Rockfall Hazard Rating

Rockfall Hazard GAM Data Collection and Analysis, Tennessee Region 2

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Justin McCarley, R.G., C.E.G.
Project Geologist

TN TDOT Department of Transportation

LANDSLIDE TECHNOLOGY
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STGEC '24
Hosted by DOTD

Project Overview

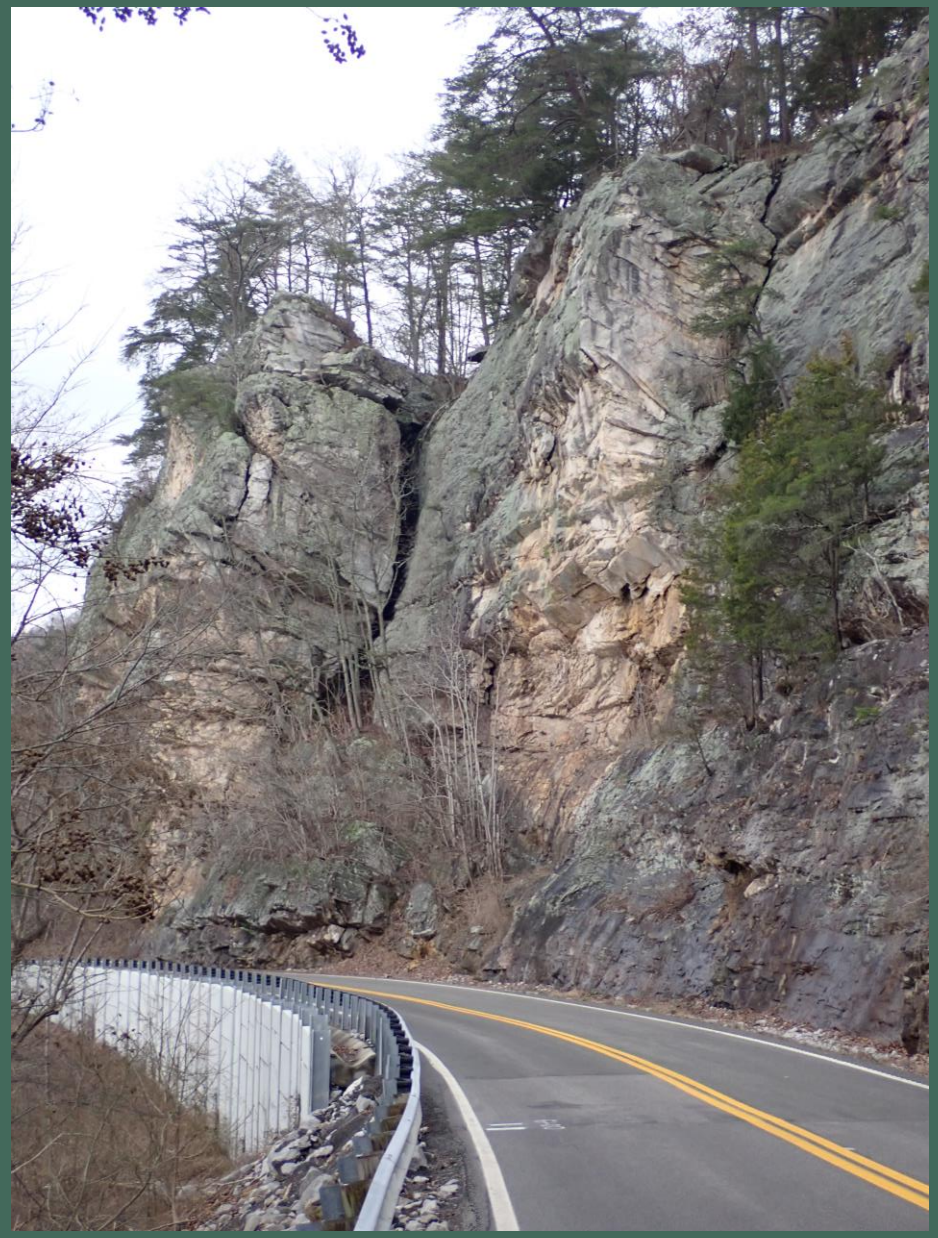
1. Project Initiation
2. Rating Calibration
3. Field Data Collection
4. Maintenance Interviews
5. QAQC
6. GES Review

Purpose

- Ratings would cover the 10 counties in Tennessee Region 2
- Previous ratings were completed in 2018-2019
- Previous ratings included 153 slopes

