Eversource Copper Conductor and Shield Wire Replacement Projects

Planning Advisory Committee Meeting

January 21st, 2021

January 19th, 2021 Version

Agenda

- Project Background and Drivers
  - Main Driver
    - Copper Conductor and Shield Wire Asset Condition
  - Overlap with Other Needs
    - Wood Structure Asset Condition
    - Lattice Structure Asset Condition
    - Optical Ground Wire (OPGW)
- Project Locations
  - CT
  - MA
  - NH
- Summary
- Appendix

Copper Conductor and Shield Wire Asset Condition

- Copper conductor and shield wire are susceptible to thermal degradation as well as degradation due to environmental factors
- Eversource periodically tests samples of conductor and shield wire obtained from existing lines during repairs and maintenance
- Recent test results show loss of strength in copper conductor and shield wire
  - Test Results Indicate:
    - Damaged areas and loose strands
    - Outer copper conductor strands have visible verdigris and black oxide
    - Excessive elongation in some strands, potentially due to overheating
    - Conductor and shield wire failed to exceed 95% of the rated breaking strength by American Society for Testing and Materials (ASTM) standards for hard drawn copper wire (84.2-91.1% depending on sample)
    - Severe corrosion of shield wire
- Copper conductors are no longer an industry standard conductor and spare parts are difficult to obtain
- Failure of copper conductor or shield wire present a safety hazard and create risks to the reliable operation of the transmission system
- Other obsolete shield wire materials, such as extra-high strength (EHS) steel, also suffer from similar issues

Copper Conductor and Shield Wire Asset Condition

Damaged Strand of Existing 2/0 Copper Conductor Sample

Severe Corrosion of 3/8 Shield Wire Sample

Overlap with Other Needs

- Degradation of copper conductor and shield wire is the primary driver for projects included in this presentation
- Eversource transmission lines with copper conductor or shield wire tend to be old
  - Copper conductor has not been installed since ~1960
  - Copperweld shield wire has not been installed since ~1990
- Most Eversource transmission lines with copper conductor and shield wire also suffer from other age-related deficiencies and deterioration
  - Wood pole asset condition issues
  - Steel lattice tower deterioration
  - Lack of secure, high-speed telecommunications infrastructure
- Many of these issue are best addressed when replacing copper conductor and/or shield wire

Wood Structure Asset Condition

- Many existing wood structures have one or more of the following deficiencies:
  - Woodpecker damage
  - Pole top rot
  - Cracked arms
  - Split pole top
  - Decay
- Other structures do not adhere to Eversource design standards for uplift, clearance, and lightning shield angle
- Nearly all structures cannot support new conductor and/or OPGW

Typical Wood Structures

Lattice Structure Asset Condition

- Many lattice towers are approaching 100 years in service and suffer from multiple deficiencies including lack of redundant bracing, corrosion and rust, and overstress
- Deterioration of lattice structure frame members or foundations may significantly weaken the strength of the structure while being difficult to detect through visual inspections
- Tower arm failures have occurred during storms and routine maintenance
- Structures also have missing/broken insulators and fretting/deteriorating hardware

Typical Lattice Structures

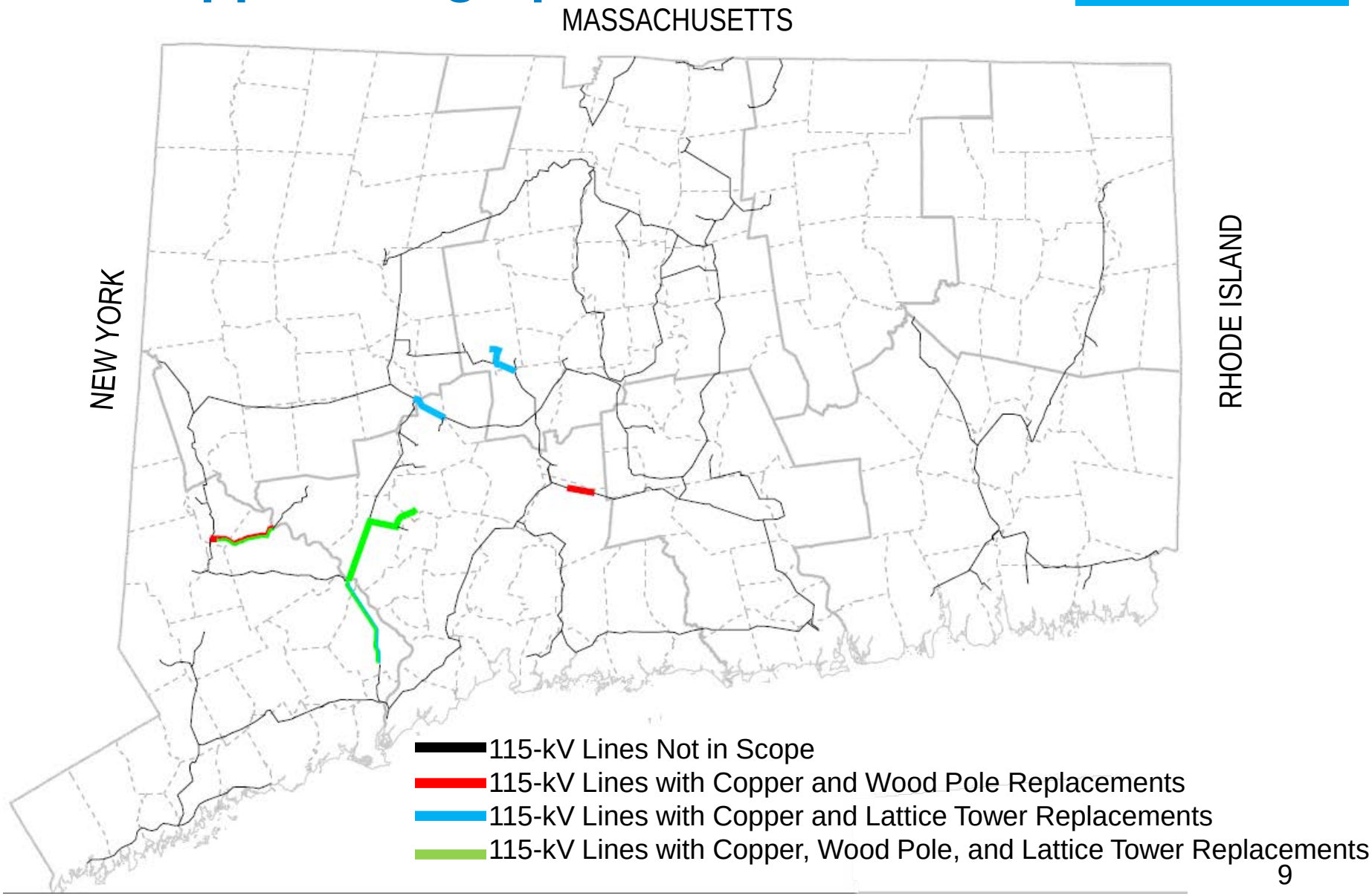
OPGW (cont'd)

