Evaluating Rock Fall Hazards for the US 460 Connector Project, Southwestern Virginia

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Objectives of Presentation

- Describe the project
  - US 460 Connector – Phase I Project
- Discuss local rock slope performance
  - Nearby cut slopes in the same formations
- Give some examples
  - Stratigraphy and rock source zones
  - Bench configurations and accumulation
  - Roadway cut slopes
  - Construction slopes for bridge piers

US 460 Connector – Phase I

- Twin high-level structures (~1,600 feet long)
- Mainline four-lane divided highway (~4,800 feet long)
- Two-lane connector road to Route 80
- Project Partners
  - VDOT
  - Bizzack/ENTRAN
  - MACTEC

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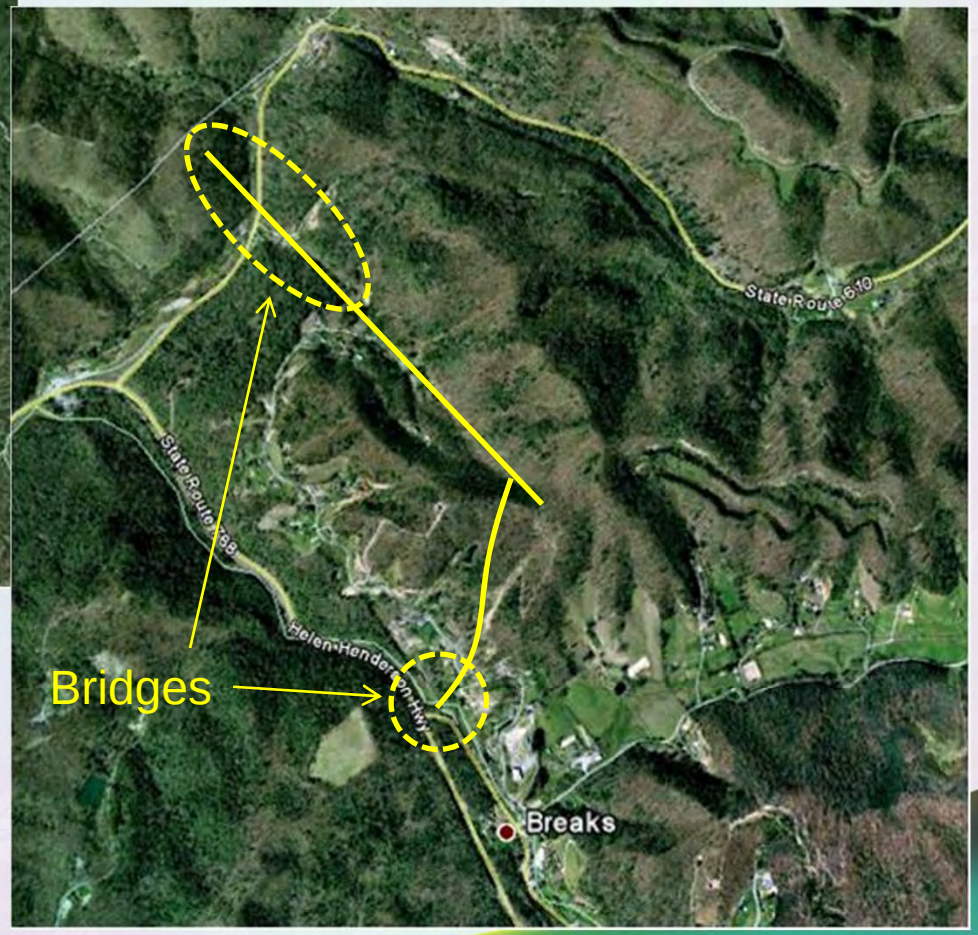
US 460 Connector



-Design-Build
-Cut slopes up to 150 ft high
-2.7 million yards of fill
-Grassy Creek Bridge – 250 ft tall
(tallest in the Commonwealth)

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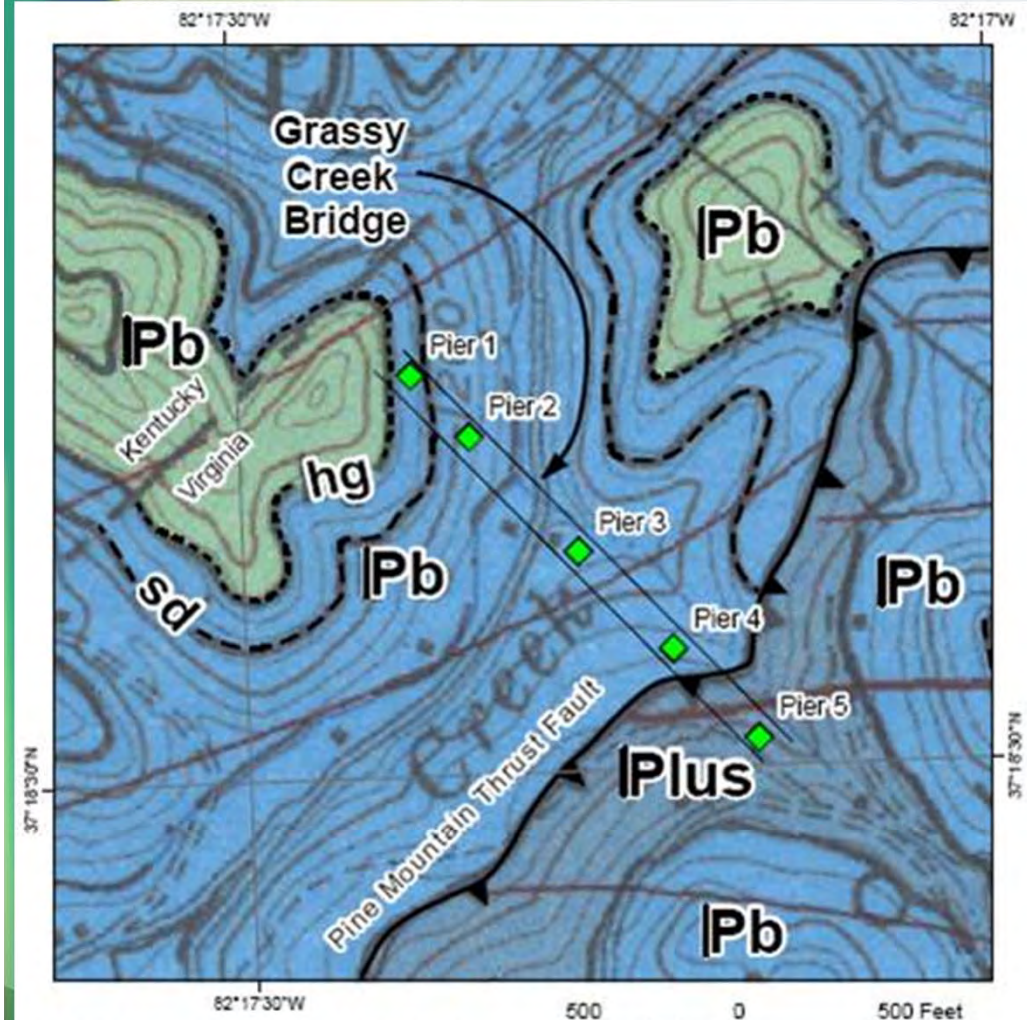
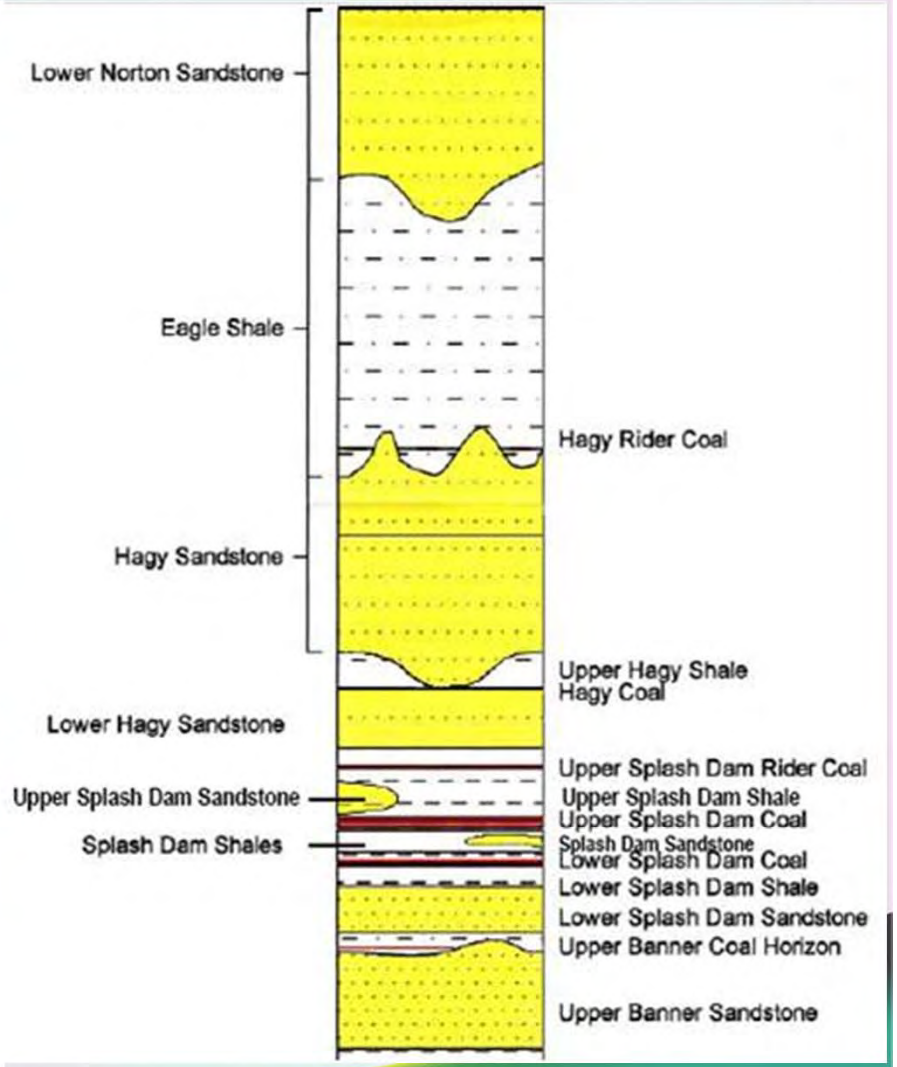
US 460 Connector



