CONNECTICUT SITING COUNCIL APPLICATION

FOR THE

FROST BRIDGE TO CAMPVILLE 115-kV PROJECT

BY

THE CONNECTICUT LIGHT AND POWER COMPANY

DOING BUSINESS AS EVERSOURCE ENERGY

VOLUME 1: DESCRIPTION OF THE PROPOSED PROJECT AND ALTERNATIVES ANALYSES

DECEMBER 2015

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VOLUME 1: DESCRIPTION OF THE PROPOSED PROJECT AND ALTERNATIVES ANALYSES

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FORMAL REQUIREMENTS AND APPLICATION GUIDE

A. PURPOSE

The Connecticut Light and Power Company doing business as Eversource Energy (Eversource) is submitting this Application to the Connecticut Siting Council (Council or CSC) for the issuance of a Certificate of Environmental Compatibility and Public Need for the construction and operation of the Frost Bridge to Campville 115-kV Project, consisting of a new 115-kilovolt (kV) electric transmission line and associated facilities between Frost Bridge Substation in the Town of Watertown, Litchfield County and Campville Substation in the Town of Harwinton, Litchfield County, related modifications to Frost Bridge Substation and Campville Substation, and the reconfiguration of a short segment (0.4-mile) of two existing 115-kV transmission lines that are supported on common structures in the towns of Litchfield and Harwinton. The Project will upgrade the transmission system serving the Northwest Connecticut (NWCT) Sub-area so that it will comply with applicable mandatory reliability standards.

The public can obtain information about the Project in any of the following ways:

- The Project website at www.eversource.com
- By calling Eversource's toll free number 1-800-793-2202
- By emailing TransmissionInfo@eversource.com

B. STATUTORY AUTHORITY

Eversource is applying to the Council pursuant to Connecticut General Statutes Section 16-50g et seq.

C. LEGAL NAME AND ADDRESS OF APPLICANT

The Connecticut Light and Power Company doing business as Eversource Energy, with corporate offices at 56 Prospect Street in Hartford, Connecticut.

Mailing Address:

Eversource Energy
56 Prospect Street
Hartford, CT 06141-0270

D. APPLICANT'S CONTACTS

Correspondence and other communications with regard to the application are to be addressed to, and notices, orders and other papers may be served upon the following:

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E. QUANTITY, FORM, AND FILING REQUIREMENTS

1. **Quantity:** Per the Council's request, Eversource is providing one (1) original and fifteen (15) copies of this Application, as well as an electronic copy.
2. **Administrative Notice:** Eversource requests administrative notice of the following documents.

FEDERAL

- FEDERAL ENERGY REGULATORY COMMISSION, GUIDELINES FOR THE PROTECTION OF NATURAL, HISTORIC, SCENIC AND RECREATIONAL VALUES IN THE DESIGN AND LOCATION OF RIGHTS-OF-WAY AND TRANSMISSION FACILITIES (November 27, 1970)

REGIONAL

- ISO NEW ENGLAND, INC., OVERVIEW OF THE BULK POWER SYSTEM AND ISO NEW ENGLAND, ISO 101, October 1, 2014, *available at* http://isonewengland.org/static-assets/documents/2014/08/iso101-t1-isocore.pdf

- ISO NEW ENGLAND, INC., 2014 REGIONAL SYSTEM PLAN (November 6, 2014), *available at* http://www.iso-ne.com/trans/rsp/2014/index.html

- ISO NEW ENGLAND, INC., 2015 REGIONAL SYSTEM PLAN (November 5, 2015) http://www.iso-ne.com/system-planning/system-plans-studies/rsp

- ISO NEW ENGLAND, INC., FORECAST REPORT OF CAPACITY, ENERGY, LOADS & TRANSMISSION (CELT), May 1, 2013, *available at* http://www.iso-ne.com/trans/static-assets/documents//2013/05/2013_celt_report.pdf

- ISO NEW ENGLAND, INC., FORECAST REPORT OF CAPACITY, ENERGY, LOADS & TRANSMISSION (CELT), May 16, 2014, *available at* http://www.iso-ne.com/trans/static-assets/documents//2014/05/2014_celt_report.pdf

- ISO NEW ENGLAND, INC., FORECAST REPORT OF CAPACITY, ENERGY, LOADS & TRANSMISSION (CELT), May 1, 2015, *available at* http://www.iso-ne.com/trans/static-assets/documents//2015/05/2015_celt_report.pdf

- ISO NEW ENGLAND INC. TRANSMISSION, MARKETS AND SERVICES TARIFF (FORMERLY KNOWN AS FERC ELECTRIC TARIFF NO. 3). October 1, 2011, *available at* http://www.iso-ne.com/regulatory/tariff/sect_1/sect_i.pdf

- Northeast Power Coordinating Council, Inc. Regional Reliability Reference Directory #1, Design and Operation of the Bulk Power System. December 1, 2009 (replaced Document A-2), *available at* https://www.npcc.org/Standards/Directories/Directory%201_Design%20Ops%20BPS%20clean%20GJD%2020150331_GJD.pdf

- Northeast Power Coordinating Council, Inc. Regional Reliability Reference Directory #4, Bulk Power System Protection Criteria. December 1, 2009 (replaced Document A-5), *available at* https://www.npcc.org/Standards/Directories/Directory%204%20-%20System%20Protection%20Criteria%20Clean_20150331_GJD.pdf

STATE

Connecticut Siting Council

- CONNECTICUT SITING COUNCIL, ELECTRIC AND MAGNETIC FIELD BEST MANAGEMENT PRACTICES FOR THE CONSTRUCTION OF ELECTRIC TRANSMISSION LINES IN CONNECTICUT (Revised on February 20, 2014), *available at* http://www.ct.gov/csc/lib/csc/emf_bmp/emf_bmp_12-14-07_20080603083907.pdf

- CONNECTICUT SITING COUNCIL, DOCKET NO. F-2012/2013, REVIEW OF THE TEN-YEAR FORECAST OF CONNECTICUT ELECTRIC LOADS AND RESOURCES (December 12, 2013), *available at* http://www.ct.gov/csc/lib/csc/pendingproceeds/forecast_2012_2013/f2012_13_finalreport20131212.pdf

- CONNECTICUT SITING COUNCIL, WHITE PAPER ON THE SECURITY OF SITING ENERGY FACILITIES (October 8, 2009), *available at* http://www.ct.gov/csc/lib/csc/docket_346/whiteppr_final.pdf

- CONNECTICUT SITING COUNCIL, INVESTIGATION INTO THE LIFE CYCLE COSTS OF ELECTRIC TRANSMISSION LINES (November 15, 2012), *available at* http://www.ct.gov/csc/lib/csc/life_cycle_rfp/43714q1.pdf

- Letter from Robert Carberry, Project Manager, NEEWS Siting and Permitting, Connecticut Light & Power Company to Melanie Bachman, Acting Executive Director, Connecticut Siting Council regarding underground reconstruction of distribution line segments at transmission line road crossings, dated May 17, 2013.

Department of Energy and Environmental Protection

- CONNECTICUT COUNCIL ON SOIL AND WATER CONSERVATION, STATE OF CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION, CONNECTICUT GUIDELINES FOR SOIL EROSION AND SEDIMENT CONTROL, DEP BULLETIN 34 (May 2002, last revised September 2007), *available at* http://www.ct.gov/dep/cwp/view.asp?a=2720&q=325660&depNav_GID=1654

- STATE OF CONNECTICUT DEPARTMENT OF ENERGY AND ENVIRONMENTAL PROTECTION, THE CONNECTICUT STORMWATER QUALITY MANUAL (2004), *available at* http://www.ct.gov/DEP/cwp/view.asp?a=2721&q=325704&depNav_GID=1654#download

- CONNECTICUT DEPARTMENT OF ENERGY AND ENVIRONMENTAL PROTECTION, AMPHIBIANS AND REPTILES IN CONNECTICUT, Michael W. Klemens (2000), *available at* http://ctdepstore.com/Amphibians-and-Reptiles-in-Connecticut-101.htm

- PLANNING AND STANDARDS DIVISION, BUREAU OF WATER MANAGEMENT, CONNECTICUT DEPARTMENT OF ENERGY AND ENVIRONMENTAL PROTECTION, WATER QUALITY STANDARDS, (Surface Water Quality Standards Effective February 25, 2011 and Ground Water Quality Standards Effective April 12, 1996), *available at* http://www.ct.gov/deep/lib/deep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf

- Connecticut Air Quality Standards, Connecticut Dept. of Energy and Environmental Protection, Regs. Conn. State Agencies §§ 22a-174-24, et seq.

- Connecticut Noise Control Regulations, Connecticut Dept. of Energy and Environmental Protection, Regs. Conn. State Agencies §§22a-69-1, et seq.

Department of Public Health

- CONNECTICUT DEPARTMENT OF PUBLIC HEALTH, ELECTRIC AND MAGNETIC FIELDS (EMF): HEALTH CONCERNS FACT SHEET (April 2008), *available at* http://www.ct.gov/dph/lib/dph/environmental_health/eoha/pdf/emf_fact_sheet_-_2008.pdf

Other State Agencies

- STATE OF CONNECTICUT OFFICE OF POLICY AND MANAGEMENT, CONSERVATION AND DEVELOPMENT POLICIES PLAN FOR CONNECTICUT 2013-2018, July 30, 2013, *available at* http://www.ct.gov/opm/cwp/view.asp?q=383182

- STATE OF CONNECTICUT ENERGY EFFICIENCY BOARD, 2014 PROGRAMS AND OPERATIONS REPORT (MARCH 1, 2015), *available at* http://www.energizect.com/sites/default/files/uploads/Final%20ALR%202014%20Pages.2.26.15.pdf

- CONNECTICUT CLEAN ENERGY FUND, FY 2013– FY 2015 COMPREHENSIVE PLAN, *available at* http://www.ctcleanenergy.com/Portals/0/FY13%20Comprehensive%20Plan.pdf

- An Act Establishing Connecticut Heritage Areas, as amended, 2009 Conn. Acts 221 (Reg. Sess.), codified at Conn. Gen. Stat. §16a-27 (2010), *available at* http://www.cga.ct.gov/2009/ACT/PA/2009PA-00221-R00HB-06584-PA.htm

- State Plan of Conservation and Development, as amended, Conn. Gen. Stat. §§ 16a-27 to 16a-32a (2015).

TECHNICAL

- INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, IEEE STANDARD PROCEDURES FOR MEASUREMENT OF POWER FREQUENCY ELECTRIC AND MAGNETIC FIELDS FROM AC POWER LINES, IEEE Std 644-1994(April 30, 2013), *available at* https://sbwsweb.ieee.org/ecustomercme_enu/start.swe?SWECmd=GotoView&SWEView=Catalog+View+(eSales)_Standards_IEEE&mem_type=Customer&SWEHo=sbwsweb.ieee.org&SWETS=1192713657

- INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, IEEE GUIDE FOR THE DESIGN, CONSTRUCTION, AND OPERATION OF SAFE AND RELIABLE SUBSTATIONS FOR ENVIRONMENTAL ACCEPTANCE, IEEE Std 1127-1998 (Reaffirmed 2009) (December 5, 2009) (updated August 1, 2011), *available at* https://sbwsweb.ieee.org/ecustomercme_enu/start.swe?SWECmd=GotoView&SWEView=Catalog+View+(eSales)_Standards_IEEE&mem_type=Customer&SWEHo=sbwsweb.ieee.org&SWETS=1192713657

- AMERICAN NATIONAL STANDARDS INSTITUTE, NATIONAL ELECTRICAL SAFETY CODE, ANSI C2-2012. August 1, 2011.

ENVIRONMENTAL

- RICHARD M. DEGRAAF & DEBORAH D. RUDIS, NEW ENGLAND WILDLIFE: HABITAT, NATURAL HISTORY, AND DISTRIBUTION (University of Massachusetts Press, 1983), *available at* http://www.treesearch.fs.fed.us/pubs/4148

- ARAM J.K. CALHOUN & MICHAEL W. KLEMENS, BEST DEVELOPMENT PRACTICES: CONSERVING POOL-BREEDING AMPHIBIANS IN RESIDENTIAL AND COMMERCIAL DEVELOPMENTS IN THE NORTHEASTERN UNITED STATES, MCA TECHNICAL PAPER SERIES: NO. 5 (Metropolitan Conservation Alliance 2002), *available at* http://www.nae.usace.army.mil/Portals/74/docs/regulatory/VernalPools/BestDevelopmentPractices20Oct2014.pdf

- ARAM J.K. CALHOUN, et. al., *Conserving pool-breeding amphibians in human-dominated landscapes through local implementation of Best Development Practices*, WETLANDS ECOLOGY AND MANAGEMENT (2005), *available at* http://www.environmental-expert.com/Files%5C0%5Carticles%5C9373%5CConservingpool-breeding.pdf

MAPS

- NATURAL RESOURCES DIVISION, CONNECTICUT DEPARTMENT OF ENERGY AND ENVIRONMENTAL PROTECTION, ATLAS OF CONNECTICUT TOPOGRAPHIC MAPS, DEP BULLETIN 17 (1992), *available at* http://www.ctdepstore.com/Maps_c16.htm;jsessionid=1FF9EB902F8695DF048A7BD535715052.qscstrfrnt02

- CONNECTICUT FOREST & PARK ASSOCIATION, CONNECTICUT WALK BOOK WEST (Ann T. Colson, ed., 19th ed. 2006), *available at* http://www.ctwoodlands.org/connecticut-walk-book-west

- National Audubon Society, *Connecticut Important Bird Areas* (2015), *available at* http://ct.audubon.org/important-bird-areas-11

- United States Geological Survey, Connecticut Topographic Map Collection, *available at* http://magic.lib.uconn.edu/topographic_maps.html

MISCELLANEOUS

- United States Code of Federal Regulations Title 33, Clean Water Act, Sections 401 and 404.

- Conn. Gen. Stat. §16-243 and §§16-11-134, and 135 of the Regulations of Connecticut State Agencies.

- The Connecticut Light and Power Company, 2012 Forecast of Loads and Resources for the Period 2012-2021. March 1, 2012, *available at* http://www.ct.gov/csc/lib/csc/pendingproceeds/forecast_2012_2013/annual_reports/f2012-20120301-cl&p.pdf

- The Connecticut Light and Power Company, 2013 Forecast of Loads and Resources for the Period 2013-2022. March 1, 2013, *available at* http://www.ct.gov/csc/lib/csc/pendingproceeds/forecast_2012_2013/annual_reports_2013/cl&p_20130301.pdf

- The Connecticut Light and Power Company, 2014 Forecast of Loads and Resources for the Period 2014-2023. February 28, 2014, *available at* http://www.ct.gov/csc/lib/csc/pendingproceeds/forecast_2014_2015/2014documents/f2014-20140228-cl&p.pdf

- The Connecticut Light and Power Company, doing business as Eversource Energy, 2015 Forecast of Loads and Resources for the Period 2015-2024, March 2, 2015, *available at* http://www.ct.gov/csc/lib/csc/pendingproceeds/forecast_2014_2015/2015_documents/1_marchfilings/f-2014-2015-20150302_eversourcerpt.pdf

- The New England Energy Alliance, Electricity Transmission Infrastructure Development in New England Value through Reliability, Economic and Environmental Benefits. Polestar Communications & Strategic Analysis. December 2007, *available at* http://www.newenglandenergyalliance.org/

- World Health Organization, Electromagnetic Fields and Public Health, Exposure to Extremely Low Frequency Fields – Fact Sheet #322. June 2007, *available at* http://www.who.int/mediacentre/factsheets/fs322/en/index.htm

3. **Application Guide:** This Application is presented based on the Council's April 2010 *Application Guide for an Electric and Fuel Transmission Line Facility*, which is intended to assist applicants in filing for a Certificate from the Council for the construction of an electric or fuel transmission line as defined in Connecticut General Statutes § 16-50i (a) (1) and (2). Eversource also consulted Connecticut General Statutes §§ 16-50g through 16-50aa and §§ 16-50j-1 through 16-50z-4 of the Regulations of Connecticut State Agencies in preparing this Application. At the end of this section, Eversource has provided a reference table which acts as a directory between the Council's Application Guide and this Application. This table provides a summary of the Application Guide and identifies the corresponding section of the Application where the information is addressed.

4. **Pre-Application Process (General Statutes § 16-50*l*(e)):** Eversource consulted with representatives of each of the affected municipalities and municipalities having a border within 2500 feet of the proposed facility prior to distribution of the Municipal Consultation Filing (MCF) for the Project in September 2015. This MCF was provided to the Chief Elected Official of each of these municipalities, thereby commencing the municipal consultation period for this Application. During this time, Eversource sought input from the public and local government representatives regarding the Project, as presented in the MCF.

F. APPLICATION FILING FEES

(General Statutes § 16-50v(a); Application Guide § IV; General Statutes § 16-50*l*(a))

The filing fee for this Application is determined by the following schedule:

Estimated Construction Cost		Fee
Up to	$5,000,000	0.05% or $1,250.00, whichever is greater
Above	$5,000,000	0.1% or $25,250.00, whichever is less

Based on this schedule and the estimated construction cost for the Project of $51 million a check for the filing fee in the amount of $25,250 accompanies this Application. Eversource understands that additional assessments may be made for expenses in excess of the filing fee, and that fees in excess of the Council's actual costs will be refunded to Eversource. Pursuant to §16-50*l*(a)(3*)* and § 16-50bb, Eversource also encloses a check in the amount of $25,000.00 for the municipal participation fees.

G. PROOF OF SERVICE

(General Statutes § 16-50*l*(b))

This Application was served on the following:

- The chief elected official, the zoning commission, planning commission, the planning and zoning commissions, and the conservation and wetlands commissions of the site municipality and any adjoining municipality having a boundary not more than 2,500 feet from the facility;
- The regional planning agency that encompasses the route municipalities;
- The State Attorney General;
- Each member of the Legislature in whose district the facility is proposed;
- Any federal agency which has jurisdiction over the proposed facility;
- The State Department of Energy and Environmental Protection, Public Health, Economic and Community Development, Agriculture and Transportation; the Council on Environmental Quality; and the Office of Policy and Management.
- Other state and municipal bodies as the Council may by regulation designate, including but not limited to, the State Historic Preservation Officer of the Commission on Culture and Tourism and the Department of Emergency Management and Homeland Security.

Attachments to the cover letter accompanying the filing of this Application to the Council include the transmittal memos sent to these officials and agencies as well as a copy of the service list and an affidavit attesting that appropriate service was made.

H. NOTICE TO COMMUNITY ORGANIZATIONS
(Guide, § VIII)

The applicant made reasonable efforts to provide notice of this Application on the following:

- Affected community groups including Chambers of Commerce, land trusts, environmental groups, trail organizations, historic preservation groups, advocacy groups for the protection of Long Island Sound, and river protection organizations within the watershed affected by the proposed facility that have been identified by a municipality where the facility is proposed to be located, or those that have registered with the Council to be provided notice;
- Any affected water company within the watershed affected by the proposed facility.

Attachments to the cover letter accompanying the filing of this Application to the Council include a listing of the community groups and water companies to whom notice of this Application is being provided as well as the transmittal memo sent to these organizations and an affidavit that such notice was given.

I. PUBLIC NOTICE
(General Statutes § 16-50*l*(b))

Notice of this Application was published at least twice prior to the filing of the Application in newspapers having general circulation in the site municipalities. The notice included the name of the applicant, the date of filing, and a summary of the Application. The notice was published in not less than ten point type. Affidavits of publication are attached to the cover letter accompanying the filing of this Application to the Council.

J. NOTICE IN UTILITY BILLS
(General Statutes § 16-50*l*(b))

Notice of the proposed Project was provided to each Eversource customer located within the municipalities of the proposed route on a separate enclosure with each customer's monthly bill for one or more months not earlier than 60 days prior to the filing of this Application with the Council. This included all Eversource customers in the towns of Watertown, Thomaston, Litchfield, and Harwinton.

An affidavit attesting to delivery of the bill insert and a copy of the actual insert itself are attached to the cover letter accompanying the filing of this Application to the Council.

K. NOTICE TO OWNERS OF PROPERTY ABUTTING SUBSTATION SITES

(General Statutes § 16-50*l*(b))

Notice of the proposed modifications to the Frost Bridge Substation in Watertown, Connecticut and Campville Substation in Harwinton, Connecticut, was provided to abutters of each substation, respectively, via certified mail, return receipt requested. An affidavit regarding this notice is attached to the cover letter accompanying the filing of this Application to the Council.

L. APPLICATION DIRECTORY FOR COMPLIANCE WITH THE COUNCIL'S APPLICATION GUIDE FOR ELECTRIC AND FUEL TRANSMISSION LINE FACILITIES

The following table provides references to indicate where information requested in the Council's *Application Guide for Electric and Fuel Transmission Line Facilities* (April 2010) is located in this Application.

Cross-Reference between the Council's 2010 *Application Guide* and the Project Application

Council's Application Guide (Section No. and Summary Description)	Eversource Application (Section Reference)
General Applicants shall consult General Statutes §§ 16-50g through 16-50aa and Sections 16-50j-1 through 16-50z-4 of the Regulations of Connecticut State Agencies to ensure complete compliance with the requirements of those sections.	Application meets the intent of these state requirements.
I. Pre-Application Process **(General Statutes § 16-50*l* (e))** Requirements for municipal consultation and provision of information to the Connecticut Energy Advisory Board (CEAB).	Volume 1, Executive Summary, Sections 1 and 9
II. Form of Application **(Regs., Conn. State Agencies § 16-50*l*-2)** Review of information to be included in the application.	Volume 1, Application Formal Requirements and entire Application. (Application conforms to these document component requirements.)

Council's Application Guide (Section No. and Summary Description)	**Eversource Application (Section Reference)**
III. Filing Requirements (General Statutes § 16-50j-12) Review of requirements for submission of copies of application, bulk filings, application format, format for exhibits and sworn testimony, and requirements for CEAB "request for proposal" process, if applicable. All application fees shall be paid to the Council at the time an application is filed with the Council. Municipal participation fee.	Volume 1, Application Formal Requirements; overall application conforms to these requirements
IV. Application Filing Fees Proof of Service **(General Statutes § 16-50*l* (a) and Regs., Conn State Agencies § 16-50v-1a)** Filing fees shall be paid to the Council at the time the application is filed.	Procedural requirement, completed at Application submission to the Council
V. Municipal Participation Account (General Statutes § 16-50bb; § 16-50*l*(a)(3)) Each application shall be accompanied by a payment of $25,000 to be deposited in the Municipal Participation Account.	Procedural requirement, completed at Application submission to the Council
VI. Contents of Application **(General Statutes § 16-50*1*(a) (1) (A) and § 16-50p and § 16-50(o))** An application for a Certificate for the construction of a transmission line facility should include or be accompanied by the following:	Volumes 1 - 5
A. An executive summary	Volume 1, Executive Summary
B. A description of the technical specifications for the project, including design and cost information.	Volume 1, Section 3
C. A statement describing the need for the project.	Volume 1, Section 2; Volume 4
D. A justification for overhead portions, including life cycle cost studies comparing overhead alternatives with underground alternatives.	Volume 1, Section 3; Sections 10, 11, and 12
E. A program of dates showing the proposed program of ROW or property acquisition, construction, completion and operation.	Volume 1, Section 8

Council's Application Guide (Section No. and Summary Description)	Eversource Application (Section Reference)
F. Information for property within the proposed project area, including access roads and the proposed ROW and information regarding visual inspections from public ROWs of any project areas not accessible.	Volume 5
G. A proposed route map, at a scale no smaller than 1"=2,000 feet or a USGS topographic map and aerial photographs showing details of the ROWs and proximity to defined land use and environmental features.	Volume 5, Exhibits 1 and 2
H. A narrative description of the proposed transmission line and transmission line alternatives, including the following:	Volume 1, Sections 3, 5, 10, 11, and 12; Volumes 2 - 5
1. <u>Existing Conditions</u> a) The ecological communities of the wetlands, watercourses and upland systems, and their functional significance including, but not limited to:	Volume 1, Sections 5, 6 and 11; Volume 2; Volume 3, Exhibit 1; Volume 5, Exhibits 1 and 2
i. Floral associations;	Volume 1, Section 5 (5.1.3 and 5.2) and Sections 11 and 12; Volume 5, Exhibits 1 and 2
ii. Inventory of wildlife habitat with observed and expected wildlife users;	Volume 1, Section 5 (5.1.3, 5.2) and Sections 11 and 12; Volume 3, Exhibits 1- 3; Volume 5, Exhibits 1 and 2
iii. Species of Special Concern and rare or endangered species, including their habitats;	Volume 1, Sections 5, 6, and 11; Volume 3, Exhibit 3 (redacted); Volume 5, Exhibits 1 and 2
iv. Inventory of breeding birds and their habitats;	Volume 1, Section 5 (5.1.3, 5.2); Volume 3, Exhibit 2
v. Riparian environments and buffer vegetation; and	Volume 1, Section 5 (5.1.2, 5.2), Section 11; Volume 2; Volume 3, Exhibit 1; Volume 5, Exhibits 1 and 2
vi. Fishery habitat and cold water fisheries.	Volume 1, Section 5 (5.1.3, 5.2), 11, and 12; Volume 5, Exhibits 1 and 2
b) Existing infrastructure (where applicable):	Volume 1, Sections 3, 5.1.5, 5.1.6, 11 and 12; Volume 5
i. Existing ROW boundaries;	Volume 1, Section 3; Volume 5, Exhibits,1, 2, and 4
ii. Components of existing transmission line; and	Volume 1, Sections3, 11, and 12;

Council's Application Guide (Section No. and Summary Description)	Eversource Application (Section Reference)
	Volume 5
iii. Other improvements within existing and proposed rights-of-way.	Volume 1, Section 3; Volume 5, Exhibits 1, 2, and 4
2. <u>Proposed Conditions</u>	Volume 1, Sections 3, 4, and 6; Volumes 3 and 5
a. Areas of disturbance (temporary and permanent)	Volume 1, Sections 3, 4, 6, 11 and 12; Volume 5
b. Proposed construction staging areas, conductor pulling sites, material marshaling yards, and construction field offices	Volume 1, Sections 3 and 4; Volume 5, Exhibits 1 and 2
c. Proposed access roads and opportunities for alternative access	Volume 1, Section 4.1.5; Volume 5, Exhibits 1 and 2
d. Proposed structure location envelopes	N/A
e. Proposed blasting, grading, and changes to drainage	Volume 1, Section 4.3.2
I. Proposed route plans, at a scale no smaller than 1 inch = 100 feet, showing the existing conditions and certain proposed transmission line changes, expanding on the narrative descriptions in Section H. 1. <u>Existing Conditions</u> a. Identification of existing and proposed ROW boundaries;	Volume 5, Exhibit 2 Volume 5, Exhibit 2
b. Location of any existing transmission line structures and accessways;	Volume 5, Exhibits 1 and 2
c. Contour mapping at 2-foot intervals;	Volume 5, Exhibit 2
d. Inland and tidal wetlands boundaries, vernal pools, and intermittent and perennial watercourses, as determined in the field, unless existing mapping is adequate, with a 50 foot buffer shown for wetlands and a 100 foot buffer shown for vernal pools and watercourses;	Volumes 2, 3 (Exhibit 1), 5 (Exhibits 1 and 2)
e. Coastal Management Zone boundaries;	N/A
f. 100-year flood plain boundaries as identified by the Federal Emergency Management Agency;	Volume 5

Council's Application Guide (Section No. and Summary Description)	Eversource Application (Section Reference)
g. Locations of protected and special concern species;	Volume 1, Section 5.1.3 for narrative description. Locations of protected and special concern species not included on Volume 5 maps to protect species; only general NDDB locations are shown. Volume 3, Exhibit 3 includes Rare Species Report (redacted, not for public review).
h. Areas susceptible to soil erosion;	Volume 5, Exhibits 1, 2, and 4 (topographic contours and Plan and Profile drawings)
i. Habitat for protected and special concern species, including those represented by the CTDEEP Natural Diversity Data Base (confidential data provided in an appropriate manner); and	Refer to (g), above.
j. Fishery habitat and cold water fisheries.	Fishery habitat described in Volume 1 (Section 5.1.3); streams illustrated on the Volume 5 (Exhibits 1 and 2) maps
2. <u>Changes to existing conditions for the proposed transmission line</u>: a. Additional ROW width required, if any;	Volume 1, Section 3; Volume 5 maps and cross-sections (No additional ROW required)
b. Anticipated transmission line structure location envelopes;	N/A
c. Anticipated areas of disturbance (temporary and permanent);	Volume 5
d. Anticipated area of disturbance to an inland wetland buffer boundary or to an inland wetland;	Volume 5, Exhibits 1 and 2
e. Anticipated area of disturbance for material staging and conductor pulling sites;	Discussed in Volume 1, Section 4
f. Anticipated access roads and opportunities for alternative access;	Volume 5, Exhibits 1 and 2
g. Substation connections; and	Volume 1, Section 3.2; Volume 5, Exhibit 3
h. Other sensitive areas requiring special attention.	Volume 1, Sections 5.1.4, 5.1.7, 6.1.4, and 6.1.6; Volume 5, Exhibits 1 and 2

Council's Application Guide (Section No. and Summary Description)	**Eversource Application (Section Reference)**
J. Justification for the adoption of the route selected, including a comparison of alternative routes which are environmentally, technically, and economically practical. Justification for overhead portions of transmission lines, including comparative cost studies and a comparative analysis of effects described in Conn. Gen. Stat. § 16-50pl (a)(1)(A) and Section K (below) for undergrounding. Include enough information for a complete comparison between the proposed route and any alternative route contemplated	Volume 1, Sections 1, 2, 3, 10, 11, 12, and 13
K. A description of the effect that the proposed facility would have on the environment, ecology, and scenic, historic, and recreational values, including effects on:	Volume 1, Sections 4, 6, and 7
1. Public health and safety	Volume 1, Section 7
2. Local, state, and federal land use plans including energy security;	Volume 1, Sections 4.4.4, 5.1.4, 5.2, and Sections 6.1.4 and 6.2.5
3. Existing and future development;	Volume 1, Sections 5.1.4, 5.2, 6.1.4, and 6.2.5
4. Road and waterway crossings;	Volume 1, Sections 4, 5, and 6
5. Wetland crossings;	Volume 1, Sections 4 and 6; Volume 2; Volume 3, Exhibit 1
6. Wildlife and vegetation, including rare and endangered species, and species of special concern, with documentation by the CTDEEP Natural Diversity Data Base;	Volume 1, Sections 4 and 6; Volume 3, Exhibit 3, including NDDB correspondence (redacted); Volume 5, Exhibits 1, 2, and 3 (vegetation types and clearing limits)
7. Water supply areas;	Volume 1, Sections 6.1.2 and 6.2.2
8. Archaeological and historic resources, with documentation by the SHPO; and	Volume 1, Section 6.1.6, 6.2.6; Volume 3, Exhibit 4
9. Other environmental concerns identified by the applicant, the Council, or any public agency:	Volume 1, Sections 4, 5, and 6
Coastal Consistency Analysis	N/A
Connecticut Heritage Areas	N/A
Ridgeline Protection Zones	N/A

Council's Application Guide (Section No. and Summary Description)	Eversource Application (Section Reference)
Aquifer Protection Zones	Volume 1, Sections 5.1.2, 5.2, 6.1.2, and 6.2.2
DOT Scenic Lands	Volume 1, Sections 5.1.4 and 6.1.4; Volume 3, Exhibit 5
State Parks and Forests	Volume 1, Sections 5.1.3, 5.1.4., 6.1.3, 6.1.4; Volume 3, Exhibit 5; Volume 5, Exhibits 1 and 2
Agricultural Lands	Volume 1, Section 5.1.3, 6.1.3,; Volume 5, Exhibits 1 and 2
Wild and Scenic Rivers	N/A
Protected Rivers	N/A
Endangered, Threatened, and Special Concern Species	Volume 1, Sections 5.1.3, 5.2, 6.1.3 and 6.2.4; Volume 3, Exhibit 3 (redacted)
L. A statement explaining mitigation measures for the proposed transmission line including:	Volume 1, Sections 4 and 6
1. Description of proposed site clearing for access including type of vegetation scheduled for removal and quantity of trees greater than 6" diameter at breast height and involvement with wetlands	Volume 1, Sections 5.1.3, 6.1.3
2. Construction techniques designed specifically to minimize adverse effects on natural areas and sensitive areas;	Volume 1, Sections 4 and 6; Eversource BMP Manual for CT
3. Special routing or design features made specifically to avoid or minimize adverse effects on natural areas and sensitive areas;	Volume 1, Sections 3, 4, and 6; Volume 5
4. Justification for maintaining retired or unused facilities on the ROWs if removal is not planned;	N/A
5. Methods to prevent and discourage unauthorized use of the ROWs;	Volume 1, Section 4.1.9.3
6. Establishment of vegetation proposed near residential, recreational, and scenic areas; and at road crossings, waterways, ridgelines, and areas where the line would be exposed to view;	Volume 1, Section 4.4
7. Methods for preservation of vegetation for wildlife habitat and screening;	Volume 1, Sections 4, 6.1.3

Council's Application Guide (Section No. and Summary Description)	**Eversource Application (Section Reference)**
M. Safety and reliability information, including: 1. Provisions for emergency operations and shutdowns; and 2. Fire suppression technology.	Volume 1, Sections 4.4.3 and 4.4.4
N. Justification that the location of the proposed facility would not pose an undue safety or health hazard to persons or property along the area traversed by the proposed facility, including:	Volume 1, Section 7
1 Measurements of existing EMF at the boundaries of adjacent schools, daycare facilities, playgrounds, and hospitals (and any other facilities described in **Conn. Gen Stat. § 16-50*l*,** with extrapolated calculations of exposure levels during expected normal and peak normal line loading;	Volume 1, Section 7
2 Calculations of expected EMF levels at the above listed locations that would occur during normal and peak normal operation of the transmission line;	Volume 1, Section 7
3 A statement describing consistency with the Council's "Best Management Practices for Electric and Magnetic Fields", as amended; and	Volume 1, Section 7
4 A description of siting security measures for the proposed facility, consistent with the Council's "White Paper on the Security of Siting Energy Facilities", as amended.	Volume 1, Section 4.4.5, 4.5.4
O. A schedule of proposed program for ROW or property acquisitions, construction, rehabilitation, testing and operation.	Volume 1, Section 8
P. Identification of each federal, state, regional, district and municipal agency with which Proposed Route reviews have been undertaken or will be undertaken, a copy of each written agency position on such route, and a schedule for obtaining approvals not yet received.	Volume 1, Section 9
Q. Bulk filing of the most recent conservation, inland wetland, zoning, and plan of development documents of the municipality, including a description of the zoning classification of the site and surrounding areas, and a narrative summary of the consistency of the project with the Town's regulations and plans.	Narrative summary and maps in Volume 1, Sections 5 and 6; Volume 5, Exhibits 1 and 2 Bulk filing submitted separately

Council's Application Guide (Section No. and Summary Description)	Eversource Application (Section Reference)
R. Such information any department or agency of the state exercising environmental controls may, by regulation, require.	Volume 1, Sections 5 and 6; Volumes 2, 3, and 5
S. Pursuant to **Conn. Gen. Stat. § 16-50o**, the applicant shall submit into the record the full text of the terms of any agreement, and a statement of any consideration therefore, if not contained in such agreement, entered into by the applicant and any party to the certification proceeding, or any third party, in connection with the construction or operation of the facility. This provision shall not require the public disclosure of proprietary information of trade secrets.	n/a
T. Such information the applicant may consider relevant.	Application
VII. Proof of Service **(General Statutes § 16-50*l* (b))** Each application shall be accompanied by proof of service of such application on: A. The chief elected official, the zoning commission, planning commission, the planning and zoning commissions, and the conservation and wetlands commissions of the site municipality and any adjoining municipality having a boundary not more than 2,500 feet from the facility; B. The regional planning agency that encompasses the route municipalities; C. The State Attorney General; D. Each member of the Legislature in whose district the facility is proposed; E. Any federal agency with jurisdiction over the proposed facility; and F. The state departments of Energy and Environmental Protection, Public Health, Public Utilities Regulatory Authority, Economic and Community Development, Agriculture and Transportation; the Council on Environmental Quality; and the Office of Policy and Management; and G. Other state and municipal bodies as the Council may designate by regulation, including but not limited to the SHPO and the Department of Emergency Management and Homeland Security.	Procedural requirement, completed at Application submission to the Council; refer to Formal Requirements section in Volume 1

Council's Application Guide (Section No. and Summary Description)	Eversource Application (Section Reference)
VIII. Notice to Community Organizations The applicant shall use reasonable efforts to provide notice of the application on the following: A. Affected community groups including Chambers of Commerce, land trusts, environmental groups, trail organizations, historic preservation groups, advocacy groups for the protection of Long Island Sound, and river protection organizations within the watershed affected by the proposed facility that have been identified by the municipality where the facility is proposed to be located or that have registered with the Council to be provided notice; and B. Any affected water company within the watershed affected by the proposed facility.	Volume 1, Section 9 provides summary information; data filings related to the MCF are submitted separately as part of Application filing process; refer to Formal Requirements section in Volume 1
IX. Public Notice **(General Statutes § 16-50*l* (b))** Provide appropriate notice of the Application, pursuant to the Council's regulations. Notice must be published at least twice prior to the filing of the application, in a newspaper having general circulation in the site municipalities, and shall be in a format as specified by the Council's requirements.	Completed as part of Application submission process; refer to Formal Requirements section in Volume 1
X. Notice in Utility Bills **(General Statutes § 16-50*l* (b))** For electric transmission facilities, notice shall also be provided to each electric company customer in the municipality where the facility is proposed on a separate enclosure with each customer's monthly bill.	Completed as part of Application submission process; refer to Formal Requirements section in Volume 1.

The Application also includes the information required pursuant to General Statutes **§ 16-50j-59 (2012).**

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EXECUTIVE SUMMARY

ES.1 PROPOSED PROJECT PURPOSE AND LOCATION

The Connecticut Light and Power Company doing business as Eversource Energy (Eversource) proposes to construct a new 10.4-mile 115-kilovolt (kV) predominantly overhead[1] electric transmission line between its Frost Bridge Substation in the Town of Watertown and its Campville Substation in the Town of Harwinton, to make related improvements to both substations, and to reconfigure a short (0.4-mile) segment of two existing 115-kV transmission lines that are supported on common structures. These proposed electric transmission system improvements, referred to collectively as the Frost Bridge to Campville 115-kV Project (Project), are required to bring the electric supply system in northwest Connecticut into compliance with applicable national and regional reliability standards and criteria by eliminating potential thermal overloads and voltage violations identified in studies conducted by Independent System Operator New England (ISO-NE), the independent regional system planning authority.

The Proposed Route for the new 115-kV transmission line, which would cross portions of four towns in Litchfield County (Watertown, Thomaston, Litchfield, and Harwinton), would be located entirely within Eversource's existing 250-400-foot-wide transmission line right-of-way (ROW), adjacent to other overhead transmission lines. The ROW has been devoted to utility use for approximately 90 years.

Both Frost Bridge and Campville substations are located on Eversource property. The proposed substation modifications, as required to connect the new 115-kV line to the existing transmission system, would be on these properties, which also have been dedicated to utility use for decades.

Similarly, the 0.4-mile segment of the two existing transmission lines that would be reconfigured extends across the Naugatuck River (which forms the border between Litchfield and Harwinton), within the same ROW as the new 115-kV transmission line. Along this segment, Eversource proposes to remove the two lattice steel structures that currently support both of the existing overhead 115-kV transmission lines (designated by Eversource as the 1191 and 1921 Lines) at the river crossing, and to relocate each of the transmission circuits onto new steel monopole structures. With the proposed reconfiguration, each of

[1] An approximately 0.1 mile section of the new 115-kV line, located on Eversource property within and adjacent to the Frost Bridge Substation, would be installed as an underground cable.

these existing transmission lines then will be supported on its own set of structures for the entire distance between Frost Bridge and Campville substations (in the case of the 1191 Line) and between Thomaston and Campville substations (in the case of the 1921 Line), thereby further enhancing the reliability of the transmission system.

ES.2 THE CONNECTICUT SITING COUNCIL APPLICATION: ORGANIZATION AND CONTENT

The proposed Project is subject to the regulations of the Connecticut Siting Council (Council or CSC) and other state and federal regulatory agencies. Accordingly, Eversource submits this *Application for a Certificate of Environmental Compatibility and Public Need* (Application) to the Council. The Application consists of five volumes, as follows:

- **Volume 1** presents detailed information about the proposed Project, including the Proposed Route on Eversource property and within Eversource's existing ROW, transmission facilities design, construction and operation procedures, existing environmental conditions, potential environmental effects and mitigation measures, and electric and magnetic field (EMF) mitigation. In addition, Volume 1 identifies the alternatives considered to the proposed Project.
- **Volume 2** includes information concerning wetlands and water resources along the Proposed Route, including wetland delineation forms.
- **Volume 3** provides environmental reports concerning vernal pools, breeding birds, rare species, cultural resources, and visual resources, and also includes copies of agency correspondence concerning rare species (Note: Rare Species Report redacted to protect species locations).
- **Volume 4** consists of technical electric transmission system planning reports. Some of these reports have been redacted for public review to protect Critical Energy Infrastructure Information (CEII). Eversource expects to provide unredacted versions of these reports to the Council and to qualified participants in the Council proceedings regarding this Application pursuant to a protective order entered in accordance with the Council's procedures that preserve the confidentiality of CEII.
- **Volume 5** presents all Project maps and drawings, including a U.S. Geological Survey (USGS) map of the proposed Project, aerial photography based maps at scales of 1"=400' and 1"=100', Plan and Profile maps, as well as cross-sections, of the proposed transmission line, and drawings of the proposed substation modifications.

Eversource's Best Management Practices (BMP) Manual for transmission line construction and maintenance activities in Connecticut is not included in hard copy in this Application, but is available for download via the following link: http://www.transmission-nu.com/contractors/pdf/CT_BMP.pdf

ES.3 PROPOSED TRANSMISSION FACILITIES

New 115-kV Transmission Line. The proposed new 115-kV transmission line (designated by Eversource as the 1304 Line) would be located adjacent to existing Eversource overhead transmission lines, which presently occupy the ROW segments that extend between Frost Bridge and Campville substations.

Except for a short segment of underground cable on Eversource property at the Frost Bridge Substation, the proposed line would be overhead and would be supported on steel monopole structures in either a delta or a vertical configuration. The existing ROW is sufficiently wide such that the new monopoles would be installed without affecting the existing transmission lines (i.e., without requiring the relocation or rebuilding of existing structures). The new monopole structures would be weathering steel, with a typical structure height of 90 feet above ground for delta configuration structures and 105 feet above ground for vertical configuration structures, depending on terrain.

To exit the Frost Bridge Substation overhead while minimizing conflicts with existing overhead transmission lines and substation equipment, the new 115-kV line would exit the substation overhead to a transition structure immediately outside of the substation fence. The line would then transition to an underground configuration for approximately 0.1 mile. In this area, which is located entirely within Eversource property inside or directly adjacent to the substation fence, the 115-kV line will consist of a cross-linked polyethylene (XLPE) underground cable encased in a concrete duct bank. Directly outside of the western fence line, the 115-kV underground line will transition to an overhead configuration via a second new transition structure. To accommodate the new 115-kV line exit from the substation, one existing lattice tower located outside of Frost Bridge Substation that presently supports the 1191 Line will be removed and replaced with a steel monopole structure.

The length that the new 115-kV line would traverse through each of the four municipalities is as follows in Table ES-1:

Table ES-1: Length of Proposed 115-kV Line by Town

Town	Eversource ROW Characteristics	
	Length (Miles)	Width Range (Feet, Typical)
Watertown	4.7*	250 – 400
Thomaston	2.6	250
Litchfield	1.8	250
Harwinton	1.3	250
Total	**10.4**	

* Includes 0.1 mile underground on Eversource property at the line exit from the Frost Bridge Substation.

Separation of Existing 115-kV Double Circuit. Within Eversource's existing 250-foot-wide ROW at the Naugatuck River crossing between the Towns of Litchfield and Harwinton, the two 155-foot-tall lattice steel towers would be removed and the 1191 and 1921 Lines would be placed on separate vertical steel monopoles, each of which would be approximately 155 feet tall.

Substation Modifications. To interconnect the new 115-kV transmission line to the transmission grid, modifications are required to both Frost Bridge and Campville substations. At Frost Bridge Substation, all of the proposed modifications will be accomplished within the developed portion of the existing station. However, at Campville Substation, the modifications will require the expansion of the developed portion of the substation by approximately 0.4 acre, involving an extension of the existing station fence to the east by approximately 90 feet.

ES.4 CONSTRUCTION AND OPERATION / MAINTENANCE PROCEDURES

Eversource would construct, operate, and maintain the proposed transmission facilities in accordance with all regulatory approvals and its standard practices. Construction of the proposed facilities would be performed in several stages, some overlapping in time.

Transmission Line**:** The primary activities involved in the construction of the overhead transmission line would include the following:

- Survey to stake the vegetation clearing boundaries and proposed structure locations.
- Mark the boundaries of previously delineated wetland and watercourse areas, as well as areas to be avoided (e.g., sensitive cultural or environmental resource areas).
- Establish construction field office(s) and material staging sites (e.g., storage, staging and laydown areas) to support the construction effort. The preferred locations for such areas are typically in the vicinity of the ROW.

- Perform vegetation clearing along those portions of the ROW to be used for the construction of the transmission lines.
- Install erosion and sedimentation controls in accordance with best management practices.
- Construct new access roads (and/or improve existing roads) and work pads for structure and conductor installation.
- Construct foundations and erect/assemble new structures. (At the Frost Bridge Substation exit and at the Naugatuck River, remove the existing lattice steel structures and replace with new monopoles.)
- Install conductors and shield wires.
- Restore disturbed sites.

After the installation of the new 115-kV transmission line, Eversource would manage the ROW in accordance with its established vegetation management program.

Underground Transmission Cable Segment. The 0.1-mile segment of underground transmission cable would be installed by excavating a trench on Eversouce property, installing the concrete-encased duct bank, and then pulling the 115-kV XLPE cable into the duct. The cable trench would be backfilled and the area disturbed by cable construction would be stabilized with gravel within the substation and otherwise restored to low-growing vegetation (outside the substation).

Substation Modifications: The modifications to the two existing substations would involve standard construction procedures (e.g., site preparation, implementation of erosion and sedimentation controls, installation of foundations and equipment, and site stabilization with crushed stone or equivalent). The operation and maintenance of the substation modifications would not substantially affect or alter existing practices at these stations.

ES.5 ENVIRONMENTAL RESOURCES, POTENTIAL EFFECTS, AND MITIGATION MEASURES

Eversource conducted comprehensive research to compile existing baseline environmental data concerning the Project region, as well as field surveys to characterize the existing environmental resources along the ROW. Environmental information for the Project was compiled, mapped, and described in accordance with the Council's A*pplication Guide for an Electric Transmission and Fuel Transmission Line Facility* (April 2010).

Along the proposed transmission line ROW and at the substations, field investigations were performed to identify and characterize site-specific natural resources (e.g., soils, topography, wetlands, watercourses, vegetative communities, vernal pools and amphibian breeding habitats, breeding bird habitat), cultural resources, and visual resources. As a result of this baseline research and field studies, the Proposed Route is characterized in terms of the following principal environmental conditions, land-use features, and natural resources, among others:

- Existing transmission line ROW, transmission line structures, access roads, and substations
- Locations of Eversource-owned properties
- Vegetative community types
- Areas of steep slopes and rock outcrops
- Land uses, including agricultural, residential, commercial, and industrial areas
- Municipal boundaries and zoning classifications
- Federal and state jurisdictional wetlands, watercourse, and other waterbodies
- Floodplain boundaries
- Public recreational, scenic, open space, and other protected areas, including the Mattatuck State Forest, Black Rock State Park, Mattatuck Trail, Northfield Brook Recreation Area, Thomaston Dam recreational trails along the Naugatuck River, and other designated recreational trails
- Existing infrastructure, including roads and railroads

The environmental characteristics along the Project ROW and in the immediately surrounding region are also illustrated on the aerial-photography-based maps in Volume 5.

Using both the baseline environmental data and the plans for the development of the proposed Project, Eversource identified and analyzed the potential short- and long-term effects that the construction of the Project and operation of the resulting transmission facilities would have on the environment, ecology, and scenic, cultural (historic and archaeological), and recreational values. In addition, Eversource identified possible measures for avoiding, minimizing, or mitigating adverse effects. The avoidance, minimization, and mitigation of adverse effects to environmental resources, land uses, and cultural resources were key considerations in the Project planning process and will continue to be important during the finalization of Project design and the preparation of Development & Management (D&M) Plans.[2]

Based on current Project engineering plans, analyses of the existing environmental data, and the mitigation measures identified to date, the proposed Project would have localized and relatively minimal environmental effects. Specifically, the Project would:

- Result in minimal, short-term, and localized soil disturbance as a result of on-ROW construction activities and substation modifications.
- Have minor effects on wetlands and watercourses. Of the total 95 wetlands identified within the project area[3] and 104 new structures proposed, only one structure would be located in a wetland. A total of 58 watercourses (including waterbodies) were identified; however, no structures would be located within watercourses or waterbodies and no construction access would be required across larger rivers or streams.
- Avoid the placement of new transmission structures within a Federal Emergency Management Area (FEMA) designated 100-year flood zone or floodway.
- Convert approximately 48.9 acres of forested habitat (42.2 acres of forested upland and 6.7 acres of forested wetland) into shrub land.
- Be located near approximately 22 vernal pools.
- Use best management practices to minimize potential adverse effects on vernal pools and other sensitive resource areas.
- Result in incremental and generally localized visual effects associated with the installation of the new 115-kV overhead line along the existing ROW. The replacement of the double-circuit lattice steel structures at the Naugatuck River with steel monopoles could be viewed as a visual benefit.

In general, the proposed Project would minimize adverse environmental effects by collocating the new 115-kV transmission line along Eversource's existing ROW, adjacent to long-established overhead transmission lines, and by developing the proposed substation modifications on property that is already designated for utility use. Further, Eversource has identified measures that can be effectively applied to mitigate these effects to the extent practical.

[2] A D&M Plan is a condition of the Council's issuance of an approval to construct the Project. The Project D&M Plans would include specifications for Project construction, including environmental mitigation measures. It is anticipated that separate D&M Plans would be prepared for the substation and transmission line components of the Project.

[3] Of the 95 wetlands identified within the project area, 91 are located within ROW. The remaining four wetlands are located off-ROW and were identified as a result of their proximity to off-ROW access roads.

ES.6 EMF ANALYSES

As required pursuant to the Council’s 2014 Electric and Magnetic Fields (EMF) *Best Management Practices for the Construction of Electric Transmission Lines in Connecticut* (EMF BMP), Eversource calculated EMF along the Frost Bridge to Campville ROW associated with the existing transmission facilities, as well as the changes in EMF levels that can be expected once the new line is constructed and in-service. These calculations show that the addition of the new line will not substantially increase electric or magnetic fields at the edge of the ROW, and will decrease such levels in some locations, compared to existing conditions.

Pursuant to the guidance in the Council’s EMF BMP, the Council also requires an applicant proposing to build an overhead electric transmission line to develop and present a Field Management Design Plan (FMDP) that identifies design features to mitigate magnetic fields (MF) that would otherwise occur along an electric transmission ROW, particularly where the ROW is near certain land uses, such as playgrounds, residential areas, schools, and licensed day-care facilities. Accordingly, Eversource reviewed land use developments along the Frost Bridge to Campville ROW and identified three locations, referred to as “Focus Areas”, which merited further consideration in the Project’s FMDP. The three focus areas include a public baseball field in Veteran’s Memorial Park (Watertown), as well as portions of the ROW near residential areas in Thomaston (Walnut Hill Road vicinity) and Litchfield (Campville Road vicinity). The Project’s base overhead transmission line design already incorporates “no-cost” magnetic field reduction measures. Specifically, these measures include arranging the conductors in a compact triangular “delta” configuration and arranging the phases of the proposed 115-kV line to achieve better cancellation with the magnetic field from the existing overhead transmission lines.

Eversource reviewed other mitigation measures as part of the FMDP analyses; however, none represented “low-cost” options, and none would achieve substantial reduction of MF levels. Accordingly, Eversource does not recommend the use of additional MF mitigation techniques at any of the three Focus Areas.

ES.7 ALTERNATIVES CONSIDERED

The proposed Project is the result of a comprehensive evaluation process conducted by ISO-NE, Eversource, The United Illuminating Company, and others. This process began with a determination of the need for a solution to reliability issues in the northwest Connecticut region, then continued with the identification and analysis of alternative solutions for addressing the need, and concluded with the examination of specific alternative routes and route variations for the proposed transmission facilities. As a result of these analyses, the Proposed Route and proposed transmission line configurations were selected as the proposed Project.

The following types of alternatives were considered:

- **No Action Alternative**. Under this alternative, no action would be taken and the northwestern Connecticut electric transmission system would not be improved. The No Action Alternative was rejected because it would not resolve the identified regional electric reliability problems. Thus, the electric supply system in the region would not comply with national and regional reliability standards and criteria.
- **System Alternatives**. Following the evaluations of the need for the Project, transmission system alternatives that would potentially meet that need were identified and evaluated. The results of these analyses led to the selection of a 115-kV transmission solution that would connect Eversource's Frost Bridge and Campville substations. Although potential non-transmission system alternatives (e.g., generation, demand reduction) that could address the need served by the transmission solution were investigated, no practical non-transmission alternative was identified.
- **Overhead and Underground Transmission Line and Route Alternatives**. After a new 115-kV circuit between Frost Bridge and Campville substations was selected as the preferred transmission system solution, Eversource identified and evaluated potential routes and configurations for the new line. As part of this process, Eversource evaluated both overhead and underground transmission line designs, with potential alignments along various existing ROWs and "greenfield" corridors. All of the route alternatives were evaluated against standard Eversource objectives and criteria for overhead and underground transmission lines. The Proposed Route within Eversource's existing ROW, using an overhead transmission line design, was determined to be the preferred alternative. This alternative does not require the acquisition of any additional property or ROW, represents the lowest cost solution, and would avoid or minimize environmental and social impacts.
- **Potential Variations to the Proposed Transmission Line Route**. Because the proposed 115-kV line can be entirely accommodated within the existing ROW, only two potentially viable route variations were identified. These two route variations were identified during the alternatives analysis process and would involve different alignments and configurations to the portion of the Proposed Route exiting, in an underground cable configuration, from the Frost Bridge Substation. Because this substation presently connects to nine overhead transmission lines, Eversource carefully considered options for extending the new 115-kV line out of the substation, with the goal of avoiding potential conflicts with these lines and the proposed substation modifications. One variation would involve the use of an all- overhead configuration, exiting from the east side of Frost Bridge Substation, and then wrapping around the east and north sides of the substation fence before traversing west across Frost Bridge Road, State Route 8, and Echo Lake Road to connect to the Proposed Route within Eversource's ROW. The other Frost Bridge variation would consist of a combination of underground cable and overhead configurations. Under this option, the new 115-kV line would exit overhead to a transition structure immediately outside the substation fence and then would transition to underground crossing the substation. Immediately

outside the western edge of the substation, the line would transition back to an overhead configuration. Thereafter, the variation would follow the same route as the all-overhead variation, traversing west to the Proposed Route. After investigation, Eversource determined that the Proposed Route and the planned 115-kV line exit from Frost Bridge Substation was preferable to either of these route variations.

- **Potential Variations to the Proposed Transmission Line Configuration**.

  In addition to the route variations, alternative transmission structure configurations were investigated for the proposed 115-kV overhead line. Initially, these configuration analyses examined and compared the potential use of delta monopoles, vertical monopoles, or H-frame structures to support the new 10.4-mile transmission line. Taking into consideration constructability issues, environmental factors (e.g., amount of forest vegetation clearing), and cost, Eversource identified monopole structures as preferred. However, during the Municipal Consultation Filing (MCF) public outreach conducted as part of the Council's pre-filing process, landowners and local representatives in the Town of Thomaston requested that Eversource evaluate the use of H-frame structures instead of monopoles along a segment of the ROW. Specifically, the landowners suggested that 10 proposed monopole structures be replaced with 10 H-frame structures, which would be shorter and less visible above the adjacent tree line. After assessing this configuration design alternative, Eversource determined that compared to the proposed monopoles, the use of H-frame structures would result in greater environmental impact (additional forest vegetation clearing and disturbance to water resources), and also would be more costly. As a result, Eversource prefers the 115-kV overhead line design as proposed.

ES.8 COST AND SCHEDULE

The estimated capital cost of the Project is approximately $51 million. Project construction is anticipated to commence in the second quarter of 2017 with a scheduled In Service Date (ISD) of year end 2018.

ES.9 AGENCY AND MUNICIPAL CONSULTATIONS

The municipal consultation process for the Project involved both formal and informal consultations with federal, state, and local agencies and the public. Federal and state agencies consulted included the Connecticut Department of Energy and Environmental Protection, State Historic Preservation Office, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and National Park Service.

Pursuant to the Public Utility Environmental Standards Act, Connecticut General Statutes §16-50g et. seq., Eversource contacted representatives of the four towns in which the Project facilities would be located and, in early September 2015, submitted to the Chief Elected Officials of each town a five-volume MCF that described the proposed Project and identified alternatives. In addition, the MCF was similarly provided to the City of Waterbury and the Town of Plymouth; although not traversed by the proposed Project facilities, the boundaries of both of these municipalities are located within 2,500 feet of the portions of the Project.

The MCF also was posted online and available in town libraries. The purpose of the MCF process, which extended for 60 days in accordance with statutory requirements, was to both inform the towns and the public about the proposed Project and to solicit public and agency input regarding the Project.

During the 60-day MCF process, Eversource held open houses in the Project area on September 29 and September 30, 2015. These forums were designed to allow the public and municipal officials the further opportunity to review and provide input concerning the proposed Project. The Application incorporates responses, as appropriate, to such municipal and public input.

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1. DESCRIPTION OF THE PROPOSED PROJECT

1.1 PROJECT BACKGROUND

The Connecticut Light and Power Company doing business as Eversource Energy (Eversource or the Company) proposes to construct a new 10.4-mile 115-kilovolt (kV) predominantly overhead[4] electric transmission line between its Frost Bridge Substation in the Town of Watertown and its Campville Substation in the Town of Harwinton, and to make related improvements to both substations. In addition, within the same right-of-way (ROW) as the proposed new 115-kV transmission line, Eversource proposes to reconfigure a short (0.4-mile) segment of two 115-kV circuits (i.e., the 1191 and 1921 Lines) that are currently supported by common transmission structures so that each circuit will be supported by its own set of structures for the entire distance between Frost Bridge and Campville substations (in the case of the 1191 Line) and between Thomaston and Campville substations (in the case of the 1921 Line).

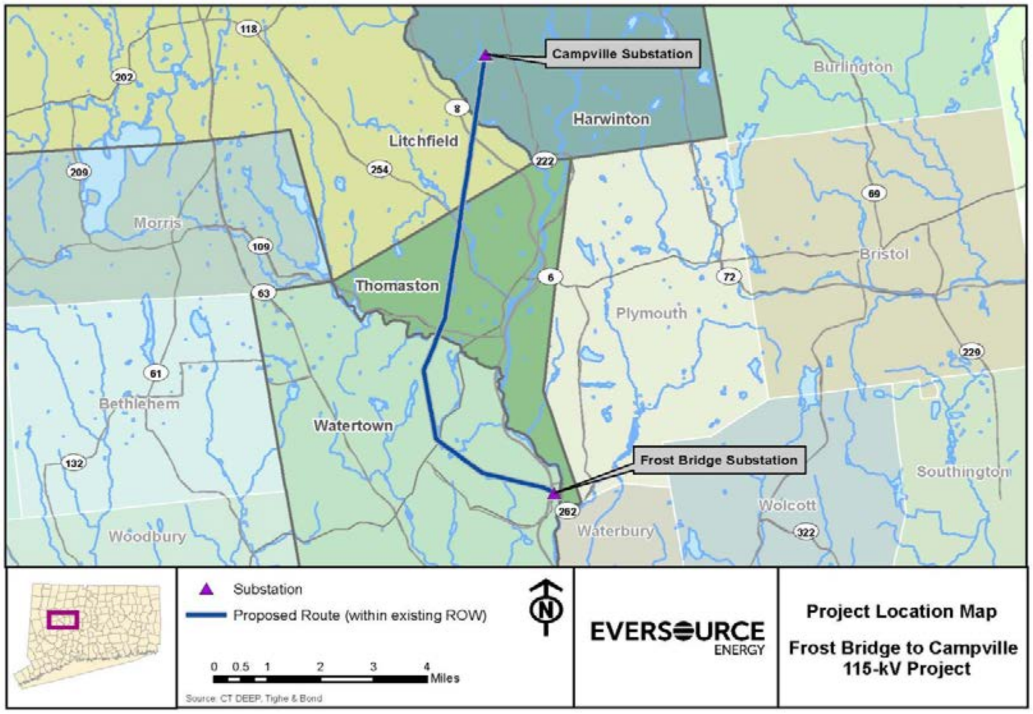
These proposed electric transmission system improvements, referred to collectively as the Frost Bridge to Campville 115-kV Project (Project), are required to bring the electric supply system in northwest Connecticut into compliance with applicable national and regional reliability standards and criteria by eliminating potential thermal overloads and voltage violations identified in studies conducted by Independent System Operator New England (ISO-NE), the regional system planning authority.

The proposed new 115-kV transmission line would cross portions of four towns in Litchfield County: Watertown, Thomaston, Litchfield, and Harwinton. The new line would be located entirely within Eversource's existing transmission line ROW. In addition, both Frost Bridge and Campville substations are located on Eversource property. The proposed modifications to these substations, as required to connect the new 115-kV line to the existing transmission system, would also be on Eversource property.

Figure 1-1 illustrates the general location of the proposed Project facilities; detailed maps of the Proposed Route and Project are provided in Volume 5. Eversource would construct, own, and operate the Project facilities, which are subject to the review and approval of the Connecticut Siting Council (Council or CSC). Accordingly, Eversource submits to the Council this *Application for a Certificate of Environmental Compatibility and Public Need* (Certificate) for the proposed Project.

[4] A 0.1 mile portion of the Proposed Route, located on Eversource property within and adjacent to Frost Bridge Substation, will be in an underground configuration.

Figure 1-1: Project Location Map



The facilities proposed for the Project were identified as a result of system planning studies and alternatives analyses performed by ISO-NE. After these studies determined a need for a new 115-kV transmission line in northwest Connecticut to improve system reliability[5], Eversource developed and analyzed potential alternatives before identifying the Proposed Route and a proposed overhead configuration for the new transmission line.[6] The primary objectives of this routing and configuration selection process were to identify Project facilities that could be constructed and operated to:

- Comply with state and federal statutory requirements, regulations, and siting policies
- Minimize adverse effects to natural and human resources
- Achieve a reliable, operable, and cost-effective solution

Based on these objectives, the principal factors considered in selecting the Proposed Route and overhead transmission line structure configurations were:

[5] In addition to eliminating reliability criteria violations, the proposed new 115-kV line also would have better voltage performance, would not adversely affect existing transfer limits; and would be cost-effective, compared to other system alternatives initially considered. Refer to the discussion of Project Need in Section 2, as well as to the systems alternatives analyses in Section 10.

[6] The alternatives analyses conducted for the Project are detailed in Sections 10, 11, and 12.

- Availability of existing ROWs within which the proposed facilities could be developed without the need for additional easement acquisition
- Avoidance or minimization of effects on environmental resources
- Avoidance or minimization of effects on significant cultural resources (archaeological and historical)
- Avoidance or minimization of effects on designated scenic resources
- Consideration of visual effects
- Constructability/engineering considerations
- Cost
- Maintenance of public health and safety
- Minimization of the need to acquire property
- Minimization of conflicts with developed areas

The Proposed Route and transmission line configurations best meet these criteria while representing Eversource's preferred solution for providing reliable, cost-effective, and environmentally sound improvements to the regional electric transmission system.

1.2 PROPOSED PROJECT FACILITIES

1.2.1 New 115-kV Transmission Line

Except for the 0.1-mile segment of underground 115-kV cable within and adjacent to the Frost Bridge substation[7], the proposed new 115-kV transmission line between Frost Bridge Substation and Campville Substation (referred to as the 1304 Line) would be constructed overhead, entirely within an existing Eversource ROW that ranges from 250 to 400 feet in width. No additional easements would be required for the Project, with the possible exception of off-ROW access road easements. The new line would be aligned within the ROW adjacent to Eversource's existing 115-kV overhead transmission lines, and, along a portion of the ROW in Watertown, an existing 345-kV overhead transmission line.

The ROW in which the new 115-kV transmission line would be located has been dedicated to utility use for almost 90 years. The existing Eversource transmission lines that presently occupy the Project ROW include:

7 The line exit at Frost Bridge Substation consists of a 0.1-mile underground line segment, which would be located entirely within the developed portion of the substation or on adjacent Eversource property.

- Frost Bridge Substation to Purgatory Junction (Town of Watertown): Line 1238 (115 kV), Line 1191 (115 kV), and Line 352 (345 kV);
- Purgatory Junction (Town of Watertown) to Walnut Hill Junction (Town of Thomaston): Line 1191;
- Walnut Hill Junction (Town of Thomaston) to Naugatuck River crossing (Towns of Litchfield and Harwinton): Line 1191 and Line 1921 (115 kV); and
- Naugatuck River crossing (Towns of Litchfield and Harwinton) to Campville Substation (Town of Harwinton): Line 1191 and Line 1921.

These existing overhead transmission lines are supported on various structure types, including delta and vertical steel monopoles, delta wood laminate, and delta wood monopoles, wood H-frames, and lattice steel towers.

Table 1-1 summarizes the length of the proposed 115-kV transmission line in each of the four towns along the Proposed Route, and the typical width of the existing Eversource ROW within which the proposed line would be located. The table also provides a key to the location of the Proposed Route as depicted on the aerial photograph mapsheets in Volume 5, and identifies the Cross-Section (XS) drawings in Section 3, Appendix 3A in this Volume and in Volume 5 that illustrate the proposed alignment and configuration of the new overhead line within each ROW segment.

Table 1-1: Proposed 115-kV Transmission Line ROW Segments: Miles, Width, and Cross-Sections (By Town and Volume 5, 400 Scale Mapsheet No. and Cross-Section Reference)

Town	ROW Characteristics		Volume 5, Exhibit 1, 400 Scale Mapsheet No.	Cross-Section (refer to Section 3, Volume 1, and Volume 5, Exhibit 4)
	Length (Miles)	Width Range (Feet, Typical)		
Watertown	0.1 (UG) 0.1 (OH) 4.5	Frost Bridge Substation exit 250 – 400	1 - 4	XS-1 (Underground Cable) XS-2, XS-3
Thomaston	2.6	250	4-7	XS-3, XS-4
Litchfield	1.8	250	7-8	XS-4, XS-5
Harwinton	1.3	250	8-9	XS-5, XS-6
Total	**10.4**			

Along most of the Proposed Route, the new overhead 115-kV transmission line would be supported on direct embedded monopole structures in a delta or vertical configuration. In certain locations, such as for angle or deadend structures, monopole structures in a vertical configuration on drilled shaft foundations will be used. The existing ROW is sufficiently wide such that the new 115-kV monopoles would be installed without affecting the existing transmission lines (i.e., without requiring the relocation or rebuilding of existing structures). The only exception is within the ROW directly west of Frost Bridge Substation, where an existing lattice tower that presently supports the 1191 Line (Structure 3080) will be removed and replaced with a steel monopole in order to make room for an adjacent new structure (Structure 2) to support the proposed 1304 Line (refer to the Volume 5 maps, Exhibits 1 and 2).

The new 115-kV line would exit the Frost Bridge Substation overhead to a transition structure immediately outside of the substation fence. The line would then transition to an underground configuration for approximately 0.1 mile. Directly outside of the western fence line, the 115-kV underground line will transition to an overhead configuration via a second new transition structure. Along the segment of ROW from the second new transition structure to Purgatory Hill Junction, the new 115-kV line structures would be aligned near the middle of the existing ROW, between the existing 345-kV (Line 352) and 115-kV (Line 1191) lines. Along the remainder of the Proposed Route, the new 115-kV line structures would be aligned east of an existing 115-kV line (i.e., east of the 1191 Line from Purgatory Hill Junction to Walnut Hill Junction, and east of the 1921 Line from Walnut Hill Junction to Campville Substation).

The new monopole structures would be weathering steel, with typical structure heights of 90 feet above ground for delta configuration and typically 105 feet above ground for vertical configuration, depending on terrain. Eversource’s preference for structure material is weathering steel, due to superior maintenance and constructability benefits.

1.2.2 Double Circuit Separation

Within Eversource’s existing 250-foot-wide ROW at the Naugatuck River crossing, two lattice steel towers (one on each side of the river) support both the existing 115-kV 1191 and 1921 Lines. As part of the Project, the two 155-foot-tall lattice steel towers would be removed and the 1191 and 1921 Lines would be placed on separate vertical monopoles, each of which would be approximately 155 feet tall. The 1191 Line (between the Frost Bridge and Campville substations) and the 1921 Line (between the Thomaston and Campville substations) would then each be supported on its own set of structures for its entire length.

1.2.3 Substation Modifications

To interconnect the new 115-kV transmission line to the transmission system, Eversource proposes to modify both Frost Bridge Substation and Campville Substation, as described below.

1.2.3.1 Frost Bridge Substation

Frost Bridge Substation, which is located in the southeastern portion of the Town of Watertown, occupies approximately 5.7 acres of a 128.5-acre property owned by Eversource. The substation is situated on the central-western portion of the parcel, east of and adjacent to Frost Bridge Road. The Eversource parcel is bordered by Frost Bridge Road and State Route 8 to the west; an inactive railroad and the Naugatuck River to the east; State Route 262 to the north; and open land and transmission line infrastructure to the south.

The Frost Bridge Substation property was acquired for utility use and the substation has been in operation for decades. Seven 115-kV and two 345-kV transmission lines presently connect to the Frost Bridge Substation.

To interconnect the new 115-kV line to Frost Bridge Substation, Eversource proposes the following modifications to the substation, which will all be located within the existing fenced area:

- Expand the existing one-position 115-kV bay to a two-position bay. The proposed 115-kV line would use an existing, vacant 115-kV transmission line-terminal position. Although a 115-kV line terminal structure exists, there is currently no transmission line exiting the substation in this position. The substation currently has four 115-kV bays, with a total of seven 115-kV lines exiting the substation.
- Install one new 115-kV circuit breaker and connect the new 115-kV transmission line to the existing vacant terminal structure position.
- Install one motor-operated disconnect switch, one ground switch, three lightning arrestors, three capacitor-coupled voltage transformers (CCVTs), and one wave trap. Appropriate junction boxes and yard control boxes would be installed and connected to a pre-existing conduit raceway for control cable.

1.2.3.2 Campville Substation

Eversource's Campville Substation is located in the southwestern portion of the Town of Harwinton and currently occupies approximately 1.65 acres of a 42.33-acre Eversource property. The Eversource property is bordered by Wildcat Hill Road on the west, Hayden Road on the south, and private property on the north and east. The substation property was acquired for utility use in 1926, with additional lands acquired in 1928 and 1936. The Campville Substation has been in operation for decades.

To accommodate modifications required to interconnect the new 115-kV transmission line, Eversource proposes to expand the substation's fenced area by approximately 0.4 acre. These modifications would require an extension of the substation fence by approximately 90 feet to the east to enclose the expansion area.

At Campville Substation, Eversource proposes the following Project modifications:

- Expand the existing ring bus to accommodate five new 115-kV breakers and one new transmission line-terminal position. The expansion would require the demolition of one existing breaker and the connection of the new equipment in its place. A new transmission line terminal structure would be required to connect the new 115-kV transmission line from Frost Bridge to the Campville Substation line position. In addition, another existing breaker would be shifted slightly to allow the installation of one new 115-kV circuit breaker adjacent to the relocated breaker.
- Install the new 115-kV line terminal structure, which would be approximately 60 feet tall. Install one motor operated disconnect switch, one ground switch, three lightning arrestors, three CCVTs, and one wave trap. Appropriate junction boxes and yard control boxes would be installed and connected to a new conduit raceway for control cable.
- Install four 115-kV disconnect switches, approximately 60 feet of aluminum tube conductor, six 115-kV breakers, one 60-foot-tall lightning mast, and steel support structures and foundations for all new equipment.
- Extend the existing substation ground grid, grading as necessary to manage stormwater flows, and install an extension of the substation fence.
- Install a new substation enclosure to house additional protection and control equipment. Augment the existing protection and control equipment in the existing substation enclosure to accommodate new substation equipment.

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2. PROJECT BACKGROUND AND NEED

This section explains how the Project was developed to upgrade the transmission system serving northwestern Connecticut so that it would comply with applicable mandatory reliability standards. The section first identifies the applicable reliability standards and reviews how they evolved as the North American electric supply system was developed, then summarizes the Greater Hartford Central Connecticut (GHCC) studies that identified the need for a group of projects to resolve reliability problems throughout four contiguous study areas in Connecticut, including in northwestern Connecticut; and finally describes how the improvements proposed in this Application will address reliability needs in northwestern Connecticut.

2.1 THE SYSTEM PLANNING PROCESS AND RELIABILITY CRITERIA

Maintaining continuity of service to customers has been the primary objective of electric utilities in North America since their very beginning. As electric supply systems have grown and become more complex, more interconnected, and increasingly critical to human welfare and a healthy economy, standards for ensuring continuity of service have become mandatory and more stringent, requiring the use of increasingly sophisticated analytical tools. Today, engineers using detailed and highly sophisticated and accurate computer models are able to evaluate the reliability of the existing interconnected transmission system and to plan modifications or additions needed to comply with those standards by simulating the performance of the existing system, as well as the system with proposed potential improvements to it. The following sections review the development of reliability planning standards and their current application.

2.1.1 A Brief History of Electric Reliability Planning

During the first half of the 20th Century, individual power systems each developed and applied their own planning criteria. By mid-century, however, with the dramatic growth of synchronous interconnections and the increasing use of the electric transmission system to move power over longer distances, utilities began to coordinate their planning activities.

When the Northeast Blackout of 1965 occurred, it became obvious that a more closely coordinated strategy was necessary. Shortly after the blackout, the electric utilities across North America formed regional reliability councils to promote and improve the reliability of the interconnected bulk power system. In northeastern North America, electric utilities formed the Northeast Power Coordinating

Council (NPCC) consisting of the six New England states, New York State, and the Canadian provinces of Ontario, Québec, New Brunswick, and Nova Scotia. The U.S. systems of the NPCC also formed two new power pools: the New England Power Pool, which eventually became ISO-NE, and the New York Power Pool, which evolved into the New York Independent System Operator (NYISO). Each regional reliability council established its own reliability criteria. Each also developed procedures for assessing conformance with these criteria. With time, individual electric utilities and power pools often developed their own more detailed and stringent planning and operating procedures to ensure the reliability of their portions of the interconnected bulk-power electric system; however, those procedures had to continue to comply with the broader regional criteria requirements.

In 1968, the U.S. regional reliability councils formed the National Electric Reliability Council (NERC) to coordinate their activities nationally and developed voluntary reliability guidelines for their collective systems. NERC has evolved over the years. In 1981, its name was changed to the North American Electric Reliability Council, to reflect the addition of Canadian members. But the most dramatic changes occurred in the wake of the August 14, 2003 Midwest/Middle Atlantic blackout. The Energy Policy Act of 2005 (EPAct) directed the Federal Energy Regulatory Commission (FERC) to establish an Electric Reliability Organization (ERO), whose major role would be to develop and enforce mandatory reliability standards for planning and operations. After a period of study, FERC designated NERC as the ERO, and its name was changed to the North American Electric Reliability Corporation, Inc.