- OPGW installation expands a private Eversource OPGW / Synchronous Optical Networking (SONET) loop
  - This will provide a controlled alternate fiber communication path supporting the long term build out initiative of the fiber optic network. This greatly reduces the reliance on leased services for protection, SCADA and future Phasor Measurement Units (PMU) and Dynamic Disturbance Recorders (DDR) installations (ISO-NE OP-22)
  - A private network is segregated from third-party Telecom services improving the overall reliability and security of the communications path to BES Cyber Systems
- CIP: Fiber provides the necessary bandwidth for physical security monitoring and triaging of alarms for BES Cyber Systems at Medium and Low impact substations

OPGW

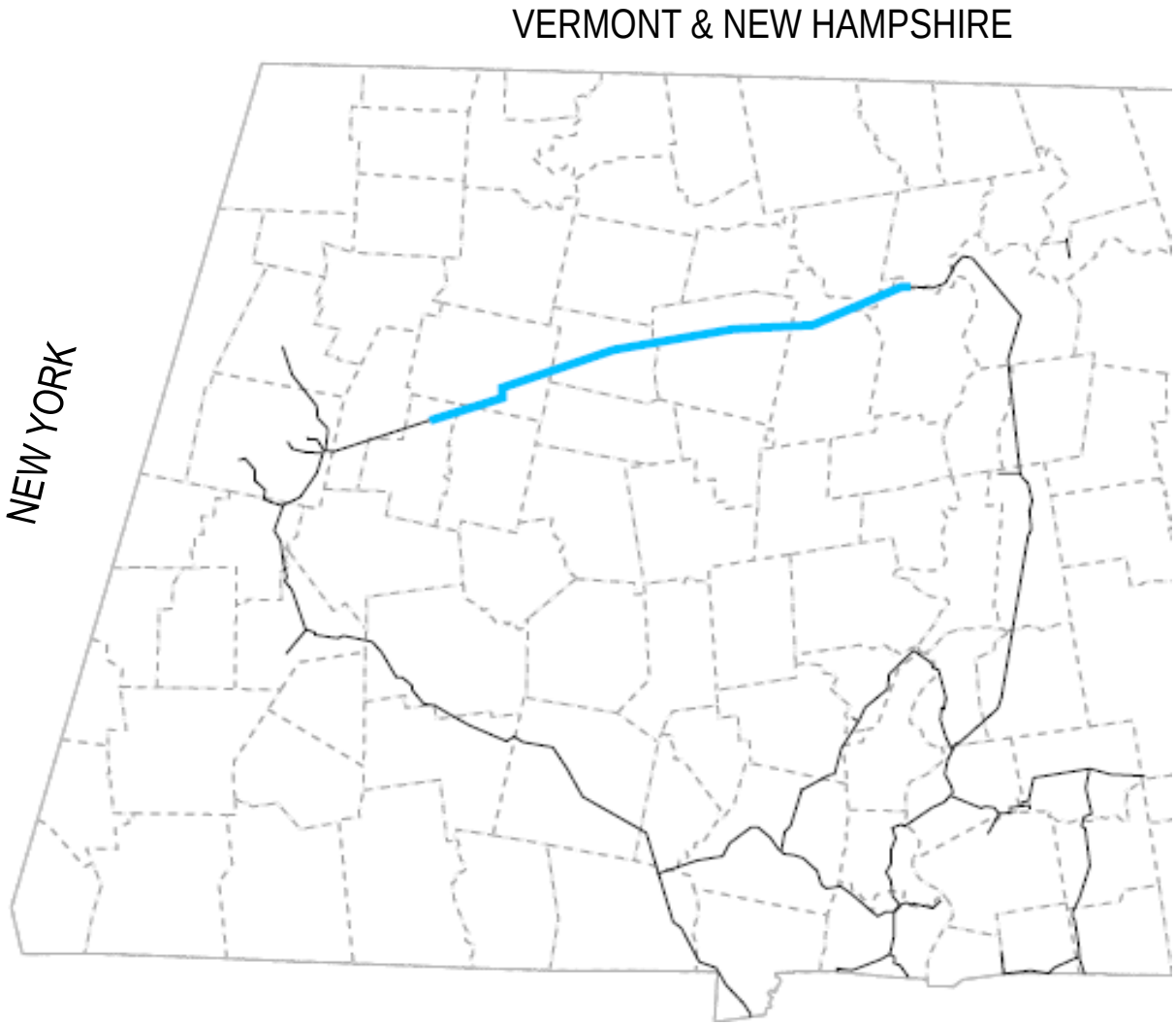
- SCADA Load Shedding procedures are directed by ISO OP-7 and OP-13. SCADA load shedding is required for a rapid response to prevent cascading contingencies and/or equipment damage
  - OPGW provides a dedicated communication path allowing high-speed operations
- The DOE and EPRI recommend fiber as a means to strengthen the security and resilience of critical communication infrastructure on which the nation depends against the consequences of electromagnetic pulse (EMP) attacks
- Fiber optic cable is a non propagating media for electric and magnetic fields (EMF) and therefore is considered generally immune to the effects of geomagnetic disturbances

