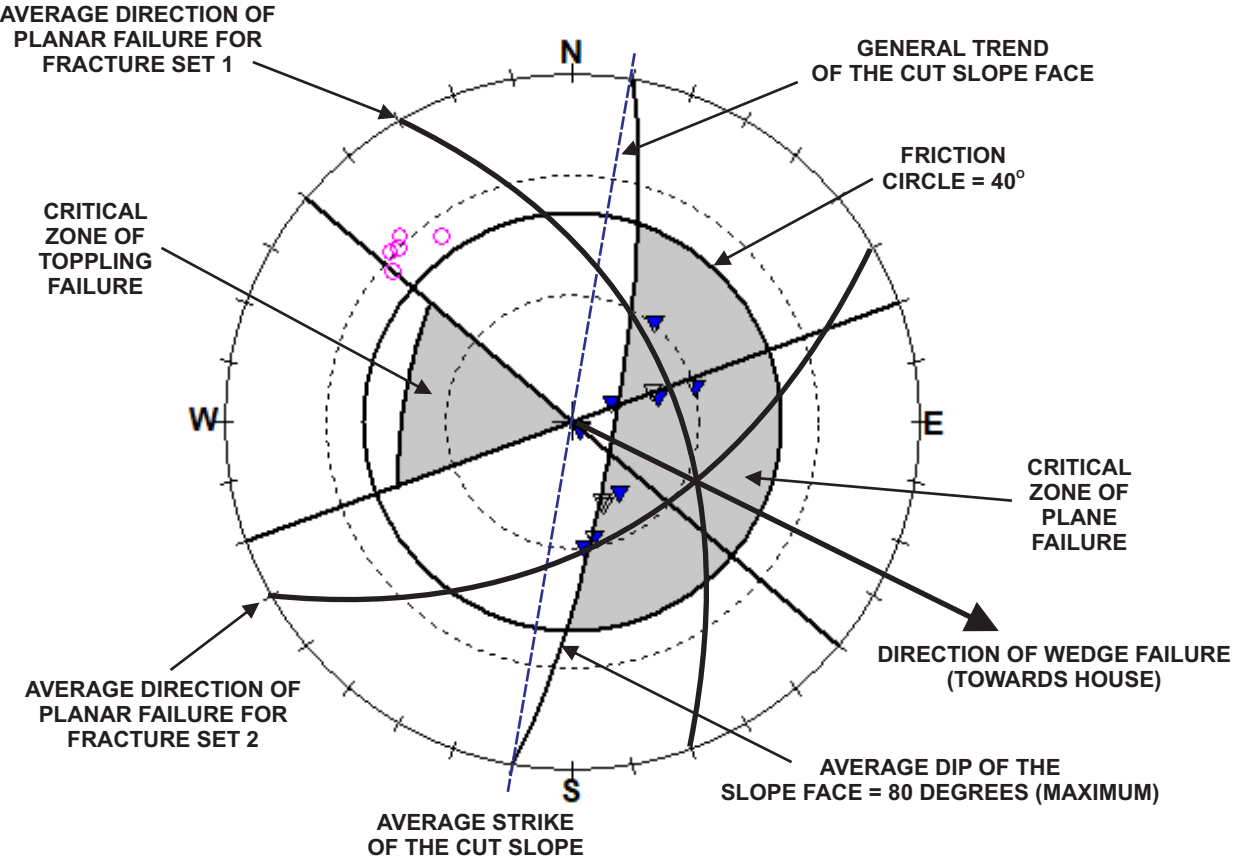


Explanation

- Qt - Colluvium and Alluvium
- Xp-Tp(?) - Pegmatites
- Xqmg - Alternating Quartz-Muscovite Gneiss and Schist
- Xqms - Quartz-Muscovite Schist
- Xis - Iron Rich Quartz-Muscovite Schist
- Xha - Quartzite and Hornblende Amphibolite
- Xhma - Hornblende-Mica Amphibolite
- Contact - Dashed Where Approximately Located
- Strike and Dip of Foliation
- Contour Interval 100 Ft

THE ROCK MASS THAT COMPRISES THE SITE IS PREDOMINANTLY QUARTZ - MUSCOVITE SCHIST (Xqms) THAT IS HIGHLY TO MODERATELY WEATHERED AND FRACTURED. REGIONALLY, THE STRIKE OF THE FOLIATION SOUTH OF THE SITE IS APPROXIMATELY 234° WITH A FOLIATION DIP OF 44° TO THE NORTHWEST. FURTHER, THE REGIONAL STRIKE OF THE FOLIATION WEST OF THE SITE IS APPROXIMATELY 228° WITH A DIP OF 27° TO THE NORTHWEST. BOTH SETS OF CONDITIONS SHOULD BE ANTICIPATED AT THE SITE. TO THE NORTH-NORTHWEST OF THE SITE, A PEGMATITE DIKE TRENDS FROM NORTH-NORTHEAST TO WEST-SOUTHWEST (DENOTED BY A SOLID LINE).