2.1.2 Modern Reliability Standards and Criteria

The NERC standards today are subject to approval by FERC and are much more specific than they were in the past. Further, transmission owners' compliance is mandatory under federal law. Violations are punishable by fines as high as $1 million per day per violation. Regional reliability councils may have their own criteria, but these must conform to all NERC requirements – planning, system design and operations. Similarly, an ISO and individual electric systems may also have their own criteria and procedures, but they all must conform to both NERC standards and the regional criteria. Thus, in conducting planning studies, all transmission owners in New England are required to comply with NERC standards, NPCC criteria, and ISO-NE planning procedures. ISO-NE Transmission Planning Technical Guide, a copy of which is included in Volume 4, summarizes how these standards, criteria, and procedures are applied in planning the New England transmission system.

2.1.3 Simulating Contingencies

A key element of the reliability standards is the consideration of "contingency" events wherein generation and/or transmission facilities are assumed to suddenly and unexpectedly cease operating (trip out of service). Such contingency events could be caused by weather; by generator, transmission line, or substation equipment failures; by contingencies on other transmission systems connected to the New England transmission system; or by some combination of these factors.

NERC, NPCC, and ISO-NE standards, criteria and procedures specify the contingencies that must be considered in planning studies. The NPCC criteria and ISO-NE procedures must be consistent with all NERC standards. Thus, NPCC criteria may be more stringent than, but must as a minimum conform to, the NERC standards. Likewise, ISO-NE procedures may be even more stringent than, but must as a minimum conform to the NPCC criteria and NERC standards.

When a generating unit or a transmission line suddenly and unexpectedly trips out of service, power flows increase instantaneously on the transmission lines that remain in-service. (This is in accordance with the laws of physics as applied to electric power systems.) Consequently, an area's transmission system must be designed not only to transmit and/or import power required to offset anticipated generation deficits with all transmission facilities in service, but also must be capable of transmitting or importing power reliably following specific contingencies as required by the mandatory national standards and regional criteria. Otherwise, post-contingency power flows could exceed emergency transmission element ratings and/or result in low voltage conditions (below prescribed minimum levels) on portions of the electric system.

Because each transmission line must be able to carry the additional current that would instantaneously flow in the event of the sudden loss of a generating unit, transmission line, or other system element, normal power flows on transmission lines will typically be well below the thermal ratings of the line.

Contingencies, as specified by NERC, NPCC, and ISO-NE standards and criteria, are usually characterized as loss of a single system element – that is, a generator, transmission line, bus section, etc. Sometimes, however, a single contingency can result in the loss of two transmission elements, such as where two electric circuits share a common set of towers, forming a "double-circuit tower" (DCT) transmission line. Both of these types of events are referred to as "N-1" contingency events. Another type of contingency involves the occurrence of two separate and unrelated outages within a short period of time (30 minutes per NPCC criteria and ISO-NE procedures). These are referred to as "N-1-1" events.

When such a contingency event is simulated, reliability standards and criteria require an assumption that there will be sufficient time between contingency events for the system operator to implement specific "manual system adjustments" to the system before the second contingency event occurs.

Thus, the reliability standards and criteria applicable for the New England area (the Applicable Reliability Standards) require that in a planning study, after performing each of the required N-1 contingency analyses with all transmission facilities assumed to be initially in service, planning engineers test the ability of the system to be operated reliably with a key facility out of service. To do this, they apply a contingency; measure and document system performance prior to readjusting or reconfiguring the system (with "manual system adjustments"); then apply a second (unrelated) contingency; and then study the electric system's response. The criteria governing planning studies for the New England control area provide that, to make the system ready for the next contingency, only those manual adjustments that can be implemented within 30 minutes may be considered. These include adjusting the output of generation units, activating "quick start" generating reserves, and changing phase angle regulator taps.

To evaluate compliance with Applicable Reliability Standards, the specified contingencies are simulated on computer models developed to represent the power grid with expected future modifications and additions, operating with projected future loads. If the simulations show that currents on a transmission element will exceed its thermal ratings (a thermal overload), or that system voltages cannot be maintained within acceptable limits following one or more of the contingencies (a voltage violation), appropriate solutions must be developed and implemented in order to maintain the reliability of the electric grid.

Because years are required for the design, siting, engineering, and construction of major transmission improvements once they are recognized to be needed, transmission reliability studies are conducted by modeling expected future system conditions, including expected future generation resources, other planned transmission improvements, and projected future loads. A study year in the future is selected, and conditions expected for that year are modeled. ISO-NE uses a 10-year planning horizon; therefore, transmission reliability analyses consider system conditions expected 10 years in the future from the date a study is commenced are considered.

Modelling of the specific contingencies prescribed by the NERC standards for power-flow analyses identifies improvements that will protect the transmission system against the actual occurrence of those design contingencies. That is, should one of the specified contingency events occur, the remainder of the system would survive without a transmission element overload, an unacceptably low voltage condition, instability, cascading outages, system separation, or loss of firm customer load[8]. However, modeling of these specific contingencies does more than demonstrate how the power grid would perform should the specific events being modeled occur. The simulations also represent stresses that could result from multiple other potential events, some of which may not even be foreseeable at present. The objective of the simulations is not just to ensure that the system will withstand the specific contingencies defined by the standards, under the specific conditions modeled, but also to document that the system will be strong and robust enough to survive a wide range of potential events that could impose comparable stresses.

2.1.4 Generation Dispatches in Power-Flow Simulations

In accordance with the reliability criteria and procedures of NPCC and ISO-NE, the regional transmission power grid must be designed for reliable operation during stressed system conditions. Stressed conditions are simulated, in part, by developing generation dispatches. First, a base case that reflects the planners' expectation of likely generation resource availability in the study period is constructed. Resources may be assumed to be unavailable in the base case based on operating experience, announced retirement, or other reasons. Then, to simulate critical system conditions, at least the largest and most critical generating unit or station in the study area is assumed to be out of service (OOS), and usually two generation resources are assumed as OOS. Assuming generators are OOS in a base case addresses issues such as the following:

- Higher forced outage rates for generators than for other system elements
- Higher generator outages and limitations during stressed operating conditions such as a heat wave or a cold snap
- Past experience with simultaneous unplanned outages of multiple generators
- High cost of Reliability Must Run Generation
- Generator maintenance requirements
- Unanticipated generator retirements
- Fuel shortages

As with modelling contingencies, modeling existing generators as OOS in planning studies is not conducted simply to ensure that the system will be able to do without those generators in specific system conditions. This technique also tests the performance of the system under stresses that it may be required to withstand, whether from the unavailability of those specific generators or for other reasons.

[8] Firm customer load is also defined as uninterruptable service and is intended to be available at all times.

Generating units assumed to be unavailable or otherwise OOS should not be confused with the loss of a generating unit as a contingency, as described earlier. The former is a base case assumption – the system as represented before any contingency is applied. The latter is one of the many contingencies specified by the NERC, NPCC, and ISO-NE standards, criteria and procedures, which the pre-contingency system must be able to withstand without experiencing a transmission line or substation element overload, a low voltage condition, instability, cascading outages, system separation, or loss of firm customer load.

2.1.5. Coordinating Ongoing Studies

At any point in time there are numerous studies of the New England transmission system underway. The New England planning process requires study teams to communicate with other study teams to ascertain if the different teams have identified issues that may be addressed, in whole or in part, by a common solution, or if changes to the transmission system are being proposed that might impact their study. In order to ensure that needed improvements to the system will be identified and designed efficiently and cost-effectively, studies of area needs are sometimes combined and/or split apart as they proceed. As discussed in Section 2.2, development of the Project was done in coordination with the development of several other projects for the GHCC areas, as part of the GHCC studies; and as discussed in Section 2.2.3, the GHCC studies as a whole were conducted in coordination with studies of the Southwest Connecticut (SWCT) system needs.

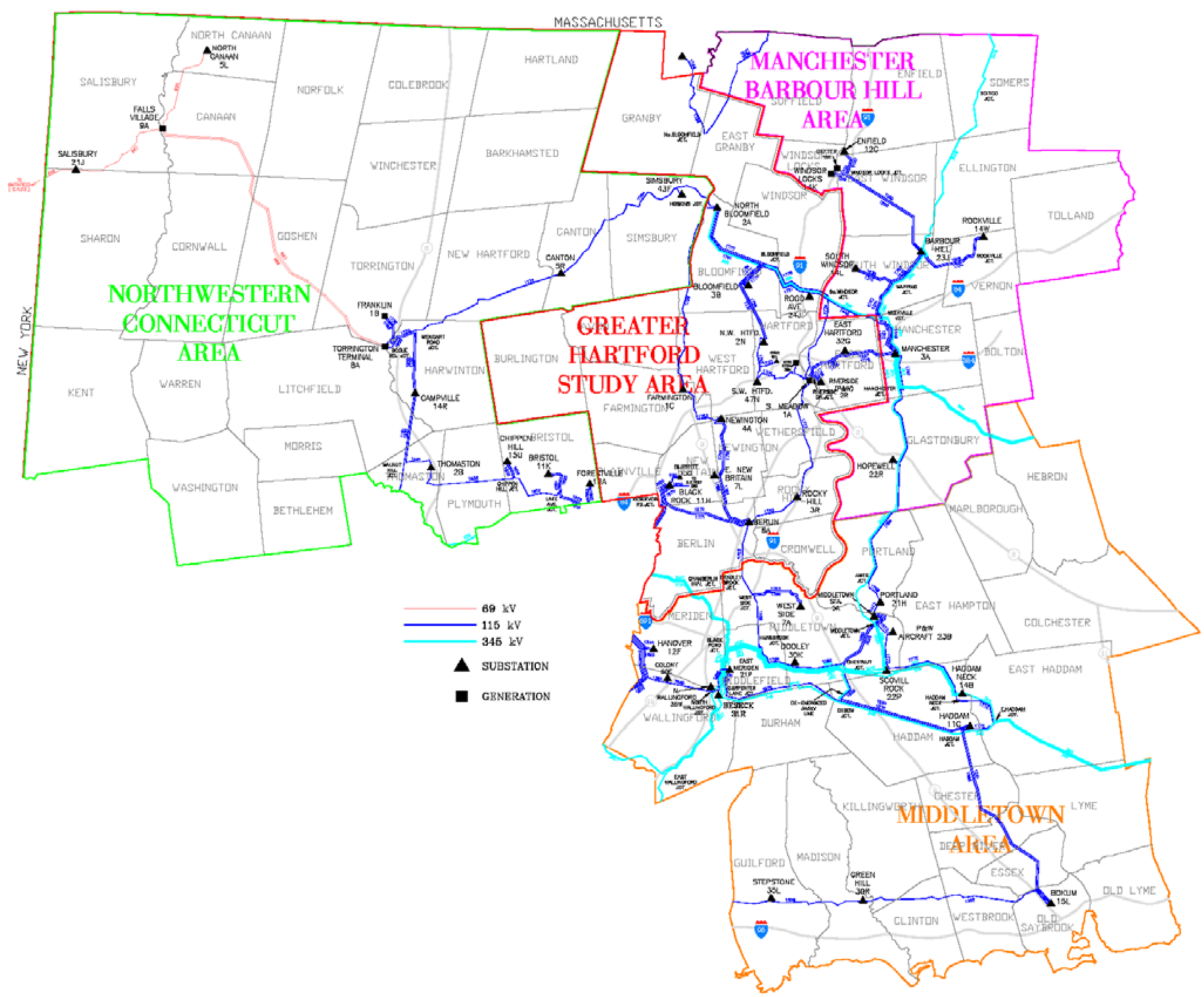
2.2 DEVELOPMENT OF THE PROJECT

The Project proposed is the product of more than nine years of planning studies. In 2005, ISO-NE identified potential future criteria violations on the 115-kV system in the Greater Hartford area in the course of early studies that ultimately resulted in the New England East-West Solution (NEEWS) Plan, a comprehensive set of 345-kV improvements to the Southern New England transmission system in Connecticut, Rhode Island, and Massachusetts. Initially, these 115-kV problems were considered as part of the NEEWS studies. However, in early 2010, ISO-NE removed 115-kV issues from the scope of the NEEWS studies and initiated the Greater Hartford Area Reliability Study. The Northwest Connecticut (NWCT) sub-area was initially treated as part of the Greater Hartford area for the purpose of this study. In early 2011, the geographical scope of the Greater Hartford Area Study area was expanded and the study was re-named to the Greater Hartford and Central Connecticut (GHCC) Area Study. In this expanded scope, the NWCT sub-area was considered separately from the Greater Hartford sub-area, and the study was combined with other ongoing studies into an assessment of load serving problems in four contiguous sub-areas:

- Greater Hartford
- Manchester – Barbour Hill
- Middletown
- Northwestern Connecticut

To conduct this study, ISO-NE formed a working group consisting of transmission planners from ISO-NE, from Northeast Utilities Service Company (now Eversource Energy Service Company), and from The United Illuminating Company. The combined study area is illustrated in Figure 2-1.

Figure 2-1: Greater Hartford Central Connecticut Study Area



In addition, an ongoing reassessment of the need for the Central Connecticut Reliability Project (CCRP), one of the four NEEWS 345-kV projects, was folded into the combined study. Periodically, the Working Group reviewed its methods, assumptions, and results with the ISO-NE Planning Advisory Committee (PAC).[9]

The GHCC studies proceeded to consider potential interdependencies in the load serving needs and potential solutions for the four sub-areas and ultimately determined that the solutions for the different sub-areas could be analyzed independently of one another, because the needs in each were largely driven by criteria violations following the loss of critical 115-kV sources into each sub-area. After many presentations to the PAC, ISO-NE published a final Needs Assessment in May, 2014 (the "*GHCC Needs Report*")[10]. Because the study scope and assumptions were finally determined in 2012, the study considered system needs in the study year of 2022, consistent with ISO-NE's 10-year planning horizon. After further presentations to the PAC, in early 2015 ISO-NE published a report identifying preferred solutions for the needs of the entire Greater Hartford and Central Connecticut study area, including the improvements in the NWCT sub-area proposed in this filing (the *GHCC Solutions Report*)[11]. After further detailed studies and review, and a positive recommendation by its Reliability Committee, ISO-NE issued a technical approval of the preferred GHCC solutions, including the NWCT improvements proposed in this filing, on April 16, 2015.

2.2.1 The Northwest Connecticut Sub-area

The NWCT electrical sub-area is the portion of the state bounded by the Massachusetts and New York state borders, and roughly by State Route 8 to the east and Interstate 84 to the south. It is bordered on the

[9] The ISO-NE PAC is an advisory committee open to all parties interested in regional system planning activities in New England. ISO-NE is required by its FERC-approved tariff to conduct an open and transparent planning process. Pursuant to this requirement, ISO-NE presents to the PAC the scope of work, assumptions, and draft results for its annual Regional System Plan and for supporting studies, including Needs Assessments and Solution Studies, and considers the comments of the PAC members in developing its final plans and recommendations.

[10] ISO New England, *Greater Hartford and Central Connecticut (GHCC) Area Transmission 2022 Needs Assessment* (May, 2014). A copy of this document, redacted to delete Critical Energy Infrastructure Information (CEII) that Eversource is required to keep confidential, is provided as part of Volume 4 of this Application. A complete copy is expected to be filed with the Council pursuant to its CEII filing procedure, and to be made available to qualified participants in the proceeding who subscribe to a CEII protective order entered pursuant to the Council's procedures for protection of CEII.

[11] ISO New England, *Greater Hartford and Central Connecticut (GHCC) Area Transmission 2022 Solutions Study,* February 2015. A copy of this document, redacted to delete Critical Energy Infrastructure Information (CEII) that Eversource is required to keep confidential, is provided as part of Volume 4 of this Application. A complete copy is expected to be filed with the Council pursuant to its CEII filing procedure, and to be made available to qualified participants in the proceeding who subscribe to a CEII protective order entered pursuant to the Council's procedures for protection of CEII.

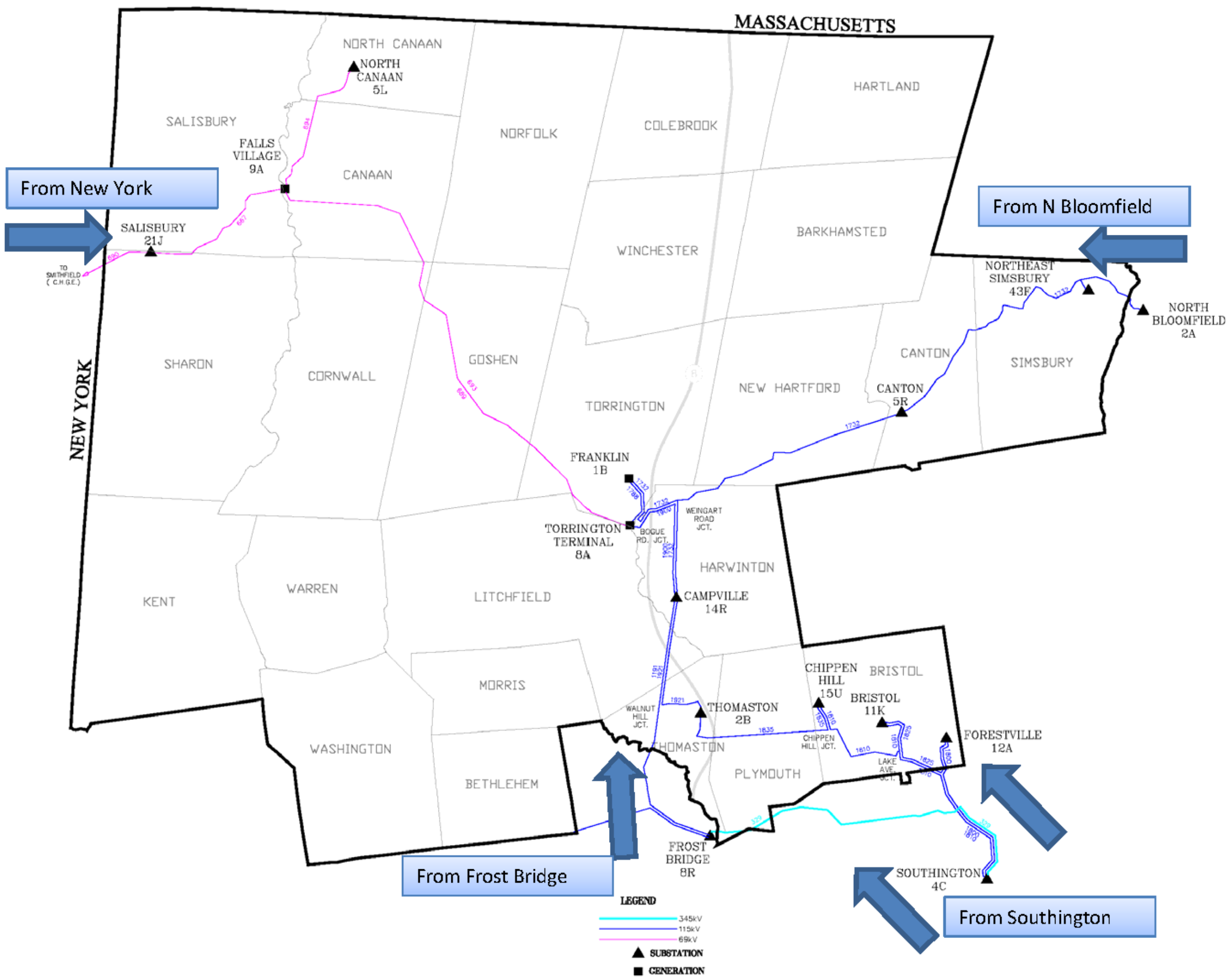
south by the SWCT sub-area. Specifically, NWCT includes the towns of Barkhamsted, Bethlehem, Bristol, Canaan, Canton, Colebrook, Cornwall, Goshen, Hartland, Harwinton, Kent, Litchfield, Morris, New Hartford, Norfolk, North Canaan, Plymouth, Salisbury, Sharon, Simsbury, Thomaston, Torrington, Warren, Washington, and Winchester. (However, the Frost Bridge Substation in Watertown is electrically within the SWCT sub-area).

The NWCT sub-area net load for 2022 after demand resources are subtracted is about approximately 509 megawatts (MW). The area has one generator at Forestville, which is classified as a regular unit and a hydro station (Falls Village). The sub-area also has two fast start generators in the City of Torrington at Franklin Drive and Torrington Terminal. NWCT is a net importer of energy and relies on the surrounding areas to serve local load. The major 115-kV lines that feed this sub-area are:

- Three 115-kV lines from the Southington Substation (1810 Line and 1800 Line)
    - 1800: Southington Substation (in Southington) to Forestville Substation (in Bristol)
    - 1810: Southington Substation to Chippen Hill Substation (in Bristol) and to the Bristol Substation
- A 115- kV line from North Bloomfield (1256 Line)
    - 1256: North Bloomfield Substation (in Bloomfield) to Northeast Simsbury Substation (in Simsbury)
- A 115-kV line from Frost Bridge Substation
    - 1191: Frost Bridge Substation in (in Watertown) to Campville Substation (in Harwinton)
- A 69-kV line from New York (690 Line)
    - 690: Smithfield Substation (in Smithfield, NY) to Salisbury Substation (in Salisbury)

Figure 2-2 is a geographic map of the sub-area, which shows the existing transmission facilities within the sub-area and, in some cases, line terminations outside of the sub-area.

Figure 2-2: Northwest Connecticut Sub-Area



2.2.2 The Need for Transmission Improvements in NWCT

The GHCC studies showed that there were criteria violations in the NWCT "load pocket." A load pocket is an area that has insufficient generation and/or transmission to serve its load. The electric system in the NWCT load pocket is subject to overloads when the system attempts to serve peak load under many contingent conditions.

2.2.2.1 Power-Flow Modeling Assumptions

The assumptions built into the power-flow modeling are set forth in detail in the *GHCC Needs Report.* In summary, the power flow study cases were derived from the ISO-NE model representing the New

England electric system, with selected upgrades to reflect relevant system conditions in 2022. All transmission projects with ISO-NE Proposed Plan Application approvals as of the April 2011 Regional System Plan Project listing were included in the base case. These projects included three NEEWS projects - the Greater Springfield Reliability Project (GSRP), the Rhode Island Reliability Project (RIRP) and the Interstate Reliability Project (Interstate). The CCRP was not included in the case, because the need for it was being reassessed as part of the study. New projects in Connecticut that were relevant to the study area were added to the base case as of the October 2013 project listing.

Both existing generation plants and new projects expected to be in-service during the study years, because they had accepted a Forward Capacity Market (FCM) Capacity Supply Obligation, were included in the study base case. All existing and proposed units that accepted a supply obligation in ISO-NE’s Forward Capacity Auction #7 (FCA 7) were included. FCA 7 was held in February 2013, and resulted in the purchase of resources to meet forecasted demand in 2016 – 2017. Certain generation units that were expected to retire imminently (and which have since retired) were assumed to be out of service. The units assumed to be OOS were Bridgeport Harbor 2, AES Thames, and Norwalk 1, 2 and 10. The planned Towantic Generating Station in the Town of Oxford, Connecticut was not included in the study because it was not entered in FCA 7.

In accordance with ISO-NE planning procedures, the modeled load was based on the 90/10 weather forecast for 2022 in ISO’s 2013 Capacity, Energy, Loads, and Transmission (CELT) load forecast. The forecast 2022 summer peak 90/10 was 34,105 MW. This load, adjusted to take system losses into account, was distributed across New England based on 2013 load distribution data. The forecast Connecticut load was 8,825 MW. Area loads were then adjusted downwards to reflect the effect of passive and active demand response measures committed in FCA 7 and predicted future energy efficiency measures that were expected to be implemented by 2022. Transfers of power into and out New England were modeled in accordance with applicable reliability criteria and standard practice. Finally, generator dispatch scenarios in each sub-area under study were constructed. In this set of studies, 22 dispatches were set up for the four study areas and for the assessment of the need to transfer power across from east to west. The dispatches were set up by taking out either one or two critical units in each sub-area studied. Four dispatches were designed for testing the NWCT sub-area: one set of cases assumed one area unit to be OOS and the other assumed two units to be OOS. For each case, two dispatches were created based on the dispatch of different fast start units within the area.

ISO-NE planning practice requires an assumption that approximately 20% of fast start generation will be OOS. Accordingly, one of the two fast start units was assumed OOS. In accordance with ISO-NE Planning Procedure #3, the output of generation in the study area and its vicinity was reduced following a first contingency if the re-dispatch would position the system so that a second contingency would not result in a violation.

2.2.2.2 Power-Flow Modeling Results – Thermal and Voltage Criteria Violations

Many thermal criteria violations were found in the GHCC study area for N-1 and N-1-1 contingency events. The detailed results are provided in the *GHCC Needs Analysis*. The NWCT sub-area had three transmission elements with N-1 thermal violations and five Pool Transmission Facilities (PTF)[12] buses with N-1 low-voltage violations. Under N-1-1 conditions, there were ten elements with thermal violations and 12 PTF buses with low voltage violations. Two 115-kV non-PTF buses had N-1-1 voltage violations. There were no N-0 thermal violations, but one 69-kV non-PTF bus had an N-0 base case voltage violation. The worst-case violations observed were for the loss of two or more import paths into the NWCT sub-area. Although the study year modelled in the *Needs Assessment Report* was 2022, the study showed that the improvements required to meet the identified needs should be constructed as soon as possible. ISO-NE calculates a "year of need" for system improvements by estimating when the "critical load level" (CLL) for which improvements are needed will be reached. The CLL is the demand level at which criteria violations begin to occur. Above this load level, the system needs to be expanded to continue to reliably support the demand. The *2012 Needs Assessment Report* found that the year of need for the NWCT sub-area improvements was 2013, because the Connecticut net load forecast for 2013 was 7,776 MW, whereas the modeled thermal overloads and low voltages occurred at load levels that were lower than 7,776 MW. Thermal violations began to occur at a 4,225 MW net load and low voltage violations began to occur at a 5,694 MW net load.

2.3 THE PROPOSED SOLUTION FOR THE NORTHWEST CONNECTICUT SUB-AREA NEEDS

The *GHCC Solutions Report* identified preferred solutions for the load serving problems documented in the *GHCC Needs Report* in each of the four load-serving sub-areas. Some of the solution elements were minor system improvements that have been or are being implemented independently of this application.

[12] "Pool Transmission Facilities are transmission facilities under the authority of ISO-NE. Generally, they are facilities that operate at or above 69 kV and are connected to other transmission lines or systems. The construction of new PTF facilities is generally funded through the ISO on a load ratio share among its member utilities.

The major elements of the solution, together with other improvements that are closely tied to them, are described in this document.

2.3.1 The Frost Bridge – Campville Line and Its Associated Terminal Equipment Improvements

The major element of the solution recommended for the NWCT sub-area was the addition of a new 115-kV overhead line from Frost Bridge Substation to Campville Substation, which also required the installation of associated terminal equipment. Since the worst thermal and voltage violations were observed for the loss of two sources that feed the NWCT load pocket, a new source into the area was needed. The preferred solution is to build this new 115-kV line, thereby bringing in a new source from a substation just outside the load pocket to the closest substation within the load pocket. See Figure 2-2. The addition of this new line into the sub-area both provides an additional system element to share the load that is automatically redistributed upon the failure of other system elements, and provides a source to help maintain continuity of supply to the load from external sources in such an event. With the new 115-kV line in place and with the use of re-dispatch after the first contingency, the flows on most system elements in the sub-area were reduced sufficiently so that they did not overload in the modeled N-1-1 contingencies. The terminal equipment associated with the installation of the new line will include the addition of five new circuit breakers at the Campville Substation, including two pairs in series, in order to eliminate problematic stuck breaker contingencies.

2.3.2 Separation of the 1191 and 1921 Lines at Naugatuck River Crossing

An existing 115-kV line (the 1191 Line) extends along the entire ROW between the Frost Bridge and Campville substations. Another 115-kV Line (the 1921 Line) extends from the Thomaston Substation to Campville Substation. At Walnut Hill Junction (approximately 3.9 miles south of Campville Substation), the 1921 Line enters the Frost Bridge to Campville ROW. From Walnut Hill Junction to the Campville Substation, the 1921 Line is located east of the 1191 Line. Except for a 0.4-mile segment, the two 115-kV lines are supported on separate sets of structures.

However, along the 0.4-mile segment of ROW at the Naugatuck River crossing (which forms the border between the towns of Litchfield and Harwinton), these two 115-kV lines are both supported on a single set of lattice steel structures (one on each side of the river crossing), thus comprising a double-circuit tower (DCT) line. The loss of both lines must therefore be modeled as a single contingency. Modeling of the existing system with the addition of the proposed new Frost Bridge to Campville line shows that, even with the new 115-kV line, certain design contingencies that include the loss of both the 1191 and 1921 lines will cause voltage violations on several area buses. Separation of the 1191/1921 DCT segment, which will result in each line being supported by its own set of structures for its entire length, together with the addition of a circuit breaker at the Campville Substation, eliminates these potential overloads. With the addition of the circuit breaker, each of the former DCT lines will be served by its own breaker. If both lines were served by a single breaker after being separated, they would both still be subject to loss from a single stuck breaker contingency.

2.3.3 Conformance to Long-Range Plan for Expansion of Electric Power Serving the State and Interconnected Utility Systems

FERC has charged ISO-NE with the responsibility for conducting long-term transmission system planning for New England. To discharge that responsibility, the ISO-NE continually assesses the needs of the entire New England bulk power system, through the preparation of annual Regional System Plans and long term studies. As explained in Section 2.2, the proposed Project is an outgrowth of the NEEWS studies, which began in 2006, and of the Greater Hartford area study that began in 2010. Ultimately, the need for the CCRP component of NEEWS and the load serving needs of the Greater Hartford, Manchester-Barbour Hill, Middletown, and NWCT sub-areas were examined together in the GHCC Needs Analysis. The grouping of these needs into a single study was to assure that co-ordinated and cost efficient solutions to the identified needs would be developed.

In parallel, ISO-NE has also been examining transmission needs in SWCT in 2022. The GHCC and SWCT studies have been coordinated so as to avoid redundant solutions. Together, the GHCC and SWCT studies identify solutions for Connecticut’s transmission system that will comply with applicable reliability requirements through 2022, and that form a part of the ISO-NE Regional System Plan for all of New England.

2.3.4 Identification of Facility in the Forecast of Loads and Resources

Pursuant to Section 16-50r(a) of the Connecticut General Statutes, concerning forecasts of electric loads and resources, transmission owners are required to file with the Council periodic reports that include, among other things, a list of planned transmission lines for which route reviews are being undertaken or for which certificate applications have already been filed, and a decription of the steps taken to upgrade existing facilities. For instance, in its March 1, 2012 report, the Company advised the Council that the ongoing *GHCC Needs Assessment* was considering needs in NWCT. Eversource announced its intention to build the Frost Bridge to Campville 115-kV line in the first forecast report that it filed after ISO-NE identified the line as a preferred solution in July 2014. That forecast report was filed on March 2, 2015.

In the report, Eversource included the Frost Bridge to Campville line in its list of "Proposed Transmission Line Projects."

2.4 CONCLUSION

The Project is the product of years of careful study of reliability needs in the NWCT sub-area, coordinated with studies of needs in the Greater Hartford, Manchester-Barbour Hill, and Middletown sub-areas, and with those of SWCT. The Project will address violations of reliability criteria identified in these studies, and will assist Eversource in the discharge of its obligation to maintain the reliability of the Connecticut bulk transmission system in accordance with mandatory federal and regional standards and criteria.

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3. TECHNICAL PROJECT SPECIFICATIONS

This section describes the technical specifications for the Project, including:

- The proposed 0.1-mile 115-kV underground transmission cable exit at Frost Bridge Substation;
- The replacement of one lattice structure that presently supports Eversource's existing 1191 115-kV transmission line to the west of Frost Bridge Substation;
- The new 115-kV overhead transmission line along the Proposed Route between Frost Bridge Substation and Campville Substation;
- Separation of two existing Eversource 115-kV transmission lines at the Naugatuck River crossing by replacing two existing lattice steel transmission structures with new monopole structures; and
- Modifications to Eversource's existing Frost Bridge and Campville substations.

The technical information provided for the Project includes:

- Conductor size and specifications
- Cable system design, including conductor size and specifications;
- Overhead structure design, appearance, and height
- Route length, by municipality, and terminal points
- Initial and design voltages and capacities
- ROW and proposed on- and off-ROW access roads
- Proposed work pad locations (i.e., as needed for structure installation, conductor/OPGW pulling, guard structures)
- Proposed structure locations
- Removal and replacement of the existing 115-kV transmission line facilities at the Naugatuck River crossing
- Substation connections and proposed modifications
- Estimated capital (construction) and life-cycle costs

3.1 PROPOSED TRANSMISSION LINE FACILITIES

The proposed 115-kV transmission line, designated as the 1304 Line, would extend for approximately 10.4 miles, and would be aligned adjacent to other existing 115-kV and / or 345-kV transmission lines, as summarized in Table 3-1. The new 115-kV line would be located such that sufficient space exists between the proposed and existing lines for safe and reliable line operations.

Table 3-1: Existing Transmission Lines Sharing ROW with the Proposed 115-kV Transmission Line

Eversource Existing Transmission Line Number	Line Location Description	Line Voltage / Structure Type
352	Frost Bridge Substation to Purgatory Junction	345 kV (Wood H-Frame)
1238	Frost Bridge Substation to Purgatory Junction	115 kV (Vertical Lattice Tower/Steel Monopole)
1191	Frost Bridge Substation to Campville Substation	115 kV (Lattice Tower/Wood H-Frame)
1921	Walnut Hill Junction to Campville Substation	115 kV (Delta Laminate Monopole)

The Proposed Route for the new transmission line would be located entirely within an existing Eversource ROW that ranges in width from approximately 250 to 400 feet or on Eversource fee-owned land. Of the 10.4 miles, approximately 1.3 miles of the Proposed Route would extend across property that Eversource owns.

The proposed underground 115-kV transmission system line exit at Frost Bridge Substation, which would extend for approximately 0.1 mile, would consist of a single-circuit XLPE cable system, which would be contained within a concrete-encased duct bank (consisting of several polyvinyl chloride [PVC] conduits), as well one concrete splice vault. A splice vault is required to stage the installation (pulling) of the transmission cable through conduits, to accommodate activities required to splice together the cable sections, and to provide access to portions of the cable system to perform maintenance and repair activities. The splice vault would be located on Eversource property.

In addition to the transmission line cable, three fiber optic cables would be installed in the duct bank. Two fiber optic cables are required for remote protection and control of the cable system and associated equipment, while the other fiber optic cable is for monitoring the operating temperature of the cables. A ground continuity conductor also would be installed to ground the cable sheaths and equipment within the splice vault. The fiber optic cables would be spliced and pulled into a pre-cast handhole located near the splice vault.

Eversource proposes to install the underground cable system within Eversource owned property as shown in Volume 5. The exact location of the cables and the splice vault would be determined based on final engineering design, taking into consideration the constraints posed by existing buried utilities and the location of other physical features.

3.1.1 115-kV Conductor and Cable Size and Specifications

The following describes the design of the proposed 115-kV transmission line. More detailed transmission line design information will be provided in the Development and Management (D&M) Plans for the Project. A D&M Plan is required by the Council subsequent to receipt of a Certificate and prior to the Council's approval for construction to proceed. Eversource anticipates that two D&M Plans would be prepared for the Project: one for the transmission line and one for the substation modifications.

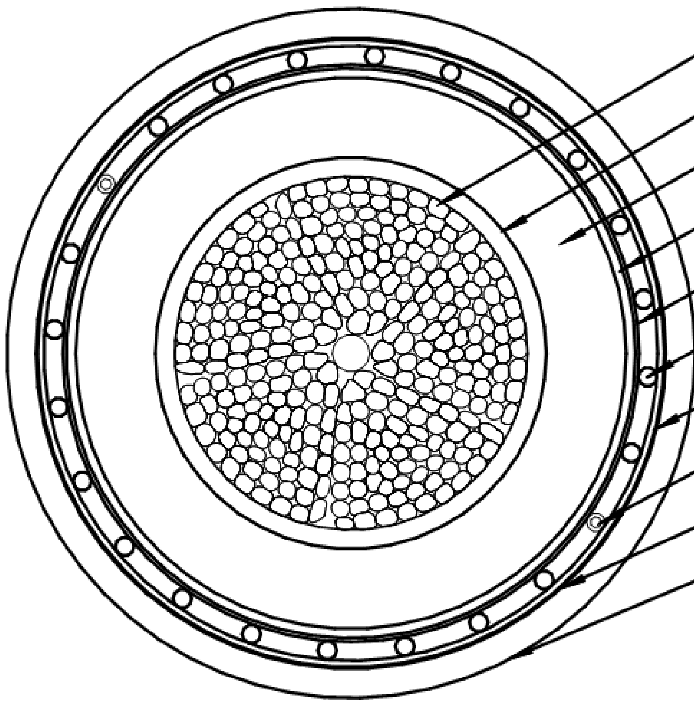
Overhead Line. The new overhead 115-kV transmission line would consist of three sets of phase conductors. Each set is comprised of one 1,590,000 circular mil (1,590-kcmil) Aluminum Conductor Steel Supported (ACSS). This selection is a standard Eversource conductor utilized for new 115-kV line construction.

The new line would be protected by two overhead lightning shield wires[13]. One of the overhead shield wires would also contain optical glass fibers for communication purposes (also referred to as Optical Ground Wire or OPGW). The other lightning shield wire would be conventional 19 No. 10 Alumoweld.

Underground Cable Segment. The Project's 0.1 mile single-circuit 115-kV underground transmission system for the line exit at Frost Bridge Substation would consist of three cables, or phases. Each phase of the circuit would consist of one 5000-kcmil copper-conductor cable insulated to 115 kV with approximately 1.4 inches of XLPE insulation. Each cable would be approximately 4.7 inches in diameter. Figure 3-1 provides a cross-section of a typical 5000-kcmil copper-conductor XLPE 115-kV cable.

[13] The line segment from Frost Bridge Substation to Purgatory Junction (XS-2) would be protected by only one shield wire containing optical glass fibers for communication purposes.

Figure 3-1: Typical 5000-kcmil Copper Conductor 115-kV Cable Cross-Section



Three electric cables would be installed in PVC ducts encased in concrete. Smaller conduits would also be installed for the communications, temperature monitoring, and ground continuity cables. Volume 5 illustrates a typical underground duct back cross section (XS-1). The power cables would be installed one cable per duct. One of the ducts will be unoccupied and would be available for the installation a replacement cable in the event of a failure of one of the other cables or damage to one of the other ducts.

Splice Vault

The underground XLPE cable system line exit at Frost Bridge Substation would be installed in two sections, due to limitations such as the maximum allowed pulling tension (while installing the cable in the conduit) and maximum allowed side wall pressure (while pulling the cable into the conduit). The splice vault consists of reinforced concrete.

The splice vault size and layout is determined by the space required for cable pulling, cable splicing, and supporting the cable in the vault. The outside dimensions of the splice vault for the Project are expected to be approximately 24 feet long by 8 feet wide and 8 feet high. The top of the splice vault would be installed at a minimum of 30 inches below grade with two access holes, or manhole covers, each approximately 36 inches in diameter.

3.1.2 Proposed Line Overhead Design, Appearance, and Heights

New 115-kV Transmission Line

The new 115-kV transmission line would be located entirely within an existing Eversource ROW. The ROW is occupied by an existing 115-kV transmission line (i.e., the 1191 Line) and, in locations, other 115-kV lines and a 345-kV line (i.e., the 352 Line, 1238 Line, and 1921 Line; refer to Table 3-1). The existing structures that support these transmission lines consist of wood H-frames, laminated and steel monopoles, and steel lattice towers.

The existing 115-kV 1191 Line is supported primarily on wood-pole H-frame structures with a typical height of approximately 60 feet. The 345-kV 352 Line, which occupies the ROW between Frost Bridge Substation and Purgatory Junction, is also supported on wood-pole H-frame structures; the 345-kV structures have a typical height of about 80 feet.[14]

The existing 115-kV 1238 Line and the 115-kV 1921 Line are supported on steel and wood laminate monopoles, respectively. The 1238 Line is arranged in a vertical configuration with typical structure heights of about 95 feet, whereas the 1921 Line is configured in a delta design and is characterized by typical structure heights of approximately 75 feet.

Steel lattice tower structures support the existing lines along the ROW in two locations:

- Along an approximately 0.3-mile segment of the ROW from Frost Bridge Substation, northwest across State Route 8 (Town of Watertown), the 1238 and 1191 Lines are supported on steel lattice towers that are approximately 100 and 110 feet in height, respectively.
- On each side of the Naugatuck River crossing in the towns of Litchfield and Harwinton, the existing 1921 and 1191 Lines are supported by double circuit steel lattice towers. These towers (one on each side of the river) are approximately 155 feet tall.

[14] Wood H-frame tangent structures, which are the predominant type of structure along the existing 1191 Line and 352 Line, have two poles. However, within the H-frame "family" of structures, three-pole structures are used at angle points (turns in the ROW). Refer to Appendix 3B, found at the end of this section, for further information.

As illustrated on the Volume 5 maps, most of the new transmission line structures would generally be placed near or adjacent to existing line structures. However, in certain locations, new structure sites were shifted to avoid sensitive environmental or cultural areas, to address constructability and design issues, or to minimize potential impacts to property owners.

Along 10.3 miles of the 10.4-mile Proposed Route, the new 115-kV transmission line would be installed on weathering steel monopoles. The proposed structure design and configuration for the new 115-kV line would typically be direct-buried tubular steel monopoles in a delta or vertical configuration, with a typical height of about 90 feet (for delta) and 105 feet (for vertical). Self-supported vertical tubular steel monopoles would be used at angle points and as deadend structures, with a typical height of approximately 105 feet.

Delta deadend tubular steel structures would be used to support the new 115-kV transmission line crossing of the Naugatuck River. The new 1304 Line structures on each side of the river would be approximately 155 feet in height, the same height as the existing steel lattice tower structures that presently support the double-circuit (1191 / 1921 Lines) crossing of the river.

Cross-sections drawings depicting the typically proposed structure types and general location in relation to the existing structures along each ROW segment are included in Appendix 3A, located at the end of this section.[15] Although the cross-sections illustrate the typical proposed structures, in certain locations along each ROW segment (such as at turns [angles] in the ROW), structures of the same type (e.g., monopole), but with slightly different appearance would be used. Appendix 3B (also found at the end of this section) provides illustrations of the family of structure types that Eversource uses in steel-pole lines with delta or vertical conductor configurations, as well as for lines with H-frame configurations. In addition, Appendix 3B provides an illustration of the underground to overhead transition structure type to be used for the 0.1-mile underground segment outside Frost Bridge Substation.

<u>Modifications to Existing Facilities: Removal and Replacement of 1191 Line Structure</u>

The replacement structure for the existing 110-foot-tall lattice tower (Structure 3080) that supports the 1191 Line outside Frost Bridge Substation will be a weathering steel monopole. The proposed structure design and configuration for the replacement structure would be tubular steel monopole in a vertical

[15] These cross-sections are also included in Volume 5.

configuration, with a height of approximately 150 feet[16]. The structure would be supported on a drilled shaft foundation. The existing steel lattice tower would be dismantled and removed from the ROW. Short-term outages of the 115-kV 1191 Line circuit would be required to safely install the new vertical deadend monopole structure, remove the existing conductor and steel lattice tower, install the 115-kV line on the new vertical monopole structure, and interconnect the new conductor segment to the 1191 Line.

Modifications to Existing Facilities: 1191 Line and 1921 Line Circuit Separation at Naugatuck River Crossing

At the Naugatuck River crossing, the 1191 and 1921 Lines are presently supported by 155-foot-tall double circuit steel lattice towers (one on each side of the river)[17]. To maintain the reliability of the electric system, Eversource proposes to separate these two circuits, placing each line on separate monopoles (refer to XS-5 in Appendix 3A).

Four vertical deadend tubular steel structures – two on each side of the river - would be installed to replace the steel lattice tower structures and to support separately the 1191 Line and 1921 Line. Each of these new structures would be approximately 155 feet in height.

The two existing 155-foot-tall steel lattice towers would be dismantled and removed from the ROW. Temporary line sections and short-term outages of each 115-kV circuit would be required to safely install the new vertical deadend monopole structures, remove the existing conductor and steel lattice towers, and install each 115-kV line on its new vertical monopole structures.

3.1.3 Design Voltage and Capacity

The proposed transmission line is designed to operate at 115,000 volts and would provide approximately 400 megavolt amperes (MVA) of summer normal line capacity and a summer long-term emergency (LTE) capacity of 525 MVA.

[16] The replacement for structure 3080 of the 1191 line is approximately 40 feet taller than the existing lattice tower it replaces due to the span being slightly longer, the additional sag of the new conductor, and updated Eversource clearance standards.

[17] In all locations along the ROW except at the Naugatuck River crossing, the 1191 and 1921 Lines occupy separate structures.

3.1.4 Proposed Structure Locations

Along the overhead line route the preliminary location for each of the proposed transmission line structures was determined using transmission line design software (Power Line System's PLS-CADD"™). The proposed structure locations are shown on the Plan and Profile Drawings in Volume 5, as well as on the 400 scale and 100 scale maps in Volume 5.

As a starting point in the Project design process, all proposed new 115-kV line structures were initially aligned adjacent to existing structures. This design approach was based on the assumptions that alignment of the new structures adjacent to the existing structures would maximize the use of existing on-ROW access roads (which are already situated to reach most existing structures), minimize changes to the visual environment, and mimic existing span lengths to minimize potential clearance violations under certain high-wind conditions. Based on these analyses, Eversource determined that 10 of the 104 new 115-kV structure locations, as determined by the initial structure siting (i.e., placement of new structures adjacent to existing structures) would be in wetlands.

Following this preliminary structure siting, each proposed structure location was further evaluated to account for other factors, such as potential environmental effects. Based on the constructability studies that have been performed thus far, nine of the 10 structures initially proposed for location in wetlands were shifted to upland locations.

Structure locations may further change as the Project design process continues. Future changes could occur based on information obtained from more detailed field studies (e.g., subsurface investigations, final engineering and environmental surveys, constructability reviews), as well as input from municipalities, the Council, and other regulatory agencies. After this additional information has been evaluated, final detailed line engineering would be performed to determine the exact locations of the new structures. Typically, the final structure locations are expected to be within 100 feet (longitudinally along the line) of the proposed structure locations, as depicted on the Volume 5, 100 scale maps.

3.1.5 ROW and Access Road Requirements

ROW Requirements and Easement Acquisition

Eversource proposes to construct and operate the new 115-kV transmission line along its existing ROW without the need for any additional easement acquisition. The typical easement widths along different segments of the existing transmission line ROW are summarized in Table 3-2 (located at the end of

Section 3.1) and shown on the cross-section drawings (refer to Appendix 3A at the end of this section and to the Volume 5 maps).

As part of the Project design process, Eversource reviewed the existing easement rights and restrictions for its existing ROW along the entire Proposed Route. Eversource has sufficient rights within existing easement agreements to construct the Project. New easements may be required for off-ROW access roads.

<u>Access Road Requirements</u>

Various access roads are already established along and within the Eversource ROW ("on-ROW access roads"), where existing transmission lines have been operated and maintained for almost 90 years. To construct, operate, and maintain the new overhead 115-kV transmission line along the Proposed Route, contiguous access along the ROW is not required and these existing access roads would be used to the extent practical.

However, access to each new transmission structure location, as well as to pulling pads and guard structure sites, would be required. As a result, additional temporary and permanent access roads must be established and most of the existing on-ROW access roads would require improvements to allow the safe movement of the heavy construction equipment needed to install the new 115-kV line.

In addition, other temporary access along the ROW may be required to facilitate vegetation removal during construction. Refer to Section 4.1.4.2 for further information regarding temporary access for vegetation removal.

Further, in some areas, to avoid traversing linearly along the ROW over rugged terrain or through sensitive environmental or cultural resources, access roads to the ROW would be developed or improved across private property or across land owned by Eversource ("off-ROW access roads"). Such off-ROW access roads would typically provide access to the ROW from a public road.

The locations and type of new access roads and access road improvements would depend on the terrain, presence / absence of environmental features, and whether the access road would be temporary (used only during construction) or permanent (retained for long-term maintenance of the line). Access roads must have appropriate grades and sufficient width and capacity to support the large, heavy construction equipment (such as flat-bed tractor-trailers, drilling rigs, cranes, and concrete trucks) required to construct the new 115-kV line. The need for access by flat-bed trailers and concrete trucks (including turning radii) typically determines the scope of access road improvements.

In general, all construction access roads (on- or off-ROW) must have a stable base and grades of 10% or less. Whether restored, improved, or newly constructed for the Project, on- and off-ROW access roads would have an approximate 16-to-20-foot-wide travel way and, overall, a 20-to-25-foot-wide footprint (including road shoulders). However, access road widths would vary depending on site-specific conditions (principally slope and presence of water resources) and on factors such as the amount of grading (cutting and filling) required and on whether a particular section of road must accommodate equipment turning radii and/or equipment passing/turn-out locations.

Access roads would be graveled or would consist of temporary construction (timber) mats or equivalent. In general, gravel would most commonly be used in constructing access roads in upland areas. In some locations, particularly on steep slopes and at intersections with public roads, asphalt millings could be used to improve road stability and vehicle traction.

Across wetlands where only temporary (construction) access is required, timber mats would typically be used. These mats would be removed upon the completion of construction. Where permanent access is unavoidably required across wetlands, road construction would be more extensive and would involve the use of gravel. To maintain drainage patterns across the ROW, access road construction would typically incorporate timber mat (or equivalent) bridges, flumes, or culverts as needed. Refer to Section 4.3.1 for additional information regarding water resource crossings, including permanent access roads in wetlands.

New access roads would have to be constructed to reach certain proposed structure locations where sufficient access does not currently exist. However, permanent access roads would typically not be developed through long expanses of wetlands with deep standing water or unstable soils, or in locations where consecutive line structures are separated by long distances. In such areas, off-ROW access roads that provide ingress and egress to work sites on the ROW may be required to facilitate construction or to avoid crossings of sensitive environmental resources, such as rivers or large wetland complexes.

As part of the Project planning, Eversource evaluated the existing public roads leading to or intersecting with the transmission line ROW. Based on that review, an inventory of public roads that could provide access to the ROW was prepared. Table 4-3 in Section 4 identifies the public roads, or sites, that potentially could be used for access to the transmission line ROW. The Volume 5 maps illustrate locations of these roads with respect to the Proposed Route.

Eversource would conduct a detailed evaluation of the access requirements for the Project as part of final design. Access road information would be included in the Project-specific D&M Plans, which would be required as a condition of the Council's approval.

3.1.6 Facilities on ROW Post-Construction (Proposed Line Design)

The configurations of the proposed 115-kV line are illustrated on the typical cross-sections presented in Appendix 3A, as well as on the maps located in Volume 5. Table 3-2 (located at the end of Section 3.1) summarizes the information presented in the cross-sections, identifying both the existing and proposed transmission line configurations.

Cross-sections are provided for each of the six different segments of the ROW, beginning at Frost Bridge Substation and proceeding to Campville Substation. For each ROW segment, the cross-sections depict the configurations of both the existing transmission lines and the new 115-kV transmission line that Eversource proposes.

The following subsections summarize the typical proposed configurations for the new 115-kV line, by ROW segment. These descriptions correspond to the cross-sections included in Appendix 3A and in Volume 5 (Exhibit 4).

3.1.6.1 Frost Bridge Substation Line Exit – XS-1

XS-1 illustrates the typical configuration of the proposed 0.1-mile segment of the 115-kV underground cable system from Frost Bridge Substation towards the transmission line corridor to the west in the Town of Watertown. This cross-section illustrates the typical configuration of the underground cable system as viewed to the west. As the cross-section shows, the underground cable system would be installed within Eversource fee-owned property. The Frost Bridge Substation line exit also includes overhead configurations (0.1 mile) associated with the transition structures. Refer to Transition Structure shown in Appendix 3B.

3.1.6.2 Frost Bridge Substation Line Exit West to Purgatory Junction – XS-2

XS-2 illustrates the typical proposed transmission line configuration along the 2.5-mile segment of ROW extending from the Frost Bridge Substation line exit to Purgatory Junction in the Town of Watertown. The proposed steel vertical monopole 115-kV structures would be located between the 352 345-kV Line and 1191 115-kV Line H-frame structures within the existing 400-foot-wide ROW. This cross-section illustrates the proposed layout of the new 115-kV line, presenting a typical view, looking west, along the ROW.

3.1.6.3 Purgatory Junction to Walnut Hill Junction – XS-3

XS-3 illustrates the typical proposed transmission line configuration along this 3.8-mile ROW segment in the towns of Watertown and Thomaston. Along this segment, the proposed 115-kV delta line would be aligned adjacent to the existing 1191 Line's 115-kV H-Frame structures within the existing 250-foot-wide ROW. This cross-section illustrates the proposed layout of the new 115-kV line, presenting a typical view along the ROW to the north.

3.1.6.4 Walnut Hill Junction to Naugatuck River – XS-4

XS-4 illustrates the typical proposed transmission line configuration along this 2.5-mile ROW segment in the towns of Thomaston and Litchfield. Along this segment, the proposed 115-kV delta line would be aligned adjacent to and east of the existing 1921 Line's 115-kV delta structures within the existing 250-foot-wide ROW. The existing 1191 Line (supported on H-frames) is located within the ROW to the west of the 1921 Line. This cross-section illustrates the proposed layout of the new 115-kV line, presenting a typical view to the north along the ROW.

3.1.6.5 Naugatuck River Crossing – XS-5

XS-5 illustrates the typical proposed transmission line configuration along this 0.4-mile ROW segment at the Naugatuck River crossing in the towns of Litchfield and Harwinton. At the river crossing, the new 115-kV line would be installed on delta monopole structures. The lattice steel structures that currently support Eversource's two existing 115-kV lines (the 1191 and 1921 Lines) would be replaced with steel monopoles (both vertical). The new proposed 115-kV delta line would be located adjacent to and east of the rebuilt 115-kV structures.

All of the line structures would be accommodated within Eversource's existing 250-foot-wide ROW. XS-5 depicts both the new 115-kV line and the reconfigured 1921 and 1191 Lines, as viewed to the north, at the river crossing.

3.1.6.6 Naugatuck River Crossing to Campville Substation – XS-6

XS-6 illustrates the typical proposed 115-kV transmission line configuration along this 1.0-mile ROW segment in the Town of Harwinton. Along this segment, the proposed 115-kV delta line would be aligned adjacent to and east of Eversource's existing Line 1921 115-kV delta structure. The existing Line 1191 (H-frame structures) is located on the western portion of the ROW. This cross-section illustrates the proposed layout of the new 115-kV line, presenting a typical view to the north (toward Campville Substation), along the ROW.

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Table 3-2: Summary of Existing and Proposed Transmission Line Configurations

Transmission Line By Cross-Section (Municipality)	Approx. ROW Mileage	Existing Line Configurations and Typical ROW Width		Proposed 115-kV Transmission Line Configurations and Typical ROW Width	
		Typical Structure Type and Height (above ground)	ROW Width (feet)	Typical Configuration, Structure Type, and Height (above ground)	Typical ROW Width (feet)
XS-1 (Watertown)	0.2	(Includes 0.1 mile of UG and 0.1 mile OH)	N/A	Install one 115-kV circuit in a underground cable system configuration Install two transition structures and one115-kV circuit exiting the Frost Bridge Substation to the transition structure.	Entirely within Eversource-owned property.
XS-2 (Watertown)	2.5	One 345-kV circuit supported on wood-pole H-frame structures; heights vary, ranging from 59 to 90 feet, with a typical height of 80 feet. One 115-kV circuit supported on wood pole H-Frame chair structures; heights vary, ranging from 50 to 80 feet, with a typical height of 60 feet. One 115-kV circuit supported on steel double circuit vertical monopole structures; heights vary, ranging from 65 to 110 feet, with a typical height of 90 feet.	400	Install one 115-kV circuit on steel vertical monopole structures between existing 115-kV H-Frame and 345-kV H-Frame structures; heights vary, ranging from 75 to 125 feet, with a typical height of 105 feet.	400 (No additional ROW required)
XS-3 (Watertown & Thomaston)	3.8	One 115-kV circuit supported on wood pole H-Frame structures; heights vary, ranging from 50 to 80 feet, with a typical height of 60 feet.	250	Install one 115-kV circuit on steel delta monopole structures east of existing 115-kV H-Frame structures; heights vary, ranging from 70 to 125 feet, with a typical height of 90 feet.	250 (No additional ROW required)
XS-4 (Thomaston & Litchfield)	2.5	One 115-kV circuit supported on wood pole H-Frame chair structures; heights vary, ranging from 50 to 80 feet, with a typical height of 60 feet. One 115-kV circuit supported on steel delta monopole structure; heights vary, ranging from 55 to 100 feet, with a typical height of 80 feet.	250	Install one 115-kV circuit on steel delta monopole structures east of existing 115-kV delta structures; heights vary, ranging from 70 to 110 feet, with a typical height of 90 feet.	250 (No additional ROW required)
XS-5 (Litchfield & Harwinton)	0.4	Two 115-kV circuits supported on double circuit steel lattice structures, typical height of 155 feet.	250	Remove existing lattice structures and install two pairs of 115-kV single circuit steel vertical monopole structures; with a typical height of 155 feet.	250 (No additional ROW required)
XS-6 (Harwinton)	1.0	One 115-kV circuit supported on wood pole H-Frame chair structures; heights vary, ranging from 50 to 80 feet, with a typical height of 60 feet. One 115-kV circuit supported on steel delta monopole structures; heights vary, ranging from 55 to 100 feet, with a typical height of 80 feet.	250	Install one 115-kV circuit on steel delta monopole structures east of existing 115-kV delta structures; heights vary, ranging from 75 to 120 feet, with a typical height of 90 feet.	250 (No additional ROW required)

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3.2 SUBSTATION CONNECTIONS AND MODIFICATIONS

In order to interconnect the new 115-kV transmission line with the existing transmission system, modifications would be required at two existing Eversource substations (Frost Bridge and Campville). None of these modifications would require the acquisition of any additional property.

The proposed Project modifications at the Frost Bridge Substation would be accomplished within the existing developed (fenced) area of the station. However, the proposed Project modifications to the Campville Substation would require an approximately 0.4-acre expansion beyond the existing developed (fenced) area of the substation. This expansion would be on Eversource property.

Preliminary design drawings of the proposed station modifications are included in Volume 5. The technical specifications regarding these modifications are detailed for each substation, as follows. Detailed designs would be included as part of the D&M Plans.

3.2.1 Frost Bridge Substation

The Frost Bridge Substation is located in eastern Watertown, adjacent to Frost Bridge Road, State Route 8, and the Naugatuck River, on 5.7 developed acres within a 128.5-acre site owned by Eversource as shown in Figure 3-2. The modifications required to interconnect the Frost Bridge Substation to the new 115-KV transmission line would be accomplished within the developed (fenced) portion of the property. No expansion or modification to the existing fence line would be required. Preliminary plan and section views for the substation modifications are illustrated in Volume 5; these preliminary plans will be updated as the substation design process proceeds.

The new facilities proposed at the Frost Bridge Substation include the following:

- Expand the existing one-position 115-kV bay to a two-position bay. This would require use of an existing 115-kV transmission line-terminal position). The physical line terminal structure exists, although no transmission line currently exits the substation in this position. The substation currently has a total of four 115-kV bays with a total of seven 115-kV lines exiting the substation, two lines per bay except where the new line will be positioned.
- Install one new 115-kV circuit breaker and one new 115-kV transmission line to an existing terminal structure, approximately 60 feet in height.
- Install one motor operated disconnect switch, one ground switch, three lightning arrestors, three CCVTs, and one wave trap. Appropriate junction boxes and yard control boxes would be installed and connected to a pre-existing conduit raceway for control cable.
- Install new protection and control equipment within the existing relay/control enclosure.

3.2.2 Campville Substation

Campville Substation is located in the southwest portion of the Town of Harwinton, adjacent to Wildcat Hill Road. The substation occupies approximately 1.7 acres of a 42.3-acre property owned by Eversource as shown in Figure 3-3. The proposed Project expansion would include modifications that would increase the developed substation (fenced area) by approximately 0.4 acre. This expansion would be on Eversource owned land.

A preliminary plan and section views for the substation modifications are illustrated in Volume 5; these preliminary plans will be updated as the substation design process proceeds.

The new Project facilities proposed at Campville Substation include the following:

- Expand the existing ring bus to accommodate four new 115-kV breakers and one new transmission line-terminal position. The expansion would require the demolition of one existing breaker and connection of the new equipment in its place. A new transmission structure is required to connect the new 115-kV transmission line from Frost Bridge to the Campville line position. In addition, another existing breaker would be shifted slightly to allow the installation of a new 115-kV circuit breaker adjacent to the relocated breaker.
- Install one new 115-kV line terminal structure, approximately 60 feet tall. Install one motor operated disconnect switch, one ground switch, three lightning arrestors, three CCVTs, and one wave trap. Appropriate junction boxes and yard control boxes also would be installed and connected to a new conduit raceway for control cable.
- Install four 115-kV disconnect switches, approximately 60 feet of aluminum tube conductor, six 115-kV breakers, one 60-foot-tall lightning mast, as well as steel support structures and foundations for all new equipment.
- Extend the substation's existing ground grid, grading as appropriate to accommodate stormwater management controls, install an extension of the substation fence.
- Install a new substation enclosure to house additional substation batteries and the associated DC panel boards. Modification to the existing substation building is also required for protection and control.

Figure 3-2: Frost Bridge Substation Location Map

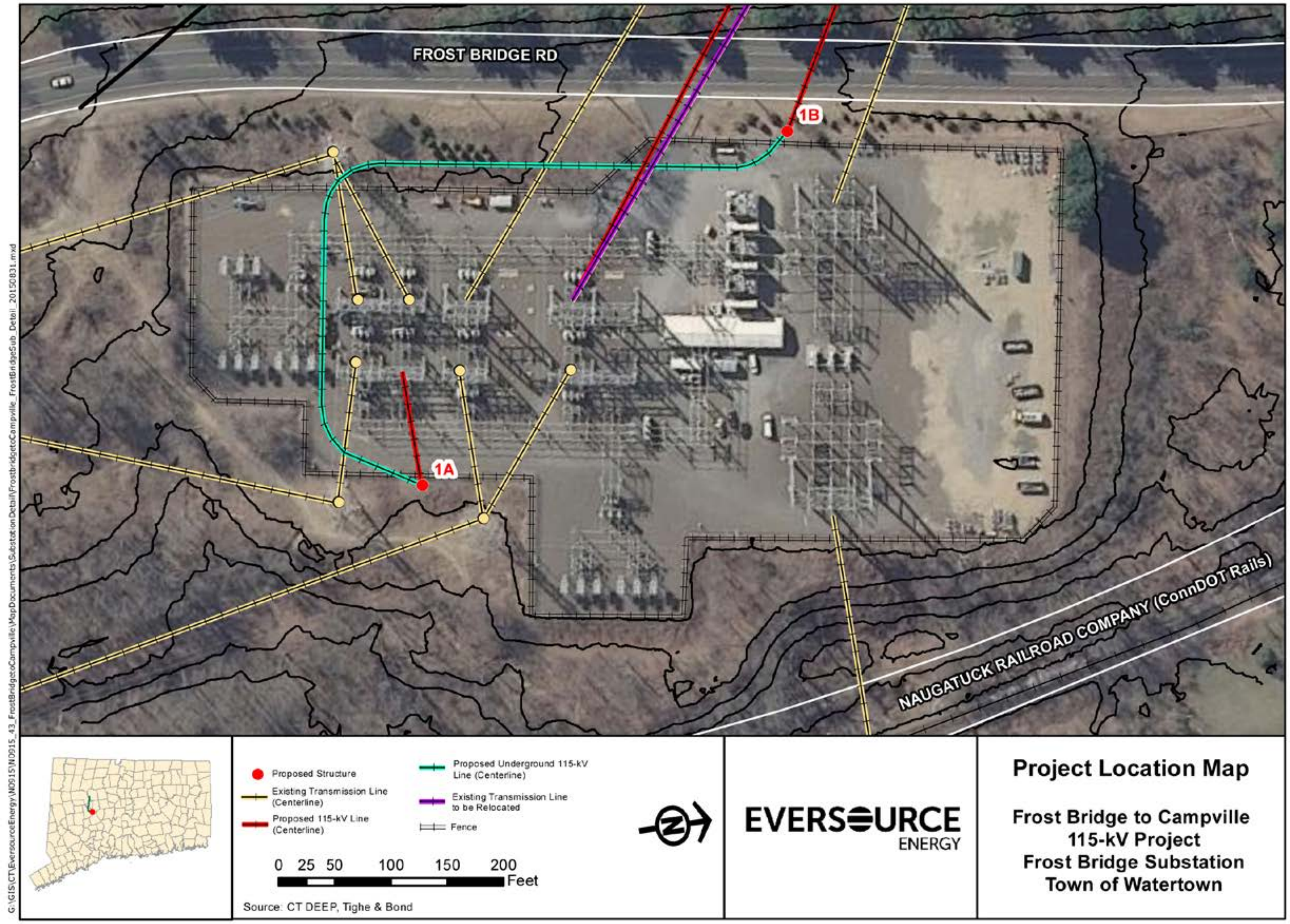

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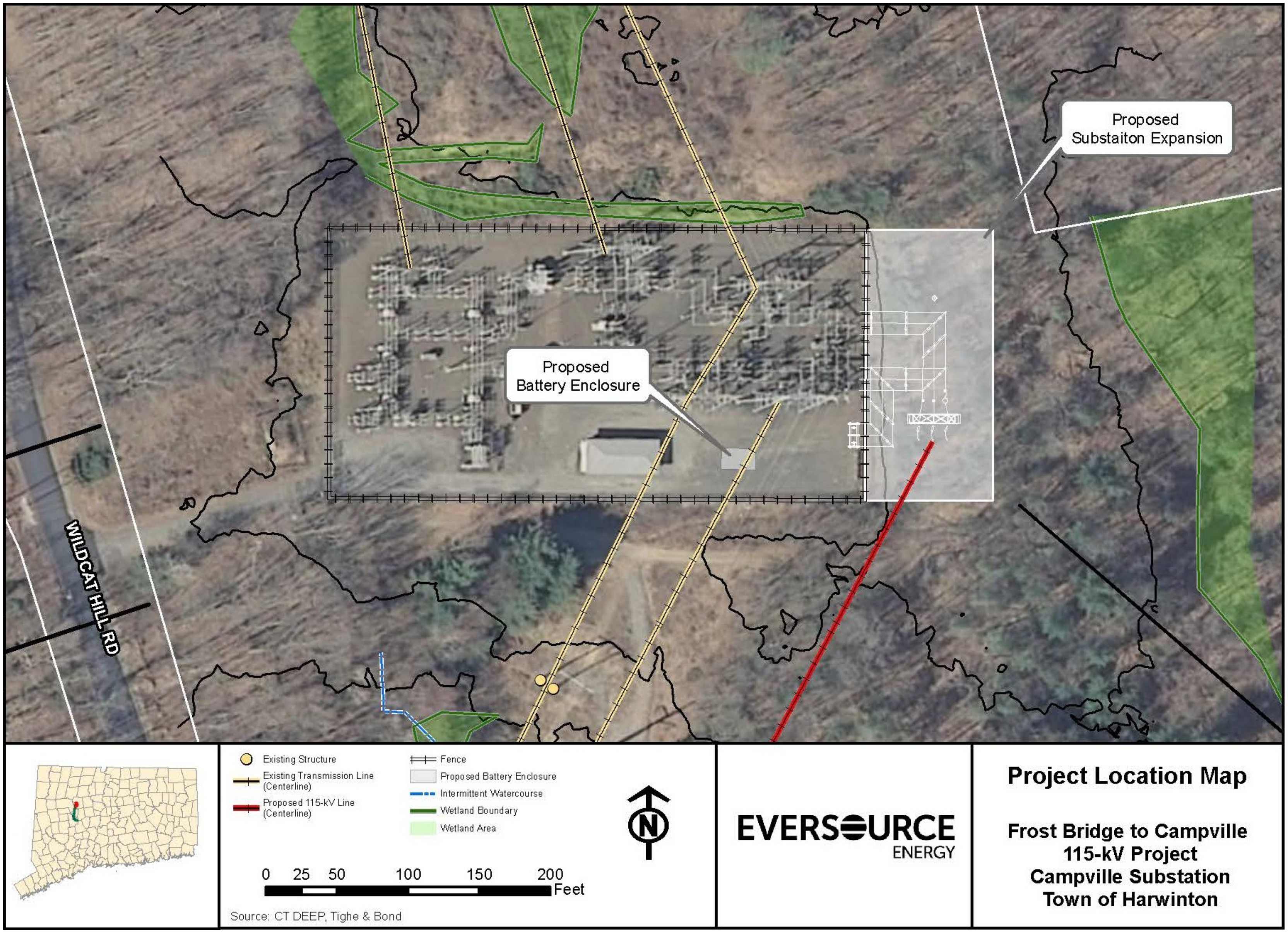
Figure 3-3 Campville Substation Location Map



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3.3 ESTIMATED PROJECT COSTS

3.3.1 Estimated Capital Cost

The estimated capital cost for the Project is approximately $51 million, with the transmission line construction accounting for approximately $46 million and substation modifications accounting for approximately $5 million.

3.3.2 Life-Cycle Cost

In accordance with the Council's *Life-Cycle Cost Studies for Overhead and Underground Transmission Lines* (2012), Eversource performed a present-value analysis of capital and operating costs over a 35-year economic life of the Project. The following items were considered:

- Annual carrying charges of the capital cost
- Annual operation and maintenance costs
- Cost of energy losses
- Cost of capacity

Applying these factors, the life-cycle cost for the proposed transmission line is approximately $76.4 million.

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Appendix 3A – Cross-Sections

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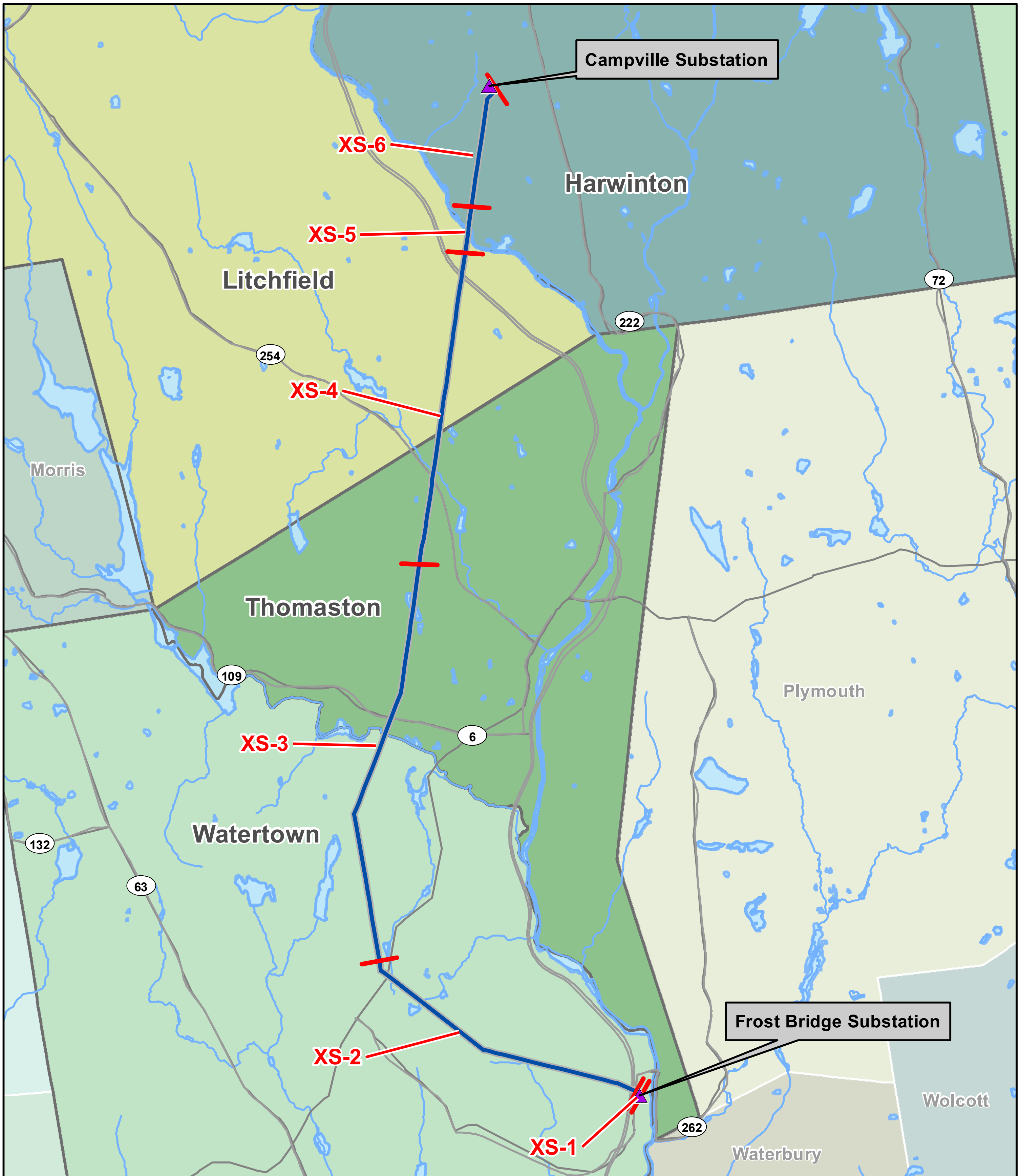

0.5 0.25 0 0.5 1 1.5
Miles

Source: CT DEEP, Tighe & Bond

EVERSOURCE
ENERGY

Cross-Section Location Map

Frost Bridge to Campville 115-kV Project

G:\GIS\CT\EversourceEnergy\N0915\N0915_43_FrostBridgetoCampville\MapDocuments\HighLevelOverview\FrostbridgetoCampville_HighLevelOverview_XSections_Letter_Portrait_20150903_.mxd

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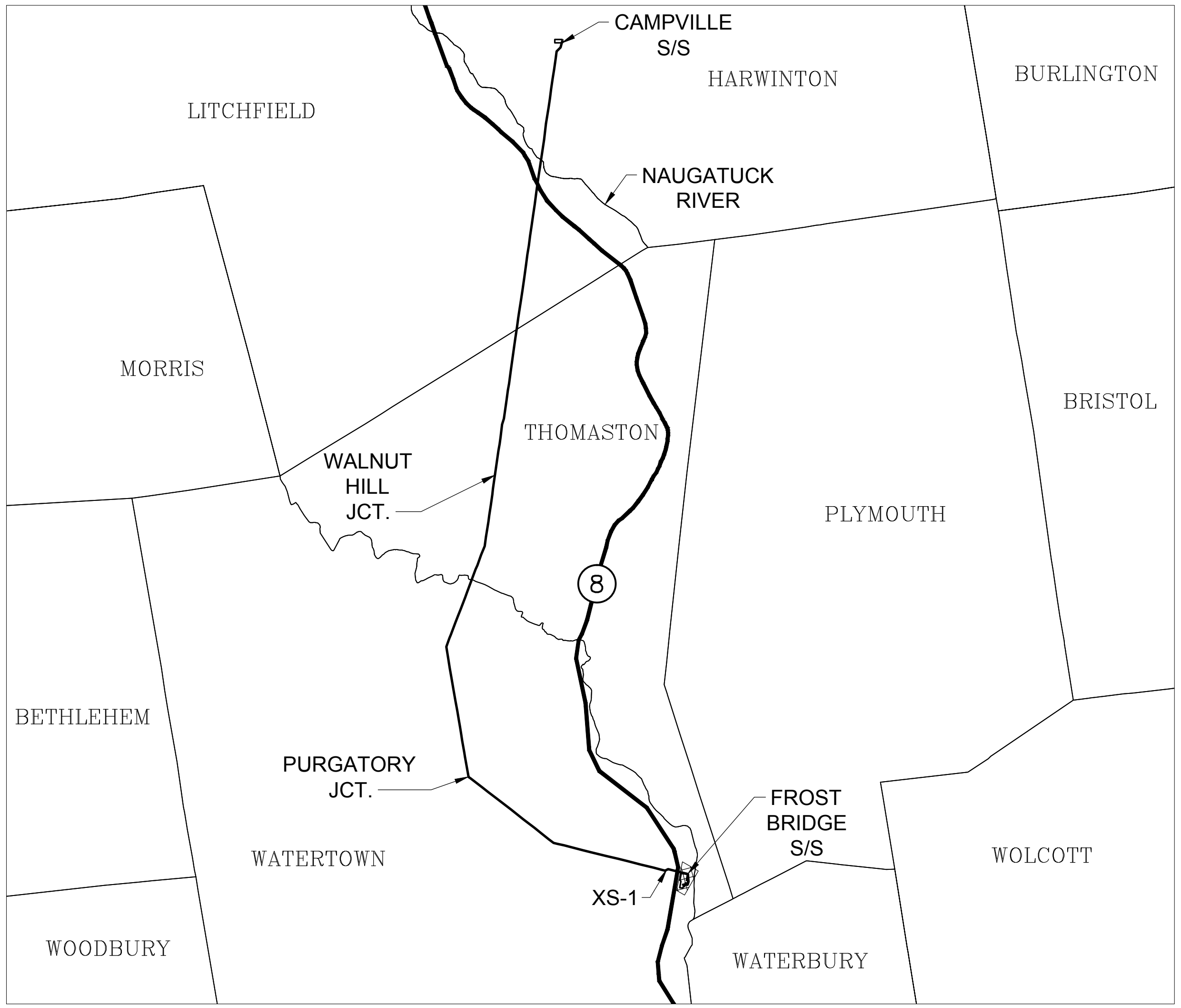
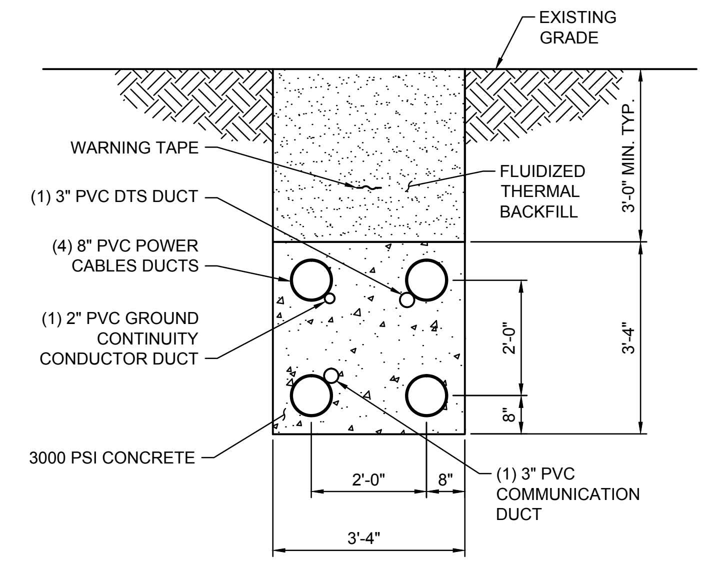


KEY MAP
NOT TO SCALE



TYPICAL 115-kV DUCT BANK SECTION
NOT TO SCALE

PROPOSED ORIENTATION

FROST BRIDGE SUBSTATION LINE EXIT

IN THE TOWN OF
WATERTOWN

LOOKING
SOUTH, EAST AND NORTH

(0.1 MILE)

PRELIMINARY
DESIGN

NOTES:

1. NEW TRANSMISSION LINE ALIGNMENT ON EVERSOURCE-OWNED PROPERTY.
2. DOES NOT INCLUDE THE LENGTH OF THE OVERHEAD TRANSMISSION LINE FROM THE SUBSTATION TERMINAL STRUCTURE TO THE TRANSITION STRUCTURE OUTSIDE THE FENCE LINE. THE LINE EXIT IS SHOWN IN FIGURE 3-2 OF VOLUME 1 AND EXHIBIT 1 AND 2 OF VOLUME 5.