CT Copper Geographic Locations



See appendix for details by line

WMA Copper Geographic Locations

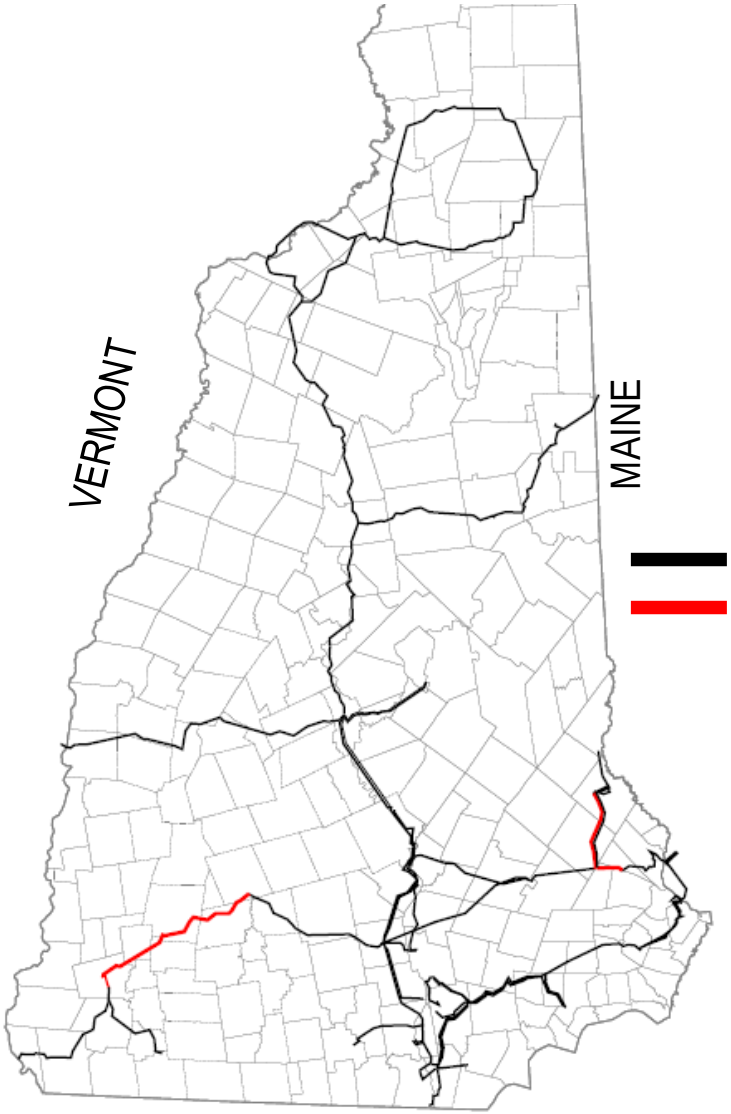


115-kV Lines Not in Scope

115-kV Lines with Copper and Lattice Tower Replacements

See appendix for details by line

NH Copper Geographic Locations



115-kV Lines Not in Scope
115-kV Lines with Copper and Wood Pole Replacements

See appendix for details by line

Summary

State	Line	Copper Conductor Length (Miles)	Copperweld Shield Wire Length (Miles)	Structures	Cost Estimate ($M)*
CT	1560/1808	-	1560: 8.1 1808: 8.1	56	19.7
	1580/1142/1808	1580: 12.4	1580: 23.8 1808: 5.2 1142: 2.7	168	68.1
	1588	2.6	5.2	23	9.6
	1268/1485/1887	1485: 5.8 1887: 6.5	1485: 5.8 1887: 6.5	36	29.6
	1163/1150	-	1550: 3.5	26	16.7
	1825	2.8	1.8	13	7.3
WMA	1231/1242	1231: 25.0 1242: 25.0	1231: 25.0 1242: 25.0	171	97.0
NH	C129	-	7.1*	61	18.5
	D108	-	1.4	19	6.7
	G128	-	3.8	22	7.6
	L163	-	19.3	62	23.3
	X104	-	5.3	16	7.0
	Totals:	80.1	157.6	673	311.1

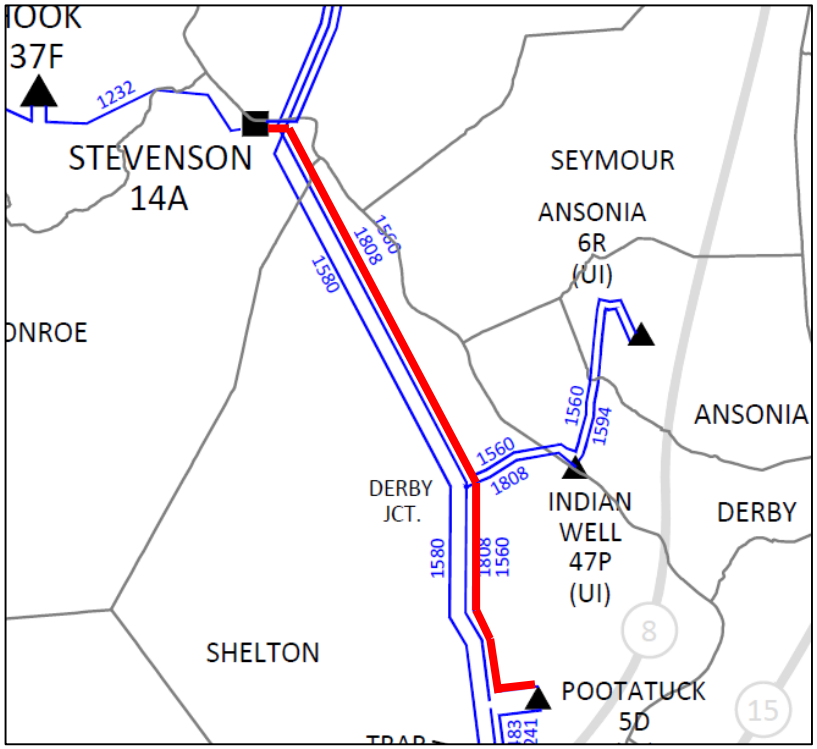
All cost estimates are -25%/+50%
All lines are 115-kV – See Appendix for line-by-line details
* EHS Steel Shield Wire

Questions

APPENDIX

1560/1808 Line – CT

- **Reconductoring Scope:**
  - 1560: Replacement of 8.1 miles of 795 ACSR with 1272 ACSS between Stevenson and Pootatuck substations
  - 1808: Replacement of 8.1 miles of 795 ACSR with 1272 ACSS between Stevenson and Pootatuck substations
  - Existing conductor has many splices along the length of the line
- **Shield Wire Scope:**
  - 1560: Replacement of 8.1 miles of copperweld shield wire with two OPGW between Stevenson and Pootatuck substations
  - 1808: Replacement of 8.1 miles of copperweld shield wire with two OPGW between Stevenson and Pootatuck substations
- **Structure Replacement Scope:**
  - Replacement of 55 double-circuit lattice structures and 1 wood structure with double-circuit weathering steel vertical monopole structures
  - 3 steel structures to remain (only carrying 1560)
  - Installation of lightning arrestors every 5th structure