Source: Elkhorn City Geologic Quadrangle, Kentucky Geological Survey (p59_gq.sid). Projection: NAD 83 Kentucky State Plane Single Zone, US Feet



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Nearby Slope Performance

Rte 460 Buchanan County VA / Grundy

Nearby Slope Performance

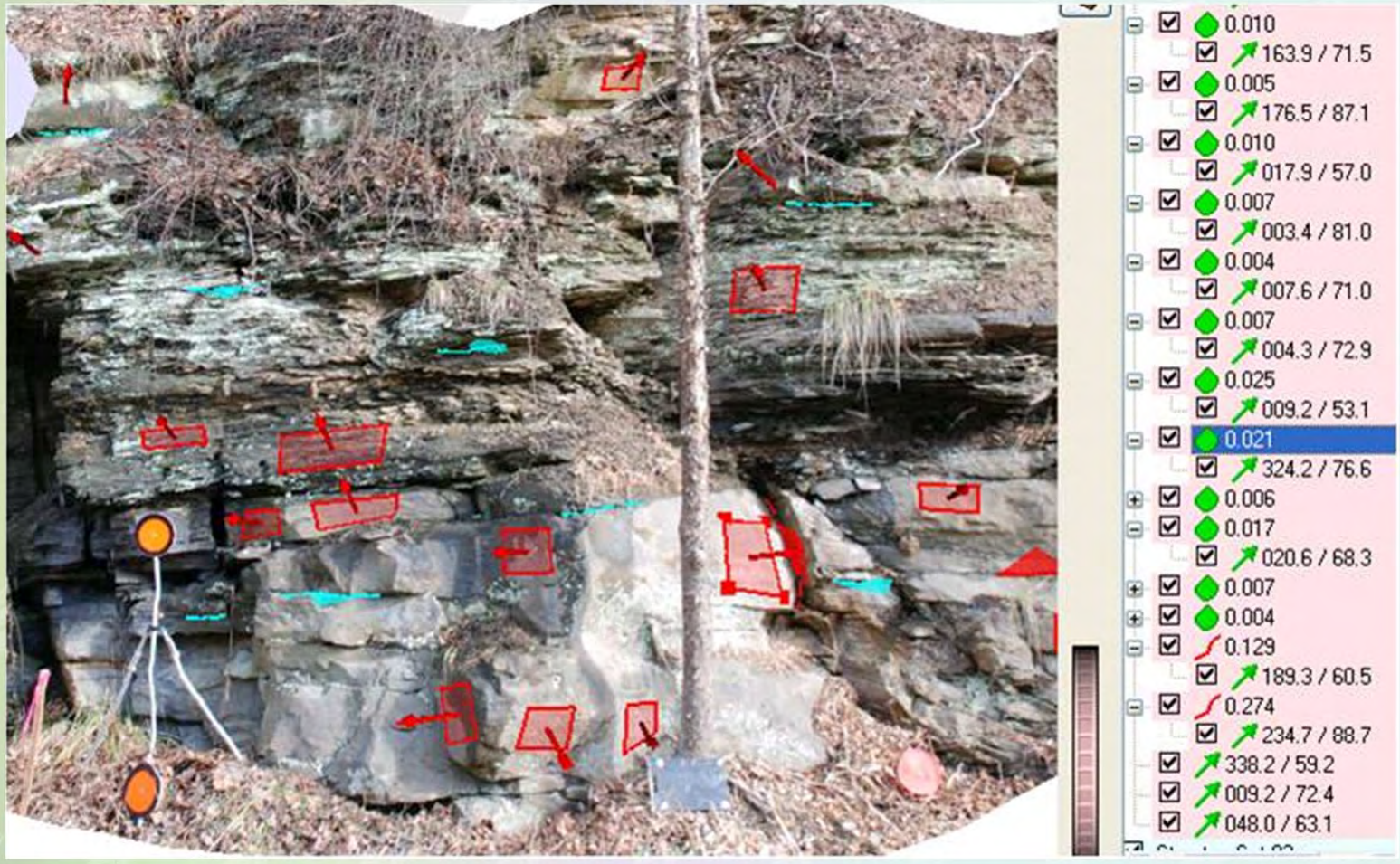
Rte 460 Phase I Cuts

Nearby Slope Performance

Rte 460 Vansant Cuts

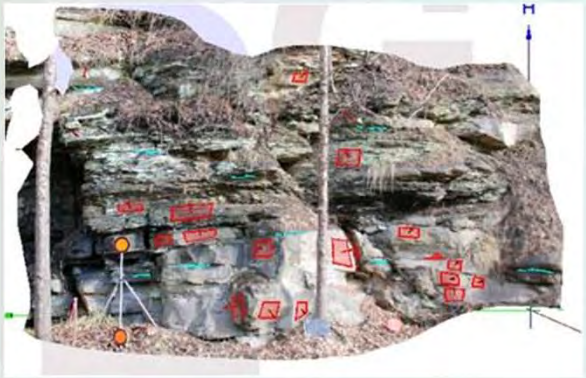
1994 1997

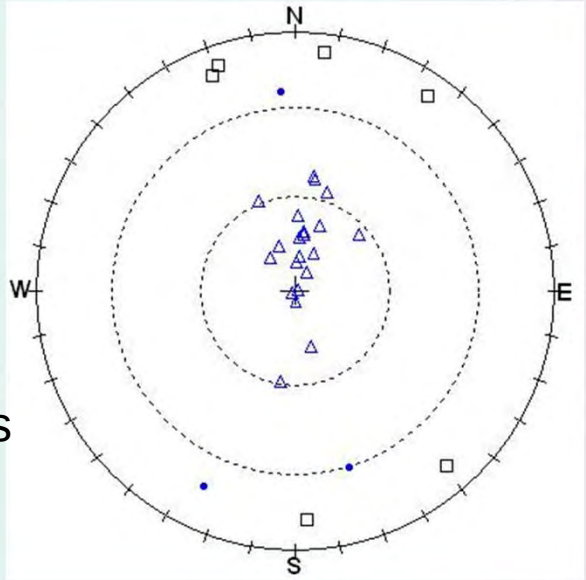
US 460 Connector Examples