GEOLOGIC MAP REFERENCED FROM ARIZONA STATE UNIVERSITY LIBRARY, GEOLOGIC MAP OF MUMMY MOUNTAIN, BY AYLOR, J.G., 1973, MS THESIS, ARIZONA

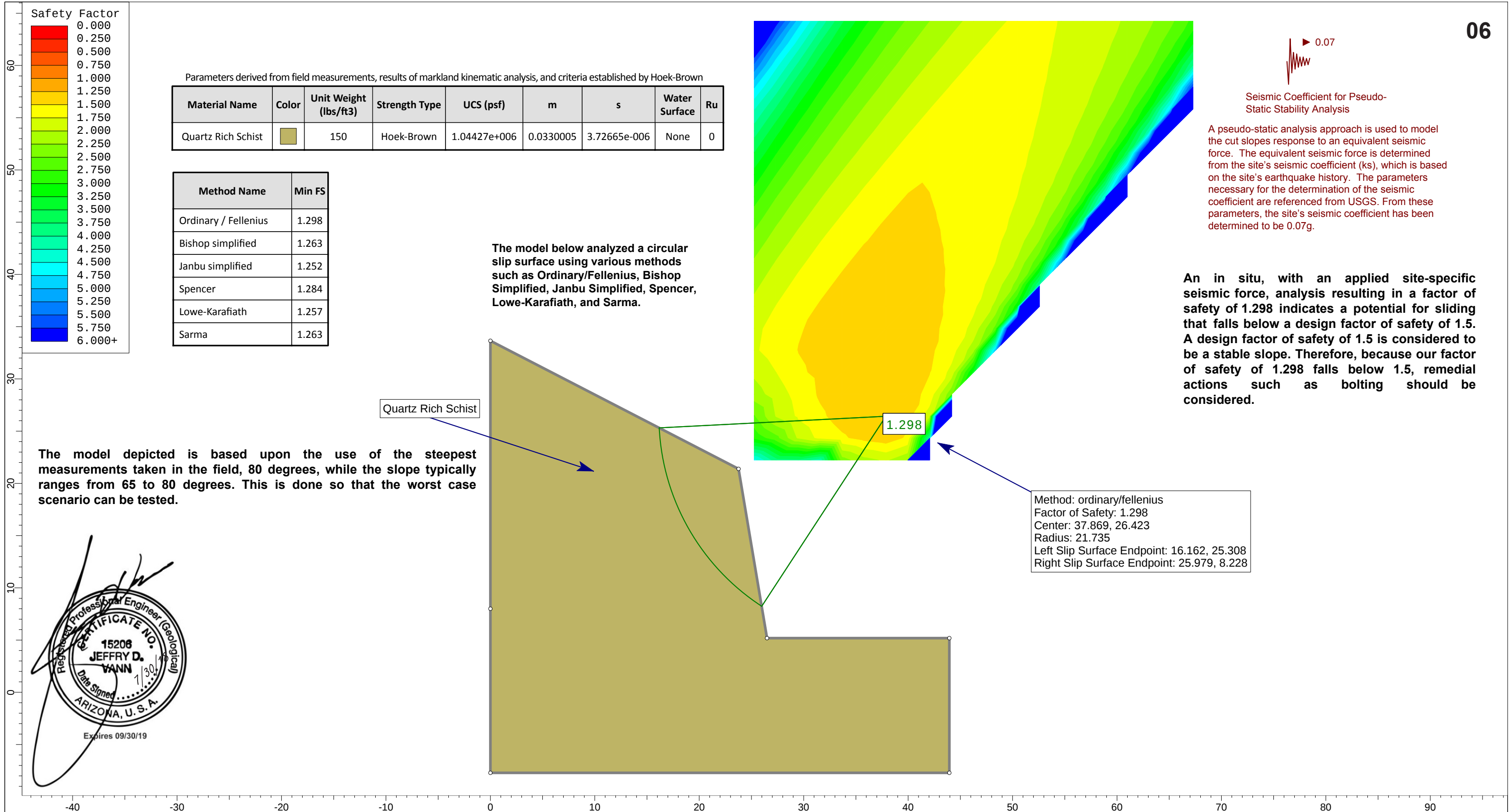


THE IMAGE ABOVE IS A STERONEUT AND IS USED FOR KINEMATIC STABILITY ANALYSIS. STEREOGRAPHIC PROJECTION INVOLVES PLOTTING 3D DATA (FOLIATION, BEDDING, AND FRACTURES) ON TO A 2D SURFACE WHERE IT CAN BE MANIPULATED AND INTERPRETED. FOR THIS STUDY, OPEN PINK CIRCLES REPRESENT FOLIATION OF THE CUT SLOPE WHILE BLUE TRIANGLES REPRESENT FRACTURES. STERONEUTS ARE PARTICULAR USEFUL IN THE GEOTECHINICAL REALM BECAUSE THEY CAN PROJECT POSSIBLE MOVEMENT OR FAILURES (PLANAR, WEDGE, OR TOPPLE) OF THE COLLECTED FIELD DATA. FROM OUR DATA WE CAN SEE THAT THERE IS LITTLE RISK OF TOPPLE FAILURE, REPRESENTED BY NO DATA

THE MAIN CUT IS LOCATED ON THE WESTERN EDGE OF THE SITE. THE ROCKS ASSOCIATED WITH THIS CUT SLOPE ARE PREDOMINANTLY QUARTZ-MUSCOVITE-SCHIST THAT CONTAIN DIFFERENT MAGNITUDES OF FOLIATION. QUARTZ VEINS AND A MAFIC INTRUSION ARE ALSO PRESENT. THE MOST PREDOMINANT DISCONTINUITY ALONG THE WESTERN AND EASTERN 1/3 OF THE SLOPE IS FOLIATION, AND THE MOST COMMON DISCONTINUITIES ALONG THE CENTRAL



SITE GEOLOGY & MARKLAND KINEMATIC STABILITY ANALYSIS		
DATE: 7/30/18		REVIEWED BY: JEFFREY D. VANN, MS PE D.GE F. ASCE
PROPOSED CUSTOM HILLSIDE RESIDENCE APN 169-04-007 7550 NORTH HUMMINGBIRD LANE PARADISE VALLEY, ARIZONA		
PROJECT 25998		VANN ENGINEERING INC



0.07
Seismic Coefficient for Pseudo-Static Stability Analysis

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	Water Surface	Ru