Cost Estimate: $19.7 M

ISD: Q3 2022

1560/1808 Line – CT

Lattice Tower Degradation –
Structure #1362

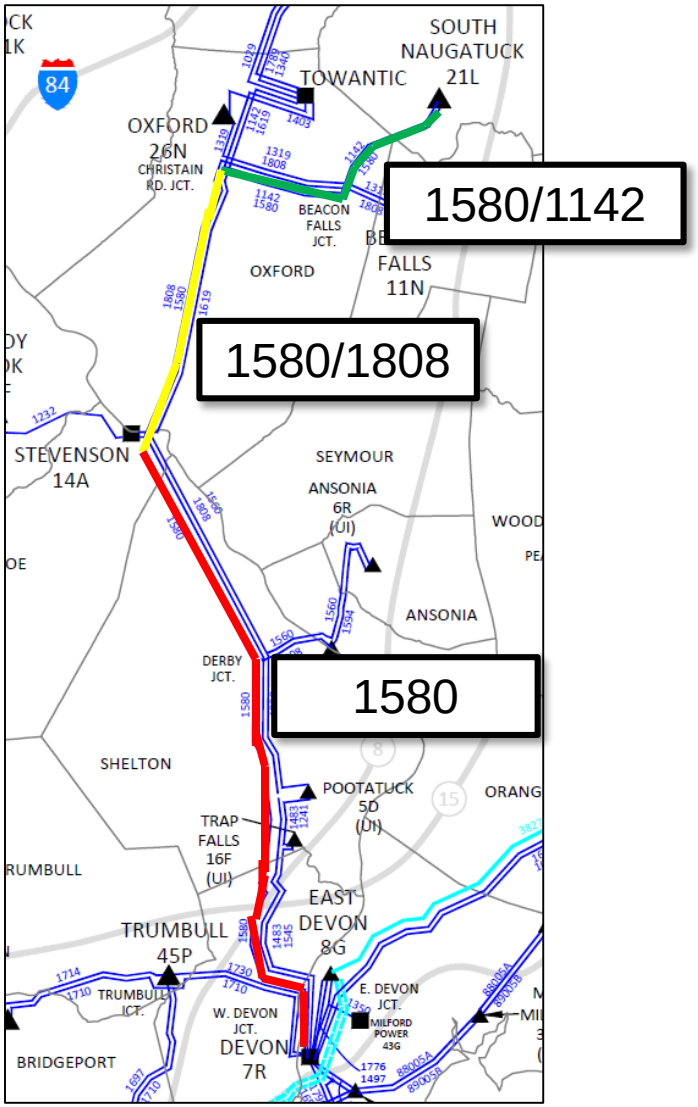
Lattice Tower Degradation –
Structure #1348

1580/1142/1808 Line – CT

- **Reconductoring Scope**
  - 1580: Replacement of 12.4 miles of 4/0 copper with 1272 ACSS between Stevenson and Devon substations
  - 1580: Replacement of 3.5 miles of 556 ACSR and 7.9 miles of 795 ACSR between Stevenson and South Naugatuck substations
  - 1808: Replacement of 17.1 miles of 795 ACSR between Beacon Falls and Pootatuck substations
  - 1142: Replacement of 2.7 miles of 556 ACSR between South Naugatuck substation and Beacon Falls Junction
- **Shield Wire Scope**
  - 1580: Replacement of 23.8 miles of copperweld shield wire with OPGW between South Naugatuck and Devon substations
  - 1808: Replacement of 5.2 miles of copperweld shield wire with OPGW between Christian Road Junction and Stephenson substation
  - 1142: Replacement of 2.7 miles of copperweld shield wire between South Naugatuck substation and Beacon Falls Junction
- **Structure Replacement Scope**
  - Replacement of 168 structures (5 wood H-frames, 4 single circuit steel poles and 159 steel lattice towers) with vertical and delta configuration structures or engineered structures on concrete foundations
  - No structures to remain
  - Installation of Lighting Arrestors on at least every 5th structure and/or installation of counterpoise
  - Some portions of the 1580 line run on double-circuit towers with the 1142 and 1808 lines

Cost Estimate: $68.1 M

ISD: Q3 2022



1580/1808 Line – CT

Damaged, Cracking, Crumbling Lattice Tower Leg Foundation – Structure #233

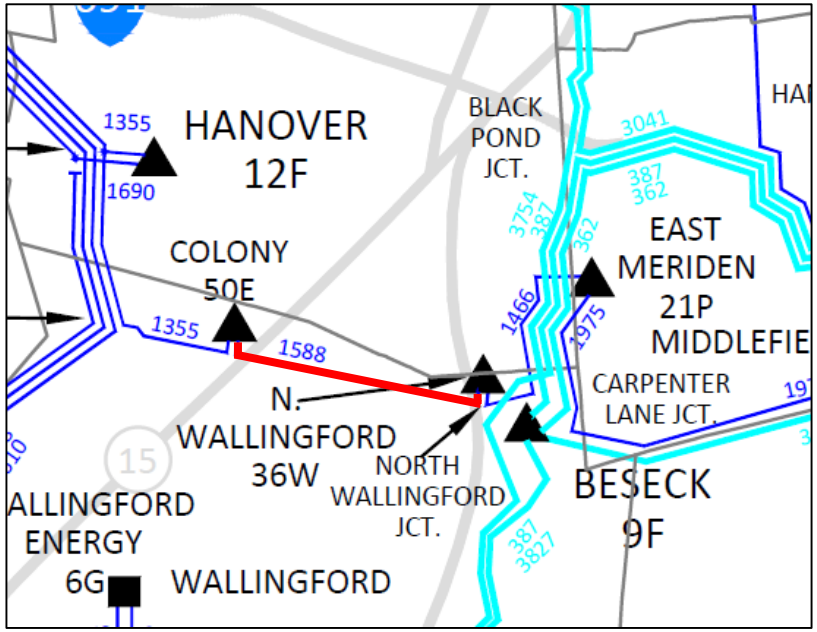
Lattice Tower Leg in Standing Water, Rusted and Eroding – Structure #248

1588 Line – CT

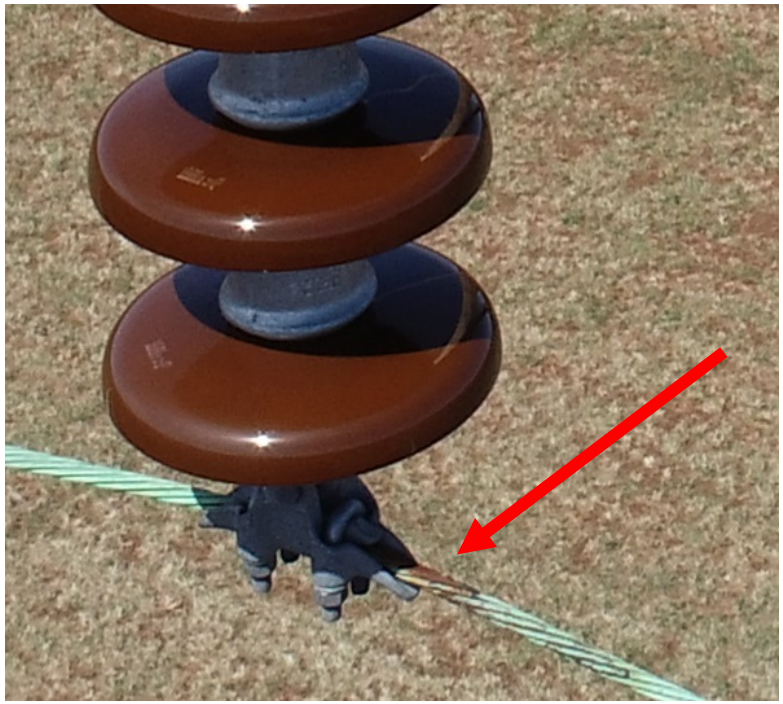
- **Reconductor Scope:**
  - Replacement of 2.6 miles of 4/0 copper conductor with 1272 kcmil ACSS between Colony and North Wallingford substations
- **Shield Wire Scope:**
  - Replacement of two runs of 2.6 miles of copperweld shield wire (5.2 miles total) with two OPGW between Colony and North Wallingford substations
- **Structure Replacement Scope:**
  - Replacement of 23 wooden H-Frame structures with direct-embed H-Frame steel structures or engineered structures on concrete foundations
  - 1 steel structure to remain
  - Installation of lightning arrestors every 5th structure
  - Installation of counterpoise