TITLE **FROST BRIDGE TO CAMPVILLE 115-kV PROJECT**
FROST BRIDGE SUBSTATION LINE EXIT

BY C. KUNTZ	CHKD D. GOGOL	APP	APP
DATE 12/4/15	DATE 12/4/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-1	
P.A. #			

Z:\CLIENTS\TND\NUSC\81960_GHCC\DESIGN\FROST BRIDGE-CAMPVILLE\CADD\WORKING\UG\GHCC X-SECT DUCTBANK.DWG 12/16/2015 8:37 AM DAGOGOL

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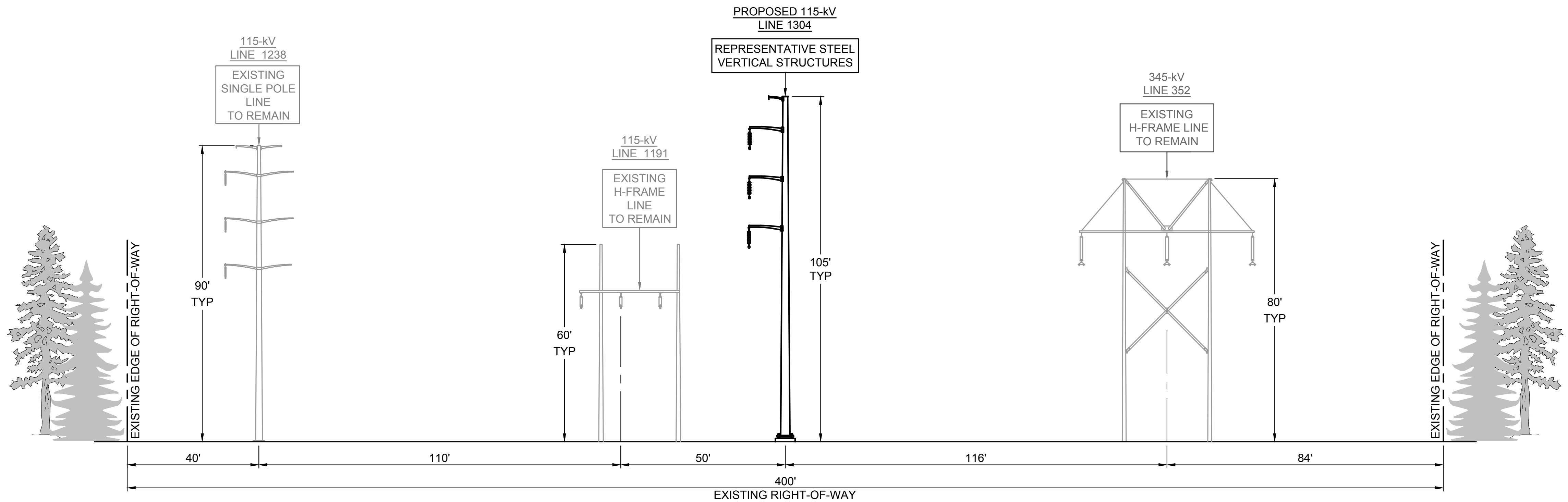


PROPOSED CONFIGURATION

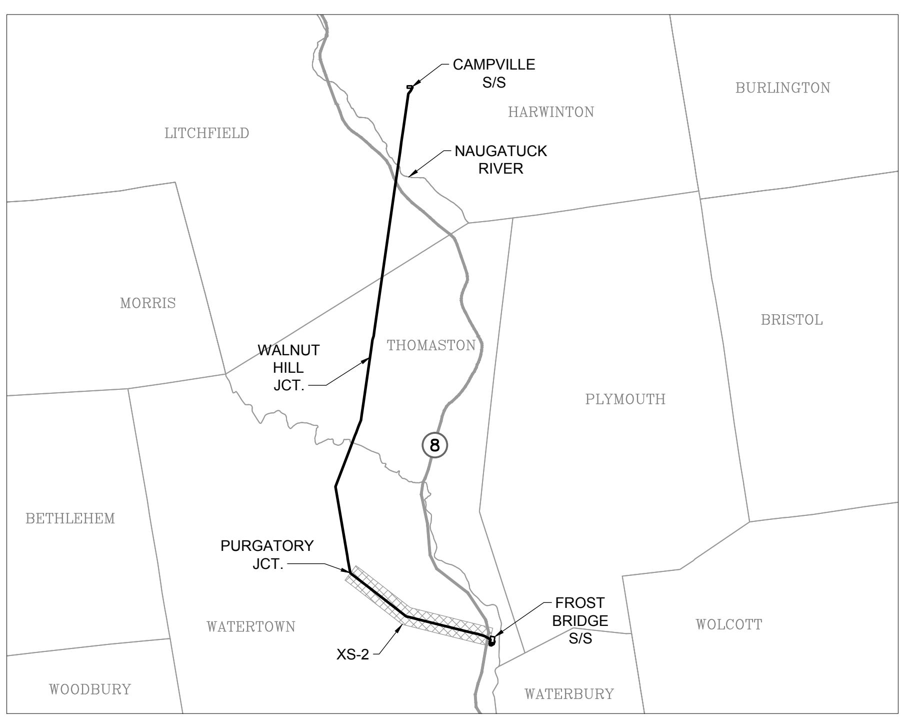
VERTICAL DESIGN

FROST BRIDGE SUBSTATION LINE EXIT
TO
PURGATORY JUNCTION

IN THE TOWN OF
WATERTOWN

LOOKING
WEST

(2.5 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY DESIGN

NOTES:

1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING DIRECT EMBEDDED FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL DIFFER AND BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
PROPOSED CROSS SECTIONS
FROST BRIDGE S/S LINE EXIT TO PURGATORY JCT.

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-2	
P.A. #			

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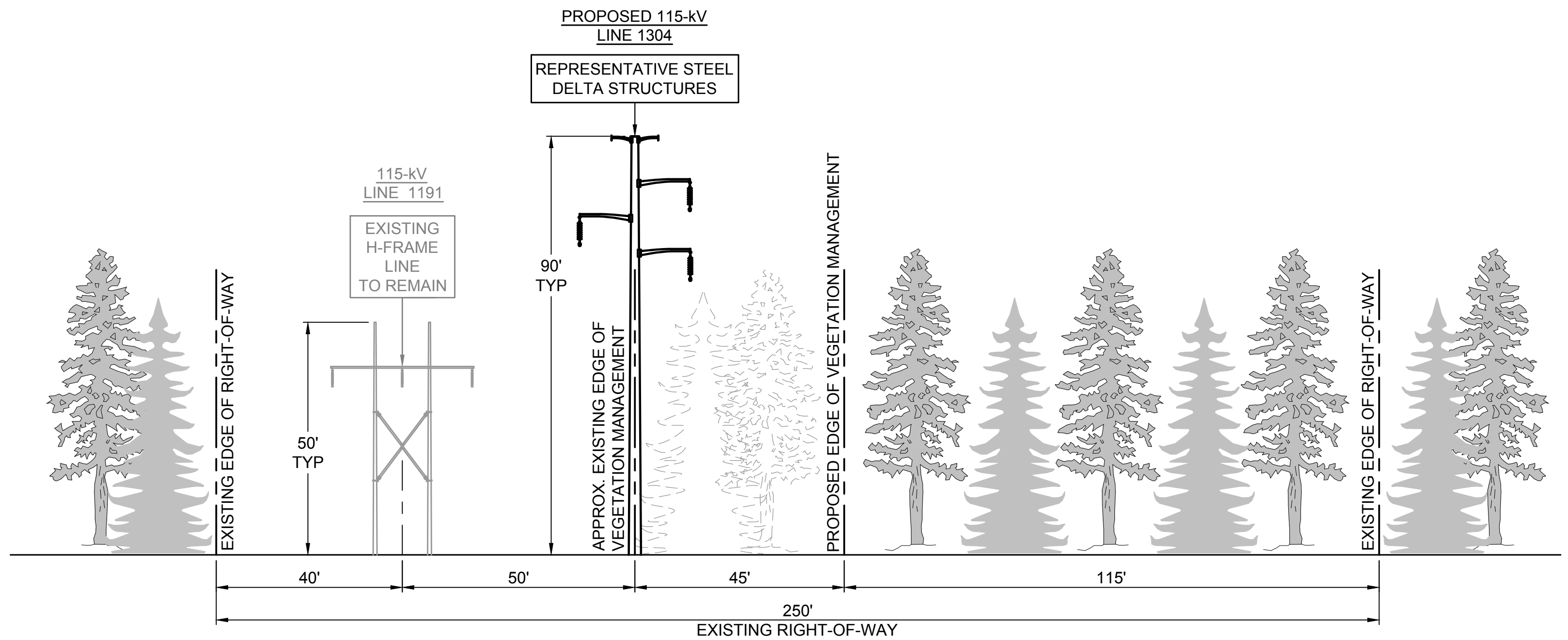


PROPOSED CONFIGURATION

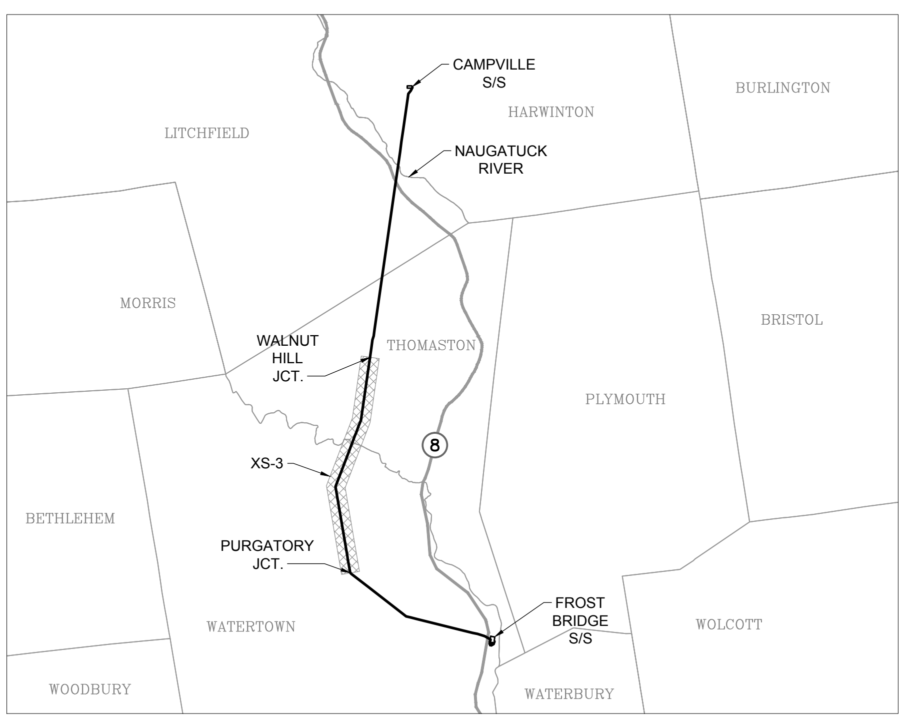
DELTA DESIGN

PURGATORY JUNCTION
TO
WALNUT HILL JUNCTION

IN THE TOWNS OF
WATERTOWN & THOMASTON

LOOKING
NORTH

(3.8 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY DESIGN

NOTES:
1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING DIRECT EMBEDDED FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL DIFFER AND BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
**FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
PROPOSED CROSS SECTIONS
PURGATORY JCT. TO WALNUT HILL JCT.**

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-3	
P.A. #			

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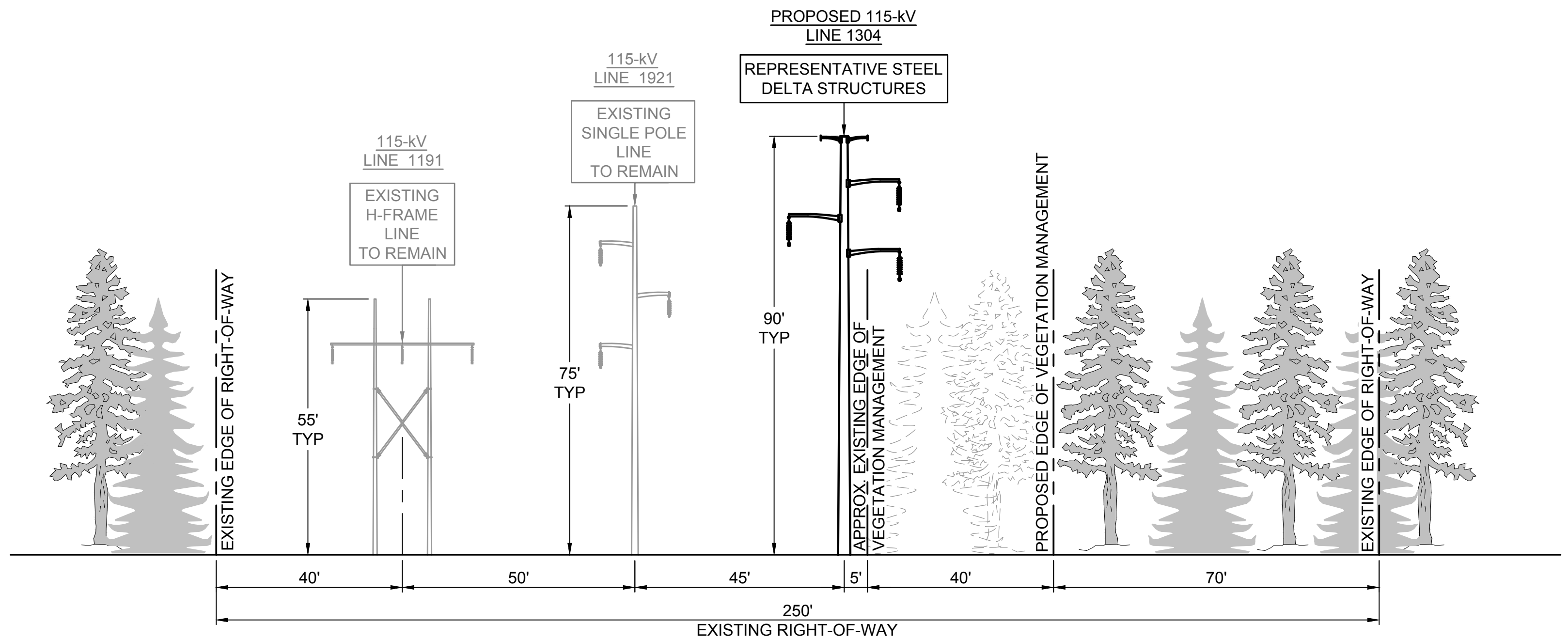


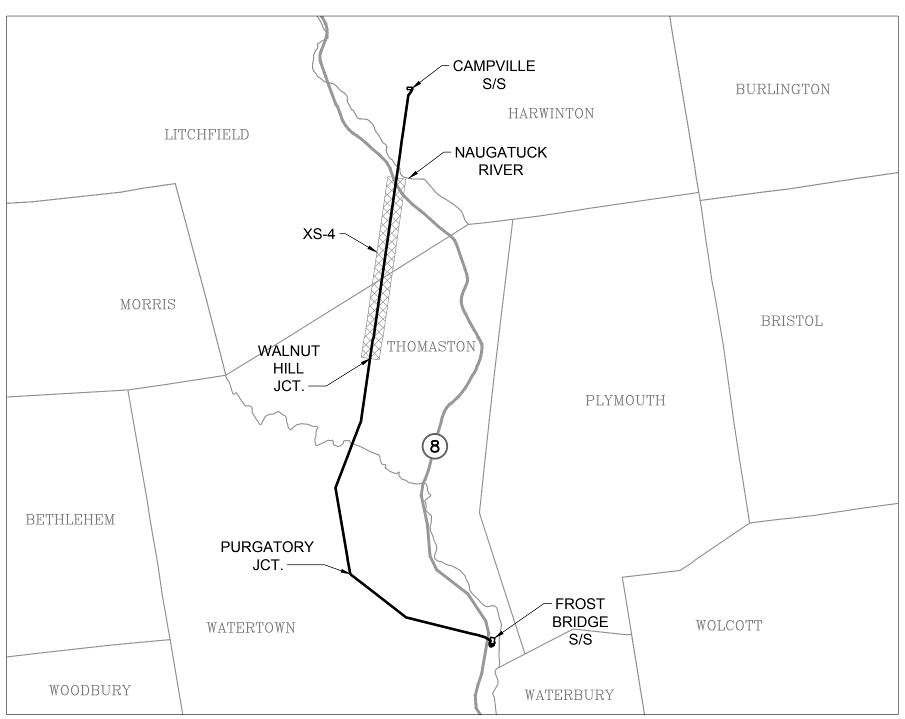
PROPOSED CONFIGURATION
DELTA DESIGN

WALNUT HILL JUNCTION
TO
SOUTH BANK OF NAUGATUCK RIVER

IN THE TOWNS OF
THOMASTON & LITCHFIELD

LOOKING
NORTH

(2.5 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY
DESIGN

NOTES:
1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING DIRECT EMBEDDED FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL DIFFER AND BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
PROPOSED CROSS SECTIONS
WALNUT HILL JCT. TO S. BANK OF NAUGATUCK RIVER

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO.	XS-4
P.A. #			

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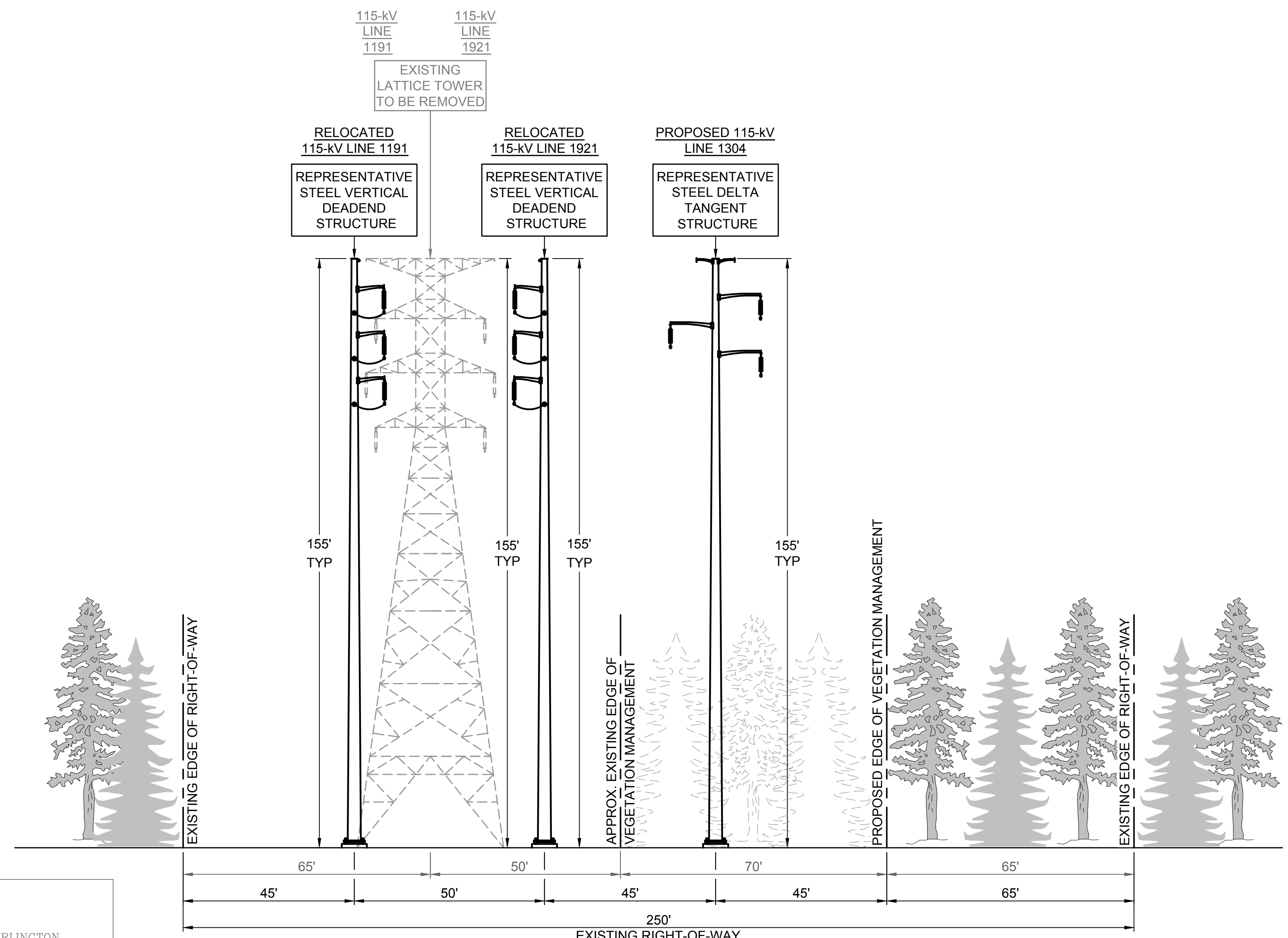


PROPOSED CONFIGURATION

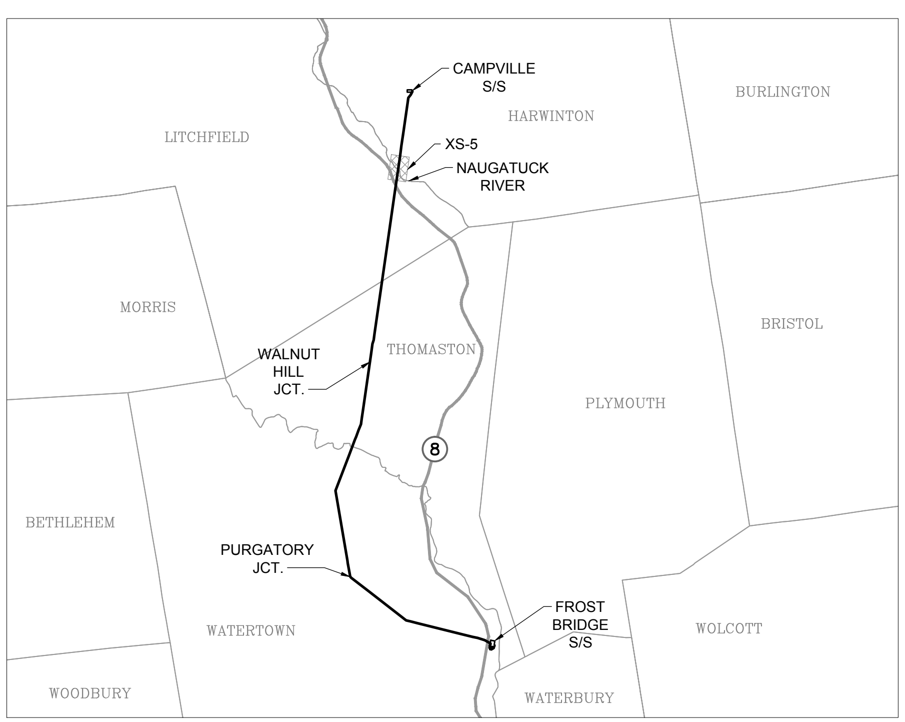
DELTA DESIGN

SOUTH BANK OF NAUGATUCK RIVER
TO
NORTH BANK OF NAUGATUCK RIVER

IN THE TOWNS OF
LITCHFIELD & HARWINTON

LOOKING
NORTH

(0.4 MILE)



KEY MAP
NOT TO SCALE

NOTES:

1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.

PRELIMINARY DESIGN

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
PROPOSED CROSS SECTIONS
S. BANK OF NAUGATUCK RIVER. TO N. BANK OF NAUGATUCK RIVER

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-5	
P.A. #			

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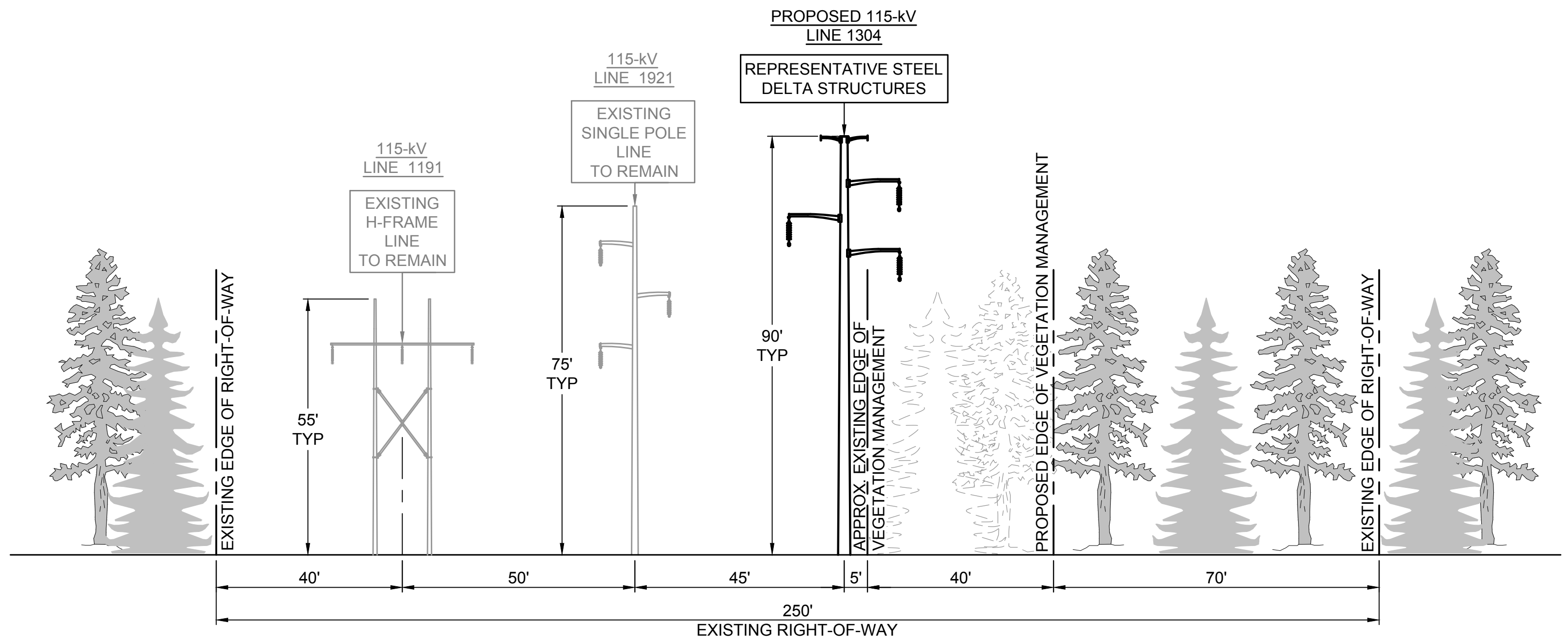


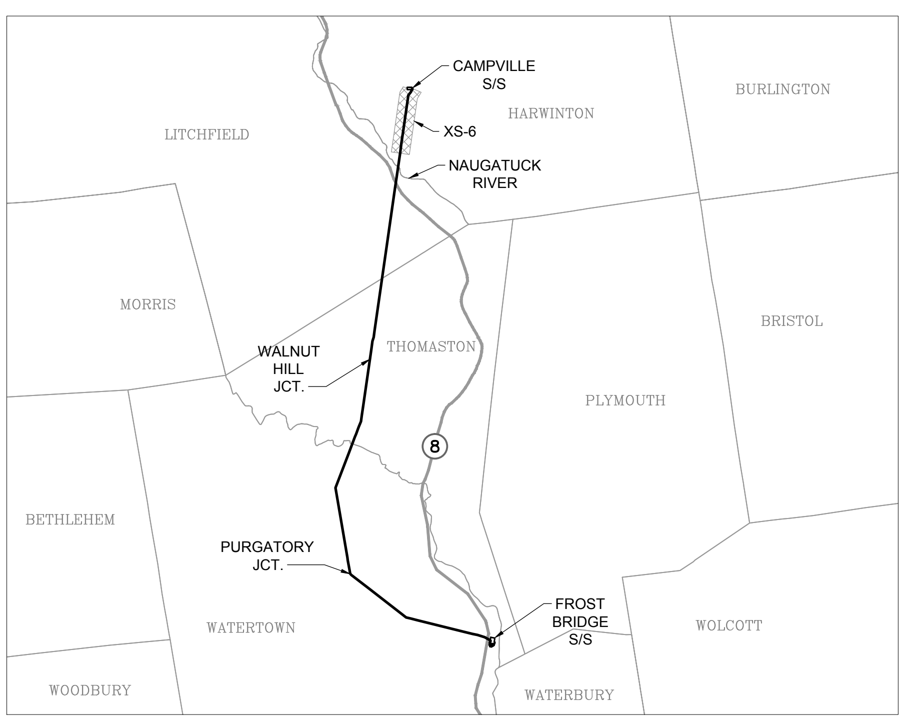
PROPOSED CONFIGURATION
DELTA DESIGN

NORTH BANK OF NAUGATUCK RIVER
TO
CAMPVILLE SUBSTATION

IN THE TOWN OF
HARWINTON

LOOKING
NORTH

(1.0 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY DESIGN

NOTES:
1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING DIRECT EMBEDDED FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL DIFFER AND BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
PROPOSED CROSS SECTIONS
N. BANK OF NAUGATUCK RIVER TO CAMPVILLE SUBSTATION

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-6	
P.A. #			

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Appendix 3B – 115-kV Transmission Line Structure Types

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115-kV TRANSMISSION LINE STRUCTURE TYPES

Transmission line structures, which are typically the element of an electric transmission system that are most apparent to the public, support the conductors (wires) that are used to transport electric power from generation sources to customer load centers.[18] Four 115-kV transmission line structure families have been identified for use on the proposed Project or as configuration options for certain segments of the proposed Project:

- Delta Steel Pole
- Vertical Steel Pole
- H-Frame (configuration option only)
- Transition Steel Pole

Each of these structure families includes different functional types of structures. Where and how a particular type of structure is used along a transmission line depends on a variety of factors, such as availability of ROW, load requirements[19], and terrain (topography). In each structure family, the basic types of structures commonly used along a transmission line are described as follows:

- **Tangent structure**. Tangent structures are the type most commonly used on a transmission line and are used on relatively straight portions of the transmission line. Because the conductors are in a relatively straight line passing through them, tangent structures are designed only to handle small line angles (changes in direction) of 0 to 2 degrees. Tangent structures are usually characterized by suspension (vertical) insulators, which support and insulate the conductors and transfer wind and weight loads to the structure.
- **Angle structure**. Angle structures are used where transmission line conductors change direction. These types of structures are designed to withstand the additional forces placed on them by the change in direction. Angle structures may be: (1) similar to tangent structures, using suspension insulators to attach the conductors and transfer wind, weight, and line angle loads to the structure; or (2) similar to strain or dead-end structures, using insulators in series with the conductors to bring wind, weight, and line angle loads directly to the structure.

[18] The conductors proposed for the Project are aluminum with a steel core for strength; these conductors are connected to the transmission line structures by insulators (typically made of porcelain) that must be strong enough to support tensile forces and the weight of the conductors while preventing electrical contact between the conductors and the structure. Shield wires, which are connected directly to the structures, are installed above the conductors to protect the conductors from direct lightning strikes.

[19] Each structure must be designed for both the loads imposed on it by the weight of the conductors and dynamic loads resulting from factors such as wind and ice accumulation.

- **Dead-end structure.** A dead-end structure is typically used where transmission line conductors turn at a wide angle or end. Compared to tangent structures, a dead-end structure is designed to be stronger and often is a larger structure. Typically, insulators on a dead-end structure are in line with the conductors (horizontal) to bring wind, weight, and line angle loads directly to the structure. A dead-end structure is designed to resist the full unbalanced tension that would occur if all conductors were removed from one face of the structure.
- **Strain structure**. A strain structure is similar in appearance and design strength to a tangent structure. The difference in appearance is the conductor attachment hardware. The conductor attachment hardware is the same as a deadend or large angle, where the insulator bells are in line with the conductor. Whereas a dead-end structure is designed to withstand the full unbalanced tension that would occur from the loss of all conductors from one face of the structure, a strain structure is designed to withstand only unbalanced tensions associated with the loss of a single phase on one face of the structure.
- **Transition Structure.** A transition structure is used to facilitate the transition of underground configuration to an overhead configuration. They are similar to dead-end structures in that they are larger than a typical tangent structure and designed to support heavier loads, including the full tension of the overhead conductor. In addition, the transition structure supports the underground cables as they rise up and terminate at the overhead phase positions. It also supports the surge arrestors which protect the underground cable from over voltages.

As illustrated in this appendix, structures are self-supported and may include different insulator configurations (e.g., horizontal, vertical).

Delta Steel Pole Family

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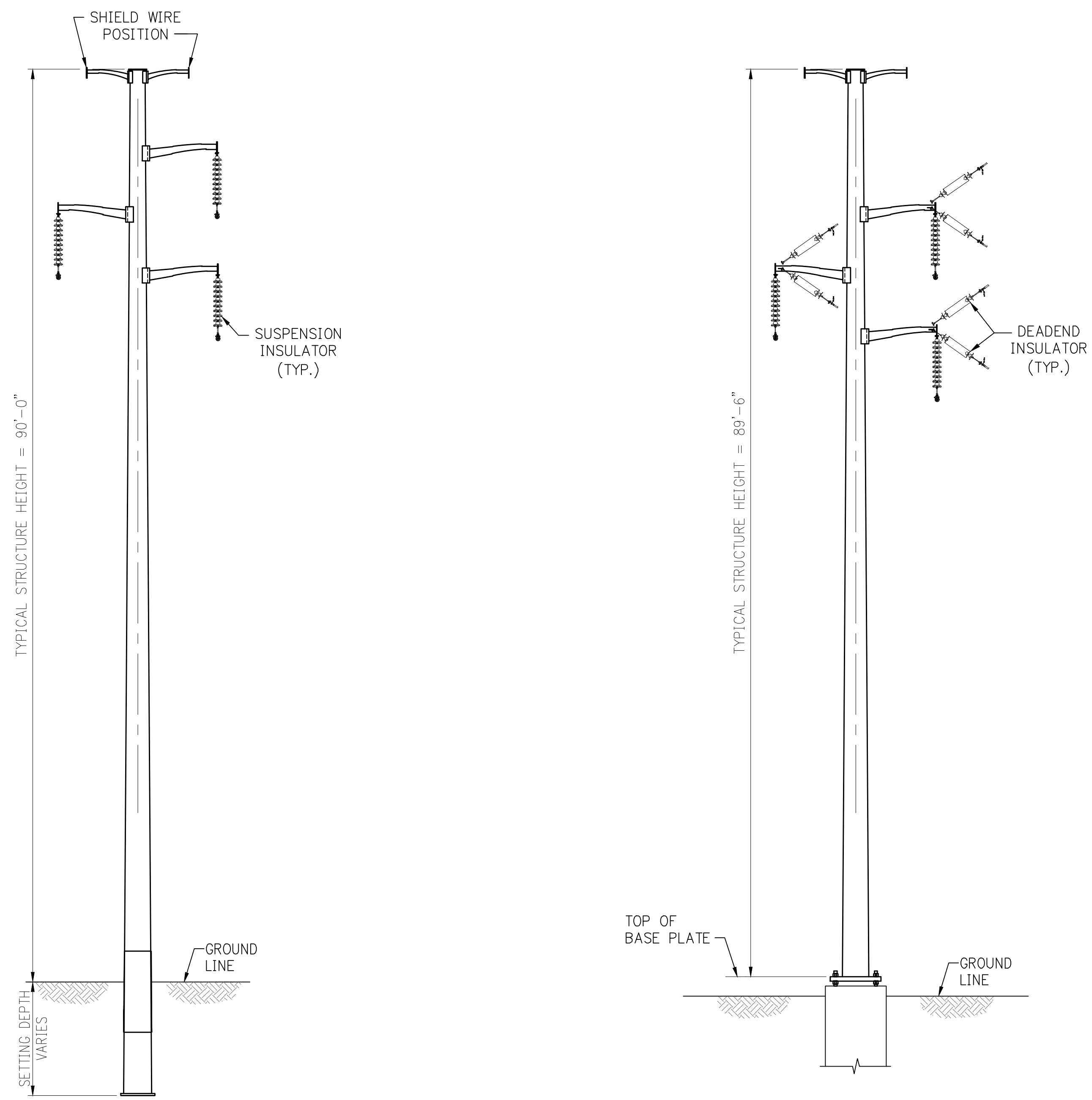

DELTA CONDUCTOR CONFIGURATION TANGENT (0–2 DEGREES)

DELTA CONDUCTOR CONFIGURATION STRAIN (0–30 DEGREES)

PRELIMINARY DESIGN

NOTES:

1. STRUCTURES SHOWN DEPICT STEEL POLE CONSTRUCTION.
2. DRILLED PIER FOUNDATIONS MAY BE UTILIZED FOR TANGENT STRUCTURES.
3. STRUCTURE GROUNDING EQUIPMENT NOT SHOWN.

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BURNS McDONNELL

83707

date DEC. 17, 2015 | detailed D. LAURSEN

designed V. MONTEMURRO | checked P. WILLIAMS

NO.	DATE	AS BUILT REVISIONS	BY	CHK	APP	APP
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EVERSOURCE ENERGY

TITLE FROST BRIDGE TO CAMPVILLE 115-kV PROJECT

DELTA CONDUCTOR CONFIGURATION

FAMILY OF STRUCTURES

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Vertical Steel Pole Family

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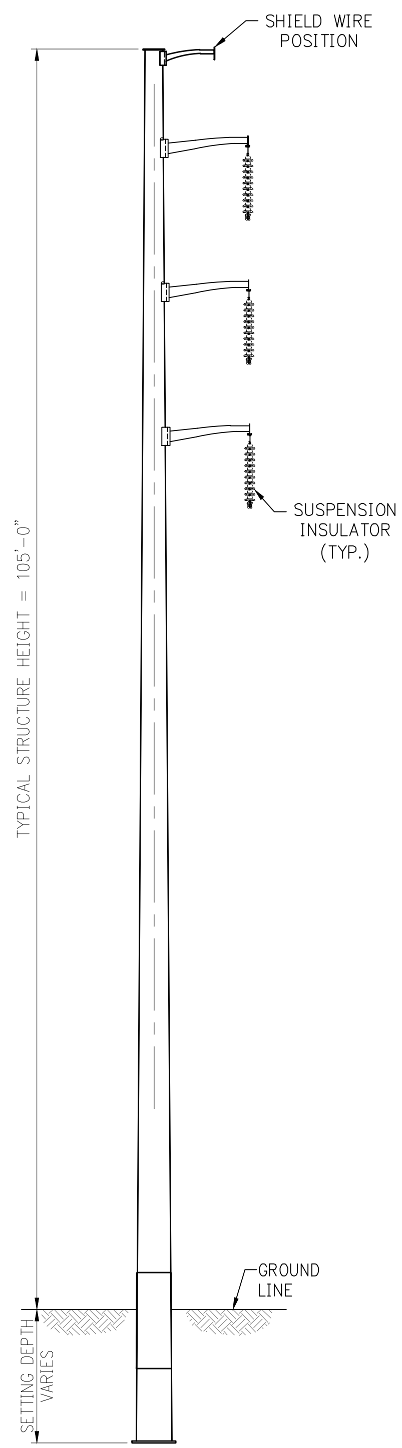
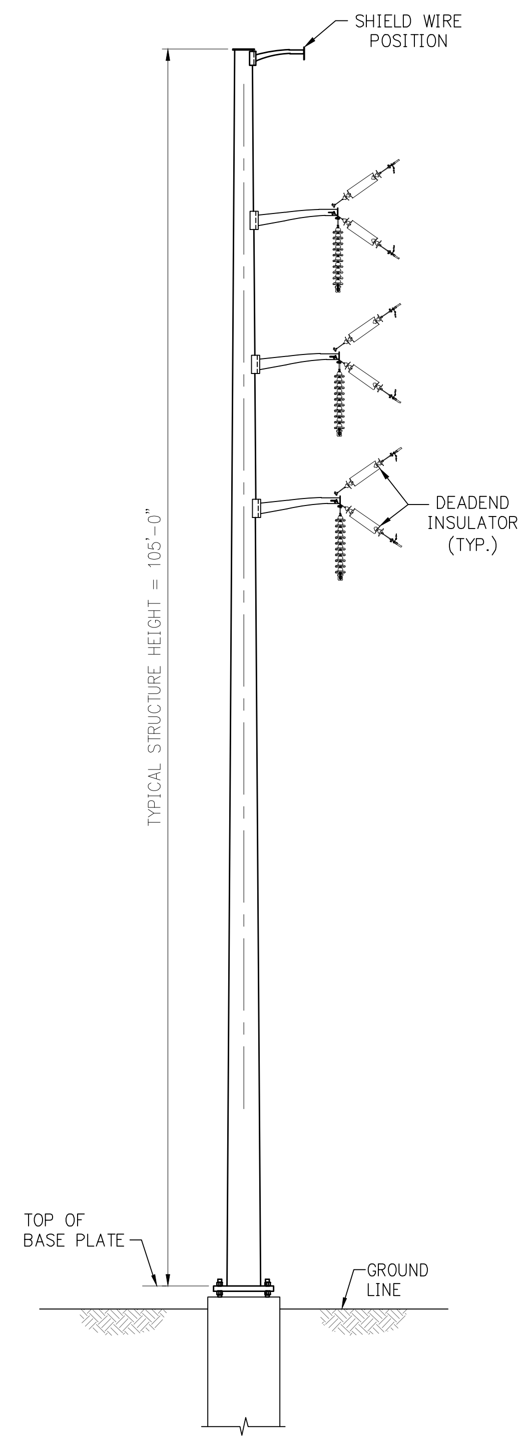
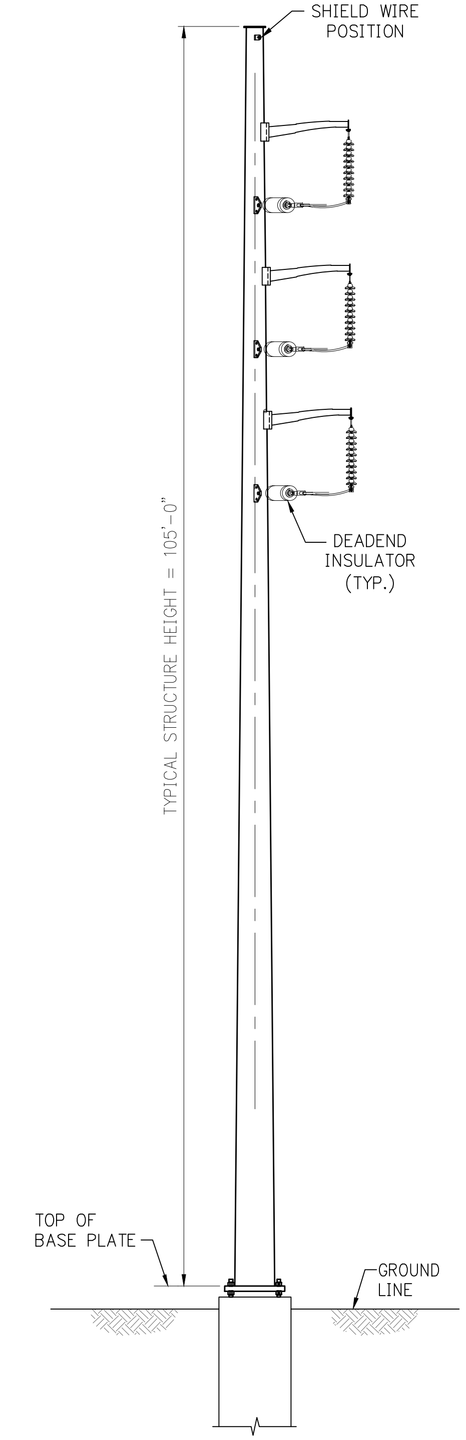


VERTICAL CONDUCTOR CONFIGURATION TANGENT (0–2 DEGREES)



VERTICAL CONDUCTOR CONFIGURATION STRAIN (0–30 DEGREES)



VERTICAL CONDUCTOR CONFIGURATION DEADEND

PRELIMINARY DESIGN

NOTES:

1. STRUCTURES SHOWN DEPICT STEEL POLE CONSTRUCTION.
2. STRUCTURE GROUNDING EQUIPMENT NOT SHOWN.
3. DRILLED PIER FOUNDATIONS MAY BE UTILIZED FOR TANGENT STRUCTURES.

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BURNS McDONNELL

83707

date	detailed
DEC. 17, 2015	D. LAURSEN
designed	checked
V. MONTEMURRO	P. WILLIAMS

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EVERSOURCE ENERGY

TITLE FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
VERTICAL CONDUCTOR CONFIGURATION
FAMILY OF STRUCTURES
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H-Frame and Horizontal 3-Pole Structure Family

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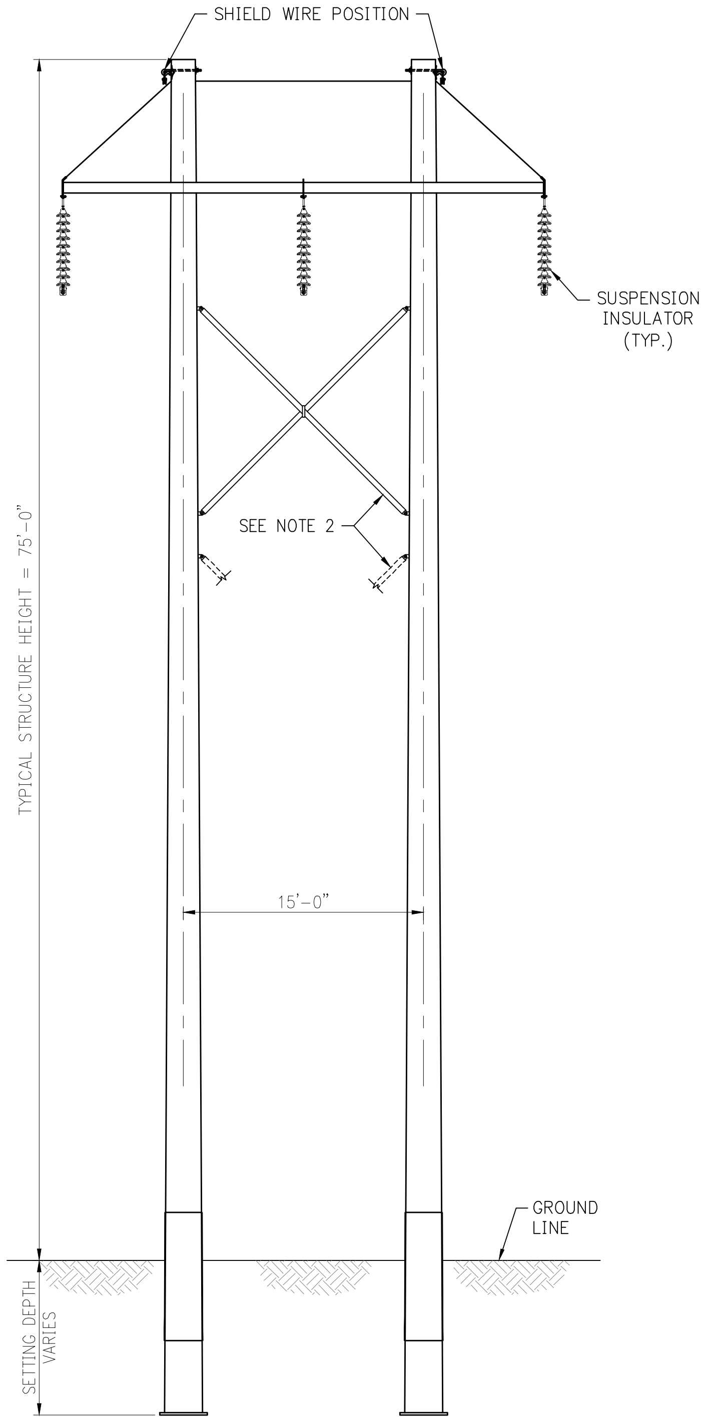
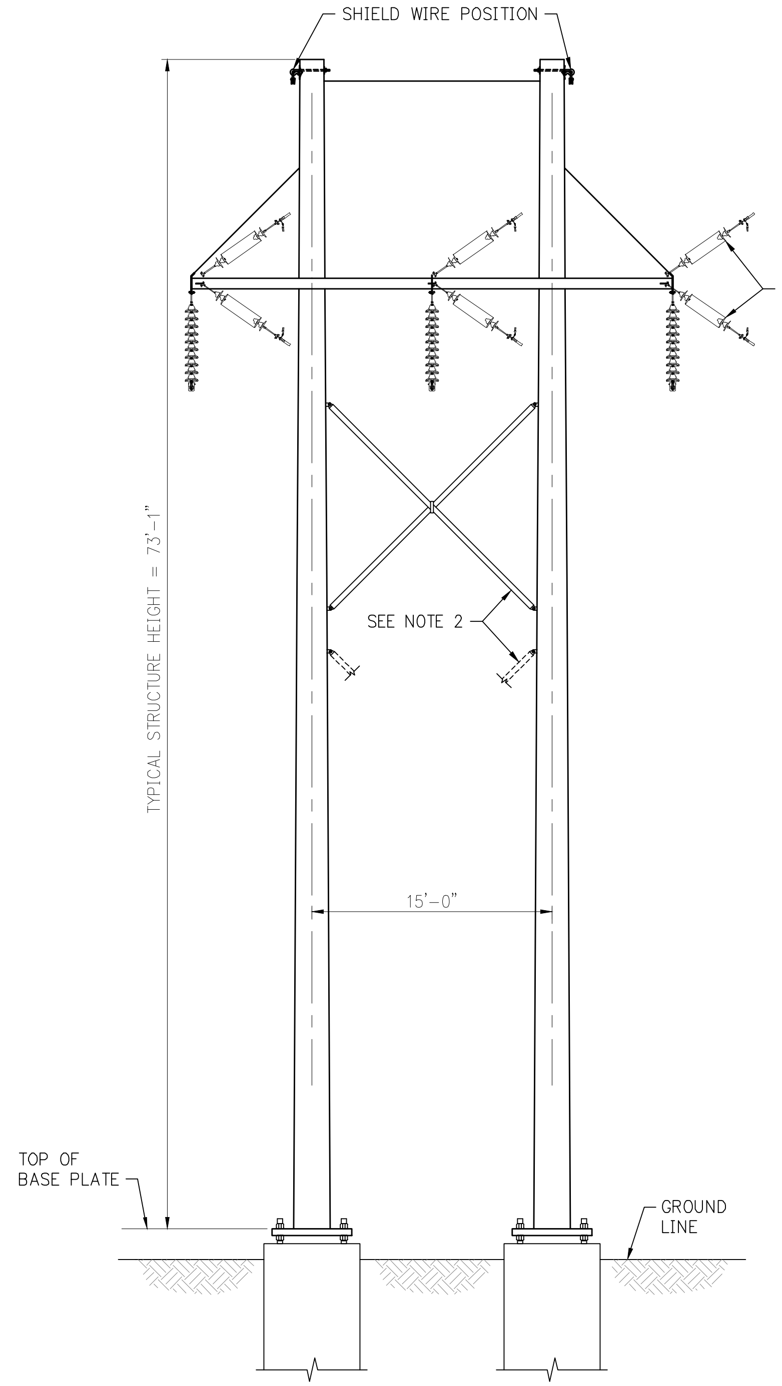
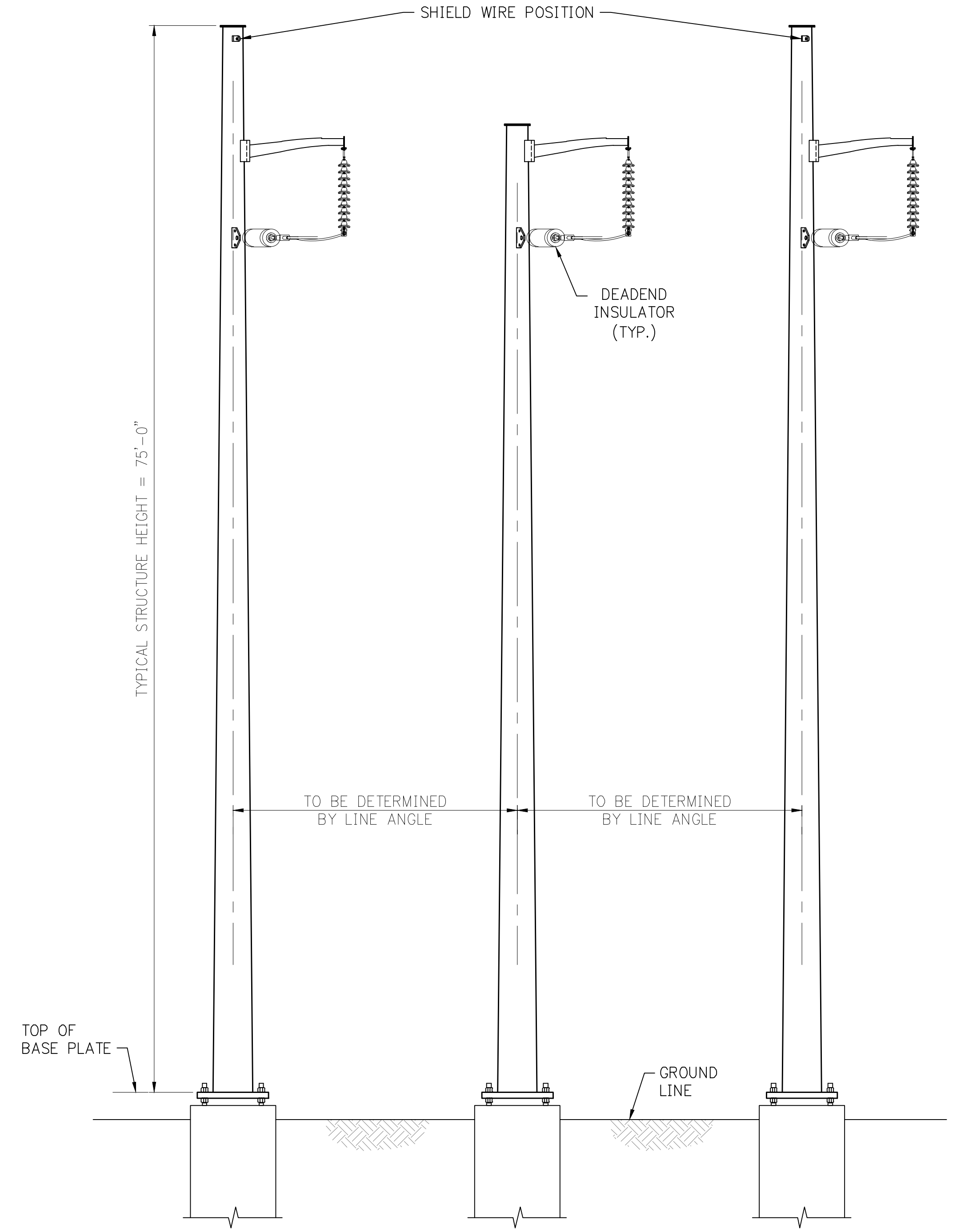


HORIZONTAL CONDUCTOR CONFIGURATION H–FRAME TANGENT (0–2 DEGREES)



HORIZONTAL CONDUCTOR CONFIGURATION H–FRAME STRAIN (0–30 DEGREES)



HORIZONTAL CONDUCTOR CONFIGURATION 3–POLE DEADEND

PRELIMINARY DESIGN

NOTES:

1. STRUCTURES SHOWN DEPICT STEEL POLE CONSTRUCTION.
2. A NEED FOR AND NUMBER OF X–BRACES ON A STRUCTURE WILL DEPEND ON SITE–SPECIFIC FACTORS, SUCH AS STRUCTURE LOCATION AND HEIGHT. TYPICALLY, A 75–FOOT H–FRAME TANGENT STRUCTURE WOULD HAVE A SINGLE X–BRACE.
3. DRILLED PIER FOUNDATIONS MAY BE UTILIZED FOR TANGENT STRUCTURES.
4. STRUCTURE GROUNDING EQUIPMENT NOT SHOWN.

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BURNS McDONNELL

83707

date DEC. 17, 2015	detailed D. LAURSEN
designed V. MONTEMURRO	checked P. WILLIAMS

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EVERSOURCE ENERGY

TITLE FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
HORIZONTAL CONDUCTOR CONFIGURATION
FAMILY OF STRUCTURES
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Transition Steel Pole Family

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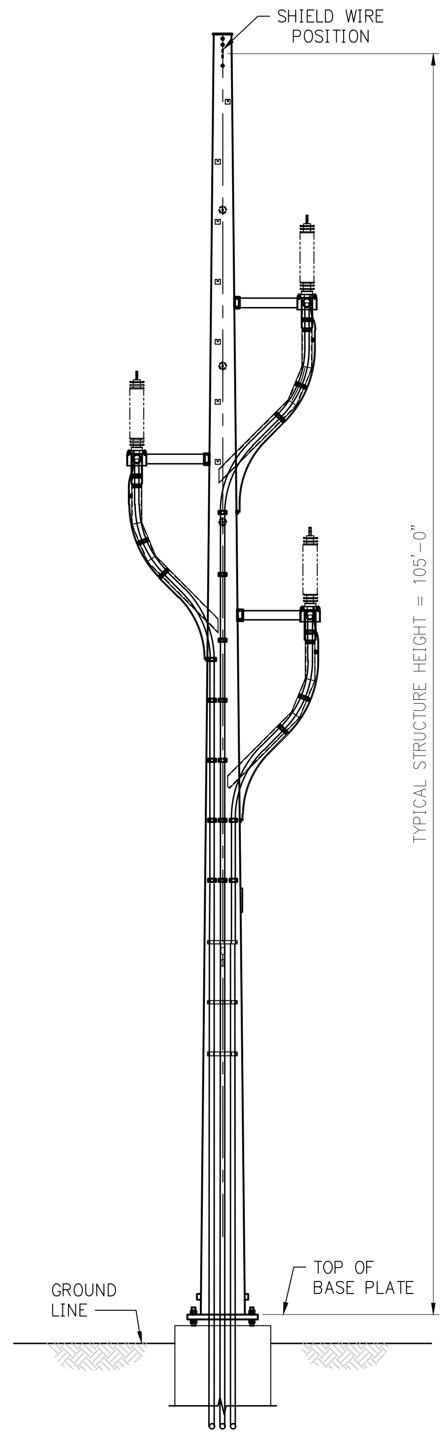
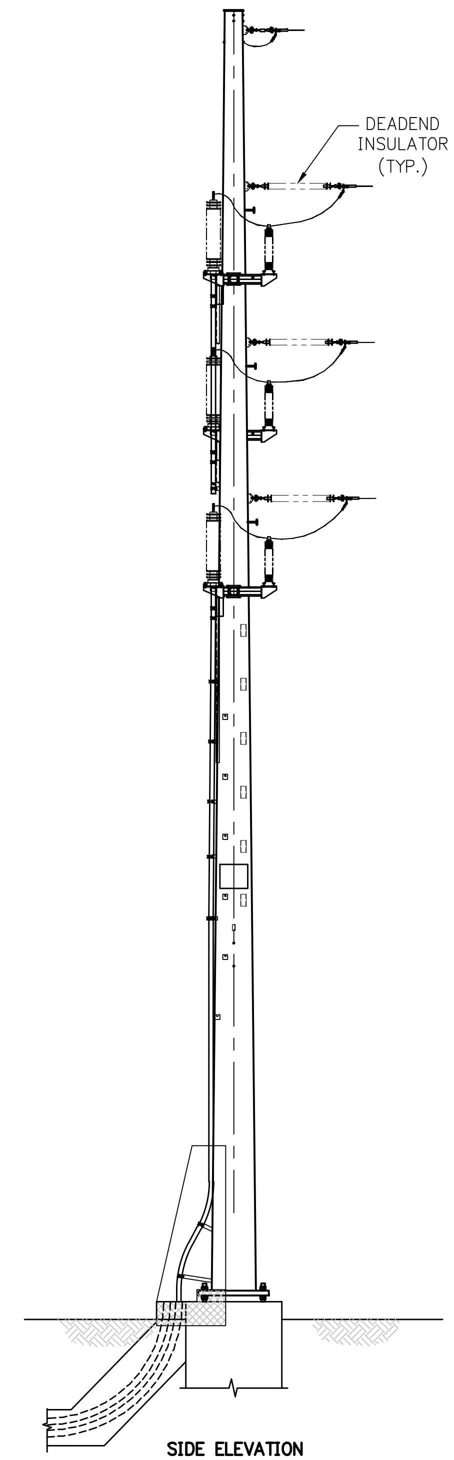


FRONT ELEVATION



SIDE ELEVATION

VERTICAL CONDUCTOR CONFIGURATION
DEADEND
(0-10 DEGREES)

PRELIMINARY DESIGN

NOTES:
1. STRUCTURES SHOWN DEPICT STEEL POLE CONSTRUCTION.
2. STRUCTURE GROUNDING EQUIPMENT NOT SHOWN.

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BURNS McDONNELL
83707

date DEC. 17, 2015	detailed D. LAURSEN
designed V. MONTEMURRO	checked P. WILLIAMS

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EVERSOURCE ENERGY

TITLE FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
TRANSITION STRUCTURE CONFIGURATION
FAMILY OF STRUCTURES
CT

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DATE 12/17/2015	DATE –	DATE	DATE
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4. CONSTRUCTION AND OPERATION / MAINTENANCE PROCEDURES

The proposed Project would be constructed, operated, and maintained in accordance with established industry practices, as well as pursuant to Eversource's specifications. Construction, operation, and maintenance activities also would conform to any conditions identified in the Council's Decision and Order and in federal and state permits obtained for the Project, such as those issued by the U.S. Army Corps of Engineers (USACE), New England District and the Connecticut Department of Energy and Environmental Protection (CT DEEP).

Section 4.1 describes the standard procedures to be used for the installation of the proposed overhead 115-kV transmission line, including construction sequencing, material staging sites, construction field offices, access roads, ROW preparation, structure installation, counterpoise installation, conductor work, ROW cleanup and restoration, and general considerations for traffic control. Procedures are also described for: (1) the removal and replacement of the existing steel lattice tower on the 1191 Line west of Frost Bridge Substation with a monopole; and (2) the separation of the 1921 and 1191 Lines at the Naugatuck River crossing (i.e., removal the existing lattice steel towers and replacement with steel monopoles).

Section 4.2 describes the standard procedures to be used for the installation of the proposed underground transmission cable system for the Frost Bridge Substation line exit.

Section 4.3 reviews the special procedures that would be followed when specific conditions are encountered during construction (e.g., procedures for water resource crossings, blasting, soils management, and dewatering). The proposed configurations of the 115-kV transmission line along each ROW segment are depicted on the cross-section drawings, which are included in Section 3 of this volume (refer to Appendix 3A) and in Volume 5. (The Volume 5, Exhibit 4 cross-sections are full-size, scale drawings and include detailed notes; the cross-sections in Appendix 3A and on the Volume 5, 400 scale maps are reduced-size versions).

Section 4.4 summarizes the construction methods for the proposed modifications to Frost Bridge Substation and Campville Substation. Operation and maintenance procedures applicable to the new 115-kV transmission line and associated substations are detailed in Section 4.4.

4.1 STANDARD PROCEDURES FOR OVERHEAD TRANSMISSION LINE CONSTRUCTION

4.1.1 Introduction and Overview of Construction Sequencing

Eversource would construct the proposed Project in several stages, some overlapping in time. The following summarizes the activities, materials, and equipment generally expected to be involved in the construction of the overhead transmission line facilities:

- Survey and stake the ROW boundaries and monument line (where necessary), vegetation clearing boundaries, and proposed structure locations.
- Mark the boundaries of previously delineated wetland and watercourse areas.
- Identify and mark areas to be avoided (e.g., sensitive cultural or environmental resource areas).
- Establish construction field office area(s), typically including space for office trailer(s), equipment storage and maintenance, sanitary facilities, and parking.
- Prepare material staging sites (e.g., storage, staging and laydown areas) to support the construction effort. The preferred locations for such areas are typically in the immediate vicinity of the ROW.
- Perform vegetation clearing. Vegetation would be removed along those portions of the ROW to be used for the construction of the transmission line facility, as well as areas that contain undesirable, tall-growing, woody species that could reach heights that would interfere with the operation of the transmission line should they not be removed. For example, as part of construction, vegetation would be removed to the designated limits of clearing as required, including at work sites (work pads), as well as along existing or new access roads. Vegetation also would be removed, as necessary, along existing or new access roads that may be on the ROW (but outside the designated limits of clearing) or off the ROW (but required to reach the ROW). In addition, as authorized by its easements or permission from the landowner, hazard trees outside the limits of clearing (on or off the ROW) would be removed as necessary to protect the integrity of the proposed or existing transmission lines. Vegetation removal activities typically require flatbed trucks, brush hogs or other types of mowing equipment, skidders, bucket trucks for canopy trimming, tree shears for larger trees, wood chippers, log trucks, and chip vans. Effects on wetlands, watercourses, or other environmentally sensitive areas would be minimized to the extent practicable (refer to Sections 4.2 and 6 for a discussion of potential mitigation measures). Vehicles with tracks or low-ground-pressure tires may be used to remove vegetation in wetlands. In addition, depending on soil saturation, vegetation removal activities in wetlands may include the use of temporary timber mats or timber riprap to provide a stable base for clearing equipment or hand cutting to avoid any vehicular access.
- Install erosion and sedimentation controls in accordance with best management practices (typically, controls are deployed using pickups and other small trucks, or small track vehicles). After vegetation removal, soil erosion and sedimentation controls typically are installed around work limits (e.g., access roads, work pads) in or near wetlands and streams.
- Construct new access roads or improve existing roads to provide a minimum travel-way of 16 to 20 feet in width (overall a 20-25-foot-wide footprint, including road shoulders). This typically requires bulldozers or front loaders, excavators, dump trucks for crushed stone or gravel, pickups or stake-body trucks for culverts, and/or mat installers for wetland mats. Roads may be

temporary (for use during construction only) or permanent (for use during both construction and the subsequent maintenance of the lines). Temporary roads may be constructed of wood (timber) mats or gravel, whereas permanent access roads are generally constructed of gravel only. Roads must have sufficient width and capacity for heavy construction equipment for both over-the-road and off-road vehicles, including oversized tractor trailers. The need for access by flat-bed trailers and concrete trucks often determines the scope of access road improvements. Road grades must be negotiable for over-the-road trucks; acceptable grades are typically 10% maximum, less if wet weather or surface conditions result in traction problems.

- Prepare level work (crane) pads as necessary at new structure sites, conductor pulling sites, and guard structure sites. Work pad installation may involve grading and requires the installation of a stable base (consisting of gravel, timber mats, or equivalent) for drilling and other structure installation equipment.
- Construct structure foundations and erect/assemble new structures, This requires flat-bed trucks for hauling new structure components, new hardware, and augers, other trucks for hauling reinforcing rods, drill rigs, cranes, concrete trucks for structures that require concrete for foundations, dump trucks for structures that require crushed rock backfill, and bucket trucks. Dump trucks are also needed for foundation work if excess excavated material has to be removed from the ROW. In wet conditions or if groundwater is encountered during excavation, pumping (vacuum) trucks or other suitable equipment would be used to pump water from the excavated areas. The water then would be discharged in accordance with applicable local, state, and federal requirements.
- Install counterpoise, where needed. Depending on site-specific soil conductivity, supplemental grounding will be installed. A ditch witch is typical equipment for this activity.
- Install shield wires, OPGW, and conductors. The equipment required for these activities would include conductor reels, conductor pulling and tensioner rigs, and bucket trucks. Helicopters also may be used to install the initial pulling lines for the conductors or shield wires.
- Demolish and remove from the ROW the existing 115-kV lattice steel structures, as well as the existing shield wires, conductors, and other transmission line materials on and between the structures. The equipment required for these activities would be generally the same as required for installing the new structures, conductors, and OPGW, as described above.
- Remove temporary roads and construction debris and stabilize disturbed sites. Haul construction debris off the ROW for disposal. Vegetative materials cut along the ROW and not otherwise planned for use by the landowner (e.g., brush) may be piled, scattered, or chipped on the ROW, depending on site-specific environmental features. If the ROW to be restored is in an agricultural field, the soil may be de-compacted by disking.
- Maintain temporary erosion and sediment controls until vegetation is re-established or disturbed areas are otherwise stabilized. Steep areas may be stabilized with jute netting or pre-made erosion control fabric containing seed, mulch, and fertilizer. Culverts or crushed stone fords installed along access roads would be either left in place or removed pursuant to regulatory approvals. After site stabilization is achieved, all temporary erosion and sedimentation controls that are not biodegradable (e.g., geotextile material, twine, stakes) would be removed from the ROW and disposed of properly.

4.1.2 Material Staging Sites

To support the construction of the new 115-kV transmission line, temporary contractor yards, storage areas, staging areas, and work pads would be necessary. The preferred locations for contractor yards, as well as temporary storage and staging sites, are in the general vicinity of the ROW. Although the staging areas do not necessarily have to be adjacent to the transmission line ROW, establishing these areas in proximity to construction sites would improve construction efficiency and minimize the potential for inconvenience or nuisance effects to the public (e.g., as a result of the movement of equipment, manpower, and supplies to and from the ROW along public roads). Work pads would be located within the ROW, at individual transmission line structures, conductor pulling sites, and guard structure sites.

If practical, material storage and staging areas would be established on Eversource-owned property. Based on the general acreage requirements for each type of staging location (refer to the discussions in Sections 4.1.2.1 and 4.1.2.2), Eversource performed a preliminary review to identify its properties in the vicinity of the ROW that could potentially serve as storage and staging area locations for the Project. Table 4-1 lists the Eversource-owned sites identified as a result of this preliminary assessment. Because each of the identified sites is more than 2 acres, any of these properties could potentially be used for either material storage or staging in support of Project construction.

Table 4-1: Potential Material Storage or Staging Sites on Eversource-Owned Properties

Town	Eversource Property Location (Volume 5, 400 Scale Mapsheet No.)
Watertown	
	Frost Bridge Substation (Mapsheet 1) North and South of Echo Lake Road (Mapsheet 1) Nova Scotia Hill Road (Mapsheet 2) U.S. Route 6 / Thomaston Road (Mapsheet 3)
Thomaston	
	North of State Route 109 (Mapsheet 5) North of Walnut Hill Road (Mapsheet 6)
Litchfield	
	North of State Route 8 (Mapsheet 8)
Harwinton	
	Campville Substation (Mapsheet 9)

However, it is likely that additional material storage and staging areas would be necessary to support Project construction. If Eversource-owned properties are not available or suitable, previously developed sites (such as parking lots, previously used commercial or industrial properties) or vacant land would be evaluated for use as contractor yards, material storage, or staging areas, taking into consideration parcel size requirements and location in relation to the Proposed Route. At any location not already developed (e.g., paved parking lots) or previously used for such construction support work would likely be required to prepare the site for use as a contractor yard, material storage, or staging area. Such site preparation work may include vegetation removal, grading, adding gravel, installing fencing, and installing crushed stone anti-tracking pads at vehicular access points from public roads.

