

# Clearing the Fog on the Aging I-77 Rock Slopes



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# Clearing the Fog on the Aging I-77 Rock Slopes

I-77 Corridor

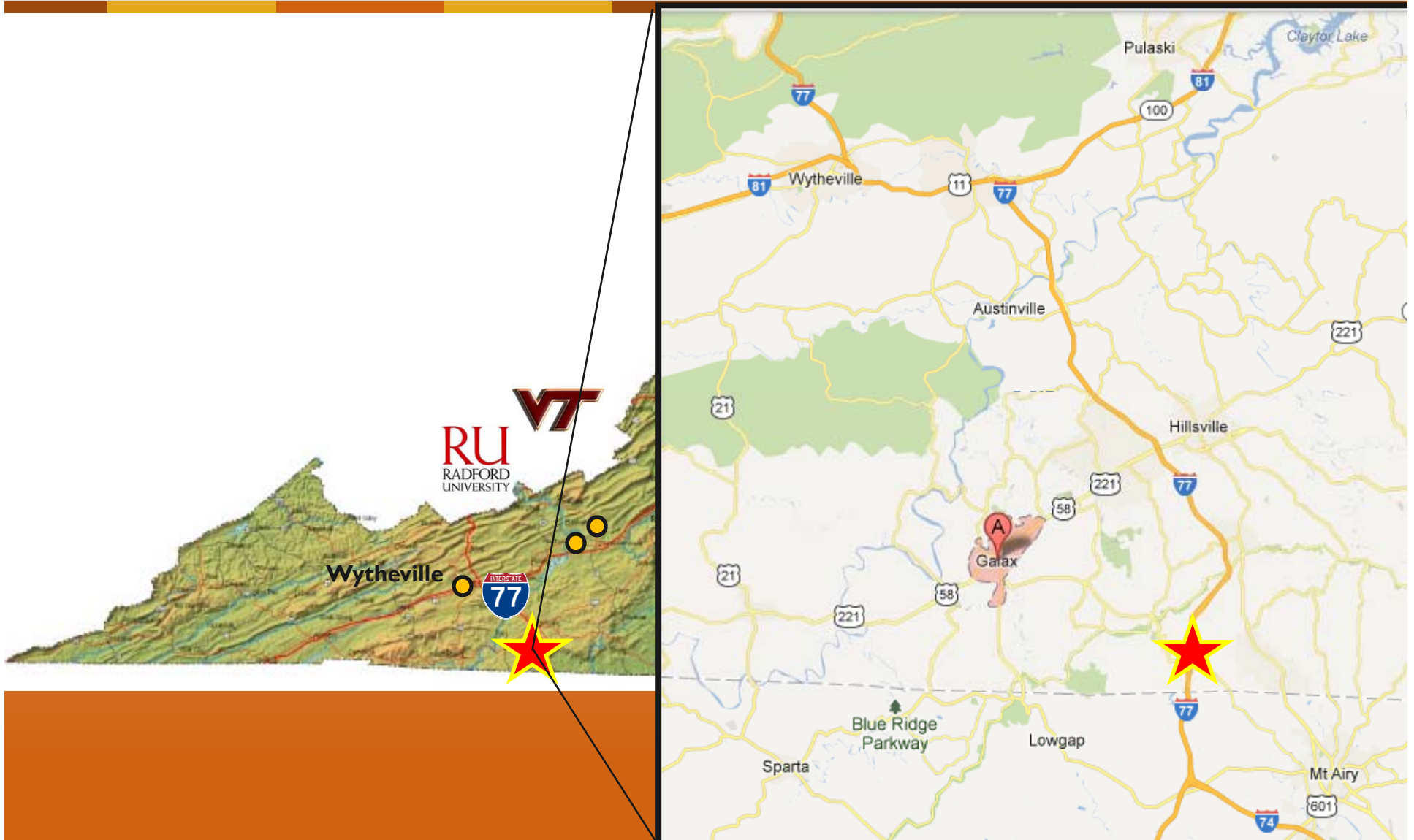
Corridor Challenges

I-77 Rock Slope Management Program

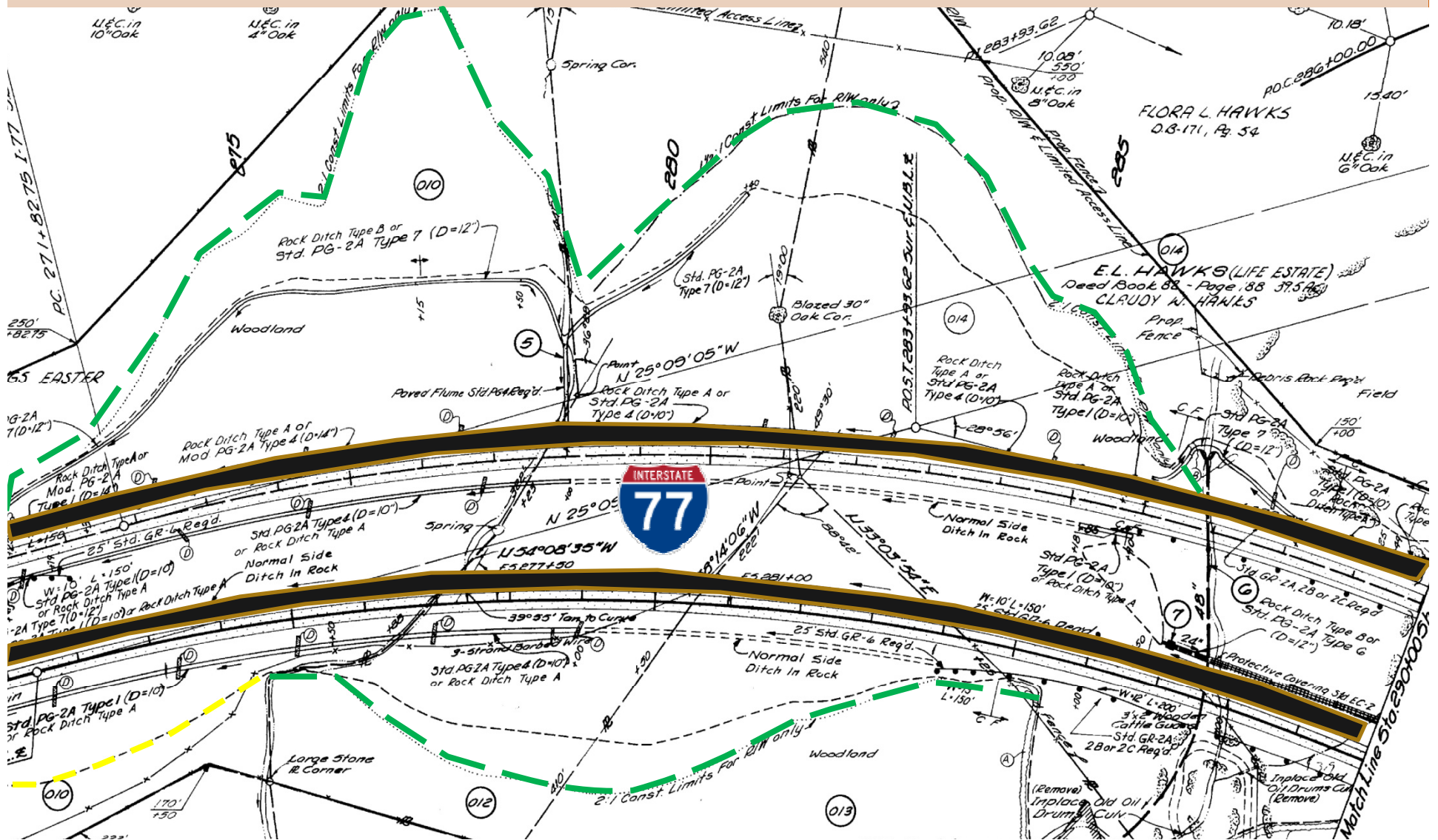
Conclusions and a Look Ahead



# I-77 Corridor: Project Location

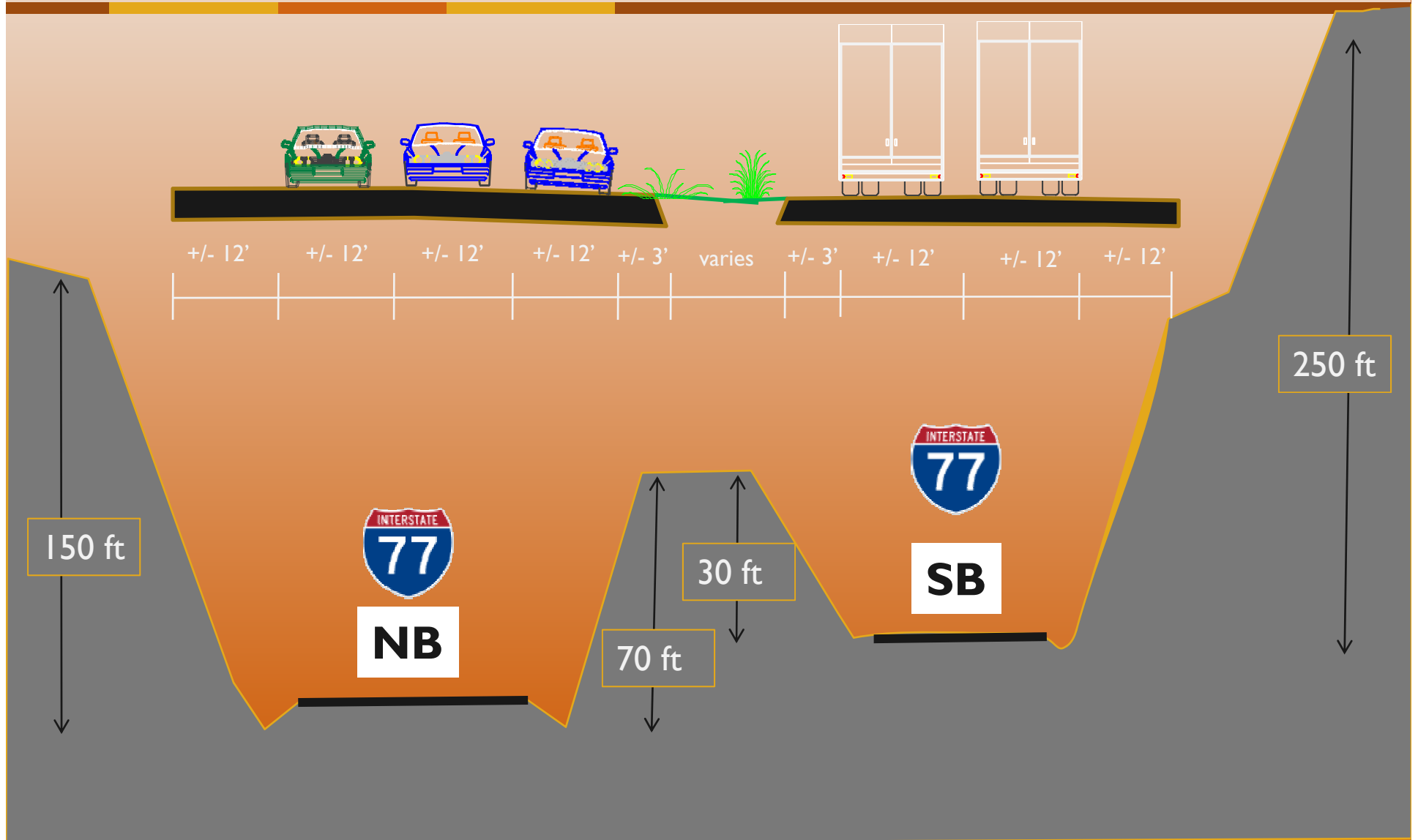


# Original I-77 Construction





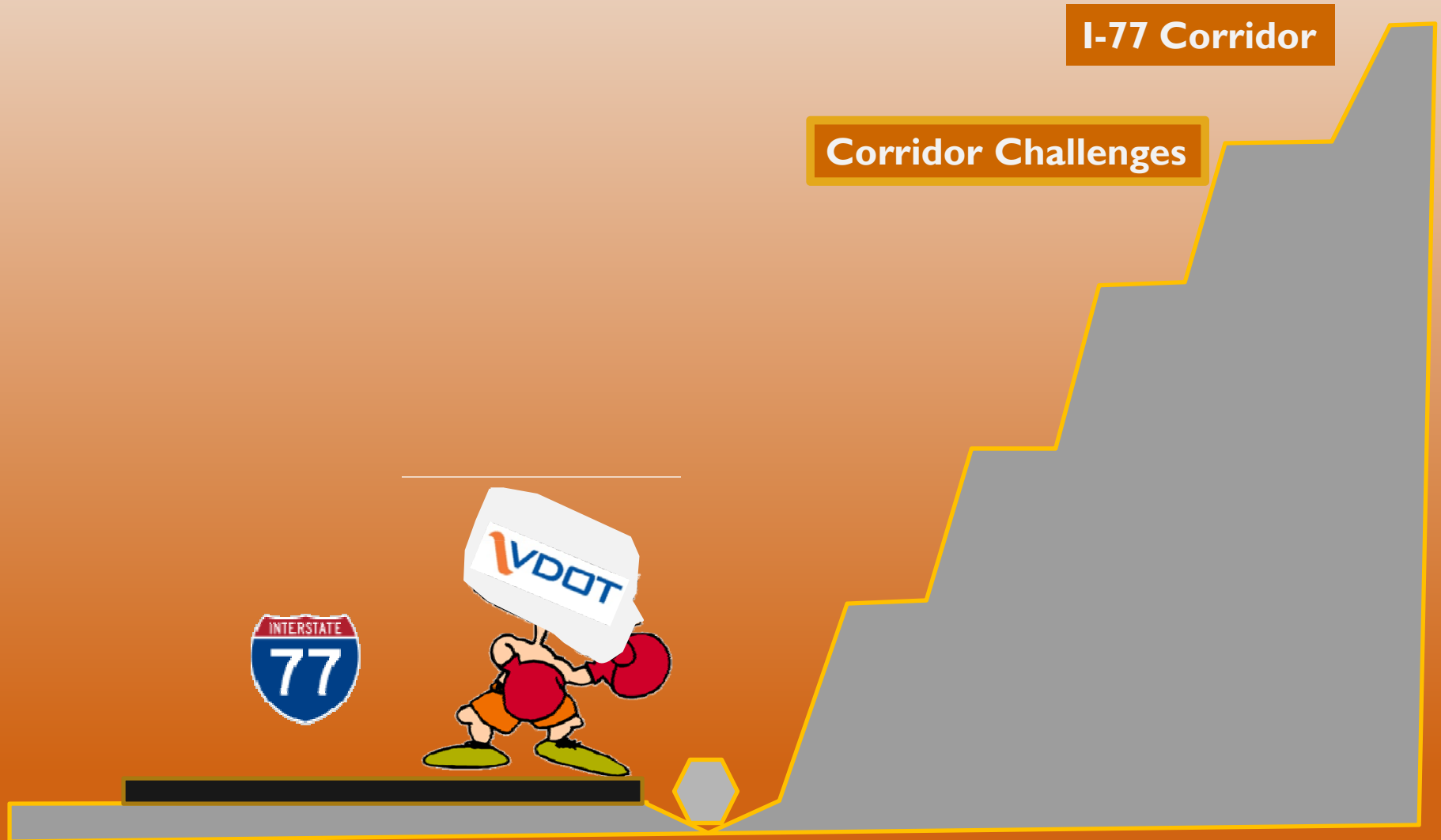
