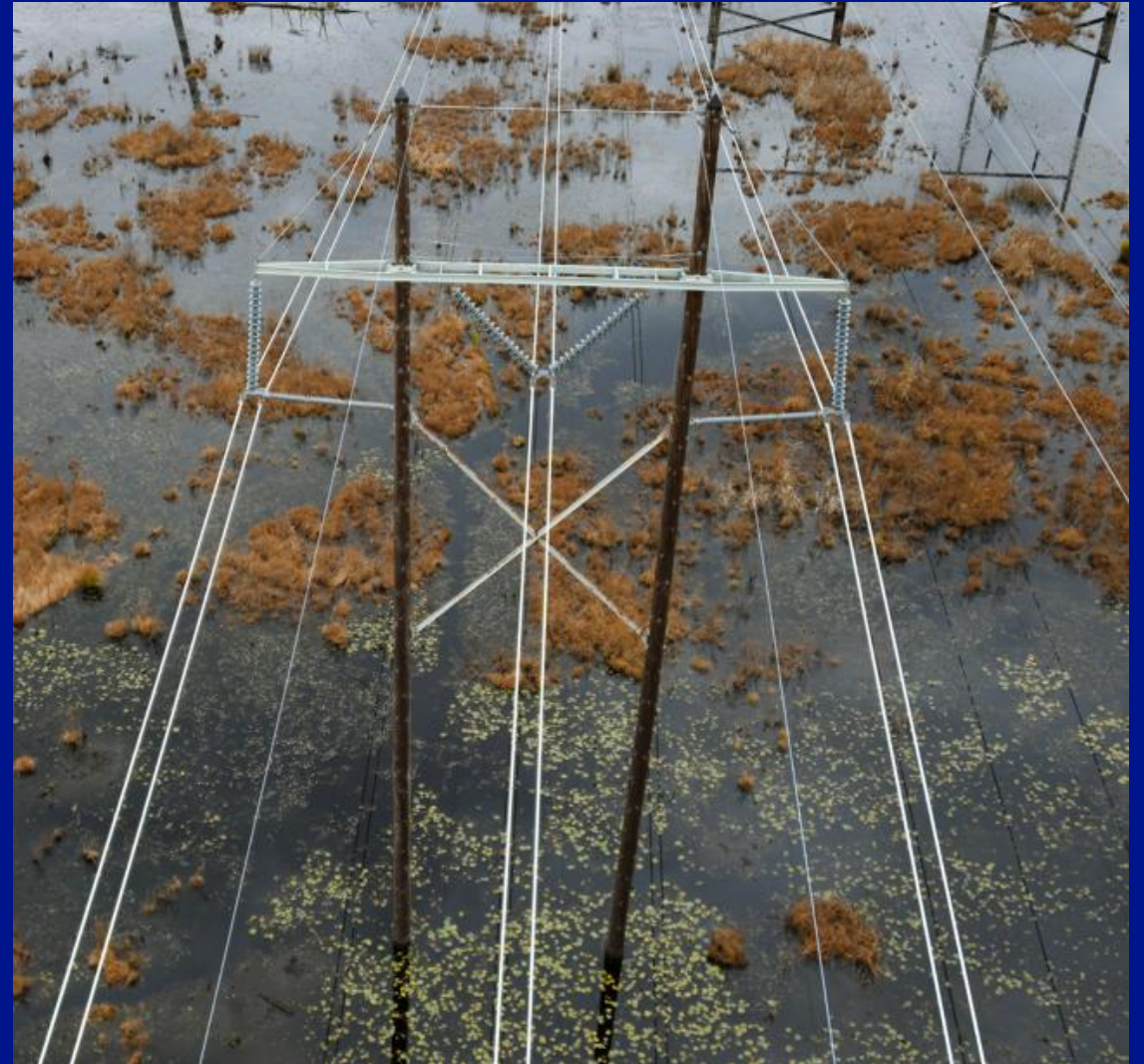


394/397 345 kV Lines Asset Condition Replacement

Rafael Panos
National Grid
07/28/26



Outline

- Project Summary
- Background Information
- Project Needs and Drivers
- Solution Alternatives
- Selection of Preferred Solution
- Schedule and Contact Information

Project Summary

Project Drivers

The drivers were determined using information from aerial inspection, 5-year cyclical foot patrol, and PIT (Pole Inspection and Treatment) inspections performed on the line

Primary Driver:

- Inspections have identified multiple structure concerns including signs of checks, cracks, internal shell rot, insect activity, and woodpecker damage.
- Splices identified on the shieldwire. This poses mechanical corrosion risks, increasing the chances of failure
- Insulation is flashed and damaged

Secondary Driver:

- Telecommunication needs
- Improve existing access in the right-of-way (ROW)