The actual locations of the contractor yards, staging, and storage sites would be determined by, or with input from, the contractor responsible for constructing the line. The contractor would be responsible for finalizing the locations of yards, staging, and storage areas, and also for making arrangements with property owners regarding the use of the properties. Eversource would review and approve the contractor's proposed construction support sites, and then would obtain approval from the Council and, if necessary, from other regulatory agencies.

The development, use, and restoration of any staging sites would conform to conditions of the Council's approval and any other applicable federal, state, and local requirements. Because the locations of the staging sites would not be finalized until after a construction contractor is selected, Eversource would either specify such sites in the D&M Plans for the Project or submit them separately to the Council for approval prior to use.

4.1.2.1 Temporary Storage Areas

Temporary storage areas typically range in size from approximately 2 to 5 acres, but may be larger. These areas would be used to temporarily store construction materials, equipment, and supplies. Storage areas also would be used for mobile construction offices, parking the personal vehicles of construction crew members, parking construction vehicles and equipment, and performing minor maintenance, if needed, on construction equipment.

In addition, storage areas may function as staging areas. For example, components for new transmission line structures may be temporarily stored at these locations prior to delivery to structure sites. Transmission line materials or structures also may be assembled at storage areas prior to delivery to the ROW.

Storage areas for the proposed Project would typically be selected based upon proximity to work locations along the ROW. As the construction of the transmission lines progresses, subsequent storage areas are typically used to keep equipment and materials close to the locations where line construction work is being performed. Once a storage area is no longer used to support construction activities, it would be restored pursuant to the use agreement with the property owner.

4.1.2.2 Staging Areas

Staging areas, which are generally less than 2 acres in size, are typically used for temporarily stockpiling materials for transmission line construction (e.g., erosion and sedimentation control materials, poles and structure components, insulators and hardware, and construction equipment). In addition, staging areas may be used to temporarily stockpile materials removed from the ROW or used during the construction process, prior to off-site disposal. The number and proposed locations of staging areas required to support the construction effort would be determined by the transmission line construction contractor.

Staging areas would be required in proximity to the transmission line route and may be located on or off the ROW. Eversource-owned property that is presently used for utility purposes would be used for staging areas to the extent practical. Locations along the ROW could also be used, provided sufficient easement rights exist.

As construction progresses, subsequent staging areas would likely be used to coincide with nearby construction work. When a particular staging area is no longer required, the site would be restored pursuant to the use agreements with the property owners.

4.1.3 Construction Field Offices

Field offices for both the contractor and Eversource provide headquarters for construction field representatives, engineers, and other Project field personnel near the areas where work is being performed. Optimally, such construction field offices are located in existing commercial or industrial facilities near the Project, including at Eversource substations. If not practical to locate in existing commercial or industrial facilities, these field office sites typically would consist of trailers, portable sanitary facilities, and associated parking areas.

The field offices also may be co-located with other construction support sites, such as staging or storage areas. At the completion of the Project, the office trailers and other construction support equipment or materials would be removed, and the area would be restored.

For construction office sites located on private property, restoration would be in accordance with landowner agreements. If field office sites are located on Eversource-owned property, restoration would be pursuant to Eversource's requirements.

4.1.4 Right-of-Way Preparation

Along with the development or improvement of access roads (refer to Section 4.1.5), ROW preparation constitutes the first step in the transmission line construction process. ROW preparation activities typically involve vegetation removal and the associated deployment of erosion and sedimentation controls. In addition, during this phase of construction, exclusion fencing or other types of boundary markings are typically installed to demarcate areas of restricted construction access or environmental sensitivity.

4.1.4.1 Temporary Erosion and Sedimentation Controls

Temporary erosion controls (e.g., silt fence, hay/straw bales, filter socks, mulch, and seeding) would be initially installed as practicable prior to and/or during vegetation clearing operations, in compliance with the 2002 *Connecticut Guidelines for Soil Erosion and Sedimentation Control* and Eversource's 2011 Best Management Practices (BMP) manual entitled, "*Best Management Practices Manual: Construction and Maintenance Environmental Requirements for Connecticut*" (BMP Manual; available on-line via the following link: http://www.transmission-nu.com/contractors/pdf/CT_BMP.pdf

Temporary controls, such as silt fence, hay/straw bales, straw waddles, and filter socks, also may be deployed during any of the transmission line construction phases involving soil disturbance. Such controls would be maintained (i.e., repaired and replaced as necessary) throughout the construction period, until disturbed areas are revegetated or otherwise stabilized. After stabilization is achieved, these materials would be removed and disposed of appropriately.

Generally, in areas where soils have been or would be disturbed near sensitive environmental resources (e.g., wetlands, vernal pools, watercourses, threatened and endangered species habitat), temporary controls would be deployed as appropriate to minimize the potential for erosion and sedimentation off ROW or into water resources (on or off the ROW).[20] In addition, temporary erosion and sedimentation

[20] In some locations, such as areas where vegetation is cleared and water resources are situated nearby but no further earth-disturbing construction activities are required, soils may be stabilized with permanent measures (e.g., final revegetation). Refer to Section 4.1.8.1 for a discussion of final revegetation and permanent erosion control measures.

controls (e.g., silt fence, straw/hay bales), orange construction fencing, or signage may be deployed after vegetation removal to demarcate the limits of work within sensitive environmental areas (i.e., limits of access roads, work pads).

The need and extent of temporary erosion and sedimentation controls would be a function of considerations such as:

- Slope (steepness, potential for erosion, and presence of environmentally sensitive resources, such as wetlands or streams, at the bottom of the slope).
- Type of vegetation removal method used and the extent of vegetative cover remaining after clearing (e.g., presence/absence of understory or herbaceous vegetation to minimize the potential for erosion and degree of soil disturbance as a result of the clearing equipment movements).
- Type of soil.
- Soil moisture regimes.
- Schedule of future construction activities.
- Proximity of cleared areas to water resources, roads, or other sensitive environmental resources.
- Time of year. The types of erosion and sedimentation control methods utilized along the ROW would depend on the time of year construction work is initiated and completed. For example, re-seeding is typically ineffective during the winter months. In winter, with frozen ground, controls other than re-seeding (such as wood chips, straw and hay, geotextile fabric, erosion control logs) typically would be deployed or maintained to control erosion and sedimentation and thus to stabilize disturbed areas until reseeding can be performed under optimal seasonal conditions.

4.1.4.2 Vegetation Removal, Including Tree Clearing

Vegetation Clearing Requirements and Estimates

Along the majority of the 10.4-mile Proposed Route, the new 115-kV transmission line would be located adjacent to one or more existing overhead transmission lines, which are situated within Eversource's ROW that varies in width from approximately 250 to 400 feet. Beneath and in the vicinity of the existing transmission lines that occupy this ROW, Eversource routinely manages vegetation pursuant to requirements for the reliable operation of the overhead transmission lines.

Since April 7, 2006, Eversource's ROW vegetation management practices have been required to comply with mandatory standards adopted by NERC following the August 14, 2003 Northeast blackout.[21] These vegetation management practices are designed to allow the reliable operation of the transmission facilities

[21] Transmission line outages triggered by overgrown vegetation in Ohio were substantial factors in causing the blackout.

by preventing the growth of trees or invasive vegetation that would otherwise interfere with the transmission facilities or hinder access along the ROWs. As a result, the vegetation within the managed portions of Eversource's ROWs typically consists of shrubs, herbaceous species, and other low-growing species.

To accommodate the construction and subsequent operation of the new 115-kV line, additional vegetation removal would be required. Vegetation along the ROW would be removed to allow for construction equipment at each structure location, to provide cleared access roads and spurs to structure sites, as needed, and to provide no imminent risk to the new line along the new or existing edge from danger trees. However, the amount and type of vegetation clearing required would vary and would depend on factors such as the existing width of the managed ROW, vegetation communities present (e.g., forested, herbaceous, scrub-shrub, open field), the type of the new 115-kV transmission structures, configuration and spacing of the transmission line conductors, transmission line span lengths, and terrain.

Along the ROW within which the new 115-kV line would be located, the width of the currently managed portions varies, depending on the number and configuration of the existing transmission lines that occupy each ROW segment. The cross-sections illustrate the location of the proposed transmission line along each ROW segment (refer to Section 3, Appendix 3A of this Volume and to Exhibit 4 in Volume 5).

For example, along the 2.5 miles from the vicinity of Frost Bridge Substation to Purgatory Junction (refer to XS-2), the 400-foot-wide ROW currently includes one 345-kV circuit and two 115-kV circuits. The new 115-kV line is proposed for location near the middle of the ROW, between the 345-kV and one of the existing 115-kV circuits. Because Eversource already manages most of this ROW segment for low-growth vegetative communities, clearing for the construction of the new 115-kV line would predominantly involve the removal of scrub-shrub type vegetation. However, some areas of taller-growing vegetation are predominant within the limits of clearing for the new 115-kV transmission line and thus would have to be removed.

On the other hand, along the majority of the remaining 7.7 miles of the Proposed Route, the new 115-kV line would be located adjacent to and east of one or two existing 115-kV lines, within a typical 250-foot-wide ROW. Along these ROW segments, Eversource presently manages (on average) a 95-to-140-foot-wide area beneath and adjacent to the existing lines. The development of the proposed 115-kV line, supported on delta monopole structures, would require (typically) an additional 40-to-45 feet of new vegetation removal for construction and subsequent management within the ROW. Table 4-2 summarizes the widths of the ROW segments along which the proposed 115-kV line would be located, together with the typical widths of the existing managed portions of the ROW and the anticipated additional widths of vegetation removal required along each ROW segment of the Project.

Table 4-2: Summary (by Cross-Section) of Total ROW Widths, Existing Managed ROW Widths, and Additional New Vegetation Clearing Widths Required for the Proposed 115-kV Transmission Line

	Existing Eversource ROW or Property			
Town	Cross-Section Reference (refer to Vol. 1, Appendix 3A and to Vol. 5)	Total ROW Width (feet)	Width of Current Vegetation Management Area along ROW (feet, typical)	Estimated Width of New Vegetation Clearing* Required for Proposed 115-kV Transmission Line (feet)
Watertown	XS-1	Fee-owned	N/A Substation	N/A Substation
Watertown	XS-2	400	400	0
Watertown / Thomaston	XS-3	250	90	45
Thomaston / Litchfield	XS-4	250	140	40
Litchfield / Harwinton	XS-5	250	115	70
Harwinton	XS-6	250	140	40

*Note: The estimated width of new vegetation clearing refers to the additional areas of the ROW, outside of the portions of the ROW that Eversource presently manages, where vegetation (typically forest) would have to be removed for the new 115-kV transmission line. To accommodate the construction of the new transmission line, vegetation (mostly shrub-scrub) would also have to be removed along portions of the existing managed ROW. Along the 2.2-mile segment of ROW represented by XS-2, the new 115-kV line would be aligned near the middle of Eversource's 400-foot-wide ROW, which is presently occupied by three other overhead transmission lines. Eversource performs vegetation management within this ROW segment consistent with the safe and reliable operation of these transmission lines. As a result, whereas the overall width of the managed ROW would not be expanded along this segment, some areas of forested and other vegetation, located in the interior of the Eversource ROW, would have to be removed.

Along the 250-foot-wide ROW north of Purgatory Junction (XS-3 through XS-6), after the installation of the new 115-kV transmission line, portions of the ROW to the east of the line would remain unaffected by construction or vegetation management activities associated with this project. These unused (non-managed) portions of the ROW support taller vegetation, including forested uplands and wetlands. The widths of the un-managed portions along the east side of the ROW range from 65 to 115 feet, as illustrated on the cross-section drawings (refer to Appendix 3A and Volume 5).

As part of the construction of the new transmission lines, undesirable, tall-growing, woody species within the ROW areas proximate to the new line would be removed. Desirable species would be preserved to the extent practical. In selected cases, certain desirable, low-growing trees may be kept on the ROW in specific locations and only trimmed to ensure adequate clearance from wires and structures, pursuant to

Eversource's *Right-of-Way Vegetation Initial Clearance Standard for 115-kV and 345-kV Transmission Lines*. Generally, all tall-growing tree species would be removed from the managed portion of the ROW and low-growing tree species and taller shrub species would be retained in the areas outside of the conductor zones (the area directly under the conductors extending outward a distance of 15 feet from the outermost conductors).

These activities would modify, but not eliminate, vegetation and wildlife habitats along the ROW. In general, the principal long-term effect of vegetation removal along the ROW would be to forested habitat. Specifically, within the additional areas where new vegetation clearing would be required to accommodate the proposed Project, trees would be removed and would not be allowed to regenerate. Over time, these previously forested areas would be recolonized by native shrubs, herbaceous flowering plants, and grasses, creating additional old field and scrub-shrub communities.

Landowner Outreach and Beneficial Use of Forestry Products

The timber resources along the Proposed Route belong to the landowners across whose properties the ROW is aligned. Eversource's policy is to pro-actively coordinate with landowners regarding the disposition and use of the trees to be removed along the ROW. If requested by the landowner, the timber portions of the trees would be left on the landowner's property, in upland areas on the edge of the vegetatively managed portion of the ROW. After the limbs are removed, the wood would be piled in tree lengths for landowners to cut and remove at their convenience.

Timber removed along the ROW on Eversource-owned property or on parcels where the landowners are not interested in retaining the wood would become the property of the Project's land clearing contractor. Eversource would competitively bid the vegetation removal work for the Project and would select a contractor taking into consideration the contractor's plans for the beneficial use of the forest products.

Vegetation Clearing Methods

Vegetation would be typically removed from the proposed transmission line construction workspace (including the areas of managed vegetation in the vicinity of the new line) using mechanical methods. Where necessary, Eversource will encourage the selected vegetation clearing contractor to use low-impact tree clearing means and methods to remove forested vegetation. Low-impact tree clearing incorporates a variety of approaches, techniques, and equipment to minimize site disturbance and to protect wetlands, watercourses, soils, rare species and their habitats, and cultural resources.

During vegetation removal, timber mats or equivalent may be used to provide a stable base for clearing equipment across or within wetlands along the ROW. Such temporary support would minimize rutting in wetlands and would be removed after the clearing activities are completed. The locations where temporary support would be required would be determined in the field, based on site-specific conditions (e.g., soil saturation) present at the time of construction, and may not be the same as the permanent or temporary access roads illustrated on the Volume 5 maps.

Appropriate erosion and sedimentation controls would be deployed as necessary (refer to Section 4.1.4.1). Where removal of woody vegetation is required, vegetation would typically be cut to within 3" of ground surface to the extent possible. Where practical, trees would be felled parallel to and within the ROW to minimize the potential for damage to residual vegetation.

Eversource would direct the Project contractor to retain lower growing vegetation along stream banks and within wetlands, to the extent possible. In general, Eversource may alter to some degree vegetation management activities in the following areas, provided that the construction and operation of the facilities remains in accordance with national transmission line vegetation management standards and consistent with Project permits and approvals:

- Areas of visual sensitivity where vegetation removal may be limited for aesthetic purposes;
- Steep slopes and valleys spanned by transmission lines;
- Agricultural lands; and
- Residential areas where maintained landscapes do not interfere with the construction, maintenance, or operation of the transmission lines.

Danger and Hazard Trees

During and/or after the initial vegetation removal activities, a licensed arborist will evaluate trees beyond the proposed edge of clearing (i.e., both on and off-ROW) to identify and mark any hazard and danger trees that pose an imminent risk to the new 115-kV transmission line.[22] Individual "danger" or "hazard" trees are typically determined based on factors such as species, soil conditions (including wetland vs. upland, susceptibility to flooding, depth of rock), health of the tree, inclination of trunk and shape of

[22] A danger tree is a tree that, due to its location and height, could cause a flashover or damage to the transmission line structures or conductors, or violate conductor zones, if it were to fall toward the transmission line. A hazard tree is a tree that exhibits some type of defect or damage (e.g., weakness, broken limbs, decay, infestation) that increases the risk of it falling into the transmission line.

crown, etc.. Hazard or danger trees located in un-managed areas outside of the limits of Project clearing would be removed after identification; prior to the removal of any such trees off-ROW, Eversource would inform the affected landowner.

4.1.5 Access Roads

As discussed in Section 3.1.5, access roads are required during construction. "On-ROW access roads" would be used to move equipment and material between structure locations. Further, in some areas, to avoid traversing along the ROW through sensitive environmental resources (i.e. wetlands and vernal pools) or rugged topography along the ROW, access roads to the ROW may be developed across private property or across land owned by Eversource (“off-ROW access roads”).

Depending on site-specific conditions, grading may be required to develop or to improve access roads. Some access roads would be needed only during construction and thus would be used temporarily, whereas other access roads will be required permanently for the long-term operation and maintenance of the new transmission lines.

Typically, at points of intersection with public roads, Eversource would install signs along the access roads that specify the roads are for construction purposes and are restricted from use by public vehicular traffic. In addition, where on-ROW access roads or off-ROW dirt roads intersect with public roads, rock aprons or equivalent would typically be installed to minimize tracking of dirt from the ROW onto the public road as a result of construction vehicle movements. Public roads in the vicinity of access roads may also be periodically swept to remove dirt that is tracked from construction activities.

4.1.5.1 On-ROW Access Roads

Contiguous access along the existing ROW is generally not necessary for the construction of the proposed 115-kV overhead transmission line; although access to each proposed transmission structure location is required. Along most of the Proposed Route, the existing transmission lines have been in service for approximately 90 years and, as a result of the operation and maintenance of those transmission lines, many access roads are already established. Such existing access roads would be used for the construction of the Project wherever possible. The on-ROW access roads expected to be used for the proposed Project are illustrated on the maps in Volume 5.

However, most of the existing access roads would have to be improved, widened, or otherwise modified in order to be used safely and effectively during construction. For example, to safely support the heavy construction equipment (e.g., flat-bed trailers, cranes, drill rigs, and concrete trucks) required to install 115-kV transmission line structure foundations and structures, access roads must be sufficiently wide, with a stable base and grades that typically must be 10% or less.

Access road improvements typically include clearing adjacent vegetation and widening roads as needed to provide a minimal travel surface approximately 16 to 20 feet wide (additional width would be needed at turning or passing locations). Access roads will be graveled. Where access roads traverse streams or wetlands, culverts and timber mats (or equivalent) may be used. Existing culverted crossings may also be improved. Erosion and sedimentation controls would be installed as necessary before the commencement of any improvements to or development of access roads.

4.1.5.2 Off-ROW Access Roads

Along portions of the Proposed Route, terrain and environmental features (e.g., steep slopes, rock outcrops, wetland complexes, Branch Brook Reservoir Dam, Morton Pond, Northfield Brook Lake, Naugatuck River) make linear construction access along the ROW difficult or impractical. In such locations, to avoid or minimize adverse environmental effects while allowing safe access to the ROW, Eversource proposes to use off-ROW access roads as necessary. Such off-ROW access roads will entail the use of public roads or access roads across private property.

Eversource performed an initial review of existing access roads leading to the transmission line ROW for the Project. Based on this initial review, an inventory of possible access roads was prepared. Table 4-3 lists the public roads that provide access to the transmission line ROW.

Table 4-3: Potential Public Road Access to ROW

Town	1”=400’ Aerial Mapsheet No. (Volume 5)	Existing Access to ROW via the following Town/City Streets or Sites
Watertown		
	1	Frost Bridge Road (State Route 262)
	1	Echo Lake Road
	2	Park Road
	2	Seemar Road
	2	Nova Scotia Hill Road
	3	Highmeadow Road
Thomaston		
	4	Old Branch Road
	5	Branch Road (State Route 109)
	5	Old Northfield Road
	6	Walnut Hill Road
Litchfield		
	7	Mason Hill Road
	7	Hopkins Road
	7/8	Campville Road
	8	State Route 8
Harwinton		
	8	Valley Road
	9	Wildcat Hill Road

As planning for the Project continues and off-ROW access roads are further defined, some of the on-ROW access roads depicted on the Volume 5 maps may be modified or eliminated to minimize adverse effects on environmental resources (e.g., to avoid or minimize wetland crossings). Conversely, new access roads that optimize ingress and egress to the ROW may be identified. A detailed evaluation of the access roads required for construction would be conducted and included in the D&M Plans to be prepared for the Project.

4.1.5.3 Work Pads

Work pads would be required at each transmission line structure site, as well as at conductor and OPGW pulling sites and at locations where temporary road/rail guard structures are necessary during conductor installation.

At each transmission line structure site, a work pad is required to stage structure components for final on-site assembly and to provide a safe, level work base for the construction equipment used to install foundations and erect the structure. The size and configuration of the work pad at a particular line structure location would vary based on site-specific conditions; however, a typical pad for a tangent structure averages about 100 feet by 100 feet and for a deadend structure averages about 200 feet by 100 feet.

The preliminary location and configuration of the work pads, as determined based on the environmental field studies and constructability reviews conducted to date, are included on the Volume 5 maps. The exact locations and configurations of work pads would be determined during final Project design, based on site-specific conditions (e.g., to avoid or minimize work in wetlands or other environmentally- or culturally-sensitive areas). These final work pad locations would be illustrated in the D&M Plans.

A typical (upland) installation of a work pad at a structure location involves several steps, beginning with the removal of vegetation, if necessary. The work pad site then would be graded to create a level work area and, if necessary, the upper 3 to 6 inches of topsoil (which is typically unsuitable to support the necessary construction activities) would be removed. The topsoil would be temporarily stockpiled within the ROW, typically near the work pad. A rock base, which allows drainage, would be layered on top of filter fabric (if used). Additional layers of rock with dirt/rock fines are typically placed over this rock base. Finally, a roller typically is used to flatten and compact the pad.

Pulling work pads, which would be required in certain locations along the ROW for conductor and OPGW installation, typically will be 100 feet by 200 feet, but can be as large as 100 feet by 300 feet. Pulling work pads would be constructed using techniques similar to those for work pads at structure locations.

Guard structure work pads are typically required at road and other crossings to provide locations for guard structures or equipment used during conductor and OPGW installation. Typically, such temporary guard structure work pads are 50 feet by 80 feet, with an associated 16 to 20-foot-wide access road.

In areas where work pads must unavoidably be located in wetlands, timber mats are typically used to construct the pads. Alternatively, a geo fabric layer is overlaid with large rock base layer used to allow water to flow underneath the pad. Smaller rock is layered on top of larger rock, followed by the final layer of gravel intermixed with soil.

Upon completion of the transmission line installation, work pads at structure sites in uplands would remain in place, unless directed to be removed by the landowner. Work pads located in active agricultural lands or within manicured or otherwise improved residential, commercial, or industrial areas would typically be removed unless the landowner requests that they remain in place.

All work pads or portions of work pads in wetlands (typically consisting of timber mats) would be removed and the affected wetlands would be restored, pursuant to Project permits and approvals. Guard structure pads and pulling pads also would be removed.

Where work pads would remain in place, topsoil stripped from beneath the work pad and stockpiled nearby also typically would remain in place or be spread over nearby upland areas of the ROW and re-seeded. In locations where gravel work pads must be removed, the rock base and fabric materials would be excavated and removed for appropriate off-site disposal or re-use.

4.1.6 Structure Installation

4.1.6.1 Foundation Work (Foundation Types and Excavation)

The proposed new 115-kV transmission line structures would be either direct embedded or drilled shaft foundations. The tangent structures would typically be direct embedded. Angle and deadend structures would typically have a drilled shaft foundation. Excavations for line-structure foundations are expected to be accomplished using mechanical excavators (drill rigs) and pneumatic hammers. During non-working hours, fencing or other barricades would be placed around or over open foundation excavations for structures.

If blasting is required, a controlled drilling and blasting plan would be developed by a certified blasting contractor in compliance with state and local regulations. Residents would be contacted in advance of the blasting, and pre-blast surveys would be performed as appropriate. The specific locations where blasting would be required are determined by conducting field studies (borings) at the proposed structure locations.

4.1.6.2 Structure Placement

Structures would be delivered to installation locations in sections, then assembled and installed with a crane. Insulators and connecting hardware would be installed on most structures at this time. Supplemental grounding also would be installed on the new structures. Such grounding consists of a ground ring and sometimes counterpoise (i.e., buried conductors). The type of grounding required at each structure would depend on the electrical characteristics of the soil.

4.1.6.3 Alternate Foundation and Structure Placement Methodology for Inaccessible Areas

To reach some Project structure locations, constructing access roads may not be practical due severe terrain limitations or other constraints. In such locations, helicopter construction methods may be utilized.

However, helicopters do not have the lift capacity to transport the drill rigs or other heavy equipment required to install the drilled shaft foundation typically expected to be used on the Project. As a result, an alternative foundation design involving micro-piles would be required. Specifically, a group of smaller micro-pile foundations, tied together by a steel or concrete cap, would effectively support the new 115-kV structures. These alternative foundation designs can be installed utilizing smaller and lighter equipment that can be safely transported to remote work sites by a heavy lift helicopter.

In addition, helicopters would also be used to transport the structures and other materials and equipment from staging areas near the ROW to the structure sites. The heavy lift helicopters, also sometimes referred to as sky cranes, that would be used to install the new 115-kV structures in remote locations are larger than the helicopters used for stringing conductor, OPGW, and related activities. Because mobilizing and using heavy lift helicopters would be significantly more expensive than traditional construction techniques, this method would only be used at selected structure sites, if access overland is determined to be impractical.

4.1.7 1921 and 1191 Line Double-Circuit Structure Removal and 1191 Structure Removal

The same procedures would be used to remove both the existing lattice steel structures that presently support the 1921 and 1191 Lines at the Naugatuck River crossing and the existing lattice steel structure that supports the 1191 Line near Frost Bridge Substation. After removal of the existing conductors, shield wires, and insulators, the existing lattice steel structures would be disassembled, by section, using a crane. The structure sections would be placed on the ground and then further taken apart so that the steel pieces fit inside a standard dumpster. Eversource would recycle all steel demolished and would properly dispose of all other miscellaneous hardware.

4.1.8 Conductor Work

The installation of overhead line conductors and shield wires requires the use of special pulling and tensioning equipment, which would be positioned at pre-determined locations at intervals of 1 to 3 miles. Helicopters also may be used to install the initial pulling lines at the commencement of the conductor / shield wire pulling process.

The wires would be pulled under tension to avoid contacting the ground and other objects. The remaining insulators and hardware would then be installed at angle and deadend structures. Finally, the conductors and shield wires would be pulled to their design tensions and attached to the hardware by linemen in bucket trucks in accordance with industry standards and design specifications.

Various pulling sites would be established along the approximately 10.4-mile transmission line route. These sites, which are typically approximately 100 feet wide and 100 to 300 feet long, are usually located within the ROW. Specific conductor pulling sites would be identified by the Project construction contractor, in consultation with Eversource.

The selection of conductor pulling sites is based upon a variety of factors including: accessibility, terrain, angles within the line sections where the conductors would be pulled, the locations of deadend structures (which keep installed conductors under high tension), the length of conductors and OPGW to be pulled, puller capacity, and snub structure[23] loads. Other considerations include the placement of pullers, tensioners, conductor anchors, and other associated pulling equipment, including the installation of a temporary grounding system. Along the Proposed Route, conductor pulling sites would be determined based on the consideration of these factors, the design load of the structures, and the avoidance or minimization of environmental effects.

Steps would be taken to minimize temporary disturbance to adjacent landowners from noise and activity associated with the pulling operation. In addition, conductor pulling sites would be located outside of wetlands, and would avoid other areas of environmental sensitivity to the extent practical.

[23] A structure located at one end of a sag section and considered as a zero point for sagging and clipping offset calculations. A snub is a pole stub or log that is set or buried in the ground to serve as a temporary anchor. Snubs are often used at pull and tension sites.

4.1.9 Cleanup and Restoration

ROW cleanup and restoration activities would include the removal of construction debris, signs, flagging, and fencing, as well as the removal of temporary access roads and work pads. Areas affected by construction would be re-graded as practical and stabilized using revegetation or other measures before removing temporary erosion and sedimentation controls.

4.1.9.1 Final Grading, Revegetation, and Permanent Erosion and Sedimentation Controls

During final grading, areas of the ROW disturbed by construction and not otherwise occupied by permanent access roads or work pads, generally would be back-bladed to approximate preconstruction contours, where possible. Some areas (e.g., slopes, bluffs) affected by construction activities may not be fully restored to original contours. Such areas would be stabilized as warranted by site-specific conditions.

Permanent controls, such as water diversion bars or crushed stone, would be installed as appropriate to minimize the potential for erosion and sedimentation. Other permanent ROW stabilization measures include revegetation, or the use of erosion control blankets to promote revegetation.

For work sites along the ROW in agricultural fields, the soil may be decompacted by disking or using equivalent methods. Where permanent access is not required across wetlands or streams, temporary crossings (e.g., timber mats, other temporary crossing materials such as rock) would be removed and the affected areas re-graded to match the grade of areas outside of the construction work zone, to the extent practicable.

Temporary erosion and sedimentation controls would be left in place and maintained until final stabilization is achieved. Steep areas would be stabilized with jute netting, pre-made erosion and sedimentation control fabric containing seed, mulch, and fertilizer or the equivalent.

Restoration typically is deemed successful based on the effectiveness of stabilization measures as defined in and in accordance with applicable permit and certificate requirements. Based on the results of inspections of ROW stabilization (refer to Section 4.1.11), Eversource would determine the appropriate time frame for removing temporary erosion controls.

Upland areas disturbed by construction activities typically would be seeded with appropriate seed mixes, as needed. Mulch or other erosion controls would be applied as necessary based on slope and land use.

Wetland areas disturbed by construction would be reseeded with annual rye, or an equivalent native seed mix, which would serve to provide a temporary vegetative cover until wetland species become reestablished. No fertilizer, lime, or mulch would be applied in wetlands unless specified in regulatory approvals for the Project.

Vegetative species compatible with the use of the ROW for transmission line purposes are expected to regenerate naturally over time. Eversource would promote the re-growth of desirable species by implementing vegetation management practices to control tall-growing trees, and where practicable, undesirable invasive species, thereby enabling native plants to dominate the ROW. Vegetation management practices along the ROW also would conform to Project-specific conditions regarding habitat restoration and enhancement as may be included in approvals from the Council, CT DEEP, and USACE (refer to Section 4.4.1 for additional information regarding Eversource's long-term ROW vegetation management program, including invasive species control).

4.1.9.2 Permanent Access Roads and Work Pads

Access roads in uplands would be left in place to facilitate future transmission line maintenance. Structure work pads in uplands would be left in place, unless directed to be removed by the landowner. Access roads and work pads located in agricultural lands or within manicured or otherwise improved residential, commercial, or industrial areas would typically be removed unless the landowner requests that they remain in place. No new permanent access roads or work pads would be left in wetlands or streams unless approved by the involved regulatory agencies. The locations where permanent access roads and work pads will remain would be identified in the end-of-Project report to the Council.

4.1.9.3 Methods to Prevent or Discourage Unauthorized Use of the ROW

Eversource's existing transmission line easements restrict the types of activities that can be conducted within the ROW. Easements typically prohibit the construction of buildings, pools, and other structures within its ROWs. Additionally, Eversource has policies addressing requests from property owners and other parties external to Eversource. These policies outline an evaluation process and provide guidelines for allowing certain uses (such as driveways or parking lots), where appropriate.

In addition, Eversource routinely works with landowners to discourage unwarranted access onto and use of its ROWs, such as by third-party users of off-road vehicles such as all-terrain vehicles (ATVs) and snowmobiles. Where Eversource holds an easement rather than land ownership in fee, Eversource must receive landowner approval prior to installing barriers (such as fences, gates, and access control berms) to discourage such access onto its ROWs.

Pursuant to Connecticut General Statutes Section 14-387, written landowner permission is required for the use of ATVs and snowmobiles on privately-owned property. Eversource does not grant permission for ATV or snowmobile use on its property or easements (other than for its own purposes), and seeks the cooperation of local police departments in discouraging these off-road vehicular uses along its ROWs. In addition, upon request, Eversource will provide landowners along the ROW with "no trespassing" signs for posting on their property and will install gates[24] or other barriers at public road crossings to deter unauthorized vehicular access along the ROW.

4.1.10 Traffic Considerations and Control

During the installation of the new transmission line, construction-related vehicular and equipment movements would occur on roads in the Project area. However, the Project-related traffic is generally expected to be temporary and highly localized in the vicinity of the ROW and staging areas. Due to phasing of construction work, these Project-related traffic movements are not expected to significantly affect transportation patterns or levels of service on public roads.

During the Project construction phase, vehicles and equipment also would enter and exit the ROW from various public roads. To safely move construction vehicles and equipment onto and off the ROW while minimizing disruptions to vehicular traffic along public roads, Eversource or its Project contractor would, as appropriate, work with representatives of the four affected towns or the Connecticut Department of Transportation (ConnDOT). The construction contractor is typically responsible for posting and maintaining construction warning signs along public roads near work sites and for coordinating the use of flaggers or police personnel to direct traffic, as necessary.

4.1.11 Construction and Post-Construction Monitoring: D&M Plans

In accordance with the Council's requirements, after the certification of the Project, Eversource would prepare and submit for Council approval D&M Plans that would detail the procedures to be used to construct the proposed transmission facilities. The D&M Plans would incorporate the conditions of the

[24] Of the possible types of access barriers, Eversource typically prefers to install locking gates, which best allow company access to the ROW when needed. Typically, locked gates are installed along the ROW at public access points (e.g., public road crossings) to deter unauthorized off-road vehicular use.

Council's Certificate for the Project, as well as the conditions of the permits received from other regulatory agencies, as appropriate.

Eversource would retain engineering and environmental consultants to monitor the conformance of construction activities to the D&M Plans, the Council's Certificate, other regulatory requirements, and Company standards.

After the completion of construction activities (including ROW restoration), Eversource would conduct periodic monitoring of the Project ROW pursuant to state and federal permits. The monitoring would continue until ROW revegetation or other forms of stabilization are determined to be successful, as defined by Project permits. Thereafter, the ROW would be monitored in accordance with Eversource's standard operation and vegetation management protocols.

4.2 UNDERGROUND TRANSMISSION CABLE CONSTRUCTION PROCEDURES

The following typical activities will be involved in the construction of the 0.1-mile underground cable system (consisting of the cable and a single splice vault) within and adjacent to Frost Bridge Substation:

- Conduct pre-construction surveys to identify underground facilities along the cable system route, as well as to characterize soil and groundwater conditions.
- Survey and mark the cable system route.
- Establish material staging locations.
- Establish erosion and sedimentation controls, if necessary, at work sites where earth will be disturbed or spoil will be temporarily stored.
- Install construction work zone signs and implement other traffic control procedures, as needed, along Frost Bridge Road.
- Excavate for and install the splice vault.
- Excavate a trench for the cable conduits.
- Install the conduits.
- Encase the conduits in concrete.
- Backfill the trench with excavated spoils and/or a concrete-like substance known as a fluidized thermal backfill (FTB) and repave disturbed areas.
- Pull the cables into the conduits.
- Splice the cables within the splice vault.
- Terminate the cables on the transition structures.

- Stabilize areas affected by construction, using gravel (within the substation) or seeding (outside the substation), as necessary.

The sequence in which some of these construction activities will be performed will depend on construction scheduling. The types of activities generally expected to be involved in the underground cable system installation at Frost Bridge Substation are summarized below.

Construction of the underground portion of the Project would conform to the Company's December 2011 BMP Manual. To install the duct bank, a trench would be excavated approximately 6 to 10 feet deep and approximately 5 feet wide (for trench depths requiring shoring to stabilize the sidewalls). Excavated soil and rock would typically be placed directly into dump trucks and hauled away to a suitable disposal site or hauled to a temporary storage area on-site for screening/testing prior to final disposal or re-used in the excavations for backfill. Rock would be removed using mechanical methods; blasting is not anticipated. If groundwater is encountered, dewatering would be performed in accordance with authorizations from applicable regulatory agencies and may involve discharge to catch basins, temporary settling basins, temporary holding tanks (frac tanks), or vacuum trucks.

The duct bank system would consist of 8-inch PVC conduits for the XLPE cables; 2-inch PVC conduits for the ground continuity conductors and temperature sensing fiber, and 3-inch PVC conduits for the fiber optic relaying cables and the temperature sensing fiber cables. The conduit would be installed in sections, each of which would be about 10 to 20 feet long and would have a bell and spigot connection. Conduit sections would be joined by swabbing the bell and spigot with glue then pushing the sections together. After installation in the trench, the conduits would be placed into spacers that hold the conduit in the desired configuration and then encased in high strength concrete. The trench would then be backfilled with excavated spoils or FTB with sufficient thermal characteristics to help dissipate the heat generated by the cables.

Small portions of the trench (~200 feet) may have to be left open between work shifts. However, all such areas would be on Eversource property. During non-work hours, temporary cover (plywood or steel plates) would be installed over the open trench. After backfilling, the trench area within the substation would be stabilized with gravel; outside the substation, the area over the trench would either be stabilized with gravel or reseeded as necessary.

The single splice vault required for the underground cable segment would have two entry points to the surface. After backfilling, these entry points would be identifiable as manhole covers, which would be set flush with the ground or road surface.

After the vault and duct bank are in place, the conduits would be swabbed and tested (proofed), using an internal inspection device (mandrel), to check for defects. Mandrelling is a testing procedure in which a “pig” (a painted aluminum or wood cylindrical object that is slightly smaller in diameter than the conduit) is pulled through the conduit. This is done to ensure that the “pig” can pass easily, verifying that the conduit has not been crushed, damaged, or installed improperly.

After successful proofing, the transmission cables and ground continuity conductors would be installed and spliced. Cable reels would be delivered by special tractor trailers to the site, where the cable would be pulled into the conduit using a truck-mounted winch and special cable handling equipment. A single cable would be pulled into place within each conduit.

To install each transmission cable, ground continuity conductor, communications cable, and temperature-sensing fiber-optic cable within the conduits, the large cable reel would be set up over the splice vault, and a winch would be set up at one of the adjacent terminus points of the duct bank at the transition structures. The cables and the ground continuity conductors (during a separate mobilization) would then be inserted in the conduits by winching a pull rope attached to the ends of each cable. The splice vault would also be used as a pull point for installing the communications cables and temperature sensing fiber-optic cables under a separate pulling operation. In addition, a pull box would be installed near the splice vault for the pulling and splicing operations required for the remaining fiber optic cables.

After the transmission cables and ground continuity conductors are pulled into their respective conduits, the ends would be spliced together in the vault. Because of the time-consuming and precise nature of splicing high-voltage transmission cables; the sensitivity of the cables to moisture, which reduces cable life; and the need to maintain a clean working environment; splicing XLPE cables involves a complex procedure that requires a controlled atmosphere. This “clean room” atmosphere would be provided by an enclosure or vehicle that must be located over the manhole access points during the splicing process. It is expected to take approximately five to seven days to complete the splices in the one splice vault (three XLPE 115-kV cable splices in the splice vault). Each cable and associated splice would be stacked vertically and supported on the wall of the splice vault on a racking system.

At the transition structures adjacent to the Frost Bridge substation, terminations would be connected to the ends of the cables. These terminations would link the underground cables to the overhead conductor.

If groundwater is encountered, the trench or splice vault excavations would be dewatered as necessary. Depending on authorizations from state and local regulatory agencies, dewatering activities could result in groundwater discharge to catch basins, temporary settling basins, sanitary sewer, or watercourses (if the water is sufficiently free of sediments). Alternatively, the water may be pumped into a tank truck for off-site disposal. Any dewatering activity would be in accordance with permit conditions.

The equipment typically required for the installation of an underground cable segment is listed by construction phase, as follows:

Site Preparation

- Transport trucks and cranes to deliver portable field offices, sanitary facilities, equipment, and construction materials.

General Activities

- Vehicles to transport personnel and pick-up trucks for supplies and possibly refueling
- Trucks to haul sanitary and solid wastes from the construction site.

Earth Work

- Backhoe, excavator and hand tools for trench excavation.
- Earth hauling trucks to remove excavated materials from site.
- Portable air compressors with pneumatic excavating tools.
- Water pumps (if dewatering is required).
- Frac tanks for settling of removed groundwater
- Pneumatic drivers for shoring.
- Temporary shoring.
- Pavement breakers.
- Thick steel plates to cover the trench as needed.

Installation

- Side booms, forklifts, and cranes to handle the pre-cast splice vault, conduit, equipment, and materials.
- Ready-mix concrete trucks and pumps for encasing the conduits.
- Truck-mounted winch to pull cable, and trailers containing the reels of cable.

- Radio equipment for communications between splice vaults.
- Splicing trailer to regulate splice vault environment during splicing.
- Trucks carrying testing and miscellaneous equipment.

Backfill and Restoration

- Backhoe.
- Concrete trucks or dump trucks delivering thermal backfill.
- Tampers, compactors.

4.3 CONDITIONS REQUIRING SPECIAL CONSTRUCTION PROCEDURES

The Proposed Route extends across various wetlands and waterbodies, as well as areas of bedrock outcrops or where bedrock is close to the surface. In some locations, the water table also is close to the surface, resulting in the potential for encountering groundwater in excavations for structure installations. Furthermore, the Proposed Route may traverse certain areas that may potentially contain contaminated soils or groundwater.

The following subsections describe the general construction procedures that Eversource would use for water resource crossings, blasting, soils / groundwater characterization and management, and construction site dewatering. Additional, site–specific procedures would be provided in the D&M Plans, as applicable, after the completion of a final Project design.

4.3.1 Water Resource Crossings

During the construction of the Project, Eversource proposes, to the extent practical, to avoid or limit work in watercourses (streams, rivers, ponds), and to minimize the placement of structures and permanent access roads in wetlands. In addition, Eversource would implement erosion and sedimentation controls in upland areas near water resources to limit the potential for upland erosion and sedimentation into water bodies or wetlands.

All construction activities involving water resources would be performed in accordance with the conditions of the Council's Certificate, as well as pursuant to the conditions of the Project-specific water resource permits issued by the CT DEEP and the USACE. In addition, construction activities would conform to Eversource's BMP Manual, as well as to the requirements of Project-specific plans (e.g., *Stormwater Pollution Control Plan*; *Wetland Invasive Species Control Plan*; *Spill Prevention and Control Plan*), which would be prepared prior to the commencement of construction.

The water resource permit conditions and related plans would be incorporated into the D&M Plans or similar Project documents. Eversource would require the construction contractor(s) to adhere to such conditions and plans during the construction of the Project facilities.

4.3.1.1 Wetlands

To minimize or avoid adverse effects to wetlands, Eversource has attempted to locate new transmission line structures in upland areas wherever practical; based on the current line design, only one proposed structure would be situated in a wetland. Eversource would avoid access roads across wetlands if there are practical upland alternative access routes available to reach the structure locations. Eversource would limit the effects to the wetlands to the extent practical. Mitigation measures may include, for example, reducing the structure work pad size or configuring the work pad, if practical, to avoid or minimize the placement of temporary fill in wetlands.

In general, where a new structure must be located in a wetland, temporary construction mats would be used for construction support. In some wetland areas, however, field conditions (such as thickness of organics, depth of water or steep slopes) may require the use of a temporary crushed stone pad to provide a safe working surface. After the completion of structure installation, the temporary fill used for the work pads in wetlands would be removed, to the extent practicable and in accordance with the conditions of the Project-specific water resource permits issued by the CT DEEP and the USACE.

The wetland boundaries along the ROW would be clearly flagged prior to the commencement of work. When working in or traversing wetlands, Eversource would:

- Comply with the conditions of the Council's certificate and of federal and state permits related to wetlands;
- Install, inspect, and maintain erosion and sedimentation controls and other applicable construction best management practices;
- Conduct vegetation clearing in wetlands to minimize adverse effects such as by using low-impact equipment and installing temporary timber mats (or equivalent) to minimize rutting;
- Pile cut woody wetland or upland vegetation in upland areas so as not to block surface water flows within wetlands or otherwise to adversely affect the wetland integrity;
- Cut forested wetland vegetation without removing stumps unless it is determined that intact stumps pose a safety concern for the installation of structures, movement of equipment, or the safety of personnel;
- Install temporary construction matting or geotextile and stone pads for access roads across wetlands or to establish safe and stable construction work pads within wetlands, where necessary. The type of stabilization measures to be used in wetlands would depend on soil saturation;

- Avoid or minimize access through wetlands to the extent practical. Where access roads must be improved or developed, the roads would be designed, where practical, so as not to interfere with surface water flow or the wetland functions;
- Limit grading for access roads and structure foundations in wetlands to the amount necessary to provide a safe workspace;
- Install and maintain temporary erosion controls around work sites in or near wetlands to minimize the potential for erosion and sedimentation;
- Implement procedures for petroleum product management that would avoid or minimize the potential for spills into wetlands. For example, to the extent practical, store petroleum products in upland areas more than 25 feet from wetlands; refuel construction equipment, except for equipment that cannot be practically moved, in upland areas and if refueling must occur within a wetland, provide temporary containment. Similarly, except for equipment that cannot be practically moved (e.g., cranes), equipment would not typically be parked overnight on access roads or work pads in wetlands;
- Restore structure work sites in – and temporary access ways through – wetlands following the completion of line installation activities; and
- Restore wetlands, after transmission facility construction, to pre-construction configurations and contours to the extent practicable, and stabilize such areas by initial re-vegetation with annual ryegrass or native seed equivalent.

To provide new access across wetlands (where no access road currently exists), Eversource would either construct a new gravel and crushed stone access road underlain by geotextile fabric, or install a timber mat road. In wetlands where there is a deep organic layer or the wetlands are prone to extended inundation, the crushed stone access roads would remain in place permanently to provide a firm base for future access to the transmission facilities. The surficial fill materials used to construct the access roads would be removed down to the pre-construction elevation so as to not interfere with the wetland surface hydrology. The underlying material serves as either a firm base for equipment access or for the future placement of temporary timber mats to cross these larger wetland systems. Eversource anticipates this practice of establishing a permanent "access road base" may occur in some wetland systems. All other timber mat or gravel access roads would be removed in their entirety after construction.

4.3.1.2 Waterbodies

Eversource proposes to avoid direct construction work in watercourses to the extent feasible and to limit the potential for effects associated with erosion, sedimentation, or spills into streams, rivers, and ponds from construction activities. The proposed transmission line conductors would span all major watercourses, and no transmission line structures are proposed for location in waterbodies. However, temporary and possibly permanent access would be required (i.e., use of existing access roads or creation of new access roads) across some of the smaller streams along the ROW.

Along the Proposed Route, no access would be required across the Naugatuck River or any lakes. Instead, the ROW would be accessed from either side of these water crossings.

In contrast, temporary and possibly permanent access across smaller streams along the ROW would be required. However, the installation of new access roads for construction equipment crossings would be minimized to the extent practical. Whenever possible, equipment would use existing (permanent) culverted access roads to traverse watercourses. As part of pre-construction planning, Eversource would conduct integrity inspections of the existing culverted access roads. Culvert structures that are deemed to be either in disrepair or unable to support the weights of the construction equipment would be replaced at the same location and designed to maintain the stream flows. At some stream crossings, new access roads may have to be constructed or existing roads, involving fords, may require culverts or temporary bridges. Any proposed new culvert crossings would be designed and installed in accordance with applicable regulatory requirements, based on consultations with CT DEEP.

Alternatively, temporary bridges consisting of timber mats, metal bridges, or equivalent may be used for equipment stream crossings. The temporary bridges would be installed and removed to limit or avoid direct effects to banks and stream-bottom sediments.

Where practical at stream crossings, vegetation removal will be limited to that necessary for the safe construction and operation of the transmission facilities. If possible, vegetation removal near streams would be performed selectively, preserving desirable streamside vegetation within a 25-foot-wide riparian zone adjacent to either stream bank for habitat enhancement, shading, bank stabilization, and erosion/sedimentation control.

Eversource would take the following actions for construction activities across or near watercourses:

- Where existing access roads crossing stream bottoms must be improved, clean materials would be used (e.g., clean riprap or equivalent, rock fords). To the extent possible, the improvement of existing access roads across streams supporting fishery resources would be scheduled to avoid conflicts with fish spawning/migration;
- Water flows (if water is present at the time of construction) would be unconstrained throughout construction; and
- Concrete would not be mixed, placed, or disposed of so as to create the potential to enter a watercourse.

4.3.1.3 Vernal Pools

To avoid or minimize adverse effects on amphibians, Eversource would locate new structures, access roads, and work areas, to the extent practicable, outside of wetlands that provide vernal pool habitat. Based on the current Project design, no new structures would be located within vernal pool depressions or "cryptic" vernal pool habitat.[25]

In addition, Eversource's consultants have reviewed Calhoun and Klemens', *Best Development Practices, Conserving Pool-Breeding Amphibians in Residential and Commercial Developments in the Northeastern United States*.[26] While a linear overhead transmission line such as the Project is not entirely consistent with the types of development described in this document, there are conservation issues and management recommendations that are applicable.

Eversource has identified the following types of measures that may be applicable to minimize adverse Project effects on vernal pools:

- Where feasible in areas proximate to vernal pools, adhere to the seasonal windows for tree clearing to avoid adverse effects on amphibians during migration periods.
- Install appropriate erosion and sediment controls around distinct work sites and access roads to minimize the potential for sediment deposition into vernal pools, and remove such controls promptly after final site stabilization.
- For Project activities that must occur adjacent to vernal pools during amphibian migration periods, implement measures on a site-specific basis as necessary to facilitate unencumbered amphibian access to and from vernal pools. Mitigation measures will be identified after taking into consideration site-specific conditions, including the type of construction activity in proximity to a vernal pool, the amphibian species known to occur in the vernal pool, and seasonal conditions. Options to allow amphibian access to vernal pools may include, but not be limited to: syncopated silt fencing in the immediate vicinity of vernal pools; elevated construction matting; and aligning erosion and sedimentation controls to avoid bifurcating vernal pool habitat.
- Evaluate the use of temporary timber mat access roads in wetlands in lieu of constructing gravel access roads in the vicinity of vernal pools.
- Minimize the removal of low-growing vegetation surrounding vernal pools.

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[25] Cryptic vernal pools are vernal pools that are contained within larger wetland systems.

[26] Calhoun, A.J.K. and M.W. Klemens. 2002 *Best development practices: Conserving pool-breeding amphibians in residential and commercial developments in the northeastern United States*. MCA Technical Paper No. 5, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York.

The specific measures that would be implemented to protect vernal pool amphibians would be defined in consultation with the involved regulatory agencies (e.g., CT DEEP and the CSC) and would be incorporated into the D&M Plans for the Project.

4.3.2 Blasting

If blasting is necessary (e.g., for access, word pads, structure foundations), Eversource would take the following steps:

- A certified blasting specialist would develop site-specific blasting procedures, taking into account geologic conditions and nearby structures, and ensuring compliance with state regulations;
- The blasting plan would be provided to the local Fire Marshal for approval. Blasting charges would be designed to loosen only the material that must be removed to provide a stable foundation, and to avoid fracturing other rock;
- Eversource would seek to meet with each property owner in proximity to the blasting to explain where and when the blasting is expected to occur, and why blasting is necessary;
- Pre-blast surveys, to document existing conditions, would be conducted for any property within a specified distance of the area where blasting is to occur. This distance would be determined by Eversource’s blasting contractor, in consultation with the Fire Marshal, and with Eversource’s approval;
- The areas where blasting is to occur would be covered with heavy blanketing materials and charges would be sized appropriately;
- Seismographs would measure each blast to confirm that levels are within prescribed limits; and
- Excavated material that cannot otherwise be used at the site would be removed and properly disposed of elsewhere, pursuant to Project specifications.

4.3.3 Soils and Groundwater Testing and Management

4.3.3.1 Pre-Construction Studies and Plans

Soils and groundwater will be managed in accordance with applicable state regulations during the construction of the Project. As part of the final Project design, Eversource would implement specific plans for characterizing the soils and groundwater (i.e., presence/absence of contaminants) along the ROW, and subsequently for handling and managing such materials during construction. These plans would be developed based upon the results of a due diligence review of existing data regarding the current and historical uses of areas along the ROW, properties along the ROW, and nearby off-site sources. The scope of the due diligence work would comply with Sections 8.1 and 8.2 of the American Society for Testing and Materials (ASTM) Standard E1527-05. The objective of the work would be to identify known locations of potential past or current contamination sources, such as leaking underground storage tanks, sites designated as hazardous by federal or state government, and locations of reported spills of petroleum products or hazardous material, etc.

For soil and groundwater testing and management, Eversource would conform to the guidance issued by the CT DEEP for Utility Company Excavation. This guidance applies to cases where contaminated soils / waste are encountered during construction or maintenance activities on property not owned by the utility and the contamination was not created by the utility. The utility may reuse the contaminated soil in the same excavation, within the same area of concern, without prior approval by CT DEEP provided:

- Any condition that would be a significant environmental hazard, as defined in Connecticut General Statutes Section 22a-6(u), is reported by the utility and that the location is identified on a map submitted to the CT DEEP Remediation Division;
- Any excess contaminated material is disposed of appropriately in accordance with solid and hazardous waste regulations; and
- The upper 1 foot of the excavation is filled with clean fill material or paved.

Construction contractors would be required to conform to CT DEEP requirements and to any Project-specific material handling plans.

4.3.3.2 Soils / Groundwater Handling and Management

The approach used to handle and manage soils disturbed by construction activities would depend on whether or not contamination is present, as determined by the due diligence work described in Section 4.3.3.1.

If the results of investigations indicate that contaminants may exceed acceptable concentrations, Eversource typically would prepare a Project-specific *Material Handling Guideline*, or equivalent, to assist the Contractor in properly handling and disposing potentially impacted soils or groundwater. The *Material Handling Guideline* would be implemented in areas where the excavation of potentially contaminated soils or the dewatering of potentially contaminated groundwater may be necessary during Project construction and would detail the procedures that would be followed to properly handle and manage such materials in order to minimize exposure to the general public and environmental receptors.

Excavated materials to be transported from the ROW would be loaded directly onto trucks for off-site disposal at an appropriate facility, or stockpiled temporarily on-site or at a permitted facility before being disposed at a permanent facility. Soil transported from the ROW would be transported under a Bill of

Lading or a Hazardous Waste Manifest, as appropriate. These soils would be disposed of in accordance with the applicable federal, state and local regulations.

4.3.4 Groundwater and Construction Site Dewatering

Neither the construction nor the operation of the Project is expected to result in adverse effects on groundwater resources or public water supplies. During construction, care would be taken to avoid effects to municipal water lines that may be located within road ROWs or that otherwise extend across the transmission line ROW.

If groundwater is encountered during excavations for transmission line structure foundations, the water would be pumped from the excavated areas and discharged in accordance with applicable local and state requirements. Depending on regulatory authorizations, the water may be discharged on-site into an appropriate sediment control basin/filter bag or directly into municipal storm water catch basins, if available. Proper catch-basin inlet protection would be installed as needed to prevent disturbed soils excavate and construction debris from entering storm water systems.

Contaminated groundwater; if encountered, may require treatment before being discharged to either the storm water or municipal sanitary sewer system. Contaminated groundwater may also be pumped into a temporary fractionization (frac) tank and then pumped into a tanker truck for disposal at appropriate wastewater treatment facilities. Residual silt/sediment collected at the bottom of the frac tanks would be disposed off-site at an appropriately designated disposal facility.

4.4 CONSTRUCTION PROCEDURES FOR SUBSTATION MODIFICATIONS

4.4.1 Overview of Proposed Construction at Stations

The proposed Project will involve modifications to Eversource’s Frost Bridge and Campville substations.

The actual sequence of construction activities and methods of construction will vary for each station, based upon the specific engineering design ultimately developed for the substation modifications and the extent of work required at each site. Furthermore, more detailed construction requirements and, as appropriate, environmental mitigation measures specific to each substation, may be defined during the Council’s Project review process. In addition, the modifications to the Frost Bridge Substation will be scheduled to avoid conflicts with the installation of the 0.1-mile segment of underground 115-kV cable.

The following summarizes the general sequential, phased, approach expected to be used in modifying these existing stations.

4.4.2 Site Preparation

The type of site preparation work required at each site would vary, in accordance with the characteristics of each station and the areas proposed for the facility modifications. Site preparation work may include:

- Establishing construction offices and material staging sites (either on or off the existing substation properties)
- Installing and maintaining, as necessary, temporary soil erosion and sedimentation controls (e.g., silt fence, hay/straw bales) around areas of planned soil disturbance
- Removing minimal vegetation (if present) from work areas and equipment staging locations
- Creating temporary access to the sites for heavy construction equipment
- Grading (rough), if necessary, to create level work areas
- Excavating unsuitable soils
- Installing protective fencing around work sites

Site preparation work typically could involve the use of construction equipment such as bulldozers, backhoes, man-lift vehicles, compressors, trucks (various sizes), a large capacity crane (e.g., 100-ton), and flat-bed trailers.

4.4.3 Foundations and Equipment Installation

The foundation installation process generally involves excavation, form work, use of steel reinforcement, and concrete placement. Excavated material would either be reused on-site or disposed of off-site in accordance with applicable requirements.

If groundwater is encountered in excavations, the procedures described in Section 4.3.4 would be followed. Similarly, if contaminated soils are encountered, the procedures summarized in Section 4.3.3 would be followed.

After the foundations are installed, construction activities would shift to the erection of structures and equipment as specified for each station modification. Such structures and equipment include steel structures, bus and insulators, circuit breakers, switches, voltage transformers, lightning masts, relay / control enclosures or expansion of existing enclosures, cable trench, ground grid, surge arresters, conduits and cables.

4.4.4 Testing and Interconnections

New structures and associated conductors and wires would be installed, as necessary, to connect the new 115-kV facilities at the substations. All of the substation equipment would be commission-tested prior to final connection to the transmission grid.

4.4.5 Final Cleanup, Site Security, and Landscaping

After the completion of construction, any remaining construction debris would be collected and removed from the station sites. Temporary erosion controls would be maintained until the disturbed areas are satisfactorily stabilized.

Because the proposed Project modifications would be within the developed (fenced) area at Frost Bridge Substation and would require only a minor (0.4-acre) expansion of the Campville Substation, landscaping is not expected to be warranted.

4.5 OPERATION AND MAINTENANCE PROCEDURES

4.5.1 ROW Vegetation Management

Eversource's long-term vegetation management program includes the selective removal of targeted species (e.g., tall growing trees and selected state-listed invasive woody shrubs) within the portions of its ROWs occupied by transmission lines. In addition to tree removal within the ROW, danger and hazard trees adjacent to the managed ROW that could fall onto a conductor will be trimmed or removed. Brush control within Eversource's ROWs is performed every four years, and side trimming (i.e., removal of trees or tree limbs that encroach along the edge of the managed ROW) is performed every 10 years. All work is performed in accordance with Eversource's *Specification for Rights-of-Way Vegetation Management (2015)*.

In addition, based on recent experience in the development of other new transmission line facilities, Eversource anticipates that a *Wetland Invasive Species Control Plan,* or similar documentation of the current presence of invasive species in wetlands along the ROW and an approach for the control of these species, would be required for the Project. The *Wetland Invasive Species Control Plan* (or equivalent) would be developed after consultations with the USACE, CT DEEP, and other involved agencies regarding the types of wetland invasive species to be targeted for control along the Project ROW and the overall objectives of the control program. Typically, the *Wetland Invasive Species Control Plan* is prepared as part of Eversource's regulatory applications to the USACE and CT DEEP.

4.5.2 Substation Maintenance

The proposed Project modifications to the Frost Bridge and Campville substations would not substantially affect or alter existing maintenance practices at these existing facilities.

4.5.3 Compliance with Applicable Codes and Standards

The proposed Project would be constructed in full compliance with the National Electrical Safety Code (NESC), standards of the Institute of Electrical and Electronic Engineers (IEEE) and the American National Standards Institute (ANSI), good utility practice, and the CT DEEP Public Utilities Regulatory Authority (PURA) regulations covering the method and manner of high voltage line construction.

4.5.3.1 Emergency Operations and Shutdown

If a transmission line experiences an insulation or conductor failure, then high-speed protective relaying would immediately remove the line from service, thereby protecting the public and the line. If equipment at the substations experiences a failure, then protective relaying would immediately remove the equipment from service, thereby protecting the public and the equipment within the substations.

Protective relaying equipment would be incorporated into the Project design to automatically detect abnormal system conditions and send a protective trip signal to the respective circuit breaker(s) at each end of a line to isolate the faulted section of the transmission system. The protective relaying schemes include fully redundant primary and backup equipment. This ensures that if a line or station equipment failure were to occur at a time when one of the protective relaying schemes fails or is removed from service for maintenance, the redundant protective relaying scheme would initiate the removal from service of the faulted transmission facility being monitored.

Fiber optic strands will be installed within the lightning shield wires above the overhead line. These strands provide a robust and reliable communications path for the protective relaying systems. Additionally, the overhead transmission line facilities may also provide for electronic communications between substations using signals impressed upon line conductors ("carrier signal") for protective relaying and operations.

4.5.3.2 Fire Suppression Technology

Smoke detection systems are already in place in the existing relay and control enclosures at Frost Bridge Substation. The existing relay and control enclosure at Campville Substation does not have a fire/smoke detection system. However, as part of the Project, the Campville Substation will require a new control building to house DC battery banks, along with applicable chargers and other miscellaneous equipment. This new building will be equipped with fire suppression systems as specified in Eversource standards. These standards detail power supply sources, smoke detector locations, control panel requirements, and wiring requirements for a fire suppression system. In addition, fire extinguisher types, mounting locations, and replacement criteria are outlined. In the event that fire or smoke is detected, these fire/smoke detection systems would automatically activate an alarm at the Connecticut Valley Electric Exchange (CONVEX), and the system operators then would take the appropriate action. The relay/control enclosures at each station are equipped with fire extinguishers.

The new protective relaying and associated equipment within the substations, along with a Supervisory Control and Data Acquisition (SCADA) system for remote control and equipment monitoring, would be installed in the existing relay and control enclosures.

4.5.4 Project Facilities Reliability, Safety and Security Information

The Project would be designed in accordance with sound engineering practices and constructed in full compliance with the standards of the NESC and good utility practice. Should equipment experience a failure, protective relaying would immediately remove the equipment from service, thereby protecting the public, the equipment within the substations, as well as the associated transmission line infrastructure.

4.5.4.1 Emergency Operations and Shutdown

Protective relaying equipment will be incorporated into the Project design to automatically detect abnormal system conditions and send a protective trip signal to the respective circuit breaker(s) at each end of the line to isolate the faulted section of the transmission system. Specifically, fiber optic strands would be installed within the overhead ground wire as part of the transmission line between the Frost Bridge and Campville substations. These strands would provide a robust and reliable communications path for the protective relaying systems.

The protective relaying schemes include fully redundant primary and back up equipment. This ensures that if a line or station equipment failure were to occur at a time when one of the protective relaying schemes is removed from service for maintenance, the redundant protective scheme would initiate the removal from service of the faulted transmission facility being monitored.

If the transmission line experiences an insulation or conductor failure, then high-speed protective relaying would immediately remove the line from service, thereby protecting the public and the transmission line. If equipment at the substations experiences a failure, then protective relaying would immediately remove the equipment from service, likewise protecting the public and equipment within the substations.

4.5.4.2 General Site Security

The access driveways to both the Frost Bridge and Campville substations are gated and the perimeter of each substation is entirely enclosed with a 7-foot high chain-link fence topped with an additional foot of barbed wire to discourage unauthorized entry and vandalism. As part of the Project, the Campville Substation will be expanded; the substation's perimeter fencing will be extended accordingly to encompass this expansion area.

Lighting is installed within the substation yards to facilitate work at night under emergency conditions and during inclement weather. The substations also presently have low-level lighting for safety and security purposes.

During construction, access to both substations will be controlled, with the substation gates kept closed and locked as needed. In addition, all substation gates will be padlocked at the end of the workday during Project construction and at all times after the Project is completed. Appropriate signage is posted at Frost Bridge and Campville substations alerting the general public of the high voltage facilities within each substation.

4.5.4.3 Physical Security of Proposed Facilities

The physical security of the Frost Bridge and Campville substations presently is consistent with the Council's *White Paper on the Security of Siting Energy Facilities,* as amended, initially adopted in the Council's Docket 346 ("White Paper"). The *White Paper* Guidelines focus on the unpredictable intentional act of perpetrators designed to damage the physical structures of the certificated facilities (as opposed to, for instance, cyber security). The Project modifications also will be consistent with the Council's *White Paper* Guidelines.

The following summary follows the format suggested by the Council in its White Paper, which focuses on security issues associated with four areas: Planning, Preparedness, Response, and Recovery. Each section first presents the discussion topic included in the White Paper, and then provides Eversource's proposed security approach for the particular area.

Identify the physical vulnerabilities most likely to pose a security threat:
Except for the short segment of underground cable on Eversource property at the Frost Bridge Substation, Eversource proposes to construct the new 115-kV transmission line overhead, on an existing ROW, which extends principally through undeveloped tracts of land (including state and federal recreational properties) and sparsely settled areas. The ROW is not, and cannot be, fenced. The location of the ROW, which is occupied in part by existing Eversource overhead transmission lines and managed to promote low-grown vegetation, is shown on easily accessible on-line mapping resources. Accordingly, trespassers may relatively easily identify the ROW and could gain access to, and remain on the ROW without being detected by adjacent landowners or passers-by. Thus, a trespasser could have more time to prepare an attack on the facility than would be the case in a more settled area.

However, the facilities will not be easily damaged. What is more important is that the transmission system is designed to withstand the sudden unexpected loss of a single line and the overlapping loss of a second line, without widespread loss of service, and without damage to customer or utility equipment. Moreover, if elements of an overhead line are damaged or destroyed, they can be quickly repaired or replaced. Accordingly, an attack designed to destroy or interfere with a section of overhead transmission line is unlikely to cause severe and long lasting damage to the overall system.

The Project will involve modifications to Eversource's existing Frost Bridge and Campville substations. These existing substations are points of greater system vulnerability than transmission lines. Because multiple transmission and distribution circuits connect to both substations, an attack on a one of these points would be more likely to affect more than one circuit (and therefore more than one source of supply) than would an attack on a portion of the transmission line. However, although both Frost Bridge and Campville substations are visible and easily accessible from public roads, both are fenced and monitored. In fact, there are already security precautions in place in these two substations and the proposed Project improvements will not add any new vulnerabilities.

Identify the type and characteristics of the facility and any ways in which the facility's setting affects security concerns:

Eversource proposes to install the new 115-kV transmission line on three different types of structures. The majority of the proposed line would be supported on steel monopole structures in either a delta or a vertical configuration. The existing ROW is sufficiently wide such that the new monopoles would be installed without affecting the existing transmission lines (i.e., without requiring the relocation or rebuilding of existing structures). The new monopole structures would be weathering steel, with typical structure heights between 80 and 105 feet above ground, depending on terrain.

To interconnect the new 115-kV transmission line to the transmission grid, modifications are required to both Frost Bridge and Campville substations. At Frost Bridge Substation, all of the proposed modifications will be accomplished within the developed portion of the existing station. However, at Campville Substation, the modifications will require the expansion of the developed portion of the substation by approximately 0.4 acre, involving an extension of the existing station fence to the east by approximately 90 feet.

The setting of the proposed facilities poses no particular security concern, apart from the rural nature of the areas traversed by the ROW, which would make detection of hostile activity less likely than it would be in a settled area. As the Volume 5 maps illustrate, the proposed new line will generally traverse rural and sparsely settled areas, where hostile activity may be more difficult to detect in a timely manner than would be the case in settled areas, and the ROWs cannot be fenced. However, the Frost Bridge and Campville substations are secure and are classified as a “low” risk per the NERC Physical Security Standard. Security at low risk sites includes electronic access control and Closed Circuit TV. Additional security measures may be installed based on experience at the specific location, as is the case with Frost Bridge Substation. Currently, Eversource is in the process of installing base security measures at “low” risk sites. Frost Bridge Substation currently has these measures; similar facilities at the Campville Substation are planned for 2016.

Examine any pertinent ways in which the facility is linked to other facilities and systems and potential repercussions from a facility or system interruption. Examine whether the proximity of the facility to other electric facilities, either dependent or independent, presents security challenges:

Section 2 describes the interrelationship of the proposed Project to the electric transmission system in the adjacent region. Because the region’s electric supply systems are tightly networked, a disturbance to one part of the system can cause an overload or voltage violation on other, fairly distant parts of the system. However, in a system that is planned and operated according to applicable reliability standards, the sudden and unexpected loss of even a critical system element when the system is already under stress will not result in a cascading outages, or damage to customer or utility equipment. The proposed Project facilities will help to provide such a robust system. There is nothing about the particular points of interconnection of the proposed facilities, or their proximity to other facilities, that presents any enhanced security challenge.

The new 115-kV transmission line will share an existing ROW with an existing 115-kV line and, in some segments, a 345-kV line and other 115-kV lines. Separations between the new and existing lines will be maintained as required by the NERC, the NESC, Eversource's own safety criteria, and other regulatory requirements.

Placement of more than one line on the same ROW, although common and necessary to minimize conflict with other land uses, does create a risk that a physical attack on one line can affect the other lines on the ROW simultaneously, or that the lines could be attacked at the same time. However, it would be extremely difficult to cause a structure to fall onto an adjacent line. Because the structures are connected by conductors under high tension, they tend to fall longitudinally along the ROW in the event that they are felled – rather than in a lateral direction that would cause them to fall into an adjacent line.

Nevertheless, the consequences of the simultaneous loss of all lines on a single ROW (which could occur accidentally such as by an airplane crash or a large fire, as well as by sabotage) are evaluated by transmission planners as a possible "extreme contingency." The system is not required to withstand such contingencies without an interruption of service.

Some ROWs contain as many as six transmission circuits. In the case of the proposed Project, there would predominantly be only two to three lines within the ROWs (although in XS-2, the new 115-kV line will occupy a ROW segment that includes both the existing 345-kV line and two other 115-kV lines). In the event of the simultaneous outage of the lines on the ROW, loss of service, if any, would last for only a short time, and might be avoided by transmitting power over alternate paths for the period of time required to effect emergency repairs.

Overhead transmission lines can usually be restored to service after a damaging outage within a few days.

Examine if there is an established method to help regional, state and national security officials maintain situational awareness of this facility.

Eversource has established procedures to help regional, state and national security officials maintain situational awareness of its facilities. CONVEX monitors Eversource's transmission facilities and those of other member utilities in Connecticut and Western Massachusetts in real time, and ISO-NE similarly monitors the security status of the entire New England bulk power system.

Causes of outages are investigated promptly and, when appropriate, reported to law enforcement officials. Maintaining situational awareness is a dynamic task. In 2006, when NERC applied to be designated by the FERC as an Electric Reliability Organization (ERO), NERC included a provision for maintaining situational awareness and it continues to develop improvements to address and/or improve awareness.

Preparedness

Examine site security infrastructure, including site monitoring, physical and nonphysical barriers and access controls:

Both Frost Bridge and Campville substations are presently gated and the perimeter of each substation is enclosed with a 7-foot high chain link fence topped with an additional foot of 3 strands of barbed wire to discourage unauthorized entry and vandalism. Access is limited through a locked gate and only authorized personnel are permitted to enter. Frost Bridge and Campville substations are secure and are classified as a "low" risk per the NERC Physical Security Standard. Security at low risk sites includes electronic access control and Closed Circuit TV. Additional security measures may be installed based on experience at the specific location, as is the case with Frost Bridge Substation. Currently Eversource is in the process of installing base security measures at "low" risk sites. Frost Bridge Substation currently has these measures, for the Campville Substation this work is planned for 2016.

Site security monitoring will largely be provided by Eversource security's central monitoring station located in Berlin, Connecticut. Additionally, as part of its duties, CONVEX maintains a procedure regarding sabotage events will be identified and reported to local and federal officials, neighboring entities, and regulatory authorities. NERC provides guidelines for assessing the degree of protection each component of the grid should receive and recommended types of precautions that these faculties should have in place.

Personnel

Review any simulated exercises that include local police, fire, and other emergency response teams. Examine whether local law enforcement/emergency response liaison is in place, and review mutual aid agreements between affected entities:

Eversource regularly consults with first responders across its service territory. The addition of the proposed Project facilities will not call for any change in established procedures that are in place for notification and response. Eversource Public Outreach personnel are available to act as liaisons between town officials and the Company through well-documented and exercised protocols.

The Connecticut Department of Emergency Services and Public Protection ("DESPP") Training and Exercise Division sponsors emergency preparedness training, seminars, exercises, and conferences for local first responders, as defined in Homeland Security Presidential Directive 8 (i.e., police, fire, emergency management, emergency medical services, public health, public works, private sector, non-governmental organizations and others. These presentations and seminars are designed to cover Mitigation, Preparedness, Response and Recovery. Eversource is represented on the Private Sector Council of DESPP, which meets quarterly and more frequently as needed. Eversource has participated, and will continue to participate, in state and regional emergency exercises.

Response

Examine notification procedures to public and/or local officials, including the types of security issues that would warrant such notification.

Upon completion of construction, the proposed Project will not require any change in existing, pre-established public notification procedures. After the Project is constructed, Eversource will adhere to NERC and CONVEX protocols and will coordinate further with these entities regarding the best mechanism for communicating incidents.

Mitigation

Examine mitigation measures, including alternate routing of power, strategically located spares and mobile backup generation.

As discussed in Section 2, the proposed Project will improve the reliability of the grid in Connecticut. In the event of the interruption of the new line, power flow would be automatically redirected to other lines. Eversource continually prepares for outage contingencies. The system is planned and operated so that the sudden and unexpected loss of the new line would not result in a widespread loss of load or in damage to utility or customer equipment.

Eversource keeps an inventory of spare equipment to enable it to quickly restore facilities to service after most failures. For example, temporary transmission line support structures are maintained in depots from which they may be quickly transported to the ROW. Spare transformers and substation and switching station equipment are located either at the station or in a central storage area to be deployed as may be required. Moreover, most substations contain a circuit switcher and a disconnect switch to facilitate the installation of a mobile transformer in case one of the permanently installed transformers is removed from service for prolonged period of time. Since transformers could fail without warning, Eversource is prepared to quickly respond to a transformer failure.

Recovery

Identify measures that will be taken, if necessary, to restore natural resources at the site of the facility:

In the event of an incident, the first priority would be to eliminate any threat to public safety and then to repair the transmission facilities. During the response to an incident, natural resources at or adjacent to the site would be protected to the extent practical and subsequently restored to pre-incident conditions as appropriate. Mitigation protocols for impacts to wetlands and water resources would be coordinated with the appropriate resource agencies, such as the USACE the CT DEEP.

Reporting

Determine whether reporting procedures are established to evaluate and improve the effectiveness of local emergency response teams, methods to limit negative impacts on neighboring electric facilities, and restoration of the natural environment.

Eversource will investigate and respond to any incident associated with its infrastructure. Depending on the magnitude and consequences of the incident, Eversource's processes and/or after action reviews will evaluate what improvements may be needed to minimize the potential for future adverse effects on its facilities and the environment and neighboring electric facilities in future incidents response, as well as the effectiveness of the interface with local emergency response teams.

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5. DESCRIPTION OF EXISTING ENVIRONMENT

This section describes the existing environment and cultural resources along, and in the vicinity of, the Proposed Route. Section 5.1 discusses the environmental conditions in the vicinity of the proposed new 115-kV transmission line and double-circuit separation. Section 5.2 presents existing environmental conditions at the Frost Bridge and Campville substations. The information concerning these existing environmental and cultural features reflects the results of baseline data research, as well as field investigations conducted along the Project ROW in 2009 (as part of the initial planning for a new 345-kV line that was not advanced for development) and again in 2015 (for this Project).