# I-77 Typical Section



# Corridor Challenges

I-77 Corridor

Corridor Challenges



# I-77 Corridor: Challenges



# I-77 Corridor Challenges: High ADDT



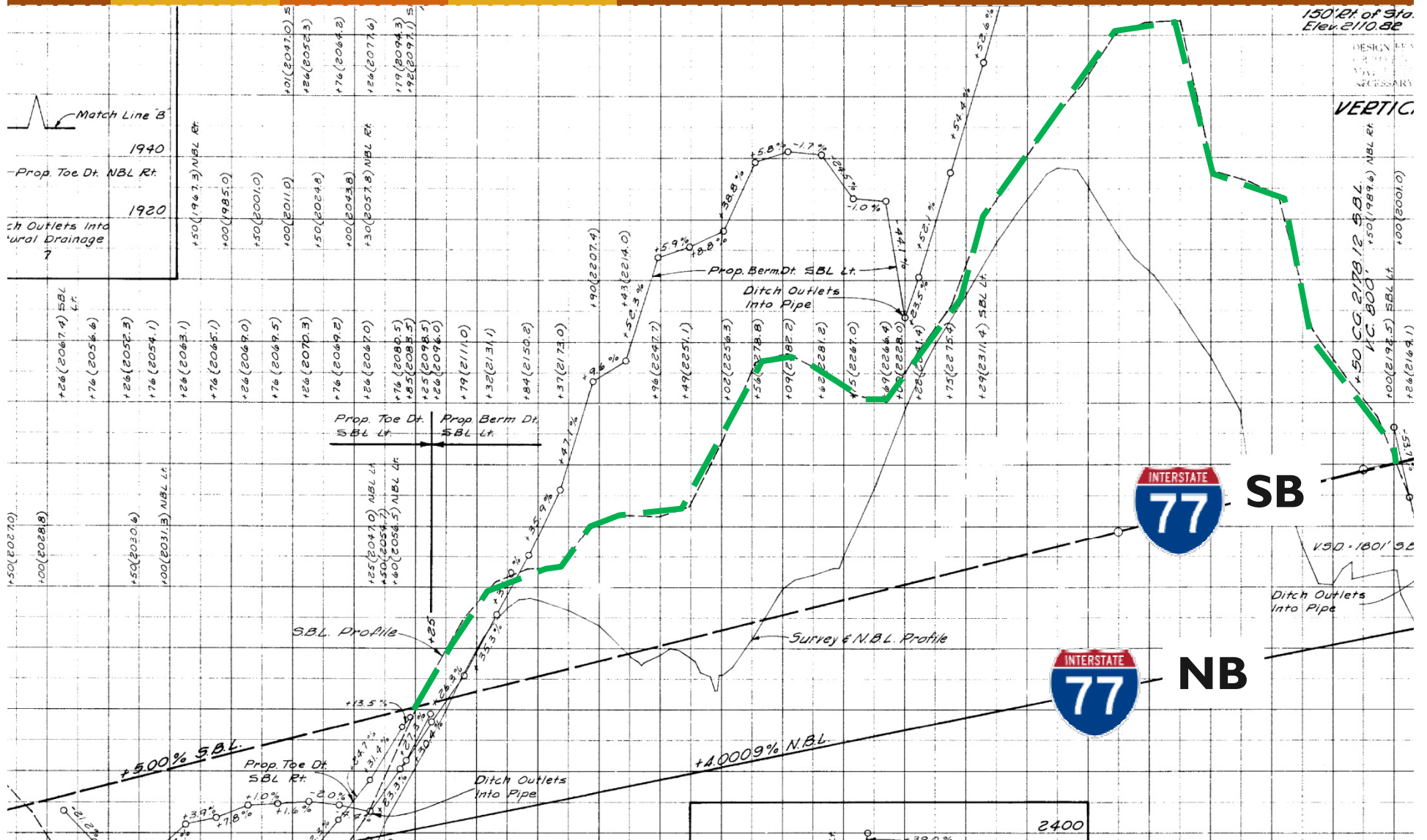
**ADT**  
18,000 NB  
18,000 SB

**% Trucks**  
21% NB  
27% SB





# I-77 Corridor Challenges: Steep Grades



# I-77 Corridor Challenges: Foggy Conditions



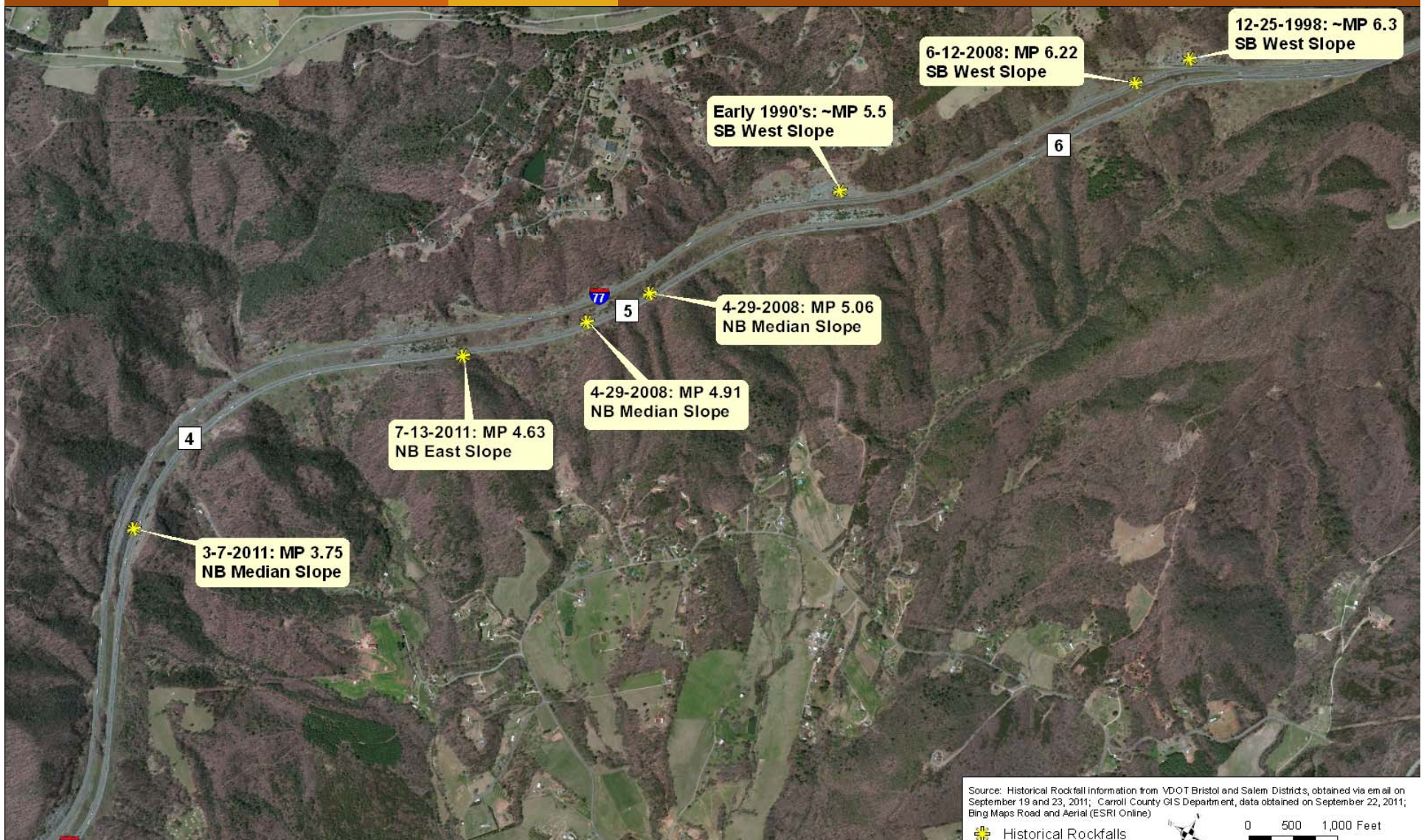


# I-77 Corridor Challenges: Rockfalls





# I-77 Rockfall History





# I-77 NB Median Slope MP 3.7



# I-77 Rock Slope Management Program

## VDOT's Proactive Approach





# RHRS Implementation

## FINAL REPORT

IMPLEMENTATION OF THE ROCK SLOPE MANAGEMENT PROJECT  
AT THE VIRGINIA DEPARTMENT OF TRANSPORTATION

Edward J. Hoppe, Ph.D., P.E.  
Senior Research Scientist

Derek H. Whitehouse, C.P.G.  
Chief Transportation Geologist

Virginia Transportation Research Council  
(A partnership of the Virginia Department of Transportation  
and the University of Virginia since 1948)