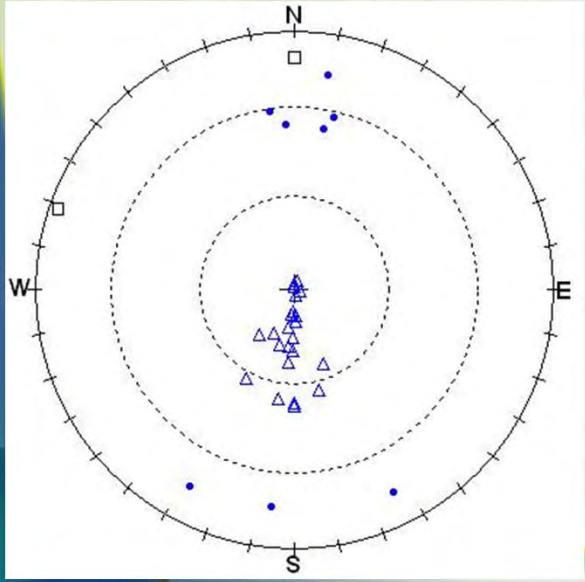
3GSM ShapeMetrix3D Model

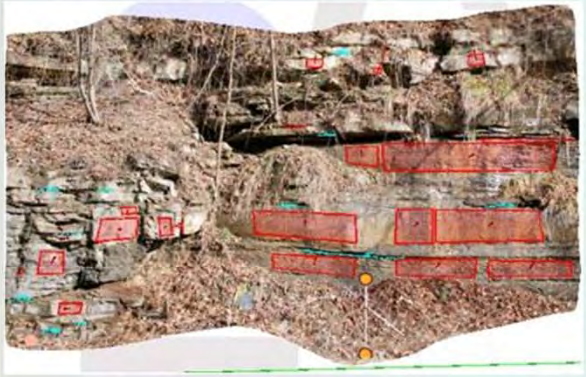
US 460 Connector Examples



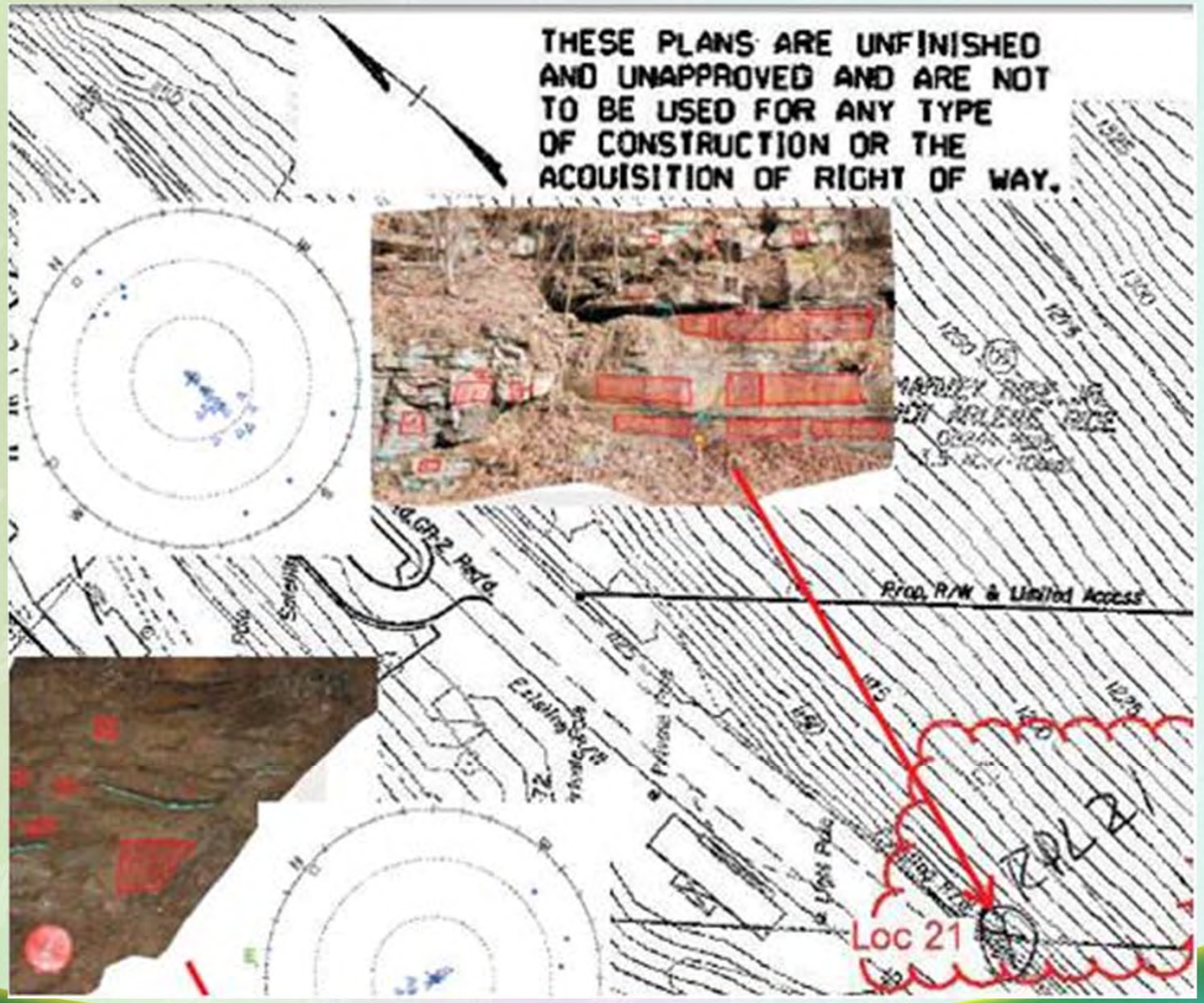


3GSM ShapeMetrix3D Models
RockPack III Dip Vector Plots

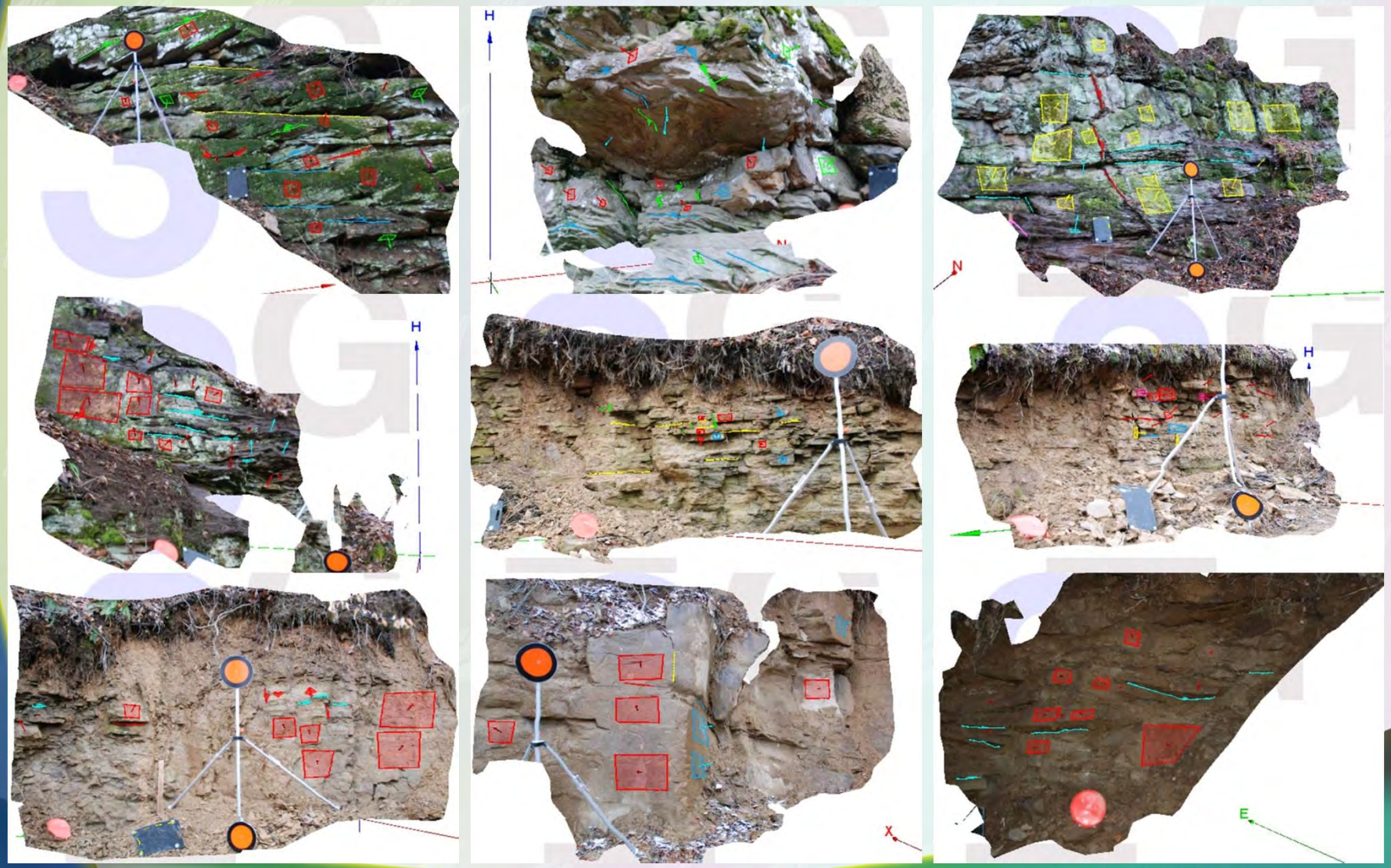