Cost Estimate: $9.6 M

ISD: Q2 2022



1588 Line – CT

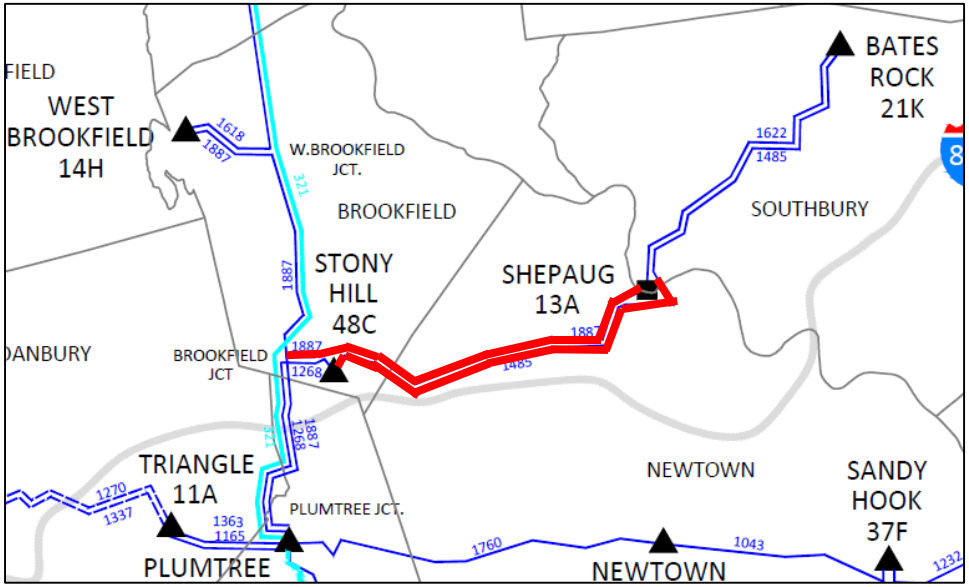


Corrosion of Copper Conductor –
Line 1588

Split Pole Tops, Cracks and
Woodpecker Damage –
Structure #3624

1268/1485/1887 Line – CT

- **Reconductor Scope:**
  - 1485: Replacement of 5.8 miles of 4/0 copper conductor with 1272 ACSS between Stony Hill and Shepaug substations
  - 1887: Replacement of 6.5 miles of 4/0 copper with 1272 ACSS between Brookfield Junction and Shepaug substation
- **Shield Wire Scope:**
  - 1485: Replacement of 5.8 miles of copperweld shield wire with OPGW between Stony Hill and Shepaug substations
  - 1887: Replacement of 6.5 miles of copperweld shield wire with OPGW between Brookfield Junction and Shepaug substation
- **Structure Replacement Scope:**
  - Replacement of 36 lattice towers with direct-embed monopoles
  - 89 structures to remain
  - Potential replacement of additional structures based on structure analysis
  - Installation of counterpoise
- **Cost Estimate: $29.6 M**
- **ISD: Q3 2022**



1268/1485/1887 Line – CT

Lattice Structures in Standing Water and Wetlands Along Train Tracks Between Brookfield Jct and Structure #4620

Typical Lattice Structure on Lines 1485 and 1887 with 4/0 Copper – New Conductor and Shield Wire Would Overstress the Structures

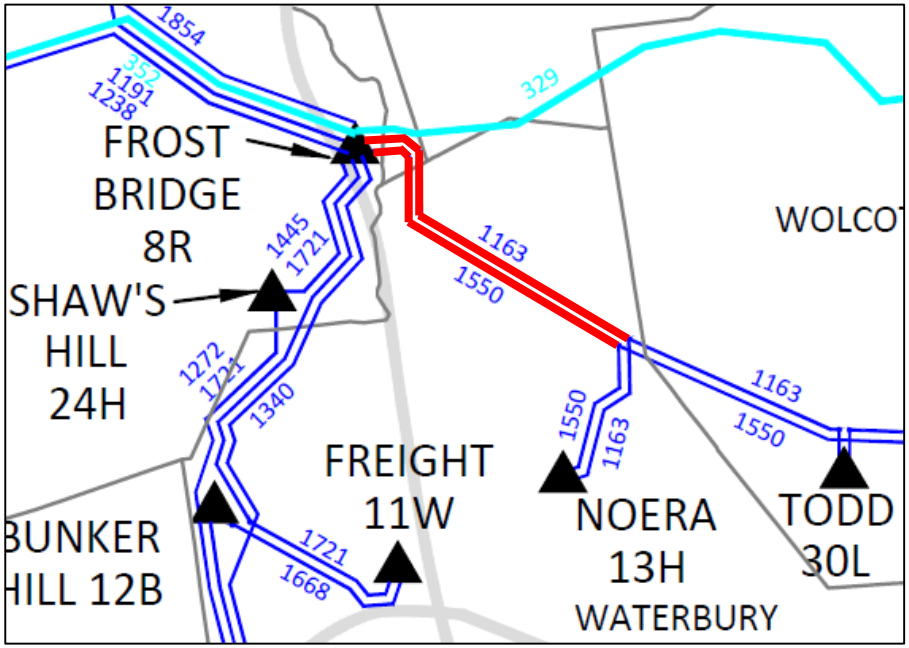
Lattice Structure in Standing Water and Wetlands Along Train Tracks

1163/1550 Line – CT

- **Reconductor Scope:**
  - 1163: Replacement of 3.3 miles of 795 ACSR with 1272 ACSS between Frost Bridge substation and Noera Junction
  - 1550: Replacement of 3.3 miles of 795 ACSR with 1272 ACSS between Frost Bridge substation and Noera Junction
- **Shield Wire Scope:**
  - 1550: Replacement of 3.5 miles of copperweld shield wire with OPGW between Frost Bridge substation and Noera Junction
- **Structure Replacement Scope:**
  - Replacement of 26 lattice towers with direct-embed, steel monopoles or engineered steel monopoles on concrete foundations
  - 24 structures to remain