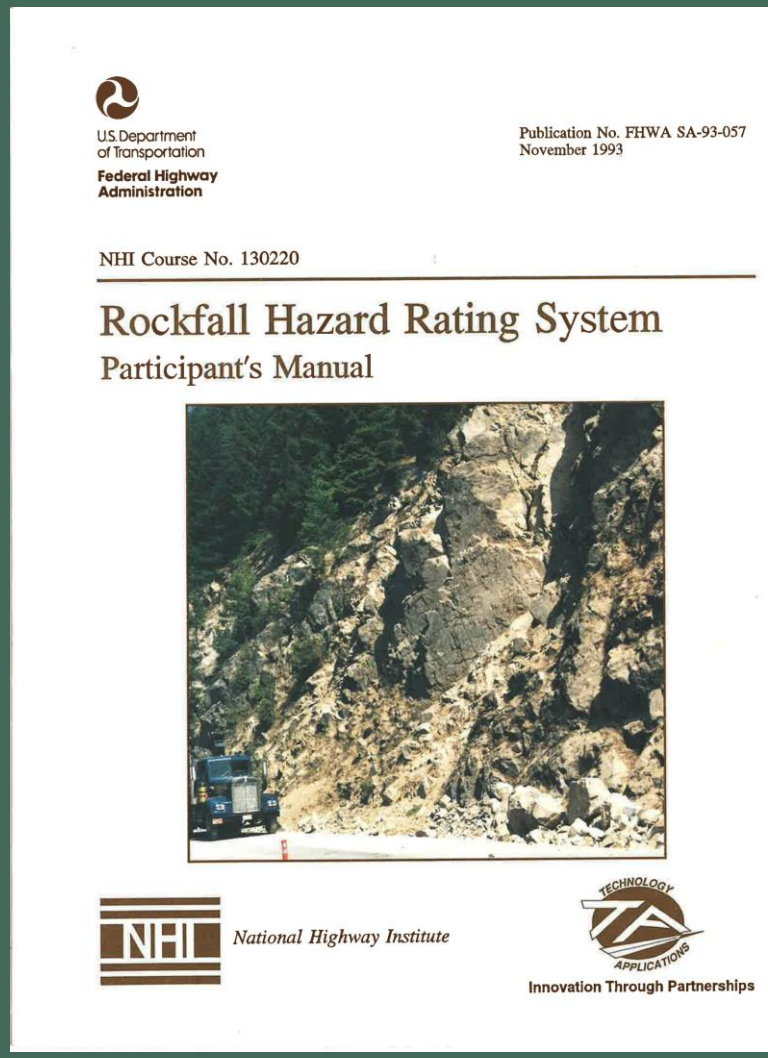
GAM Background

- Geotechnical Asset Management (GAM) leverages GIS to inventory infrastructure
- Utilized by an increasing number of DOTs to track unstable slopes
- Repeat ratings allow for monitoring changes in condition



Rockfall Hazard Rating System

- Development of the RHRS began at ODOT in 1984 and was finalized over about 10 years and adopted by the National Highway Institute (NHI)
- Provides a standardized, repeatable method for qualifying road adjacent rock slope hazards
- Gives DOTs a way to be proactive in preventing rockfall incidents rather than just reactive
- Is customizable based on the needs or geology of the state implementing it.
- Gives DOTs a rational way to allocate mitigation funds



U.S.Department of Transportation
Federal Highway Administration

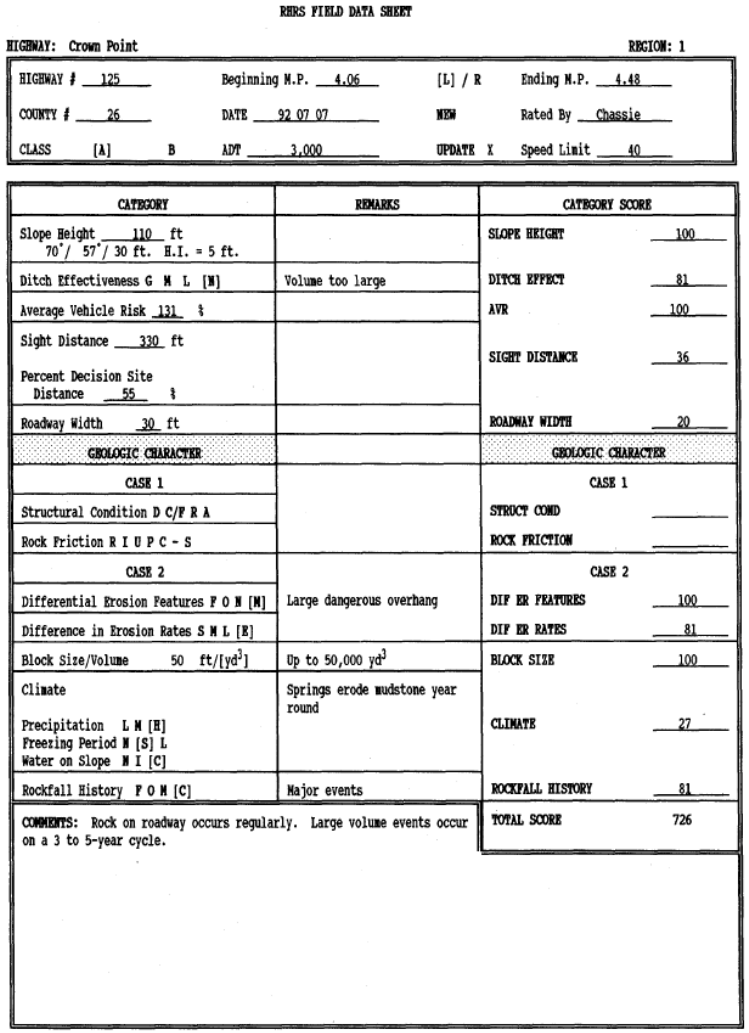
Publication No. FHWA SA-93-057
November 1993