Two sets of aerial-photography based maps depicting the environmental and cultural conditions in the Proposed Route were prepared: the Volume 5, 400 scale maps show the proposed Project facilities in relation to environmental features in the surrounding areas, whereas the Volume 5, 100 scale maps provide a closer view of the conditions in the immediate vicinity of the proposed Project facilities. The principal environmental conditions, land use features, and natural resources shown on the Project maps include, but not are limited to:

- Location of the existing ROW, transmission line structures access roads, and work pads, as well as the Frost Bridge and Campville substations and junctions with other Eversource transmission lines;
- Location of Eversource fee-owned properties;
- Vegetative cover types;
- Areas of steep slopes;
- Land uses, including agricultural, residential, commercial, and industrial areas;
- Municipal boundaries;
- Municipal zoning classifications;
- Federal and state jurisdictional wetlands;
- Vernal pools;
- Water resources, including streams, rivers, and ponds;
- Floodplains, as designated by the Federal Emergency Management Agency ([FEMA]; Special Flood Hazard Areas[27])

[27] Special Flood Hazard Areas are defined as the area that will be inundated by the flood event having a 1% chance of being equaled or exceeded in any given year. The 1-% annual chance flood is also referred to as the 100-year flood.

- Public recreational, scenic, open space, and other protected areas, including forests, parks, water supply areas, hunting/wildlife management areas, and designated recreational trails;
- Schools and community facilities; and
- Existing infrastructure, including roads, utility corridors, and railroads.

5.1 PROPOSED ROUTE: FROST BRIDGE SUBSTATION TO CAMPVILLE SUBSTATION

The Proposed Route traverses approximately 10.4 miles in a general northerly to northeasterly direction, extending between Eversource's existing Frost Bridge and Campville substations following an existing Eversource ROW and aligned adjacent to an existing 115-kV line, through portions of the towns of Watertown, Thomaston, Litchfield, and Harwinton, in Litchfield County. Along a portion of the route in Watertown, the ROW also includes a 345-kV line.

5.1.1 Topography, Geology and Soils

The information presented below is based on analyses of existing published information and – in the case of soils – field investigations conducted as part of wetland surveys. Prior to final engineering design, additional investigations will be performed in some areas along the Proposed Route to further characterize the physical and structural characteristics of the subsurface geologic features. The results of such investigations may be used in the design of structure foundations.

5.1.1.1 Topography

The Proposed Route is situated within the Northwest Hills physiographic region of Connecticut.[28] This region is characterized moderately hilly glacial till dominated landscapes of intermediate elevation with narrow glacial outwash valleys and local areas of steep and rugged terrain. Elevations throughout the Proposed Route range from approximately 300 feet in Watertown to 880 feet in Litchfield. The Proposed Route does not traverse any traprock ridge[29] or amphibolite ridge[30] areas as specified in Connecticut

[28] Dowhan, J.J., and R.J. Craig. 1976. *Rare and Endangered Species of Connecticut and Their Habitats.* State Geological and Natural History Survey of Connecticut, Department of Environmental Protection. Report of Investigations No. 6. 137 p.

[29] According to definitions provided in the Connecticut General Statutes, Chapter 124, § 8-1aa, "traprock ridge" means Beacon Hill, Saltonstall Mountain, Totoket Mountain, Pistapaug Mountain, Fowler Mountain, Beseck Mountain, Higby Mountain, Chauncey Peak, Lamentation Mountain, Cathole Mountain, South Mountain, East Peak, West Peak, Short Mountain, Ragged Mountain, Bradley Mountain, Pinnacle Rock, Rattlesnake Mountain, Talcott Mountain, Hatchett Hill, Peak Mountain, West Suffield Mountain, Cedar Mountain, East Rock, Mount Sanford, Prospect Ridge, Peck Mountain, West Rock, Sleeping Giant, Pond Ledge Hill, Onion Mountain, The Sugarloaf, The Hedgehog, West Mountains, The Knolls, Barndoor Hills, Stony Hill, Manitook Mountain, Rattlesnake Hill, Durkee Hill, East Hill, Rag Land, Bear Hill, Orenaug Hills.

General Statutes (CGS) § 8-1aa (1) and no such geologic formations are located within the Project area towns. Following Eversource's existing ROW, the Proposed Route generally does not parallel ridgelines.[31]

5.1.1.2 Geology

Connecticut's bedrock geology has a direct effect on landscape forms due to differing resistances to weathering and erosion. Bedrock geologic mapping[32] indicates that the Proposed Route traverses extensive areas of schist bedrock (e.g., Taine Mountain formation), and exhibits north-trending belts and outcrops.

The predominant surficial deposit along the Proposed Route is shallow till in moderate to strongly sloping bedrock-controlled topography. Where these deposits are present, the slopes and outline of the landform generally reflect the form of the underlying bedrock, which is draped by a shallow mantle of till. Till thicknesses overlying the bedrock are generally less than 15 feet and may include frequent bedrock outcrops. Bedrock is frequently exposed or shallow (within 4 feet of the ground surface) in the following sections of the ROW that are characterized by steeply-sloping terrain:

- From the southern terminus of the Project at Frost Bridge Substation to Park Road in Watertown;
- From Thomaston Road (U.S. Route 6) in Watertown to Mason Hill Road in Litchfield (including through Black Rock Park in Watertown, where bedrock outcrops are common); and
- West of Route 8 in Litchfield and east of the Naugatuck River bottomlands to Wildcat Hill Road in Harwinton.

Deep till deposits occur where glacial ice overriding the land surface pushed up rounded hills oriented along the localized travel direction of the last continental ice sheet. These rounded hills, or drumlins,

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30 According to definitions provided CGS § 8-1aa, "amphibolite ridge" means Huckleberry Hill, East Hill, Ratlum Hill, Mount Hoar, Sweetheart Mountain.

31 According to definitions provided in CGS § 8-1aa, "ridgeline" means the line on a traprock or amphibolite ridge created by all points at the top of a 50% slope, which is maintained for a distance of 50 horizontal feet perpendicular to the slope and which consists of surficial basalt geology, identified on the map prepared by Stone et al., United States Geological Survey, entitled "Surficial Materials Map of Connecticut".

32 Rodgers, J. 1985. *Bedrock Geologic Map of Connecticut*. Connecticut Geological and Natural History Survey, CT Department of Environmental Protection. Hartford CT. 1:125,000.

generally have till depths exceeding 15 feet and depths of 100 feet are not uncommon.[33] The ROW traverses deep till deposits along Campville Road in Litchfield.

Glacial outwash deposits, typically characterized by stratified sand and gravel, were derived from meltwater steams flowing from retreating glacial ice. Along the Proposed Route, outwash deposits are associated with the Naugatuck River Valley in Watertown, Litchfield, and Harwinton. Bedrock depths generally exceed 30 feet beneath these sand and gravel deposits and are often more than 100 feet below the ground surface. Floodplain deposits are also associated with the Naugatuck River Valley in Watertown, Litchfield, and Harwinton. Bedrock is generally deep (greater than 30 feet) beneath these deposits.

5.1.1.3 Soils

Information regarding the soils along the Proposed Route was obtained from on-line soil surveys and maps published by the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS).[34] These surveys and maps provide soil classifications and characteristics, including depth to bedrock, slope, drainage, and erosion potential. Table 5-9 (which is located at the end of this section due to its length) summarizes the principal soil associations, as identified by the NRCS along and in the general vicinity of the Proposed Route. The table also identifies soils classified by the NRCS as "Prime Farmland" soils or "Farmlands of Statewide Importance".

The baseline soils information obtained from the NRCS maps and surveys is a supplement to the field investigations that are required to identify Connecticut wetlands, which are defined based on the presence of poorly drained, very poorly drained, or floodplain soils. Wetlands along the Proposed Route were delineated by registered professional soil and wetland scientists, working along with biologists, as part of field studies conducted along the ROW in 2009 and again in 2015.

5.1.2 Water Resources

Water resources along the existing Eversource ROW include inland wetlands, watercourses (intermittent and perennial streams and rivers), waterbodies (ponds), and groundwater resources, including public water supplies and floodplains. Eversource commissioned both baseline research to identify Project area

[33] Melvin, R.L., Stone, B.D., Stone, J.R., and N.J. Trask. 1992. *Hydrogeology of Thick Till Deposits in Connecticut*. U.S. Geological Survey Open-File Report. p. 92-43.

[34] Web Soil Survey, accessed 2015.

water resources, and field investigations to delineate state and federal wetlands and watercourses along the Proposed Route.

In April and May of 2015, Eversource's consultants delineated water resource areas along the Proposed Route. Consultants delineated water resources along the entire width of the Eversource ROW within which the new 115-kV transmission line would be located. During the delineations, wetlands and watercourses were field-demarcated using numbered flagging. These boundary flags were subsequently surveyed using a Trimble Global Positioning System (GPS) survey unit. Resource areas are depicted on the Volume 5 maps, summarized in Table 5-10 (which is provided at the end of this section due to its length), and described in detail in the *Wetlands and Watercourses Report* in Volume 2.

5.1.2.1 Drainage Basins and Waterbodies

Connecticut is divided geographically into eight major drainage basins and 45 regional basins. The Proposed Route is located in portions of the Housatonic (major) drainage basin. This basin is characterized by watercourses that flow into the Housatonic River, which flows in a south to southeasterly direction from western Massachusetts and discharges to Long Island Sound at Milford Point, Connecticut. The Proposed Route is located within the Naugatuck River regional drainage basin.

CT DEEP maintains detailed water resources information concerning the drainage basins in Connecticut and promotes watershed management efforts to improve water quality. As a central element of the state's clean water program, the CT DEEP also has established Water Quality Standards and Classifications, which identify the water quality management objectives for each waterbody.

Overall, Connecticut's water quality policies are established to protect surface and groundwater from degradation; restore degraded surface waters to conditions suitable for fishing and swimming; restore degraded surface and groundwater to protect existing and designated uses; and to provide a framework for establishing priorities for pollution abatement. The use goals that the state has established for surface waters and groundwater are summarized in Table 5-1.

Table 5-1: Summary of Connecticut Water Use Goals

Water resource	Classification use description
Surface Waters	
Class AA	Public water supply, fish and wildlife habitat, recreation.
Class A	Potential public water supply, fish and wildlife habitat, recreation, industrial water supply, agricultural water supply.
Class B	Fish and wildlife habitat, recreation, industrial water supply, agricultural water supply, discharge of treated wastewaters.
Class C, D	Goal is Class B. Impaired water quality affecting one or more Class B uses.
Ground Waters	
Class GAA	Public water supply.
Class GAAs	Existing or potential public supply, stream base flow industrial and miscellaneous, tributary to a public reservoir. Natural quality, or suitable for drinking
Class GA	Existing private water supply and potential public water supply suitable for drinking without treatment.
Class GB	Industrial water supply and miscellaneous non-drinking supply.
Class GC	Assimilation of wastes, such as landfill leachate.

The Proposed Route crosses a total of 58 watercourses (including waterbodies). Of these, 20 are perennial streams, rivers, or ponds and 38 are intermittent watercourses. Table 5-11 (located at the end of this section due to its length) provides a summary of major characteristics, including surface water classifications, of the delineated watercourses and waterbodies along the Proposed Route.

Three of the identified perennial watercourses average greater than 20 feet wide and are named brooks or rivers. These include Branch Brook, Northfield Brook, and the Naugatuck River. At Eversource's existing ROW crossing in Litchfield and Harwinton, the Naugatuck River is an estimated 110 feet wide. None of the watercourses crossed by the Proposed Route met the criteria for federal designation as navigable[35] pursuant to Section 10 of the Rivers and Harbors Act. All of these watercourses are presently spanned by Eversource's overhead transmission lines that occupy the existing ROW along which the Proposed Route would be located.

Of the 20 perennial water crossings along the Proposed Route, six are ponds, as detailed below.

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[35] The USACE's general definition of navigable waters of the United States is "those waters subject to the ebb and flow of the tide shoreward to the mean high water mark and/or presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce." Waterways considered to be navigable waters may be subject to regulatory jurisdiction under Section 10 of the Rivers and Harbors Act.

- Town of Watertown: two unnamed ponds (one located east of Nova Scotia Hill Road, and one located east of Thomaston Road/U.S. Route 6).
- Town of Thomaston: Morton Pond located east of Old Northfield Road.
- Town of Litchfield: two unnamed ponds (one located south of Campville Road, and one located south of State Route 8).
- Town of Harwinton: one unnamed pond located south of Wildcat Hill Road.

The ponds include natural areas of standing water, man-made agricultural and recreational ponds, and beaver ponds. All of these water resources are already spanned by Eversource's overhead transmission lines that occupy the existing ROW along the Proposed Route.

The Proposed Route does not cross any rivers designated as a National Wild and Scenic River under the National Wild and Scenic Rivers Act (16 U.S.C. §§ 1271-1287). The Connecticut Protected Rivers Act (CGS §§ 25-200 through 25-210) requires CT DEEP to adopt a list of rivers in the state considered appropriate for designation as protected river corridors. To date, the CT DEEP has not designated any rivers along the Proposed Route under the Protected Rivers Act.

5.1.2.2 Wetlands

As identified in Table 5-10, a total of 91 wetlands were delineated within Eversource's easements or fee-owned properties in proximity to Project activities. An additional four wetlands were delineated along publically accessible (State Park/Forest) off-ROW access roads that are proposed for use in constructing the Project. Of the total 95 wetlands delineated, 48 would be within the portions of the ROW traversed by the new transmission line.[36] The maps in Volume 5 illustrate the locations of the wetlands along the Proposed Route.

State jurisdictional wetlands were characterized using Connecticut delineation methodology pursuant to the Connecticut Inland Wetlands and Watercourses Act, CGS §§ 22a-36 through 22a-45 (the Act). The Act defines a wetland as land, including submerged land, consisting of poorly drained, very poorly drained, alluvial, and floodplain soils as defined by the USDA Cooperative Soil Survey. Such areas may include filled, graded, or excavated sites possessing an aquic (saturated) moisture regime as defined by the USDA Cooperative Soil Survey. The Act defines watercourses as rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs, and also other bodies of water, natural or artificial, public or private, contained within, flow through or border upon the state, or any portion thereof.

[36] The 48 wetlands are those located within the footprint of the new 115-kV line

As part of the Project field investigations, federal jurisdictional wetlands were delineated in accordance with the USACE's *Wetland Delineation Manual* (Technical Report Y-87-1, "1987 USACE Manual") and *Regional Supplement to the Corps of Engineers Delineation Manual*[37] (Regional Supplement) and *Field Indicators for Identifying Hydric Soils in New England, Version 3.*[38] According to the 1987 USACE Manual, areas must exhibit three distinct characteristics to be considered federal jurisdictional wetlands:

1. **Vegetation**. The prevalent vegetation must consist of plants adapted to life in hydric soil conditions. These species, due to morphological, physiological, and/or reproductive adaptations, can and do persist in anaerobic soil conditions.
2. **Hydric Soils**. Soils in wetlands must be classified as hydric or they must possess characteristics associated with reducing soil conditions (typically resulting in redoximorphic features or gleyed soils).
3. **Hydrology**. The soil must be inundated either permanently or periodically at mean water depths less than 6.6 feet (2 meters) or the soil must be saturated at the surface for some time during the growing season of the prevalent vegetation.

Wetlands meeting the above technical criteria and determined to be traditional navigable waters, tributaries to traditional navigable waters, or wetlands exhibiting significant nexus are subject to federal jurisdiction under Section 404 of the Federal Clean Water Act (33CFR 320-332).

For the purpose of documenting and organizing the water resource information on tables and maps for the Project, groups of wetlands occurring along the ROW between selected road crossings were identified by letters of the alphabet A through G[39]. Wetlands within each segment were then labeled in an alpha-numeric sequence (e.g., W-A1, W-A2, W-A3). Watercourses were numbered independently of the wetlands and prefixed by the letter S.

Wetlands that were considered to be hydrologically connected to, or part of a larger ecological functional unit were typically included within the same alpha-numeric label. Frequently, wetlands that appear to

[37] Wetlands Regulatory Assistance Program. (2102). *Regional Supplement to the Corps of Engineers Wetlands Delineation Manual: Northcentral and Northeast*, U.S. Army Engineer Research and Development Center, Vicksburg, MS

[38] New England Hydric Soils Technical Committee. 2004. *Field Indicators for Identifying Hydric Soils in New England, 3rd ed*.. New England Interstate Water Pollution Control Commission, Lowell, MA.

[39] Wetlands in the vicinity of the Frost Bridge Substation were identified with the letters FB. Wetlands identified along an existing access road in Mattatuck State Forest (off Echo Lake Road) were identified with the letters MSF. Wetlands identified with the letter A, or "A – Series" begin at Echo Lake Road (Watertown); B - Series at Park Road (Watertown); C - Series at Thomaston Road-Route 6 (Watertown); D - Series at Branch Road-Route 109 (Thomaston); E - Series at Northfield Road-Route 254 (Thomaston); F - Series at Campville Road (Litchfield); and G - Series at Wildcat Hill Road (Harwinton).

lack direct surface water connectivity (such as those bisected by historic disturbance activities such as road construction) were included under the same wetland label if they were considered to be part of the same hydrologic system. A similar approach was taken for small wetlands arrayed along the length of a connecting watercourse.

Due to differences in state and federal wetland delineation criteria and methodology, the boundaries of state and federal jurisdictional wetlands do not correspond in all cases. For example, in Connecticut, areas of alluvial and floodplain soils, which may not include hydric soils or exhibit evidence of wetland hydrology, are characterized as state, but not federal, jurisdictional wetlands. For the most part, however, the state and federal wetland boundaries along the Proposed Route are comparable. Of the 95 wetlands delineated along the Eversource ROW, portions of only two wetlands located within the Naugatuck River floodplain, in Watertown and Litchfield, were identified as being strictly state jurisdictional (refer to the Volume 5 maps).

In accordance with *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al., 1979), wetlands delineated for the proposed Project were classified as palustrine[40] forested (PFO), palustrine scrub-shrub (PSS), palustrine emergent (PEM), palustrine open water (POW), and palustrine unconsolidated bottom (PUB).

These wetland classifications are characterized as follows:

- **Palustrine Forested Wetlands (PFO):** Forested wetlands are characterized by woody vegetation that is 6 meters (approximately 20 feet) tall or taller and normally includes an overstory of trees, an understory of young trees or shrubs and an herbaceous layer. These wetland types are located predominantly in the unmanaged areas of the existing ROW or in adjacent off-ROW areas.
- **Palustrine Scrub-Shrub Wetlands (PSS):** Scrub-shrub wetlands are typically dominated by woody vegetation less than 6 meters (approximately 20 feet) tall. Scrub-shrub wetland types may represent a successional stage leading to a forested wetland and include shrubs, saplings, and trees or shrubs that are small and/or stunted due to environmental conditions or human vegetation management practices.
- **Palustrine Emergent Wetlands (PEM):** Emergent wetlands are characterized by erect, rooted, herbaceous hydrophytes not including mosses and lichens. These wetlands maintain the same

[40] Palustrine wetlands are wetlands occurring in the Palustrine System, one of five systems in the classification of wetlands and deepwater habitats. Palustrine wetlands include all non-tidal wetlands dominated by trees, shrubs, persistent emergent plants, or emergent mosses or lichens, as well as small, shallow open water ponds or potholes. Palustrine wetlands are often referred to as swamps, marshes, potholes, bogs, or fens.

appearance year after year, are typically dominated by perennial plants, and the vegetation of these wetlands is present for the majority of the growing season.

- **Palustrine Open Water (POW):** Areas of permanent open water that border on palustrine systems are referred to as POW. Area of open water may exist as man-made or natural waterbodies.
- **Palustrine Unconsolidated Bottom (PUB):** Areas of open water with unconsolidated bottoms that border on palustrine systems are referred to as PUB.

Some wetlands along the Proposed Route exhibit more than one wetland classification type (i.e., PFO / PSS) or have inclusions of multiple vegetative cover types. In such situations, transitions between wetland types are demarcated on the maps in Volume 5 and cover types are categorized by the most dominant classification type.

The results of the wetland field surveys demonstrate that wetland types within Eversource's existing ROW vary. Many of the wetlands along the ROW have been historically affected by ROW maintenance activities, which promote low-growing vegetation to insure the safe operation of the existing overhead transmission lines. Thus, the majority of the wetlands in the ROW are well-vegetated and dominated by PSS and shallow PEM communities. The majority of the PSS and PEM wetlands located on the managed portions of the ROW also extend into adjacent areas or in currently unmanaged portions of the ROW, transitioning into PFO wetlands characterized by mixed hardwood deciduous and coniferous forested vegetation.

5.1.2.3 Groundwater Resources, Public Water Supplies, and Aquifer Protection Areas

In the vicinity of the Proposed Route, potable water is derived from groundwater wells and surface water supplies or reservoirs. For the most part, in the vicinity of the Proposed Route, the groundwater quality is classified as "GA" (i.e., existing private water supply and potential public water supply suitable for drinking without treatment).

CT DEEP's Aquifer Protection Area Program identifies Level A and Level B Aquifer Protection Areas by municipality. Aquifer Protection Areas are delineated for active public water supply wells in stratified drift that serve more than 1,000 people, in accordance with CGS § 22a-354c and §22a-354z. Level A mapping delineates the final Aquifer Protection Area, which becomes the regulatory boundary for land use controls designated to protect the well from contamination. Level B mapping delineates a preliminary Aquifer Protection Area, providing an estimate of the land use controls designated to protect the well from contamination.

According to the CT DEEP, the Proposed Route does not traverse any designated Aquifer Protection Areas.[41] The closest such area is Reynolds Bridge, a Level A Aquifer Protection Area located approximately 0.48 mile east of the Proposed Route where it crosses Branch Road (Route 109).

The water quality of surface water reservoirs is also protected by the Connecticut Public Health Code (PHC.). PHC Section 25-37c-1 and 2 establishes criteria for classification of water company-owned land and provides definitions for classes of land warranting different levels of protection. Section 25-37d-1 of the PHC establishes a process for permitting changes in ownership or the land use of watershed lands owned by water companies. Review standards require the Commissioner of Public Health to determine that the action would not have a significant adverse impact upon the purity and adequacy of the public drinking water supply before a permit for such an action may be issued.

The following list identifies the drinking water supplies for the towns along the Proposed Route.[42]

- **Watertown** – Watertown is served by a combination of public wells with a public water supply system in the "downtown" portion of town and by private groundwater wells in the more rural sections of town. Reynolds Bridge, a Level A Aquifer Protection Area, is located approximately 0.48 mile east of the Proposed Route near the Watertown / Thomaston town lines. The groundwater in the vicinity of the route is classified as "GA[43]" or "GAA[44]". Portions of the Town of Watertown are mapped as a public water supply watershed (Waterbury Water Department) and located approximately 0.95 mile west of the Proposed Route where it crosses Black Rock State Park north of Thomaston Road (U.S. Route 6).
- **Thomaston** – Thomaston is served by a large-scale community well, managed by the Connecticut Water Company for water supply in portions of the town, and private groundwater wells that provide water supply to the remainder of the town. Reynolds Bridge, a Level AA Aquifer Protection Area, is located approximately 0.48 mile east of the Proposed Route near the Watertown / Thomaston town lines. The groundwater in the vicinity of the route is classified as "GA" or "GAA". Portions of the Town of Thomaston are mapped as a public water supply watershed (Waterbury Water Department); these areas are located approximately 1.25 miles west of the Proposed Route where it crosses Walnut Hill Road.
- **Litchfield** – The Litchfield town center, which is located more than 5 miles to the west/northwest of the Proposed Route, is served by a community well system managed by Aquarion Water Company and the remainder of the town is served by private groundwater wells in the more rural sections of the town. The Proposed Route does not cross any mapped Aquifer Protection Areas.

41 CT DEEP Aquifer Protection Area Maps: (Accessed July 2015)

42 Information on groundwater quality and municipal water supplies was obtained from CT DEEP Geographic Information System Ground Water Quality Classifications, Town and State websites accessed July, 2015

43 Designated uses: existing private and potential public or private supplies of water suitable for drinking without treatment; baseflow for hydraulically connected surface water bodies.

44 Designated uses: existing or potential public supply of water suitable for drinking without treatment; baseflow for hydraulically connected surface water bodies.

The groundwater in the vicinity of the route is classified as “GA”.[45] Portions of the Town of Litchfield are mapped as a public water supply watershed (Waterbury Water Department) and located approximately 1.50 miles west of the Proposed Route where it crosses Mason Hill Road. However, the Proposed Route is entirely within the Naugatuck River Watershed and does not drain toward a public water supply watershed.

- **Harwinton** – Harwinton is served by a combination of community wells in the more populated areas of town, with private groundwater wells providing water supply to the remainder of the town. The Proposed Route does not cross through a public water supply watershed or mapped Aquifer Protection Area. The groundwater along the Proposed Route is rated “GA”.

5.1.2.4 Flood Zones

The FEMA classifies flood zones for insurance and floodplain management purposes and has prepared maps designating certain areas according to the frequency of flooding. An area within the 100-year flood designation has a 1% chance of flooding each year or is expected to flood at least once every 100 years.

A review of FEMA maps indicates that the Proposed Route extends across 100-year flood zones associated with three watercourses, including Branch Brook in Watertown, Northfield Brook in Thomaston, and the Naugatuck River along the Litchfield and Harwinton town lines. These watercourses, as well as their 100-year flood zone boundaries, are depicted on the Volume 5 maps. No existing transmission line structures along the ROW are located within a 100-year floodplain.

5.1.3 Biological Resources

5.1.3.1 Vegetative Communities

Vegetation along the Proposed Route consists of a mix of associations and cover types, providing a variety of wildlife habitats. The width of the ROW along which vegetation is currently managed to ensure consistency with existing transmission line use and clearance requirements ranges from approximately 90 feet to 400 feet. The remaining areas within Eversource’s existing ROW are currently unmanaged and generally comprised of forest land.

[45] Town of Litchfield, Connecticut. Litchfield Plan of Conservation and Development. Adopted by the Litchfield Planning and Zoning Commission June 4, 2007.

Eight habitat types/land uses were documented along or within 200 feet of the Project ROW within which the proposed 115-kV transmission line would be aligned, as illustrated on the Volume 5 maps[46] and detailed below.

- **Old Field/Shrub land**: This habitat type includes the existing managed ROW in most areas, as well as adjacent abandoned fields, natural shrub lands, and early successional forests.
- **Upland Forest**: This forest type includes mature mixed deciduous/coniferous forests adjacent to the existing ROW in upland areas. Mature mixed forests consist typically of tree species common to the Northeast such as maples, oaks, hickories, spruce, and pine. The ratio of deciduous to coniferous species and age of stands varies.
- **Forested Wetland**: Forested wetlands generally include swamps dominated by a mature canopy including deciduous and coniferous trees.
- **Scrub-Shrub Wetland**: Shrub swamp areas exist either within or adjacent to the existing ROW. These types of wetlands typically include components of emergent marsh, where shrub coverage is substantial.
- **Emergent Wetland**: Emergent marshes are dominated by herbaceous wetland plant species.
- **Open Water**: This includes substantial areas of open water found along the existing ROW such as, ponds and large streams/rivers, with the vegetation found along the shorelines of these areas.
- **Agricultural Lands**: This includes cultivated fields, croplands, hay fields, pastures, and orchards in active agricultural use.
- **Urban Areas**: Urban areas refer to suburban and urban residential developments, subdivisions, areas developed for industrial or commercial use, recreational areas such as parks and golf courses, maintained lawns, and roadside vegetation.

In accordance with Eversource's ROW vegetation management program, woody vegetation that could interfere with the operation of the overhead transmission lines is periodically removed from the managed portion of the ROW, and trees located along the edges of the managed ROW are periodically trimmed or removed. The vegetation within the ROW is managed on an approximate five-year rotating basis.

As a result of Eversource's vegetation management program, the predominant vegetation types within the managed portions of the transmission line ROW consist of dense shrub and herbaceous species (old field/shrubland). In New England, old field/shrubland areas are often disturbance-dependent and ephemeral. Historically, the occurrence and distribution of shrublands and other early successional cover types were largely influenced by humans. The widespread abandonment of farms in the early 20th

[46] Note that the habitat types are specifically identified only on the Volume 5, 100 scale maps. However, vegetation can generally be discerned on the Volume 5, 100 scale maps, which provide a more detailed view of the location of the proposed 115-kV line in relation to the managed portions of Eversource's ROW.

Century, along with increases in suburban development and fire suppression, has led to a consistent decline in the area of early successional cover types over the last century and the subsequent decline in several wildlife species dependent on this habitat.[47]

5.1.3.2 Wildlife and Fisheries Resources

This section describes the general wildlife resources expected to be common in the vicinity of the Proposed Route, and then presents specific location information, including data developed as a result of research and field investigations within the ROW.

5.1.3.2.1 General Wildlife Description

The following summarizes the wildlife habitats and some of the species that commonly occur in the vegetative communities found along and in the vicinity of the Proposed Route

- **Upland Forest**: Forests in Southern New England support a wide array of wildlife and is the dominant cover type in the State. Typically common mammalian species in forested habitats include a variety of rodents (e.g., mice, voles, moles and shrews), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), grey fox (*Urocyon cinereoargenteus*), white-tailed deer (*Odocoileus virginianus*), striped skunk (*Mephitis mephitis*), Virginia opossum (*Didelphis virginiana*), chipmunk (*Tamias striatus*) and grey squirrel (*Sciurus carolinensis*). Less common forest-dwelling species include black bear (*Ursus americanus*), fisher (*Martes pennanti*) and porcupine (*Erithizon dorsatum*). Birds typical of forested areas include raptors (owls, hawks), wild turkey, woodpeckers and migratory songbirds, including a number of species solely associated with forested habitats (i.e., habitat specialists). Reptiles and amphibians likely to occur include vernal pool specialists (e.g., mole salamanders), toads and *hylid* treefrogs.
- **Old Field/Shrublands**: Old field/shrubland habitats are some of the rarest and most critical wildlife habitats in the State. Common mammalian wildlife include small mammals such as meadow voles (*Blarina brevicauda*), shrews, various mice, woodchuck (*Marmota monax*), rabbits, and white-tailed deer. Predatory and scavenging species such as red fox, coyote, weasels, skunk, and raccoon (*Procyon lotor*) often forage or bed in fields. Various species of shrubland-dependent birds including the prairie warbler (*Setophaga discolor*) and blue-winged warbler (*Vermivora cyanoptera*) are common.
- **Wetlands/Open Water**: Freshwater wetlands and other aquatic habitat (e.g., streams, ponds) provide excellent habitat for a wide range of wetland-dependent wildlife. Many of the species using upland forest and shrubland habitats also utilize forested wetland, shrub swamp, shallow marsh, or wet meadow communities. Several common mammalian species are adapted primarily to wetlands or other aquatic habitat including beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*). Reptiles and amphibians are particularly adapted to wetlands and aquatic habitats. Typical species include mole salamanders, *Ranid* frogs, toads (*Bufo sp.*), *Hylid* treefrogs, spotted

[47] Liviatis, J.A. 1993. *Response of early successional vertebrates to historic changes in land use*. Conservation Biology 7:4, and Liviatis J.A. 2003. *Shrublands and early-successional forests: critical habitats dependent on disturbance in the northeastern United States.* Forest Ecology and Management 185:1-4

turtle (*Clemmys guttata*) and various snakes including the eastern ribbon snake (*Thamnophis sauritus*).

- **Agricultural and Urban Lands**: A variety of wildlife habitats are included in this category. These include hayfields, suburban and urban residential areas, commercial and industrial developments, developed recreational areas (e.g., state and federal parks, municipal parks, playgrounds), maintained lawns, and road corridors. Wildlife in these habitats can be abundant, as animals are attracted to human food sources (e.g., crop fields, orchards, bird feeders, landfills), but the species inhabiting them must be tolerant to some degree of human disturbance. Some of the most recognizable wildlife species can be found in these areas, such as white-tailed deer, raccoon, woodchuck, and birds such as Canada geese (*Branta canadensis*), robin (*Turdus migratorius*), house sparrow (*Passer domesticus*), and other numerous bird species frequenting feeders. Other common but less visible species, such as red fox, coyote and skunk are also common. Nuisance wildlife species such as crows, rats, and other small rodents are also often abundant in these habitats. Some wildlife species are even dependent on human activity to thrive, such as birds nesting almost exclusively in human structures (e.g., chimney swift, barn swallow). Reptiles and amphibians tend to be scarce in these habitats because they are typically less tolerant of human activity than birds or mammals. Common amphibian and reptile species in suburban habitats include green frog (*Rana clamitans*), bullfrog (*Rana catesbeiana*) and garter snake (*Thamnophis sirtalis*).

5.1.3.2.2 Fisheries

As summarized in Table 5-11, the Proposed Route traverses various freshwater watercourses, several of which support fisheries. The CT DEEP's inland fisheries management efforts for rivers and streams are directed primarily toward providing recreational fishing opportunities, particularly trout which have traditionally been an important part of Connecticut's angling activity.

The implementation of CT DEEP's *Trout Management Plan* (1999), developed based upon the compilation of fish population, physical habitat and water chemistry information for approximately 800 Connecticut streams, is designed to improve fishing quality by diversifying angler opportunities. The *Trout Management Plan* designates various special management areas for trout. These include streams where self-sustaining wild trout populations are encouraged through catch-and-release angling, trout management areas, streams where CT DEEP stocks catchable size hatchery trout, trophy trout areas (stocked with larger hatchery trout), and trout parks (offering easy access to the public and stocked more frequently to promote angler success). The CT DEEP also stocks select rivers, including the Naugatuck River, with broodstock Atlantic salmon to provide additional fishing opportunities.

The CT DEEP's *2015 Connecticut Angler's Guide* identifies the following stocked or actively managed fishing areas within the vicinity of the Proposed Route:

- Branch Brook ([Trout Park] within Black Rock State Park, Watertown);
- Black Rock Pond ([Trout Park] Watertown within Black Rock State Park);
- Black Rock Lake (Watertown);
- Northfield Brook (Thomaston);
- Naugatuck River Trout Management Area (Litchfield/Harwinton/Thomaston - from State Route 118 to the Thomaston Dam); and
- Naugatuck River Broodstock Salmon Area (Litchfield/Harwinton/Thomaston - from State Route 118 to the Thomaston Dam).

The Proposed Route's crossing of the Naugatuck River between Litchfield and Harwinton is designated by CT DEEP as a Trout Management and Broodstock Salmon Area. At this crossing location, Eversource's existing and proposed 115-kV transmission lines span the Naugatuck River at an elevation that is well above the height of the riparian forest and the river.

The CT DEEP also has a Bass Management Plan (1999), which recognizes the importance of warm water species like largemouth and smallmouth bass, chain pickerel, northern pike, walleye, channel fish, panfish, brown bullhead and American eel. The existing Eversource ROW crosses warm-water fisheries, such as Morton Pond in Thomaston, and is in close proximity to Jericho Brook Pond in Watertown; however, these areas are not listed in the Connecticut Bass Management Plan.

5.1.3.2.3 Vernal Pools

During the spring of 2015, vernal pool assessments were performed along Eversource's ROW within which the Proposed Route would be located. A detailed description of the survey methodology and results is presented in the *Inventory and Assessment of Vernal Pools* in Volume 3. Vernal pool locations are shown on the 100-scale maps in Volume 5.

CT DEEP describes vernal pools as *"small bodies of standing fresh water found throughout the spring*" that are "*usually temporary"* and "*result from various combinations of snowmelt, precipitation and high water tables associated with the spring season*."

Vernal pools are included as one of six types of "Special Wetlands" identified in the General Permit (GP) issued by the USACE for the State of Connecticut.[48] The USACE defines a vernal pool as an often temporary body of water occurring in a shallow depression of natural or human origin that fills during

[48] The current Connecticut General Permit is valid for the period of July 2011 to July 2016.

spring rains and snow melt and typically dries up during summer months.[49] Vernal pools also are defined as supporting populations of species specially adapted to reproducing in these habitats, which may include wood frogs, mole salamanders (*Ambystoma* sp.), fairy shrimp, fingernail clams (*Sphaeriidae*), and other amphibians, reptiles, and invertebrates. Vernal pools lack breeding populations of fish.

Best Development Practices, Conserving Pool-Breeding Amphibians in Residential and Commercial Developments in the Northeastern United States (Calhoun and Klemens 2002 ["BDP Manual"])[50] provides the following operational definition of vernal pools:

> *Vernal pools are seasonal bodies of water that attain maximum depths in the spring or fall, and lack permanent surface water connections with other wetlands or water bodies. Pools fill with snowmelt or runoff in the spring, although some may be fed primarily by groundwater sources. The duration of surface flooding, known as hydroperiod, varies depending upon the pool and the year; vernal pool hydroperiods range along a continuum from less than 30 days to more than one year. Pools are generally small in size (<2 acres), with the extent of vegetation varying widely. They lack established fish populations, usually as a result of periodic drying, and support communities dominated by animals adapted to living in temporary, fishless pools. In the region, they provide essential breeding habitat for one or more wildlife species including Ambystomid salamanders (Ambystoma spp., called "mole salamanders" because they live in burrows), wood frogs (Rana sylvatica), and fairy shrimp (Eubranchipus spp.).*

Vernal pool physical characteristics can vary widely while still providing habitat for indicator species. "Classic" vernal pools are natural depressions in a wooded upland with no hydrologic connection to other wetland systems. Manmade depressions such as quarry holes, old farm ponds, and borrow pits can also provide similar habitat. Often, vernal pools are depressions or impoundments within larger wetland systems. These vernal pool habitats are commonly referred to as "cryptic" vernal pools.

Several species of amphibians depend on vernal pools for reproduction and development. These species are referred to as indicator[51] vernal pool species, and their presence in a temporary wetland during the breeding season helps to identify that area as a vernal pool. Indicator species present in Connecticut include the following:

- Blue-spotted Salamander (*Ambystoma laterale*);

[49] Definition as included in the USACE's General Permit for Connecticut

[50] Calhoun, A.J.K. and M.W. Klemens. 2002. *Best development practices: Conserving pool-breeding amphibians in residential and commercial developments in the northeastern United States.* MCA Technical Paper No. 5 Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York. 57 p.

[51] Calhoun and Klemens (2002) argue that "indicator" species is a better word than the commonly used "obligate" species, as they will occasionally breed in roadside ditches and small ponds that are not vernal pools.

- Wood Frog (*Rana sylvatica*);
- Spotted Salamander (*Ambystoma maculatum*);
- Jefferson Salamander (*Ambystoma jeffersonianum*);
- Eastern Spadefoot Toad (*Scaphiopus holbrookii*)
- Marbled Salamander (*Ambystoma opacum*); and
- Fairy Shrimp (*Branchiopoda anostraca*).

Facultative vernal pool species are fauna that utilize, but do not necessarily require, vernal pools for reproductive success. Examples of facultative species include the spotted turtles (*Clemmys guttata*) and four-toed salamander (*Hemidactylium scutatum*). These species may breed or feed in vernal pools, but are also capable of carrying out all phases of their lifecycle in other types of wetlands or waterbodies. Evidence of breeding by facultative species alone is not considered indicative of a vernal pool.

For the purpose of the studies conducted for this Project, a vernal pool is defined as an area that meets the physical characteristics described above and contains evidence of breeding activity for any of the indicator species listed above, including the presence of egg masses and larvae. This vernal pool assessment also makes an important distinction between wetlands in which indicator species may breed and those wetlands where they breed *and* successfully develop. A common phenomena is for breeding (i.e., mating and egg laying) to occur in bodies of water such as road ruts or temporary puddles where development and metamorphosis of larvae is unsuccessful. Such areas are referred to as "decoy vernal pools" as reproductive efforts are unsuccessful. In the BDP Manual, Calhoun and Klemens specifically note the negative impact associated with ruts: "*Site clearing can cause water-filled ruts. These ruts intercept amphibians moving toward the vernal pool and may induce egg deposition. Often these ruts do not hold water long enough to allow development of amphibians and therefore acts as "sinks" that result in population declines.*"

Several examples of decoy pools are present within the Project ROW, most often within existing or historic access roads at wetland crossings. Unlike "classic" or "cryptic" vernal pools, these areas often suffer recurring disturbance and generally contain little vegetation to which egg masses can be attached. Small numbers of vernal pool obligate species such as wood frog and spotted salamander may breed in these ephemeral pools, though there may be little chance for larvae to complete development.

Field Assessments

Field assessments began in April 2015, shortly after vernal pool amphibians had emerged from hibernation and were beginning breeding activity. During this period, chorusing wood frogs and spring peepers were heard, spotted salamander spermataphore (a protein capsule containing a mass of spermatozoa) were observed and adult amphibians were observed in amplexus (the mating position of frogs and toads in which the male clasps the female about the back). A number of pools remained ice covered in early April, particularly those pools that were deeply shaded. At some pools, adult wood frogs were observed hopping across iced covered portions of the pools in search of open water. Surveys continued throughout April and into early May as temperatures began to warm. Multiple visits to each pool were conducted to document breeding productivity via egg mass counts. This was done on sunny days where visual detection of egg masses is optimized. A fine-mesh dipnet was used throughout the survey period to search for larval amphibians, and cover searching (turning of rocks, logs, and debris) around the margins of the pools was conducted to search for adult amphibians.

In order to assess these pools qualitatively, the methodology described in the BDP Manual was used. This assessment methodology utilizes a three-tiered rating system, with the tier designation determined by examining the biological value of the pool in conjunction with the condition of the habitat surrounding the pool, which is the area used by vernal pool amphibians during the non-breeding season. The higher the species diversity and abundance coupled with an undeveloped and forested landscape surrounding the pool, the higher the tier rating. Tier 1 pools are considered the highest quality pools, while Tier 3 are the lowest. For this assessment, the potential tier rating was assessed based on the *biological value* of each pool which considers both species richness and species abundance. Per the BDP Manual, Tier 1 and 2 pools are those pools that meet at least one of the following criteria:

- The presence of a breeding state-listed species;
- Two or more indicator species breeding; or
- 25 or more egg masses of a vernal pool indicator species.

A pools tier rating is based on which of the above *biological* criteria are met coupled with an analysis of the level of development within two landscape management zones surrounding the pools, the Vernal Pool Envelope (VPE, 0-100 feet from the pool) and the Critical Terrestrial Habitat (CTH, 100-750 feet from the pool).

A Tier 1 Pool must meet one of the above *biological* criteria *and* have at least 75% undeveloped land within the Vernal Pool Envelope (VPE, 0-100 feet from the pool) and at least 50% undeveloped land within the Critical Terrestrial Habitat (CTH, 100-750 feet from the pool).

A Tier 2 pool must meet one of the above *biological* criteria along with one of the landscape criteria, either 75% undeveloped land within the VPE *or* 50% undeveloped land within the CTH.

A Tier 3 pool is a pool that either has high *biological* value coupled with a high percentage of developed land within the VPE and CTH *or* low biological value coupled with one of the landscape criteria being met (either 75% undeveloped land within the VPE *or* 50% undeveloped land within the CTH).

Results

Wetlands that have been determined to provide vernal pool habitat are listed in Table 5-10 and are depicted on the Volume 5 maps. Each vernal pool has been assigned a Project-specific numerical identifier that corresponds to the designation presented in Table 5-10. Vernal pools were labeled with an alpha-numeric sequence beginning with VP or DVP (decoy vernal pool) followed by a letter and number corresponding to the associated wetland (e.g., VP B2-1, VP B4-1, DVP F13-1).

A total of 22 vernal pools were identified within the Project ROW and along publically accessible off-ROW access roads, supporting three vernal pool indicator species - wood frog, spotted salamander, and marbled salamander. Fifteen of these pools (68%) are potential Tier 1 pools due to the fact that they had significant numbers of egg masses (i.e., 25 or more) or they had two or more indicator species breeding.

Pools C4-1, E2-1, E2-2 and F13-1 are all associated with access road activities, which have created small ponded areas associated with rutting, culvert inlets (i.e., backwater pool) or culvert outlets (i.e. scour pool). These pools are of low ecological significance, and can reasonably be classified as decoy pools as defined in the BDP Manual. Pool F13-1, a decoy pool identified during the spring 2015 survey, was removed following pre-existing access road improvements associated with routine line maintenance conducted in the summer of 2015. This pool was located along an existing access road within the maintained ROW, and its hydrology was the result of surface-water impoundment along the existing access road.

Several noteworthy pools were documented, including pools MSF-1, C12-1, C15-1, C21-1, D4-1 and D15-1; all of which contained large numbers of both spotted salamander and wood frog. All six of these pools were found along the Project ROW or off-ROW access roads in the towns of Watertown and Thomaston. Pool D4-1 in Thomaston was noteworthy as it contained the only record of marbled salamander within the Project area. Marbled salamanders are uncommon in Connecticut, particularly at higher elevations, and this pool represents the only documented breeding location of the species from the Town of Thomaston.

5.1.3.2.4 Birds

A breeding bird inventory and assessment was conducted along the Proposed Route in the spring of 2015. The results are provided in the Project's *Inventory and Assessment of Breeding Birds (Inventory),* located in Volume 3. The *Inventory* includes descriptions of the avian habitat types present and an inventory of observed and potential breeding birds in the vicinity of the Proposed Route. Various sources were analyzed in order to develop the inventory of all bird species known to breed in the vicinity of the Project. The primary source utilized was *The Atlas of Breeding Birds of Connecticut,*[52] which is the result of a five-year study (1982-1986) of all bird species known to breed in the state. The study is the most comprehensive review to date of Connecticut's breeding birds, involving the efforts of more than 500 individuals and covering virtually the entire 5,009-square-mile area of the state.

That inventory was then refined by considering such factors as bio-geographical species distribution, minimum patch size requirements, and the presence or absence of critical habitat features identified within the Project area. The inventory was supplemented with direct observations compiled during field investigations conducted in April and May of 2015. All birds seen or heard within suitable breeding habitat were noted as observed in the inventory and are considered "possible[53]" breeders within the Project area. Because field work was conducted in April and May, birds observed consisted of those that arrive in Connecticut in the early to mid-spring.

<u>Results</u>

A total of 99 species were identified as potential breeders. Of these, 45 were identified during field observations. All identified species were found within suitable breeding habitat and are considered possible breeders.

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52 Bevier, L. R. (Ed.). *Atlas of Breeding Birds of Connecticut*. 1994. Bulletin 113. State Geological and Natural History Survey of Connecticut. 461 p.

53 A "possible" breeder as defined by Bevier (1994) includes observation of bird (male, female or singing male) within suitable habitat during the breeding season.

In order to evaluate the Project area's value for species of high-conservation priority as opposed to common species and habitat generalists, the inventory of birds was prioritized based on conservation status. Species that are included either on *Connecticut's List of Endangered, Threatened and Special Concern Species* (2015) or classified as *Species of Greatest Conservation Need* (SGCN) by *Connecticut's Wildlife Action Plan*[54] (WAP) were considered to be species of high conservation priority. The WAP was created to establish a framework for proactively conserving Connecticut's fish and wildlife, including their habitats. The WAP designates birds of high-conservation priority as SGCN. SGCN fall into three categories in descending order of significance from *most important* to *very important* and finally *important*.

The inventory includes six State-listed species, one of which, the broad-winged hawk *(Buteo platypterus)* was observed within the ROW in Harwinton. The remaining five species were considered potentially present based on bio-geographical species distribution and the presence or absence of critical habitat features identified within the Project area. These species are discussed in detail in the Inventory and in Section 5.1.3.3, below. A total of 35 species (or 35% of the 99 total species) are SGCN. Of those 35 species, seven are classified as *most important*, 16 as *very important* and 12 as *important*. Of the 35 SGCN identified, 15 are associated with managed early-successional ROW vegetation (e.g., shrubland and PSS wetlands) and 13 are associated with forested habitats (e.g., upland forest and PFO wetlands). The remaining seven SGCN species are associated with edge habitats or agricultural lands. A greater percentage of the seven SGCN classified as *most important* are associated with managed early-successional ROW vegetation (e.g., shrubland) as opposed to forested habitats (five species versus two species).

5.1.3.3 Federal and State Listed or Proposed Threatened, Endangered, or Special Concern Species

Eversource consulted with the CT DEEP Bureau of Natural Resources – Wildlife Division, Natural Diversity Database (NDDB), and the United States Fish and Wildlife Service (USFWS) Information, Planning, and Conservation System (IPaC) to determine whether there is a potential for the Project to affect species identified by federal or state authorities as threatened, endangered, species of concern, or their critical habitats. The following sections describe the species that may occur in the Project vicinity. More specific information is included in the *Rare Species Report*, included in Volume 3, Exhibit 3; however, this report is not provided for public review in order to protect exact species locations.

[54] *Connecticut's Wildlife Action Plan* (2015). CT DEEP, Bureau of Natural Resources

IPaC Identified Federal-listed Species

Screening using the USFWS IPaC indicated that only one species – the northern long-eared bat *(Myotis septentrionalis),* a federal-threatened[55] species, may be present in proximity to the Proposed Route. The northern long-eared bat was also State-listed endangered in August 2015. The USFWS recommended that consultations regarding this species be coordinated through CT DEEP. Based on consultation between Eversource and CT DEEP on July 30, 2015[56] there are no known records or species occurrences or hibernacula in the vicinity of the Proposed Route. CT DEEP recommended that an assessment be conducted to document habitat suitability (summer roosting) and potential Project impacts to this habitat if it is found to occur. Accordingly, in the fall of 2015, Eversource consultants performed surveys to assess the potential for the Proposed Route to provide suitable summer roosting habitat for the Northern long-eared bat (NLEB). This assessment concluded that portions of the vegetation that will be cleared along the Proposed Route may provide suitable NLEB summer roosting habitat (refer to the *Rare Species Report* in Volume 3 for further information).[57] Based on the results of the 2015 assessment, additional acoustic surveys may be conducted along the Proposed Route in the summer of 2016.

NDDB Identified State-listed Species

To assess the potential for the Project facilities to be located in or near habitat of State-listed species, Eversource initially reviewed publically-available maps depicting large "polygon" areas within which listed-species may occur. In addition, because of its state-wide transmission facilities and projects, Eversource has a data-sharing agreement with CT DEEP whereby authorized Eversource personnel and its representatives are allowed to review more specific, confidential information about the potential location of listed species within a polygon. As a part of this data sharing agreement, the CT DEEP Bureau of Natural Resources Wildlife Division provided Eversource with species information associated with the publically-available NDDB polygons in the Project area. Eversource reviewed this information and conducted field studies of the ROW to assess the presence of suitable habitat for the listed species.

Following a review of this information, Eversource submitted written correspondence to the CT NDDB for concurrence regarding the potential presence of State-listed threatened, endangered, or special concern species in the vicinity of the Project area, as well as protection strategies for State-listed species that might be affected by Project activities.

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[55] USFWS listing became effective on May 4, 2015

[56] Meeting with Jenny Dickson and Kate Moran (CT DEEP), Eversource Energy, and Tighe & Bond

[57] The Rare Species Report is redacted to protect confidential information per Eversource's and CT DEEP's NDDB data sharing agreement

The following species were identified as potentially occurring the Project area following a review of the CT DEEP –provided NDDB polygon data:

- Wood Turtle *(Glyptemys insculpta)* – State-listed Special Concern
- Smooth Green Snake *(Liochlorophis vernalis)* – State-listed Special Concern
- Northern Spring Salamander *(Gyrinophilus porphyriticus)* – State-listed Threatened
- Frosted Elfin Butterfly *(Callophyrs irus)* – State-listed Threatened

The following is a description of each species' habitat requirements and potential habitat suitability within the Project area.

Wood Turtle

Wood turtles *(Glyptemys insculpta)* require riparian habitats bordered by floodplain, woodland, or meadows. They hibernate in deep pools, below undercut banks, or in tangled tree roots along streams and rivers. During late spring and throughout the summer, wood turtles may become quite terrestrial, moving into nearby fields, and woodlands.[58] Immediately after emergence from hibernation, activity is confined within and immediately adjacent to the waterway. From late spring (ca. May) and throughout summer, upland terrestrial habitats are utilized, including agricultural lands (e.g. cropland, pasture), early-successional habitats including ROWs, railroad beds, and forest. Nesting occurs from late May through second week of June. Suitable nesting areas consist of more open, scarified or sparsely vegetated areas near the waterway. Nesting could occur within the maintained ROW.

Field investigations confirmed habitat suitability for wood turtle within several larger watercourses and adjacent terrestrial habitat within the Proposed Route.

Smooth Green Snake

Smooth green snakes *(Liochlorophis vernalis)* favor open, unforested habitats including meadows, pastures, fens, coastal grasslands, and mountaintop "balds", but are also found in transitional and lightly forested habitats such as grassy old fields with scattered shrubs and trees, as well as oak-pitchpine

[58] Klemens, M.W. 1993. Amphibians and Reptiles of Connecticut and Adjacent Regions. State Geological and Natural History Survey of Connecticut, Bulletin No. 112.

woodland (Klemens 1993). Open grassland habitat often associated with wetlands is considered this species' favored habitat.[59] Smooth green snakes are active from May through November.

Because this species utilizes early-successional habitats including shrublands, the maintained ROW in its entirety may not be eliminated from consideration as potential green snake habitat. However, the extent of preferred habitat – open grassland associated with wetlands, is much more confined as the majority of the maintained ROW is occupied by dense woody shrubs as opposed to grasses.

Northern Spring Salamander

Northern spring salamanders *(Gyrinophilus porphyriticus)* require clean, cold, well-oxygenated water. Steep, rocky and heavily forested hemlock ravines are favored habitats. Habitats include steep, rocky high-gradient ravines, brooks, seepage areas, springs including below ground anthropogenic spring pipes and wells (Klemens 1993).

Several wetlands within the Project area lie within the upper reaches of the watershed known to support this species and contain suitable habitat either within or immediately adjacent to the ROW. All of these wetlands contained streams and/or groundwater seepage and could potentially support spring salamander or drain directly to off-ROW wetlands or streams that may support this species.

Frosted Elfin Butterfly

Frosted elfins *(Callophyrs irus)* require open habitats maintained by disturbance in which their host plants grow.[60] Eggs are laid on their primary host plant, lupine *(Lupinus perennis)*, which then provides food for the larvae throughout metamorphosis. Wild indigo *(Baptisia tinctoria)* may also serve as a host plant for this species.[61] This species has been negatively impacted by the loss of its associated host plant species. As a result, the potential occurrence of the species is based on mapping for the presence of these host plant species.

The locations of host plant communities were identified and mapped along the Project ROW within areas supporting suitable habitat, both in 2009 and again in 2015.

[59] CT DEEP Webpage: http://www.ct.gov/deep/cwp/view.asp?a=2723&q=325780 (accessed 3/9/2015)

[60] Albanese, G., P. D. Vickery, and P. R. Seivert. 2007. Habitat Characteristics of Adult Frosted Elfins (*Callophrys irus*) in Sandplain Communities of Southeastern Massachusetts, USA. Biological Conservation, in press.

[61] Albanese et al. 2007. Ibid.

Additional Observed and Potentially Occurring State-listed Species

In addition to the above-referenced species, the following State-listed species were considered to be potentially occurring or observed within the Project area during the field studies performed in 2015 as part of the Project.

Spotted Turtle

A single spotted turtle *(Clemmys guttata)* was seen basking in a vernal pool in Harwinton on May 2, 2015. At that time, spotted turtle was not a State-listed species. It was listed as a State special concern species on August 5, 2015.

Spotted turtles are found throughout the Connecticut lowlands, close to slow-moving bodies of water. They use shallow water bodies, including unpolluted bogs, pond edges, ditches, marshes, fens, vernal pools, red maple swamps, and slow-moving streams. Water bodies with a soft, murky bottom and abundant aquatic vegetation are preferred. Upland habitats also are used for nesting, aestivating, and travel corridors between wetlands.

Spotted turtles emerge from hibernation in early spring, usually in March, and begin looking for mates. After breeding, the females leave the breeding pools in search of nesting areas. Preferred nesting sites are generally located in open, upland habitats, such as a meadow, field, or the edge of a road. The eggs hatch in mid-September through October, but some hatchlings may overwinter in the nest and surface the following spring.[62]

Birds

The following State-listed bird species were considered to be potentially occurring or observed within the Project area during the field studies performed as part of the *Inventory*.

- Broad-winged Hawk (*Buteo platypterus*) – State-listed Special Concern
- Brown Thrasher (*Toxostoma rufum*) – State-listed Special Concern
- Savannah Sparrow (*Passerculus sandwichensis*) – State-listed Special Concern
- Bobolink (*Dolichonyx oryzivorus*) – State-listed Special Concern
- Alder Flycatcher (*Empidonax alnorum*) – State-listed Special Concern
- American Kestrel (*Falco sparverius*) – State-listed Threatened

62 CT DEEP Webpage: http://www.ct.gov/deep/cwp/view.asp?a=2723&q=475298 (accessed 12/1/2015)

Broad-winged Hawk

The Broad-winged Hawk inhabits deciduous or mixed forest types often near a lake, pond or wetland. Bevier (1994:102) noted that "the Broad-winged Hawk exhibits a diversified nest site habitat selection". A single male broad-winged hawk was observed on May 2, 2015 calling from a perch along the forest edge within the ROW adjacent to a wetland in Harwinton. The area consisted of upland forest edge adjacent to wetlands and represents suitable breeding habitat.

Brown Thrasher

Brown thrashers inhabit thickets, brushy hillsides and woodland edges in suburban and rural areas (Bevier, 1994). Maturation of forest and other factors causing loss of early successional habitat are driving the decline in this species. Shrubland dominated (managed) portions of the Project ROW represent suitable breeding habitat for thrasher.

Savannah Sparrow and Bobolink

The savannah sparrow and bobolink are grassland specialists that inhabit early old field habitat, managed grasslands (e.g., airport runway fields) or hayfields. Generally, larger contiguous fields are favored, with a minimum area requirement of 5-10 acres for bobolink and 20-40 acres for savannah sparrow.[63] Within the Project area, agricultural fields that extend across the ROW and are located on the east side of Park Road in the Town of Watertown totaling approximately 25 acres, represent the only potentially suitable nesting habitat for these grassland species. Both species are ground nesting birds: therefore, a delayed mowing regime (late June-August) would be required to allow for successful nesting. However, if the subject field is managed solely for the production of forage hay, which is presumably the case, such a management regime would not be compatible with these species' nesting requirements.

Alder Flycatcher

The alder flycatcher occurs in habitats with an interspersion of low vegetation, including shrubs with trees over eight feet high in the vicinity of streams or other open water.[64] Suitable nesting habitat occurs in the managed early-successional portions of the ROW that include streams, wetlands, or open water.

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[63] Comins, P., Hanisek, G, and Oresman, S. 2003. Protecting Connecticut's Grassland Heritage. A Report of the Connecticut Grasslands Working Group. Audubon, Connecticut.

[64] Bevier, L. R. (Ed.). 1994. Ibid.

American Kestrel

The American kestrel can be found in a wide variety of open to semi-open habitats including meadows, grasslands, deserts, early old field successional communities, open parkland, agricultural fields, and both urban and suburban areas; regardless of dominant vegetation form present. Breeding territories are characterized by either large or small patches covered by short ground vegetation, with taller woody vegetation either sparsely distributed or lacking altogether. Suitable nest trees and perches are required. Typical breeding habitat in the Northeast U.S. is large (>62 acre) pasture or recently fallowed field, with one or few isolated large dead trees for nesting and several potential perches.[65]

There is limited suitable habitat available for American kestrel within the Project area due to the narrow linear configuration of early-successional habitats available and the limited graminoid (grass-like) dominated areas. The agricultural fields located on the east side of Park Road in the Town of Watertown (refer to Volume 5 maps) represent the only area potentially suitable for American kestrel within the Project area.

5.1.3.4 Designated Wildlife Management Areas (WMAs)

The Proposed Route does not cross any national wildlife refuges, forests, or parks, or State-designated Wildlife Management Areas (WMAs). State-designated WMAs are established by use of funding related to the federal Pittman-Robertson Act of 1937, which specifies the use of taxes/fees on hunting for game management.

5.1.4 Land Uses and Scenic Resources

The Proposed Route for the new 115-kV transmission line would be aligned within Eversource's existing transmission line ROW between Frost Bridge Substation and Campville Substation. Lands in the general Project region are characterized by a variety of uses and types. The predominant uses include forest lands, recreational areas, transportation corridors (state and local roadways), and residential, commercial, and industrial developments.

Eversource's ROW encompasses both lands occupied by existing overhead transmission lines and lands within the utility easement, but not presently managed for utility use. Beneath and in the vicinity of the portions of the ROW occupied by existing transmission lines, Eversource conducts vegetation

[65] Smallwood, John A. and David M. Bird. 2002. American Kestrel (Falco sparverius), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/602

management to promote shrub or similar low-growth vegetation, consistent with utility use. Lands within the unmanaged portions of the ROW are undeveloped and consist of forested, shrub, and agricultural or other open lands. Within the ROW, developed land uses (e.g., buildings) are not permitted, pursuant to Eversource's easement agreements with landowners.

To identify and assess land uses along the ROW, as well as existing and future land use plans and conditions in the Project vicinity, Eversource consulted existing published resources utilizing a geographic information system (GIS); analyzed aerial photography and maps; examined state, local, and regional land-use plans (including data concerning federal- and state–designated recreational areas); and reviewed data concerning public and private recreational resources, including the CT DEEP's Black Rock State Park and Mattatuck State Forest; the USACE's Black Rock Lake, Northfield Brook Lake, and Thomaston Dam recreational areas; Connecticut Forest and Park Association's (CFPA's) blue-blazed trail system, as defined in the CFPA's *Connecticut Walk Book West (The Guide to the Blue-Blazed Hiking Trails of Western Connecticut. 2006, 19th Edition*) and town recreational areas. In addition, Eversource conducted research to identify whether any parcels preserved by land trusts (e.g., Watertown Land Trust, Harwinton Land Trust) are located near the Proposed Route.

Based on this research, Eversource determined that the Project is not located near any Connecticut Heritage Areas, national scenic or historic trails, or state- or federally-designated scenic highways. Two ConnDOT scenic land strips (undeveloped parcels) are located adjacent to State Route 8, approximately 0.25 mile south of the ROW crossing of this highway.[66] No land trust parcels are located along or in the immediate vicinity of the ROW.

The following subsections describe existing land uses along the Proposed Route, as well as community facilities, and designated protected and scenic resources. Zoning classifications of properties along and in the vicinity of the ROW are identified on the Volume 5 maps.

5.1.4.1 Existing Land Uses

Commencing at Eversource's existing Frost Bridge Substation in the Town of Watertown, the Proposed Route for the new 115-kV transmission line would extend first west-northwest and then north-northeast across portions of the Towns of Watertown, Thomaston, Litchfield, and Harwinton before terminating at

[66] ConnDOT scenic lands are roadside properties, located primarily outside of highway ROW, which were purchased at least in part with federal Highway Beautification Act (1965) funds in order to control the proliferation of billboards and other unsightly views along federal highways.

Campville Substation. The entire route would be aligned within a long-established Eversource ROW that traverses or borders a variety of land uses. The ROW extends across properties that Eversource owns in fee and across private or public lands over which Eversource has easements for utility use.

Table 5-2 summarizes the length of the Proposed Route in each of the four towns, along with the Eversource-owned and the publicly-owned property (length) traversed along the ROW in each town. Table 5-3 summarizes the land uses along the proposed 115-kV transmission line route within the existing Eversource ROW, by land use type within each town.

Table 5-2: Approximate Distance Traversed by Proposed Route, by Town, and across Eversource-Owned Property or Public Lands

	Approximate Distance Traversed (Miles)		
Town	**Total ROW**	**Eversource-Owned Property**	**Public Property**
Watertown	4.7	0.47	2.5 miles State Route 8; US Route 6 Mattatuck State Forest (CT DEEP) Black Rock State Park (CT DEEP) Veterans Memorial Park (Town)
Thomaston	2.6	0.22	0.43 Mile Mattatuck State Forest (CT DEEP) Black Rock State Park (CT DEEP) Branch Brook Reservoir / Dam (USACE) Northfield Brook Lake Recreation Area (USACE)
Litchfield	1.8	0.09	0.18 Mile State Route 8 (ConnDOT) Thomaston Dam Recreation Area (USACE)
Harwinton	1.3	0.16	0.19 mile Thomaston Dam Recreation Area (USACE)
TOTAL	**10.4**	**0.94**	**3.3**

Table 5-3: Approximate Area (Acres) of Each Land Use within the Project ROW, by Town

Land Use Type[1]	Town (Approximate Area by Land Use Type)				Total
	Watertown	Thomaston	Litchfield	Harwinton	
Upland Forest	46.4	35.3	17.3	15.1	114.1
Old Field /Shrubland	91.8	24.3	11.8	13.7	141.6
Agricultural Land	11	1.3	2.3	0.5	15.1
Urban Areas[2]	19.7	10.8	8.7	3.6	42.8
Wetlands	22.5	6.3	14.5	7.6	50.9
Open Water	1.1	1.8	0.1	0.4	3.4
TOTAL	**192.5**	**79.8**	**54.7**	**40.9**	**368**

[1] Land use types are depicted on the Volume 5, 400 scale maps. Land use type boundaries were determined using aerial mapping and field reconnaissance in some places.
[2] Includes Commercial/Industrial, House/Yard and Other as depicted on the Volume 5, 400 scale maps.

The following summarizes the primary land-use patterns, by town, along and in the vicinity of the Proposed Route.

Town of Watertown

From Frost Bridge Substation, the Proposed Route would extend for approximately 4.7 miles through the eastern portion of the Town of Watertown. For approximately 2.5 miles of the 4.7 miles in Watertown (between Frost Bridge Substation and Purgatory Junction), the new 115-kV transmission line would be aligned either on Eversource property (i.e., near the Frost Bridge Substation) or near the middle of Eversource's existing 400-foot-wide ROW, between the existing 345-kV line (352 Line) and 115-kV line (1191 Line; refer to XS-1 and XS-2 in Section 3, Appendix A of this Volume, as well as to the maps in Volume 5). Along this 2.5-mile segment of the route, Eversource currently manages most of the land within the ROW for utility use (i.e., the ROW segment is characterized by lower-growing vegetation consistent with required clearances from overhead transmission line conductors, except in isolated areas along the Proposed Route where taller-growing vegetation has become established). As a result, although there are areas of forest and taller-growing shrub vegetation, most of the land within this ROW segment consists of scrub-shrub land or grassland.

This 2.6-mile segment of the ROW crosses State Route 8 and U.S. Route 6, as well as various local roads; Mattatuck State Forest; and undeveloped portion of the Town of Watertown Veteran's Memorial Park; commercial / industrial areas; and residential developments. Within Mattatuck State Forest, the ROW crosses the CFPA's Whitestone-Jericho Connector Trail and the Jericho Trail, which connects to the CFPA's Mattatuck Trail. Across the ROW, the Jericho Trail is asphalted. The Whitestone-Jericho Connector Trail extends, in part, along Echo Valley Road before traversing northwest along the 400-foot-wide ROW for a short distance before diverging north into the forest.

Along the remaining approximately 2 miles of the Proposed Route in Watertown (i.e., from Purgatory Junction to the Town of Thomaston border), the new 115-kV line would be aligned within Eversource's 250-foot-wide ROW, east of the existing 1191 Line (refer to XS-3 in Section 3, Appendix 3A of this Volume). Predominant land uses along or near this portion of the ROW include single-family residences, Mattatuck State Forest, Crestbrook Park and Golf Club, and Black Rock State Park. Within Black Rock State Park, the ROW crosses the CFPA's Mattatuck Trail and the park's Red Trail Loop. Branch Brook / Branch Brook Reservoir (Black Rock Lake) Dam, which is managed by the USACE and the CT DEEP, forms the boundary between Watertown and Thomaston.

Town of Thomaston

The Proposed Route traverses approximately 2.6 miles through the Town of Thomaston. Land uses in the vicinity of the Proposed Route consist of a mix of forestland, residences, open land, and public and private recreational areas (including Mattatuck State Forest, the USACE's Branch Brook Reservoir (Black Rock Lake) / Dam and North Brook Recreational Area, Thomaston Fish and Game Club property, and town open space).

Land uses within the existing 250-foot-wide Eversource ROW include principally scrub-shrub land with forest along the uncleared portion of the ROW. The proposed 115-kV line would be aligned within this ROW, east of the existing 1191 Line south of Walnut Hill Junction and east of both the 1191 Line and the 1921 Line north of Walnut Hill Junction (refer to XS-3 and XS-4 in Appendix 3A and to the Volume 5 maps).

Town of Litchfield

Extending northeast from Thomaston, the Proposed Route for the new 115-kV line would cross approximately 1.8 miles through the southeastern portion of the Town of Litchfield. In Litchfield, the new 115-kV transmission line would be aligned east of the existing 1191 and 1921 Lines, within the Eversource's 250-foot-wide ROW (refer to XS-4 in Appendix 3A of this Volume).

Lands in the vicinity of the ROW in Litchfield consist predominantly of residences, agricultural land, and forest land. Land uses within the existing ROW include forest, undeveloped shrub land, and agricultural land. Residences are located near the ROW at road crossings, such as Mason Hill Road, Hopkins Road, and Campville Road.

The Proposed Route also would extend across State Route 8, the former Conrail railroad tracks (now owned by ConnDOT), and lands along the Naugatuck River that are part of the USACE's Thomaston Dam Recreational Area. The Naugatuck River is bordered by recreational trails (hiking, ATV, snowmobile) and is designated by CT DEEP as a trout fishery.

In addition to the proposed new 115-kV line, within the existing ROW at the Naugatuck River crossing, Eversource proposes to replace the existing lattice steel tower (located west of the river) that presently supports the river crossing for both the 1191 and 1921 Lines, with new monopole structures, placing each of these two existing 115-kV lines on a separate structure (refer to XS-5 in Appendix 3A of this Volume). At and in the vicinity of the Naugatuck River crossing, the ROW is bordered by forest land. Portions of the ROW that are not maintained with low-growth vegetation also are forested. The existing 1191 and 1921 Lines are currently elevated 155 feet above the Naugatuck River, spanning the area such that no forested vegetation has had to be cut to maintain appropriate clearances from the conductors.

Portions of the USACE's Thomaston Dam Recreational Area extend linearly along both sides of the Naugatuck River. Along the west side of the river in the Litchfield, an extensive system of hiking, snowmobiling, and ATV trails traverse adjacent to the river.

Town of Harwinton

From the Litchfield border at the Naugatuck River crossing, the Proposed Route traverses approximately 1.3 miles through the southwestern portion of the Town of Harwinton before terminating at Campville Substation. Lands in the vicinity of the route consist primarily of undeveloped forest, with some residences located along Wildcat Hill Road. At the Naugatuck River crossing, the ROW extends across undeveloped USACE-owned property that is part of the Thomaston Dam Recreational Area. In addition, a sand and gravel mining operation is located adjacent to the Naugatuck River, along Valley Road, directly south of the ROW. The existing ROW is characterized principally by forest and open field / shrub lands. Forested areas dominate land use-patterns near the ROW.

East of the Naugatuck River in Harwinton, Eversource also proposes to replace the existing lattice steel tower that presently supports both the 1191 and 1921 Lines. As described above for the proposed lattice steel tower replacement on the west side of the river in Litchfield, Eversource proposes to install two new monopoles to separately support the 1191 and 1921 lines. These two new structures, as well as the new 115-kV line structure, will be located within Eversource's existing ROW east of Valley Road. In this area, existing land uses consist of forest land and shrubland.

5.1.4.2 Federal, State, and Local Use Plans/Future Land-Use Development

To assess the relationship of the proposed Project with respect to established land use plans and policies, Eversource compiled and reviewed federal, state, regional, and local land use plans, including Connecticut's *Conservation and Development Policies Plan* (C&D Plan, 2013). Eversource also consulted with representatives of the four municipalities along the Proposed Route. Each municipality along the Proposed Route has established municipal land use plans, all having goals and objectives consistent with the operation of transmission lines within Eversource's existing ROW, where the new 115-kV line would be located.

5.1.4.2.1 Federal Plans

There are no specific federal land use plans that pertain to the Project. The only federal lands along the Proposed Route are the USACE properties associated with the various projects to control flooding on the Naugatuck River (i.e., Branch Brook / Black Rock Lake and Dam; Northfield Brook Dam, and Thomaston Dam). The USACE actively manages these flood control projects and maintains its surrounding properties for public recreational uses. All of the USACE flood control projects were implemented in the 1960s, decades after the Eversource transmission line ROW was established. Eversource's existing 115-kV transmission lines span Branch Brook, Northfield Brook, and the Naugatuck River, and are compatible with the USACE's flood control programs. The Eversource ROW also does not affect any of the public recreational uses of these USACE properties.

In addition, the U.S. Department of the Interior, National Park Service (NPS), through its Rivers, Trails, and Conservation Assistance Program (Northeast Region), is assisting in the planning of a greenway along the Naugatuck River. Under this program, the NPS provides technical assistance to community groups and local, state, and federal agencies seeking to protect natural areas and water resources and to enhance "close-to-home" outdoor recreational opportunities. The NPS is assisting the Towns of Watertown and Thomaston, among others, to develop a 44-mile greenway trail along the Naugatuck River from Torrington to Derby.

5.1.4.2.2 State and Regional Plans

Eversource reviewed the C&D Plan prepared by the Connecticut Office of Policy and Management. The objective of the C&D Plan is to guide and balance response to human, environmental, and economic needs in a manner that best suits Connecticut's future. Based on the general planning information provided in the C&D Plan, the Project is consistent with the overall goals and objectives of the C&D Plan and is particularly relevant to the Plan's Growth Management Principle #1: Redevelop and Revitalize Regional Centers and Currently Planned Infrastructure. The Project would serve a public need by providing an environmentally-sound approach to the reliable transmission of electricity, which, as the C&D Plan (p. 8) notes is needed, along with other physical infrastructure, to "…take full advantage of Connecticut's strategic location within the Northeast Megaregion, while also proactively addressing the needs and desires of a changing demographic base."

In addition, there are several regional planning agencies that serve the municipalities along the Project, including the Naugatuck Valley Council of Governments (NVCOG), which includes the towns of Watertown and Thomaston, and the Northwest Hills Council of Governments ([NHCOG[67]]: including Litchfield and Harwinton). The regional planning agencies establish land use, conservation, and development policies to assist in coordinating regional growth patterns, with the objective of maximizing efficiencies in shared environmental, economic, and infrastructure facilities. The Project, which is located entirely on Eversource's fee-owned properties and long-established ROW, will improve the reliability of the regional electric system and thus will be consistent with these regional planning agencies' overall goals.

5.1.4.2.3 Local Land-Use Plans

All four of the towns traversed by the Proposed Route have published plans of conservation and development:

- Watertown: Plan of Conservation and Development (December 2007)
- Thomaston: Plan of Conservation and Development (2014)
- Litchfield: Plan of Conservation and Development (Adopted June 2007, revised January 2010)

[67] NHCOG was formed January 1, 2014 and is a consolidation of the Litchfield Hills Council of Elected Officials (LHCOE) and the Northwestern Connecticut Council of Governments. The NHCOG is a coordinating body for 21 towns, including Litchfield and Harwinton. A combined Plan of Conservation and Development has not yet been prepared for the 21 municipalities. As a result, the *Plan of Conservation and Development* (2009) prepared by the LHCOE remains in effect for Litchfield and Harwinton.

- Harwinton: Plan of Conservation and Development (January 2010)

In general, these plans identify the areas traversed by the Proposed Route as continuing to maintain current land use patterns in the future (e.g., public recreational or protected lands, low-density residential development). None of the plans identify local land use policies that would be inconsistent with the development of the new 115-kV transmission line within Eversource's existing ROW.

5.1.4.3 Community Facilities

The Council's *Application Guide for Electric and Fuel Transmission Facilities* (April 2010; Section VI.G) specifies that the proximity of the proposed Project to certain community facilities, as identified below, must be identified. These facilities are, in particular:

- Public and private schools, licensed daycare centers, licensed youth camps, and public playgrounds;
- Hospitals;
- Group homes; and
- Recreational areas.