Charlottesville, Virginia

June 2006  
VTRC 06-R23



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 Implementation on

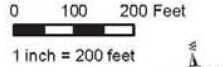
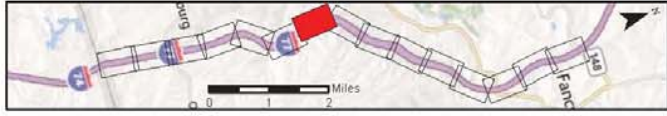


- NB/SB MP Marker
- NB/SB Median Slope Begin
- NB/SB Median Slope End
- NB/SB Outside Slope Begin
- NB/SB Outside Slope End
- NB/SB Begin/End Median Slope
- NB/SB Begin/End Outside Slope
- [364] 2012 RHRS Detailed Rating Score
- A RHRS Preliminary Rating A
- B RHRS Preliminary Rating B
- C RHRS Preliminary Rating C
- ✦ Historical Rockfall
- Slope Length
- SB MP Baseline
- NB MP Baseline



Note: 1. Slope Limits and Mile Posts are Approximate Only

Created by R. Roa  
Checked by R. Tinsley



Virginia Department of Transportation - Salem District  
Interstate 77, MP 0.0 to MP 8.0 (Fancy Gap)  
Slope Inventory and RHRS Slope Rating





# RHRS Implementation on



## RHRS Detailed Rating Field Data Sheet

CUT 8-5B  
PHOTOS 79, 71, 72, 73, 74,  
76, 1

Date: 5-18-12

Rating: (A) B

Rater: L. ARTMAN, P.G.

County/City	<u>CARROLL</u>	Start Latitude	<u>36.602539</u>	Start Longitude	<u>80.736913</u>
Route No.	<u>I-77</u>	End Latitude	<u>36.605746</u>	End Longitude	<u>80.736360</u>
Nearest Inter.	<u>EXIT 1 (SB)</u>	Start MP (est)	<u>3.95</u>	End MP (est)	<u>3.15</u>
ADT	<u>18,000 (SB)</u>	Speed Limit	<u>65</u>	Left / (Right) Heading	<u>N S E W</u> <u>(S-SW)</u>

Category	Remarks	Category Score
<b>Slope Geometry</b>		
Slope Height	<u>100</u> ft. <u>0'</u> <u>0'</u>	Slope Angle H.I. <u>1/2:1</u> <sup>70°</sup>
Ditch Effectiveness	G M (L) N	Ditch Width <u>10'-15'</u>
Average Vehicle Risk	<u>105</u> %	Section Length <u>775</u> ft.
Sight Distance	<u>120</u> ft.	Sign Present <u>Yes</u> / (NO)
% Decision S.D.	<u>40</u> %	Sight Distance
Roadway Width	<u>39</u> ft.	Roadway Width
<b>Geologic Characteristics</b>		
Case 1		
Structural Condition	D (C) / F R (A)	Struct. Cond.
Rock Friction	R I (U) P C-S	Rock Friction
Case 2		
Differential Erosion Features	F O N M	Erosion Feat.
Difference in Erosion Rates	S M L E	Erosion Rates
<b>Rockfall Characteristics</b>		
Block Size/Volume	<u>&gt; 4</u> (R) or yd <sup>3</sup>	Block Size
Rockfall History	F O M (C)	Rockfall History
Total Score <u>565</u>		

**Comments:**

- \* MUST ROCKFALL OBSERVED ON SB SIDE.
- \* FREQUENT WEDDER/PLANAR FAILURES. JOINTS SEPARATED
- \* POISED BLOCKS HIGH ON SLOPE. MANY LAUNCH FEATURES.
- \* SPORADIC WATER
- \* SPORADIC VEGETATION
- \* GEOLOGY SLIGHTLY DIFFERENT, MORE OXIDATION AND WEATHERING.

P. RATING = A



### Average Vehicle Risk:

ADT = 18,000  
Avg. Slope Length = 775 feet  
AVR Score > 81



# RHRS Implementation on



## RHRS Detailed Rating Field Data Sheet

CUT 8-5B  
PHOTOS 79, 71, 72, 73, 74,  
70, 1

Date: 5-18-12

Rating: (A) / B

Rater: L. ARTMAN, P.G.

County/City	<u>CARROLL</u>	Start Latitude	<u>36.602539</u>	Start Longitude	<u>80.736913</u>
Route No.	<u>I-77</u>	End Latitude	<u>36.605746</u>	End Longitude	<u>80.736360</u>
Nearest Inter.	<u>EXIT 1 (SB)</u>	Start MP (est)	<u>3.95</u>	End MP (est)	<u>3.15</u>
ADT	<u>18,000 (SB)</u>	Speed Limit	<u>65</u>	Left / (Right) Heading	<u>N S E W</u> <u>(S-SW)</u>

Category	Remarks	Category Score
<b>Slope Geometry</b>		
Slope Height	<u>100</u> ft. <u>0' 0'</u>	Slope Angle H.I. <u>1/2:1</u> <u>1/2:1</u>
Ditch Effectiveness	G M <u>(L)</u> N	Slope Height <u>81</u>
Average Vehicle Risk	<u>105</u> %	Ditch Width <u>10'-15'</u> Ditch Effect. <u>27</u>
Sight Distance	<u>420</u> ft.	Section Length <u>1208.0</u> AVR <u>100</u>
% Decision S.D.	<u>40</u> %	Sign Present Yes / (No) <u>(No)</u> Sight Distance <u>81</u>
Roadway Width	<u>39</u> ft.	Roadway Width <u>6</u>
<b>Geologic Characteristics</b>		
Case 1		
Structural Condition	D <u>(C)</u> / F R <u>(A)</u>	Struct. Cond. <u>81</u>
Rock Friction	R I <u>(U)</u> P C-S	Rock Friction <u>27</u>
Case 2		
Differential Erosion Features	F O N M <u>N/A</u>	Erosion Feat. <u>0</u>
Difference in Erosion Rates	S M L E <u>N/A</u>	Erosion Rates <u>0</u>
<b>Rockfall Characteristics</b>		
Block Size/Volume	<u>&gt; 4</u> <u>(B)</u> or yd <sup>3</sup>	Block Size <u>81</u>
Rockfall History	F O M <u>(C)</u>	Rockfall History <u>81</u>
Comments:		Total Score <u>565</u>

- # - MUST ROCKFALL OBSERVED ON SB SIDE.
- \* FREQUENT WEDGGE/PLANAR FAILURES. JOINTS SEPARATED
  - \* POISED BLOCKS HIGH ON SLOPE. MANY LAUNCH FEATURES.
  - SPORADIC WATER
  - SPORADIC VEGETATION
  - GEOLOGY SLIGHTLY DIFFERENT, MORE OXIDATION AND WEATHERING.

P. RATING = A



**Sight Distance:  
Worst Case: 420 ft  
Percent DSD Score = 81**

# RHRS Implementation on



CUT 8-5B  
PHOTOS 79, 71, 72, 73, 74,  
70.1

**RHRS Detailed Rating Field Data Sheet**

Date: 5-18-12 Rating: (A) B Rater: L. ALTMAN, P.G.