This project will be subject to interim ISO-NE Asset Condition Reviewer process

Project Summary

Alternatives Considered		
Alternative	Description	Cost Estimate
Base Alternative (Replace all category C wood structures and replace existing shieldwires with new shieldwires)	Replace 127 category C wood structures with direct embedded suspension H-frame steel pole structures and engineered steel pole deadend H-frame structures on concrete caisson foundations, replace existing 28.35 circuit miles of existing (2) 3/8" EHS shieldwire with 28.35 circuit miles of new (2) 3/8" EHS shieldwire, 3.8 miles of existing (1) 3/8" EHS shieldwire and existing (1) OPGW to remain, replace flashed and damaged insulators with toughened glass insulators, build new access and refresh existing access in the ROW (approximately 105,513 linear feet)	\$106.11M (+200%, -50%) (PTF)
Alternative 2 (Replace all wood structures and replace existing shieldwires with new shieldwires)	Replace 148 wood (127 category C and 21 category B) structures with direct embedded suspension H-frame steel pole structures and engineered steel pole deadend H-frame structures on concrete caisson foundations, replace existing 28.35 circuit miles of (2) 3/8" EHS shieldwire with 28.35 circuit miles of new (2) 3/8" EHS shieldwire, 3.8 miles of existing (1) 3/8" EHS shieldwire and existing (1) OPGW to remain, replace all insulators with toughened glass insulators, build new access and refresh existing access in the ROW (approximately 105,513 linear feet)	\$115.45M (+200%, -50%) (PTF)
Alternative 3 (Replace all wood structures and replace existing shieldwires with new OPGWs)	Replace 148 wood structures (127 category C and 21 category B) with direct embedded suspension H-frame steel pole structures and engineered steel pole deadend H-frame structures on concrete caisson foundations, replace existing 28.35 circuit miles of (2) 3/8" EHS shieldwire with 28.35 circuit miles of new (2) 1/2" OPGW, replace 3.8 miles of (1) 3/8" EHS shieldwire with 3.8 miles of (1) 1/2" OPGW, 3.8 miles of existing (1) OPGW to remain, replace all insulators with toughened glass insulators, build new access and refresh existing access in the ROW (approximately 105,513 linear feet)	\$117.87M (+/-25%) (PTF)

Project Summary

Preferred Alternative		
Alternative	Reason for Recommendation	Cost Estimate
Alternative 3	- All alternatives address the deteriorated wood poles and shieldwire - Alternative 3 is marginally higher in cost but addresses the secondary need for fiber by installing OPGW. A future project to install fiber on the line would be prohibitively more expensive than installing it now, as it would require traversing the entire line length again for construction, resulting in additional mobilization, permitting, and labor costs. - Ultimately, alternative 3 is chosen as it addresses the primary and secondary needs in a cost-effective manner	\$117.87M (+/-25%) (PTF)