Recreational areas, including public playgrounds, are discussed in Section 5.1.4.4.

A review of public records indicates the Proposed Route is not located within 500 feet of any schools, licensed residential child day-care facilities, youth camps, hospitals, or group homes.[68] The only public schools located in the general vicinity of the Project are Thomaston High School and Black Rock Elementary School (pre-K to Grade 3), which are both located approximately 0.5 mile southwest of the Proposed Route south of State Route 109 (Branch Road).

Two group day-care facilities, both in the Town of Watertown, are located within 0.5 mile of the Proposed Route: Kidz Child Care Center, 169 Callender Road, which is located approximately 0.19 mile southwest of the Proposed Route, south of Park Road, and Ledgewood Private Pre-School, 720 Thomaston Road (U.S. Route 6), which is located approximately 0.07 mile southwest of the Proposed Route.

[68] http://www.dir.ct.gov/dcf/Licensed_Facilities/listing_CCF.asp; https://www.elicense.ct.gov/Lookup/DownloadRoster.aspx

5.1.4.4 Public Forests, Parks, Open Space, Recreational / Public Trust Lands, and Trails

The Proposed Route traverses or is located near various forests, parks, open space lands, and recreational areas (including trails), including Mattatuck State Forest, Veterans Memorial Park, Black Rock State Park and Black Rock Lake, Northfield Brook Lake Recreation Area, and areas along the Naugatuck River in Litchfield and Harwinton that are part of Thomaston Dam Recreation Area. The Black Rock Lake, Northfield Brook Lake, and Thomaston Dam areas are owned by the USACE and were created when the USACE developed dams to control flooding within the Naugatuck River basin. These flood control projects, which were completed in the 1960s, were prompted by the significant damage and loss of life caused by severe flooding on the Naugatuck River during Hurricane Diane in 1955.

The recreational areas crossed by or near the Proposed Route are described below and are summarized in Table 5-12 (located at the end of this subsection), and depicted on the maps located in Volume 5.

- **Mattatuck State Forest.** The Mattatuck State Forest, which is owned and managed by CT DEEP, encompasses approximately 4,673 acres and is comprised of a variety of parcels located in six towns, including all four of the Project towns. The Proposed Route traverses approximately 1.77 miles through portions of the forest in the towns of Watertown (1.50 miles) and Thomaston (0.27 mile). In Thomaston, the ROW extends across the forest's largest single parcel (1,327 acres), which adjoins Black Rock State Park. CT DEEP manages the forest for a wide variety of recreational uses (e.g., hunting, hiking, mountain biking, etc.), as well as for forest products and wildlife habitat. The CFPA's Mattatuck Trail passes through several portions of the forest.
- **Jericho-Whitestone Connector Trail, Jericho Trail, Mattatuck Trail.** The Mattatuck Trail, which is managed by the CFPA, is a 36-mile hiking trail that stretches across nine towns in central-northwestern Connecticut, extending from the Town of Wolcott northwest to the Town of Cornwall. The Jericho-Whitestone Connector Trail extends along Echo Valley Road and from there crosses onto the 400-foot-wide ROW for a short distance before diverging north into Mattatuck State Forest and eventually joining the Jericho Trail, north of the Project ROW. In the vicinity of the ROW, views from this trail are presently influenced by Echo Valley Road and developments along it, as well as by the existing transmission lines within the ROW. The Jericho Trail, which connects to the Mattatuck Trail, originates at Echo Lake Road in Watertown and extends north, across the Eversource ROW, to connect to the Mattatuck Trail in the Mattatuck State Forest. In addition to crossing the Jericho Trail, the Proposed Route crosses the Mattatuck Trail within Black Rock State Park in the Town of Thomaston.
- **Veterans Memorial Park.** This Town of Watertown park, which encompasses approximately 100 acres, provides year-round multi-use recreational opportunities. The park includes baseball fields, soccer fields, basketball courts, walking trails, a playground, gazebo, covered pavilion, Jericho Brook Pond (fishing), horseshoe pits, bocce courts, and picnic areas. The Eversource ROW extends across the northern boundary of the park land. In this area, the ROW is 400 feet wide. The proposed 115-kV transmission line would be aligned near the middle of the ROW, away from the park and north of the existing 1191 Line. Mature trees screen virtually all of the developed portion of the Park from the ROW.
- **Black Rock State Park and Black Rock Lake.** CT DEEP's Black Rock State Park, a multi-use outdoor recreational area, encompasses 439 acres in Watertown. The park includes Black Rock

Pond (used for swimming and fishing), various hiking trails (including the CFPA's Mattatuck Trail and the park's Red Trail), a campground with 78 sites, picnic areas, and a nature center. The park abuts the Mattatuck State Forest on the south, and Branch Brook and Black Rock Lake, which forms the boundary between the towns of Watertown and Thomaston, to the north.

In 1970, the USACE completed the construction of Black Rock Dam, damming the upstream portion of Branch Brook and creating the 21-acre Black Rock (Conservation) Lake as well as Wigwam Reservoir. The dam is part of a network of USACE flood control projects within the Naugatuck River basin. The USACE and CT DEEP cooperatively manage approximately 341 acres[69] of land and water resources in the Black Rock Lake area for recreation, wildlife, and forestry resources. Recreational opportunities include fishing and hiking, as well as nature viewing. An overlook on top of the dam is accessible from State Route 109, and a portion of the CFPA's Mattatuck Trail extends west along the south side of the lake and reservoir. The Black Rock Lake recreational area is located in both Watertown and Thomaston, spanning the border between the two towns.

The Proposed Route follows Eversource's existing 250-foot-wide ROW across approximately 1.06 mile of Black Rock State Park lands within the Town of Watertown, and approximately 0.10 mile of Black Rock State Park property in the Town of Thomaston.

- **Thomaston Fish & Game Club.** The Proposed Route would be located within Eversource's existing 250 foot ROW across approximately 0.24 mile of the privately-owned Thomaston Fish and Game Club lands in the Town of Thomaston. The club's property is located off Old Northfield Road.
- **Northfield Brook Lake and Recreation Area.** Northfield Brook Lake Recreation Area is a 208-acre day use park, owned by the USACE and located north of State Route 254. The area includes an 8-acre lake (which CT DEEP stocks with trout), a small beach and swimming area, picnic areas (with picnic shelters and grills), and a 1.7-mile self-guided hiking trail. This area is also a CT DEEP-designated deer and turkey bow hunting area. The Eversource ROW crosses approximately 0.07 mile through the northern portion of the recreation area, near the entrance off State Route 254. The self-guided trail crosses the ROW near Northfield Brook, as well as in an upland area east of the park access road.
- **Thomaston Dam and Naugatuck River Greenway.** This USACE-owned area encompasses approximately 850 acres along both sides of the Naugatuck River in the towns of Thomaston, Litchfield, Harwinton, and Plymouth. The area includes Thomaston Dam, which is part of the USACE's network of dams built to control flooding in the Naugatuck River Basin. The area is managed for a variety of recreational uses including hiking, snowmobiling, trail biking, fishing, picnicking, model airplane flying, and upland hunting (pheasant, small game, waterfowl, deer bow hunting and turkey). In addition, the Naugatuck River corridor as a whole is designated as a state greenway (refer to discussion, below). As noted in Section 5.1.4.2.1, the NPS (Rivers, Trails and Conservation Assistance Program[70]) is working with towns along the Naugatuck River to create a Naugatuck River Greenway trail, which would extend for 44 miles along the river between Torrington and Derby. In the Project area, this trail would extend along the USACE-owned land along the Naugatuck River. The Proposed Route would include an approximately 0.4-mile span of the Naugatuck River and associated USACE recreational areas, including the greenway (refer to XS-5 in Appendix 3A).

[69] The 314 acres includes approximately 173 acres of USACE land and 141 acres of CT DEEP land.

[70] The NPS's Rivers, Trails, and Conservation Assistance program provides technical assistance to community groups and government agencies that are planning projects to protect natural areas and water resources and to enhance outdoor recreational opportunities.

The Proposed Route traverses two state-designated greenways: the CFPA's Mattatuck Trail in the Town of Watertown and the Naugatuck River, which forms the border between the towns of Litchfield and Harwinton.[71] According to CGS § 23-100, a "greenway" means a corridor of open space that may protect natural resources, preserve scenic landscapes and historical resources or offer opportunities for recreation or non-motorized transportation; may connect existing protected areas and provide access to the outdoors; may be located along a defining natural feature, such as a waterway, along a man-made corridor, including an unused ROW, traditional trail routes or historic barge canals; or may be a greenspace along a highway or around a village. The Naugatuck River greenway was designated in 2001 and extends along the river through portions of 11 communities (Torrington, Litchfield, Harwinton, Thomaston, Watertown, Waterbury, Naugatuck, Beacon Falls, Seymour, Ansonia, and Derby). An economic impact study is presently being conducted (2015-2016) by the NVCOG and others to assess the economic and quality of life impacts that would result from the construction of the planned multi-use greenway trail along the river.

Table 5-4: Public Forest, Parks, Open Space, Land-Trust Parcels, and Trails along and in the vicinity of the Proposed Route

Town	Proximity to Route	Recreational/Scenic/Open Space Feature (Refer to Volume 5 maps for parcel location)
Watertown		
	Crosses	Mattatuck State Forest
	Extends along ROW	Jericho-Whitestone Connector Trail
	Crosses	CFPA Jericho Trail
	Crosses	Veterans Memorial Park
	Adjacent	Crestbrook Park and Golf Club
	Crosses	Black Rock State Park
	Crosses	CFPA Mattatuck Trail
	Crosses	Black Rock State Park Red Trail Loop (two crossings)
	Crosses	Black Rock Lake Dam (USACE)
Thomaston		
	Crosses	Black Rock Lake Dam (USACE)
	Crosses	Mattatuck State Forest
	Crosses	Thomaston Fish and Game Club
	Adjacent	Town Open Space (Dug Road)

71 CT DEEP, *Connecticut Greenways Council: Officially Designated Greenways 2015*. http://www.ct.gov/deep/lib/deep/greenways/greenwaysmap2015.pdf

Town	Proximity to Route	Recreational/Scenic/Open Space Feature (Refer to Volume 5 maps for parcel location)
	Crosses	Northfield Brook Recreation Area (USACE)
	0.07 mile to west	Mattatuck State Forest
Litchfield		
	0.28 mile to west	Humaston Brook State Park Scenic Reserve
	Crosses	Thomaston Dam Recreation Area / Naugatuck River Greenway (USACE)
Harwinton		
	Crosses (spans)	Thomaston Dam Recreation Area / Naugatuck River Greenway (USACE)

5.1.5 Designated Protected and Scenic Resources

As summarized in in this section, described in more detail in the *Visual Resources Analysis* (Volume 3), and depicted on the Volume 5, 400 scale maps, the proposed 115-kV transmission line would be located within Eversource's existing ROW across or near several areas that have scenic attributes, such as established recreational trails (e.g., the CFPA's Jericho-Whitestone Connector Trail, Jericho Trail and Mattatuck Trail; the Red Trail Loop within Black Rock State Park); Veteran's Memorial Park; Black Rock State Park; Black Rock Lake and Dam; Northfield Brook Recreational Area; and the Naugatuck River greenway. Through all of these areas, the proposed 115-kV line would be located adjacent to one or more of Eversource's existing overhead 115-kV lines and, in portions of Watertown, also located adjacent to a 345-kV overhead transmission line.

The ROW also traverses near one locally-designated scenic road: Hayden Road in the Town of Harwinton. The ROW extends west of the intersection of Hayden Road with Wildcat Hill Road. In addition, Hayden Road forms the southern boundary of the 42.33-acre Eversource property on which the Campville Substation is located.

The Project area does not encompass any state heritage corridors, as designated in July 2009 pursuant to Connecticut Public Act No. 09-221, codified at CGS § 23-81. As set out in CGS § 23-81, a heritage area is defined as a place within Connecticut that has historic, recreational, cultural, natural, and scenic resources that form an important part of the state's heritage. State agencies must take the resources of the heritage areas into consideration in planning and project decision-making.

On December 23, 2009, the Council issued a memorandum to routine applicants / participants concerning, among other issues, the consideration of scenic quality and the aesthetic attributes of land that might be affected by projects under the Council's jurisdiction. In the same memorandum, the Council advised applicants to use photographs of aesthetic areas, particularly for use in photo-simulations that depict "leaf off" conditions. In the absence of deciduous vegetative screening, such "leaf off" conditions would tend to represent "worst case" (or maximum) views of potential project facilities.

Pursuant to the Council's specifications for visual resource analyses, Eversource conducted research to identify designated scenic, recreational, open space, and historic properties (collectively referred to herein as the "visual sites") crossed by or in the vicinity of the Proposed Route. These sites were identified based on the review of Project mapping, data contained in land use sections of town plans, Internet research, and other published information such as the CFPA's *Walk Book West* and data concerning ConnDOT's scenic land strips. In general, designated scenic, recreation, open space, and historic sites crossed by or within approximately 0.5 - 1 mile of the Proposed Route were identified for further evaluation. Field inspections were conducted of each of the identified potential visual sites. The objectives of the field inspections were to:

- Assess the relationship of each potential visual site to the existing Eversource ROW within which the Project is planned;
- Determine whether Eversource's existing overhead transmission line(s) are currently visible from each potential visual resource site; and
- Photo-document views, as applicable, of the existing transmission line(s) from the visual sites. Sites that were determined to be too geographically remote from the ROW or from which views of the overhead transmission lines were blocked by intervening topography, vegetation, or land uses, were not photographed.

Initial field reviews to document visual conditions under "leaf off" conditions (when the existing overhead transmission lines would be most visible) were conducted in April 2015.

In May 2015, Eversource conducted follow-up field visits to assess and photo-document conditions at the same sites when deciduous forest vegetation was leafed out. In general, such "leaves on" conditions are representative of the spring through fall seasons when public use of most of the designated recreational or scenic areas near the ROW can be expected to be highest.

Table 5-12 at the end of this section identifies the sites from which the existing Eversource transmission line(s) are visible during "leaf off" and "leaf on" conditions, based on the field inspections. In most cases, long views of the existing transmission lines from sites remote from the ROW were found to be precluded by intervening topography, vegetation, and land uses. Overall, the rugged topography along the Proposed Route limited most long views of the ROW and overhead transmission lines.

For each site with views of the existing transmission line, the table identifies its location in relation to the existing Eversource ROW and summarizes its known aesthetic, recreational, or cultural attributes. Overall, the primary scenic areas from which the existing transmission lines are visible include the Jericho-Whitestone Connector Trail, Jericho Trail, Mattatuck Trail, Black Rock State Park Red Loop Trail, Black Rock Lake / Dam, Northfield Brook Lake Recreation area (trail, picnic area, and access road), and the Naugatuck River.

5.1.5 Transportation Systems and Utility Crossings

As illustrated on the Volume 5 maps, the Project region is characterized by a well-developed transportation network consisting of roads, railroads, and airport facilities. Utilities are located primarily within roads or in defined ROWs, such as Eversource's transmission line corridors. The Volume 5 maps also depict the major utility lines crossed by the Proposed Route.

As listed in Table 5-5 and shown on the maps in Volume 5, the road transportation network in the vicinity of the Proposed Route consists of a variety of federal, state, and local roads. Principal roads include U.S. Route 6; State Routes 8 (James H. Darcey Memorial Highway), 109, 262, and 254.

Although there are no airports immediately along the Proposed Route, the Federal Aviation Administration (FAA) has the following notification requirements associated with the construction or alteration of an electric transmission line:

- Any construction or alteration exceeding 200 feet above ground level
- Within 20,000 feet of a public use or military airport which exceeds a 100:1 surface from any point on the runway of each airport with its longest runway more than 3,200 feet
- Within 10,000 feet of a public use or military airport which exceeds a 50:1 surface from any point on the runway of each airport with its longest runway no more than 3,200 feet
- Within 5,000 feet of a public use heliport which exceeds a 25:1 surface

Waterbury Airport is a privately-owned airport, open for public use located approximately 7,000 feet northeast of the Proposed Route in the Town of Plymouth. The airport has a two grass runways, 1,600 feet and 2,005 feet in length and operates using visual flight rules (VFR) with no established instrument procedures. The runway elevation is 850 feet above mean sea level (AMSL) and, based on analysis of the transmission line structures along the Proposed Route, none of the structures would exceed the FAA notification criteria for this airport.

Northfield Heliport is a privately-owned heliport, open for public use located approximately 7,100 feet west of the Proposed Route in the Town of Litchfield. The helipad is grass and operates using visual flight rules with no established instrument procedures. The helipad elevation is 903 feet AMSL and, based on analysis of the transmission line structures along the Proposed Route, none of the structures would exceed the FAA notification criteria for this heliport.

Waterbury-Oxford Airport is the nearest publicly-owned airport, located approximately 9.5 miles south of the Proposed Route in the Town of Oxford. The airport has one, 5,800-foot asphalt runway and operates using VFR and instrument flight rules (IFR) with established instrument procedures. The runway elevation is 726 feet AMSL and, based on analysis of the transmission line structures along the Proposed Route, none of the structures would exceed the FAA notification criteria for this airport.

ConnDOT owns a railroad track that extends along the Naugatuck River within the Project area, from Waterbury to Torrington. This rail line is located east of the Frost Bridge Substation and is traversed by the Proposed Route along the west side of the river in Litchfield.

The Railroad Museum of New England (RMNE) operates a heritage railroad, referred to as the Naugatuck Railroad, over portions of these tracks. The RMNE offers scenic excursions, typically from the Waterville neighborhood of Waterbury to Thomaston.

Table 5-5: Road Crossings – Proposed Route

Town	Road Name	Road Type
Watertown		
	Frost Bridge Road (State Route 262)	State Highway
	State Route 8	Major State Highway
	Echo Lake Road	Local Road
	Park Road	Local Road
	Seemar Road	Local Road
	Nova Scotia Hill Road	Local Road
	Thomaston Road (US Route 6)	Federal Highway
Thomaston		
	Old Branch Road	Local Road
	Branch Road (State Route 109)	State Highway
	Walnut Hill Road	Local Road
	Northfield Road (State Route 254)	State Highway
	Northfield Dam Access Road	Local Road
Litchfield		
	Mason Hill Road	Local Road
	Hopkins Road	Local Road
	Thomaston-Campville Road	Local Road
	State Route 8	Major State Highway
Harwinton		
	Valley Road	Local Road
	Wildcat Hill Road	Local Road

5.1.6 Energy Facilities within a Five Mile Radius

In accordance with CGS §16-50j(59)(15), Table 5-6 lists energy facilities within a 5-mile radius of the proposed Project. These facilities include the Company’s transmission facilities, including transmission substations, as well as third party-owned generators and transmission lines. These facilities are located in the Towns of Bethlehem, Woodbury, Middlebury, Watertown, Plymouth, Wolcott, Thomaston, Harwington, and Litchfield, and in the cities of Waterbury and Torrington.

Table 5-6: Energy Facilities within a Five Mile Radius

Transmission Substations	
Eversource Bunker Hill 115-kV (Waterbury)	
Eversource Campville 115-kV (Harwinton)	
Eversource Franklin Drive 115-kV (Torrington)	
Eversource Freight 115-kV (Waterbury)	
Eversource Frost Bridge 115/345-kV (Watertown)	
Eversource Noera 115-kV (Waterbury)	
Eversource Shaw's Hill 115-kV (Watertown)	
Eversource Thomaston 115-kV (Thomaston)	
Eversource Torrington Terminal 115-kV (Torrington)	
Generators	
NRG/Connecticut Jet Power LLC – Franklin Drive 16.1 MW (Torrington)	
NRG/Connecticut Jet Power LLC – Torrington Terminal 17.4 MW (Torrington)	
Waterbury Hospital – Fuel Cell 2.4 MW (Waterbury)	
FirstLight Power Resources Services LLC – Waterbury Generation 95 MW (Waterbury)	
Line Numbers	**Transmission Lines**
1575	Bunker Hill – Beacon Falls 115-kV
1585	Bunker Hill – South Naugatuck 115-kV
1732	Campville – Weingart Road Jct 115-kV
689 & 693	Falls Village – Torrington Terminal 115-kV
1732	Franklin Drive – Weingart Road Jct 115-kV
1788	Franklin Drive – Torrington Terminal 115-kV
1721	Frost Bridge – Bunker Hill 115-kV
1191	Frost Bridge – Campville 115-kV
1238	Frost Bridge – Carmel Hill 115-kV
352	Frost Bridge – Long Mountain 345-kV
1990	Frost Bridge – Stevenson 115-kV
329	Frost Bridge – Southington 345-kV
1163 & 1550	Frost Bridge – Noera 115-kV
1445	Frost Bridge – Shaw's Hill 115-kV
1163 & 1550	Frost Bridge – Todd 115-kV
1272	Shaw's Hill – Bunker Hill 115-kV
1921	Thomaston – Campville 115-kV
1732	Weingart Road Jct – Canton 115-kV
1900	Torrington Terminal – Campville 115-kV

5.1.7 Cultural (Historic and Archaeological) Resources

Cultural resources include buried archaeological sites, standing historic structures, or thematically-related groups of structures (i.e., related structures that share a common theme). To be considered significant and eligible for listing on the National or State Registers of Historic Places (NRHP/SRHP), a cultural resource must exhibit physical integrity and contribute to American history, architecture, archaeology, technology, or culture; and must possess at least one of the following four criteria:

- Association with important historic events;
- Association with important persons;
- Distinctive design or physical characteristics; and
- Potential to provide important new information about prehistory or history.

The State Historic Preservation Office (SHPO), which is part of the Connecticut Department of Economic and Community Development, is responsible for reviewing proposed projects to ensure that significant cultural resources will be protected or otherwise preserved.

As part of the Project planning effort, Eversource's cultural resources consultant (Heritage Consultants, LLC) conducted a preliminary archaeological and historical resources assessment (Phase 1A) along the Proposed Route and at each substation. This information, which amends and updates previous cultural resource studies conducted along the ROW in 2009-2010 by UMass Archaeological Services[72], is included in the *Preliminary Archaeological Assessment and Scope of Work for Completion of Cultural Resources Reconnaissance Survey* in Volume 3, Exhibit 4.

The objectives of the *Preliminary Archaeological Assessment and Scope of Work for Completion of Cultural Resources Reconnaissance Survey* were: 1) to gather and present data regarding previously identified cultural resources situated in the vicinity of the Proposed Route; 2) to investigate the Project area's natural and historical characteristics; 3) to complete a visual survey of the Area of Potential Effect, and 4) to identify culturally-sensitive areas in proximity to the Proposed Route.

The following summarizes the principal findings of the *Preliminary Archaeological Assessment and Scope of Work for Completion of Cultural Resources Reconnaissance Survey*:

[72] The cultural resource analyses performed by UMass Archaeological Services were part of the initial planning efforts for a proposed new 345-kV transmission line that the Company subsequently decided not to advance.

- There are no previously identified historic structures, known archaeological sites or NRHP properties on file with the Connecticut SHPO that are situated within 152 m (500 feet) of the proposed project corridor or in the general vicinity.
- During previous studies of the ROW performed in 2009 by UMass Archaeological Services, 14 archaeological sites were identified within "test areas" along the Proposed Route that were thought to retain a high probability for containing intact archaeological deposits. All 14 of these sites were interpreted as potentially significant cultural resources.
- During the current stratification of the Proposed Route into no/low and high/moderate areas, there was a correlation noted between the locations of the test areas examined by UMass Archaeological Services and those areas deemed by Eversource's cultural resources consultant to retain a moderate/high potential for yielding intact archaeological deposits. However, it was concluded that some areas not subjected to subsurface testing by UMass Archaeological Services should also be considered moderate/high potential areas.

For more informed interpretations of the sites with respect to their NRHP significance, the Eversource cultural resources consultant concluded that additional (Phase 1B) shovel testing is necessary at the 14 UMass identified archaeological sites to gather additional information on site size and artifact types and densities. In addition, Eversource proposes to conduct additional testing within areas that were identified as having moderate/high probability for intact archaeological deposits, based on the 2015 surveys, and that would also be subject to USACE jurisdiction.

Eversource provided the *Preliminary Archaeological Assessment and Scope of Work for Completion of Cultural Resources Reconnaissance Survey,* which includes the proposal for Phase 1B testing, to the SHPO and involved Native American tribes in December, 2015. Eversource anticipates that the proposed Phase 1B testing will commence in the spring of 2016. Further, Eversource expects to continue to coordinate with the SHPO and Tribal Historic Preservation Offices (THPOs) regarding the need for any additional studies that may be required to identify and/or further evaluate known or potentially significant cultural resources in the vicinity of the Project, and implementation of avoidance or protection measures where necessary.

5.1.8 Air Quality

Ambient air quality is affected by pollutants emitted from both mobile sources (e.g., automobiles, trucks) and stationary sources (e.g., manufacturing facilities, power plants, and gasoline stations). Naturally occurring pollutants, such as radon gas or emissions from forest fires, also affect air quality.

In addition to emissions from sources within the state, Connecticut's air quality is significantly affected by pollutants emitted in states located to the south and west, and then transported into Connecticut by prevailing winds. Ambient air quality in the state is monitored and evaluated by the CT DEEP. Air quality conditions are assessed in terms of compliance with the National Ambient Air Quality Standards (NAAQS) for selected "criteria" pollutants, as well as conformance with regulations governing the release of toxic or hazardous air pollutants. Litchfield County is in conformance with all National Ambient Air Quality Standards established by the Federal Clean Air Act Amendment standards except for the 8-hour ozone criterion. The U.S. Environmental Protection Agency (EPA) has determined that carbon dioxide (CO_2) is a pollutant and has included CO_2 in its list of criteria pollutants. Areas of non-attainment have not yet been established for CO_2 or other greenhouse gases.

In an effort to reduce particulate emissions, the CT DEEP has promulgated a regulation (RCSA § 22a-174-18), that prohibits unnecessary idling for more than 3 minutes. Exceptions are made for weather extremes, certain service vehicles, and health-related conditions.

5.1.9 Noise

Existing noise levels in the vicinity of the Proposed Route vary as a function of land use, and can be expected to range from sound levels typical of an urban environment to those typical of quiet, rural areas. Noise levels are also variable throughout the day, and are influenced by diverse factors such as vehicular traffic, commercial and industrial activities and outdoor activities typical of suburban environments. Table 5-7 lists typical sound levels associated with different types of environments and activities.

The State of Connecticut has noise regulations (RCSA §§ 22a-69-1 to 22a-69-7.4) identifying the sound limits that can be emitted by certain types of land uses. The state regulations define daytime vs. nighttime noise periods; classify noise zones based on land use; and identify noise standards for each zone. Table 5-8 summarizes Connecticut's noise zone standards, by emitter (source) and receptor (receiver) noise classification. In general, the regulations specify that noise emitters must not cause the emission of excessive noise beyond the boundaries of their noise zone so as to exceed the allowable noise levels on a receptor's land.

Table 5-7: Typical Noise Levels Associated with Different Indoor and Outdoor Activities

Outdoor Noise Levels	A-Weighted Sound Level (dBA)	Indoor Noise Levels
Jet aircraft take-off at 100 feet	+120	
Riveting machine at operator's position	+110	
Cut-off saw at operator's position	+100	
Elevated subway at 50 feet		
		Newspaper press
Automobile horn at 10 feet		
	+90	Industrial boiler room
Diesel truck at 50 feet		Food blender at 3 feet
Noisy urban daytime	+80	Garbage disposal at 3 feet
Diesel bus at 50 feet		
		Shouting at 3 feet
	+70	
Gas lawn mower at 100 feet		Vacuum cleaner at 10 feet
Quiet urban daytime	+60	Normal conversation at 5 - 10 feet
		Large business office
Quiet urban nighttime	+50	Open office area background level
Substation (transformer)	+43	
Quiet suburban nighttime		
	+40	Large conference room
		Small theater (background)
Quiet rural nighttime	+30	Soft whisper at 2 feet
		Bedroom at nighttime
	+20	Concert hall

Table 5-8: State of Connecticut Noise-Control Regulations by Emitter and Receptor Land-Use Classification

Noise Emitter Class	Noise Receptor Class			
	C: Industrial	B: Generally Commercial	A: Residential Day	A: Residential Night
C: Industrial	70 dBA	66 dBA	61 dBA	51 dBA
B: Generally Commercial	62 dBA	62 dBA	55 dBA	45 dBA
A: Residential	62 dBA	55 dBA	55 dBA	45 dBA

Definitions:
Day = 7:00 AM to 9:00 PM Monday – Saturday; 9:00 AM to 9:00 PM Sunday
Night = 9:00 PM to 7:00 AM Monday – Saturday; 9:00 PM to 9:00 AM Sunday

As illustrated in Table 5-8, the allowable noise levels vary by type of noise emitter and type of noise receptor. For example, an industrial noise emitter is allowed a 70 dBA (decibel, on the A-weighted scale) level on another industrial receptor’s property, but only a 61 dBA (daytime) level on a residential receptor’s property. Where multiple noise emitter/noise receptor types exist on the same property, the least restrictive limits apply.

The regulation also prohibits the production of prominent, audible discrete tones. If a facility produces such sounds, the applicable limits in Table 5-8 are reduced by 5 dBA to offset the undesirable nature of tonal sound in the environment. The regulation defines prominent discrete tones on the basis of one-third octave band sound levels.

Construction noise is exempted under RCSA § 22a-69-1.8(h); therefore, the noise limits presented in Table 5-8 do not apply to construction of this Project.

In accordance with the Connecticut General Statutes § 22a-73, municipalities also may adopt noise-control ordinances. Such ordinances must be approved by the Commissioner of CT DEEP and be consistent with the state noise regulations. Of the four towns traversed by the Project, only Watertown has an established noise ordinance (Chapter 12, Article 2). The ordinance does not reference acceptable noise levels for construction activities. It does, however, prevent (without special permit) the operation of heavy equipment between the hours of from 8:00 p.m. through 6 a.m. Monday through Saturday, and 6:00 p.m. through 9:00 a.m. on Sundays.

5.2 SUBSTATIONS

To interconnect the new 115-kV transmission line to the transmission system, Eversource proposes to modify both Frost Bridge Substation and Campville Substation. Characteristics of the existing environment and cultural resources that are unique to these locations are described below. Air quality characteristics at each substation are similar to the Proposed Route (refer to Section 5.1.7) and therefore, not described in this section.

5.2.1 Frost Bridge Substation

Frost Bridge Substation, which is located in the southeastern portion of the Town of Watertown, occupies approximately 5.7 acres of a 128.5-acre site owned by Eversource. The modifications required to interconnect Frost Bridge Substation to the new 115-KV transmission line would be accomplished within the developed (fenced) portion of the property. No expansion or modification to the existing fence line would be required.

5.2.1.1 Geology, Topography, and Soils

Frost Bridge Substation is located in the Naugatuck River Valley at the base of a hillside perched above the Naugatuck River. Elevations in the vicinity range approximately 350 feet at Frost Bridge Road to approximately 300 feet along the Naugatuck River. Slopes above the valley rise steeply to elevations in excess of 700 feet. Three bedrock formations interface near the Eversource property, all predominately composed of schists. Soils at the highest elevations along Frost Bridge Road are formed in shallow till deposits over bedrock. The northern portion of the substation consists of an undulating outwash terrace with a steep escarpment to the east, facing the river. Below approximately elevation 310 feet, alluvial soils associated with the Naugatuck River are encountered. Till soils are mostly well or somewhat excessively drained, outwash soils excessively drained across much of the site and very poorly drained in wetland depressions, and floodplain soils well to poorly drained.

5.2.1.2 Water Resources

Six wetland systems were identified in the vicinity of the developed substation on Eversource’s property (refer to Volume 5 maps). Portions of two of these wetlands (W-FB1 and W-FB6) are characterized by non-hydric alluvial soils and as such, are Connecticut wetlands only. The surface water quality of the Naugatuck River is rated use Class B. Groundwater at the site is rated as GA.

5.2.1.3 Flood Zones

A review of FEMA maps indicates that the Frost Bridge Substation is beyond the limits of both the 100-year and 500-year flood zones associated with the Naugatuck River to the east.

5.2.1.4 Biological Resources

The most notable biological resource present in the vicinity of the substation is the Naugatuck River, which is located approximately 260 feet east of the fence line. The substation property is separated from the river by a railroad grade. No open water habitats are present within the property. Terrestrial habitats present within the property include upland forest, upland shrubland, forested wetland, and shrub wetland. A discussion of these habitats and the associated wildlife species is provided in Section 5.1.3.2. Larger wildlife species are mostly excluded from the property by significant barriers to movement, including State Route 8 to the west, the railroad, industrial development, and the Naugatuck River to the east and north.

5.2.1.5 Existing and Future Land Uses, Recreational Areas, and Visual Resources

The substation property is bounded by the Naugatuck Railroad and Naugatuck River to the east, Frost Bridge Road and State Route 8 to the west, and undeveloped property to the north and south. The Naugatuck River forms the boundary between the towns of Watertown and Thomaston.

The substation property is classified as within a “growth area” in Connecticut’s C&D Plan and is zoned by the Town of Watertown as general industrial land (IG 80). Lands in the immediate vicinity of Frost Bridge Substation also are zoned for general industrial uses. The Town of Watertown *Plan of Conservation and Development* (2007) calls for future land use on and in the vicinity of the substation to be for industrial park purposes.

Frost Bridge Substation is isolated from other land uses by the Naugatuck River, Frost Bridge Road and State Route 8, and steep topography. There are no residential areas in the vicinity. The closest residence is located on Echo Lake Road, approximately 1,200 feet to the southwest. A portion of the Mattatuck State Forest is located east of the substation, across the Naugatuck River, and east of State Route 262, in the Town of Thomaston. The substation is not in the vicinity of any designated scenic or recreational resources.

The existing substation and the various overhead transmission line structures that extend into and out of the substation are partially visible from State Routes 8 and 262, the railroad, and Frost Bridge Road.

5.2.1.6 Transportation and Access

Frost Bridge Substation is readily accessible via Frost Bridge Road and existing ROW access roads. The existing access roads are depicted on the maps in Volume 5.

5.2.1.7 Noise

Frost Bridge Substation is located within an area zoned for industrial use and generally isolated from other land uses by the Naugatuck River, Frost Bridge Road and State Route 8, and steep topography. The ambient sound environment is predominantly influenced by vehicular traffic along State Route 8, followed by the operation of Frost Bridge Substation, and occasional train movement along the railroad tracks located to the east of the substation.

5.2.2 Campville Substation

Eversource's Campville Substation is located in the southwestern portion of the Town of Harwinton and currently occupies approximately 1.65 acres of a 42.33-acre property owned by Eversource. The property is bordered by Wildcat Hill Road to the west, Hayden Road to the south, and private property to the north and east.

To accommodate modifications required to interconnect the new 115-kV transmission line, Eversource proposes to expand the developed portion of the substation by approximately 0.4 acre. These modifications would require an expansion of the substation fence line by approximately 90 feet to the east.

5.2.2.1 Geology, Topography, and Soils

Campville Substation is located on a west-facing hillside above the Naugatuck River Valley. Elevations in the vicinity range approximately 760 feet at Wildcat Hill Road to 840 feet to the north of Campville Substation. Bedrock geologic formations near the substation are predominately composed of schists. Soils are formed in shallow till deposits over bedrock. Till soils are mostly well or somewhat excessively drained across much of the site and poorly and very poorly drained in wetland depressions.

5.2.2.2 Water Resources

Three wetland systems were identified in the vicinity of the developed substation on the Eversource property. Wetlands W-G1 and W-G2 are located south and north of the substation, respectively. Each wetland receives stormwater inputs from the fenced portions of the substation via overland flow and/or culvert outfall. Wetland W-G3 is a red maple swamp located to the east of the substation. Groundwater at the site is rated as GA.

5.2.2.3 Biological Resources

The vegetative communities in the vicinity of the substation consist principally of upland forest (mixed deciduous and coniferous forest) and open field-shrub land. A discussion of these habitats and the associated wildlife species is provided in Section 5.1.3.2.

5.2.2.4 Existing and Future Land Uses, Recreational Areas, and Visual Resources

The substation is within an area zoned by the Town of Harwinton for Country Residential Use. This zoning classification characterizes all of the land in southern Harwinton. Lands in the vicinity of the substation consist of a mix of undeveloped, mostly forested land, along with single-family residential uses. The entrance to the substation is off Wildcat Hill Road, along which single-family residential land uses predominate.

There are no designated scenic or public recreational areas in the vicinity of the Campville Substation. Hayden Road, which borders the Eversource property to the south, is a town-listed scenic road. However, due to topography and intervening vegetation, the substation is not visible from this road.

5.2.2.5 Transportation and Access

Campville Substation is readily accessible via Wildcat Hill Road and existing access roads.

5.2.2.6 Noise

Campville Substation is located in a rural / suburban area dominated by forest. The ambient noise levels are low which is typical of such areas.

Table 5-9
Soils and Soil Characteristics along the Proposed Route

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit		Parent Material	Hydric Soil	Depth to Restrictive Feature (inches)	Depth to Water Table (inches)	Hazard of –Off-Road or Off-Trail Erosion
Symbol	Name					
3	Ridgebury, Leicester, and Whitman soils , extremely stony	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss; or coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	Yes	12-30 to Dense material	0-18	Slight
5	Wilbraham silt loam[2]	Coarse-loamy lodgment till derived from basalt and/or sandstone and shale.	Yes	20-36 to Dense material	0-18	Slight
6	Wilbraham and Menlo soils, extremely stony	Coarse-loamy lodgment till derived from basalt and/or sandstone and shale.	Yes	20-36 to Dense material	0-18	Slight
12	Raypol silt loam[2]	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	Yes	—	0-12	Slight
13	Walpole sandy loam[2]	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	Yes	—	0-12	Slight
15	Scarboro muck	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	Yes	—	0-6	Slight
17	Timakwa and Natchaug soils	Woody organic material over sandy and gravelly glaciofluvial deposits; Woody organic material over loamy alluvium and/or loamy glaciofluvial deposits and/or loamy till.	Yes	—	0-12	Very Severe
18	Catden and Freetown soils	Woody organic material; organic material.	Yes	—	0-12	Very Severe
21A	Ninigret and Tisbury soils, 0 to 5 % slopes[1]	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss; Coarse-silty eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	18-30	Slight
23A	Sudbury sandy loam, 0 to 5 % slopes[1]	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	18-36	Slight
29A	Agawam fine sandy loam, 0 to 3 % slopes[1]	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
29B	Agawam fine	Coarse-loamy eolian deposits over	No	—	—	Slight

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit		Parent Material	Hydric Soil	Depth to Restrictive Feature (inches)	Depth to Water Table (inches)	Hazard of –Off-Road or Off-Trail Erosion
Symbol	Name					
	sandy loam, 3 to 8 % slopes[1]	sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.				
32A	Haven and Enfield soils, 0 to 3 % slopes[1]	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss; Coarse-silty eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
32B	Haven and Enfield soils, 3 to 8 % slopes[1]	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss; Coarse-silty eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
34A	Merrimac sandy loam, 0 to 3 % slopes[1]	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
34B	Merrimac sandy loam, 3 to 8 % slopes[1]	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
36A	Windsor loamy sand, 0 to 3 % slopes[2]	Eolian sands over sandy glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
36B	Windsor loamy sand, 3 to 8 % slopes[2]	Eolian sands over sandy glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
36C	Windsor loamy sand, 8 to 15 % slopes[2]	Eolian sands over sandy glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
37C	Manchester gravelly sandy loam, 3 to 15 % slopes[2]	Sandy and gravelly glaciofluvial deposits derived from sandstone and shale and/or basalt.	No	—	—	Slight
38A	Hinckley gravelly sandy loam, 0 to 3 % slopes[2]	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Slight
38C	Hinckley gravelly sandy	Sandy and gravelly glaciofluvial deposits derived from granite	No	—	—	Slight

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit		Parent Material	Hydric Soil	Depth to Restrictive Feature (inches)	Depth to Water Table (inches)	Hazard of –Off-Road or Off-Trail Erosion
Symbol	Name					
	loam, 3 to 15 % slopes[2]	and/or schist and/or gneiss.				
38E	Hinckley gravelly sandy loam, 15 to 45 % slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss.	No	—	—	Moderate
41B	Ludlow silt loam, 2 to 8 % slopes, very stony	Coarse-loamy lodgment till derived from basalt and/or sandstone and shale.	No	20-40 to Dense mat erial	18-30	Slight
43A	Rainbow silt loam, 0 to 3 % slopes[1]	Eolian deposits over coarse-loamy lodgment till derived from gneiss and/or schist and/or sandstone and/or basalt.	No	20-40 to Dense material	18-30	Slight
43B	Rainbow silt loam, 3 to 8 % slopes[1]	Eolian deposits over coarse-loamy lodgment till derived from gneiss and/or schist and/or sandstone and/or basalt.	No	20-40 to Dense material	18-30	Slight
44B	Rainbow silt loam, 2 to 8 % slopes, very stony	Eolian deposits over coarse-loamy lodgment till derived from gneiss and/or schist and/or sandstone and/or basalt.	No	20-40 to Dense material	18-30	Slight
45A	Woodbridge fine sandy loam, 0 to 3 % slopes[1]	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss.	No	20-40 to Dense material	18-30	Slight
45B	Woodbridge fine sandy loam, 3 to 8 % slopes[1]	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss.	No	20-40 to Dense material	18-30	Slight
45C	Woodbridge fine sandy loam, 8 to 15 % slopes[2]	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss.	No	20-40 to Dense material	18-30	Slight
46B	Woodbridge fine sandy loam, 2 to 8 % slopes, very stony	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss.	No	20-40 to Dense material	18-30	Slight
47C	Woodbridge fine sandy loam, 2 to 15 % slopes, extremely stony	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss.	No	20-40 to Dense material	18-30	Slight
50A	Sutton fine sandy loam, 0	Coarse-loamy melt-out till derived from granite and/or schist and/or	No	—	18-30	Slight

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit Symbol	Soil Map Unit Name	Parent Material	Hydric Soil	Depth to Restrictive Feature (inches)	Depth to Water Table (inches)	Hazard of –Off-Road or Off-Trail Erosion
	to 3 % slopes[1]	gneiss.				
50B	Sutton fine sandy loam, 3 to 8 % slopes[1]	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	18-30	Slight
51B	Sutton fine sandy loam, 2 to 8 % slopes, very stony	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	18-30	Slight
52C	Sutton fine sandy loam, 2 to 15 % slopes, extremely stony	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	18-30	Slight
58C	Gloucester gravelly sandy loam, 8 to 15 % slopes, very stony	Sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Slight
59C	Gloucester gravelly sandy loam, 3 to 15 % slopes, extremely stony	Sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Slight
59D	Gloucester gravelly sandy loam, 15 to 35 % slopes, extremely stony	Sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Moderate
60B	Canton and Charlton soils, 3 to 8 % slopes[1]	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Slight
60C	Canton and Charlton soils, 8 to 15 % slopes[2]	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Slight
60D	Canton and Charlton soils, 15 to 25 % slopes	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived	No	—	—	Moderate

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit		Parent Material	Hydric Soil	Depth to Restrictive Feature (inches)	Depth to Water Table (inches)	Hazard of –Off-Road or Off-Trail Erosion
Symbol	Name					
		from granite and/or schist and/or gneiss.				
61B	Canton and Charlton soils, 3 to 8 % slopes, very stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Slight
61C	Canton and Charlton soils, 8 to 15 % slopes, very stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Slight
62C	Canton and Charlton soils, 3 to 15 % slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Slight
62D	Canton and Charlton soils, 15 to 35 % slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	—	—	Moderate
67B	Narragansett silt loam, 3 to 8 % slopes, very stony	Coarse-loamy eolian deposits over sandy and gravelly melt-out till derived from gneiss and/or schist and/or sandstone and shale.	No	—	—	Slight
67C	Narragansett silt loam, 8 to 15 % slopes, very stony	Coarse-loamy eolian deposits over sandy and gravelly melt-out till derived from gneiss and/or schist and/or sandstone and shale.	No	—	—	Slight
73C	Charlton-Chatfield complex, 3 to 15 % slopes, very rocky	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	20-40 to Lithic bedrock	—	Slight
73E	Charlton-Chatfield complex, 15 to 45 % slopes, very rocky	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	20-40 to Lithic bedrock	—	Moderate

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit						
Symbol	**Name**	**Parent Material**	**Hydric Soil**	**Depth to Restrictive Feature (inches)**	**Depth to Water Table (inches)**	**Hazard of –Off-Road or Off-Trail Erosion**
75C	Hollis-Chatfield-Rock outcrop complex, 3 to 15 % slopes	Loamy melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	0-40 to Lithic bedrock	—	Slight
75E	Hollis-Chatfield-Rock outcrop complex, 15 to 45 % slopes	Loamy melt-out till derived from granite and/or schist and/or gneiss; Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss.	No	0-40 to Lithic bedrock	—	Moderate
76E	Rock outcrop-Hollis complex, 3 to 45 % slopes	Loamy melt-out till derived from granite and/or schist and/or gneiss.	No	0-20 to Lithic bedrock	—	Moderate
76F	Rock outcrop-Hollis complex, 45 to 60 % slopes	Loamy melt-out till derived from granite and/or schist and/or gneiss.	No	0-20 to Lithic bedrock	—	Very Severe
78C	Holyoke-Rock outcrop complex, 3 to 15 % slopes	Loamy eolian deposits over melt-out till derived from basalt and/or sandstone and shale.	No	0-20 to Lithic bedrock	—	Slight
78E	Holyoke-Rock outcrop complex, 15 to 45 % slopes	Loamy eolian deposits over melt-out till derived from basalt and/or sandstone and shale.	No	0-20 to Lithic bedrock	—	Slight
79E	Rock outcrop-Holyoke complex, 3 to 45 % slopes	Loamy eolian deposits over melt-out till derived from basalt and/or sandstone and shale.	No	0-20 to Lithic bedrock	—	Moderate
82B	Broadbrook silt loam, 3 to 8 % slopes[1]	Eolian deposits over coarse-loamy lodgment till derived from gneiss and/or schist and/or sandstone and/or basalt.	No	20-40 to Dense material	18-30	Slight
82C	Broadbrook silt loam, 8 to 15 % slopes[2]	Eolian deposits over coarse-loamy lodgment till derived from gneiss and/or schist and/or sandstone and/or basalt.	No	20-40 to Dense material	18-30	Moderate
83B	Broadbrook silt loam, 3 to 8 % slopes, very stony	Eolian deposits over coarse-loamy lodgment till derived from gneiss and/or schist and/or sandstone and/or basalt.	No	20-40 to Dense material	18-30	Slight
84B	Paxton and	Coarse-loamy lodgment till derived	No	20-40 to	18-30	Slight

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit		Parent Material	Hydric Soil	Depth to Restrictive Feature (inches)	Depth to Water Table (inches)	Hazard of –Off-Road or Off-Trail Erosion
Symbol	Name					
	Montauk fine sandy loams, 3 to 8 % slopes[1]	from granite and/or schist and/or gneiss; Coarse-loamy lodgment till derived from granite and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from granite.		Dense material		
84C	Paxton and Montauk fine sandy loams, 8 to 15 % slopes[2]	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss; Coarse-loamy lodgment till derived from granite and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from granite.	No	20-40 to Dense material	18-30	Slight
84D	Paxton and Montauk fine sandy loams, 15 to 25 % slopes	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss; Coarse-loamy lodgment till derived from granite and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from granite.	No	20-40 to Dense material	18-30	Moderate
85B	Paxton and Montauk fine sandy loams, 3 to 8 % slopes, very stony	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss; Coarse-loamy lodgment till derived from granite and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from granite.	No	20-40 to Dense material	18-30	Slight
85C	Paxton and Montauk fine sandy loams, 8 to 15 % slopes, very stony	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss; Coarse-loamy lodgment till derived from granite and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from granite.	No	20-40 to Dense material	18-30	Slight
86C	Paxton and Montauk fine sandy loams,	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss; Coarse-loamy lodgment till	No	20-40 to Dense material	18-30	Slight

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit		Parent Material	Hydric Soil	Depth to Restrictive Feature (inches)	Depth to Water Table (inches)	Hazard of –Off-Road or Off-Trail Erosion
Symbol	Name					
	3 to 15 % slopes, extremely stony	derived from granite and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from granite.				
86D	Paxton and Montauk fine sandy loams, 15 to 35 % slopes, extremely stony	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss; Coarse-loamy lodgment till derived from granite and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from gneiss and/or coarse-loamy lodgment till derived from granite.	No	20-40 to Dense material	18-30	Moderate
87B	Wethersfield loam, 3 to 8 % slopes[1]	Coarse-loamy lodgment till derived from basalt and/or sandstone and shale.	No	20-40 to Dense material	18-30	Slight
87C	Wethersfield loam, 8 to 15 % slopes[2]	Coarse-loamy lodgment till derived from basalt and/or sandstone and shale.	No	20-40 to Dense material	18-30	Slight
88B	Wethersfield loam, 3 to 8 % slopes, very stony	Coarse-loamy lodgment till derived from basalt and/or sandstone and shale.	No	20-40 to Dense material	18-30	Slight
100	Suncook loamy fine sand[2]	Sandy alluvium.	No	—	60-72	Slight
105	Hadley silt loam[1]	Coarse-silty alluvium.	No	—	60-72	Slight
106	Winooski silt loam[1]	Coarse-silty alluvium.	No	—	18-36	Slight
107	Limerick and Lim soils[2]	Coarse-silty alluvium; Coarse-loamy alluvium.	Yes	—	0-18	Slight
108	Saco silt loam	Coarse-silty alluvium.	Yes	—	0-6	Slight
109	Fluvaquents-Udifluvents complex, frequently flooded	Alluvium.	Yes	—	0-12	Slight
243B	Rainbow-Urban land complex, 0 to 8 % slopes	Eolian deposits over coarse-loamy lodgment till derived from gneiss and/or schist and/or sandstone and/or basalt; Drift.	No	20-40 to Dense material	18-54	Slight
302	Dumps	Miscellaneous area.	No	—	—	Slight
305	Udorthents-Pits complex,	Gravelly outwash.	No	—	24-54	Moderate/Severe

Table 5-9: Soils and Soil Characteristics along the Proposed Route

Soil Map Unit						
Symbol	**Name**	**Parent Material**	**Hydric Soil**	**Depth to Restrictive Feature (inches)**	**Depth to Water Table (inches)**	**Hazard of –Off-Road or Off-Trail Erosion**
	gravelly					
306	Udorthents-Urban land complex	Drift.	No	—	54-72	Moderate
307	Urban land	Miscellaneous area.	No	—	--	Moderate
308	Udorthents, smoothed	Drift.	No	—	24-54	Moderate
309	Udorthents, flood control	Drift.	No	—	24-54	Moderate
W	Water	Miscellaneous area.	Yes	—	0	Not Rated

Source: USDA Natural Resources Conservation Service, Online Soil Surveys, Geographic Data and Soil Data Mart information of Hartford and Litchfield Counties, accessed July 2009.

[1] Soils classified as Prime Farmland Soils.

[2] Soils classified as Farmland Soils of Statewide Importance.

— No Data Given. No restrictive features or water encountered to survey depth.

Table 5-10
Delineated Wetlands and Vernal Pools
along the Proposed Route

Table 5-10: Delineated Wetlands and Vernal Pools along the Proposed Route

Municipality; Vol. 5, Ex. 1 & 2 Mapsheet Nos.[73]	Wetland No. [1]	Dominant NWI Class[2]	Other NWI Classes	Water Regime	Associated Vernal Pool(s)[3]
Watertown					
1/1	W-FB1	PFO	PSS	Seasonally saturated	
1/1	W-FB2	PFO	PSS	Saturated	
1/1	W-FB3	PEM	PSS	Seasonally saturated	
1/1	W-FB4	PEM	PSS	Seasonally saturated	
1	W-FB5	PFO	PSS	Saturated	
1	W-FB6	PEM		Seasonally saturated	
1/3A	W-MSF1	PFO		Seasonally saturated	VP MSF-1
1/3	W-MSF2	PFO		Seasonally saturated	VP MSF-2
1/3A	W-MSF3	PFO	PSS	Seasonally saturated	
1/1	W-A1	PSS	PEM	Saturated	
1/1	W-A2	PSS	PEM	Seasonally saturated	
1/2	W-A3	PFO	PSS	Seasonally saturated	
1/2	W-A4	PFO	PEM	Saturated	
1/3	W-A5	PSS	PEM	Temporarily flooded	
1/3	W-A6	PEM		Temporarily flooded	
1/4	W-A7	PFO	PEM	Seasonally saturated	
1/4	W-A8	PSS		Temporarily flooded	
1-2/4-5	W-A9	PSS	PEM	Saturated	
1/4	W-A10	PEM		Seasonally saturated	
2/5	W-A11	PSS		Saturated	
2/6	W-A12	PSS	PEM	Seasonally saturated	
2/6	W-B1	PSS	PEM	Saturated	
2/6	W-B2	PSS	PEM	Saturated	VP B2-1
2/6	W-B3	PSS	PEM	Intermittently flooded	
2/6	W-B4	PFO		Saturated	VP B4-1
2/6-7	W-B5	PSS	PEM	Seasonally saturated	
2/6-7	W-B6	PSS	PEM	Saturated	

[73] The first number is the mapsheet(s) the watercourse/waterbody can be found in the 400-scale maps (Exhibit 1). The second number is the mapsheet(s) the watercourse/waterbodycan be found in the 100-scale maps (Exhibit 2).

Table 5-10: Delineated Wetlands and Vernal Pools along the Proposed Route

Municipality; Vol. 5, Ex. 1 & 2 Mapsheet Nos.[73]	Wetland No.[1]	Dominant NWI Class[2]	Other NWI Classes	Water Regime	Associated Vernal Pool(s)[3]
2/8	W-B7	PSS	PEM	Saturated	
2/8	W-B8	POW	PEM	Temporarily flooded	
2/8	W-B9	POW	PSS, PEM	Saturated	
3/9	W-B11	PSS	POW	Saturated	
3/10A/10B	W-C1A	PSS	PFO	Saturated	
3/10A/10B	W-C2A	PSS	PEM	Saturated	
3/10	W-C1	PFO	PSS	Seasonally saturated	
3/10	W-C2	PFO		Seasonally saturated	
3/10	W-C3	PSS	PEM	Seasonally saturated	
3/11	W-C4	PFO	PSS	Seasonally saturated	DVP C4-1
3/11	W-C6	PSS		Seasonally saturated	
3/11	W-C7	PFO		Seasonally saturated	
3/11	W-C8	PFO		Saturated	
3/11	W-C10	PFO		Seasonally flooded	VP C10-1
3/12	W-C12	PFO	PSS, PEM	Saturated	VP C12-1
3/12	W-C14	PSS	PEM	Seasonally saturated	
3-4/12-13	W-C15	PFO	PSS, PEM	Saturated	VP C15-1
3/11	W-C16	PSS	PEM, PFO (off-ROW)	Saturated	
3-4/13	W-C18	PFO		Seasonally saturated	
4/14	W-C20	PFO	PSS	Saturated	VP C20-1
4/15	W-C21	PFO	POW	Semi-permanently flooded	VP C21-1
4/16	W-C22	PEM	PFO	Saturated	
4/17	W-C23	PSS	PEM	Saturated	
Thomaston					
5/18	W-D1	PUB		Temporarily flooded	
5/18	W-D2	PEM		Seasonally saturated	
5/18-19	W-D3	PFO	PSS	Seasonally saturated	
5/19	W-D4	PFO		Seasonally saturated	VP D4-1
5/20	W-D5	PEM		Seasonally saturated	VP D5-1
5/20	W-D6	POW	PEM	Permanently flooded	

Table 5-10: Delineated Wetlands and Vernal Pools along the Proposed Route

Municipality; Vol. 5, Ex. 1 & 2 Mapsheet Nos.[73]	Wetland No. [1]	Dominant NWI Class[2]	Other NWI Classes	Water Regime	Associated Vernal Pool(s)[3]
6/21	W-D7	PFO	PEM	Seasonally saturated	
6/21	W-D8	PFO		Seasonally saturated	
6/22	W-D10	PFO	PFO	Seasonally saturated	
6/22	W-D11	PFO	PSS	Seasonally saturated	
6/22-23	W-D12	PSS	PFO, PEM	Seasonally saturated	VP D12-1
6/23	W-D13	PFO	PSS	Seasonally saturated	
6/24	W-D14	PFO		Saturated	
5/21	W-D15	PSS	PEM	Semi-permanently flooded	VP D15-1
6/24	W-E1	PFO	PSS	Permanently flooded	
7/25-26	W-E2	PSS	PFO	Saturated	
Litchfield					
7/25-26	W-E2	PSS	PFO	Saturated	DVP E2-1, DVP E2-2
7/26	W-E3	PEM		Saturated	
7/26	W-E4	PFO	PSS, PEM	Seasonally saturated	
7/26	W-E5	PEM		Seasonally saturated	
7/26	W-E6	PEM		Seasonally saturated	
7/26-27	W-E7	PSS		Seasonally saturated	
7/27	W-E8	PSS	PFO	Seasonally saturated	
7/27-28	W-E9	PFO	PSS	Saturated	VP E9-1
7/28	W-E10	PSS	PFO	Saturated	
7/28	W-E11	PSS	POW	Saturated	
7/29	W-E12	PEM		Seasonally saturated	
7/28	W-E13	PFO		Seasonally saturated	
8/29	W-F1	PEM		Seasonally saturated	
8/29	W-F2	PEM		Seasonally saturated	
8/29	W-F3	PFO		Seasonally saturated	
8/29	W-F4	PFO		Seasonally saturated	
8/29	W-F5	PSS	PEM	Seasonally saturated	
8/29	W-F6	PFO		Seasonally saturated	
8/29-30	W-F7	PSS	PFO, PEM,	Seasonally saturated	

Table 5-10: Delineated Wetlands and Vernal Pools along the Proposed Route

Municipality; Vol. 5, Ex. 1 & 2 Mapsheet Nos.[73]	Wetland No. [1]	Dominant NWI Class[2]	Other NWI Classes	Water Regime	Associated Vernal Pool(s)[3]
			POW		
8/30	W-F8	PEM	PSS	Seasonally saturated	
8/31	W-F9	PFO	POW	Intermittently flooded	
Harwinton					
8/31	W-F9	PFO	POW	Intermittently flooded	VP F9-1
8/31	W-F10	PFO		Temporarily flooded	VP F10-1
8/32	W-F11	PFO	PSS	Seasonally saturated	
8/32	W-F12	PSS	PEM	Seasonally saturated	
8-9/33	W-F13	PFO	PSS, PEM	Saturated	
9/34	W-F14	PSS	PFO	Seasonally saturated	VP F14-1
9/34-35	W-F15	PEM	PFO, PSS, POW	Seasonally saturated	VP F15-1
9/35	W-G1	PFO	PSS	Seasonally saturated	
9/35	W-G2	PSS	PFO	Saturated	
9/35	W-G3	PSS	PEM	Seasonally saturated	

[1]Wetland No. refers to the number generated during the 2015 field surveys to identify wetlands in and adjacent to the Project ROW. This Wetland No. is keyed to those depicted in Volume 5.

[2] Wetlands classified according to Cowardin et al 1979; PEM = Palustrine Emergent Wetland; PFO = Palustrine Forested Wetland; PSS = Palustrine Scrub-Shrub Wetland; POW = Palustrine Open Water.

[3] Associated Vernal Pool refers to the identification number generated during the 2015 field surveys to identify vernal pools within the Project ROW or along publically accessible off-ROW access. This vernal pool identification number is keyed to those depicted in the Volume 5, 100 scale maps.

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Table 5-11

Watercourses and Waterbodies along the Proposed Route

Table 5-11: Watercourses and Waterbodies along the Proposed Route

Municipality; Vol. 5, Ex. 1 & 2 Mapsheet Nos.[74]	Watercourse No.[1]	Watercourse /Waterbody Name	Flow Regime	Water Quality Classification	Approximate Width	Associated Wetland
Watertown						
1/1	S-FB1		Intermittent	A	1 - 2'	W-FB2
1	S-FB2	Tributary to Naugatuck River	Perennial	B/A	3 - 6'	W-FB6
1	S-FB3	Tributary to Naugatuck River	Intermittent	B/A	1'	W-FB6
1/1	S-A1	Tributary to Naugatuck River	Perennial	B/A	3 - 4'	W-A1
1/1	S-A2	Tributary to Naugatuck River	Intermittent	B/A	1 - 3'	W-A2
1/2	S-A3	Tributary to Naugatuck River	Perennial	B/A	2 - 5'	W-A3
1/3	S-A4	—	Intermittent	A	1 - 2'	W-A6
1/4	S-A5	Tributary to Turkey Brook	Perennial	A	4 - 8'	W-A8
1/4	S-A6	Turkey Brook	Perennial	A	3 - 7'	W-A9
1-2/4-5	S-A7	Turkey Brook	Perennial	A	3 - 7'	W-A9
2/8		Unnamed Pond	Perennial	A		W-B9
3/9		Unnamed Pond	Perennial	A		W-B11
3/9	S-B1	Tributary to Hannon Pond/Purgatory Brook	Intermittent	A	2 - 3'	W-B11
3/9	S-B2	Tributary to Hannon Pond/Purgatory Brook	Intermittent	A	2 - 3'	W-B11
3/9	S-B3	Tributary to Hannon Pond/ Purgatory Brook	Intermittent	A	2 - 3'	W-B11
3/10	S-C1	—	Intermittent	A	2 - 3'	W-C1, W-C2
3/10	S-C2	Tributary to Hannon Pond/ Purgatory Brook	Intermittent	A	2 - 3'	W-C1, W-C2
3/12	S-C3	—	Intermittent	A	3 - 4'	W-C12
3/12	S-C4	Tributary to Lockwood Pond	Perennial	A	3 - 4'	W-C15

[74] The first number is the mapsheet(s) the watercourse/waterbody can be found in the 400-scale maps (Exhibit 1). The second number is the mapsheet(s) the watercourse/waterbodycan be found in the 100-scale maps (Exhibit 2).

Table 5-11: Watercourses and Waterbodies along the Proposed Route

Municipality; Vol. 5, Ex. 1 & 2 Mapsheet Nos.[74]	Watercourse No.[1]	Watercourse /Waterbody Name	Flow Regime	Water Quality Classification	Approximate Width	Associated Wetland
3/12	S-C5	Tributary to Lockwood Pond	Intermittent	A	1'	W-C15
4/14	S-C6	—	Intermittent	A	2'	W-C20
4/16	S-C7	—	Intermittent	A	3'	W-C22
4/17	S-C8	Branch Brook	Perennial	A	20 - 30'	W-C23
4/17	S-C9	Tributary to Branch Brook	Intermittent	A	3'	W-C23
Thomaston						
5/18	S-D1	—	Intermittent	A	< 1'	
5/18	S-D2	Tributary to Branch Brook	Intermittent	A	2 - 3'	W-D2
5/18-19	S-D3	Tributary to Branch Brook	Intermittent	A	2 - 8'	W-D3
5/20		Morton Pond	Perennial	A		W-D6
6/21	S-D5	Tributary to Northfield Brook	Perennial	A	3 - 8'	W-D7
6/22	S-D8	—	Intermittent	A	< 1'	W-D11
6/22	S-D9	Tributary to Northfield Brook	Intermittent	A	5 - 10'	W-D12
6/22	S-D10	Tributary to Northfield Brook	Intermittent	A	2 - 4'	W-D12
6/23	S-D11	Tributary to Northfield Brook	Intermittent	A	2 - 8'	W-D13
6/24	S-E2	Northfield Brook	Perennial	A	20 - 30'	W-E1
7/25	S-E3	Tributary to Northfield Brook	Intermittent	A	3 - 4'	W-E2
Litchfield						
7/26	S-E4	—	Intermittent	A	< 1'	W-E2
7/26	S-E5	—	Intermittent	A	2'	W-E4
7/27	S-E7	—	Intermittent	A	1'	W-E9
7/28		Unnamed Pond	Perennial	A		W-E11
8/29	S-F1	—	Intermittent	A	4 - 6'	W-F4, W-F5
8/29	S-F2	—	Intermittent	A	< 1'	W-F2
8/29	S-F1/S-F3	—	Intermittent	A	3'	W-F2, W-F4, W-F5

Table 5-11: Watercourses and Waterbodies along the Proposed Route

Municipality; Vol. 5, Ex. 1 & 2 Mapsheet Nos.[74]	Watercourse No.[1]	Watercourse /Waterbody Name	Flow Regime	Water Quality Classification	Approximate Width	Associated Wetland
8/30		Unnamed Pond	Perennial	A		W-F7
8/30	S-F4	—	Intermittent	A	1 - 2'	W-F7
8/30	S-F5	—	Intermittent	A	< 1'	W-F8
8/30-31	S-F6	Tributary to Naugatuck River	Perennial	A	5-15’	
8/31	S-F7	Naugatuck River	Perennial	B	70 - 110'	W-F9
Harwinton						
8/31	S-F7	Naugatuck River	Perennial	B	70 - 110'	W-F9
8/30	S-F8	Tributary to Naugatuck River	Perennial	A	4 - 7'	W-F9
8/31	S-F9	Tributary to Naugatuck River	Intermittent	A	1 - 2'	W-F10
8/32	S-F10	Tributary to Naugatuck River	Intermittent	A	1 - 3'	W-F12
8/32	S-F11	Tributary to Naugatuck River	Perennial	A	6 - 9'	W-F11
8/33	S-F12	Tributary to Naugatuck River	Intermittent	A	4 - 8'	W-F13, W-F15
9/34	S-F13	Tributary to Naugatuck River	Intermittent	A	1 - 3'	W-F15
9/35	S-F14	Tributary to Naugatuck River	Intermittent	A	1 – 2’	
9/35		Unnamed Pond	Perennial	A		W-F15
9/35	S-G1	—	Intermittent	A	1 - 2'	W-G1
9/35	S-G2	—	Intermittent	A	1 - 2'	W-G1
9/35	S-G3	—	Intermittent	A	1 - 2'	W-G1

[1]Watercourse No. refers to the number generated during the 2015 field surveys to identify watercourses within the Project area. This Wetland No. is keyed to those depicted in the Volumes 5 maps.

Table 5-12

Summary of Potential Visual Sites Traversed by or in the Vicinity of the Proposed Route with Views of the existing Eversource Transmission Lines

Table 5-12: Summary of Potential Visual Sites Traversed by or in the Vicinity of the Proposed Route with Views of the existing Eversource Transmission Lines

Town / Potential Visual Site / Photo-Simulation	Volume 5, 400 Scale Mapsheet No./ Relation to ROW	Feature Information	Summary Results of Field Review
Watertown			
Jericho-Whitestone Connector Trail	1 Follows	The Jericho-Whitestone Connector Trail is a CFPA "blue blaze" trail that connects to the Jericho Trail.	This trail extends from State Route 8 along Echo Valley Road and then turns onto the ROW, following the ROW for approximately 600 feet before diverging north into forested areas and then into Mattatuck State Forest.
Jericho Trail / Mattatuck State Forest	1 Crosses	The Jericho Trail is a CFPA "blue-blaze" trail that connects to the CFPA's Mattatuck Trail. The Jericho Trail is accessible from Echo Lake Road, through the Mattatuck State Forest.	The Jericho Trail crosses the 400-foot-wide ROW, most of which Eversource presently manages in low-growth vegetation consistent with overhead transmission line use. At the ROW crossing, the Jericho Trail is a relatively wide, asphalt pathway. A steep slope extends to the northwest, limiting views along the ROW in that direction. However, views to the east are unobstructed, with the existing transmission lines and Frost Bridge Substation clearly visible. Due to topography and forest vegetation adjacent to the ROW, views of the transmission lines / ROW from other portions of the trail are precluded or limited.
Veterans Memorial Park	2 Crosses	Town of Watertown park that provides year-round recreational opportunities	Eversource ROW crosses the northeastern boundary of the park. The new 115-kV line will be located toward the center of the existing 400-foot-wide ROW. The existing transmission lines are slightly visible above the tree line from the park's ball fields that border the ROW, as well as from the park's entrance road, across Jericho Brook Pond.
Black Rock State Park / Mattatuck Trail, Park Red Trail	4 Crosses	CFPA Trail that extends through Black Rock State Park, also connecting to the Park's "Red Trail"	The 250-foot-wide Eversource ROW extends along the western portion of the park, crossing both the Mattatuck Trail and the Red Trail in rugged locations. Views of the ROW are limited to the immediate vicinity of the crossings, due to the topography, dense vegetation, and bends in the trails.

Town / Potential Visual Site / Photo-Simulation	Volume 5, 400 Scale Mapsheet No./ Relation to ROW	Feature Information	Summary Results of Field Review
Watertown/Thomaston			
Black Rock Lake Dam Overlook	4 Crosses	Public access on top of dam that offers views of the lake, and to the hills to the east and north	From portions of this overlook, the existing and proposed 115-kV transmission structures are visible on a wooded slope that extends north-northeast from State Route 109.
Thomaston			
Northfield Brook Recreation Area	6 Crosses	"Yellow" trail located north of the recreation areas's access road	The "Yellow Trail", a narrow hiking trail, crosses the Eversource ROW, which is occupied by two 115-kV lines. At the trail crossing, the ROW is visible along the hillside to the south of State Route 254, toward Walnut Hill Junction.
Litchfield / Harwinton			
Naugatuck River / Thomaston Dam Trails	8 Crosses	ATV / Snowmobile / hiking trails / fishing area along Naugatuck River greenway	Eversource ROW spans the river and river valley, limiting views of the transmission lines from most areas due to dense vegetation. ROW and transmission line structures are visible from Valley Road in Harwinton.

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6. POTENTIAL ENVIRONMENTAL EFFECTS AND MITIGATION MEASURES

This section identifies and analyzes the potential short- and long-term effects that the construction and operation of the proposed facilities would have on the environment, ecology, scenic, cultural (historical and archaeological), and recreational values. Furthermore, this section describes the measures that Eversource proposes to implement to avoid, minimize, or mitigate adverse effects. This analysis is based on the currently available information concerning the Project, as well as Eversource's past experience with the installation of overhead transmission facilities and substations throughout New England. The impact and mitigation analysis may be refined after Eversource addresses input from the municipal consultation process.

Section 6.1 discusses the potential effects, and measures to mitigate such effects, associated with the construction and operation of the new 115-kV transmission line and double-circuit separation. Section 6.2 discusses the potential environmental effects and mitigation measures related to the proposed modifications at the Frost Bridge and Campville Substations.

Overall, the proposed Project would minimize adverse environmental effects by locating the new 115-kV transmission line within an existing Eversource ROW, adjacent to existing overhead transmission lines and by developing the proposed substation modifications within uplands on Eversource property that are already designated for utility use. Although the construction and operation of the Project would result in unavoidable short- and long-term effects on certain environmental, cultural, and recreational / scenic resources, Eversource has identified measures that can be applied to mitigate these effects to the extent practical. The identified mitigation measures are based on Eversource's historical experience in the construction, operation, and maintenance of the existing transmission lines along the Project ROW; on the results of the field investigations and agency consultations conducted for the Project; and on recent, directly relevant expertise in siting and constructing 115-kV and other transmission facilities elsewhere in New England.

For example, as part of the Project planning process, Eversource modified the new 115-kV transmission line design to place new structures outside of wetlands wherever possible. Of the total 101 new structures proposed, only one structure would be located in a wetland. Similarly, as has been the case on other recent transmission line projects, Eversource would commit to prepare Project-specific construction plans related to erosion and sediment control; spill prevention; and ROW revegetation. Eversource would also preserve riparian vegetation near streams to the extent practical, and would make every effort to align new permanent access roads in upland (rather than wetland) areas where possible.

Furthermore, along with the mitigation methods identified in this section, additional measures to avoid or minimize adverse effects on the environment may be identified during the course of the Council proceedings and during the process of acquiring Project-specific permits and approvals from other state and federal agencies, including the CT DEEP and the USACE. Mitigation measures, as described herein or as included as conditions of regulatory approvals, would be reflected in the final Project design and incorporated into D&M Plans or other Project specifications, as appropriate. During construction, Eversource or its consultants would regularly monitor the Project construction contractors' compliance with the D&M Plans and applicable regulatory approvals.

6.1 PROPOSED ROUTE: FROST BRIDGE SUBSTATION TO CAMPVILLE SUBSTATION

6.1.1 Topography, Geology, and Soils

The construction and operation of the new 115-kV transmission line would have negligible effects on topography and geology, and only minor, short-term, and highly localized effects on soils. These effects would be concentrated in the vicinity of work sites along the ROW, or where earth-moving activities, if any, are required at off-ROW Project support areas (e.g., off-ROW access roads, staging areas).

6.1.1.1 Topography and Geology

Generally, the construction of the Project would result in minor, localized changes in elevation only at locations where grading and filling are required, such as at certain structure sites, pulling pads, and guard structure areas where level work pads must be established, or along access roads that must be improved or developed to safely support the ingress and egress of construction equipment. Grading would not be required in instances where the terrain along the ROW is relatively level, where little or no access road improvements or new access roads are needed, or where the conductors span the underlying terrain.

At structure locations, work pads must be established to accommodate the equipment needed to safely install the structure foundation, structure, and associated conductors / hardware. The size of the work pad needed, as well as the changes in grades (e.g., cut or fill) required, will depend on the type of structure and the nearby terrain in the vicinity of each structure. Cut and fill activities typically are localized to the work pad[75] and the immediately adjacent areas. Grading (cut and fill) similarly would be required as necessary at conductor / OPGW pulling work pads and at guard structure work pads. In addition, grading will be required along certain on-ROW and possibly off-ROW access roads to provide safe travel ways for heavy construction equipment.

The Volume 5, 400 scale maps identify the general locations of access roads along the ROW, whereas the Volume 5, 100 scale maps provide more detail regarding the locations of existing and potential new access roads along the Proposed Route.

6.1.1.2 Soils

Soils would be disturbed by the same types of Project construction activities that would cause localized alterations to grades, such as the creation or expansion of on- or off-ROW access roads; the establishment of staging areas and contractor yards; leveling (cut or fill) as required to create work pads; installation of underground cable system; and earth-disturbing activities required to install the transmission line structures. Soils also could be disturbed as a result of vegetation removal activities along the ROW. However, the soil disturbance would be short-term, lasting only for the duration of the construction at a particular location, until revegetation or other forms of soil stabilization are achieved.

At locations where earth-disturbing activities are required, temporary erosion and sediment control measures (e.g., silt fence, hay/straw bales, filter socks, mulching, temporary reseeding) and / or BMPs would be used to minimize the potential for soil erosion and sedimentation off the ROW, and particularly into watercourses or wetlands (either on or off the ROW). These temporary erosion controls would be deployed as necessary after vegetation removal or after / in conjunction with grading. Typically, the erosion and sediment control measures, which would be installed based on the judgment of Eversource's in-field representatives, would be inspected and maintained throughout the construction period, until final stabilization of disturbed areas is achieved, or until permanent controls (if required) are established.

The need for and extent of temporary and permanent erosion and sedimentation controls would be a function of site-specific field considerations such as:

[75] The typical construction work area for a tangent structure is 100 feet x 100 feet and the typical construction work area for a deadend structure is 200 feet x 100 feet; however, the specific size and shape of an individual work pad can vary due to site or environmental constraints.