County/City	<u>CARROLL</u>	Start Latitude	<u>36.602539</u>	Start Longitude	<u>80.736913</u>
Route No.	<u>I-77</u>	End Latitude	<u>36.605746</u>	End Longitude	<u>80.736360</u>
Nearest Inter.	<u>Exit 1 (SB)</u>	Start MP (est)	<u>2.95</u>	End MP (est)	<u>3.15</u>
ADT	<u>18,000 (SB)</u>	Speed Limit	<u>65</u>	Left / (Right) Heading	<u>N S E W (S-SW)</u>

Category	Remarks	Category Score
<b>Slope Geometry</b>		
Slope Height	<u>100</u> ft.	Slope Height <u>81</u>
Ditch Effectiveness	G M (L) N	Ditch Effect. <u>27</u>
Average Vehicle Risk	<u>105</u> %	AVR <u>100</u>
Sight Distance	<u>120</u> ft.	Sight Distance <u>81</u>
% Decision S.D.	<u>40</u> %	
Roadway Width	<u>39</u> ft.	Roadway Width <u>6</u>
<b>Geologic Characteristics</b>		
Structural Condition	D (C) / F R (A)	Struct. Cond. <u>81</u>
Rock Friction	R T (C) D C-S	Rock Friction <u>27</u>
<b>Case 2</b>		
Differential Erosion Features	F O N M <u>N/A</u>	Erosion Feat. <u>0</u>
Difference in Erosion Rates	S M L E <u>N/A</u>	Erosion Rates <u>0</u>
<b>Rockfall Characteristics</b>		
Block Size/Volume	<u>&gt; 4</u> (ft) or yd <sup>3</sup>	Block Size <u>81</u>
Rockfall History	F O M (C)	Rockfall History <u>81</u>
Total Score <u>565</u>		

Comments:  
 \* MOST ROCKFALL OBSERVED ON SB SIDE,  
 \* FREQUENT WEDGES/PLANAR FAILURES. JOINTS SEPARATED  
 \* POISED BLOCKS HIGH ON SLOPE. MANY LAUNCH FEATURES.  
 \* SPORADIC WATER  
 \* SPORADIC VEGETATION  
 \* GEOLOGY SLIGHTLY DIFFERENT, MORE OXIDATION AND WEATHERING.

P. RATING = A



Continuous and Adverse Orientation



Slopes Showing Their Age



# RHRS Implementation on



## RHRS Detailed Rating Field Data Sheet

CUT 8-5B  
PHOTOS 79, 71, 72, 73, 74,  
70, 1

Date: 5-18-12

Rating: (A) / B

Rater: L. ARTMAN, P.G.

County/City	<u>CARROLL</u>	Start Latitude	<u>36.602539</u>	Start Longitude	<u>80.736913</u>
Route No.	<u>I-77</u>	End Latitude	<u>36.605746</u>	End Longitude	<u>80.736360</u>
Nearest Inter.	<u>EXIT 1 (SB)</u>	Start MP (est)	<u>3.95</u>	End MP (est)	<u>3.15</u>
ADT	<u>18,000 (SB)</u>	Speed Limit	<u>65</u>	Left / (Right) Heading	<u>N S E W</u> <u>(S-SW)</u>

Category	Remarks	Category Score
<b>Slope Geometry</b>		
Slope Height	<u>100</u> ft. <u>0' 0"</u>	Slope Angle H.I. <u>1/2:1</u> <sup>70°</sup>
Ditch Effectiveness	G M <u>(L)</u> N	Slope Height <u>81</u>
Average Vehicle Risk	<u>105</u> %	Ditch Effect. <u>27</u>
Sight Distance	<u>120</u> ft.	Section Length <u>1209.0</u>
% Decision S.D.	<u>40</u> %	Sign Present Yes / (No)
Roadway Width	<u>39</u> ft.	AVR <u>100</u>
<b>Geologic Characteristics</b>		
Case 1		
Structural Condition	D <u>(C)</u> / F R <u>(A)</u>	Sight Distance <u>81</u>
Rock Friction	R I <u>(U)</u> P C-S	Roadway Width <u>6</u>
Case 2		
Differential Erosion Features	F O N M <u>N/A</u>	<b>Geologic Characteristics</b>
Difference in Erosion Rates	S M L E <u>N/A</u>	Case 1
<b>Rockfall Characteristics</b>		
Block Size/Volume	<u>&gt; 4</u> <u>(B)</u> or yd <sup>3</sup>	Struct. Cond. <u>81</u>
Rockfall History	F O M <u>(C)</u>	Rock Friction <u>27</u>
Total Score <u>565</u>		

**Comments:**

- \* MUST ROCKFALL OBSERVED ON SB SIDE.
- \* FREQUENT WEDDER / PLANAR FAILURES. JOINTS SEPARATED
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P. RATING = A



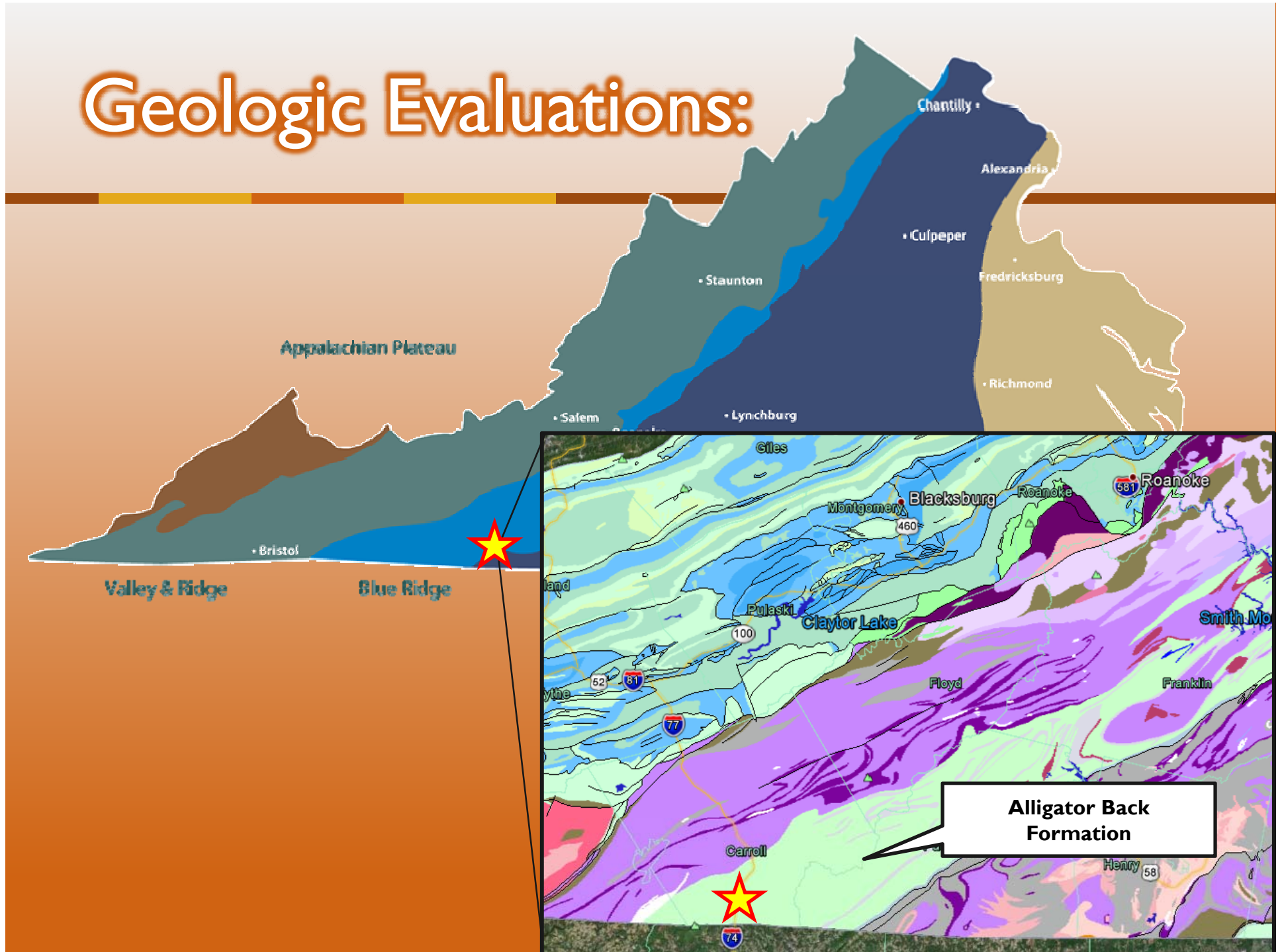
**Rockfall History :  
Constant Shedding of Rock**