Quartz Rich Schist		150	Hoek-Brown	1.04427e+006	0.0330005	3.72665e-006	None	0

Method Name	Min FS
Ordinary / Fellenius	1.167
Bishop simplified	1.090
Janbu simplified	1.119
Spencer	1.126
Lowe-Karafiath	1.133
Sarma	1.109

The model below analyzed a non-circular slip surface using various methods such as Ordinary/Fellenius, Bishop Simplified, Janbu Simplified, Spencer, Lowe-Karafiath, and Sarma.

An in situ, with an applied site-specific seismic force, analysis resulting in a factor of safety of 1.167 indicates a potential for sliding that falls below a design factor of safety of 1.5. A design factor of safety of 1.5 is considered to be a stable slope. Therefore, because our factor of safety of 1.167 falls below 1.5, remedial actions such as bolting should be considered.

The model depicted is based upon the use of non-circular slip surfaces rather than circular slip surfaces. Both are used in the study to allow for a wider range of failure mechanisms to be studied. Both non-circular and circular are within a reasonable degree of engineering certainty

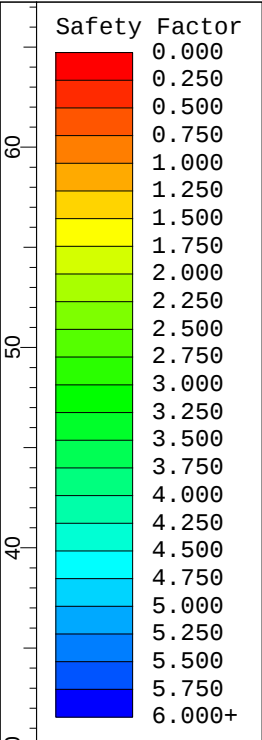
Quartz Rich Schist

1.167

Method: ordinary/fellenius
Factor of Safety: 1.167
Axis Location: 41.379, 25.026
Left Slip Surface Endpoint: 16.614, 25.075
Right Slip Surface Endpoint: 26.481, 5.244



Project			25998 - Proposed Custom Hillside Residence		
Analysis Description			Seismic Loading Condition - Non-Circular Slip Surface		
Drawn By		J. Vann; V. Smith; A. Olaiz	Scale	1:106	Company
Date		7/24/18	File Name		25998 - seismic loading.slmd
			Vann Engineering, Inc.		