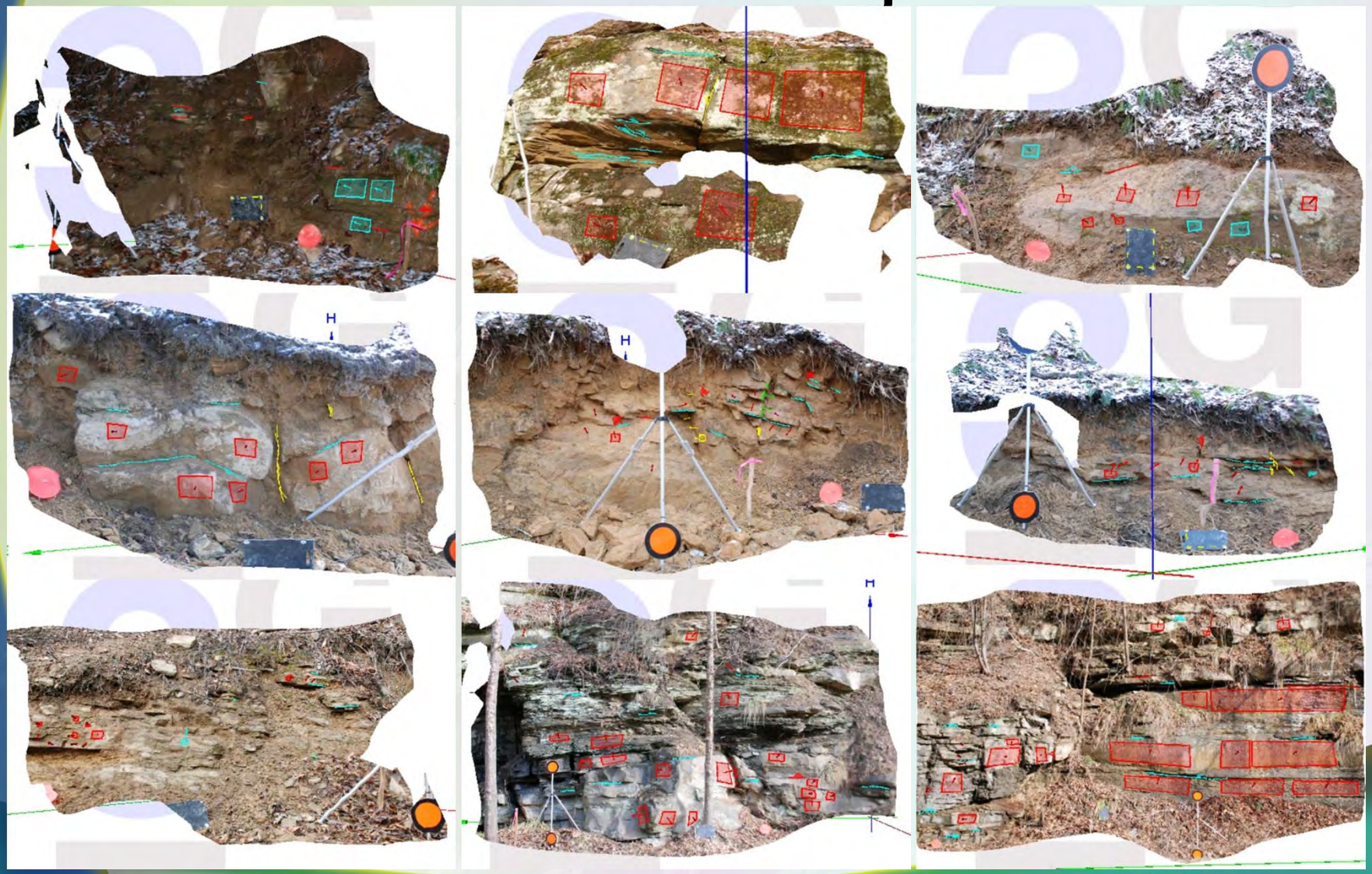
US 460 Examples



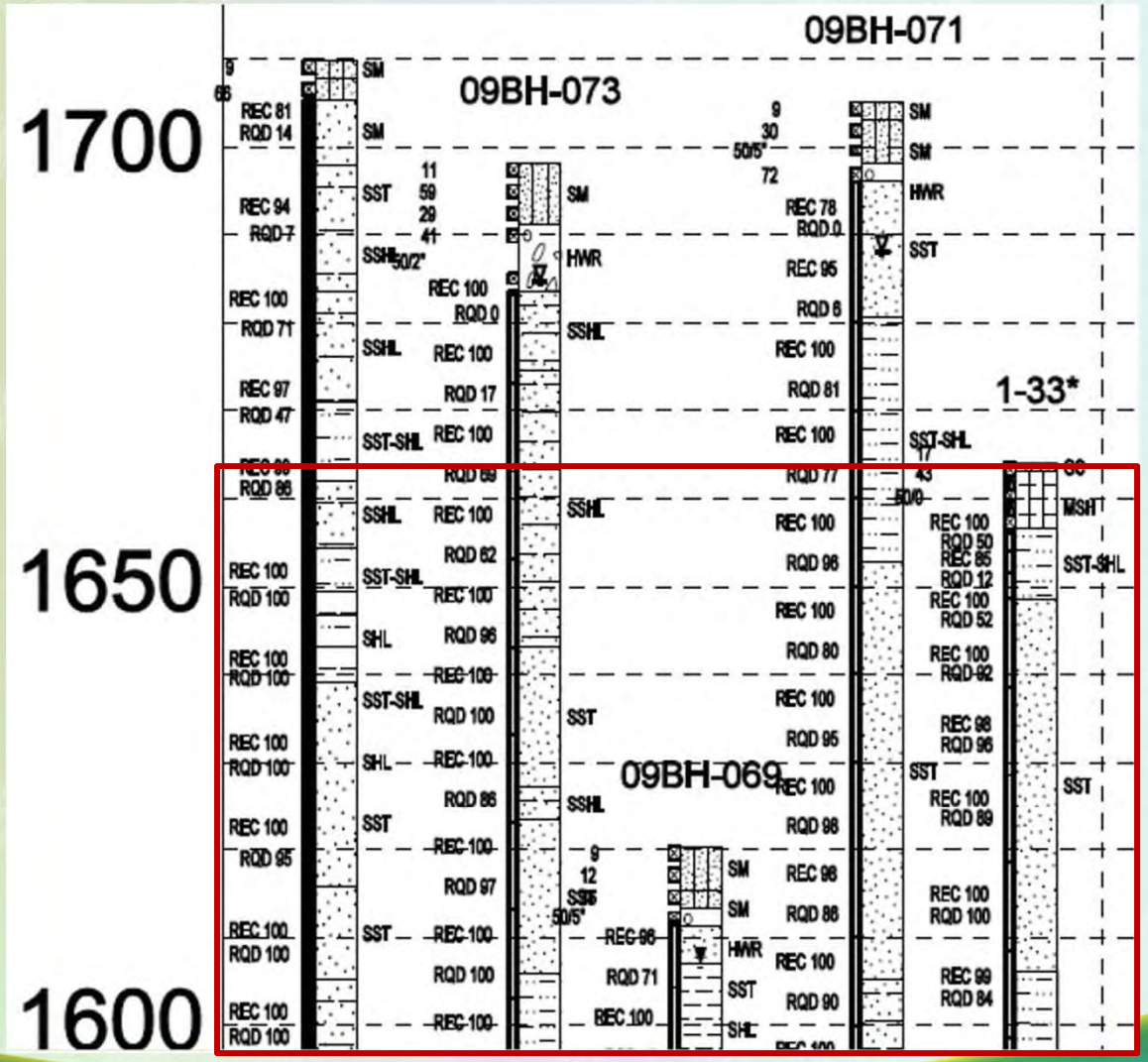
US 460 Examples



US 460 Examples



Stratigraphy and Rock Quality



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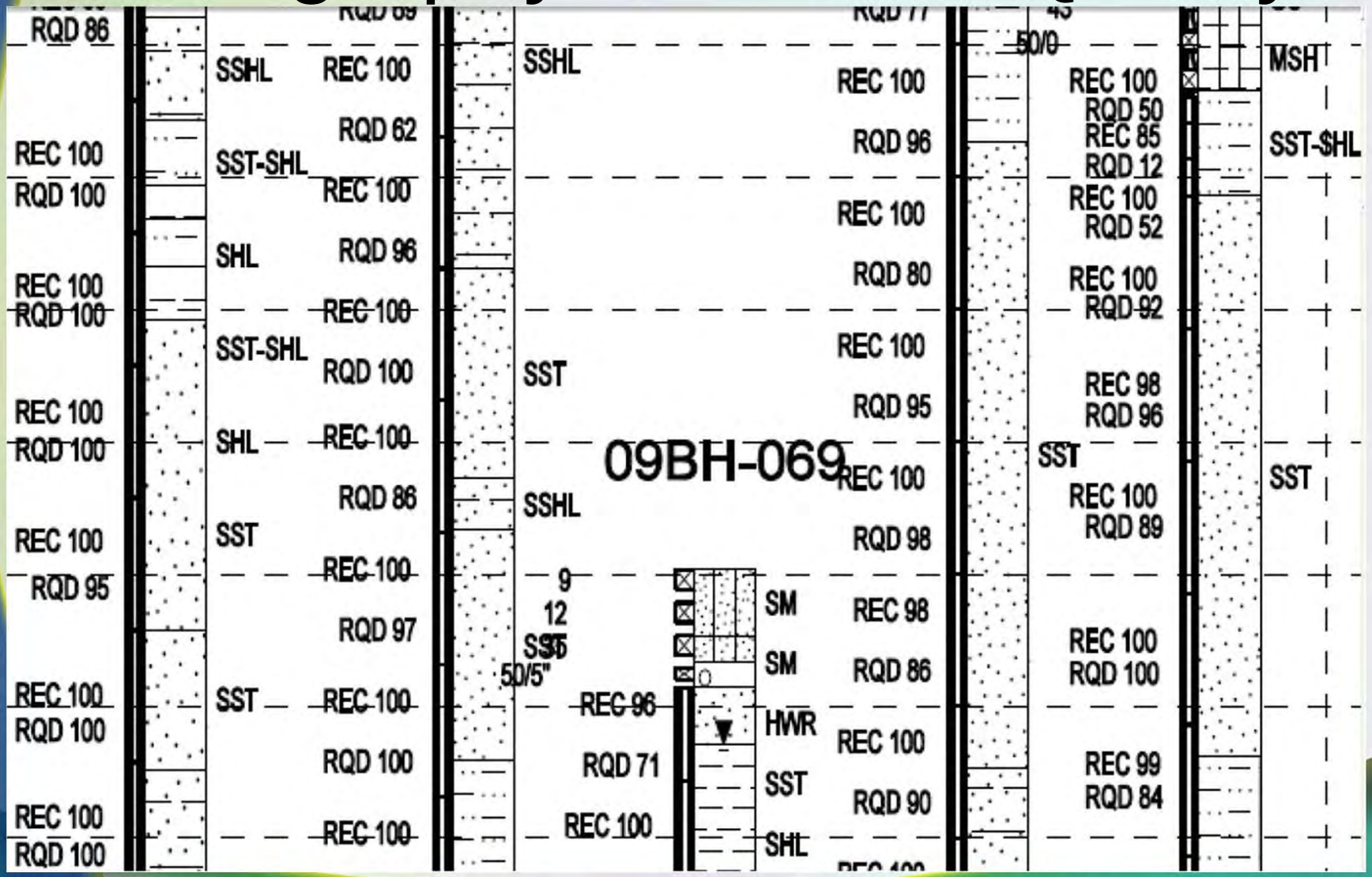