# RHRS Implementation on



Cut Slope Designation	Begin MP	End MP	Slope Height (ft)	Slope Height Score	Percent of DSD	DSD Score	Rockfall History	History Score	RHRS Detailed Rating
8-SB	2.95	3.15	100	81	40	81	Constant	81	565
14-SB	3.75	3.9	>100	81	40	81	Constant	81	565
19b-SB	4.9	5	75-100	81	40	81	Constant	81	565
23-SB	5.45	5.65	>100	81	40	81	Constant	81	565
10-NB(M)	3.6	3.9	60	27	40	81	Constant	81	560
13-SB	3.6	3.75	50-75	27	40	81	Constant	81	511
9-NB	3.7	3.85	55	27	40	81	Constant	81	506
15d-NB(M)	5.05	5.15	85	81	40	81	Constant	81	506
21-NB(M)	5.4	5.65	75-100	81	60	27	Constant	81	506
16-SB	4.45	4.65	>100	81	100	3	Constant	81	487
33-SB	6.3	6.45	>100	81	100	3	Constant	81	487
13-NB(M)	4.45	4.65	80	81	100	3	Constant	81	482
14-NB	4.45	4.65	85	81	100	3	Constant	81	482
15b-NB(M)	4.85	5	65	27	40	81	Many	27	452
19-NB(M)	5.25	5.4	65	27	40	81	Occasional	9	434
6-NB	2.9	3.05	55	27	40	81	Occasional	9	416
20-NB	5.4	5.6	65	27	40	81	Occasional	9	416
22-SB	5.3	5.45	>100	81	100	3	Occasional	9	415
7-SB(M)	2.95	3.1	45	9	40	81	Occasional	9	403

# Geologic Evaluations:





# Geologic Evaluations:

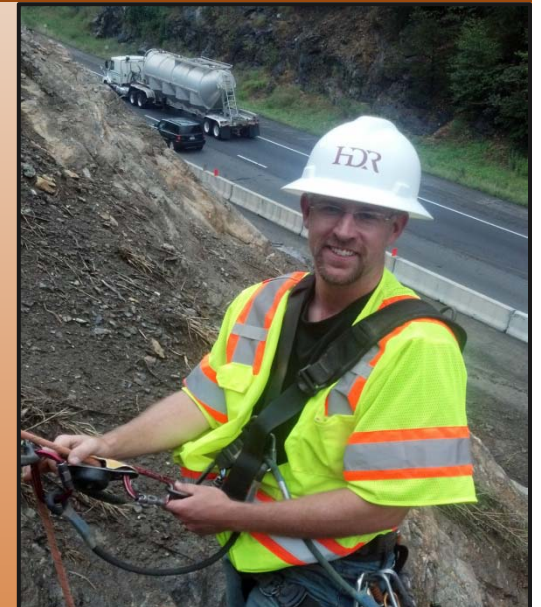




# Geologic Evaluations :

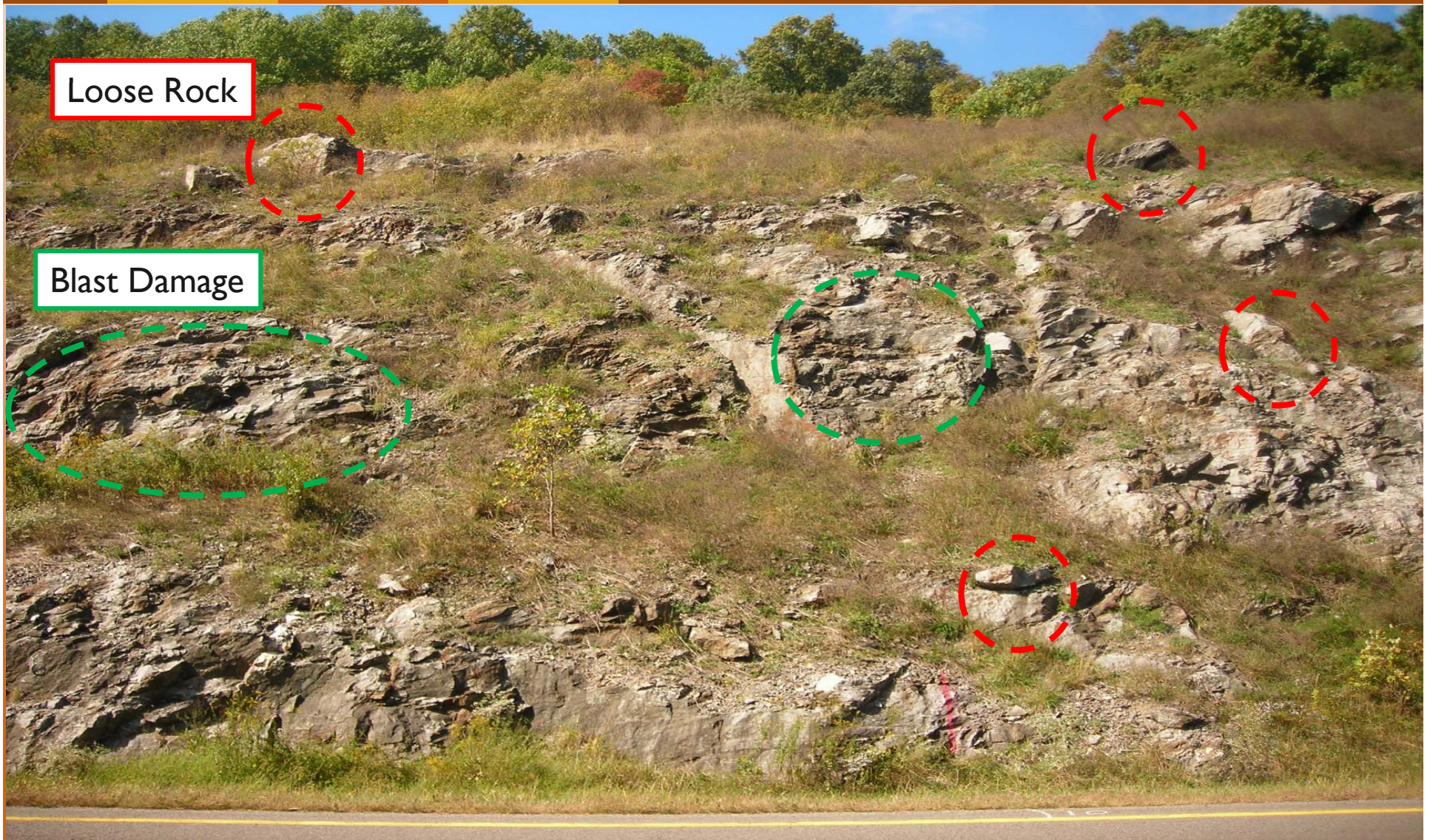
## Approach

- Establish Baseline
- Document Cut Slope Conditions
- Discontinuity Measurements
- Kinematic Analysis
- Develop Priority Slope Sections
- Develop Remediation Options