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Length (ft)	Percent of Length (%)	Bond Strength (lbs/ft)	Material Dependent
Support 1	■	Grouted Tieback	Active (Method A)	6	79000	79000	0	0	0	60	5655	No

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	Water Surface	Ru
Quartz Rich Schist	■	150	Hoek-Brown	1.04427e+006	0.0330005	3.72665e-006	None	0

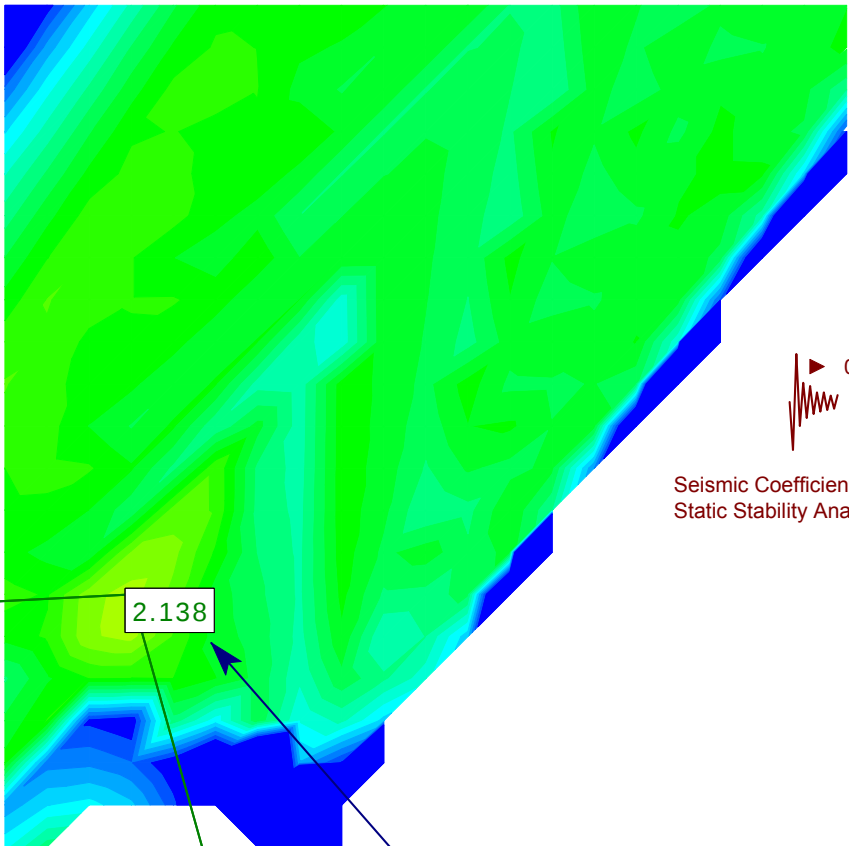
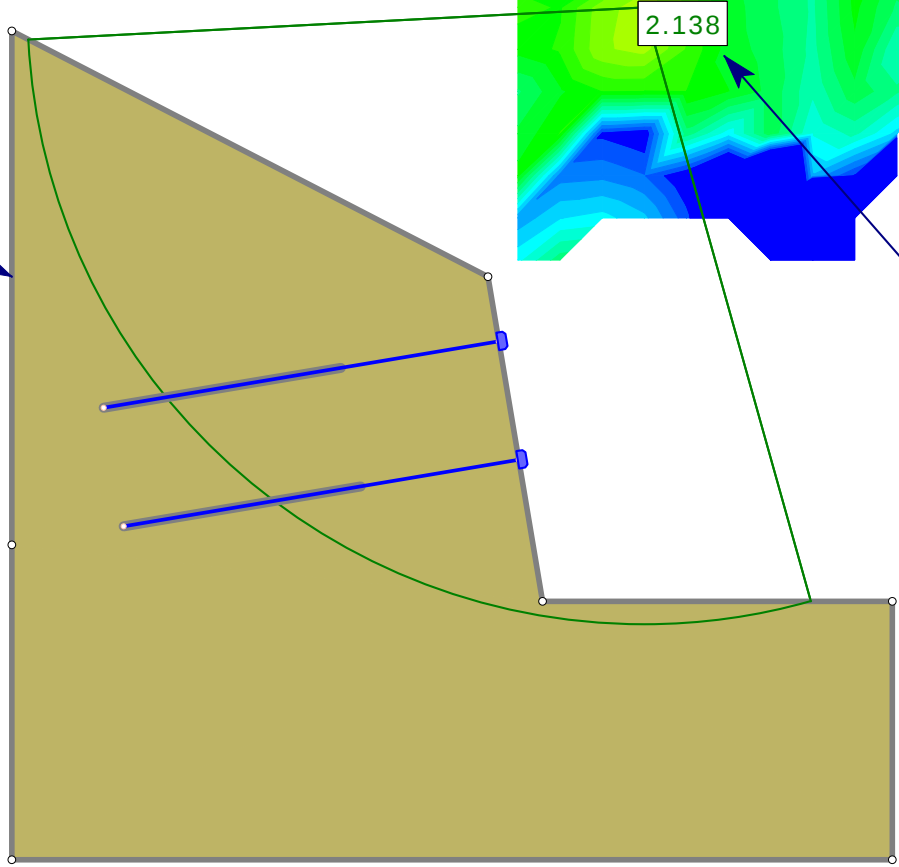
Method Name	Min FS
Ordinary / Fellenius	2.138
Bishop simplified	2.353
Janbu simplified	2.055
Spencer	2.349
Lowe-Karafiath	2.772
Sarma	2.294