NHI Course No. 130220

Rockfall Hazard Rating System
Participant's Manual

National Highway Institute

Innovation Through Partnerships



RHRS FIELD DATA SHEET

HIGHWAY: Crown Point REGION: 1

HIGHWAY # 125		Beginning M.P. 4.06	[L] / R	Ending M.P. 4.48	
COUNTY # 26		DATE 92 07 07	NEW	Rated By Chassie	
CLASS [A]	B	ADT 3,000	UPDATE X	Speed Limit 40	

CATEGORY	REMARKS	CATEGORY SCORE	
Slope Height 110 ft 70°/ 57°/ 30 ft. H.I. = 5 ft.		SLOPE HEIGHT	100
Ditch Effectiveness G M L [M]	Volume too large	DITCH EFFECT	81
Average Vehicle Risk 131 %		AVR	100
Sight Distance 330 ft Percent Decision Site Distance 55 %		SIGHT DISTANCE	36
Roadway Width 30 ft		ROADWAY WIDTH	20
GEOLOGIC CHARACTER		GEOLOGIC CHARACTER	
CASE 1		CASE 1	
Structural Condition D C/F R A		STRUCT COND	
Rock Friction R I U P C - S		ROCK FRICTION	
CASE 2		CASE 2	
Differential Erosion Features F O N [M]	Large dangerous overhang	DIF ER FEATURES	100
Difference in Erosion Rates S M L [E]		DIF ER RATES	81
Block Size/Volume 50 ft/[yd³]	Up to 50,000 yd³	BLOCK SIZE	100
Climate Precipitation L M [H] Freezing Period N [S] L Water on Slope N I [C]	Springs erode mudstone year round	CLIMATE	27
Rockfall History F O M [C]	Major events	ROCKFALL HISTORY	81
COMMENTS: Rock on roadway occurs regularly. Large volume events occur on a 3 to 5-year cycle.		TOTAL SCORE	726

Tennessee RHRS

- TDOT modified their RHRS from the NHI methods to better fit their needs
- Modifications were made to Ditch Effectiveness, Geologic Characteristic, Presence of Water on Slope, and Rockfall History
- Modifications were designed primarily to remove subjectivity from rating assessments or to account for Tennessee's unique geology and climate

TDOT RHRS FIELD SHEET v1.1

I. TRIMS/Preliminary Data

Date _____

File No. _____

County No.		Rater	
Route No.		Speed Limit	
Beg. L.M.		District	
Ref C/L		ADT	
County		Latitude	
Region		Longitude	

1. Slope Height _____
2. AVR _____
3. % DSD _____
4. Road Width _____
5. Ditch Effectiveness _____
6. Rockfall History _____
7. Water _____
8. Geologic Character _____

SCORING

TOTAL SCORE _____

II. Site and Roadway Geometry

1. Slope Height (ft)

estimated _____

alpha (a) _____ beta (b) _____

width (x) _____ ft instrument height (H.I.) _____ ft

Slope Height = $\frac{\sin a * \sin b * X}{\sin (a - b)}$ + H.I.