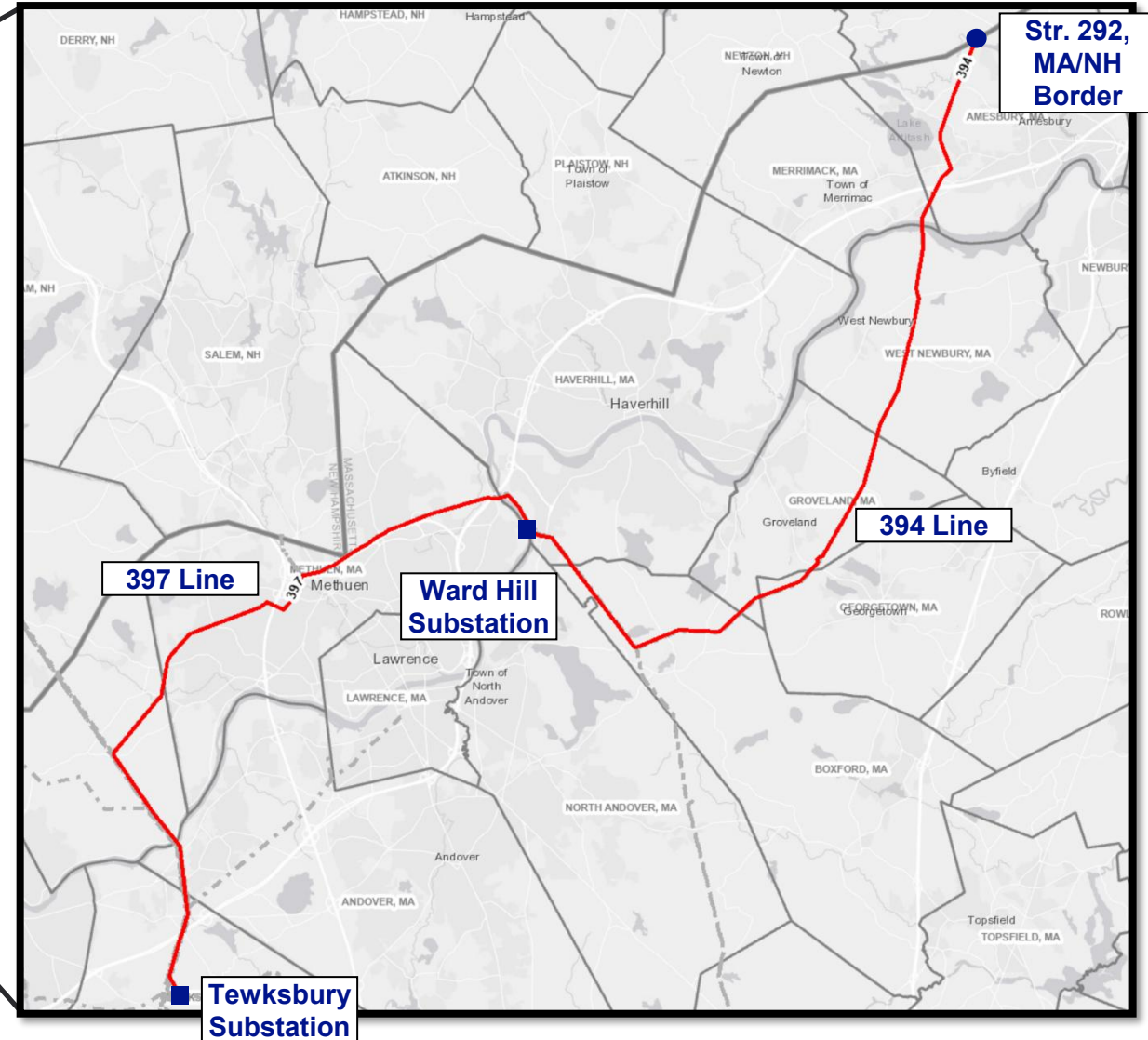
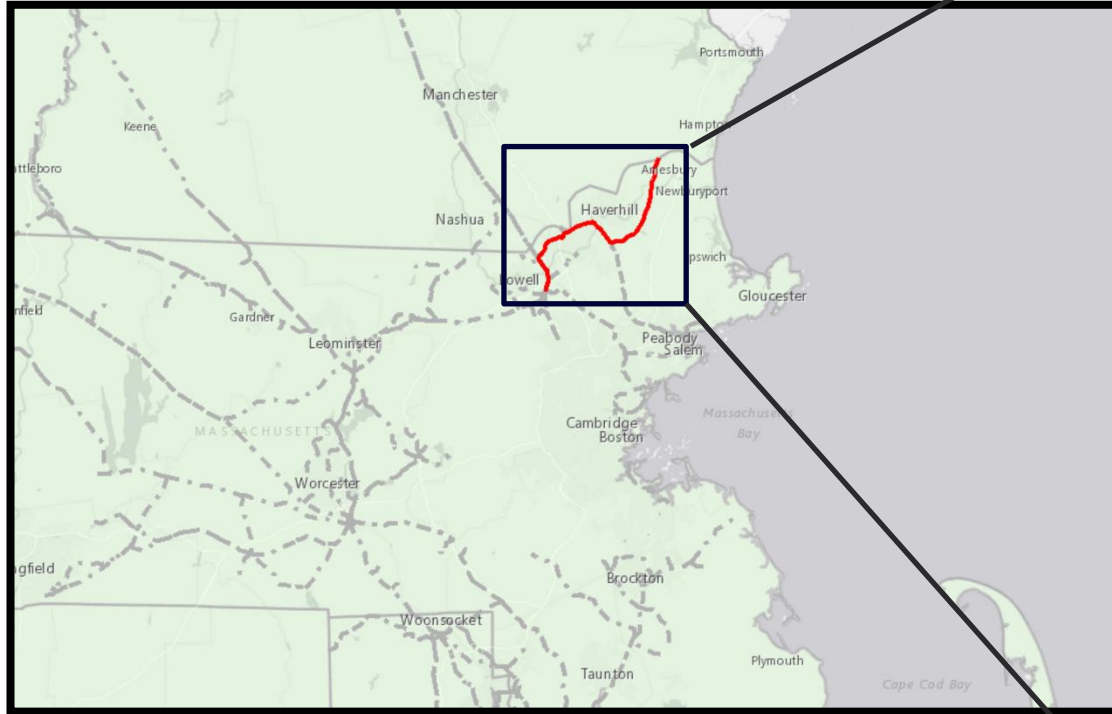
Background Information – 394/397 345kV Line

Key Details	
Location	397 Line: From: Tewksbury #22A Substation in Tewksbury, MA To: Ward Hill Substation in Haverhill, MA 394 Line: From: Ward Hill Substation in Haverhill, MA To: Structure 292, MA/NH Border
Line length	394 Line: 17.05 miles 397 Line: 15.1 miles
Operating Voltage	345 kV
Age and upgrade history	- Originally constructed in 1989 as one line - In 1997, the Ward Hill Substation was added, and the line was broken into the 394 north of Ward Hill and the 397 south of Ward Hill - The section of the 397 between structures 10 and 44 was rebuilt and relocated as part of the Merrimack Valley Reliability Project in 2017 100% PTF
Prior PAC presentations	None

Existing structures			
Material	Configuration	Number	Avg. age
394 & 397 Lines			
Wood	Single Circuit	148	36 years
Steel	Single Circuit	153	36 years

Existing conductor		
Type	Length	Avg. age
394 Line		
(2) 2156 kcmil ACSR Bluebird	14.15 miles	19 years
(2) 1590 kcmil ACSR Falcon	2.90 miles	36 years
(2) 3/8" EHS Steel	17.05 miles	39 years
397 Line		
(2) 1590 kcmil ACSR Falcon	15.1 miles	36 years
(2) 3/8" EHS Steel	11.3 miles	39 years
(1) 3/8" EHS Steel	3.8 miles	8 years
(1) OPGW	3.8 miles	8 years

Background Information – Maps and Diagrams



Project Needs and Drivers

Concerns

Primary Concerns (must be addressed)

Wood Pole Deterioration	• Signs of cracks, large checks and shell rot • Insect infestation and woodpecker damage. Simple replacement of a structure with woodpecker burrows will simply encourage the birds to transfer the nests to adjacent structures.
Insulation Deterioration	• Insulators experiencing flashover and damage • Flashover and damage to insulators indicate compromised insulation, which can lead to electrical faults, outages, or equipment damage. Timely replacement is crucial to maintain system performance and safety
Shieldwire	• Splices pose mechanical and corrosion risks, increasing the chances of failure

Project Needs and Drivers (Cont.)

