

# Rock slope remediation at the Penobscot Narrows Bridge

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**HALEY**  
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# Project team

***Owner:***

Maine Department of  
Transportation

**Geotechnical  
consultant:**

Haley & Aldrich, Inc.,  
Portland, ME

**General contractor:**

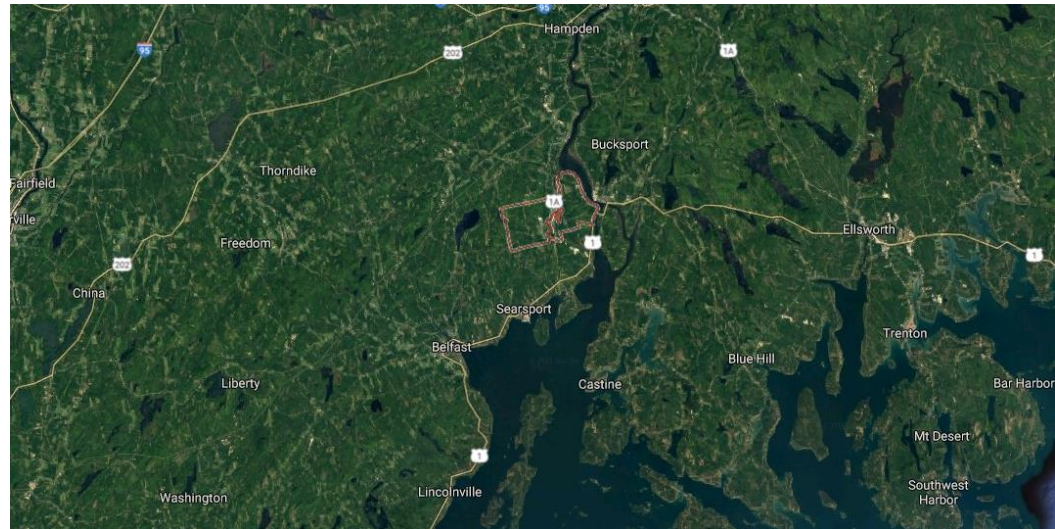
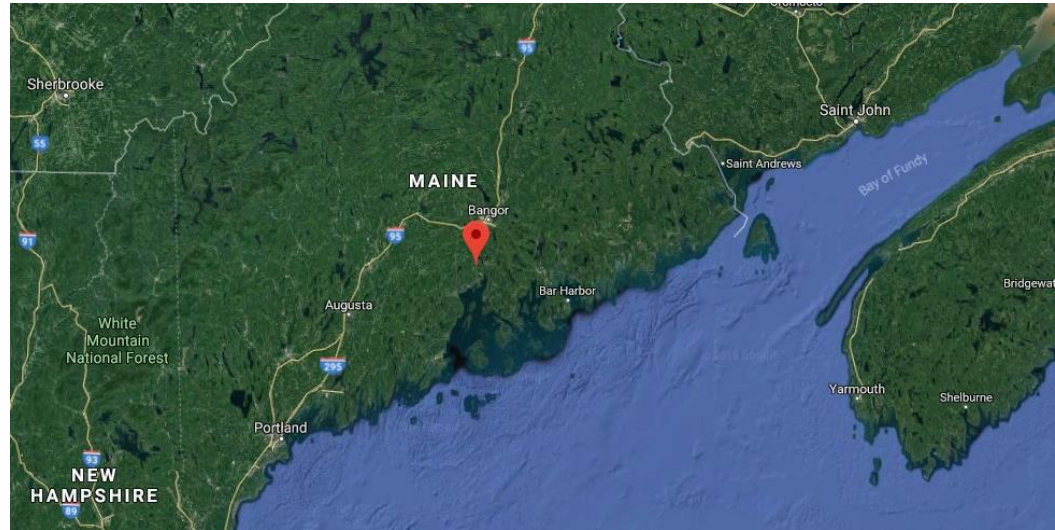
Lane Construction  
Corporation, Hermon,  
ME

**Rock slope contractor:**

APEX Rockfall  
Mitigation, Grand  
Junction, CO

# Site location

- Prospect, Maine
- Heavily travelled area of the mid-coast
- Midway between Camden and Bar Harbor
- Close proximity to Civil War era Fort Knox