2. Average Vehicle Risk (AVR)

AVR = $\frac{\text{ADT (cars/day)} * \text{(Rock Slope Length/5280)}}{\text{((24hpd)} * \text{Speed Limit (mph))}}$

Slope Length _____ ft Speed Limit _____ ft **AVR =** _____ %

3. % Decision Site Distance (% DSD)

Choose one: adequate, moderate, limited, very limited
3 9 27 81

OR

Calculate: _____ / _____ X 100 = _____ %
(observed DSD) / (AASHTO DSD)

4. Road Width (ft) _____

5. Ditch Effectiveness

Design Catchment Width (feet)

Slope Height (ft)	Recommended width for vertical slope	Recommended width for non-vertical slope
0 – 40	18	18
40 – 50	18	24
50 – 60	24	30
60 – 70	28	34
70 – 80	32	38
80 – 100	36	42
100 – 125	36	42
125 – 175	40	48
> 175	52	60

Effective catchment width (ft) _____ Launching Features? (yes or no) _____
6:1 catchment shape? (yes or no) _____

Percent of Design Catchment Width from Table	>90%	70%-90%	50%-70%	<50%
Score with 6:1 or greater catchment slope	3	9	27	81
Score w/ Poor Catchment **OR** Launch Features	9	27	81	81
Score w/ Poor Catchment **AND** Launch Features	27	81	81	81

6. Rockfall History

Benchmark	Frequency	Field Judgment	Score
Few	1 or less per year	No impact marks in the road, no rocks in the road, few rocks in ditch	3
Several	2 per year	No impact marks in the road, no rocks in the road, many rocks in the ditch	9
Many	3 – 4 per year	Few impact marks or few rocks in the road	27
Constant	5 or more per year	Many impact marks and/or many rocks in the road	81

III. Geologic Characteristics (circle all that apply; modes are additive)

	Planar				Wedge			
Abundance	<10%	10-20%	20-30%	>30%	<10%	10-20%	20-30%	>30%
score	3	9	27	81	3	9	27	81
Block size	<1ft	1-3ft	3- 6ft	>6ft	<1ft	1-3ft	3- 6ft	>6ft
score	3	9	27	81	3	9	27	81
Steepness (degrees)	0-20	20-40	40-60	>60	0-20	20-40	40-60	>60
score	2	5	14	41	2	5	14	41
Friction (micro/macro)	rough/ undulating	smooth/ undulating	rough/ planar	smooth/ planar	rough/ undulating	smooth/ undulating	rough/ planar	smooth/ planar
score	2	5	14	41	2	5	14	41

8. Geology Score = _____

	Topple/B. Release				Differential Weathering				Raveling				
Abundance	<10%	10-20%	20-30%	>30%	<10%	10-20%	20-30%	>30%	Abundance	<10%	10-20%	20-30%	>30%
score	5	14	41	122	3	9	27	81	score	3	9	27	81
Block size	<1ft	1-3ft	3- 6ft	>6ft	<1ft	1-3ft	3- 6ft	>6ft	Block size	<1ft	1-2ft	2- 3ft	>3ft
score	5	14	41	122	3	9	27	81	score	3	9	27	81
Relief					<1ft	1-3ft	3- 6ft	>6ft	Block Shape	tabular	blocky	round	
score					3	9	27	81	score	3	9	27	

7. Presence of Water on Slope

(choose one) none 3 seeping 9 flowing 27 gushing 81 _____

NOTES:

Methods

- Review previously collected ratings
- Visit known slope locations with a Geohazard Score >300
- Add new slopes when encountered
- Document slope conditions with ratings and photos
- Collect photogrammetric data for slopes with a Geohazard Score >600

Roadway Metrics

Functional Classification:

AADT:

AADT Year:
What year was the AADT recorded?

Speed Limit:

Roadway Width (feet):

Roadway Length Affected (feet):

Score Calculations

Geologic Character Score:
Highest sum of Case 1 or Case 2 scores. Automatically calculated value, do not edit.

Slope height Score:
Automatically calculated value, do not edit.

Block Size or Event Score:
Automatically calculated value, do not edit.

Annual Precipitation Score:
Automatically calculated value, do not edit.