In order to stabilize the slope and guard against a potential slope failure, rock bolting must be employed. With rock bolting, the Factor of Safety will increase above 2, with that Factor of Safety applicable only to the natural slope above the bolted portion. We recommend a bolt pattern of 6 feet by 6 feet across the slope. All measurements will be made along the slope face in a linear fashion. Both the upper and lower row of bolts will have 20-feet long bolts. We recommend the use of a 3 inch minimum diameter core hole.



A bolted surface with an applied site-specific seismic force analysis resulting in a factor of safety of 2.138. When comparing the factor of safety with bolting (2.138) and without bolting(1.298 & 1.167), the recommended factor of safety of 1.5 is obtained when this bolting pattern is implemented. Furthermore, the minimum factor of safety results in the slip surface which daylight in the toe of slope, which for this type of rock has a very low probability of occurrence.

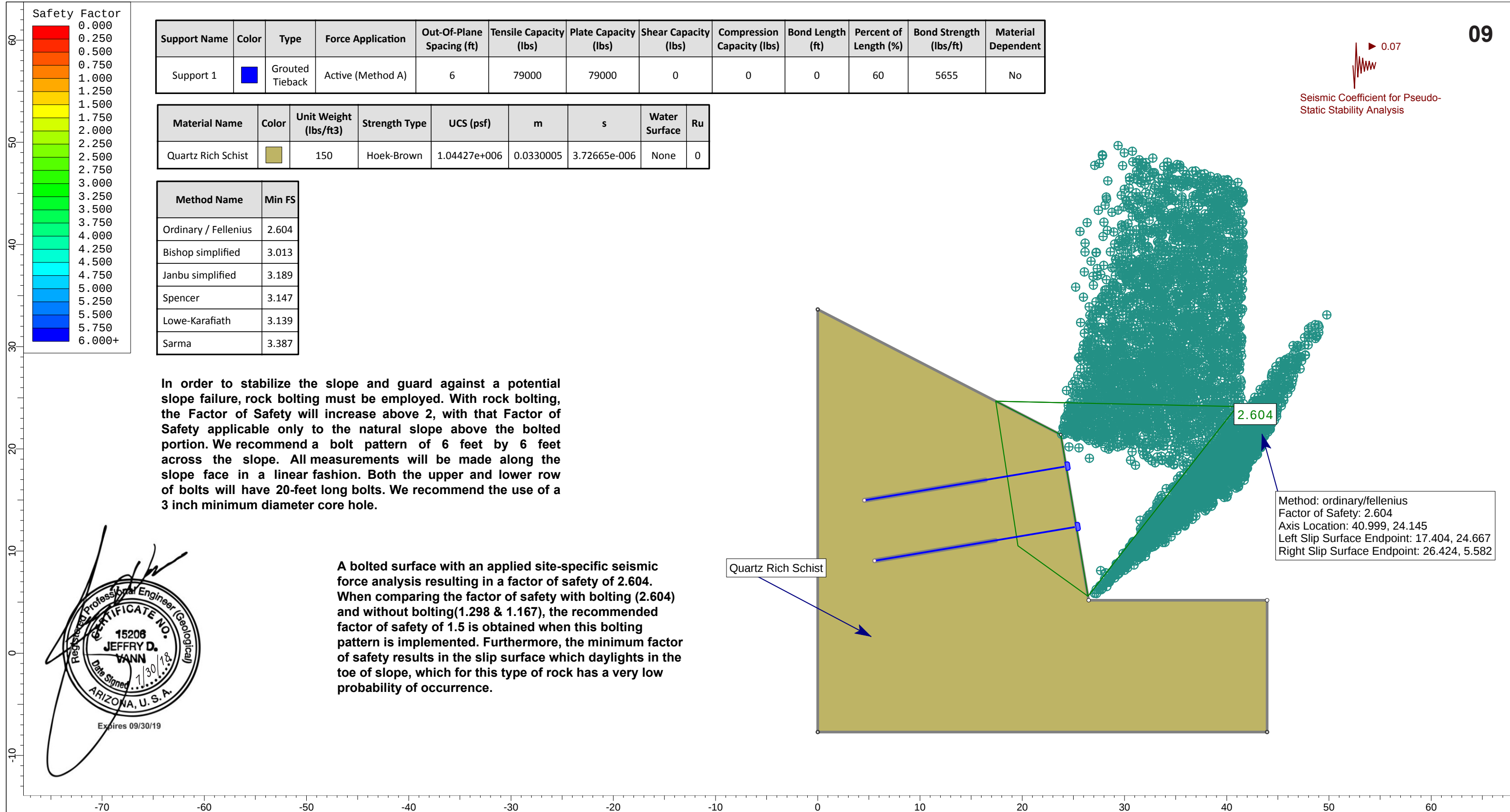
Quartz Rich Schist



Method: ordinary/fellenius
Factor of Safety: 2.138
Center: 31.566, 34.826
Radius: 30.786
Left Slip Surface Endpoint: 0.822, 33.227
Right Slip Surface Endpoint: 39.885, 5.185

Seismic Coefficient for Pseudo-Static Stability Analysis
0.07

Seismic Coefficient for Pseudo-Static Stability Analysis



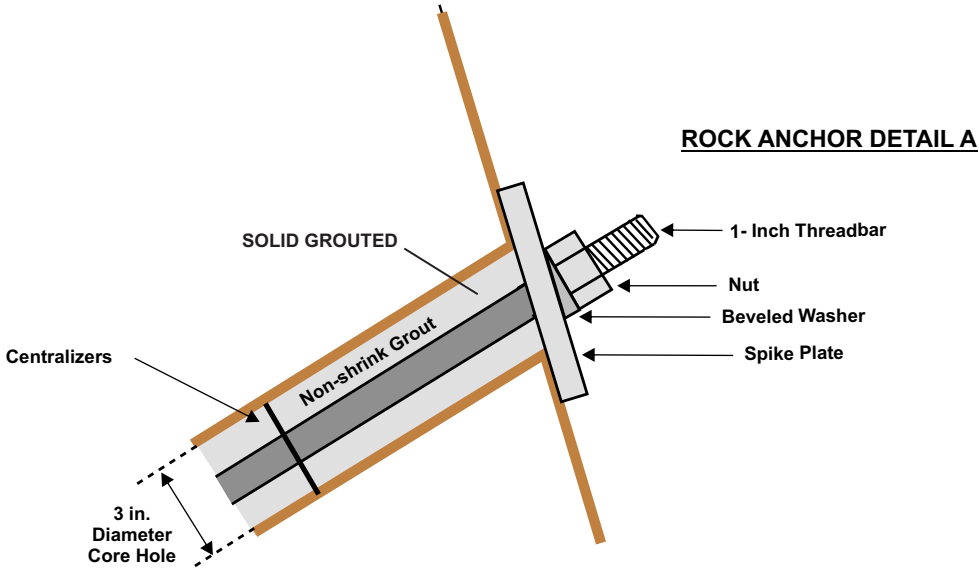
 SLIDEINTERPRET 7.01	<i>Project</i>			
	25998 - Proposed Custom Hillside Residence			
	<i>Analysis Description</i>			
	Bolted Condition - Non-Circular Slip Surface			
	<i>Drawn By</i>	J. Vann; V. Smith; A. Olaiz	<i>Scale</i>	1:107
		<i>Company</i>	Vann Engineering, Inc.	
	<i>Date</i>	7/24/18	<i>File Name</i>	25998 - bolted.slmd