Concerns

Secondary concerns (may be addressed)

Telecommunication Needs

- Fiber needed to support relaying and internal communication networks
- The 394 line OPGW will connect communications from NH Seabrook to Ward Hill. There is no other fiber along this right of way.
- The 397 line OPGW will connect the 394 line OPGW back to Tewksbury.

Access Improvements

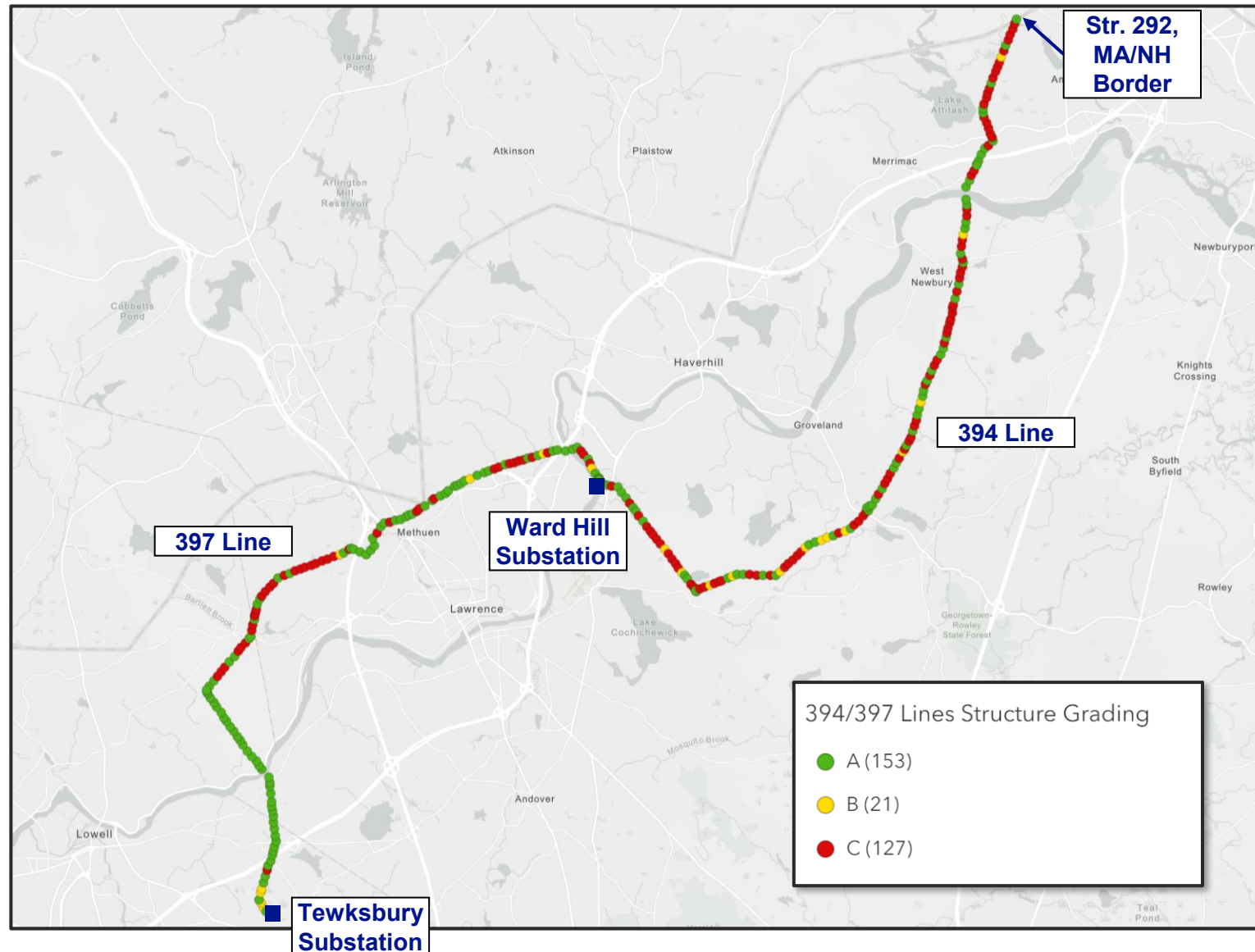
- Access along the ROW is extremely challenging. The terrain is rugged with lots of rock outcrops, sloped terrain and access is further made difficult by limited road crossings to access the ROW.
- Due to challenging terrain, work pads are required at each structure to provide access for construction including foundation installation, setting new structures, removal of existing structures, and overhead linework.

Project Needs and Drivers

Summary of Current Structure Grades		
Category	Recommended Action	Number of structures
A	No replacement required due to deterioration	153
B	Consider replacement in conjunction with other structure replacements	21
C	Initiate planned structure replacement project or Replace as part of upcoming structure replacement project	127
D	Replace immediately (emergency replacement)	0
Total		301

- One hundred twenty-seven (127) wood structures on the line are Category C due to condition
- Twenty-one (21) wood structures on the line are category B. These are considered opportunity structures due to access and due to being located in a woodpecker infested habitat
- One hundred fifty-three (153) steel structures are rated A. These structure will not be replaced as there is no asset condition need to replace.