# Geologic Evaluation: I-77 NB Median MP 3.6 to 3.9



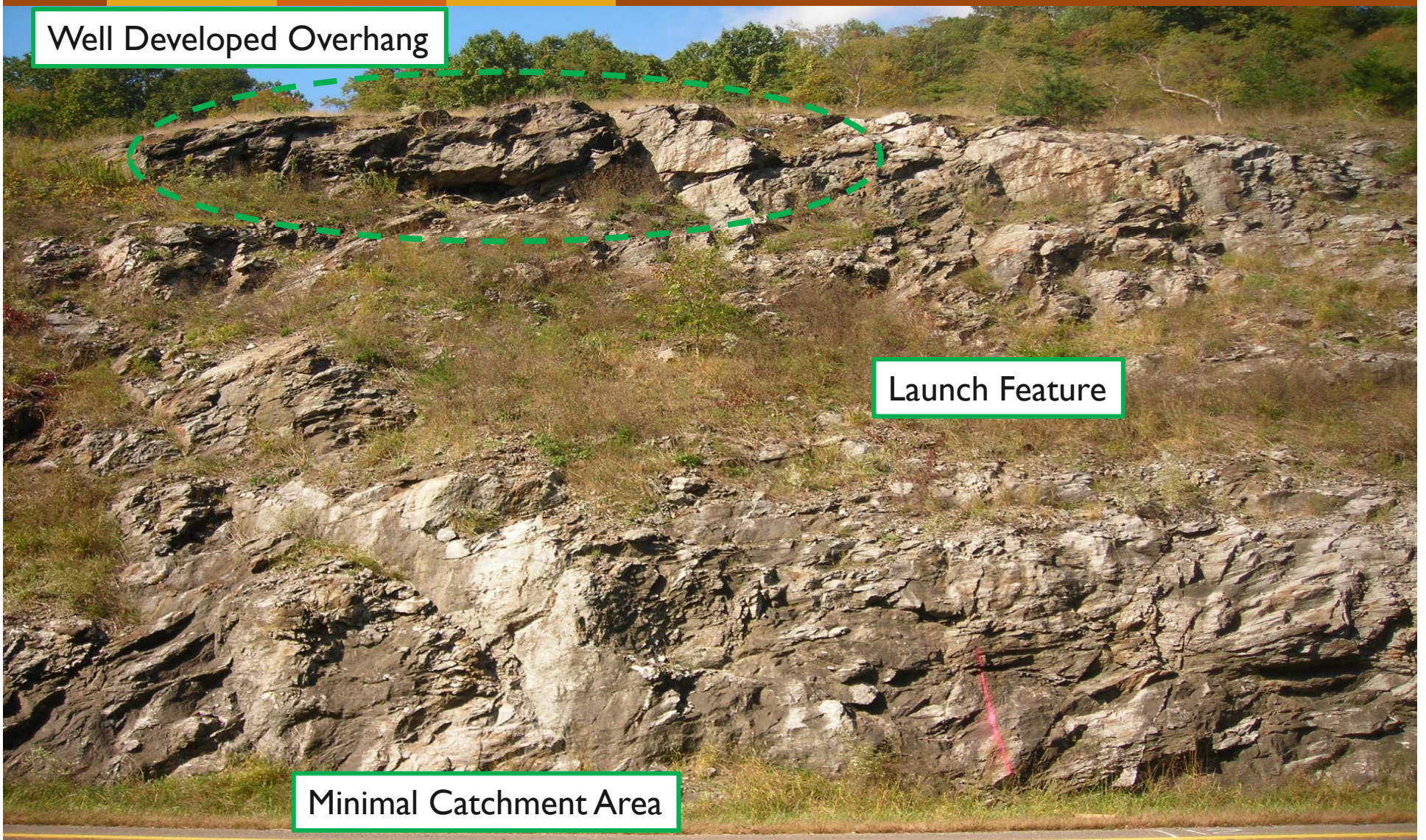


# Geologic Evaluation: I-77 NB Median MP 3.6 to 3.9

Well Developed Overhang

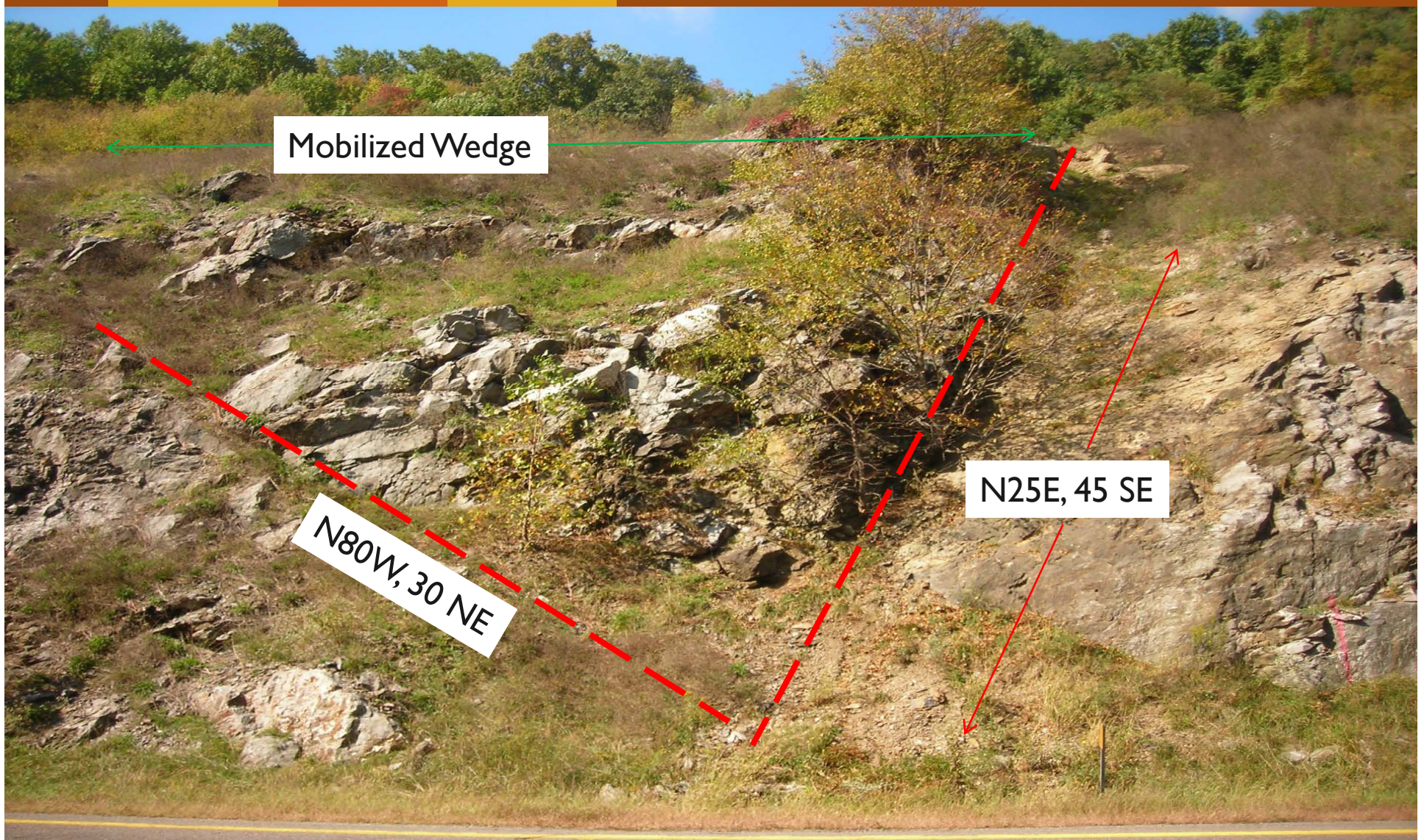
Launch Feature

Minimal Catchment Area





# Geologic Evaluation: I-77 NB Median MP 3.6 to 3.9



Mobilized Wedge

N80W, 30 NE

N25E, 45 SE



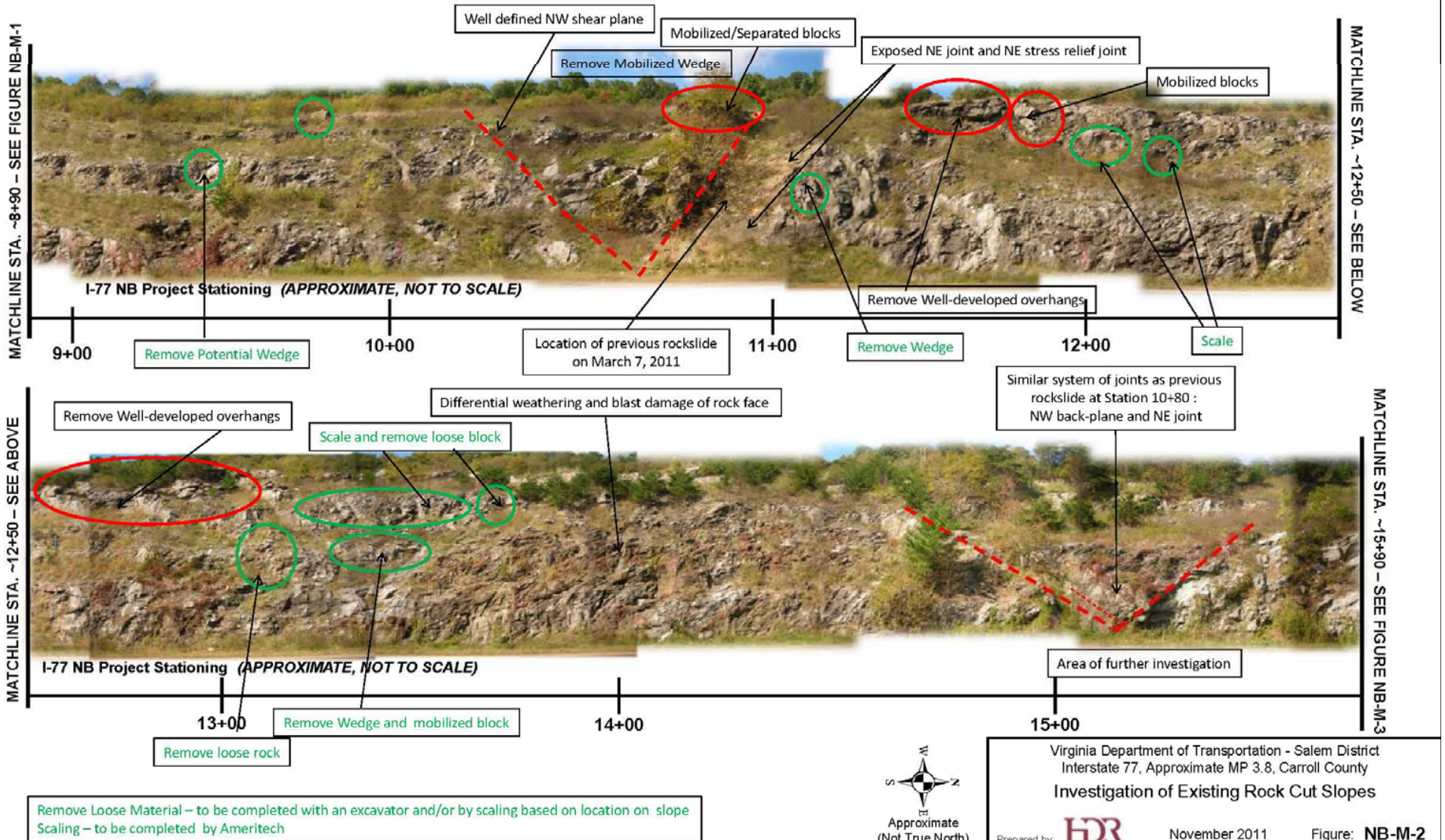
# Geologic Evaluation: I-77 NB Median MP 3.6 to 3.9





# Geologic Evaluations: I-77 NB Median MP 3.6 to 3.9

## I-77 NB – Median Slope





# Slope Remediation : I-77 NB Median MP 3.6 to 3.9

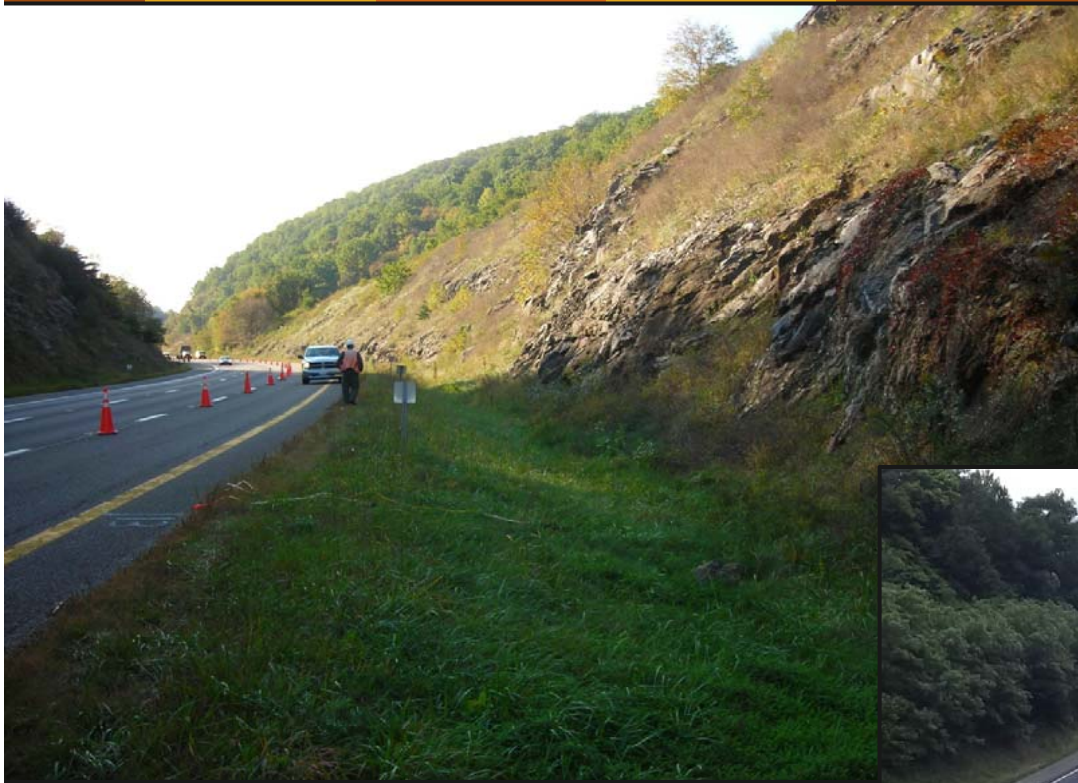
## Emergency Response Team

### Scope of Work:

- Scale approximately 1200 LF of Slope
- Remove Well Developed Overhangs
- Remove Well Developed Wedges
- Estimated Schedule : 30 to 90 days
- Construction Started on 5/29/2012



# Slope Remediation : I-77 NB Median Site Access





# Slope Remediation : I-77 NB Median Maintenance and Protection of Traffic





# Scaling within Wedge





# Scaling Around Overhangs





# Scaling Around Overhangs





# Rock Overhang





# Rock Overhang Blasting





# Rock Removal After Blast





# After Blast & Clean Up



07.17.2012 15:54



# Large Wedge Removal





# Wedge Removal Begins: 7/13/2012





# After 1<sup>st</sup> Blast within Wedge





# Layout of 2<sup>nd</sup> Blast





# After 2<sup>nd</sup> Blast



07.19.2012 14:23



# Change in Plan





# Excavation of Fill Continues





# Top and Bottom Approach





# From the bottom





# After the Wedge Blast





# Mechanical Removal Below





# The planes come together





# Project Stats

- Project completed on 8/29/2012