- Slope (steepness, potential for erosion, and presence of environmentally sensitive resources, such as wetlands or streams at the bottom of the slope);
- Type of vegetation removal method used and the extent of vegetative cover remaining after removal (e.g., presence/absence of understory or herbaceous vegetation that would minimize the potential for erosion and degree of soil disturbance as a result of clearing equipment movements);
- Type of soil and erodibility factor (K value);
- Soil moisture regimes;
- Schedule of pending construction activities in particular ROW areas;
- Proximity to water resources (e.g., wetlands, watercourses), public roads, or other sensitive environmental resources; and
- Time of year. The types of erosion and sedimentation control methods used along the ROW would depend on the time of year construction work is initiated and completed. For example, re-seeding is typically ineffective during the winter months. In winter, with frozen ground, controls other than re-seeding (such as wood chips, straw, hay, geotextile fabric, erosion control logs, etc.) typically would be deployed or maintained to control erosion and sedimentation and thus to stabilize disturbed areas until reseeding can be performed under optimal seasonal conditions.

The measures selected would be appropriate to minimize the potential for erosion and sedimentation in particular areas of soil disturbance. Eversource would adhere to its BMP Manual and would prepare a Project-specific *Erosion and Sedimentation Control Plan*, which would be included in the D&M Plans. The *Erosion and Sedimentation Control Plan* would conform to the requirements of CT DEEP's *General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities* and with the 2002 *Connecticut Guidelines for Soil Erosion and Sedimentation Control*.

After the completion of earth-disturbing activities, permanent soil stabilization measures (e.g., seeding, mulching, permanent work pad / access road stabilization) would be performed. Temporary erosion controls would be maintained, as necessary, throughout the period of active construction until restoration has been deemed successful, as determined by field inspections and adherence to BMPs for storm water pollution control/prevention and erosion control. The decision to remove temporary erosion controls would be made based on the effectiveness of restoration measures, such as percent vegetative cover achieved, in accordance with applicable permit and certificate requirements.

Rock Removal and Blasting

As currently designed, the proposed structures are steel monopoles. Some of these structures would require foundations with anchor bolts. The preferred technique for removing rock, when encountered, would be to use mechanical methods (e.g., mechanical excavators and pneumatic hammers). In the unlikely event that access roads and/or structures cannot be installed via mechanical methods alone; Eversource would supplement with controlled blasting. Potential effects from rock removal may include dust, vibration, and noise. If blasting is required, Eversource would develop a *Blasting Control Plan* in compliance with state, industry, and Eversource standards. This plan would be provided to the state and local Fire Marshals.

Furthermore, if blasting is necessary, Eversource would require its construction contractor(s) to employ methods to minimize potential adverse effects (refer to Section 4.2.2). For example, blasting charges, if required, would be designed to loosen only the material that must be removed to provide a stable foundation, and to avoid fracturing other rock. Excavated material that cannot otherwise be used at the site would be removed and properly disposed of elsewhere, pursuant to Project specifications.

6.1.2 Water Resources

The Proposed Route follows an existing Eversource ROW across and adjacent to multiple wetlands and watercourses (collectively referred to as water resources), most of which are traversed by the existing overhead transmission lines that currently occupy the ROW. Through Project design and construction planning, Eversource has attempted to avoid or minimize the potential for adverse direct and indirect effects to water resources to the extent practical. For example, only one new structure is proposed within a wetland in Harwinton. Additionally, structures proposed to the rear of Frost Bridge Substation on a steep slope above wetlands and the Naugatuck River have been moved or eliminated by utilizing an underground cable system line exit. For effects that are unavoidable, Eversource would implement mitigation measures, including construction BMPs, such as temporary erosion and sedimentation controls, restoration, and wetland mitigation. Specific water resource mitigation measures would be designed and implemented in accordance with the Project-specific regulatory approvals received from the USACE, CT DEEP, and the Council.

Most potential effects to water resources, associated with the development of the new 115-kV transmission line, would be short-term and highly localized with the exceptions of tree removal within forested wetlands, unavoidable placement of one structure within a wetland, and permanent access road improvements across wetlands and streams. Tree removal within forested wetlands (as required to allow construction and thereafter to maintain safe distances between vegetation and the transmission line conductors) would not represent any loss of wetland habitat, but would constitute a long-term effect by converting wetland habitat type from forested to scrub-shrub and emergent. In contrast, both the unavoidable placement of one new transmission line and / guy anchors structure within a wetland and the permanent improvement of historic access roads across certain wetlands and streams would involve fill, resulting in a highly localized, but permanent effect to wetlands. During the Project planning, Eversource has attempted to avoid permanent fill in watercourses and wetlands and wetland conversion effects to the maximum extent possible.

The operation and maintenance of the proposed facilities would not have long-term, adverse effects on water quality, watercourses, or waterbodies. The limited, localized, permanent effects on wetlands would be largely the result of expanding the width of the managed ROW within Eversource's existing easement. The ROW would be managed in accordance with Eversource's established vegetation management program, the objective of which is to maintain a climax vegetative community of low scrub-shrub growth that does not interfere with the overhead transmission line facilities and allows for inspection and access along the ROW.

Potential direct short-term effects on water resources could stem from erosion and sedimentation into watercourses or wetlands as a result of soil disturbance and vegetation removal along the ROW; fill or sedimentation associated with the installation and use of temporary access roads across wetlands and small watercourses; temporary fill required along existing access roads near wetlands; work pads in wetlands; and disturbance to wetland plant communities located along the ROW. In addition, the movement of construction equipment and vehicles along the ROW would increase the potential for inadvertent spills of fuels, lubricants or hydraulic oil, which could potentially enter water resources.

In designing and planning the construction of the transmission lines Eversource has incorporated, or would implement during construction, measures to avoid or limit adverse effects to water resources to the extent practical. For example, where practical, Eversource proposes to avoid direct work in watercourses (with the exception of in-water activities required for the replacement of culverted watercourse crossings), install temporary construction mats for work pads around structure locations in wetlands, and employ best management practices to limit the potential for erosion/sedimentation or for inadvertent spills of fuels and lubricants into water resources.

Eversource would prepare, and would require its construction contractor to implement, a Project-specific *Stormwater Pollution Prevention and Control Plan*, in accordance with CT DEEP requirements as specified in the *General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities*. In addition, Eversource would prepare, and its construction contractor would be required to follow, a Project-specific spill prevention and control plan. Both plans would be developed in conjunction with the preparation of the D&M Plans.

Moreover, any construction work potentially affecting water resources would be performed in accordance with the conditions of Project-specific regulatory approvals required from the USACE, the CT DEEP, and the Council.

Adherence to the conditions of Project permits issued by the CT DEEP and USACE would serve to further avoid, minimize, or mitigate potential adverse effects to water resources during the construction and operation of Eversource's proposed facilities. Eversource would incorporate the conditions of the environmental regulatory approvals into Project documents, and would require the Project construction contractor(s) to adhere to such conditions.

6.1.2.1 Waterbodies

A total of 58 waterbodies were delineated along the Proposed Route (20 perennial and 38 intermittent streams), some of which are traversed by existing Eversource access roads. However, temporary and, in some areas, permanent access (i.e., improvement to existing historic access roads) would be required across smaller streams along the ROW. No access would be required across the larger watercourses, such as the Branch Brook, Northfield Brook, and the Naugatuck River.

The development of the proposed transmission line would not create a new ROW across any waterbodies, but would increase the width of the managed portion of the existing ROW in some sections and would add another overhead transmission line span at each crossing. In-stream work would be limited to smaller streams where access road crossings must be installed or improved along the ROW, and to the two watercourses (S-D9, an intermittent stream north of Walnut Hill Road In Thomaston and S-F11, an unnamed perennial stream north of Valley Road in Harwinton; refer to Volume 5, Exhibit 2, mapsheets 22 and 32, respectively) where Eversource proposes to replace existing, deteriorated or displaced culverts.

Eversource would direct its contractors to cross streams by using, where possible, existing on-ROW access roads. In areas where new access road crossings must be installed, or where existing roads must be improved or expanded across streams, temporary and localized effects to water resources, consisting of short-term increases in turbidity, removal of stream shading vegetation at the crossing, and temporary disturbance to riparian zones, would likely occur.

Potential effects on watercourses may occur from the selective removal of vegetation within riparian zones/buffers (as necessary to allow safe construction or to maintain appropriate clearance from conductors) and the movement of construction equipment across watercourses via either temporary equipment bridges or permanent access roads. Where alternative means of access are not available, temporary bridges (consisting of timber mats, metal bridges, timber mats or metal bridges with culverts, or equivalent) may be used for equipment crossings; erosion and sedimentation controls also would be installed as appropriate. Use of such materials would minimize or avoid direct effects to banks and stream bottom sediments, and would minimize sedimentation to the extent practical.

To maintain the existing transmission lines that occupy the ROW along which the new 115-kV line would be located, Eversource currently utilizes existing access road crossings at various watercourses along the ROW, including culverted and hard-bottomed crossings.[76] Where two culvert replacements are proposed along historic access roads, it is anticipated that approvals from the USACE and CT DEEP would be required. These culverts would be designed and installed in accordance with USACE and CT DEEP stream crossing guidelines, which specify that culvert design should allow for the maintenance of ambient stream flows, the continuous flow of the 50-year frequency storm, and fish passage.

Eversource would implement the following mitigation measures to minimize the potential effects of construction activities in or near watercourses:

- Where existing access roads across streams must be improved, clean materials would be used (e.g., riprap or equivalent and rock fords).
- At streams that support fisheries resources, improvements to or the development of access road crossings involving in-water work would be scheduled, to the extent possible, to avoid conflicts with fish spawning or migration. The CT DEEP *Stream Crossing Guidelines* indicate that in inland waters, unconfined[77] in-stream construction activities should only be performed between June 1 and September 30.
- Water flows in streams (if water is present at the time of construction) would be unconfined throughout construction.
- Concrete (used for structure foundations) would be mixed, placed, and disposed of so as to avoid or minimize the risk of concrete materials entering a watercourse.

[76] Hard-bottomed or rock ford stream crossings are characterized by well-graded coarse stone placed at-grade within the stream bed at road crossings. They are intended to promote substrate stability while also providing unobstructed conveyance of stream flows.

[77] Unconfined is defined as work not contained within a cofferdam or similar water exclusion structure.

- Installation of new culverts at locations where culverts presently do not exist would be avoided to the extent possible and, where culverts must be installed, the measures recommended in the CT DEEP *Stream Crossing Guidelines* would be implemented as appropriate.
- Existing riparian vegetation within 25 feet of watercourse banks would be maintained or cut selectively, to the extent practical, and consistent with ROW vegetation management requirements.
- Temporary access roads (e.g., consisting of timber mats, metal bridges, or equivalent) across streams will be removed as part of the restoration phase of the Project.
- The D&M Plans and other construction specifications would incorporate the conditions of permits received from the USACE and the CT DEEP relating to the protection of water resources.

6.1.2.2 Wetlands

As identified in Table 5-10, a total of 91 wetlands were delineated within Eversource's ROW (easements or fee-owned properties) in proximity to the proposed Project activities. An additional four wetlands were delineated along publically accessible (Black Rock State Park/Mattatuck State Forest) off-ROW access roads that are proposed for use during Project construction. Of the total 95 wetlands delineated, 48 would be within the portions of the ROW traversed by the new transmission line.[78] The development of the Project would unavoidably affect some of these wetlands. However, Eversource has designed, and proposes to construct, the Project to avoid or minimize adverse effects to wetlands to the extent practical.

Most of the wetlands within Eversource's ROW have historically been affected, to some degree, by the vegetation management practices or other procedures associated with Eversource's operation of the existing overhead transmission lines between Frost Bridge Substation and Campville Substation. The principal effects associated with these existing lines is the ongoing maintenance of scrub-shrub and emergent wetland cover types that presently characterize the managed portions of the ROW, as well as the establishment of certain structures and access roads in wetlands.

The construction and operation of the new 115-kV transmission line along the presently un-managed portions of the ROW would result in similar, but incremental, effects to wetlands. Temporary effects to wetlands would occur from the development and use of temporary construction access roads (e.g., using timber mats or gravel placed over geotextile fabric) through wetlands; the placement of temporary work

[78] The 48 wetlands are those located within the footprint of the new 115-kV line and therefore potentially affected by the proposed Project construction and maintenance activities.

pads and – if required, temporary guard structure work pads or structure support poles[79] in wetlands; the removal of scrub-shrub or emergent wetland vegetation; and incidental sedimentation due to erosion.

Long-term effects on wetlands will result from the following activities:

- The removal of vegetation within forested wetlands (as necessary) along the ROW as required for the construction and operation of the new transmission line.[80] Within these areas, forested wetlands would be converted to scrub-shrub or emergent marsh wetland habitats, resulting in a long-term cover type change in wetland communities, but not in an overall net wetland loss.
- The improvement of historic access roads with gravel (up to 16 feet wide) through wetlands, in order to provide permanent access. Permanent access roads would only be required if no alternative upland access is available.
- The installation of one new 115-kV structure (Structure 95) within a wetland. The proposed structure would result in permanent loss of approximately 28 square feet of emergent wetland (wetland W-F15), located near the base of a fill embankment south of Wildcat Hill Road in Harwinton (refer to Volume 5, Exhibit 2, mapsheet 35). The resulting loss would not adversely affect the principal functions and values associated with this wetland, which extends across the ROW and cannot otherwise be avoided.

As summarized in Table 6-1, as a result of the proposed Project, approximately 6,970 square feet (0.16 acre) of wetlands would be permanently filled, primarily for improvements to pre-existing access roads. Approximately 2.34 acres of wetlands would be temporarily affected by construction work areas, such as work pads or timber mat (or equivalent) access roads; these areas will be restored following the completion of the 115-kV transmission line installation.

As also summarized in Table 6-1, approximately 6.7 acres of forested wetland vegetation along the ROW would be removed during Project construction. These forested wetlands would be permanently converted to scrub-shrub or emergent wetlands, representing a long-term cover type change to wetland habitat, but not a net loss of wetlands (refer to Table 6-5, located at the end of this section).

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[79] To install the new transmission line, temporary guard structure work pads (on which a bucket-type truck is positioned) or poles may have to be installed in wetlands that are located along the ROW adjacent to public road crossings. These temporary facilities are used during conductor / OPGW stringing to prevent the wires from sagging onto the public road. These temporary facilities (poles and/or work pads) would be removed following the completion of the conductor / OPGW stringing operation.

[80] The width of vegetation removal is a function of the type of transmission line structure and existing maintained ROW width. Refer to the cross-sections in Section 3 (Appendix 3A) and the Volume 5, 100 scale maps for details.

Table 6-1: Estimated Surface Area of Waters of the United States Potentially Affected by the Proposed Transmission Line (Temporary and Permanent Effects)

Project Activity	Estimated Temporary Effect (Acres)	Estimated Permanent Effect (Acres)
Access Roads[1]	1.43	0.16[3]
Work Pads	0.91	N/A
Structure Foundation	N/A	0.001
Total Primary Wetland Effects (Fill)	**2.34**	**0.16**
Total Secondary Wetland Effects (Tree Removal in Forested Wetlands)	**N/A**	**6.7**[2]

[1]The majority of temporary access road impacts are associated with temporary access for tree clearing.

[2]Area assumes tree clearing will be required over all forested areas. In some areas, such as over the Naugatuck River, tree clearing may not be required where suitable clearance between the proposed new line and tree canopy already exists.

[3]Estimated Permanent Access Road impacts are associated with improvements to existing historic access roads.

Notes:

This table provides estimates of (1) permanent effects (e.g., permanent fill at one structure site and for permanent improvements to access roads) and (2) temporary effects (e.g., work pads, temporary access roads, and temporary access for tree clearing). Temporary effects associated with the widening of existing roads to facilitate access during construction were not included at this time.

Vegetation removal is a secondary effect and all of the permanent and temporary effects, previously noted, were excluded to determine the estimated acres of forested wetland clearing.

Assumptions for Estimating Wetland Effects:

Structure work pad dimensions are assumed to be typically 100 feet by 100 feet for tangent structures and 100 feet by 200 feet for deadend structures.

Permanent access roads through wetlands are assumed to be approximately 16 feet wide.

Temporary access roads through wetlands to structures are assumed to be approximately to be approximately 16 feet wide.

Temporary access roads for tree clearing are assumed to be approximately 16 feet wide.

The amount of and type of vegetation clearing required along the ROW would vary and would depend on factors such as the existing width of the managed ROW, vegetation communities present, the type of the new 115-kV transmission structures, configuration and spacing of the transmission line conductors, transmission line span lengths, and terrain. The cross-sections illustrate the location of the existing and proposed transmission lines along each ROW segment and the existing and proposed managed ROW widths (refer to Section 3, Appendix 3A and Section 4, Table 4-2 of this volume, and Volume 5).

Best management practices, as detailed in Eversource's *Best Management Practices Manual Connecticut Construction & Maintenance Environmental Requirements* (2011), would be used to minimize disturbances to wetlands during Project construction, as applicable. The wetland boundaries along the ROW would be clearly demarcated (e.g., re-flagged by a registered soil or wetland scientist) prior to the commencement of work. Construction personnel would be provided mapping (e.g., D&M Plans) that depict wetland boundaries in relation to work areas. When working in or traversing such wetlands, Eversource would also employ the construction procedures detailed in Section 4.3.1.1 and summarized below for ease of reference:

- Comply with the conditions of federal and state permits and certificates related to wetlands;
- Install, inspect, and maintain erosion and sediment controls and other applicable construction best management practices around work sites in or near wetlands to minimize the potential for erosion and sedimentation;
- Limit grading and filling for access roads and work pads in wetlands to the amount necessary to provide a safe workspace;
- Install temporary construction matting or geotextile and crushed stone pads for access roads across wetlands or to establish safe and stable construction work areas/ work pads within wetlands, where necessary. The type of stabilization measures to be used in wetlands would depend on soil saturation;
- Cut forested wetland vegetation without removing stumps unless it is determined intact stumps pose a safety concern for the installation of structures, movement of equipment, or the safety of personnel;
- Avoid or minimize access through wetlands to the extent practical. Where access roads must be improved or developed, the roads would be designed, not to interfere with surface water flow and to minimize adverse effects on the wetland functions;
- Implement procedures for petroleum product management that would avoid or minimize the potential for spills into wetlands (e.g., to the extent possible, store petroleum products in upland areas more than 25 feet from wetlands; refuel construction equipment, except for equipment that cannot be practically moved, in upland areas only);
- Restore structure work sites in – and temporary access ways through – wetlands following the completion of line installation activities unless permanent fill is authorized in advance by the USACE and CT DEEP; and

- Restore wetlands temporarily affected by construction activities. As the final phase of transmission line construction, restore wetlands to approximate pre-construction contours and configurations to the extent practicable; replace topsoil and/or organic soils disturbed by construction (as appropriate); stabilize with temporary seeding (if necessary); and allow native vegetation to recolonize.

To compensate for the effects to wetlands that would occur as a result of the Project, Eversource would consult with the USACE and CT DEEP to assess mitigation options. The extent of compensatory wetland mitigation required would depend on the final Project design and the amount of direct permanent and temporary impacts and secondary and cumulative wetland impacts. Compensatory wetland mitigation options for the Project, which would be specifically evaluated as part of the USACE and CT DEEP regulatory review processes, may consist of wetlands restoration and/or enhancement (on or off the ROW), including invasive species control, in-lieu fee payment wetland preservation, and/or conservation restrictions.

6.1.2.3 Groundwater Resources and Public and Private Water Supplies

The construction and operation of the 115-kV transmission lines would not adversely affect groundwater resources, including Aquifer Protection Areas, public water supplies, or private groundwater wells. As identified in Section 5.1.2.3, no public wells would be traversed by, or are located in the vicinity of the Project. Private wells provide drinking water to the majority of the Project region. The Proposed Route does not cross any Aquifer Protection Areas. The closest such area is Reynolds Bridge, a Level A Aquifer Protection Area located approximately 0.48 mile east of the Proposed Route where it crosses Branch Road (State Route 109).

During construction, Eversource would require its contractors to adhere to its best management practices and any Project-specific regulatory requirements regarding the storage and handling of any hazardous materials used during the work. Proper storage, secondary containment, and handling of potentially hazardous materials such as diesel fuel, motor oil, grease and other lubricants, would be required.

Construction staging areas and contractor yards, which would be identified during the preparation of the D&M Plans or thereafter by the Project contractor(s), would typically be located at existing developed areas (parking lots, existing storage yards, warehouses, sand/gravel mining areas, etc.). At such yards, contractors may store fuels and lubricants and conduct refueling activities.

6.1.2.4 Flood Zones

The Proposed Route extends across FEMA-designated 100-year flood zones associated with Branch Brook in Watertown, Northfield Brook in Thomaston, and the Naugatuck River in Litchfield and Harwinton. However, no transmission line structures are proposed within a 100-year flood zone. The only work proposed within a designated 100-year flood zone is associated with improvements to approximately 575 linear feet of historic access road north of Valley Road in Harwinton, and replacement of a culvert within an unnamed perennial tributary of the Naugatuck River at the same location. As a part of the Project application to CT DEEP for a 401 Water Quality Certificate, Eversource would commission hydrologic/hydraulic modeling analyses, as required, to assess the potential effects of these proposed Project activities on floodplains. If necessary, compensatory flood storage volume would be designed to mitigate permanent effects on 100-year floodplains, and therefore no adverse effects to flood zones would occur.

6.1.3 Biological Resources

The construction and operation of the new 115-kV transmission line would result in generally minor effects on vegetative communities and wildlife. The potential effects will be concentrated primarily within and near the existing ROW within which the proposed facilities would be aligned. With the exception of the conversion of existing forested habitat to scrub-shrub habitat, these effects would typically be short-term lasting one to two seasons post-construction.

6.1.3.1 Vegetation

6.1.3.1.1 Vegetation Communities Affected, including Upland and Wetland Forest Clearing

The construction and operation of the Project facilities would affect portions of the various vegetative communities that presently characterize the Eversource ROW along which the new 115-kV transmission line would be located. In general, the construction of the new 115-kV line, adjacent to Eversource's existing transmission lines, would necessitate removal of trees and shrubs within the construction footprint.

Subsequently, the operation of the Project facilities would require the management of vegetation beneath and in the vicinity of the new transmission line to maintain low-growth communities, consistent with utility industry standards. Along the majority of the existing ROW, this would increase the width of the vegetation that Eversource would manage in herbaceous, shrub-scrub, or other low-growth vegetative types. In currently forested wetlands, tree removal would result in a permanent cover type change and the conversion to scrub-shrub and/or emergent wetlands, such as are characteristic of the wetlands within the presently managed portions of the ROW.

Along the ROW within which the new 115-kV line would be located, the width of the currently managed portions varies, depending on the number and configuration of the existing transmission lines that occupy each ROW segment. Along the approximately 2.1 miles from the vicinity of Frost Bridge Substation to Purgatory Junction (refer to XS-2), much of the 400-foot-wide ROW is currently managed for low growth vegetative communities.[81] Along the majority of the remaining 8.2 miles of the Proposed Route (XS-3 through XS-6), the new 115-kV line would be located within a typical 250-foot-wide ROW. Along these ROW segments, Eversource presently manages (on average) a 95- to 140-foot-wide area beneath and adjacent to the existing lines. For the new 115-kV transmission line, an additional 40-to-70-foot-wide area, located within the ROW to the east of the existing lines, would be cleared of forest and shrub-scrub vegetation for construction and subsequently managed on a long-term basis in low-growth vegetation.

The existing Eversource transmission line ROW within which the Proposed Route would be located encompasses approximately 370 acres. Of this, 114 acres (31%) are deciduous and coniferous forested upland and approximately 18 acres (5%) are palustrine forested wetland (consisting predominantly of deciduous forest cover with some areas of mixed deciduous / coniferous forest).

Approximately 48.9 acres of forested habitat would be affected by the Project (42.2 acres of forested upland and 6.7 acres of forested wetland). Refer to Table 6-2. Approximately 7,000 trees measuring 6-inches diameter at breast height (dbh) and greater would be removed as a result of Project tree clearing. These figures assume tree clearing will be required at all forested areas, regardless of clearance. In some areas, such as over the Naugatuck River, tree clearing may not be required where clearance between the proposed new line and the existing tree canopy is adequate. The majority of the acres of affected forested habitat are within Eversource's existing ROW, the only exception being minimal expansion or side trimming required along existing off-ROW access roads.

[81] Some tree clearing will be required within interior portions of the ROW segment that extends between Echo Lake Road and Purgatory Junction (XS-2).

Table 6-2: Approximate Acres of Forest Land[1] to be Converted[2] to Scrub-Shrub Land, by Town

Town	Areas within the Vegetation Removal Limits of the Proposed Route (Estimated Acres, all within Existing Eversource ROW)	
	Forested Wetlands	Forested Upland
Watertown	1	16.2
Thomaston	1.6	12.8
Litchfield	2.7	7
Harwinton	1.2	6.2
TOTAL[3]	6.7	42.2

[1] Forest land refers to mixed hardwood and deciduous tree species in both wetlands and uplands.
[2] Many areas of forest were previously agricultural or shrubland associated with post-agricultural abandonment and succession.
[3] Totals include tree removal required along the Proposed Route pursuant to 115-kV conductor clearance specifications and represent the estimated acreage that would subsequently be managed in shrubland vegetation, consistent with the operation of the 115-kV overhead transmission lines. Additional forested vegetation removal may be required along access roads and construction work areas located outside of the identified "limits of vegetation removal" for conductor clearance purposes.

Based on the results of field investigations, and analyses of aerial photography / vegetative cover types, Eversource estimates that most of the forest vegetation to be removed consists of trees with an average dbh greater than 5 to 6 inches. The predominant forested communities that would be affected by the Project are mixed deciduous upland forest. Tree species composition varies along the Proposed Route; however, consistencies were noted throughout areas of similar topographic relief, depth to bedrock (and soil morphology), and prior land use. Undulating bedrock controlled areas along the Proposed Route in Watertown and Thomaston are dominated by chestnut and red oaks. Post-agricultural forest characterizes the Proposed Route further north in Litchfield, where species composition is predominantly comprised of mixed hardwood species such as red maple and black birch. White pine forms a virtual monoculture within portions of the Proposed Route north of Valley Road in Harwinton. In the areas where tall-growing trees must be removed during construction, the ROW subsequently would be managed in shrubland or old field habitat.

Converting forest to shrubland, open field, or old field vegetation along the transmission line ROW would modify habitat, representing a long-term, but not a necessarily adverse, affect. In fact, the creation of additional shrubland and early successional habitat (and the preservation of such existing habitat) along the ROW would represent a long-term benefit for many species because shrubland habitat is otherwise declining in New England. This decline is a result of various factors (e.g., conversion of farms, suburban / urban development, ecological succession, absence of fires).

In Connecticut, transmission line ROWs are a major source of shrubland habitat. The ROWs are managed to promote early successional habitats, dominated by scrub-shrub vegetation and open areas with dense grasses and other herbaceous vegetation. Scrub-shrub communities within ROWs provide a variety of wildlife habitat functions (e.g., food, cover and nesting habitat for birds and small mammals, and cover and browse for whitetail deer; Ballard et al., 2004).[82] These plant communities also to offer habitats preferred by certain rare and other invertebrate species, including moths, butterflies, and bees, for certain stages of their annual life-cycles.

Other vegetative cover types within the ROW that would be affected by the construction of the Project include existing open field / shrubland, agricultural land, and lawn / landscaped areas associated with developed areas (e.g., houses with yards, commercial / industrial uses, road shoulders). However, the effects on these cover types and land uses would be mostly short-term. After the completion of Project construction, these community types and land uses, which are compatible and/or coexisting with the existing transmission lines, would continue to coexist with the operation and maintenance of the proposed transmission facilities.

6.1.3.1.2 Vegetation Management and Preservation Goals and Methods

The objective of Eversource's well-established vegetation management program is to maintain safe access to its transmission facilities and promote the growth of vegetative communities along its ROWs that are compatible with transmission line operation and in accordance with federal and state standards. The vegetation along the new transmission line would be managed in accordance with these standards.

Eversource has historically conducted ROW vegetation maintenance as a matter of good utility practice. However, since April 7, 2006, all public utilities have been required to comply with mandatory reliability standards adopted by the NERC following the August 14, 2003 Northeast blackout; an event which was triggered by line outages caused by overgrown vegetation. Eversource's vegetation management practices are designed to allow for the safe operation of transmission lines by preventing the growth of trees or invasive vegetation that interfere with the transmission facilities or access along the ROW. As a result, the vegetation within the managed portions of Eversource's ROW typically consists of shrubs, herbaceous species, and other low-growing species. Following construction, Eversource would restore disturbed areas with appropriate herbaceous seed mixes, and mulch with hay/straw or wood chips as

[82] Ballard, B.D., H.L. Whittier, and C.A. Nowak. 2004. *Northeastern Shrubs and Short Tree Identification, A Guide for Right-of-Way Vegetation Management*, State University of New York-College of Environmental Science and Forestry.

appropriate. Vegetative species compatible with the use of the ROW for transmission line purposes are expected to regenerate naturally, over time. Eversource promotes the re-growth of desirable species by implementing ROW vegetation management practices to control tall-growing trees and promote native plant colonization.

When performing ROW management, Eversource would take particular care to preserve vegetation along watercourses and within wetlands to the extent possible. In general, Eversource may alter, to some degree, its vegetation management activities in the following areas:

- Areas of visual sensitivity where vegetation removal may be limited for aesthetic purposes;
- Steep slopes and valleys spanned by transmission lines;
- Agricultural lands;
- Near homes where owner-maintained ornamental vegetation does not interfere with the construction or operation of the facilities;
- Within wetlands, vernal pool habitats, or along streams to preserve shrub cover;
- Within the 25-foot vegetated riparian zone adjacent to watercourses and waterbodies; and
- In areas documented to support rare animal species or host plant species that support rare invertebrates.

While undesirable tall-growing woody species within the ROW and proximate to the new line would be removed during construction, desirable species are preserved to the extent practical. In selected locations, certain desirable low-growing trees or tall growing shrubs, due to their growth characteristics and locations relative to the new lines, may be allowed to remain on the ROW. These species would be trimmed to ensure that adequate clearance from wires and structures is maintained, pursuant to Eversource's *Rights-of-Way Vegetation Initial Clearance Standard for 115-kV and 345-kV Transmission Lines*. However, any vegetation preserved during construction activities may be removed in the future in accordance with Eversource's *Specification for Rights-of-Way Vegetation Management*. Generally, all tall-growing tree species would be removed from the ROW, whereas low-growing tree species and taller shrub species would be retained in the areas outside of the wire zones. The wire zone is defined as the area directly beneath the conductors extending outward a distance of 15 feet from the outermost conductors.

6.1.3.1.3 Landowner Outreach and Beneficial Use of Forestry Products

The timber and firewood resources along the Proposed Route belong to the landowners across whose property the ROW is aligned. Eversource's policy is to proactively coordinate with landowners regarding the disposition and use of the trees to be removed along the ROW. If requested by the landowner, the firewood and timber portions of the trees would be left on the landowner's property on the edge of the ROW. After the limbs are removed, the boles of the trees would be piled in tree-lengths for landowners to cut and remove at their convenience.

Timber and firewood removed along the ROW on Eversource fee-owned property or on parcels where the landowners are not interested in retaining the wood would become the property of the Project's land clearing contractor. Eversource would competitively bid the land clearing work for the Project and would select a contractor taking into considering the contractor's plans for the beneficial use of the forest products that are not otherwise left for landowner use.

6.1.3.2 Wildlife and Fishery Resources

6.1.3.2.1 Wildlife

The development of the new 115-kV transmission line would result in both temporary and permanent alteration of wildlife habitat along the ROW, as well as direct effects on wildlife such as disturbance, displacement, or mortality. However, these effects will be localized on and in the vicinity of the ROW, and would be generally short-term (for the duration of the construction phase of the Project) and minor due to the availability of undisturbed habitat types, similar to those found on the ROW, in adjacent areas and in the Project region as a whole. Furthermore, the Project would have a long-term beneficial effect on certain wildlife species that utilize shrubland habitats.

During construction, the removal of vegetation within the construction footprint would displace wildlife and would reduce cover, nesting, and foraging habitat for some species. Other construction activities (e.g., the development of access roads and work pads; general construction equipment movements; and construction-related noise) would similarly disturb or displace mobile wildlife species, such as large mammals and birds. These species would likely move to comparable nearby habitats. Eversource would minimize adverse effects to wildlife by adhering to mitigation measures, including Project-specific procedures expected to be developed in consultation with CT DEEP and the USACE.

Within the ROW, the removal of existing forest vegetation and the conversion to low-growing vegetative communities would have a long-term beneficial effect on early-successional wildlife by providing additional habitat for species that utilize shrubland, old field and other non-forested habitats. The wildlife species that would benefit from the additional shrubland habitat include various bird species such as Prairie Warbler, Brown Thrasher, Field Sparrow, Eastern Towhee and Indigo Bunting, among others), as well as other taxa and species that favor this habitat. While early-successional habitat specialists will benefit from the creation of additional habitat resulting from this project, total habitat for forest-dwelling species would be reduced as a result of the project.

Overall, although the species of wildlife utilizing the ROW would be expected to change slightly, the ROW would continue to provide diverse wildlife habitat. The exchange of forested habitats for shrublands is often interpreted as a net gain for regional biodiversity (Confer and Pascoe, 2003[83]). A study conducted by Nickerson and Thibodeau (1984) indicated an increase in wildlife utilization, especially in avian species, following clearing of ROWs.[84] The study attributed this increase in wildlife usage to the conversion of forested areas into both wetland and upland shrub and emergent plant communities. The management of ROW vegetation provided edge-effect feeding, nesting, and cover habitat for various species. ROWs also serve as open corridors connecting non-contiguous natural areas.

6.1.3.2.2 Fisheries

The construction and operation of the Project is not anticipated to have an effect on fishery resources. The proposed 115-kV transmission line would span all major waterbodies containing fisheries (e.g., Branch Brook, Morton Pond, Northfield Brook, and the Naugatuck River). With the exception of temporary equipment access and the installation of permanent access roads across smaller watercourses, no new facilities are proposed for installation in any waterbodies, and no access roads will be installed across larger watercourses. Access roads across streams would be designed to avoid or minimize direct disturbance to stream banks and substrates to the extent practical, and would conform to USACE and CT DEEP permit requirements.

Eversource recognizes that streambank vegetation provides important cover and shading for fish. Within a 25-foot-wide area adjacent to watercourses, lower-growing riparian vegetation along the ROW would be maintained, where possible. Vegetation would be cut only if required to maintain safe clearances from conductors and access to and from the transmission facilities. Above Branch Brook, Northfield Brook,

[83] United States Department of Agriculture (USDA), 2001, Trends in Connecticut's Forests: A Half-Century of Change, USDA Forest Service, Northeastern Research Station and Connecticut Department of Environmental Protection, Division of Forestry, Hartford, CT.

[84] Nickerson, N.H. and F.R. Thibodeau. 1984. *Wetlands and Rights-of-Way. Final Report Submitted to the new England Power Company*, 25 Research Drive, Westboro, MA.

and Naugatuck River, the conductors would be installed at such heights that no vegetation removal or tree-trimming would be required. Thus, all of the existing riparian vegetation would remain.

Temporary soil erosion and sedimentation controls would be installed around areas of disturbed soils at work sites up-gradient from streams. These temporary erosion controls would remain in place until the disturbed areas are revegetated or otherwise stabilized.

6.1.3.2.3 Vernal Pools

Based on the results of ROW field surveys conducted in both 2009 and 2015, the Proposed Route would traverse or be located near 20 vernal pools. The construction of the new transmission line would result in both direct and indirect adverse effects to vernal pools. A summary of potential effects to vernal pools is provided in Table 6-6, at the end of this section. The principal construction activities that could affect vernal pools include:

- The removal of vegetation within and / or the tree canopy over vernal pools;
- The work within vernal pool envelopes and / or critical terrestrial habitat;[85]
- The movement of vehicles and equipment use on access roads in the vicinity of amphibian migratory routes;
- The potential for erosion and sedimentation into vernal pools;
- The modification of structural habitat features such as pit and mound micro-topography; and
- The development and use of distinct construction areas (work pads constructed from fill material and/or timber mats) in vernal pools during breeding periods, as well as at other times throughout the year.

Three vernal pool indicator species were observed within the Project area, wood frog, spotted salamander and marbled salamander. While wood frog and spotted salamander were observed throughout the Project area, marbled salamander was observed at only one location – vernal pool D4-1 in Thomaston. Adult migration of wood frog and spotted salamander to and from the vernal pools typically occurs between March and May, with larval development continuing, in some cases, through July. For the marbled salamander, adult migration occurs in late summer and early fall, with larval development continuing into the following summer. Overland movement of amphibians most often occurs during rain events.

[85] Vernal pool envelope is the area extending from the vernal pool edge to 100 feet, and critical terrestrial habitat includes areas between 100 and 750 feet from the vernal pool edge. (Calhoun, A.J.K. and M.W. Klemens. 2002).

To avoid or minimize adverse effects on amphibians, Eversource would locate new structures, access roads, and work areas, to the extent practicable, outside of wetlands that provide vernal pool habitat. Based on the current Project design, no new structures would be located within vernal pool depressions or "cryptic" vernal pool habitat. One temporary work pad is currently shown over a portion of vernal pool C20-1. This pool is located along an existing access road within the maintained ROW, and its hydrology is the result of the surface-water impoundment along the existing access road.

The potential for adverse impacts on vernal pools may be minimized by implementing a variety of Best Management Practices (BMPs) aimed at mitigating the effects of both permanent and temporary construction related activities. Potential BMPs, as may be considered for minimization of impacts to each vernal pool, are provided in Table 6-6 at the end of this section.

As planning for the Project continues, the specific measures that would be implemented to protect vernal pool amphibians during construction will be further defined in consultation with the applicable regulatory agencies (CSC, CT DEEP, and USACE) and would be incorporated into the D&M Plans for the Project. The following summarizes the types of measures that may be implemented to minimize potential adverse impacts to vernal pools:

1) For Project activities that must occur adjacent to vernal pools during amphibian migration periods, implement measures on a site-specific basis as necessary to facilitate unencumbered amphibian access to and from vernal pools, such as elevated construction matting. Mitigation measures will be identified after considering site-specific conditions, including the type of construction activity in proximity to a vernal pool, the amphibian species known to occur in the vernal pool, and seasonal conditions.

2) Minimize the removal of low-growing vegetation surrounding vernal pools. If low growing woody vegetation (trees and shrubs) will be removed, the cut vegetation (slash) should be left in place to provide cover and promote the development of coarse woody debris and detritus.

3) Where possible, the stumps of cut woody debris should be left in place to minimize soil disturbance.

4) Felling of trees into vernal pools should be avoided where possible.

5) Where tree clearing within and adjacent to vernal pools occurs, woody shrub cover should remain intact to the maximum extent practicable.

<u>Erosion and Sedimentation Controls</u>

1) Erosion control measures should be designed in a manner that allows unencumbered amphibian access to vernal pools and migratory pathways. Such measures may include, but not be limited to; syncopated silt fencing and/or straw wattles in the immediate vicinity of vernal pools, and aligning erosion and sedimentation controls to avoid bifurcating vernal pool habitat.

2) Install appropriate erosion and sediment controls around distinct work sites and access roads to minimize the potential for sediment deposition into vernal pools, and remove such controls promptly after final site stabilization.

3) Avoid utilizing plastic netting, which may be found in a variety of erosion control products (e.g., erosion control blankets, straw wattles, and reinforced silt fence).

<u>Restoration of Temporary Construction Areas</u>

1) Evaluate the use of temporary timber mat access roads in lieu of constructing new gravel access roads in order to minimize the loss of vegetated areas within the Vernal Pool Envelope (0-100 feet).

2) Where feasible, minimize the use of gravel fill associated with construction work pads or pull pads within vernal pool envelopes (0-100 feet).

6.1.3.2.4 Birds

The proposed Project would result in both long-term benefits and short-term, but minor, effects on bird species that inhabit the ROW and nearby areas. Temporary effects are associated with construction activities (due to direct disturbance and noise), and localized and short-term displacement as a result of periodic vegetation management activities during operation of Eversource’s facilities. These disturbances may drive birds from the work areas or generally disrupt nesting, feeding or other activities. If conducted during the breeding season, such activities may result in inadvertent takings of nests and young. Once construction is complete, avian utilization of the Project area is anticipated to resume to pre-construction levels.

Permanent effects associated with the proposed Project are associated with the conversion of forested habitats to shrubland or scrub-shrub wetland. The greatest potential for negative effects on high-conservation priority species are on those birds that are considered forest-interior birds (e.g., scarlet tanager, wood thrush). Forest-interior birds favor the interior of the forest or “forest core” away from non-forested “edge” habitat. In particular, forest interior birds may find edge habitat detrimental as it creates conditions favorable to predators such as raccoons and nest parasites such as brown-headed cowbird. Forest interior birds have become the focus of conservation efforts region-wide due to long-term population declines of many of these species due to forest fragmentation.

The Proposed Route would utilize an existing ROW and therefore would not contribute to the new fragmentation of forest interior habitats, thus minimizing the potential impact to forest-interior birds. Given that the Proposed Route is characterized in part by managed ROW, the forest bordering the managed ROW is categorized as edge forest as opposed to interior forest. Edge forest is favored by ecotone specialists or forest generalists, and is not optimal breeding habitat for forest-interior birds.

Although the Project will not directly impact core forest, it may indirectly impact core forest as the additional clearing along the edge of the ROW may result in reduced core forest within the overall forest patch.

The width of the edge forest effect can vary by region or species. In order to evaluate potential Project effects to forest-interior birds as a result of expansion of the maintained ROW, the methodology described in the *Center for Land Use Education and Research's (CLEAR) Forest Fragmentation Study (2006)*[86] was used. The CLEAR study designates a forest as core if it is greater than 300 feet away from non-forested areas with the 300-foot zone representing edge forest that is considered sub-optimal breeding habitat for forest-interior birds.

The CLEAR study, along with many other studies, has suggested that forest patch size is a critical factor for successful breeding by forest-interior birds.[87] The CLEAR study suggests that 250 acres should be considered the *absolute minimum* forest patch size needed to support area-sensitive forest-interior birds, with a recommended minimum forest patch size of 500 acres. At that scale, a forest is presumed to provide enough suitable habitat to support more diversity of interior forest species. Therefore, not all of the forest areas impacted by the Project will constitute high-value forest. This data identifies three categories to indicate the viability of the core patches with respect to the size of the patch, including; small (< 250 acres), medium (250-500 acres), and large (>500 acres).

As shown in the *Inventory and Assessment of Breeding Birds* (Volume 3), the Project area is dominated by small core (<250 acres) forest, non-forest, or forest fragments (patch or perforated forests) as opposed to large forest patches. These small core forests and forest fragments may provide some breeding habitat for forest-interior species but are generally considered sub-optimal, and may serve as population sinks. Significant core forest patches are not abundant within the Project area. Only one medium core forest patch (Black Rock State Park in Watertown) and one large core forest patch (Mattatuck State Forest in Watertown) occur. Furthermore, the single large core forest patch is located within a segment of Project area where the ROW is 400 feet wide and minimal tree clearing will be required within the interior of the managed ROW.

[86] 2006 *CLEAR Forest Fragmentation Study* http://clear.uconn.edu/projects/landscape/forestfrag/forestfrag_public%20summary.pdf

[87] Environment Canada. 2004. *How Much Habitat is Enough? (Second Edition) A Framework for Guiding Habitat Rehabilitation in the Great Lakes Areas of Concern* AND Lee, M., L. Fahrig, K. Freemark and D.J. Currie. 2002. *Importance of patch scale vs. landscape scale on selected forest birds*. Oikos, Vol. 96, No. 1, pp. 110-118.

Shrubland and other early-successional bird species will benefit from the conversion of forest to shrubland. These include a number of species of high-conservation priority, including the prairie warbler, blue-winged warbler and field sparrow. Shrublands in the northeastern United States are primarily disturbance-dependent and are typically ephemeral. Left unmanaged, these areas would naturally revert to forest. Despite the transient nature of shrublands and other early successional habitats, many species of birds and other wildlife require these habitats.

The decline of shrublands and other early-successional cover types in the Northeast has had considerable impacts on the populations of associated wildlife. In particular, many bird species have experienced statistically significant population declines due to the loss of suitable breeding habitat.[88] By some estimates, at least 45% of all shrubland birds in the Northeast have experienced statistically significant population declines between 1966 and 2000.[89]

Because transmission line corridors are one of the few sources of persistent early-successional habitat in the Northeast, they play an important role in supporting a variety of bird and wildlife species. This important role in maintaining essential habitat and wildlife biodiversity has been widely acknowledged, not only for bird species but also for a number of reptile and invertebrate species.

Statewide, transmission corridors remain critical habitat for shrubland and other early-successional birds. Vegetation management of transmission line corridors is recommended as part of the regional and national conservation strategy to reverse declines of priority shrubland birds in the eastern region. Askins notes that shrubland birds today are largely dependent on clearcuts and transmission line corridors, and that the latter typically supports a rich diversity of shrubland birds.[90] In the Connecticut Audubon Society's 2009 *State of the Birds* report (p.44), it was noted that "*…shrubland birds are benefitting from maintenance of powerline corridors by utility companies which remove tall-growing trees from the vicinity of wires, creating a habitat dominated by shrubs, grass and herbs."*

Six state-listed species were identified within the Project area as potential or confirmed breeders (five potential, one confirmed). All six of these species are associated within open or early-successional

[88] Witham, J. W., and M. L. Hunter, Jr. 1992. *Population Trends of Neotropical Migrant Landbirds in Northern Coastal New England*. In: J. M. Hagan and D. W. Johnston (Eds.), Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, D.C.
[89] Dettmers, R. 2003. *Status and Conservation of Shrubland Birds in the Northeastern U.S.* Forest Ecology and Management 185:81-93.
[90] Askins, R. A. 2000. Ibid.

habitats or forest edge habitats as opposed to forest-interior. In addition, a total of 35 species identified as potentially occurring within the Project area are designated as *Species of Greatest Conservation Need* (SGCN) by *Connecticut's Wildlife Action Plan.* Of those 35 species, seven are classified as *most important*, 16 as *very important* and 12 as *important*. Of the 35 SGCN identified, 15 are associated with managed early-successional ROW vegetation (i.e., shrubland and scrub-shrub wetlands) and seven SGCN species are associated with edge habitats or agricultural lands. Five of the seven (71%) SGCN classified as *most important* are associated with managed early-successional ROW vegetation.

6.1.3.3 Federal and State Listed or Proposed Threatened, Endangered, or Special Concern Species

Eversource is working with both the USFWS and the CT DEEP to identify general measures to avoid or minimize adverse effects on federal and state-listed species that may inhabit the ROW. As a result of the implementation of the measures discussed below, or similar or additional measures that may be identified during future agency consultations, Eversource anticipates that no significant adverse effects would occur to any known listed species.

6.1.3.3.1 IPaC Identified Federally-Listed Species

Screening using the USFWS IPaC indicated that northern long-eared bat, a federally-threated and State-endangered species, may be present in proximity to the Project area. The USFWS recommended that consultations regarding this species be coordinated through CT DEEP. Based on consultation between Eversource and CT DEEP on July 30, 2015[91] there are no known records of this species or hibernacula in the vicinity of the Proposed Route. Potential suitable Northern long-eared bat (NLEB) summer roosting habitat suitability was documented along portions of the Proposed Route in the fall of 2015. The results of this assessment are provided in the *Rare Species Report*, in Volume 3.[92] This assessment concluded that portions of the Proposed Route that will be subject to tree clearing may provide suitable NLEB summer roosting habitat. Based on the results of this assessment, Eversource would commit to appropriate time of year (TOY) restrictions for tree clearing activities unless additional acoustic surveys that will be conducted along the Proposed Route during the summer of 2016 determine no adverse Project impacts to NLEB. If presence is confirmed, Eversource will adopt appropriate TOY restrictions and/or other BMPs identified by the USFWS for tree clearing to prevent adverse impacts to NLEB.

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[91] Meeting with Jenny Dickson and Kate Moran (CT DEEP), Eversource Energy, and Tighe & Bond

[92] The Rare Species Report is redacted to protect confidential information per Eversource's and CT DEEP's NDDB data sharing agreement

6.1.3.3.2 State-Listed Species

Based on an initial consultations with the CT NDDB, followed by wildlife habitat field surveys, ten state-listed species have been identified as potentially occurring in the vicinity of the Proposed Route, one state-listed species (broad-winged hawk) was observed. Table 6-3 lists these animal species, provides the listing status of individual species, summarizes each species' ecological/habitat preference, and provides a general location of each species' habitat in relation to the ROW.

The following summarizes the potential effects and proposed protection measures that Eversource has identified to date with respect to these species. The protection measures for wood turtle, smooth green snake, northern spring salamander, and frosted elfin butterfly outlined below were provided to CT DEEP for concurrence that they are adequately protective. In response letters dated May 19, 2015 (provided as part of the *Rare Species Report* in Volume 3 Exhibit 3[93]), CT DEEP indicated that if these protection strategies are followed the Project will not have an adverse impact on these species. This determination is valid for one year. The protection measures for spotted turtle outlined below (and provided in more detail within the *Rare Species Report* in Volume 3 Exhibit 3) were provided to CT DEEP in December 2015, for a determination of adequacy. As the planning for the Project proceeds, Eversource will continue to consult with the USFWS, ACOE, and CT DEEP regarding species-appropriate mitigation strategies. Such mitigation would be incorporated into the D&M Plans and other Project specifications.

[93] The *Rare Species Report* is redacted to protect confidential information per Eversource's and CT DEEP's NDDB data sharing agreement

Table 6-3: Summary of State-Listed Threatened, Endangered, or Special Concern Species Potentially Occurring in the Vicinity of Proposed Route

Scientific (Latin) Name	Common Name	Town / Area	State Status*	Habitat (Nesting/Breeding/Active Periods)
Birds				
*Buteo platypterus***	Broad-winged Hawk	Harwinton	SSC	Deciduous or mixed forest types often near a lake, pond or wetland April-August
Toxostoma rufum	Brown Thrasher	Project ROW	SSC	Thickets, brushy hillsides and woodland edges in suburban and rural areas April-August
Dolichonyx oryzivorus	Bobolink	Watertown	SSC	Early old field habitat, managed grasslands or hayfields May-June
Passerculus sandwichensis	Savannah Sparrow	Watertown	SSC	Early old field habitat, managed grasslands or hayfields May-August
Empidonax alnorum	Alder Flycatcher	Project ROW	SSC	Low vegetation including shrubs with trees over eight feet high near streams or other open water June-August
Falco sparverius	American Kestrel	Watertown	ST	Grassland or shrubland at the edge of forest; requires cavities for nesting April-June
Reptiles				
Liochlorophis vernalis	Smooth Green Snake	Project ROW	SSC	Open, unforested habitats including meadows, pastures, fens, coastal grasslands, and mountaintop “balds”, transitional and lightly forested habitats such as grassy old fields with scattered shrubs and trees April 1-October 31
Glyptemys insculpta	Wood Turtle	Branch Brook, Northfield Brook, Naugatuck River	SSC	Riparian habitats bordered by floodplain, woodland, or meadows April 1-October 31
*Clemmys guttata***	Spotted Turtle	Harwinton	SSC	Shallow water bodies including bogs, ponds, vernal pools, swamps, and slow-moving streams
Amphibians				
Gyrinophilus porphyriticus	Northern Spring Salamander	Watertown	ST	Steep, rocky high-gradient ravines, brooks, seepage areas, springs April 1 through October 31
Lepidoptera				
Callophryus irus	Frosted elfin	Litchfield, Harwinton	ST	Xeric and open disturbance-dependent habitats on sandy soil; hosts include wild indigo or lupine
Mammal				
*Myotis septentrionalis****	Long Eared Bat	Project Area	FT/SE	Hibernates in caves and mines - swarming in surrounding wooded areas in autumn. During late spring and summer roosts and forages in upland forests.

***SSC=State Species of Special Concern, ST=State Threatened, SE=State Endangered, FT=Federal Threatened**
****Observed species**
*****No NDDB polygons over Proposed Route**

Wood turtle (*Glyptemys insculpta*)

Eversource does not anticipate any in-water work associated with the construction of the new transmission lines. Therefore, the Project would not be expected to result in any negative effects on this important habitat component. When active, this species uses woodlands, meadows, and linear ROWs bordering riparian habitats. These terrestrial habitats exist within the Proposed Route in proximity to the above-referenced riparian habitats.

Although the construction of the proposed Project is unlikely to affect turtles during the hibernating period, it is possible that activities (e.g., vegetation removal and grading) performed in terrestrial habitats along the ROW during the turtles active period (April through October) could adversely affect individual turtles. For example, turtles could be killed or temporarily displaced as a result of construction activities. However, when construction is complete, the turtles would once again utilize these habitats.

In order to minimize the potential for adverse effects to wood turtles, protection strategies and techniques have been incorporated from similar Eversource transmission line projects previously approved by the CT DEEP. In locations along the ROW where suitable wood turtle habitat was identified (including summer terrestrial habitat), the following CT DEEP approved measures are proposed for the protection of this species during Project construction activities:

<u>General:</u>

- A contractor awareness program will be developed and implemented to ensure that contractors working in the area have been instructed on the proper response in the event that a wood turtle is observed in the work area.

<u>For construction activities during the inactive season (November 1 to April 1):</u>

- The removal of low-growth vegetation and tree stumps adjacent to the banks of identified suitable riparian habitat will be avoided and minimized to the greatest extent possible.
- To the extent practicable, mowing in preparation for Project construction activities will be limited to work areas and conducted in the inactive season, between November 1 and April 1.

<u>For construction activities during the active season (April 1 to November 1)</u>:

- A sweep of the work area shall be conducted prior to heavy machinery access, construction, and/or mowing to look for basking turtles.
- If mowing during the active season is required, vegetation will be mowed to no lower than seven inches. Flail type mowers will not be used for mowing in the active season.

- Any turtle encountered during construction will be moved, unharmed, to an area immediately outside of the work area, and positioned in the same direction that it was heading when discovered. Workers will be informed that turtles should never be moved off site.
- All silt fencing will be removed after work is completed and soils are stable so that reptile and amphibian movement is not restricted.
- Any confirmed sightings of this species will be reported to the CT DEEP NDDB.

Smooth Green Snake *(Liochlorophis vernalis)*

Two main factors have influenced the conservation status and current distribution of smooth green snakes: the long-term change in land use patterns (loss of fields and early successional habitat), and historic use of pesticides such as DDT (Klemens 1993). The proposed expansion of the existing managed ROW will expand the amount of suitable (early successional) habitat for this species. Mortality as a result of construction is not anticipated to have an adverse impact on local populations because smooth green snakes are highly mobile, and thus individuals are likely to avoid interaction with construction equipment. The following measures are proposed for the protection of this species during construction activities:

- A contractor awareness program will be developed and implemented to ensure that contractors working in the area have been instructed on the proper response in the event that a smooth green snake is observed in the work area.
- If any snakes are observed, construction personnel will safely relocate them to an area immediately outside of the construction footprint.
- Any silt fence utilized will be removed after construction is complete and soils are stabilized.
- Any confirmed smooth green snake sightings will be reported to the CT DEEP NDDB.

Northern Spring Salamander *(Gyrinophilus porphyriticus)*

Potential Project effects are largely associated with the possible transport of sediment into viable downstream habitat during construction. The following measures are proposed for the protection of this species during construction activities:

- Implement erosion and sedimentation controls that incorporate best management practices to minimize or avoid sediment deposition into wetlands draining to the spring salamander's stream habitat, and/or;
- Conduct construction-phase stormwater monitoring to document the condition and, as necessary, the maintenance of erosion and sedimentation controls and best management practices. Prompt contractor response to repair / maintain these controls, as required pursuant to regulatory approvals, will avoid or minimize the potential for discharge of sediment to wetlands and watercourses, or degradation of water quality, which might adversely affect this species.

Frosted Elfin Butterfly *(Callophyrs irus)*

Potential effects to frosted elfin relate to the reduction and/or destruction of the identified host plant communities *(Baptisia tinctoria)* as a result of construction activities, as well as direct impacts to larval stages of these species, if present in areas of impacted host plant communities. Such activities include but are not limited to the establishment of staging areas, access road construction or improvements, work pad construction, construction activities related to structure locations, and pulling pad locations for stringingconductors and OPGW.

The following conservation measures are proposed to avoid and minimize impacts to host plants and potential indirect effects on frosted elfin:

- Prior to commencement of construction in the host plant areas, the boundaries of host plant communities will be flagged in the field;
- A contractor awareness program will be developed and implemented to ensure that contractors have knowledge of the presence of the host plant communities near work areas;
- Temporary impacts to identified host plant communities will be reduced to the extent practicable by minimizing mowing and ground disturbance outside of the areas required to safely complete the necessary construction activities;
- Construction-phase environmental monitoring by qualified personnel will be provided during construction; and
- Where stabilized vegetation replacing bare soil is necessary following construction, only annual seed mixtures shall be used to prevent the introduction and establishment of non-native species.

After the completion of construction, the wider managed portions of the ROW would likely promote additional habitat for the moths and butterflies that utilize shrubland communities, creating a long-term benefit for this species.

Spotted Turtle *(Clemmys guttata)*

The following measures are proposed for the protection of spotted turtle. These mitigation strategies would be incorporated into the Project D&M Plans, which are required by the Council, and other Project specifications:

- A contractor awareness program will be developed and implemented to ensure that contractors working in the area have been instructed on the proper response in the event that a spotted turtle is observed in the work area.

- The removal of low-growth vegetation and tree stumps adjacent to the banks of identified habitat will be avoided and minimized to the extent possible.

- Mowing in proximity to the observed occurrence in preparation for Project construction activities will be limited to access roads and work areas and conducted, if practical, during the inactive season, between November 1 and March 1.

<u>For construction activities during the active season (March 1 to November 1):</u>

- Exclusion fencing will be installed around proposed work pad(s) in proximity to the observed occurrence in a manner that precludes access by spotted turtles.

- If necessary, erosion control measures installed along the existing access road in proximity to the observed occurrence should be designed in a manner that allows unencumbered movement by spotted turtles. Such measures may include, but not be limited to; syncopated silt fencing and/or straw wattles, and aligning erosion and sedimentation controls to avoid bifurcating suitable habitat.

- A sweep of the work area shall be conducted prior to heavy machinery access, construction, and/or mowing to look for basking turtles.

- If mowing during the active season is required, vegetation will be mowed to no lower than 7 inches. Flail type mowers will not be used for mowing in the active season.

- Any turtle encountered during construction will be moved, unharmed, to an area immediately outside of the work area, and positioned in the same direction that it was heading when discovered. Workers will be informed that turtles should never be moved off site.

- All erosion control measures and exclusion fencing will be removed after work is completed and soils are stable so that reptile and amphibian movement is not restricted.

- During construction, any confirmed sightings of this species will be reported to the CT DEEP NDDB.

Birds

Eversource’s consultants performed a breeding bird assessment along the Proposed Route in the spring of 2015. The results of this assessment indicate that portions of the Project ROW provide suitable habitat for the six state-listed species; therefore, it is possible that these species may periodically utilize the ROW (refer to the *Inventory and Assessment of Breeding Birds*, Volume 3). One state-listed Special Concern species, broad-winged hawk, was observed May 2, 2015 calling from a perch along the forest edge adjacent to a wetland in Harwinton.

The American kestrel, brown thrasher and alder flycatcher were all identified based on the presence of suitable wetland and upland shrubland habitat which is present due to the vegetation management regime currently employed by Eversource. The Project would result in a net gain in preferred habitat for these species; therefore, no long-term adverse impacts are anticipated. The broad-winged hawk is a forest ecotone species that will continue to find suitable habitat within the Project area after site work is complete. During a meeting with Eversource on July 30, 2015[94], CT DEEP concurred that the Project would not adversely impact State-listed bird species and agreed that no additional surveys or protection measures are warranted.

6.1.4 Land Use, Recreational/Scenic Resources, and Land-Use Plans

The proposed 115-kV transmission line would be located adjacent to one or more existing Eversource 115-kV overhead transmission lines (as well as a 345-kV line for part of the route), within a ROW that has long been established for utility purposes. Similarly, both the replacement of the 1191 Line lattice steel structure near Frost Bridge Substation and the separation of the existing 1191 and 1921 Lines onto separate structures at the Naugatuck River crossing between Litchfield and Harwinton will be accomplished within Eversource's existing ROW. Consequently, the overall development of the proposed new 115-kV transmission line and the related transmission line modifications (e.g., replacement of the 1191 Line lattice steel structure and the separation of the two existing 115-kV lines at the Naugatuck River crossing) would be consistent with existing and future land use plans and would typically result in incremental effects on land uses, recreational resources, and scenic views.

6.1.4.1 Land Use

The Project would result in both short-term and long-term effects on land uses. Because the new 115-kV transmission line would be aligned within an existing Eversource ROW that has been dedicated to utility use for decades, the overall effects on land uses will be minor and localized. The new 115-kV transmission line would be located on property subject to existing Eversource easements or within Eversource-owned properties. Overall, more than 41% of the new transmission line would be aligned across Eversource-owned properties or publicly-owned properties across which Eversource has existing easements; specifically, approximately 0.94 mile (9%) of the 10.4-mile transmission line route would extend across Eversource-owned land, while an additional 3.3 miles (32%) would be across federal, state, or local properties subject to Eversource easements. The construction of the proposed transmission line would convert approximately 6.7 acres of forested wetlands and approximately 42.2 acres of forested uplands to scrub/shrub lands (refer to Table 6-2).

The upland forest land use type would be converted to open field – shrubland, whereas the forested wetland land-use type would be converted to emergent or scrub-shrub wetlands. Construction would also

94 Meeting with Jenny Dickson and Kate Moran (CT DEEP), Eversource Energy, and Tighe & Bond at Sessions Woods

temporarily affect a few agricultural areas, open fields, residential areas (house/yard), and commercial and industrial properties within Eversource's existing ROW. However, the operation of the Project would not cause long-term adverse effects on these land uses, which are required to conform to Eversource's existing easement requirements.

6.1.4.2 Consistency with Existing and Future Land-Use Plans

Based on a review of Connecticut's C&D Plan, town *Plans of Conservation and Development*, and regional planning agency land use documents, the construction and operation of the Project facilities would not conflict with local land use plans, because the proposed transmission line would be located within an existing, long-established ROW already dedicated to energy use. Moreover, within the ROW, Eversource's existing easements already specify land uses that are consistent with the safe operation of overhead transmission lines, precluding permanent non-utility structures. Further, the state C&D Plan (Growth Management Principle #1) advocates the development of utility infrastructure to continue to support the state's economic growth and revitalization of regional centers.

6.1.4.3 Public Forests, Parks, Open Space, Recreational / Public Trust Lands, and Trails

The new 115-kV transmission line would be aligned within Eversource's existing ROW across portions of various designated recreational areas, including Mattatuck State Forest, Veterans Memorial Park, Black Rock State Park, Northfield Brook Recreation Area, Thomaston Dam properties along the Naugatuck River, Naugatuck River greenway, and recreational trails (e.g., Jericho Trail, Mattatuck Trail, Black Rock State Park Red Trail, Northfield Brook Recreation Area Trail). Most of these areas offer year-round recreational opportunities, although peak uses in most areas are in the spring, summer, and fall.

Transmission line construction activities may temporarily affect recreational uses by causing traffic congestion or delays on local roads leading to recreational areas, or by requiring temporary closures of recreational trails. The ROW crosses hiking trails in Mattatuck State Forest, Black Rock State Park, and Northfield Brook Recreation Area, as well as along the Naugatuck River.

The ROW traverses the northern boundary of Veterans Memorial Park, outside of the Park's developed recreational areas; as a result, no recreational activities in the Park would be affected by the project. Similarly, at the Naugatuck River crossing between Litchfield and Harwinton, the new 115-kV transmission line conductors, as well as the separated 1191 and 1921 Line conductors, would be aligned high above the river and the recreational trails / greenway along it. Due to the height of the conductor spans, no tree clearing or trimming is expected to be required in the riparian corridor. As a result, recreational activities associated with the Naugatuck River / Thomaston Dam (e.g., fishing, ATV / snowmobile use, hiking) would not be affected.

The proposed transmission line would be consistent with the existing utility use of the ROW that already extend across the recreational areas and thus would not result in significant adverse effects on the public uses of such areas. In general, adverse effects on recreational uses would be short-term, lasting only for the duration of construction.

The operation and maintenance of the new transmission line would not alter the use of the recreational areas traversed by the ROW. Further, the expansion of shrubland habitat could benefit some recreational activities, such as hunting within the Mattatuck State Forest, Black Rock State Park, and other recreational areas where hunting is allowed.

Consistent with its typical project planning process, Eversource would coordinate with the owners or managers of the public recreational areas to develop measures to maintain public safety during construction, while also avoiding or minimizing short-term impacts to recreational users. In addition, Eversource would typically provide an anticipated construction schedule to representatives of each recreational use area. The schedule would define Eversource's proposed plans for minimizing disruptions to recreational uses during construction, such as proposed road closures, detours/re-routes, signs along trails and public use areas identifying work zones, etc.

6.1.4.4 Designated Protected and Scenic Resources

The proposed 115-kV transmission line would be aligned adjacent to one or more of Eversource's existing overhead transmission lines across or near certain designated public open space and potential scenic areas. Eversource carefully evaluated the proposed Project facilities in relation to these areas and has attempted to minimize incremental visual effects to the extent practical by aligning new structures generally parallel to existing structures.

In addition, as described in Section 5.1.4.5, Eversource conducted field reconnaissance of all known scenic and protected open space areas in the vicinity of the ROW to assess viewpoints from these areas to the existing overhead transmission lines within the ROW and, based on these analyses, to identify areas from which to perform photo-simulations to further evaluate the potential changes that the new overhead transmission line would have on the viewscape. At each location where views of the transmission line were identified as a potentially dominant component of the local viewscape, Eversource prepared photo-simulations depicting views of the ROW (illustrating the new and existing transmission lines) under two conditions:

1) During early April 2015, when no deciduous vegetation was present (i.e., "leaf off" conditions); and

2) During May 2015, when deciduous vegetation had leafed out (i.e., "leaf on" conditions). While the "leaf off" conditions represent the time periods when the ROW and transmission lines would be most visible, the "leaf on" conditions are more representative of the seasons when the public is most apt to use the public recreational facilities in the vicinity of the Proposed Route.

The results of the visual resource surveys, along with the photo-simulations, are provided in Volume 3. The following briefly summarizes potential views of the existing and proposed transmission lines, based on the field studies conducted.

- **Jericho Trail, Watertown**. The Jericho Trail, which is located within Mattatuck State Forest, extends perpendicularly across Eversource's existing 400-foot-wide ROW, which is occupied by two 115-kV and one 345-kV transmission line. The proposed 115-kV line would be located near the center of this ROW, between the existing lines. At the crossing, the trail is asphalted. Long views of the ROW to the west are blocked by a steep slope. However, from the trail, hikers have extended views to the east, where the Frost Bridge Substation and various existing overhead transmission lines are visible within the generally forested Naugatuck River Valley and adjacent hillsides. On both sides of the ROW, the Jericho Trail reverts back to a narrow trail and bends into the densely wooded Mattatuck State Forest. Consequently, the new 115-kV structures would be visible only at or in the immediate vicinity of the trail crossing
- **Jericho-Whitestone Connector Trail, Watertown.** In the Project area, this trail extends along Echo Valley Road and from there crosses onto the 400-foot-wide ROW for a short distance before diverging north into Mattatuck State Forest and eventually joining the Jericho Trail, north of the Project ROW. In the vicinity of the ROW, views from this trail are presently influenced by Echo Valley Road and developments along it, as well as by the existing transmission lines within the ROW. As a result, the development of the new 115-kV line would have only an incremental visual effect.
- **Mattatuck Trail, Black Rock State Park, and Park Red Trail, Watertown**. The ROW crosses the CFPA's Mattatuck Trail approximately 0.5 mile from the park's main gate and primary recreational areas (e.g., lake, fields, camping area). The ROW is not visible from the scenic overlook along the Trail, which offers views to the east toward the main park entrance and beyond. At the crossing of the Trail, the new 115-kV line would be located east of the existing 1191 Line. In this area, views are limited by the rugged terrain (rock outcrops, steep topography) and dense forested vegetation (coniferous and deciduous). The existing ROW and overhead transmission line are prominently visible to trail users at and in the immediate vicinity of the trail crossing during either "leaf off" or "leaf on" conditions. However, the ROW crosses the trail perpendicularly, and bends in the trail both northwest and southeast of the ROW generally prohibit long views of the transmission line structures except at and close to the ROW crossing. The ROW also crosses the Park's Red Trail, which is located to the north of the Mattatuck Trail. Visual conditions along this trail are similar to those described for the Mattatuck Trail.

- **Interpretive (Yellow) Trail, Northfield Brook Recreation Area.** The existing ROW crosses this trail twice, perpendicularly. At the first crossing, the existing 115-kV transmission lines (the 1191 and 1921 Lines) extend high above the trail near Northfield Brook; as a result, no vegetation is managed at this crossing. The proposed 115-kV line would similarly span this trail crossing. The second crossing of the trail is located on a slope above the recreation area's main access road. The managed vegetation within the ROW affords hikers long views to the south, toward State Route 254, where the ROW and transmission line structures also are visible. The new 115-kV transmission line will be similarly visible from this trail crossing. However, due to both topography and dense vegetation, views of the ROW and transmission line structures are limited, except at the actual ROW crossing.
- **Naugatuck River Greenway / Trail.** At the ROW crossing of the Naugatuck River, the proposed transmission structures (like the existing structures) are positioned high on slopes on either side of the river. The existing transmission line conductors are visible only in the immediate vicinity of the crossing, and are mostly evident due to the colored marker balls placed on them. The transmission structures are similarly not visible except at the crossing. The proposed structures and conductors are expected to be similarly visible in only the immediate vicinity of the ROW crossing. No vegetation clearing is expected to be required along the ROW adjacent to the river.

6.1.4.5 Methods to Prevent and Discourage Unauthorized Use of ROW

Eversource's existing transmission line easements restrict the types of activities that can be conducted within the ROW. Easements typically prohibit the construction of buildings, pools, and other structures within the ROW. Additionally, Eversource has policies addressing requests from property owners and other parties external to Eversource. These policies outline an evaluation process and provide guidelines for allowing certain uses (such as driveways or parking lots), where appropriate. Requests prohibited by the easement agreements, or otherwise posing safety, engineering, environmental, or other concerns are rejected.

Where Eversource holds an easement as opposed to land ownership in fee, Eversource must receive landowner approval prior to installing fences, gates, etc. Eversource seeks to work with landowners and agencies to discourage unwarranted access onto and use of its ROWs, and typically installs signs warning the general public of the overhead hazards posed by contact with the high voltage transmission lines and, with landowner approval, installs fences, gates, barricades, or berms to discourage access onto the ROWs.

In addition, Connecticut law prohibits the operation of ATVs on private land without the written permission of the landowner (CGS § 14-387). Eversource does not allow ATV use on its properties or properties subject to its easements.

6.1.5 Transportation, Access, and Utility Crossings

The construction of the new transmission line would have minor, short-term, and localized effects on transportation patterns in the immediate vicinity of the Project. These effects would stem primarily from additional traffic on local roads associated with the movement of construction vehicles and equipment to and from contractor yards, staging areas, and work sites along the ROW. The proposed 115-kV transmission line would span all roads that it crosses.

The construction of the 115-kV transmission facilities would not affect railroads or other utilities (e.g., water lines, stormwater or sanitary sewers), all of which would be spanned by the proposed overhead line. Similarly, the operation of the Project, which would not generate traffic other than that associated with periodic ROW management, would not affect transportation systems or local traffic patterns.

During construction, the well-established public road network in the Project area would afford ready access to the ROW for vehicles and equipment. Along the ROW, construction equipment, materials, and support vehicles would use existing or improved access roads to reach work sites. In certain areas, Eversource proposes to use off-ROW access roads to reach on-ROW work sites.

During construction, personnel traveling to and from work sites, as well as the movement of construction equipment, may cause temporary localized increases in traffic. When heavy equipment and large structure components must be transported along public roads for delivery to the ROW, temporary disruptions in local traffic patterns, delays, or detours could occur. Activities involving the installation of the conductors at or near road crossings also could result in minor, short-term, and localized traffic congestion, delays, or detours. However, any such traffic volume increases would be short-term, as would any detours.

Eversource would employ personnel to direct traffic at construction work sites along public roads, as needed, and would erect appropriate traffic signs to indicate the presence of construction work zones. In addition, to minimize the potential for transportation issues, Eversource would work with representatives of the affected towns as appropriate. Such plan(s), which would be implemented by Eversource’s construction contractor(s) would define traffic control requirements and identify measures for safe ingress and egress to the ROW for construction equipment and other vehicles.

Based on analysis of the transmission line structures along the Proposed Route, none of the structures would exceed the FAA notification criteria for airports or heliports located in the vicinity of the Proposed

Route; including Waterbury Airport (located approximately 7,000 feet to the northeast in the Town Plymouth), Northfield Heliport (located approximately 7,100 feet west in the Town of Litchfield), and Waterbury-Oxford Airport (located approximately 9.5 miles south in the Town of Oxford).

6.1.6 Cultural (Historic and Archaeological)

As part of the Project planning effort, Eversource's cultural resources consultant compiled baseline information about the history and prehistory of the Project area, including identifying any known cultural resources in the vicinity of the Proposed Route and substations. This review verified there are no previously identified historic structures, archaeological sites or NRHP properties on file with the Connecticut SHPO that are situated within 152 m (500 feet) of the proposed project corridor or in the general vicinity.

Eversource expects to conduct additional archaeological reconnaissance field investigations and thereafter to develop appropriate intensive survey testing and other research measures needed to determine the eligibility of any discovered sites to the NRHP/SRHP. This additional work would be performed based on consultations with the Connecticut SHPO and involved Native American tribes.

Any sites determined eligible for the NRHP/SRHP would be avoided if possible, using methods such as the adjustment of construction pad or construction road locations, low-impact forest vegetation removal with no subsurface disturbance, use of protection measures such as fill or timber mats, etc. Avoidance methods can also include placement of fill material sufficient to resist all effects of construction equipment, but marked with geotextile fabric wherever fill is removed following construction to preclude subsurface disturbance during fill removal. Eversource is sensitive to Connecticut's cultural heritage and is committed to working with the SHPO in protecting and mitigating potential effects to these resources, if applicable.

If avoidance of eligible resources is not possible, mitigation strategies would be developed for review and approval by the SHPO, in consultation with interested Native American tribes. Mitigation would include data recovery sufficient to document significant information which may be lost to adverse Project effects.

6.1.7 Air Quality

The construction of the proposed Project facilities would result in short-term, minor, highly localized effects on air quality, primarily from fugitive dust (as a result of soil disturbance at work sites and from vehicular movements on access roads along the ROW) and from vehicular emissions associated with the construction equipment operation. No long-term effects on air quality would result from the operation of the proposed 115-kV transmission line.

To minimize short-term adverse effects to air quality during construction, as necessary, access roads and other sites would be watered to suppress fugitive dust emissions. Additionally, crushed stone aprons would be installed at all access road entrances to public roadways, minimizing tracking of soil onto the road pavement. Vehicular emissions would be limited by requiring contractors to properly maintain construction equipment and vehicles, as well as to conform to Connecticut's vehicular anti-idling regulations (RCSA§ 22a-174-18).

Unlike other criteria pollutants, greenhouse gas (GHG) impacts are global in nature, not local or regional. Consumption of fuel from construction equipment or vehicles is only a part of the global GHG emission sources. The global consumption of fuel would remain the same whether it is combusted during this Project or elsewhere in the world. Since the construction of the proposed Project facilities will be short-term, actual emissions of GHGs would be very small when compared to the carbon footprint of vehicles or permanent emission sources such as a refinery.