Project Needs and Drivers – Structure Grading Map



Project Needs and Drivers – Wood Pole Deterioration



394 Line Str. 159

Installed 1989

**Woodpecker Damage,
Checking**

Grade: C



394 Line Str. 169

Installed 1989

**Checking,
Signs of decay**

Grade: C



394 Line Str. 278

Installed 1991

**Woodpecker Damage,
Checking**

Grade: C



394 Line Str. 286

Installed 1989

**Pole top deterioration,
Pole deterioration**

Grade: C



394 Line Str. 291

Installed 1989

**Woodpecker damage,
Insect damage,
Signs of decay**

Grade: C

Project Needs and Drivers – Wood Pole Deterioration



397 Line Str. 52

Installed 1989

**Woodpecker Damage,
Signs of Decay**

Grade: C



394 Line Str. 60

Installed 1989

Signs of decay

Grade: C

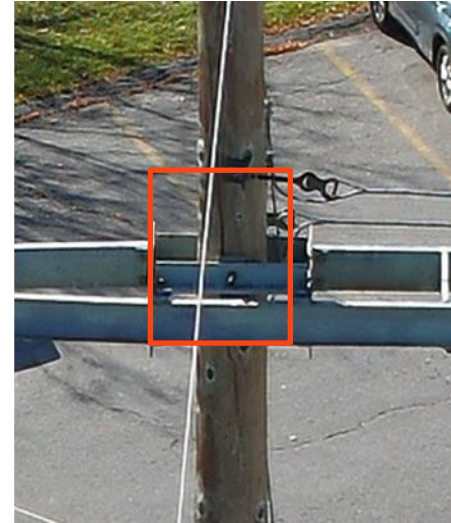


394 Line Str. 78

Installed 1989

Signs of decay

Grade: C



394 Line Str. 98

Installed 1989

**Pole deterioration
near crossarm**

Grade: C



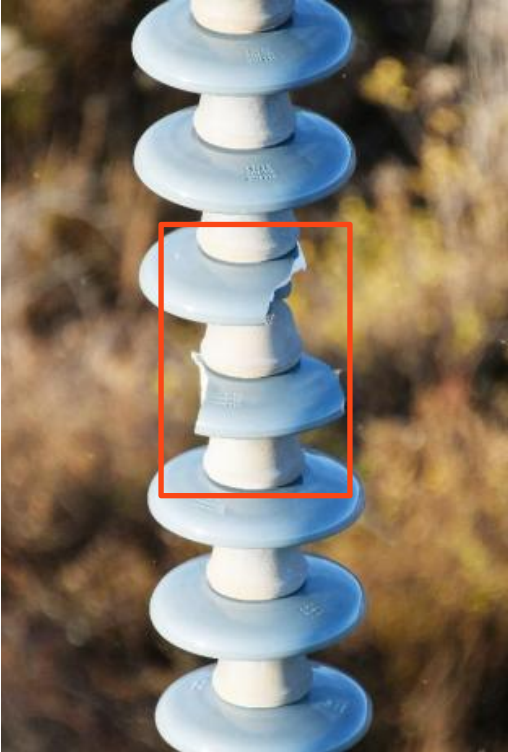
394 Line Str. 125

Installed 1989

**Pole top deterioration,
Checking**

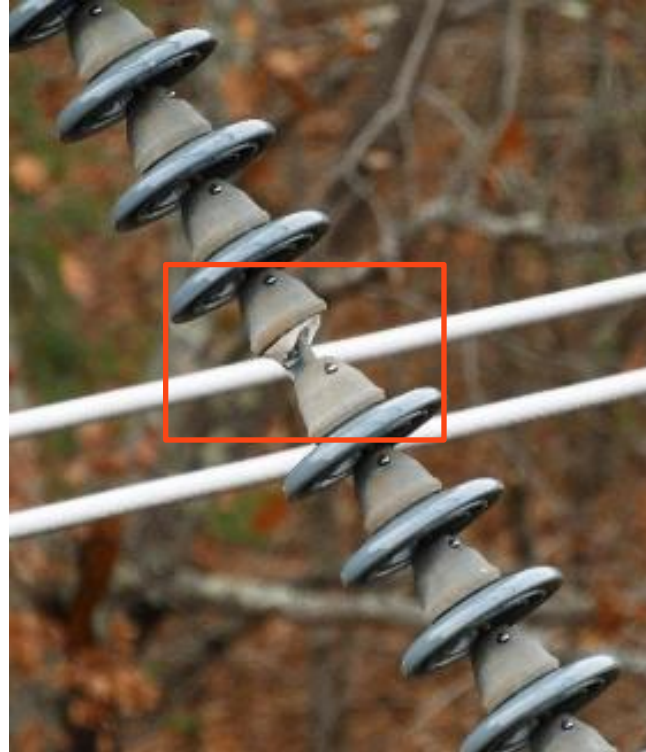
Grade: C

Project Needs and Drivers – Damaged Insulators



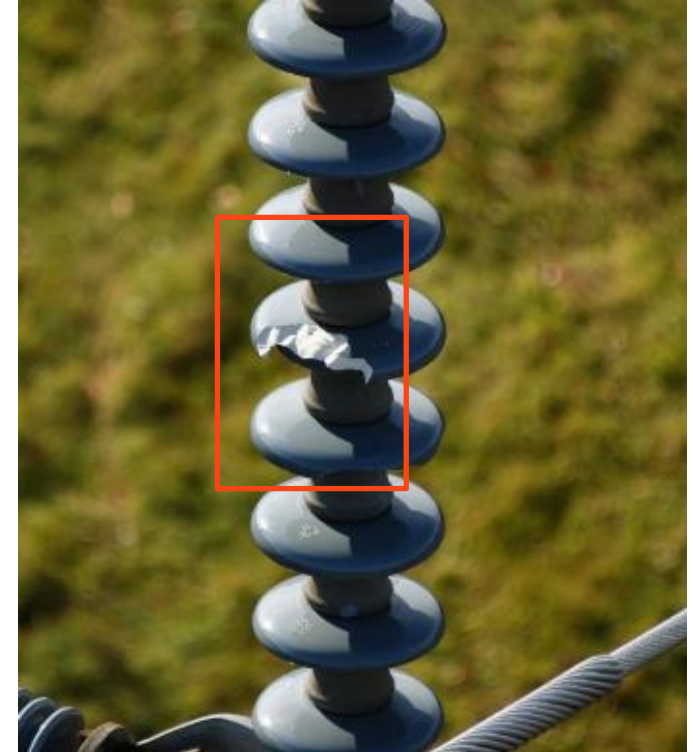
394 Str. 230

Broken Insulators



394 Str. 279

Broken Insulator



397 Str. 50

Broken Insulator

Review of Relevant Transmission Studies

Transmission Study Status
Was this line overloaded in recent Attachment K studies (Reliability Needs Assessments, Longer-Term Transmission Studies, etc.) or other recent studies?
• The 397 line segment from Tewksbury to Ward Hill was identified in the ISO-NE 2050 Transmission Study (57 GW scenario) under the worst case 2050 contingency loading (% of Winter LTE) at 131.5% • The 394 line segment from Ward Hill to West Amesbury was identified in the ISO-NE 2050 Transmission Study (51 GW scenario) under the worst case 2050 contingency loading (% of Winter LTE) at 149% • The 394 line segment from National Grid border to West Amesbury was identified in the ISO-NE 2050 Transmission Study (57 GW scenario) under the worst case 2050 contingency loading (% of Winter LTE) at 112.4%
Have modifications or upgrades to this line been identified as potential solutions in any of those studies?
No

Evaluated Solution Alternatives

Base Alternative

Replace category C wood structures and replace existing shieldwires with new shieldwires	
Description	• Replace 127 category C wood structures with direct embedded suspension H-frame steel pole structures and engineered steel pole deadend H-frame structures on concrete caisson foundations • Replace existing 28.35 circuit miles of existing (2) 3/8" EHS shieldwire with 28.35 circuit miles of new (2) 3/8" EHS shieldwire • 3.8 miles of existing (1) 3/8" EHS shieldwire and existing (1) OPGW to remain • Replace damaged and flashed insulators with toughened glass insulators • Build new access and refresh existing access in the ROW (approximately 105,513 linear feet)