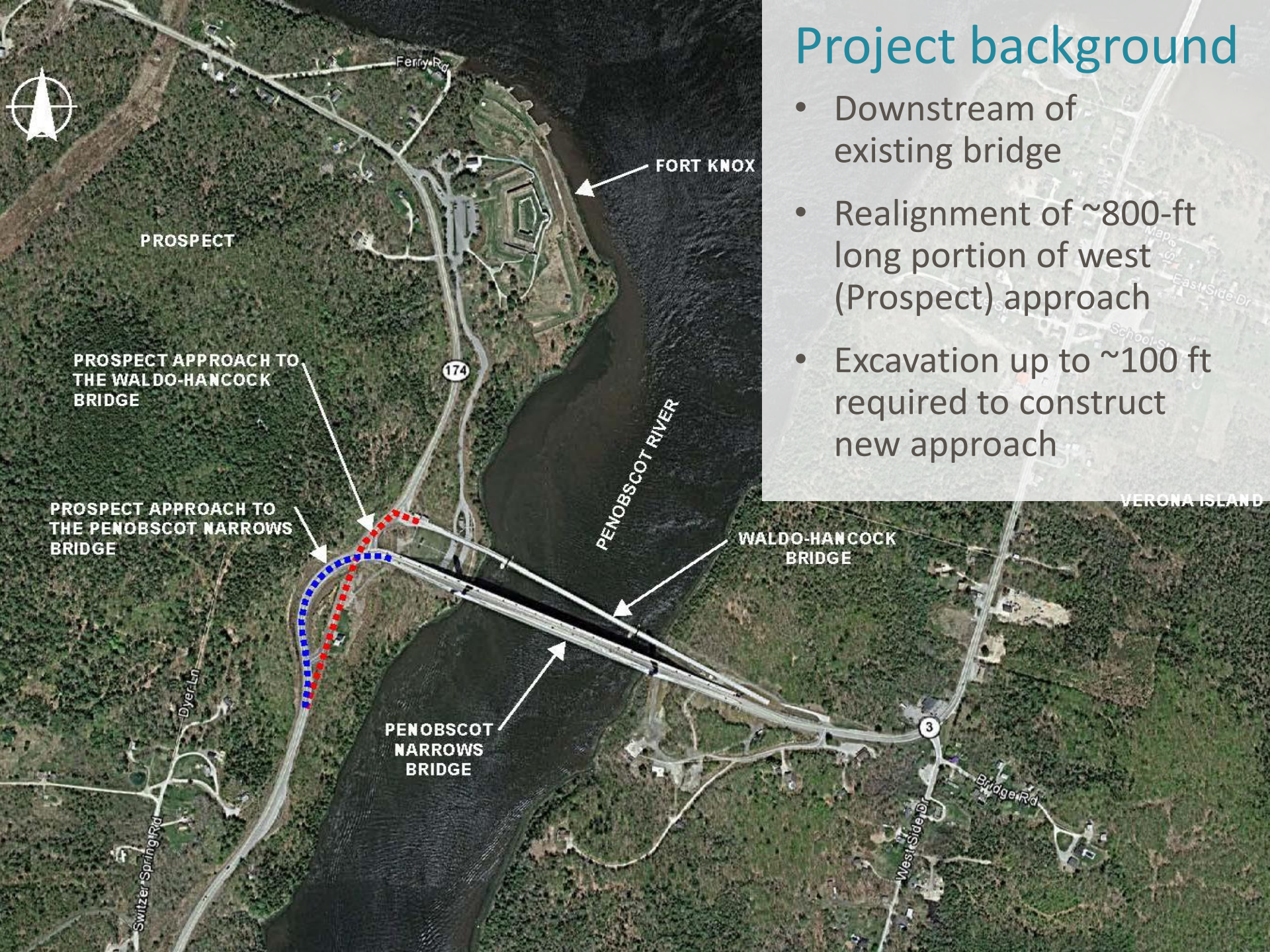
# Project background

- Waldo-Hancock Suspension Bridge constructed in 1931
- Main-span cable inspection completed in 2003
- Substantial deterioration
- Strengthen main-span cables and replace bridge