Cost Estimate: $16.7 M

ISD: Q1 2022



1163/1550 Line – CT

Damaged Flashed Insulators – Lattice Structure #25

Corrosion of Copper Shield Wire

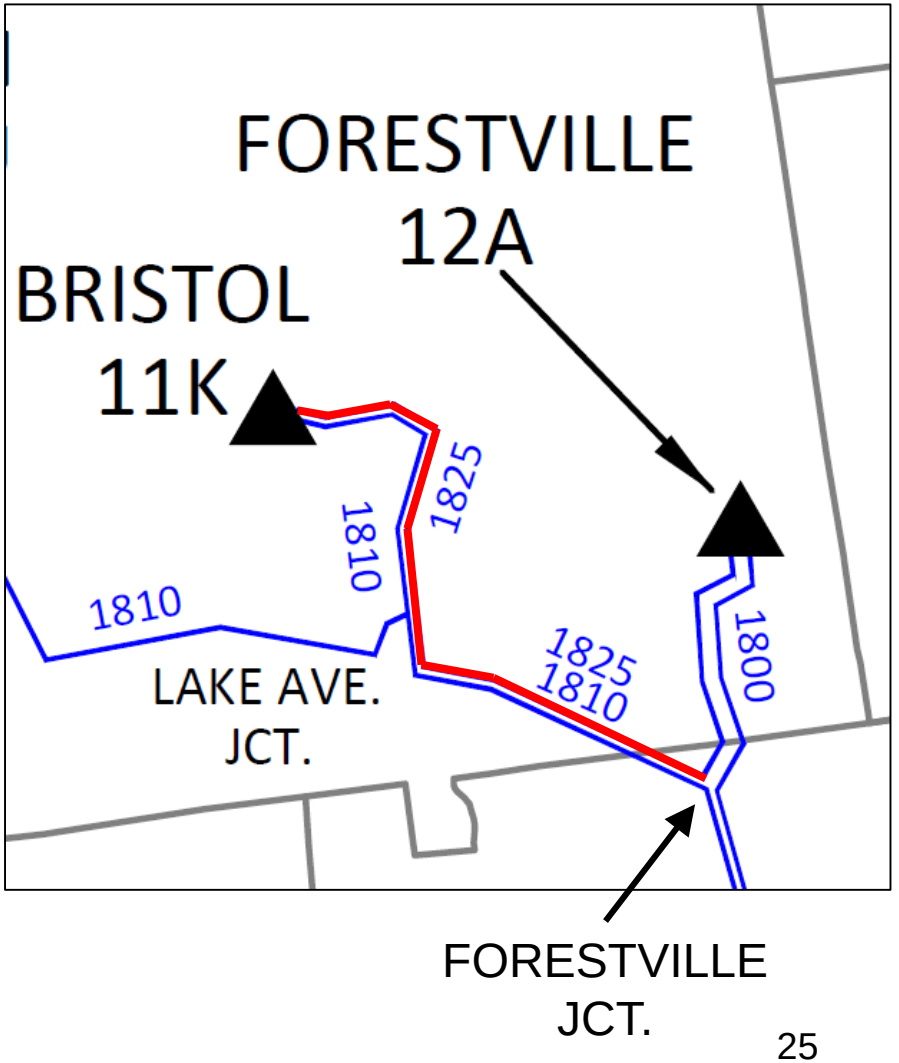
Existing Lattice Towers Built to 69-kV Spec

1825 Line – CT

- **Reconductor Scope:**
  - Replacement of 2.8 miles of 4/0 copper conductor with 795 ACSR between Bristol substation and Forestville Junction
- **Shield Wire Scope:**
  - Replacement of 1.8 miles of copperweld shield wire with OPGW between Lake Ave. Junction and Bristol substation
- **Structure Replacement Scope:**
  - Replacement of 10 wood structures and 3 lattice towers with direct-embed, steel monopoles or engineered steel monopoles on concrete foundations
  - 27 steel structures to remain
  - Installation of lightning arrestors

Cost Estimate: $7.3 M

ISD: Q4 2021



1825 Line – CT

Rotten and Split Pole Top, Woodpecker Damage – Structure #1845

Split Pole Top, Woodpecker Damage – Structure #1847

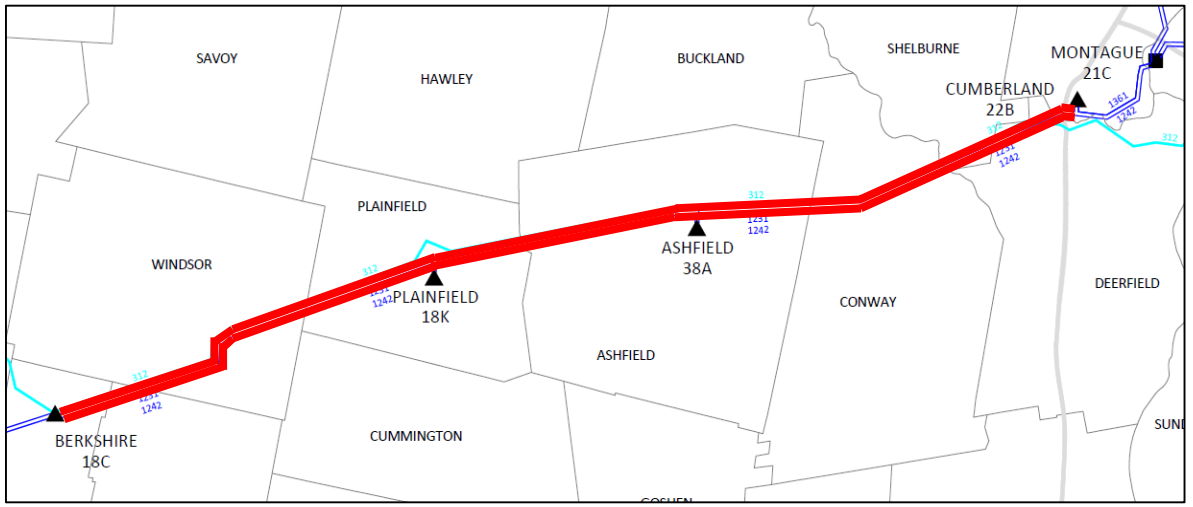
Rust on Steel, De-Galvanizing – Structure #8169

1231/1242 Line – WMA

- **Reconductor Scope:**
  - 1231: Replacement of 25.0 miles of 2/0 copper conductor with 1272 kcmil ACSS between Berkshire and Montague substations
  - 1242: Replacement of 25.0 miles of 2/0 copper conductor with 1272 kcmil ACSS between Berkshire and Montague substations
- **Shield Wire Scope:**
  - 1231: Replacement of 25.0 miles of copperweld shield wire with OPGW between Berkshire and Montague substations
  - 1242: Replacement of 25.0 miles of copperweld shield wire with OPGW between Berkshire and Montague substations
- **Structure Replacement Scope:**
  - Replacement of the 171 Double-Circuit Steel Lattice Towers with direct-embed, steel monopoles or engineered steel monopoles on concrete foundations
  - 100 structures to remain
  - Installation of 62 Lightning Arrestors
  - Installation of counterpoise