Primary Needs Addressed	Structure, Insulators
Secondary Needs Addressed	N/A
Advanced transmission technologies to be considered	N/A
Cost Estimate and Accuracy	\$106.11M (+200%, -50%) (PTF)
Longer-term transmission needs addressed	No
Key standards or criteria affecting design if different than current design	NESC-Heavy

Evaluated Solution Alternatives

Alternative 2

Replace all wood structures and replace existing shieldwires with new shieldwires	
Description	• Replace 148 wood (127 category C and 21 category B) structures with direct embedded suspension H-frame steel pole structures and engineered steel pole deadend H-frame structures on concrete caisson foundations, • Replace existing 28.35 circuit miles of (2) 3/8" EHS shieldwire with 28.35 circuit miles of new (2) 3/8" EHS shieldwire • 3.8 miles of existing (1) 3/8" EHS shieldwire and existing (1) OPGW to remain • Replace all insulators with toughened glass insulators • Build new access and refresh existing access in the ROW (approximately 105,513 linear feet)
Primary Needs Addressed	Structure, Insulators
Secondary Needs Addressed	N/A
Advanced transmission technologies to be considered	N/A
Cost Estimate and Accuracy	\$115.45M (+200%, -50%) (PTF)
Longer-term transmission needs addressed	No
Key standards or criteria affecting design if different than current design	NESC-Heavy

Evaluated Solution Alternatives

Alternative 3

Replace all wood structures and replace existing shieldwires with new OPGWs	
Description	• Replace 148 wood structures (127 category C and 21 category B) with direct embedded suspension H-frame steel pole structures and engineered steel pole deadend H-frame structures on concrete caisson foundations • Replace existing 28.35 circuit miles of (2) 3/8" EHS shieldwire with 28.35 circuit miles of new (2) 1/2" OPGW • Replace 3.8 miles of (1) 3/8" EHS shieldwire with 3.8 miles of (1) 1/2" OPGW • 3.8 miles of existing (1) OPGW to remain • Replace all insulators with toughened glass insulators • Build new access and refresh existing access in the ROW (approximately 105,513 linear feet)
Primary Needs Addressed	Structure, Insulators
Secondary Needs Addressed	Telecommunications
Advanced transmission technologies to be considered	N/A
Cost Estimate and Accuracy	\$117.87M (+/-25%) (PTF)
Longer-term transmission needs addressed	No
Key standards or criteria affecting design if different than current design	NESC-Heavy