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Rock Structure Conclusions

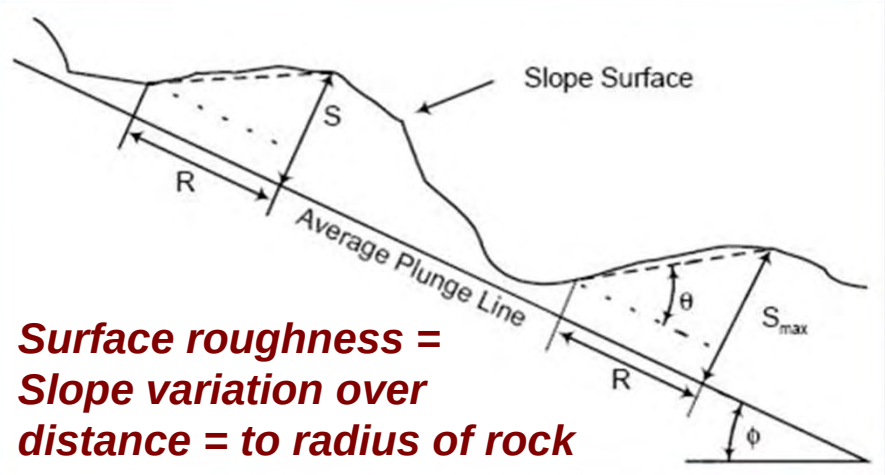
- Nearby rock cuts perform well
- Sandstone includes cross bedding and cut-and-fill structures
- Joints are short or discontinuous
- Rock mass properties control slope stability
- Sandstone formations produce a few rocks
- Falling rock dimensions ~ 1 ft x 1/3 ft

CRSP Model

- Design cut slope with benches
- Coefficients
  - Roughness
  - Tangential
  - Normal
- Analysis points
  - Intermediate
  - Crest of bench above pavement
  - Edge of pavement

CRSP Model

- Coefficients
  - Roughness
  - Tangential
  - Normal



Surface roughness = Slope variation over distance = to radius of rock

Description of Slope	Tangential Co-efficient (R_t)	Remarks	Normal Coef-ficient (R_n)	Remarks
Smooth hard surfaces and paving	0.90 – 1.0	-R_t is not very sensitive com-pared to R_n, but may be im-portant for hard or signifi-cantly vegetated slopes -Use lower R_t as the density of vegetation on the slope in-creases.	0.60 – 1.0	-For short slopes try lower val-ues in applicable range. -If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range.
Most bedrock and boulder fields	0.75 – 0.95		0.15 – 0.30	
Talus and firm soil slopes	0.65 - 0.95		0.12 – 0.20	
Soft soil slopes*	0.50 - 0.80		0.10 - 0.20	

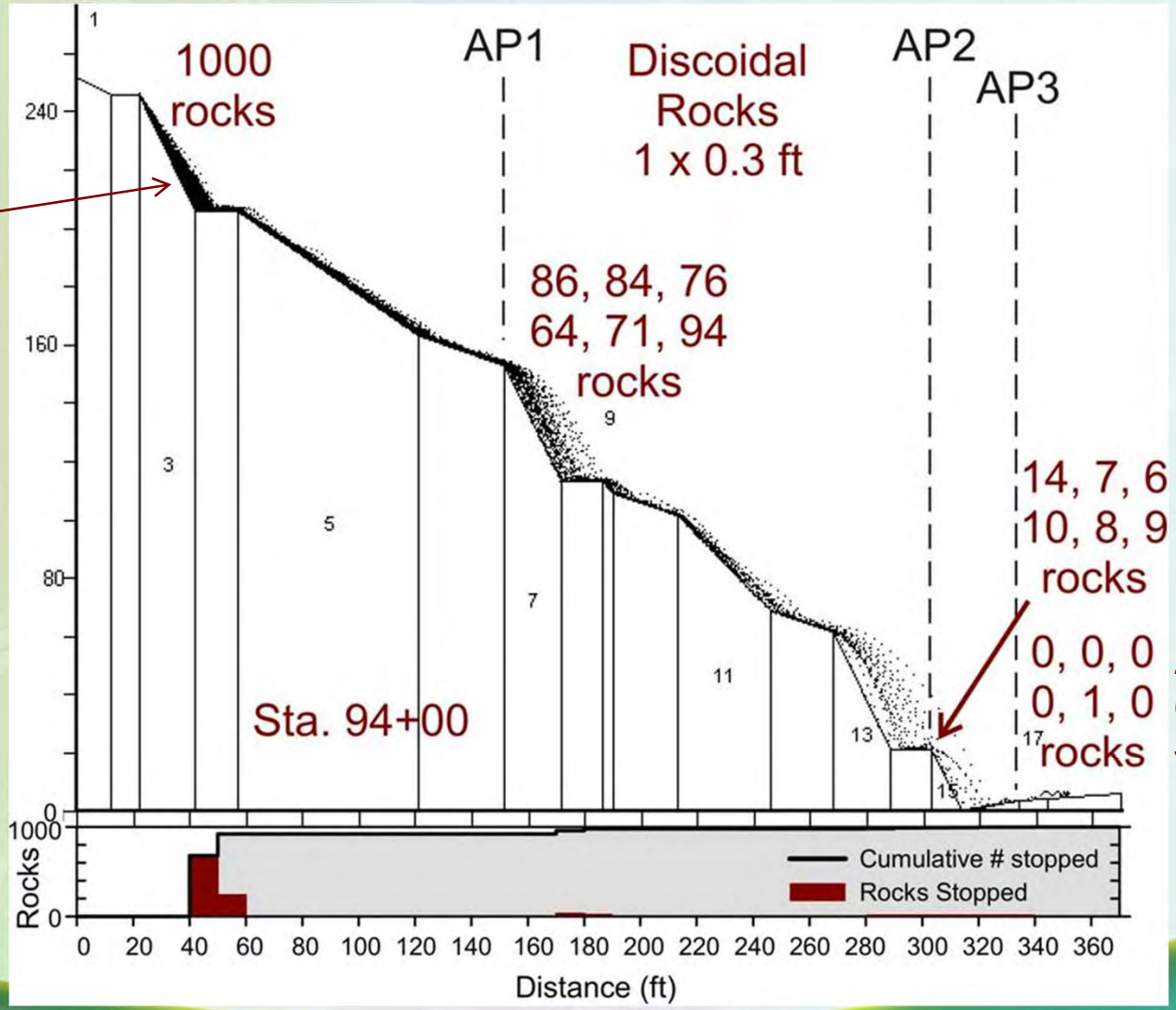
CRSP Model

- Coefficients

Cell	Rock Type	Surface Roughness	Tangential Coefficient	Normal Coefficient
1	Siltstone	0.5	0.65	0.2
2	Bench	0.5	0.9	0.25
3	Sandstone	0.5	0.9	0.25
4	Bench	0.5	0.8	0.2
5	Siltstone	0.5	0.8	0.2
6	Shale	0.25	0.7	0.2
7	Sandstone	0.5	0.85	0.25
8	Bench	0.5	0.85	0.25
9	Siltstone	0.5	0.85	0.25
10	Shale	0.25	0.7	0.2
11	Siltstone	0.5	0.85	0.25
12	Shale	0.25	0.7	0.2
13	Sandstone	0.5	0.9	0.2
14	Bench	0.5	0.85	0.25
15	Siltstone	0.5	0.85	0.25
16	Siltstone	0.5	0.8	0.2
17	Pavement	0.25	1	1
18	Pavement	0.25	1	1