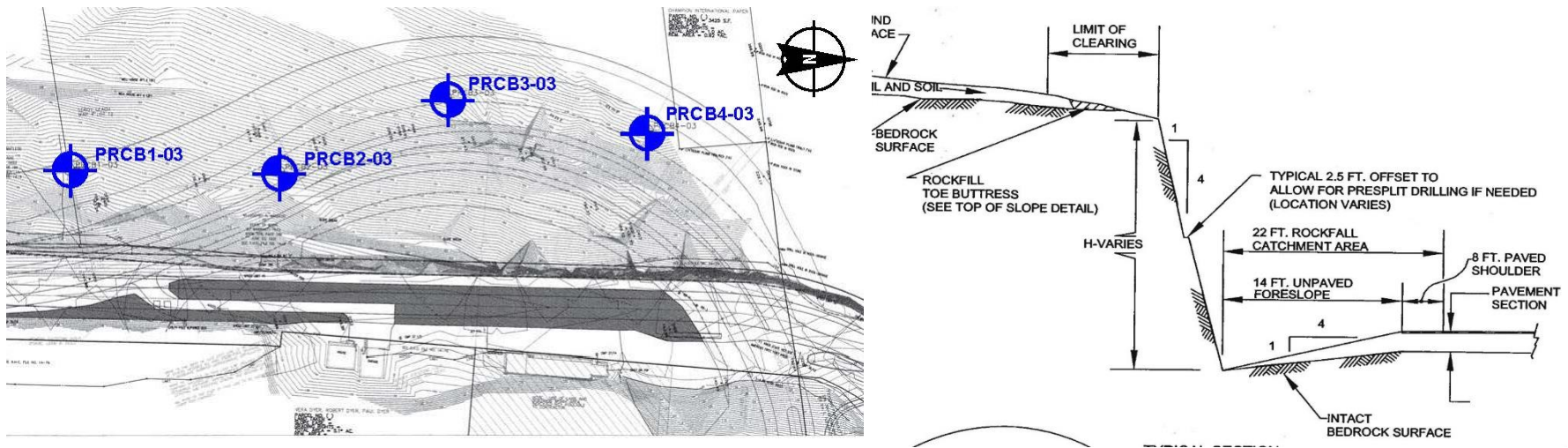


# Project background

- Downstream of existing bridge
- Realignment of ~800-ft long portion of west (Prospect) approach
- Excavation up to ~100 ft required to construct new approach



# Original investigation and rock slope design



- Test borings with bedrock core
- Rock mass and structural geologic property data collection from exposed outcrops
- Recommended 4V:1H rock slope inclination
- Potential for localized geologic features with adverse orientations that may not become apparent until excavation and may require stabilization/remediation
- Rockfall analyses used to establish catchment area geometry

# Original construction



- Began in late 2004/early 2005
- Multiple inspections and areas identified where stabilization/remediation was recommended; sketches, details and specifications prepared
- MaineDOT elected to not stabilize/remediate identified areas during construction
- Substantially complete by June 2005



# Recent rock slope assessment

- Previously identified areas re-evaluated by Haley & Aldrich in 2009 and 2012
- Sketches, details and specifications prepared for bidding and inclusion in Waldo-Hancock Bridge demolition contract
- MaineDOT elected to not stabilize/remediate identified areas
- Long-term maintenance and monitoring program developed



# Recent rock slope assessment

Funding secured in 2015: Stabilization/remediation of “moderately critical” and “most critical” areas included in Work Plan

Haley & Aldrich re-engaged with four main objectives:

- Observe current conditions and evaluate previous recommendations in identified areas
- Observe current conditions and develop design recommendations in areas not previously identified
- Identify areas where additional data collection is warranted to refine design recommendations
- Assign relative ratings to each area, prepare cost estimates and determine which areas could be stabilized/remediated with the allotted funds

# Recent rock slope assessment

- July (ground) and October (ropes) 2015 site inspections
- 23 areas identified as needing stabilization/remediation – 6 “most critical” and 5 “moderately critical”
- Stabilization/remediation design recommendations refined for “most critical” and “moderately critical” areas and one “slightly critical” area
- Cost estimate confirmed that work could be completed with available funds.