Cost Estimate: $97.0 M

ISD: Q4 2023



1231/1242 Line – WMA

52.9% Section Loss of Leg Below Grade – Structure 31223

Structure 31231 – Missing Insulator Bell

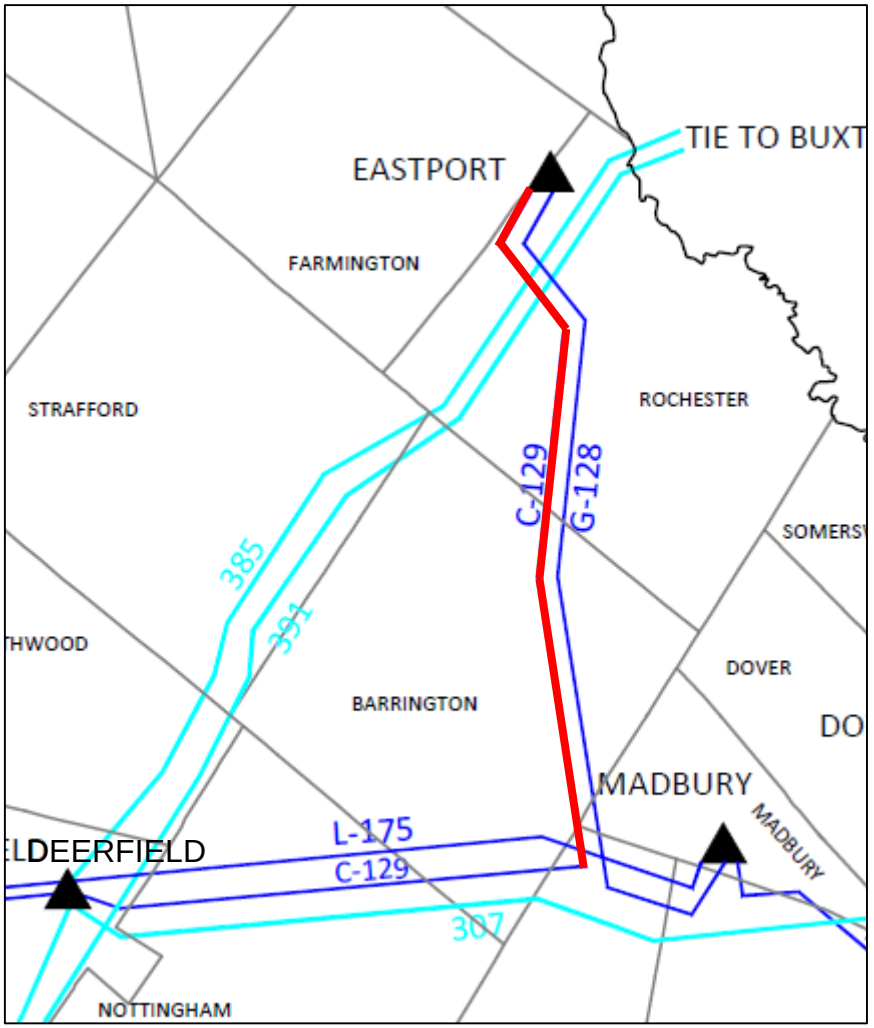
Broken Arm – Structure 31052

C129 Line – NH

- **Shield Wire Scope:**
  - Replacement of 7.1 miles of Extra High Strength (EHS) Steel shield wire with OPGW between Eastport substation and intersection with L175 Line
  - EHS steel shield wire is an obsolete material that is no longer in use on the Eversource system and connectors are no longer available
- **Structure Replacement Scope:**
  - Replacement of 61 wood H-Frame structures with light duty direct-embed steel structures
  - 225 structures to remain
  - Installation of lightning arrestors

Cost Estimate: $18.5 M

ISD: Q2 2021



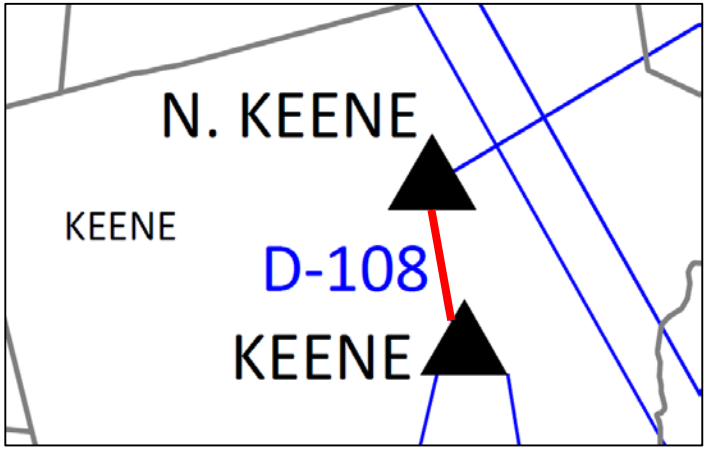
C129 Line – NH

Typical Pole Split/Woodpecker Damage –
Line C129

EHS Steel Shield Wire –
Line C129

D108 Line – NH

- **Reconductor Scope:**
  - Replacement of 1.4 miles of 336 ACSR conductor with 1272 kcmil ACSS between Keene and N. Keene substations
  - Environmental corrosion has caused degradation of the steel core of the 66-year-old existing conductor
- **Shield Wire Scope:**
  - Replacement of 1.4 miles of copperweld shield wire with OPGW between Keene and N. Keene substations
- **Structure Replacement Scope:**
  - Replacement of 19 wooden H-frame structures with light duty direct-embed steel structures
  - 3 structures to remain
  - Installation of new hardware and insulators
  - Installation of lightning arrestors



Cost Estimate: $6.7 M

ISD: Q4 2021

D108 Line – NH

Pole Top Rot –
Structure #284

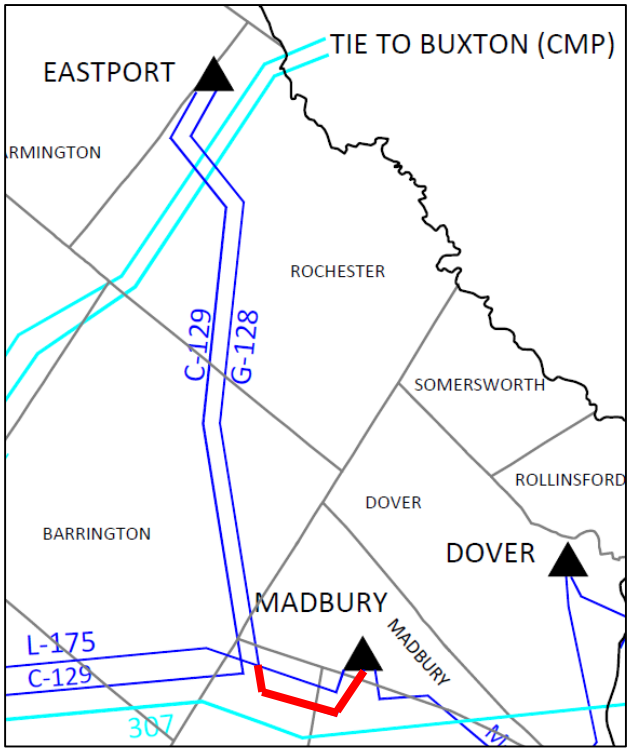
Pole Top Rot, Split Pole at
Crossarm – Structure #291