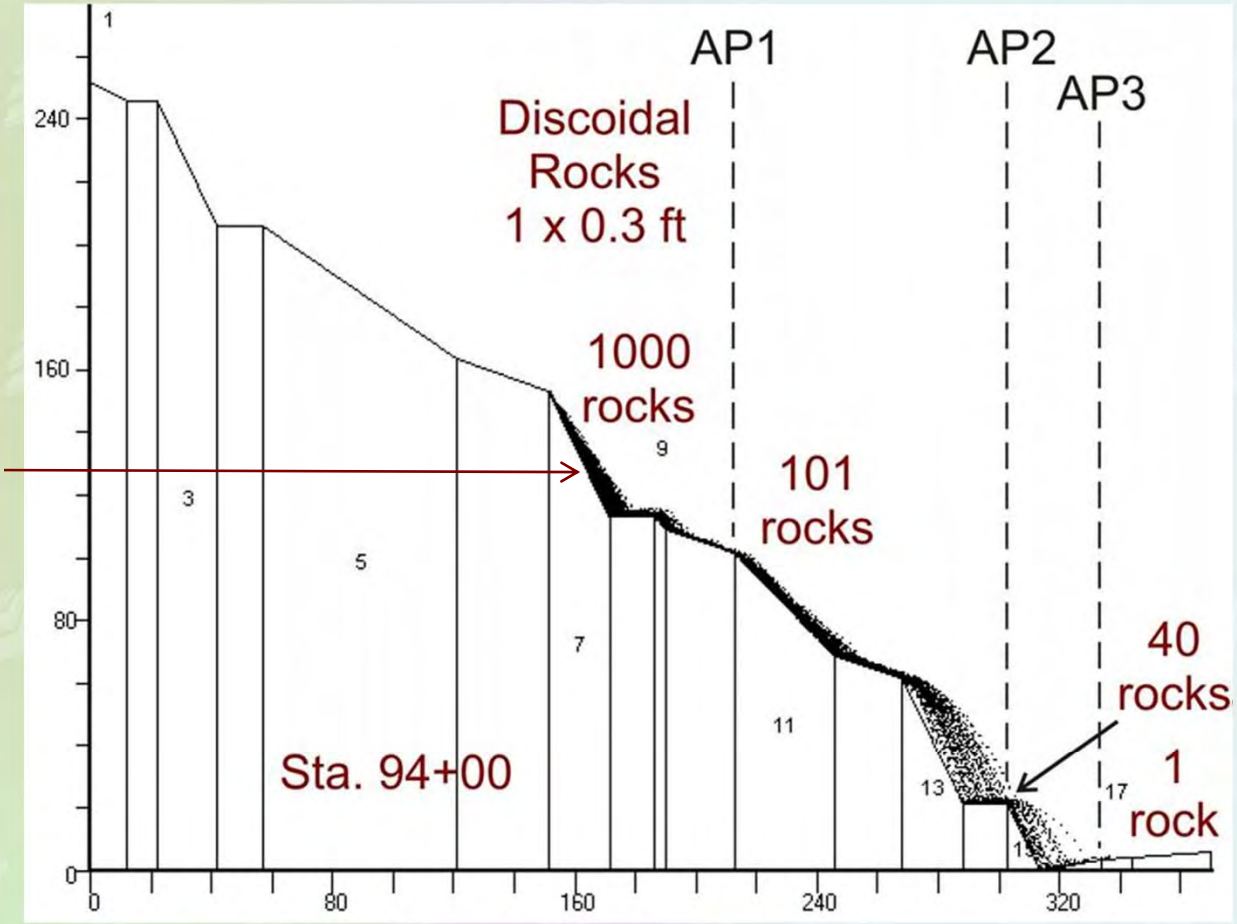
CRSP Results

Rock Source Zone



17.28 ft/s
0.2 ft bounce
Stopped in lane

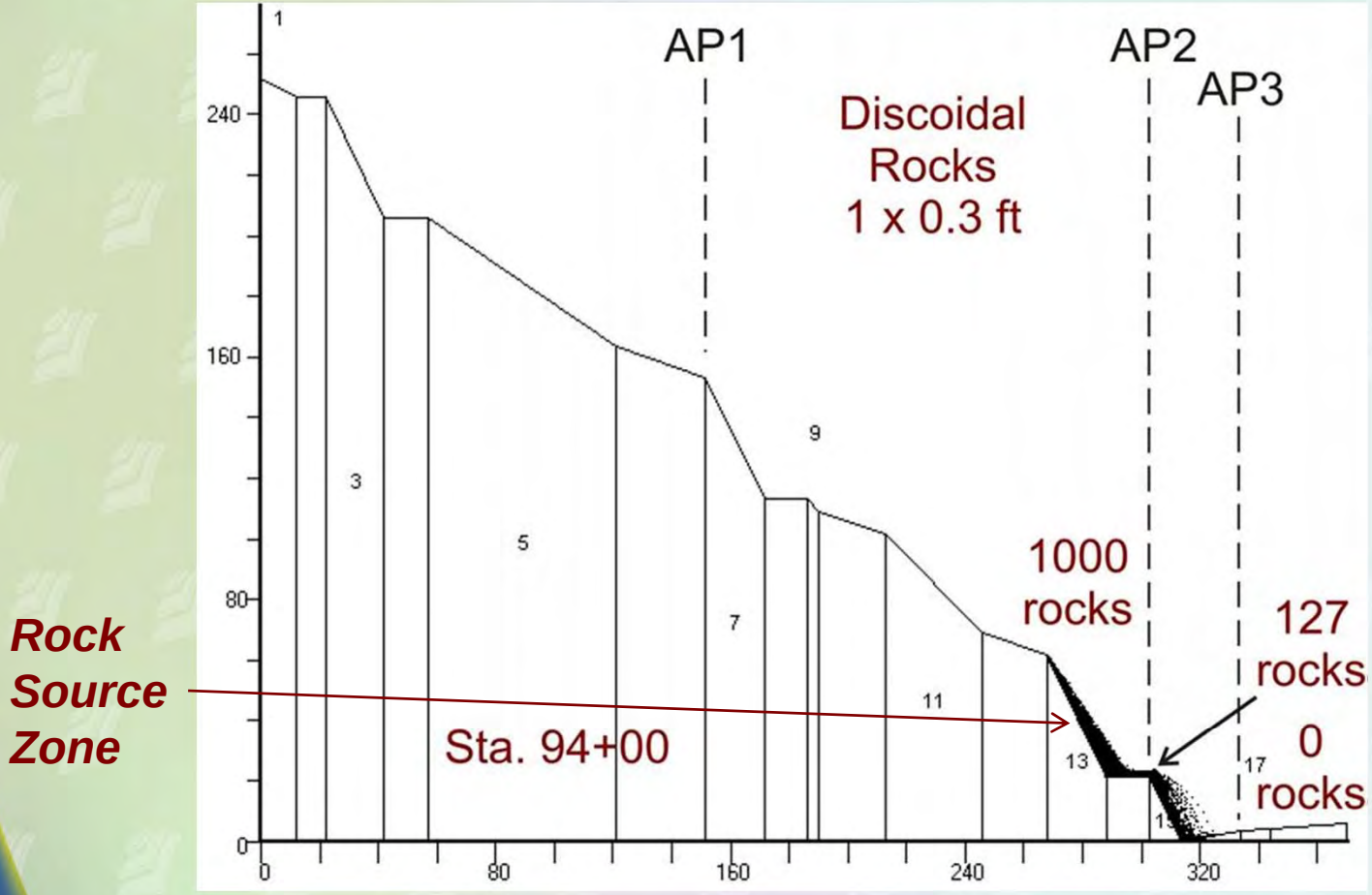
CRSP Results



Rock Source Zone

5.42 ft/s
0.3 ft bounce
Stopped in lane

CRSP Results



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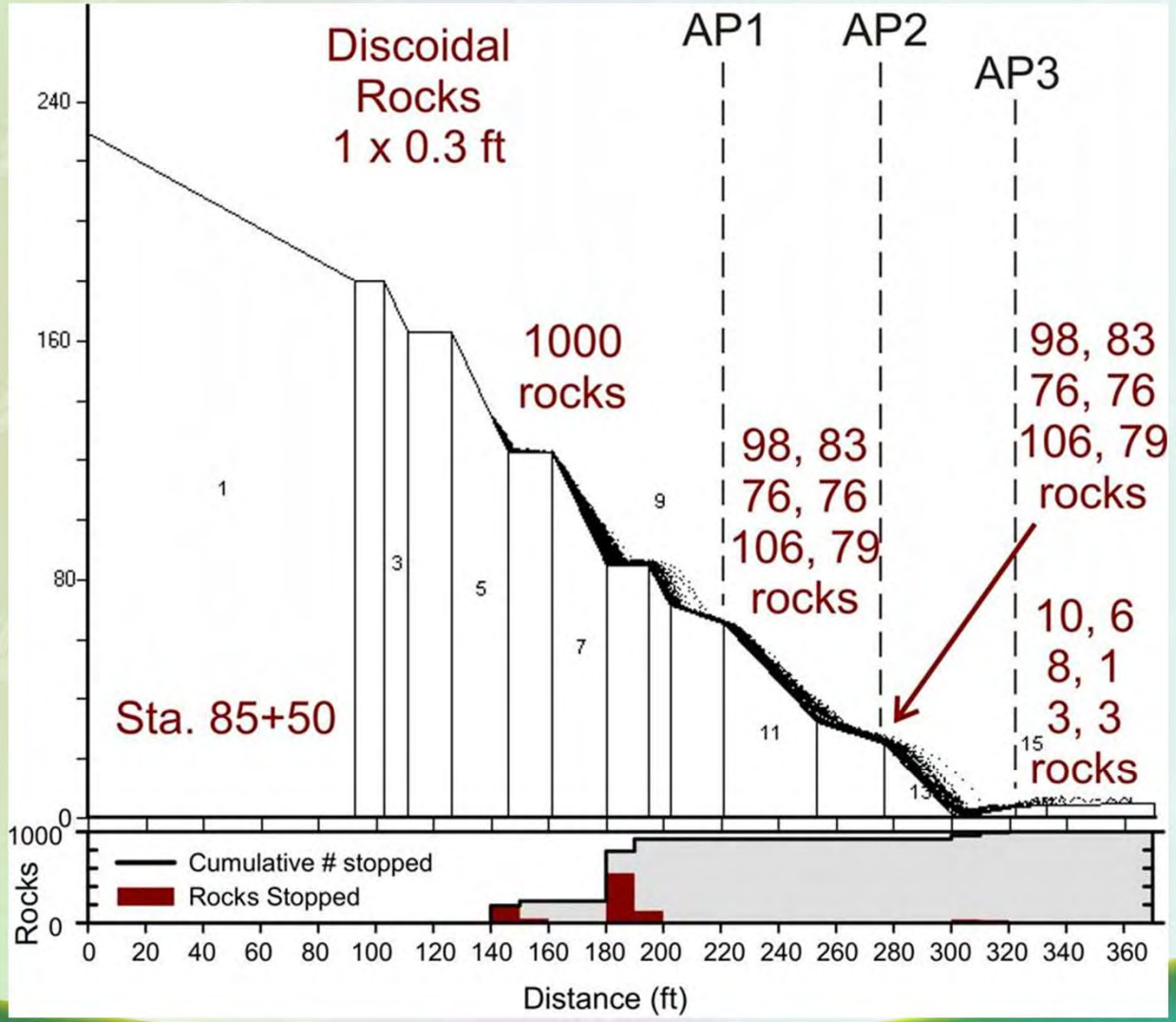
CRSP Results



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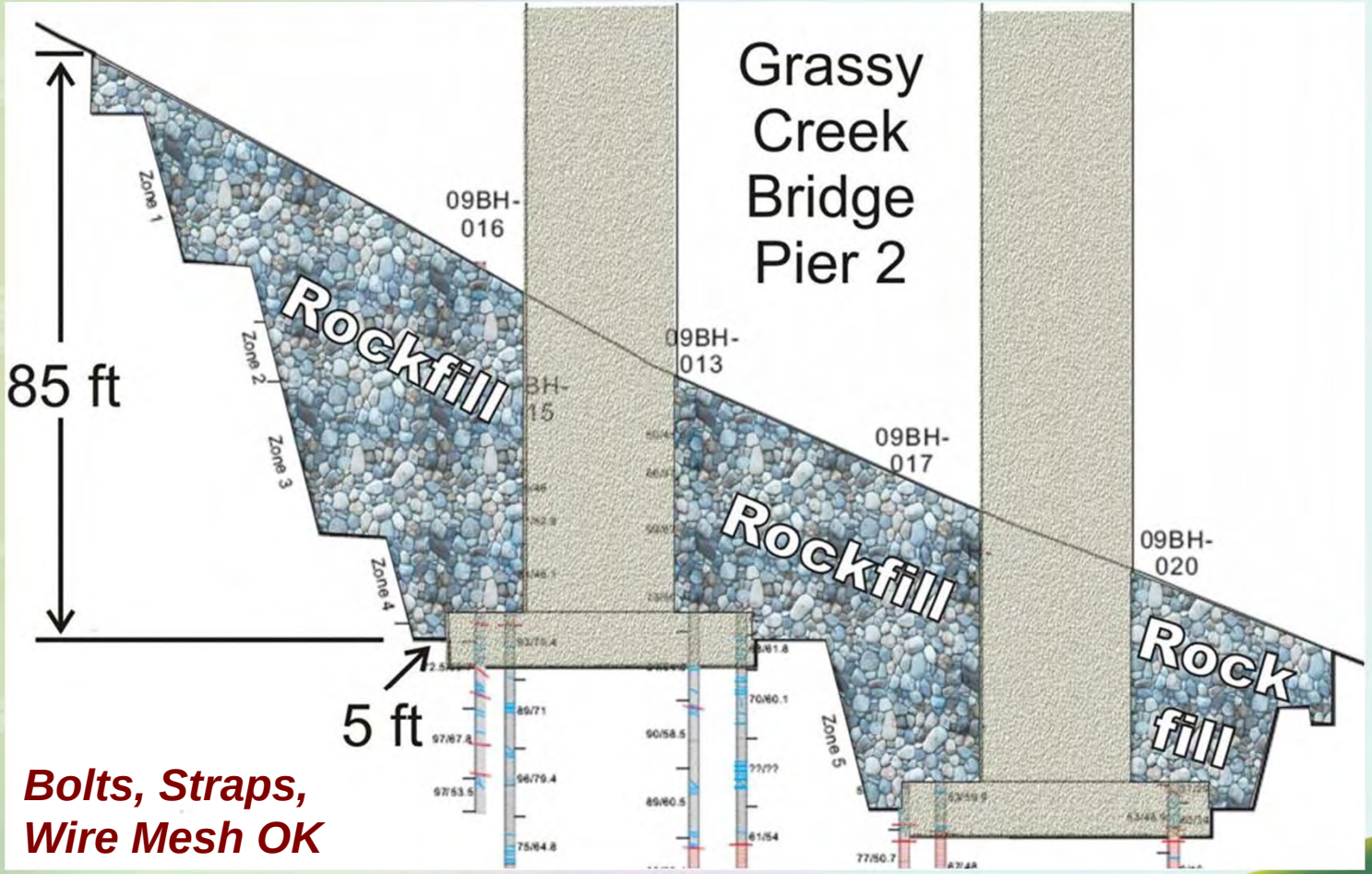
Temporary Cut Slopes



Bolts, Straps, Wire Mesh OK

Conclusions

- Nearby cut slopes perform well
- Sandstone formations produce small rocks
- Benches are effective (*no maintenance*)
- Other mitigation not permitted (wire mesh)
- Good blasting practices and thorough construction scaling are required
- Temporary cut slopes can use bolts, straps, and wire mesh

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