Area No. <sup>1</sup>	Approximate Location (Sta.)	Year Identified	Original Stabilization Recommendations	2015 Final Rating <sup>2</sup>	Preliminary Stabilization Recommendations <sup>3</sup>	Remediation in Initial Phase of Work <sup>4</sup>
1	360+50	2005-2009	Type B Rock Dowels	Red	2 Rock Dowels	Yes
1A		2015	NA	Yellow	NA	No
2	361+50	2005-2009	Type B Rock Dowels, Shotcrete, Shotcrete Rock Drains	Blue	NA	No
3	363+00	2005-2009	Type B Rock Dowels, Shotcrete, Shotcrete Rock Drains	Green	NA	No
4A	364+00	2005-2009	Type B Rock Dowels, Rock Drains	Red	2 Rock Dowels	Yes
4B			Type B Rock Dowels	Red	2 Rock Dowels	Yes
4C			Type B Rock Dowels	Red	3 Rock Dowels	No
5	365+00	2005-2009	Type A and B Rock Dowels, Wire Mesh	Red	Anchored Mesh, 32 rock dowels	Yes
5A			Type B Rock Dowels	Red	Check Scaling	Yes
6	365+50	2005-2009	Type B Rock Dowels	Red	Cable Lashing, 4 rock dowels	Yes
7	366+00	2005-2009	Type A Rock Dowels, Shotcrete, Shotcrete Rock Drains	Green	NA	No
8	366+50	2005-2009	Shotcrete, Shotcrete Rock Drains	S (Blue) N (Red)	NA	No
9	366+75	2005-2009	Type B Rock Dowels, Shotcrete, Shotcrete Rock Drains	Red	Scaling, 6 Rock Dowels	Yes
10	359+50 to 360+00	2005-2009	Wire Rope	Blue	1 Vertical Rock Dowel	Yes
11	358+75	2005-2009	NA	Green	NA	No
12	358+75	2012	NA	Blue	NA	No
13	359+75	2012	NA	Yellow	NA	No
14	364+50	2012	NA	Red	Check Scaling	Yes
15	364+50	2012	NA	Red	Check Scaling	Yes
16	364+50	2012	NA	Red	2 Vertical Rock Dowels, 4 Sub-Horizontal Rock Dowels	Yes
17	359+75	2015	NA	Green	NA	No
18	362+50	2015	NA	Green	NA	No
19	360+50	2015	NA	Blue	NA	No

**Legend:**

- "MOST CRITICAL"
- "MODERATELY CRITICAL"
- "MARGINALLY CRITICAL"
- "SLIGHTLY CRITICAL"
- "LEAST CRITICAL"

# Recent stabilization/ remediation design

- Rock slope scaling and vegetation removal
- Passive rock dowels
- Anchored wire mesh netting
- Wire rope cable lashing



# Construction: Scaling and vegetation removal

- Entire rock slope was scaled
- Three areas (5A, 14 and 15) “check” scaled and no further stabilization/remediation was required
- Work completed at night
- Work zone established and temporary traffic signal at each end
- Maximum 25-minute traffic stops; traffic allowed to clear before next stoppage
- Work primarily completed using hand tools (i.e., pry bars, picks shovels), compressed air inflatable air bags (area 9)

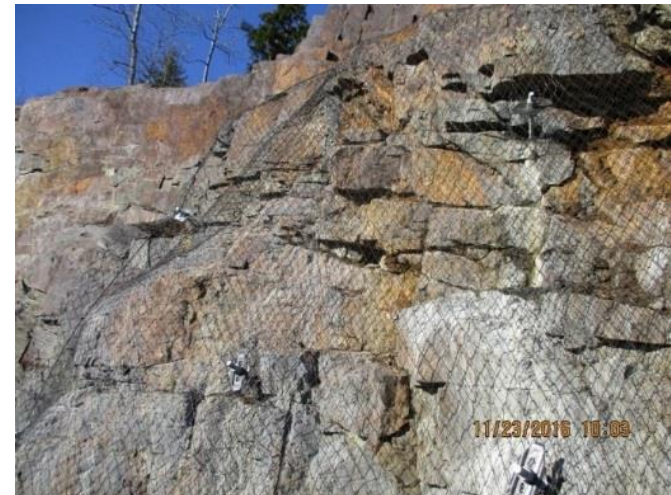
# Construction: Passive rock dowels

- 67 rock dowels installed in seven areas (1, 4, 5, 6, 9, 10, 16)
- Drilled using wagon drill or “plugger” drill
- Subhorizontal and vertical dowels
- 1-3/8” dia., Grade 150, galvanized bar
- Lengths varied from 5 to 20 ft
- 12 pull tests (1 ea. area)