G128 Line – NH

- **Shield Wire Scope:**
  - Replacement of 3.8 miles of copperweld and alumoweld shield wire with OPGW between Madbury substation and the intersection with L175 Line
- **Structure Replacement Scope:**
  - Replacement of 22 wooden structures with weathering steel structures
  - 28 structures to remain
  - Installation of lightning arrestors

Cost Estimate: $7.6 M

ISD: Q4 2021



G128 Line – NH

Typical Woodpecker Damage –
G128 Line

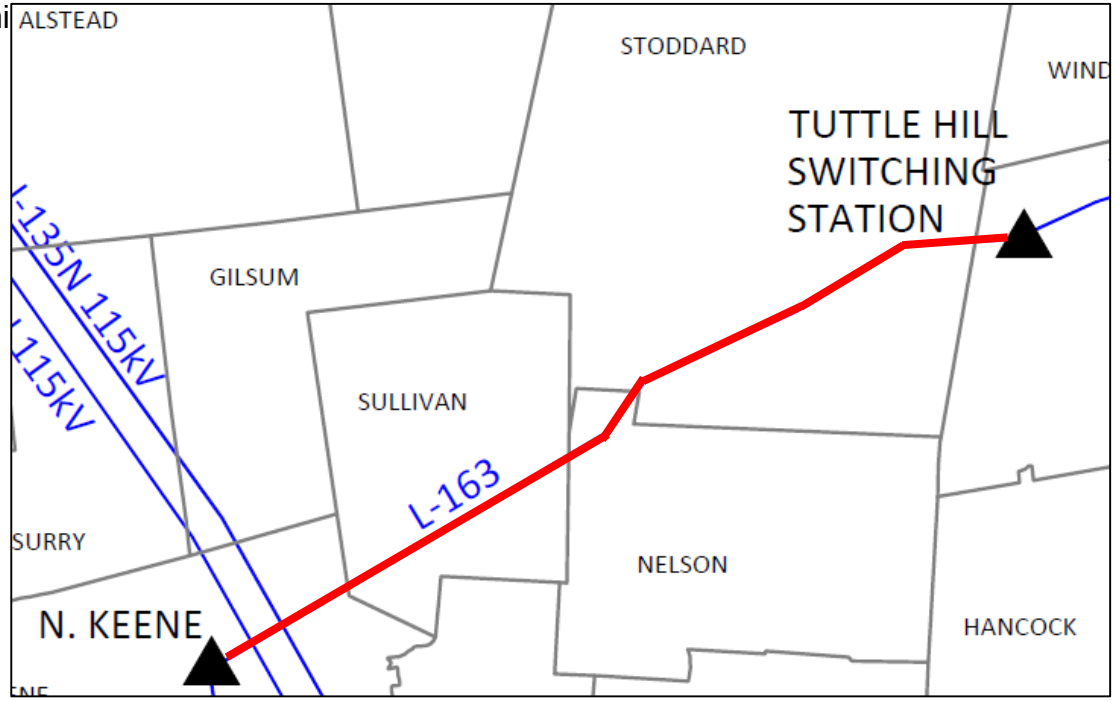
Typical Crossarm Damage –
G128 Line

L163 Line – NH

- **Shield Wire Scope:**
  - Replacement of 19.3 miles of copperweld shield wire with OPGW between Tuttle Hill and N. Keene substations
- **Structure Replacement Scope:**
  - Replacement of 62 wooden structures with weathering steel H-Frame structures
  - 155 structures to remain
  - Installation of lightni

Cost Estimate: $23.3 M

ISD: Q4 2021



L163 Line – NH

Pole Split and Woodpecker Damage –
Structure #205

Pole Top Rot –
Structure #65

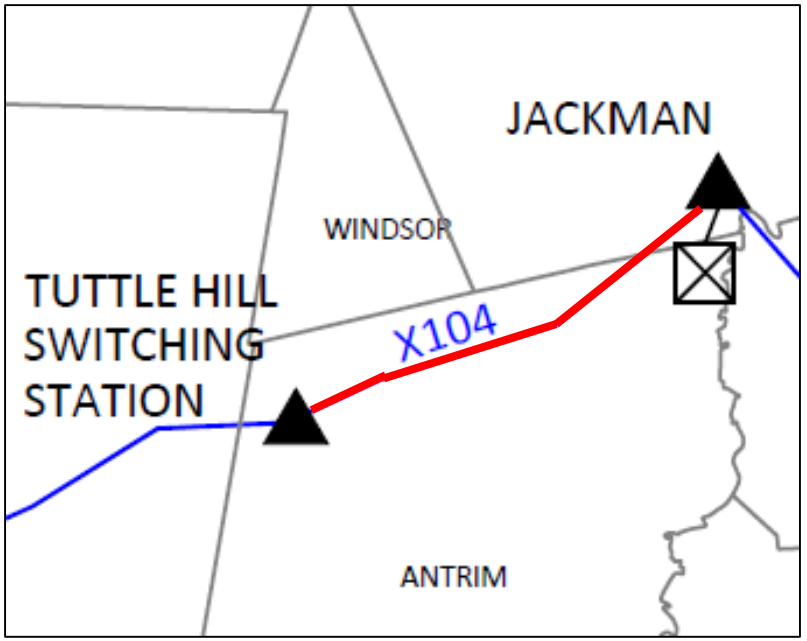
Pole Split –
Structure #95

X104 Line – NH

- **Shield Wire Scope:**
  - Replacement of 5.3 miles of copperweld shield wire with OPGW between Tuttle Hill and Jackman substations
- **Structure Replacement Scope:**
  - Replacement of 16 wood H-frame structures with light duty direct-embed steel structures
  - 49 structures to remain
  - Installation of new hardware and insulators
  - Installation of lightning arrestors

Cost Estimate: $7.0 M

ISD: Q2 2021



X104 Line - NH

Typical Pole Splits/Woodpecker Damage – X104 Line

Typical Woodpecker Damage – X104 Line