- Approximately 3 months to complete
- Approximate 7,500 CY of Rock
- No accidents and minimal impacts to traffic
- Approximate Cost 1.75 Million





# Conclusions and A Look Ahead

I-77 Corridor

Corridor Challenges

I-77 Rock Slope  
Management Program

RHRS

Detailed Geologic  
Evaluations

Slope Remediation

Conclusions and a Look Ahead





# Conclusions



## VDOT Rock Slope Management Program: 3 Step Process

1. RHRS
2. Detailed Geologic Evaluation
3. Slope Remediation

### Advantages:

- RHRS - Baseline
- Value of Geologic Evaluations
- Aids in Prioritization of Slopes
- Supports Emergency Response Remediation

# A Look Ahead



## I-77 VDOT Rock Slope Management Program

- **28 High Hazard Slopes (RHRS Rating >300)**
- **More Detailed Geologic Evaluation**
- **Development of Contract Bid Documents**
- **Contract Advertisements for Future Slope Remediation Projects**



# Acknowledgements



- Allen William, PE – District Maintenance Engineer, Salem District
- Ray Varney, PE – District Infrastructure Engineer, Salem District
- Robin Keeler – Contract Coordinator, Salem District



- Malcolm Schaeffer, PG – Professional Associate & Engineering Geologist
- Jim Sheahan, PE – National Director of Geotechnical Engineering



- Jeff Boon – President of Ameritech Slope Constructors
- Bob Forbes – Vice President of Ameritech Slope Constructors



- Stacy Edmonds – Inspector

# Clearing the Fog on the Aging I-77 Rock Slopes



**Thank You**