Comparative Analysis of Alternatives

Comparison			
Key Criteria	Base Alternative	Alternative 2	Alternative 3
Addresses Primary Need(s)	• Yes	• Yes	• Yes
Secondary Needs Addressed	• No	• No	• Yes
Cost	• \$106.11M (+200%, -50%) (PTF)	• \$115.45M (+200%, -50%) (PTF)	• \$117.87M (+/-25%) (PTF)
Constructability concerns or advantages	• No issues anticipated	• No issues anticipated	• No issues anticipated
Siting, Environmental and regulatory issues	• Same for all options	• Same for all options	• Same for all options
Governmental or Community Goals addressed	• Same for all options	• Same for all options	• Same for all options
Future-Proofing	• Addresses only category C structures and does not address replacement of category B wood structures in a woodpecker habitat • Does not address the need for fiber and 2050 contingency loading found in the ISO-NE 2050 Transmission Study	• Addresses only primary concerns but does not address the need for fiber and 2050 contingency loading found in the ISO-NE 2050 Transmission Study	• Addresses all primary and secondary needs but does not address the 2050 contingency loading found in the ISO-NE 2050 Transmission Study
Schedule and Outage Coordination	• Outage windows are similar.	• Outage windows are similar.	• Outage windows are similar.

Comparative Analysis of Alternatives

Conclusions

- All alternatives address the deteriorated wood poles and shieldwire
- Alternative 3 is marginally higher in cost but addresses the secondary need for fiber by installing OPGW. A future project to install fiber on the line would be prohibitively more expensive than installing it now, as it would require traversing the entire line length again for construction, resulting in additional mobilization, permitting, and labor costs.
- Ultimately, alternative 3 is chosen as it addresses the primary and secondary needs in a cost-effective manner
- Project will be subject to interim ISO-NE Asset Condition Reviewer process

Schedule

Planned Schedule	
Comment Deadline	08/11/2026
Start of Major Construction	Q1 2027
Project in Service	Q4 2028

Please submit any comments to pacmatters@iso-ne.com and:

Transmission Owner Contact	
Contact Name	Rafael Panos
Contact Email Address	pac.questions@nationalgrid.com

Questions

**394/397 345 kV Lines
Asset Condition
Refurbishment**



This document has been reviewed and does not contain Critical Energy/Electric Infrastructure Information (CEII).

Scope Summary for Base Alternative

Structure Characteristics		
		Per Unit
Primary Structure Configuration	H-frame	N/A
Material	Steel	N/A
Number of Structure Replacements (est)	127	3.9 per mile

Structure Characteristics	
	Total
Miles of ROW Affected	32.15 miles
Miles of shieldwire replacement	56.7 miles
Miles of conductor replacement	0 miles
ADSS substation connections	None

Structure Characteristics		
	Cost (\$M)	Per Unit Cost (\$M)
Structure Replacements	\$57.15	\$0.45/str
Shieldwire	\$7.89	\$0.13/mile
Access Costs	\$41.07	\$1.28/mile
Other Costs (risk and contingency)	Included above	
Total Cost	\$106.11	

Scope Summary for Alternative 2

Structure Characteristics		
		Per Unit
Primary Structure Configuration	H-frame	N/A
Material	Steel	N/A
Number of Structure Replacements (est)	148	4.6 per mile

Structure Characteristics		Total
Miles of ROW Affected		32.15 miles
Miles of shieldwire replacement		56.7 miles
Miles of conductor replacement		0 miles
ADSS substation connections		None

Structure Characteristics		
	Cost (\$M)	Per Unit Cost (\$M)
Structure Replacements	\$66.49	\$0.45/str
Shieldwire	\$7.89	\$0.13/mile
Access Costs	\$41.07	\$1.28/mile
Other Costs (risk and contingency)	Included above	
Total Cost	\$115.45	

Scope Summary for Alternative 3

Structure Characteristics		
		Per Unit
Primary Structure Configuration	H-frame	N/A
Material	Steel	N/A
Number of Structure Replacements (est)	148	4.6 per mile

Structure Characteristics	
	Total
Miles of ROW Affected	32.15 miles
Miles of shieldwire replacement	60.5 miles
Miles of conductor replacement	0 miles
ADSS substation connections	None

Structure Characteristics		
	Cost (\$M)	Per Unit Cost (\$M)
Structure Replacements	\$66.49	\$0.45/str
Shieldwire (OPGW)	\$10.31	\$0.17/mile
Access Costs	\$41.07	\$1.28/mile
Other Costs (risk and contingency)	Included above	
Total Cost	\$117.87	

Access Details – 394 Line

- As part of this project, approximately 61,267 linear feet of access will be constructed. The new access consists of new type R, type S and type 2 roads.
- In order to safely access the ROW, approximately 1,610,133 square feet of temporary matting will be done in the ROW. Work pads will also be constructed at each structure to provide access for construction including foundation installation, setting new structures, removal of existing structures, and overhead linework. Work pads will be constructed by placement and compaction of gravel (where feasible) or using temporary timber mats where required in wetland areas, within floodplain areas, or where placement of gravel is not feasible to provide a level workspace.