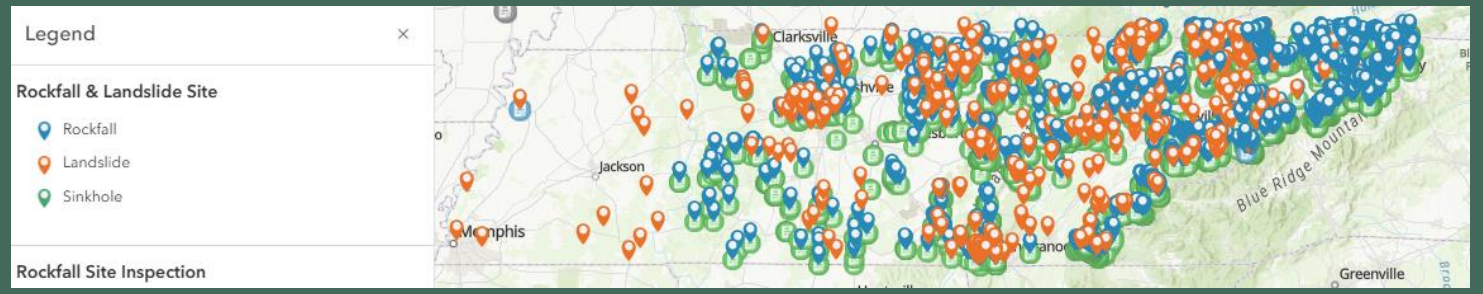
Roadway Width Score:
Automatically calculated value, do not edit.

Average Vehicle Risk Score:
Automatically calculated value, do not edit.

Decision Sight Distance Score:
Automatically calculated value, do not edit.

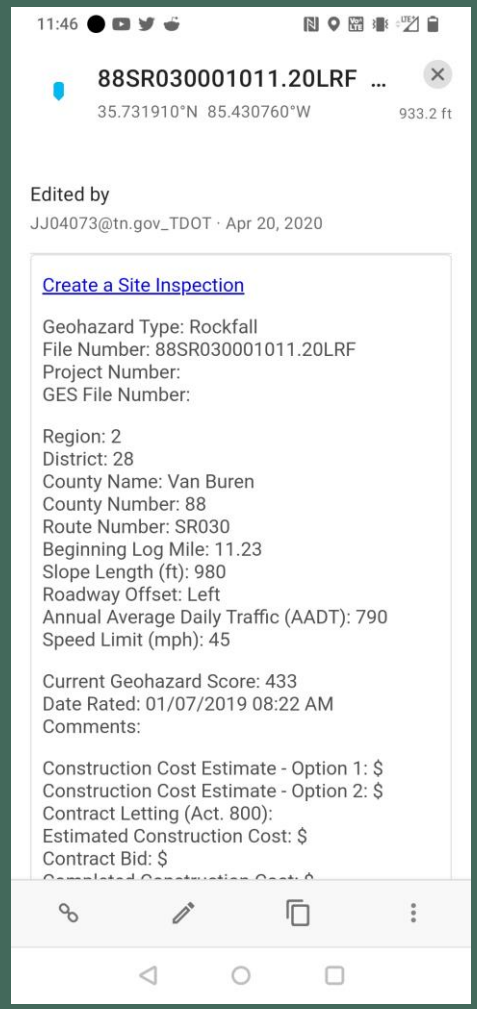
AADT Score:
Automatically calculated value, do not edit.

Total RHRS Score:
Automatically calculated value, do not edit.



Data Collection

- Ratings performed in teams of two
- Utilized ESRI mobile software for site ratings
- Performed group “calibration rating” at field work initiation
- Previous ratings reviewed on site



Results

- A total of 180 sites were inventoried
- Of those sites, 111 were rated above a geohazard score of 300
- Seven sites with scores previously above 300 were not rated
- Of the ten counties in Region 2, two of them had zero hazardous slopes

County	Previous Number of Rockfall Sites with Scores Greater Than 300	Number of Rockfall Sites Rated for WO1 (All Scores)	Number of Rockfall Sites with Scores Greater than 300 for WO-01
Bledsoe	15	14	9
Bradley	0	0	0
Grundy	17	19	14
Hamilton	19	18	10
Polk	63	80	49
Rhea	5	7	4
Sequatchie	13	17	10
Van Buren	18	18	10
Warren	0	0	0
White	3	7	5

County	Route	Log Mile	Previous Score	Reason for not Rating
Bledsoe	SR030	5.84	329	Colluvial Slope/Lack of Outcrop
Hamilton	SR148	3.44	427	Rock slope height <10'/Preliminary C Rating
Hamilton	SR148	3.73	370	Rock slope height <10'/Preliminary C Rating
Polk	SR030	6.70	427	Colluvial Slope/Lack of Outcrop
Polk	SR068	9.97	319	Colluvial Slope/Lack of Outcrop
Polk	SR030	12.53	352	Rock slope height <10'/Preliminary C Rating
Polk	SR040	16.49	359	Rock slope height <10'/Preliminary C Rating

Results

County	Route	Log Mile	Total Geohazard Score
Hamilton	SR008	15.79	830
Grundy	I0024	5.58	829
Polk	SR040	15.41	775
Polk	SR040	13.14	712
Polk	SR040	16.20	684
Polk	SR040	17.53	626
Sequatchie	SR008	20.16	614
Van Buren	SR285	4.34	612
White	SR001	14.39	612
Bledsoe	SR030	7.35	605