Discussion

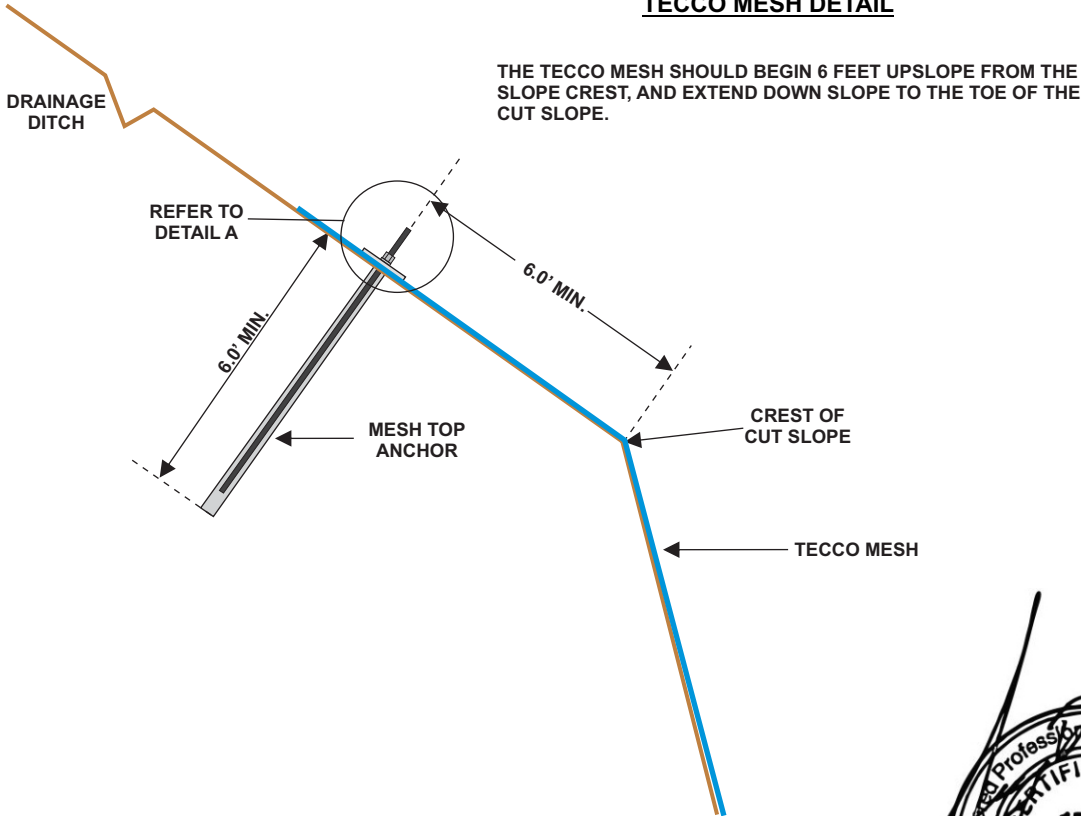
The remediation of the existing cut slope will ensure the structural integrity to remain intact well into the future. It is needed because the visual observations along with the structural data presented in the markland stability analysis show a probability of both planar and wedge failure. The remediation of the existing cut slope will not completely prevent future surface erosion or the possibility of small rock fragments from falling off of the face of the cut slope. If the client desires shotcrete and faux rock, can be used to cover the exposed face of the cut slope and minizmie possibility of detritus falling from the slope.

ROCK ANCHOR NOTES

Two (2) rows of rock bolts should be installed across the cut slope. The bolt lengths are to be 20 feet, using a 1-inch diameter bar with a 3-inch core hole diameter, spaced 6 feet vertical and 6 feet horizontal (6 feet x 6 feet grid). The annular space must be grouted a minimum of 60% of the total length of the bolt (i.e. 12'). Final locations to be marked on-site by Vann