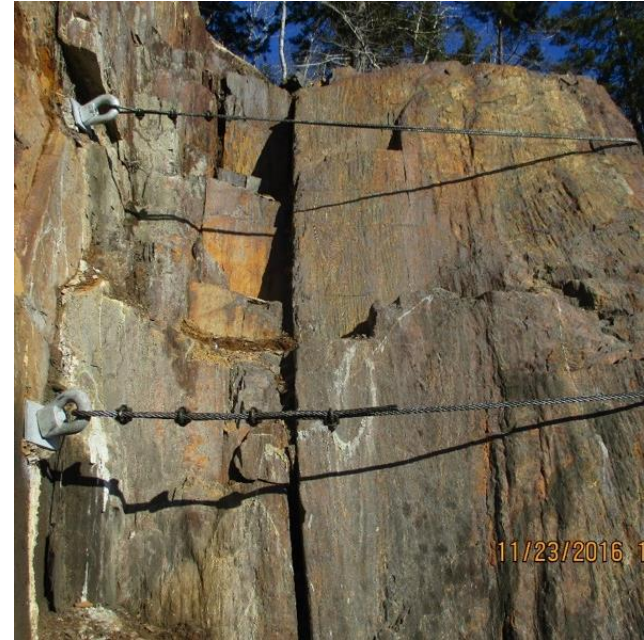
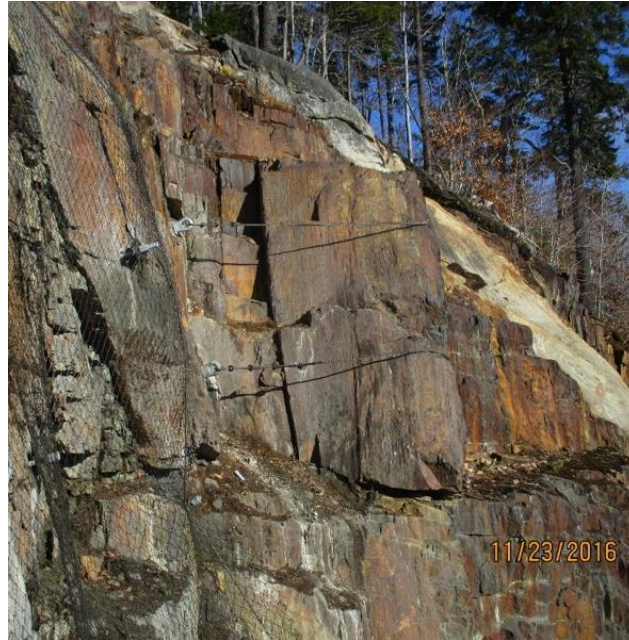


# Construction: Anchored wire mesh netting

- Geobrugg TECCO G65/3
- Mesh and spike plates powder coated black for aesthetics and have supercoating corrosion protection
- 10-ft long rock dowels
- 9-ft c-c spacing, triangular pattern



# Construction: Wire rope cable lashing



- Concerns about scaling and ability to safely install rock dowels
- Four, 5-ft long rock dowels
- $\frac{3}{4}$ -in. diameter galvanized wire rope



# Summary

- 2003 to 2005 completed investigation, design and construction.
- Identified multiple areas during construction and recommended stabilization/remediation.
- Re-evaluated rock slope and design recommendations again in 2009 and 2012.
- Developed and implemented maintenance and monitoring program in 2012.
- Re-evaluated rock slope and design recommendations in 2015.
- Stabilized/remediated “most critical” and “moderately critical” areas in 2016.

# Questions



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