- A total of 43 new slopes were added to the inventory, with 32 getting detailed ratings
- Ten of the new slopes rated above 300 and two rated near 500
- Of the total 180 sites, nine rated a geohazard score above 600, triggering 3D model collection

Issues Encountered

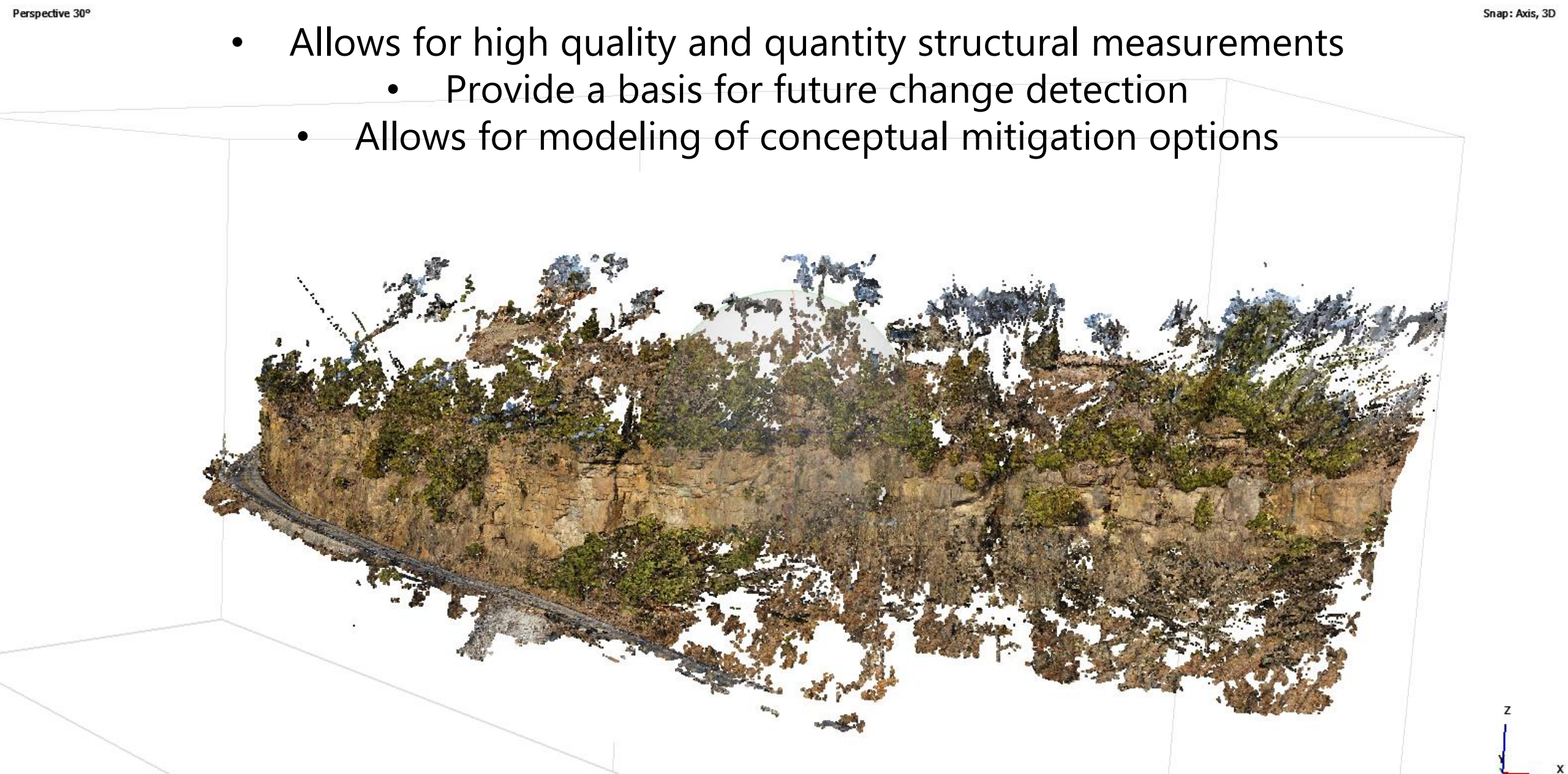
- Some site conditions were masked by maintenance activity
- Ratings overall were generally lower than previous ratings
- Some slopes were missing and some needed to be removed