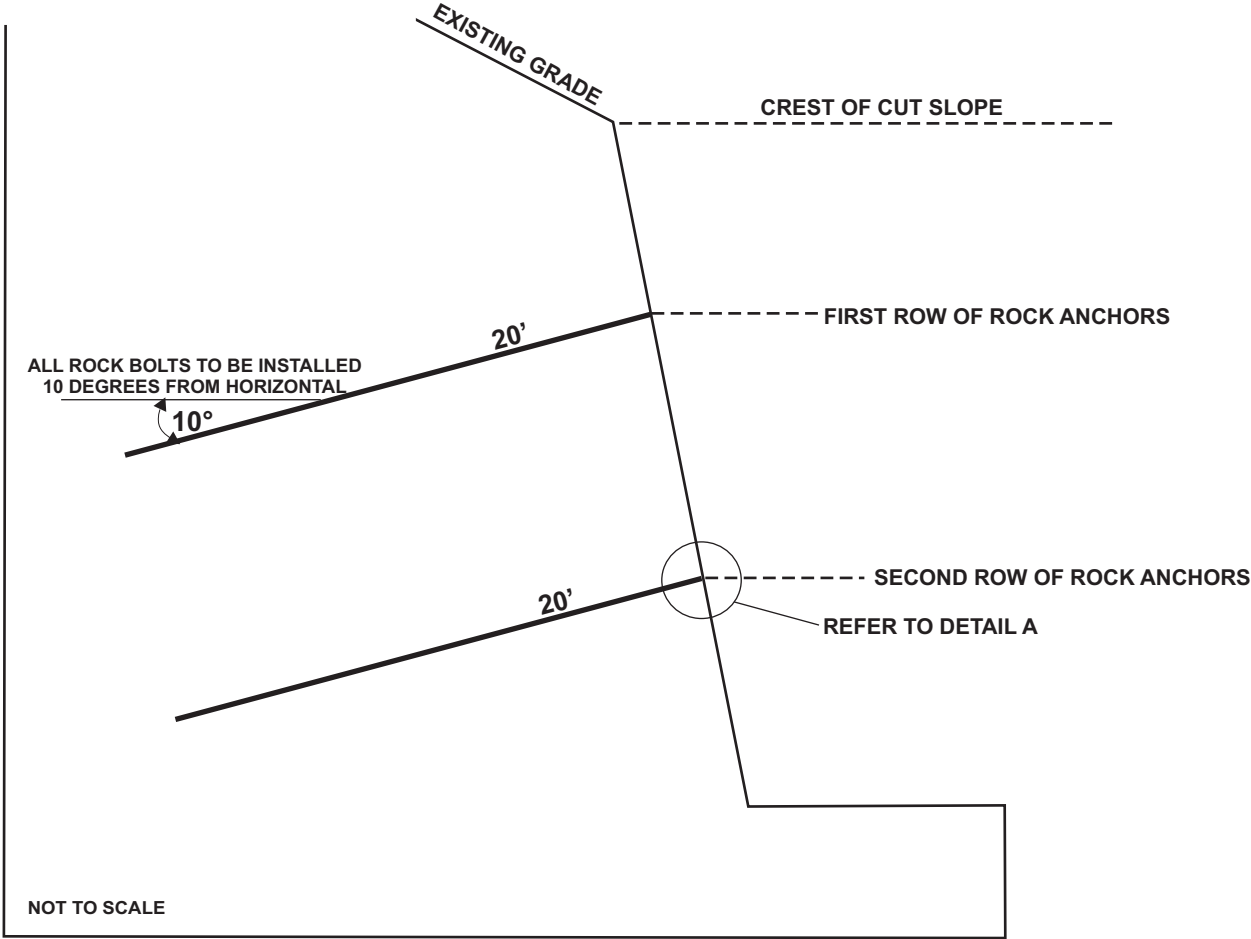
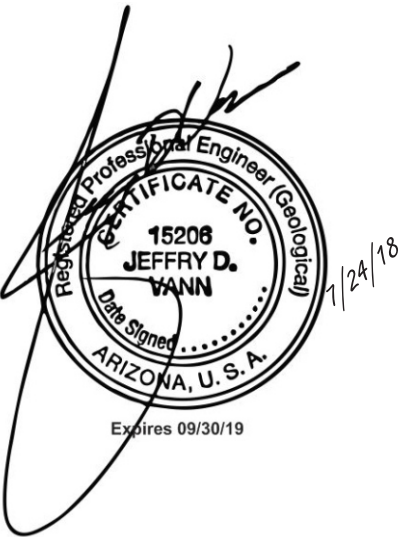
TECCO MESH DETAIL



SPECIAL INSPECTIONS

SPECIAL INSPECTIONS TO BE PERFORMED ON THE FOLLOWING ITEMS:

- 1. ROCK ANCHOR DRILL HOLE DEPTHS
- 2. INSTALLATION AND GROUTING OF ROCK ANCHORS
- 3. TECCO MESH INSTALLATION ON SLOPE FACE



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ROCK ANCHOR DETAIL, TECCO MESH DETAIL, RECOMMENDED SPECIAL INSPECTIONS AND ROCK FALL ANCHOR DETAIL NOTES		
DATE: 5/17/17		REVIEWED BY: JEFFRY D. VANN, MS, PE, F. ASCE
PROPOSED CUSTOM HILLSIDE RESIDENCE APN 169-04-007 7550 NORTH HUMMINGBIRD LANE PARADISE VALLEY, ARIZONA		
PROJECT 25998		VANN ENGINEERING INC