Road Type Classification	Description of work	Amount
Type R	Repair existing stable sub-base road.	22,390 linear feet
Type S	Refresh with stone and potentially widen existing stable sub-base road. Widen as necessary to 16 feet standard width.	36,217 linear feet
Type 2	Engineered road per National Grid standards	2,660 linear feet
Improve as necessary	Existing access roads to be improved as necessary to make it easy for construction vehicles to traverse. Done by filling pot holes, light grading and restoration to revegetation	35,191 square feet
Construction Matting	Work pads will be used to access the ROW and at structure locations to provide access for construction including foundation installation, setting new structures, removal of existing structures, and overhead linework	1,610,133 square feet

Access Details – 397 Line

- As part of this project, approximately 105,513 linear feet of access will be constructed. The new access consists of new type R, type S and type 2 roads.
- In order to safely access the ROW, approximately 1,240,867 square feet of temporary matting work pads will be done in the ROW. Work pads will also be constructed at each structure to provide access for construction including foundation installation, setting new structures, removal of existing structures, and overhead linework. Work pads will be constructed by placement and compaction of gravel (where feasible) or using temporary timber mats where required in wetland areas, within floodplain areas, or where placement of gravel is not feasible to provide a level workspace.

Road Type Classification	Description of work	Amount
Type R	Repair existing stable sub-base road.	27,198 linear feet
Type S	Refresh with stone and potentially widen existing stable sub-base road. Widen as necessary to 16 feet standard width.	5,812 linear feet
Type 2	Engineered road per National Grid standards	11,263 linear feet
Improve as necessary	Existing access roads to be improved as necessary to make it easy for construction vehicles to traverse. Done by filling pot holes, light grading and restoration to revegetation	10,911 square feet
Construction Matting	Work pads will be used to access the ROW and at structure locations to provide access for construction including foundation installation, setting new structures, removal of existing structures, and overhead linework	1,240,867 square feet

Access Details



Before construction



After construction

The example photos on the left show a transmission line before and after construction. As part of the asset condition project, structures were replaced and access improvements including new road building was done.

Access Details

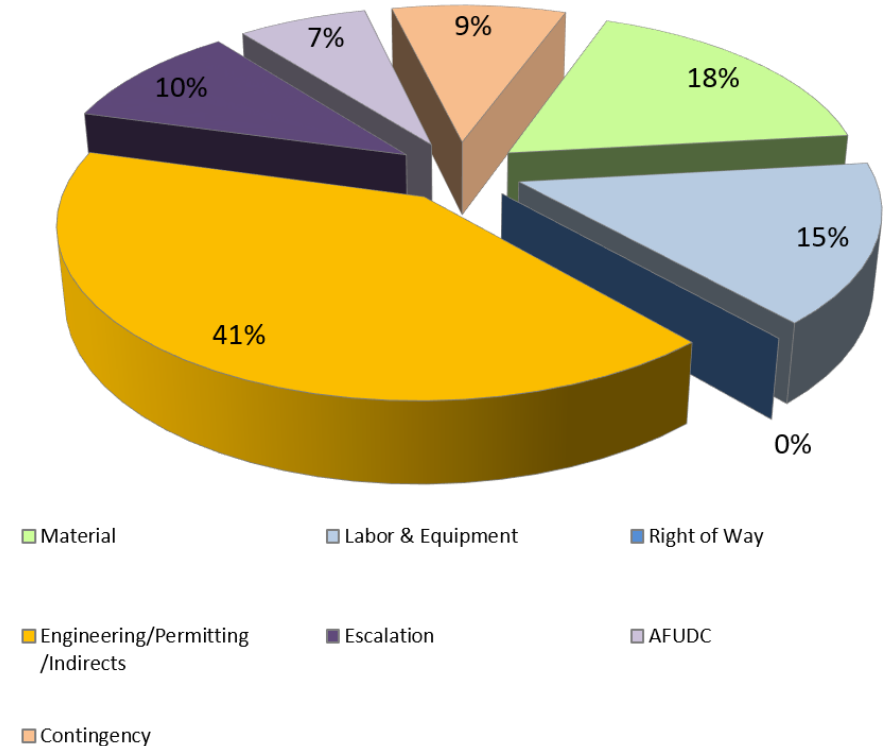


Wood temporary mats

The example photos on this slide depict the typical wood mats used to safely access the structures and work around the structures

Additional Cost Detail – Preferred Alternative (Alternative 3)

Project Cost Summary			
	PTF	Non-PTF	Total
Material	\$ 20,813,353	\$ -	\$ 20,813,353
Labor & Equipment	\$ 17,905,055	\$ -	\$ 17,905,055
Right of Way	\$ -	\$ -	\$ -
Engineering/Permitting /Indirects	\$ 48,202,830	\$ -	\$ 48,202,830
Escalation	\$ 11,917,066	\$ -	\$ 11,917,066
AFUDC	\$ 8,098,204	\$ -	\$ 8,098,204
Contingency	\$ 10,931,970	\$ -	\$ 10,931,970
Total Project Cost	\$ 117,868,478	\$ -	\$117,868,478



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