UAV Image Collection

- Collected for sites that rated over 600
- Used to develop three-dimensional models useful for change detection or conceptual mitigation planning
- Data collection took approximately 1-2hrs per site

Photogrammetric Models

- Allows for high quality and quantity structural measurements
  - Provide a basis for future change detection
- Allows for modeling of conceptual mitigation options



Lessons Learned

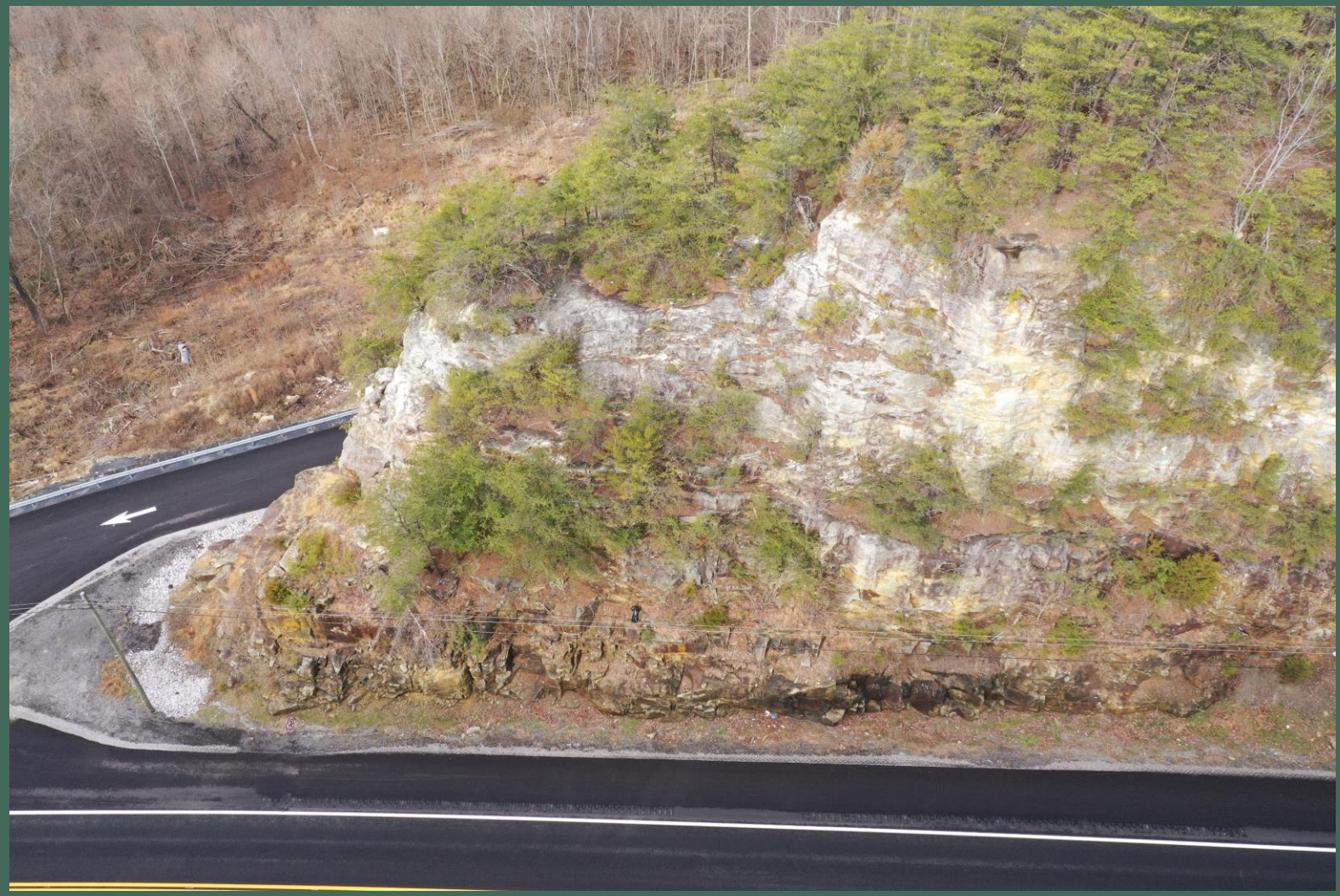
<u>Maintenance Feedback is Key</u>

- Rockfall history can be hidden by maintenance activity
- Maintenance personnel are intimately familiar with rockfall slopes
- Synthesis of both sources of information (maintenance and geotechnical) is ideal

Lessons Learned

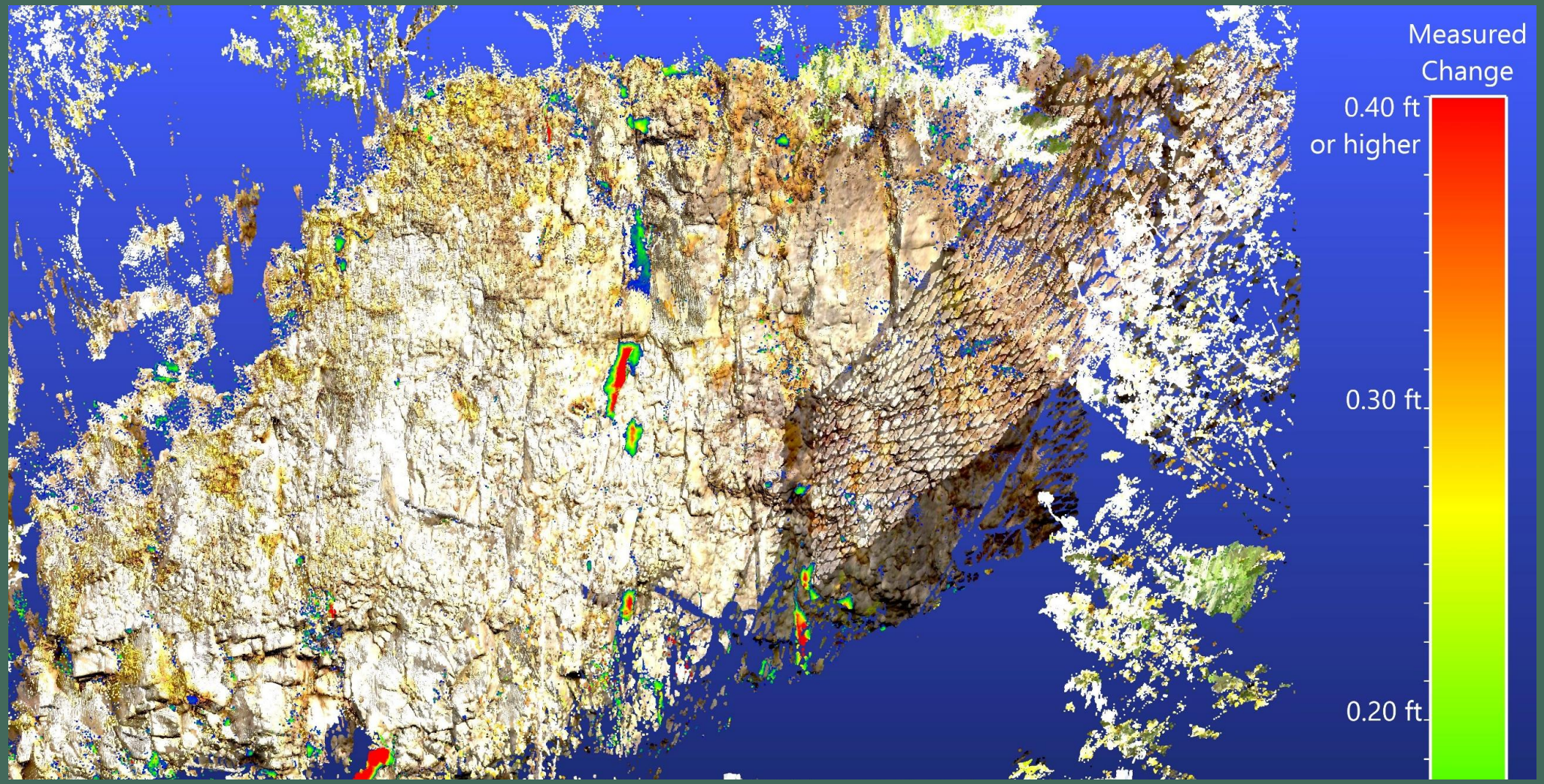
Subjectivity Will Always Remain

- Different Geotech's will always rate slopes differently
- Repeat ratings are important for monitoring slope degradation
- Normalizing or otherwise accounting for differences in rating values should be considered during repeat ratings



Lessons Learned

Sooner is better when collecting data for modeling



Going Forward

Integrate Maintenance Activity

- Allows for better event tracking
- Identifies hotspots or high cost/maintenance sites
- Identifies sites with high traffic impacts
- Provides spatial and temporal data that can be quickly searched and plotted as needed

TDOT, Mar 2023

Going Forward

Incorporate Risk Scenarios measured in Dollar Units

- Helps identify high risk routes from an economic impact perspective
- Calculate probability of a road-closing event
- Group slopes into corridor-focused rockfall projects

QUESTIONS

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