6.1.8 Noise

The construction of the new 115-kV transmission line would cause localized, short-term, and generally minor increases in ambient noise levels in the immediate vicinity of work sites. The operation of the transmission line would not affect the noise environment, except under certain weather conditions when sound from the conductors may be audible on or in the immediate vicinity of the ROW.

Construction-related noise would generally stem from construction equipment operation, truck traffic, earth-moving vehicles and equipment, jackhammers, and structure erection equipment (cranes), etc. Overall, these sound levels would be typical of construction projects.

The temporary increase in construction-related noise could potentially raise ambient sound levels at certain receptor locations near work sites, including residences, schools, and designated recreational areas. The extent of a noise effect to humans at a sensitive receptor is dependent upon a number of factors, including the change in noise level from the ambient; the duration and character of the noise; the presence of other, non-Project sources of noise; people's attitudes concerning the Project; the number of people exposed to the noise; and the type of activity affected by the noise (e.g., sleep, recreation, conversation). The effect of construction-generated noise would also depend on the noise source location relative to the receptor's location because sound attenuates with distance and with the presence of vegetative buffers or other barriers.

Noise levels diminish at a rate of approximately 6 dBA per doubling of distance from a noise source. For example, a noise level of 84 dBA measured at 50 feet from the noise source to the receptor would reduce to 78 dBA at 100 feet from the source to the receptor, and reduce to 72 dBA at 200 feet from the source to the receptor.

Table 6-4 summarizes noise level data compiled for various types of construction equipment and measured at 50 feet from the source. Such construction-generated noise would be localized to the vicinity of construction work sites along the ROW. In general, construction activities would typically occur during the daytime Monday through Saturday (between 7:00 A.M. to 7:00 P.M.), when human sensitivity to noise is lower.

Table 6-4: Noise Ranges of Typical Construction Equipment

Equipment	Noise Levels (Leq, dBA) at 50 feet[1]
Backhoe	73-95
Compressors	75-87
Concrete Mixers	75-88
Concrete Pumps	81-85
Cranes (moveable)	75-88
Cranes (derrick)	86-89
Front Loader	73-86
Generators	71-83
Jackhammers	81-98
Paver	85-88
Pile Driving (peaks)	95-107
Pneumatic Impact Equipment	83-88
Pumps	68-72
Saws	72-82
Scraper/Grader	80-93
Tractor	77-98
Trucks	82-95
Vibrator	68-82

[1] Modern machinery equipped with noise control devices or other noise-reducing design features do not generate the same level of noise emissions as shown in this table. Source: USEPA Office of Noise Abatement and Control, 1971 and U.S. Department of Transportation, Federal Highway Administration (http://www.fhwa.dot.gov/environment/noise/construction_noise/special_report/

6.2 SUBSTATION MODIFICATIONS

To interconnect the new 115-kV transmission line to the transmission system, Eversource proposes to modify both Frost Bridge Substation and Campville Substation. Potential environmental effects that are unique to these locations are described below. Potential effects to air quality at each substation are similar to the Proposed Route (refer to Section 6.1.7 for a description) and therefore, not described in this section.

The proposed modifications at Frost Bridge Substation would all occur within the fence lines (i.e., the already developed portions). As a result, most environmental effects would be minor, localized on-site, and short-term (lasting only for the duration of construction).

To accommodate modifications required to interconnect the new 115-kV transmission line at Campville Substation, Eversource proposes to expand the developed portion of the substation by approximately 0.4 acre (the fence line by would extend approximately 90 feet farther to the east). The expansion would occur over generally level topography in an area that has been subject to historic disturbance associated with the substation and ROW access road.

The proposed modifications would result in a long-term, but incremental, change in the appearance of each station. However, these effects would be negligible because each site is already developed for electric utility use.

The following subsections review the potential environmental effects associated with the construction and operation of the substation modifications, as well as the mitigation measures that Eversource has identified to date. These effects and associated mitigation measures would be similar for each substation and thus are discussed jointly. The planned modifications to each substation, along with the proposed construction procedures expected to be used at each site are discussed in detail in Sections 3 and 4.

6.2.1 Geology, Topography, and Soils

The modifications to each substation would require site preparation work, including grading and other soil disturbance (e.g., excavations) to install the new 115-kV transmission line facilities. Mechanical methods would be used to install foundations into bedrock, if encountered. As a result, no blasting is anticipated. Grading and filling, if required, may result in minor alterations to the topography and soils on the substation sites.

To avoid or minimize the potential for erosion and sediment transport beyond the limits of work, construction work would be performed in accordance with an *Erosion and Sediment Control Plan*, in conformance with the 2002 *Connecticut Guidelines for Soil Erosion and Sediment Control* and CT DEEP stormwater regulatory requirements. Typically, excess soil resulting from the construction of the substation modifications would be removed from the substation property, rather than stockpiled on site. In addition, construction activities typically would be sequenced to the extent possible, thereby minimizing the amount of time that soils are exposed. Further, after the installation of the new 115-kV facilities, disturbed areas at each substation would be stabilized with trap rock or another type of crushed stone.

6.2.2 Water Resources

The proposed substation modifications would occur in upland areas. Therefore, no direct adverse effects on water resources are anticipated.

Six wetlands were identified on undeveloped portions of Everource’s fee-owned property in the vicinity of Frost Bridge Substation. The closest resource areas to the existing fenced development include wetlands W-FB1 (a PFO wetland), W-FB2 (a PFO wetland); and W-FB3 (a PEM wetland).

Three wetlands were identified on undeveloped portions of Everource’s fee-owned property in the vicinity of Campville Substation. As a result of the proposed expansion of the substation and fence line by approximately 70 feet to the east, the new fence line would be located approximately 75 feet to the west of wetland W-G3 (a PFO wetland) which is located on undeveloped portions of Everource’s fee-owned property.

During the construction of the station modifications, appropriate temporary soil erosion and sedimentation controls would be installed and maintained, pursuant to Eversource’s regulatory approvals and best management practices. These erosion and sedimentation control measures would minimize the potential for off-site sedimentation into nearby water resources. Similarly, appropriate spill prevention, control, and countermeasure procedures would be implemented during construction to minimize the potential for inadvertent spills or leaks from construction equipment. Such procedures would be specified in the D&M Plans governing the substation modification work.

The operation of the modified substations would not affect water resources. Eversource would apply standard operation and maintenance procedures to avoid or minimize the potential for off-site erosion and sedimentation. During facility operation, Eversource also would conform to standards for minimizing the potential for spills or leaks from electrical equipment.

6.2.3 Flood Zones

A review of FEMA maps indicates that both the Frost Bridge and Campville Substations (including the proposed expansion area) are located beyond the limits of both the 100-year and 500-year flood zones. As a result of the proposed substation modifications. Therefore, no impact to flood zones would occur

6.2.4 Biological Resources

Because the proposed Frost Bridge modifications would occur within the existing station fence lines, no vegetation or wildlife resources would be affected. The proposed Campville Substation expansion would result in a loss of approximately 0.4 acre of mixed deciduous forest adjacent to the existing substation. This area has been subjected to historic disturbance associated with the existing substation and a ROW access road. Given the relatively small loss of forest habitat, and abundance of similar contiguous habitat, the expansion is not anticipated to have a long-term adverse impact on biological resources.

In addition, neither of the proposed substation modifications has the potential to affect any known state-listed special concern, threatened or endangered wildlife species.

6.2.5 Land Use, Recreational / Scenic Resources, and Land-Use Plans

The proposed modifications to the existing Frost Bridge and Campville substations would be located on Eversource property; would be consistent with the existing uses of each site for utility purposes; and would not conflict with any land use plans. Although the proposed modifications would slightly alter the appearance of each station, the changes would be minimal and would generally be similar in appearance to the existing facilities at each site.

The expansion of the Campville Substation (by approximately 0.4 acre) would convert undeveloped Eversource-owned land to developed utility use. However, this minor change in land use is consistent with Eversource’s ownership of the property.

The proposed substation modifications would not be visible from any designated scenic sites or public recreational areas. Hayden Road, a Harwinton-designated scenic road, is located south of Campville Substation, and borders Eversource’s property. However, views of the substation from the road are screened by vegetation and topography.

6.2.6 Transportation and Access

The proposed substation modifications would not adversely affect long-term transportation or access patterns. During construction, minor and short-term effects on vehicular traffic may occur as construction vehicles use local public roads leading to the sites. The operation of the modified stations would have no effect on transportation patterns or traffic.

Frost Bridge Road provides primary access to the Frost Bridge Substation and would be the principal public road used for ingress / egress to the site during construction. Similarly, Wildcat Hill Road is the principal local road in the vicinity of the Campville Substation and would be the primary access route to and from the substation during construction.

At times during construction, localized traffic congestion may occur when heavy construction equipment or electric components are transported to the substation. The movement of construction workers and equipment in general also would temporarily cause minor increased traffic on local public roads leading to the sites. However, such effects would be minor, localized, and limited to only certain periods during the construction of the substation modifications. Construction activities would be staged on Eversource property, within the fenced stations or on other previously disturbed Eversource fee-owned property.

Traffic on local roads would typically occur during normal work hours. However, some work will depend on the scheduling of allowable line outages and thus may have to be performed at other times.

6.2.7 Cultural (Historical and Archaeological)

Because all construction activities associated with the modifications to the Frost Bridge Substation would be within the existing fenced areas, where soils have been disturbed by past activities, the potential for encountering intact, previously unrecorded, significant archaeological resources is negligible. As a result, no adverse effects to cultural resources would occur from the proposed Frost Bridge Substation modifications.

Most of the proposed modification to Campville Substation would occur within the fenced substation where soils have been previously disturbed and potential for locating intact cultural artifacts is negligible. Eversource will conduct appropriate investigations of the substation expansion area in order to identify potential cultural artifacts, and if found, identify appropriate protection or mitigation measures.

6.2.8 Noise

The substation modifications would result in short-term increases in noise, which would emanate from the on-site work activities and from construction-related vehicular traffic on local roads. The operation of the modified station facilities would not cause a long-term change in the ambient noise environment.

The Frost Bridge Substation is located within an area zoned for industrial use where there are no nearby noise receptors and where the ambient sound environment is influenced by the surrounding land uses and by other activities, such as traffic on State Route 8. The Campville Substation is located in a rural / suburban area. The existing environment is typical of such areas. The ambient noise levels, albeit low, are presently influenced by the operation of the substation and vehicular movement along Wildcat Hill Road.

During construction, noise-generating activities would be generally short-term and would emanate from activities such as the operation of equipment, truck traffic, earth excavation and moving operations, and installation of electric components (refer to Table 6-4 for a summary of noise emissions from typical construction equipment). Such construction-generated noise would be localized to the vicinity of each of the stations and would typically occur during the daytime Monday through Saturday (between 7:00 A.M. to 7:00 P.M.), when human sensitivity to noise is lower. At the Campville Substation, existing forested vegetation around the developed portion of the station would assist in attenuating construction-related noise.

Under certain circumstances, especially when circuit outages are required, night work and weekend work could be necessary at the stations. Night construction would require lighting and may result in localized, temporary increases in noise levels.

Table 6-5
Summary of Wetland Effects along Proposed 115-kV Transmission Line ROW

Table 6-5: Summary of Wetland Effects along Proposed 115-kV Transmission Line ROW

Town/Wetland Number	Dominant Wetland Classification*	Type of Wetland Effect	
		Permanent	Temporary
Watertown			
W-A9	PSS		Work Pad
W-B2	PSS		Work Pad
W-B6	PSS		Work Pad
W-B11	PSS		Work Pad
W-C1	PFO	Vegetation Removal Outside of Managed ROW	
W-C4	PFO	Vegetation Removal Outside of Managed ROW	
W-C12	PFO	Vegetation Removal Outside of Managed ROW	
W-C15	PFO	Vegetation Removal Outside of Managed ROW	Work Pad
W-C20	PFO	Vegetation Removal Outside of Managed ROW	Work Pad
W-C21	PFO	Vegetation Removal Outside of Managed ROW	
Thomaston			
W-D3	PFO	Vegetation Removal Outside of Managed ROW	Work Pad
W-D4	PFO	Vegetation Removal Outside of Managed ROW	
W-D6	POW	Vegetation Removal Outside of Managed ROW	
W-D7	PFO	Vegetation Removal Outside of Managed ROW	
W-D10	PFO	Vegetation Removal Outside of Managed ROW	
W-D11	PFO	Vegetation Removal Outside of Managed ROW	
W-D12	PSS	Vegetation Removal Outside of Managed ROW, Access Road Improvements, Culvert Replacement	Work Pad
W-D13	PFO	Vegetation Removal Outside of Managed ROW	
W-E2	PSS	Vegetation Removal Outside of Managed ROW	
Litchfield			
W-E2	PSS	Vegetation Removal Outside of Managed ROW	
W-E4	PFO	Vegetation Removal Outside of Managed ROW	
W-E6	PFO	Vegetation Removal Outside of Managed ROW	Work Pad
W-E8	PFO	Vegetation Removal Outside of Managed ROW	Work Pad, Proposed Access Road
W-E9	PFO	Vegetation Removal Outside of Managed ROW	Work Pad

Table 6-5: Summary of Wetland Effects along Proposed 115-kV Transmission Line ROW

Town/Wetland Number	Dominant Wetland Classification*	Type of Wetland Effect	
		Permanent	Temporary
W-E10	PSS	Vegetation Removal Outside of Managed ROW	Work Pad, Proposed Access Road
W-E12	PEM		Work Pad
W-E13	PFO	Vegetation Removal Outside of Managed ROW	
W-F3	PFO	Vegetation Removal Outside of Managed ROW	
W-F4	PFO	Vegetation Removal Outside of Managed ROW	Work Pad
W-F7	PSS	Vegetation Removal Outside of Managed ROW	
Harwinton			
W-F10	PFO	Vegetation Removal Outside of Managed ROW	
W-F11	PFO	Vegetation Removal Outside of Managed ROW, Access Road Improvements, Culvert Replacement	Work Pad
W-F13	PFO	Vegetation Removal Outside of Managed ROW	
W-F14	PSS	Vegetation Removal Outside of Managed ROW	Work Pad
W-F15	PEM	Vegetation Removal Outside of Managed ROW, Proposed Structure	Work Pad
W-G1	PFO	Vegetation Removal Outside of Managed ROW	Work Pad

* Wetlands were classified according to Cowardin et al. PEM = palustrine emergent wetland; PSS = palustrine scrub-shrub wetland; PFO = palustrine forested wetland; POW = palustrine open water; PUB = palustrine unconsolidated bottom.

"Vegetation Removal Outside of Managed ROW" refers to the vegetation that would have to be cleared from wetlands located within the construction footprint of the proposed 115-kV line, along the presently un-managed portions of Eversource's ROW. In many instances, this activity will also necessitate temporary access road impacts for tree clearing.

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Table 6-6
Potential Effects to and BMPs for Vernal Pools

Table 6-6: Potential Effects to and BMPs for Vernal Pools

Municipality / Volume 5, 100 Scale Mapsheet No.	Wetland Number	Vernal Pool No	Proposed Project Facilities and Vegetation Removal			
			Work Proposed in Vernal Pool Envelope (from vernal pool edge to 100 feet)	Proposed Work in Vernal Pool Depression	New Vegetation Removal Required in Vernal Pool Depression (acres)	Potential BMPs
Watertown						
3	W-MSF2	VP MSF-2	Access Road Improvements			Syncopated silt fence and/or straw wattles
3A	W-MSF1	VP MSF-1	Access Road Improvements			Syncopated silt fence and/or straw wattles
6	W-B2	VP B2-1	Work Pad			Syncopated silt fence and/or straw wattles
7	W-B4	VP B4-1	Access Road Improvements			Syncopated silt fence and/or straw wattles
11	W-C4	DVP C4-1	Access Road Improvements			None, vernal pool is a decoy pool
11	W-C10	VP C10-1	Tree Clearing, New Access Road, Work Pad			Where feasible, minimize new gravel fill within 100 feet of vernal pool Syncopated silt fence and/or straw wattles
12	W-C12	VP C12-1	Access Road Improvements			Syncopated silt fence and/or straw wattles
13	W-C15	VP C15-1	Access Road Improvements			Syncopated silt fence and/or straw wattles
14	W-C20	VP C20-1	Access Road Improvements	Work Pad		If feasible, reconfigure work pad to avoid vernal pool Syncopated silt fence and/or straw wattles

Table 6-6: Potential Effects to and BMPs for Vernal Pools

Municipality / Volume 5, 100 Scale Mapsheet No.	Wetland Number	Vernal Pool No	Proposed Project Facilities and Vegetation Removal			
			Work Proposed in Vernal Pool Envelope (from vernal pool edge to 100 feet)	Proposed Work in Vernal Pool Depression	New Vegetation Removal Required in Vernal Pool Depression (acres)	Potential BMPs
15	W-C21	VP C21-1	Tree Clearing, Access Road Improvements, Work Pad	Tree Clearing	.054	Minimize the removal of shrub cover around vernal pool Where feasible, minimize new gravel fill within 100 feet of vernal pool Syncopated silt fence and/or straw wattles
Thomaston						
19	W-D4	VP D4-1	Potential Pull Pad, Access Road Improvements, Tree Clearing	Tree Clearing	.021	Minimize the removal of shrub cover around vernal pool Where feasible, minimize new gravel fill within 100 feet of vernal pool. Syncopated silt fence and/or straw wattles
20	W-D5	VP D5-1	Access Road Improvements, Tree Clearing			Syncopated silt fence and/or straw wattles
22	W-D12	VP D12-1	Work Pad, Tree Clearing, Access Road Improvements			Minimize the removal of shrub cover around vernal pool Where construction options allow, provide amphibian access to vernal pool in breeding season

Table 6-6: Potential Effects to and BMPs for Vernal Pools

Municipality / Volume 5, 100 Scale Mapsheet No.	Wetland Number	Vernal Pool No	Proposed Project Facilities and Vegetation Removal			
			Work Proposed in Vernal Pool Envelope (from vernal pool edge to 100 feet)	Proposed Work in Vernal Pool Depression	New Vegetation Removal Required in Vernal Pool Depression (acres)	Potential BMPs
21	W-D15	VP D15-1	Work Pad		No activities are proposed in proximity to vernal pool	
Litchfield						
26	W-E2	DVP E2-1/E2-2	Access Road Improvements, Tree Clearing			Syncopated silt fence and/or straw wattles Minimize the removal of shrub cover around vernal pool E2-2
28	W-E9	VP E9-1	Work Pad, Tree Clearing	Tree Clearing	.17	Minimize the removal of shrub cover around vernal pool
Harwinton						
31	W-F9	VP F9-1			No activities are proposed in proximity to vernal pool	
31	W-F10	VP F10-1	Tree Clearing, Potential Guard Structure Pad	Tree Clearing	.002	Felling of trees into vernal pool should be avoided
34	W-F14	VP F14-1	Work Pad		Minimize the removal of shrub cover around vernal pool	
34	W-F15	VP F15-1	Work Pad		Minimize the removal of shrub cover around vernal pool	

7. ELECTRIC AND MAGNETIC FIELDS

7.1 ELECTRIC AND MAGNETIC FIELDS FROM POWER LINES AND OTHER SOURCES

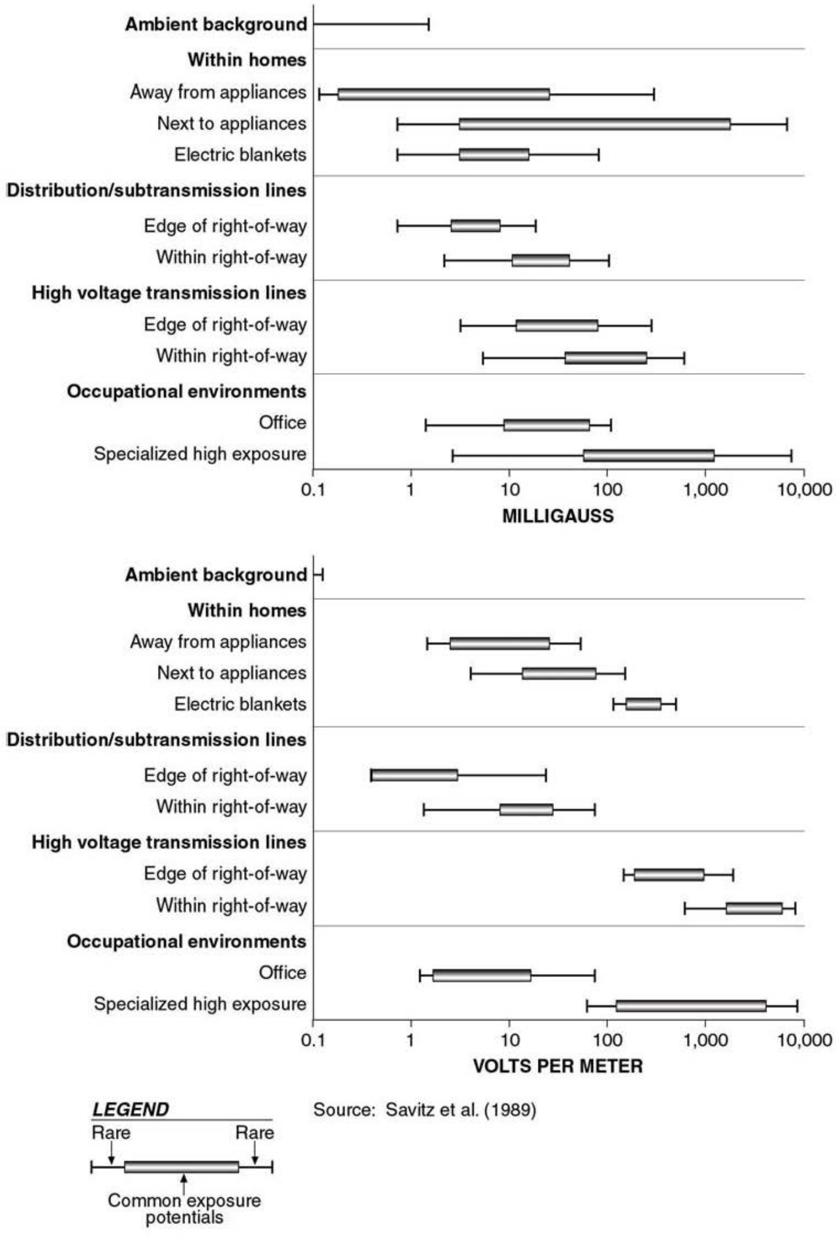
Electricity used in homes and workplaces is transmitted over considerable distances from generation sources to distribution systems. Electricity is transmitted as alternating current ("AC") to all homes and over electric lines delivering power to neighborhoods, factories, and commercial establishments. The power provided by electric utilities in North America oscillates 60 times per second (i.e., at a frequency of 60 hertz ["Hz"]).

Electric fields are the result of voltages applied to electrical conductors and equipment. The electric field is expressed in measurement units of volts per meter ("V/m") or kilovolts per meter ("kV/m"); 1 kV/m is equal to 1,000 V/m. Most objects, including fences, shrubbery, and buildings, easily block electric fields. Therefore, certain appliances within homes and the workplace are the major sources of electric fields indoors, while power lines are the major sources of electric fields outdoors (Figure 7-1, lower panel). It should be noted that electric fields from cables are contained within the sheaths of the individual cables.

Magnetic fields are produced by the flow of electric currents; however, unlike electric fields, most materials do not readily block magnetic fields. The level of a magnetic field is commonly expressed as magnetic flux density in units called gauss ("G"), or in milliGauss ("mG"), where 1 G = 1,000 mG. The magnetic field level at any point depends on characteristics of the source, including the arrangement of conductors, the amount of current flow through the source, and its distance from the point of measurement. The levels of both electric fields and magnetic fields diminish with increasing distance from the source.

Background AC magnetic field levels in homes are generally less than 20 mG when not near a particular source, such as some appliances. Higher magnetic field levels can be measured outdoors in the vicinity of distribution lines, sub-transmission lines, and transmission lines (refer to Figure 7-1, upper panel).

Figure 7-1: Electric and Magnetic Fields in the Environment

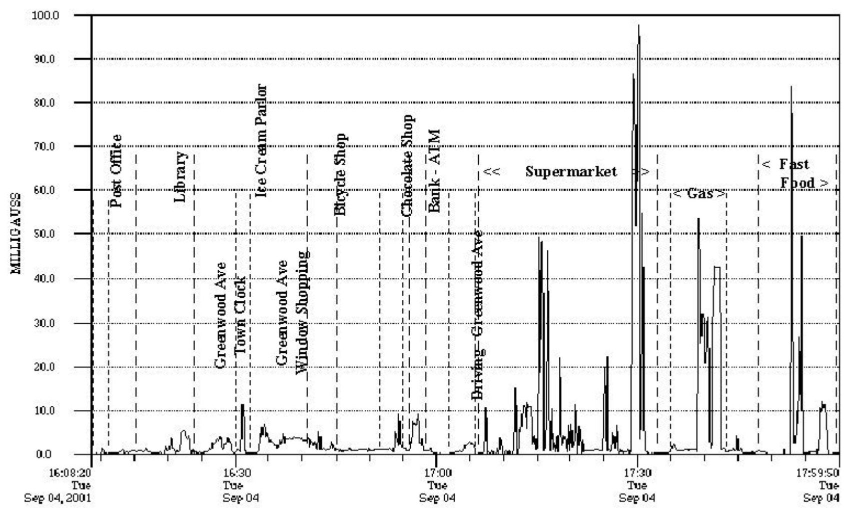


Considering EMF from a range of specific sources or environments, as illustrated in Figure 7-1, does not fully reflect the variations in an individual's personal exposure as encountered in everyday life. To illustrate this, magnetic field measurements were recorded, over a two-hour period, by a meter worn at the waist of an individual who conducted a range of typical daily activities in a Connecticut town.

As illustrated in Figure 7-2, these activities included a visit to the post office and the library, walking along the street, getting ice cream, browsing in a bicycle shop, stopping in a chocolate shop, going to the bank/ATM, driving along streets, shopping in a supermarket, stopping for gas, and purchasing food at a fast food restaurant.

Electric appliances are among the strongest sources of AC magnetic fields encountered in indoor environments. Magnetic fields near appliances can reach 1,000 mG or more. For example, Gauger (1985) reports the maximum AC magnetic field at 3 centimeters from a sampling of appliances as follows: 3,000 mG (can opener), 2,000 mG (hair dryer), 5 mG (oven), and 0.7 mG (refrigerator). Similar measurements have shown that there is a tremendous variability among appliances made by different manufacturers. The potential contribution of different sources to overall exposure over long periods is not very well characterized, but both repeated exposure to higher fields for short times and longer exposure to lower intensity fields for a long time contribute to an individual's total exposure.

Figure 7-2: Typical Magnetic Field Exposures in a Connecticut Town (Bethel)



The maximum, average and median exposures encountered during the course of the two hour measurement period are provided in Table 7-1. As Figure 7-2 shows, from moment-to-moment in everyday life, magnetic fields are encountered that vary in intensity over a wide range. Other individual patterns of exposure to magnetic fields could be very different and reflect the individual's personal activities. For example, a rider on a commuter or long-distance electric train in Connecticut would encounter higher average power-frequency magnetic fields of perhaps 14 to 50 mG during a trip, with potential peak values in the range of 100 to 400 mG (Department of Transportation, Federal Railroad Administration, 2006).

Table 7-1: Summary of Magnetic Fields Measured in a Connecticut Town (Bethel)

Magnetic Field Levels (milliGauss, mG)		
Maximum*	Average	Median
97.55	4.57	1.10

*Maximum occurred in the supermarket

7.2 EMF REGULATIONS AND GUIDELINES IN CONNECTICUT

Transmission lines are common sources of EMF, as are other components of electric power infrastructure, ranging from transformers and distribution lines, to the wiring and appliances in a home. There are no state or federal laws or regulations concerning transmission line electric and magnetic fields. However, to address concerns regarding potential health risks from exposure to EMF, the Council, after a nearly two-year proceeding, developed a policy document entitled *Electric and Magnetic Fields Best Management Practices for the Construction of Electric Transmission Lines in Connecticut* (EMF BMP), a copy of which is provided is provided as Appendix 7A.

The EMF BMP Document summarizes the latest information regarding scientific knowledge and consensus on EMF and health concerns and recommends best practices concerning the design of new transmission lines with respect to EMF. The Council most recently revised the EMF BMP on February 20, 2014. In an annual review completed in November 2015, they determined that no further revisions were warranted to the EMF BMP.

In the EMF BMP, the Council recognized “that a causal link between power-line MF exposure and demonstrated health effects has not been established, even after much scientific investigation in the U.S. and abroad,” and “that timely additional research is unlikely to prove the safety of power-line MF to the satisfaction of all.” Accordingly, the Council decided to “continue its cautious approach to transmission line siting that has guided its Best Management Practices since 1993.” As the Council states in the EMF BMP:

This continuing policy is based on the Council’s recognition of an agreement with conclusions shared by a wide range of public health consensus groups, and also, in part, on a review which the Council commissioned as to the weight of scientific evidence regarding possible links between power-line MF and *adverse health effects. Under this policy, the Council will continue to advocate the use of effective no-cost and low-cost technologies and management techniques on a project-specific basis to reduce MF exposure to the public while allowing for the development of efficient and cost-effective electrical transmission projects*.

Pursuant to this policy, the Council requires an applicant proposing to build an overhead electric transmission line to develop and present a Field Management Design Plan ("FMDP") that identifies design features to mitigate MF that would otherwise occur along an electric transmission ROW. In accordance with the BMP guidelines, the proposed new Frost Bridge to Campville 115-kV line has been designed so that it will have very little effect on magnetic field levels within and along the ROW.

The magnitude of edge of ROW magnetic fields vary greatly according to the placement and configuration of the conductors on transmission lines, and the spatial relationship and current loading of multiple lines within a single ROW. For instance, one of the EMF BMP recommended by the Connecticut Siting Council is "optimum phasing," which refers to an engineering design technique that applies in situations where more than one circuit exists within a ROW. Electric transmission circuits utilize a three-phase system with each phase carried by one conductor, or a bundle of conductors. Optimum phasing reduces MF through partial cancellation. For a ROW with two or more circuits, the phasing of the conductors of each circuit can be arranged to reduce MF levels under typical conditions. This design is the prime example of a low-cost method of reducing MF.

The relative current loading of multiple circuits on a ROW will also influence edge of ROW magnetic fields. For instance, where a circuit that is normally loaded relatively lightly is placed parallel to a much more highly loaded line, the fields associated with the high current line will be dominant, such that the edge of ROW fields from the combination of the two lines may not be measurably greater than those produced by the high current line by itself. Where two parallel circuits are constructed between the same terminal points, the two circuits will share the load being transmitted between those points, with the effect that the edge of ROW magnetic fields will be lower than they would be if the same load were transmitted on a single circuit.

Both of the situations described above will exist on the Frost Bridge to Campville ROW after the proposed new line is constructed. On the segment of the ROW, from the Frost Bridge Substation to Purgatory Junction, the proposed new line will be adjacent to the existing 345-kV Line, a heavily loaded circuit that is now and will remain the dominant magnetic field source on the ROW. In addition, the new line will be built adjacent to the existing 115-kV Line, and will share with that line the load transmitted between Purgatory Junction and Campville Substation. As a result, the addition of the proposed new line to the Frost Bridge to Campville ROW will have very little effect on the pre-existing edge of ROW magnetic fields.

7.3 EMF MEASUREMENTS AND CALCULATIONS

The EMF BMP require transmission line applicants to present calculations of MF under pre-project and post-project conditions, assuming the use of different transmission line design alternatives. The purpose of this requirement is to "allow for an evaluation of how MF levels differ between alternative power line configurations," in order to "achieve reduced MF levels when possible through practical design changes." However, the reduction of MF is only one of the factors that the Council will consider in approving particular line designs. Other factors include "cost, system reliability, aesthetics, and environmental quality."

7.3.1 Measured Electric and Magnetic Fields

In September 2, 2015, Eversource took spot measurements of existing magnetic fields at selected locations along the Proposed Route. Measurements of the MF present a "snapshot" of the conditions at a point in time. Within a day, and over the course of days, months, and even seasons, magnetic field levels change at any given location, depending on the amount and the patterns of power supply and demand within the state and surrounding region.

The Council's Application Guide requires measurements of existing EMF at the boundaries of adjacent schools, daycare facilities, playgrounds, hospitals and residential areas. There are no schools, daycare facilities, hospitals and residential areas adjacent to the ROW.

However, the baseball field at Veteran's Memorial Park in the Town of Watertown, which is adjacent to the ROW, qualifies as a playground. Accordingly, measurements were taken at the edge of the baseball field closest to the existing transmission line. In addition, measurements were taken across the ROW, including at boundaries of adjacent properties, at locations where houses are closest to the ROW.

These areas, as well as the Veteran's Memorial Park baseball field, are referred to as "Focus Areas." The measurements near each of these three Focus Areas were taken at a height of 1 meter (3.28 feet) above ground, in accordance with the industry standard protocol for taking measurements of EMF near power lines (IEEE Standard. 644-1994, R2008).

Each Focus Area is discussed in the following subsections. Measurements across the ROW at these Focus Areas were taken on a horizontal transect, as illustrated by a magenta line on the Figures 7-3 through 7-5.

7.3.1.1 Veteran's Memorial Park (Watertown)

The magnetic field spot measurement at Veteran's Memorial Park was 1.0 mG, as identified in Table 7-2, which is within the range of background magnetic field levels commonly found in homes.

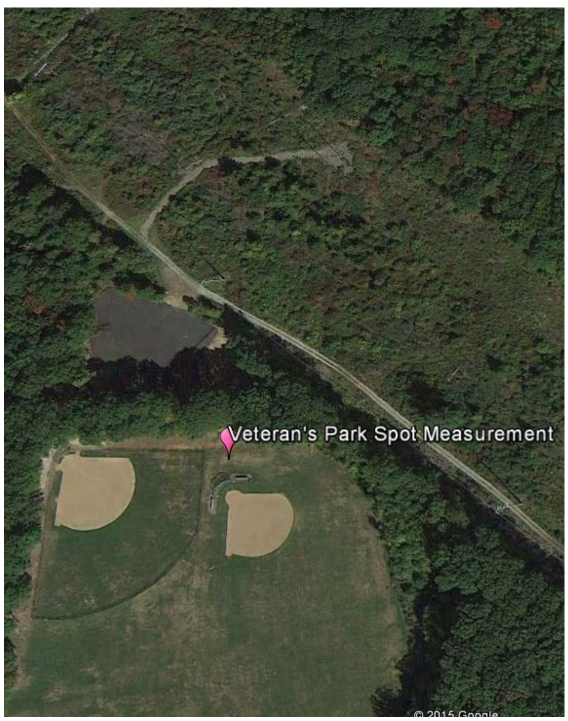


Figure 7-3: GoogleEarth™ View of Spot Measurement at Veteran's Park

Table 7-2: Spot Measurements at Veteran's Memorial Park (Focus Area A)

Spot Measurements at Veteran's Park (Focus Area A)	
Magnetic Field (mG)	1.00
Electric Field (kV/m)	0.00

7.3.1.2 Walnut Hill Rd (Thomaston)

The measured magnetic fields across the ROW in the vicinity of Walnut Hill Road in Thomaston are characteristic of the fields along the entire segment of ROW between Purgatory Junction and Walnut Hill Junction. The location of the Walnut Hill Road measurements is illustrated by the magenta line in Figure 7-4. Magnetic fields vary between 12.33 mG and 15.95 mG and electric fields vary between 0.075 kV/m and 0.332 kV/m.

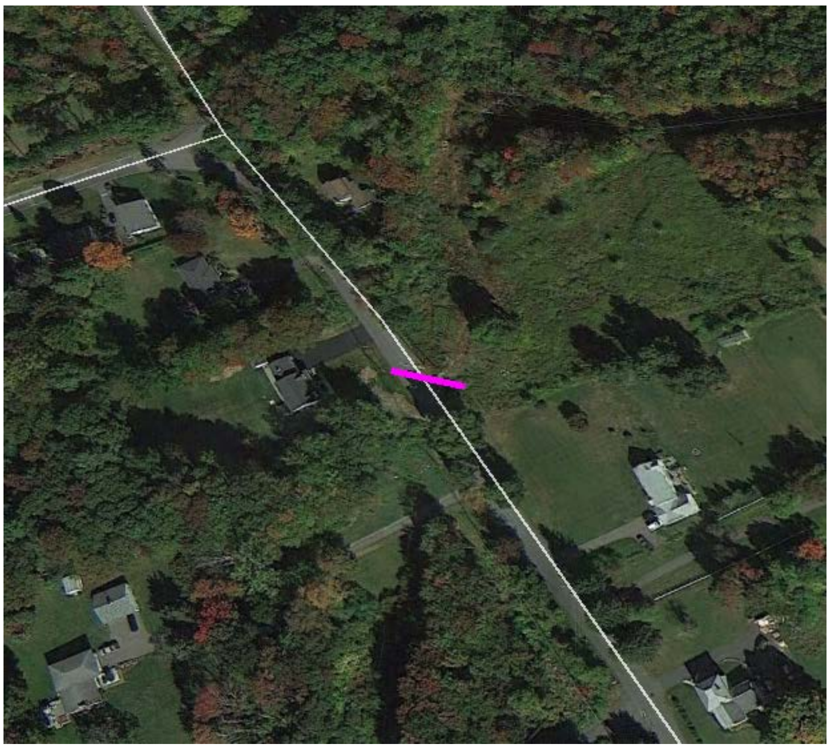


Figure 7-4: GoogleEarth™ View of Measurement Path on Walnut Hill Road Along Proposed Route

7.3.1.3 Campville Road (Litchfield)

The measured magnetic fields across the ROW in the vicinity of Campville Road in Litchfield are characteristic of the fields along the entire segment of ROW between Walnut Hill Junction and Campville Substation. The location of the Campville Road measurements is illustrated by the magenta line in Figure 7-5. Magnetic fields vary between 5.11 mG and 30.01 mG and electric fields vary between 0.096 kV/m and 0.932 kV/m.

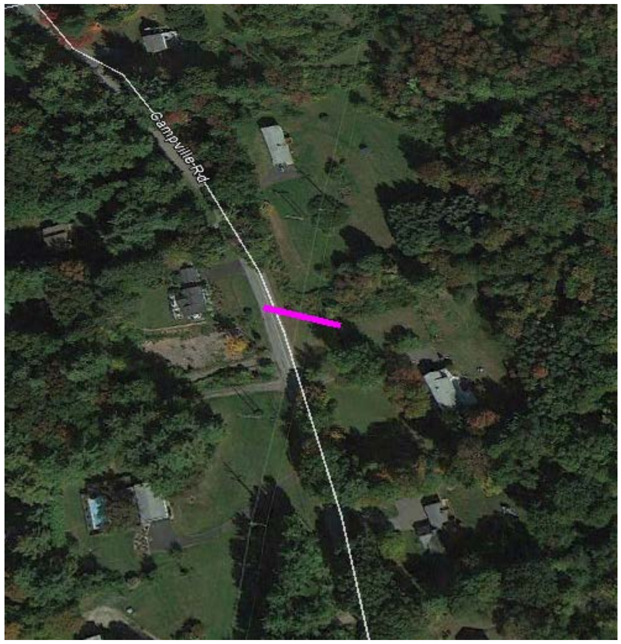


Figure 7-5: GoogleEarthTM View of Measurement Path on Campville Rd Along Proposed Route

7.3.2 Calculated Electric and Magnetic Fields

Eversource prepared initial calculations of the existing and predicted MF from the transmission lines along the Proposed Route. The calculations most representative of typical conditions are based on projected average annual loading conditions, which were assumed in these calculations. As required by the EMF BMP, loads projected for the year 2019 (the first summer when the new line would be in service) were used for the existing transmission lines and loads projected for 2024 (5 years after the line will have been placed in service) were used for the proposed transmission line. The calculations are made relative to the centerline of the proposed transmission line. As provided by standard protocols, the calculations apply at 1 meter (3.28 feet) above grade, and assume that the lowest conductor for each 115-kV circuit is 30 feet above grade and that the 345-kV circuit (which is within the ROW only between Frost Bridge Substation and Purgatory Junction) is 35 feet above grade. These calculations confirm that the addition of the new line will not substantially increase electric and magnetic fields at the edge of the ROW, and will decrease them in some locations, compared to current conditions. Table 7-3 summarizes the calculated magnetic fields at the ROW edges before and after the construction of the new line. Each of the three rows of the table relates to a segment of the ROW where the number and/or configuration of the lines on the ROW is different.

Table 7-3: Summary of Magnetic Field Calculations

Magnetic Field Calculation Summary (Average Annual Loads, field in mG)				
Section	Left Edge of ROW		Right Edge of ROW	
	Pre	Post	Pre	Post
Frost Bridge S/S to Purgatory Junction	23.9	23.5	41.3	40.9
Purgatory Junction to Walnut Hill Junction	7.3	4.2	6.1	3.9
Walnut Hill Junction to Campville S/S	20.5	12.8	0.6	1.4

*Left and right edges of ROW are defined by looking from Frost Bridge Substation to Campville Substation

Eversource also prepared calculations of EF from the transmission lines along the Proposed Route; these are summarized in Table 7-4. The calculations assume that the voltages on all transmission lines are at 1.05 per unit value (the maximum permissible voltage per ISO-NE planning criteria). The conductor heights are assumed to be the same as for the magnetic field calculations discussed above. The calculations show minimal increases and decreases in the edge of ROW electric fields after the construction of the new line.

Table 7-4 –Summary of Electric Field Calculations

Electric Field Calculation Summary (Field in kV/m)				
Section	Left Edge of ROW		Right Edge of ROW	
	Pre	Post	Pre	Post
Frost Bridge S/S to Purgatory Junction	0.23	0.22	0.98	0.96
Purgatory Junction to Walnut Hill Junction	0.23	0.20	0.02	0.08
Walnut Hill Junction to Campville S/S	1.18	1.16	0.04	0.08

The MF associated with the existing and new conditions on the ROW are graphically depicted in Figures 7-6 through 7-8. These figures represent the MF levels across the entire width of the ROW and for 100 feet beyond each edge. Each graph includes one line for the “before” condition and another line for the “after” conditions. The “after” line is nearly on top of the “before” line because there is so little change in the levels represented. Figures 7-6 through 7-8 represents the “before” and “after” MF levels.

Figure 7-6: Calculated Magnetic Fields between Frost Bridge Substation and Purgatory Junction (Average Annual Load)

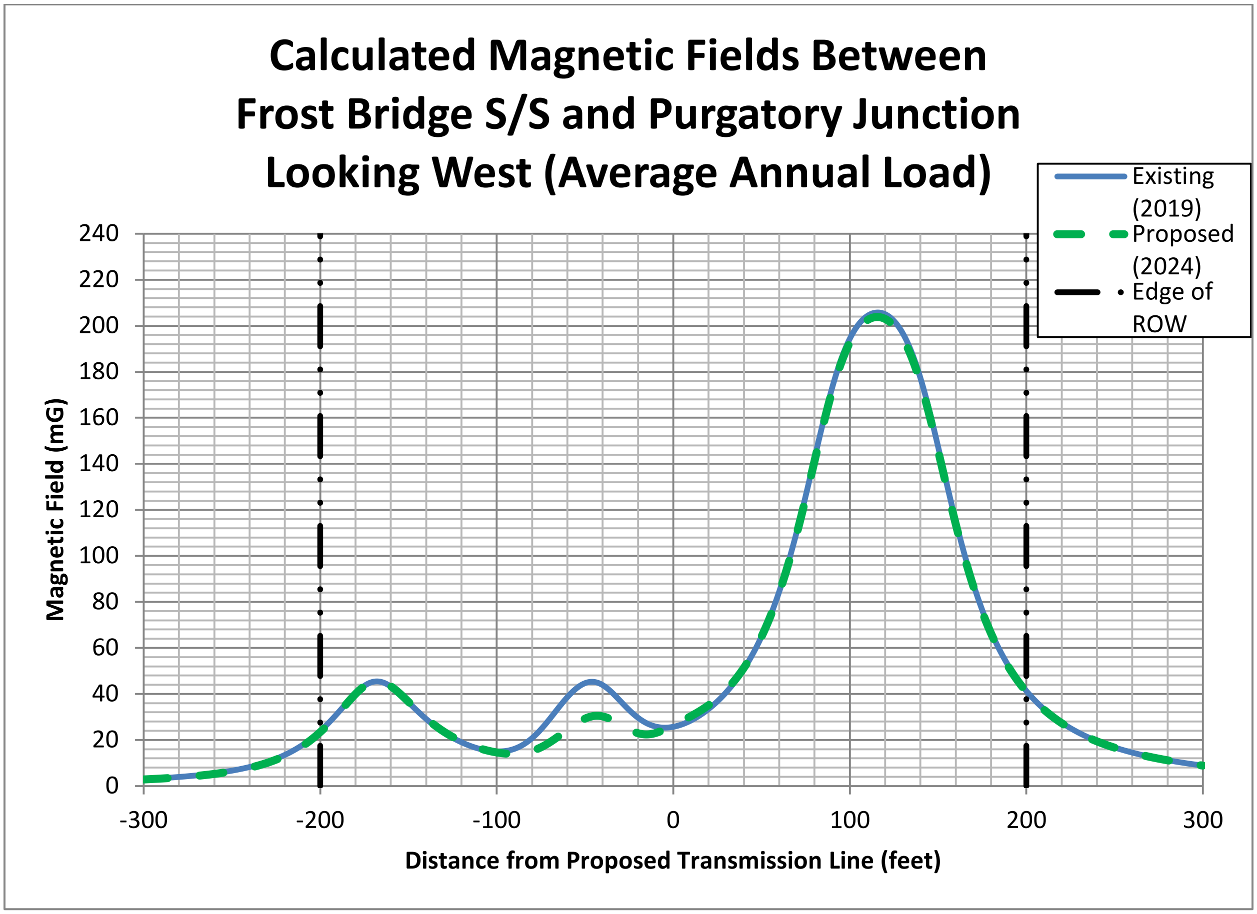


Figure 7-7: Calculated Magnetic Fields between Purgatory Junction and Walnut Hill Junction (Average Annual Load)

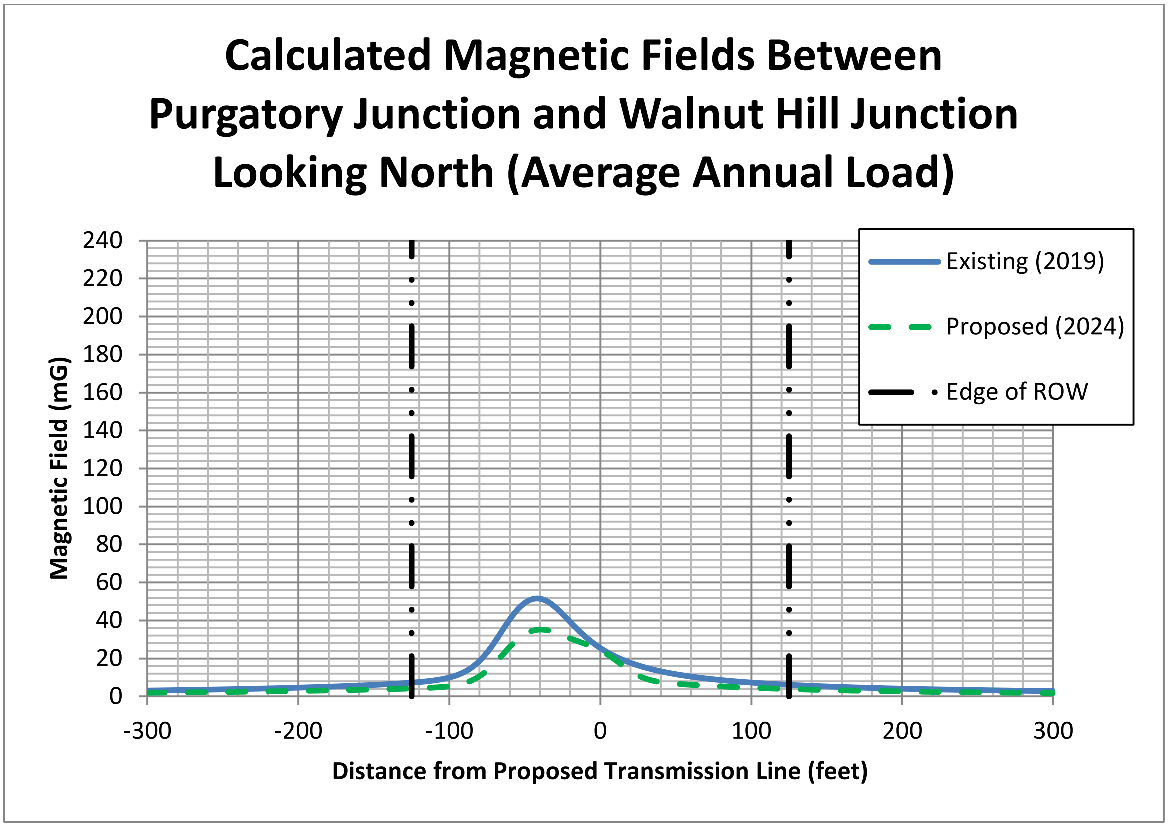
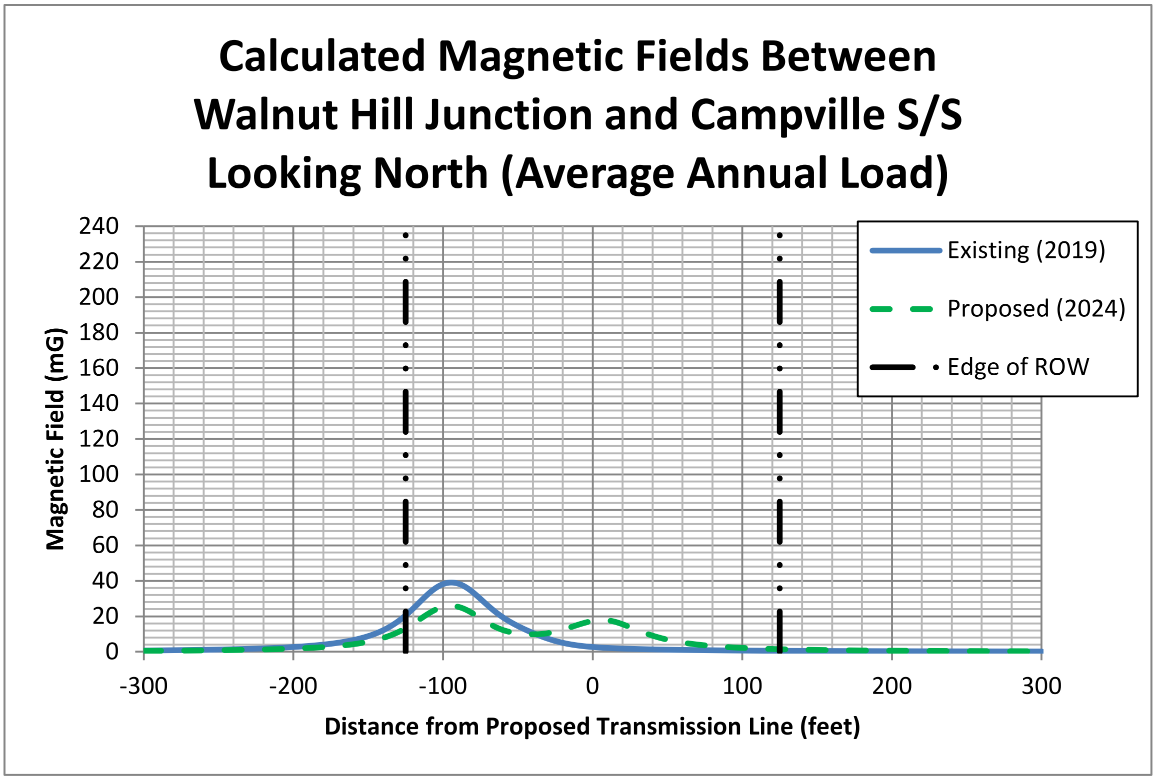


Figure 7-8: Calculated Magnetic Fields between Walnut Hill Junction and Campville S/S (Average Annual Load)



Figures 7-9 through 7-10 illustrate the calculated "before" and "after" electric fields within the ROW and to a hundred feet beyond each of its edges. As with MF, there is very little change in the levels within and beyond the ROW.

Figure 7-9: Calculated Electric Fields between Frost Bridge Substation and Purgatory Junction

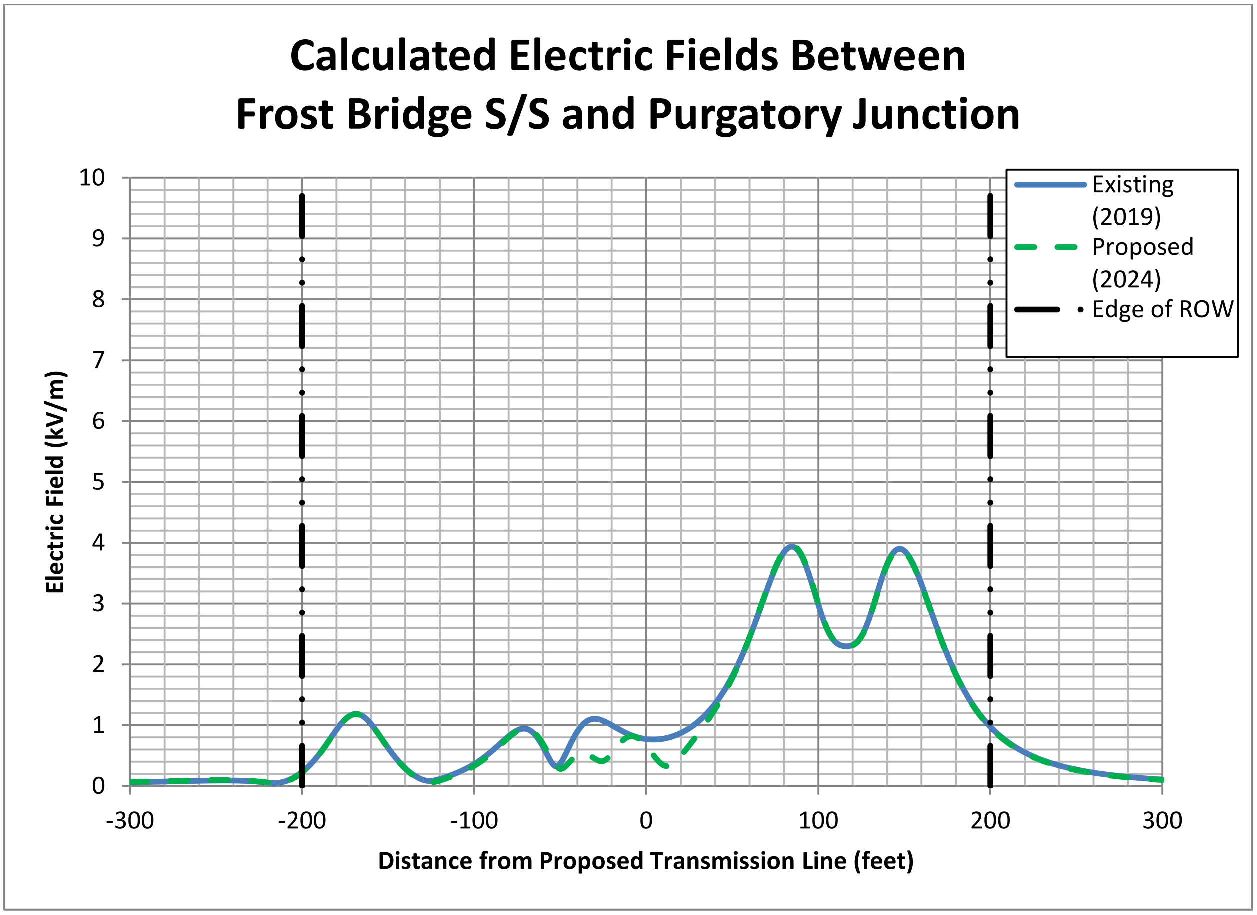


Figure 7-10: Calculated Electric Fields between Purgatory Junction and Walnut Hill Junction

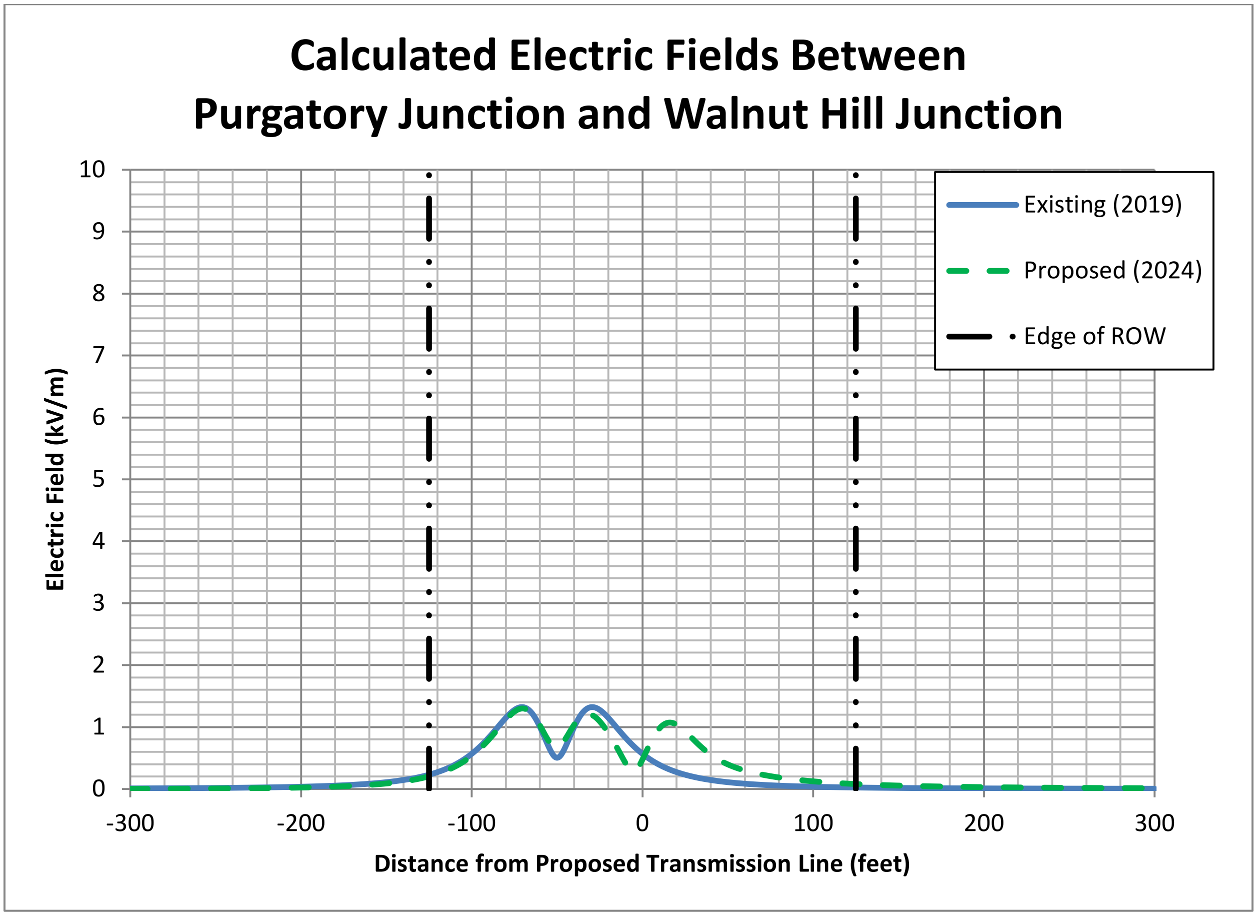
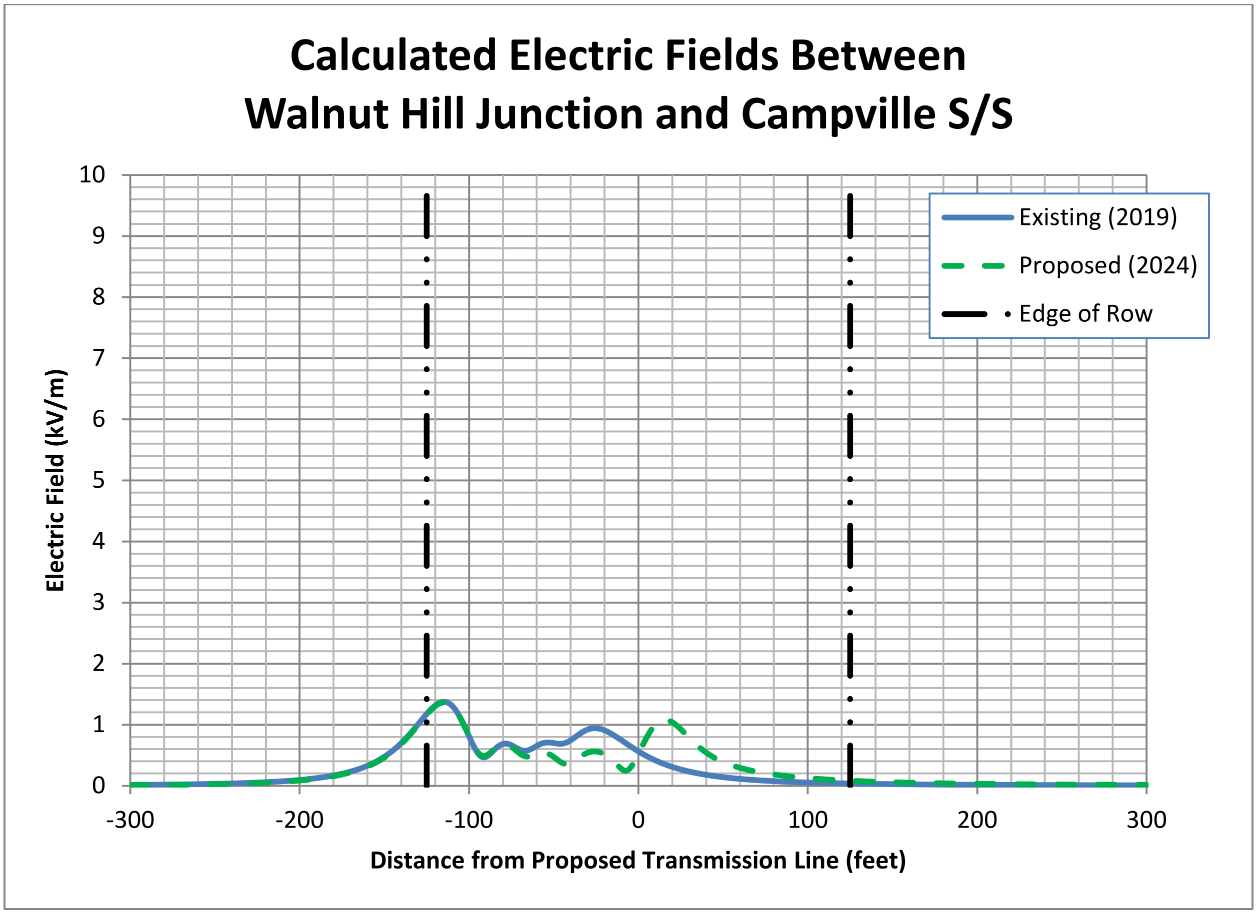


Figure 7-11: Calculated Electric Fields between Walnut Hill Junction and Campville Substation



7.4 COMPARISON OF EDGE OF ROW MAGNETIC FIELDS TO INTERNATIONAL GUIDELINES

Although there are no binding regulations limiting EMF exposures, guidelines have been developed by the international scientific community, in particular the International Committee on Electromagnetic Safety ("ICES"), a committee of the Institute of Electrical and Electronics Engineers) and the International Council on Non-Ionizing Radiation Protection ("ICNIRP"), a specially chartered independent scientific organization. Under all projected operating conditions after the proposed 115-kV line is placed in service, the calculated electric and magnetic fields will be a small fraction of the ICNIRP and ICES guidelines, which are summarized Table 7-5.

Table 7-5: International Restrictions for Electric and Magnetic Fields

	Magnetic Fields (mG)	Electric Fields (kV/M)
ICNIRP	2,000	4.2
ICES	9,040	10

The calculations presented in Section 7.3 projects that after the new line is constructed, under typical (annual average) operating conditions, edge of ROW magnetic fields will range from 1.4 mG to 40.9 mG and electric fields will range from 0.08 to 1.16 kV/m.

7.5 UPDATE ON EMF HEALTH RESEARCH

In its BMP, the Council recognized the consistent conclusions of "a wide range of public health consensus groups," as well as their own commissioned weight-of-evidence review. The Council summarized the current scientific consensus by noting the conclusions of these public health groups, including a review by the World Health Organization ("WHO") in 2007 and previously published reviews by the National Institute for Environmental and Health Sciences (1999), the International Agency for Research on Cancer (2002), the Australian Radiation Protection and Nuclear Safety Agency (2003), the National Radiological Protection Board of Great Britain (2004), and the Health Council of the Netherlands (2005). The Council noted that these scientific authorities "have not found any *consistent* associations with regard to ELF EMF exposure and any type of cancer or disease, except childhood leukemia, nor have they concluded that there is a cause-and-effect link with any health effect, including childhood leukemia." The Council also noted the WHO's conclusion with respect to other diseases: "the scientific evidence supporting an association between ELF [extremely low frequency] magnetic field exposure and all of these health effects is much weaker than for childhood leukemia". (BMP, p. 2)

Based on this scientific consensus, the Council concluded that precautionary measures for the siting of new transmission lines include "the use of effective no-cost and low-cost technologies and management techniques on a project-specific basis to reduce MF exposure to the public while allowing for the development of efficient and cost-effective electrical transmission projects." The BMP also stated that the Council will "consider and review evidence of any new developments in scientific research addressing MF and public health effects or changes in scientific consensus group positions regarding MF." (BMP, pp. 5-6)

Accordingly, in its March 16, 2010 decision approving the Greater Springfield Reliability Project, the Council evaluated extensive evidence concerning recent developments in EMF health effects research, including commentary from the Connecticut DEEP's Radiation Division, and concluded that: "There is no new evidence that might alter the scientific consensus articulated in the Council's 2007 EMF BMP document." (Docket 370, Opinion at 12; and see Findings of Fact par. 284-286)

To assist the Council in evaluating the most up-to-date research, the Exponent report, which is provided in Appendix 7D includes a review of recently published scientific research and reviews. Significantly, Exponent's report summarizes:

Eversource has commissioned a review of the current state of scientific research by Exponent Inc., an independent scientific consultant, regarding ELF EMF and potential health effects. A copy of that report is provided as Appendix 7D. The report concludes that "no recent studies provide evidence to alter the conclusion that the scientific evidence does not confirm that EMF exposure is the cause of cancer or any other disease process at the levels we encounter in our everyday environment." (Appendix 7D, p. 63)

7.6 STATEMENT OF COMPLIANCE WITH EMF BEST MANAGEMENT PRACTICES

Eversource has provided EMF measurements and calculations and an update of EMF research in accordance with the Council's Application Guide and the BMP for the proposed transmission line from the Frost Bridge Substation to Campville Substation.

7.7 REFERENCES

- Connecticut Siting Council Electric and Magnetic Field Best Management Practices for the Construction of Electric Transmission Lines in Connecticut. Rev. February 20, 2014. http://www.ct.gov/csc/lib/csc/emf_bmp/revisions_updates/754bmpfinal.pdf
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- CL&P Application to the Connecticut Siting Council for a Certificate of Environmental Compatibility and Public Need for the Stamford Reliability Cable Project (Docket 435).
- Regulations of Connecticut State Agencies, Section 16-50j-59(18).
- Exponent. "Research on Extremely Low Frequency Electric and Magnetic Fields and Health." Report. 4 Dec. 2015.

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Appendix 7A
CSC, "Electric and Magnetic Fields Best Management Practices for the Construction of Electric Transmission Lines in Connecticut," February 2014.

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Electric and Magnetic Fields Best Management Practices For the Construction of Electric Transmission Lines in Connecticut

Revised on February 20, 2014

I. Introduction

To address a range of concerns regarding potential health risks from exposure to transmission line electric and magnetic fields (EMF), whether from electric transmission facilities or other sources, the Connecticut Siting Council (Council) (in accordance with Public Act 04-246) issues this policy document *"Electric and Magnetic Fields Best Management Practices for the Construction of Electric Transmission Lines in Connecticut."* It references the latest information regarding scientific knowledge and consensus on EMF health concerns; it also discusses advances in transmission- facility siting and design that can affect public exposure to EMF.

Electric and magnetic fields (EMF) are two forms of energy that surround an electrical device. The strength of an electric field (EF) is proportional to the amount of electric voltage at the source, and decreases rapidly with distance from the source, diminishing even faster when interrupted by conductive materials, such as buildings and vegetation. The level of a magnetic field (MF) is proportional to the amount of electric current (not voltage) at the source, and it, too, decreases rapidly with distance from the source; but magnetic fields are not easily interrupted, as they pass through most materials. EF is often measured in units of kilovolts per meter (kV/m). MF is often measured in units of milligauss (mG).

Transmission lines are common sources of EMF, as are other substantial components of electric power infrastructure, ranging from transformers at substations to the wiring in a home. However, any piece of machinery run by electricity can be a source of EMF: household objects as familiar as electric tools, hair dryers, televisions, computers, refrigerators, and electric ovens.

In the U.S., EMF associated with electric power have a frequency of 60 cycles per second (or 60 Hz). Estimated average background levels of 60-Hz MF in most homes, away from appliances and electrical panels, range from 0.5 to 5.0 mG (NIEHS, 2002). MF near operating appliances such as an oven, fan, hair dryer, television, etc. can range from 1O's to 1OO's of mG. Many passenger trains, trolleys, and subways run on electricity, producing MF: for instance, MF in a Metro-North Railroad car averages about 40-60 mG, increasing to 90-145 mG with acceleration (Bennett Jr., W. 1994). As a point of comparison to these common examples, the Earth itself has an MF of about 570 mG (USGS 2007). Unlike the MF associated with power lines, appliances, or computers, the Earth's MF is steady; in every other respect, however, the Earth's MF has the same characteristics as MF emanating from man-made sources.

Concerns regarding the health effects of EMF arise in the context of electric transmission lines and distribution lines, which produce time-varying EMF, sometimes called extremely-low frequency electric and magnetic fields, or ELF-EMF. As the weight of scientific evidence indicates that exposure to electric fields, beyond levels traditionally established for safety, does not cause adverse health effects, and as safety concerns for electric fields are sufficiently addressed by adherence to the National Electrical Safety Code, as amended, health concerns regarding EMF focus on MF rather than EF.

MF levels in the vicinity of transmission lines are dependent on the flow of electric current through them and fluctuate throughout the day as electrical demand increases and decreases. They can range from about 5 to 150 mG, depending on current load, height of the conductors, separation of the conductors, and distance from the lines. The level of the MF produced by a transmission line decreases with increasing distance from the conductors, becoming indistinguishable from levels found inside or outside homes (exclusive of MF emanating from sources within the home) at a distance of 100 to 300 feet, depending on the design and current loading of the line {NIEHS, 2002).

In Connecticut, existing and proposed transmission lines are designed to carry electric power at voltages of 69, 115, or 345 kilovolts (kV). Distribution lines, i.e. those lines directly servicing the consumer's building, typically operate at voltages below 69 kV and may produce levels of MF similar to those of transmission lines. The purpose of this document is to address engineering practices for proposed electric transmission lines with a design capacity of 69 kV or more and MF health concerns related to these projects, but not other sources of MF.

II. Health Concerns from Power-Line MF

While more than 40 years of scientific research has addressed many questions about EMF, the continuing question of greatest interest to public health agencies is the possibility of an association between time weighted MF exposure and demonstrated health effects. The World Health Organization (WHO) published its latest findings on this question in an Electromagnetic Fields and Public Health fact sheet, June 2007) http://www.who.int/peh- emf/publications/facts/fs322/en/index.html The fact sheet is based on a review by a WHO Task Group of scientific experts who assessed risks associated with ELF-EMF. As part of this review, the group examined studies related to MF exposure and various health effects, including childhood cancers, cancers in adults, developmental disorders, and neurobehavioral effects, among others. Particular attention was paid to leukemia in children. The Task Group concluded "that scientific evidence supporting an association between ELF magnetic field exposure and all of these health effects is much weaker than for childhood leukemia". (WHO, 2007) For childhood leukemia, WHO concluded recent studies do not alter the existing position taken by the International Agency for Research on Cancer (!ARC) in 2002, that ELF-MF is "possibly carcinogenic to humans."

Some epidemiology studies have reported an association between MF and childhood leukemia, while others have not. Two broad statistical analyses of these studies reported an association with estimated average exposures greater than 3 to 4 mG, but at this level of generalization it is difficult to determine whether the association is significant. In 2005, the National Cancer Institute (NCI) stated, "Among more recent studies, findings have been mixed. Some have found an association; others have not .... Currently, researchers conclude that there is limited evidence that magnetic fields from power lines cause childhood leukemia, and that there is inadequate evidence that these magnetic fields cause other cancers in children." The NCI stated further: "Animal studies have not found that magnetic field exposure is associated with increased risk of cancer. The absence of animal data supporting carcinogenicity makes it biologically less likely that magnetic field exposures in humans, at home or at work, are linked to increased cancer risk."

The National Institute of Environmental Health Sciences (NIEHS) concluded in 1999 that EMF exposure could not be recognized as *"entirely safe"* due to some statistical evidence of a link with childhood leukemia. Thus, although no public health agency has found that scientific research suggests a causal relationship between EMF and cancer, the NIEHS encourages "inexpensive and safe reductions in exposure" and "suggests that the power industry continue its current practice of siting power lines to reduce exposures" rather than adopting strict regulatory guidelines (NIEHS, 1999, pp. 37-38). In 2002 NIEHS restated that while this evidence was "weak" it was "still sufficient to warrant limited concern" and recommended "continued education on ways of reducing exposures" (NIEHS, 2002, p. 14).

Reviews by other study groups, including IARC (2002), the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (2003), the British National Radiation Protection Board (NRPB) (2004a), and the Health Council of the Netherlands ELF Electromagnetic Fields Committee (2005), are similar to NIEHS and NCI in their uncertainty about reported associations of MF with childhood leukemia. In 2004, the view of the NRPB was:

"[T]he epidemiological evidence that time-weighted average exposure *tb* power frequency magnetic fields *above* 0.4 microtesla [4 mG] is associated with a small absolute raised risk of leukemia in children is, af present, an observation for which there is no sound scientific explanation. There is no clear evidence of a carcinogenic effect of ELF EMFS in adults and no plausible biological explanation of the association can be obtained from experiments with animals or from cellular and molecular studies. Alternative explanations for this epidemiological association are possible..Thus: any judgments developed on the assumption that the association is causal would be subject to a *very* high level of uncertainty." (NRPB, 2004a, p. 15)

Although IARC classified MF as "possibly carcinogenic to humans" based upon pooling of the results from several epidemiologic studies, IARC further stated that the evidence suggesting an association between childhood leukemia and residential MF levels is "limited," with "inadequate" support for a relation to any other cancers. The WHO Task Group concluded "the evidence related to childhood leukemia is not strong enough to be considered causal" (WHO, 2007).

The Connecticut Department of Public Health (DPH) has produced an EMF Health Concerns Fact Sheet (May 2007) that incorporates the conclusions of national and international health panels. The fact sheet states that while "the current scientific evidence provides no definitive answers as to whether EMF exposure can increase health risks, there is enough uncertainty that some people may want to reduce their exposure to EMF."
http://www.ct.gov/dphllib/dph/environmental_health/eoha/pdf/emf_fact_sheet_-_2008.pdf

In the U.S., there are no state or federal exposure standards for 60-Hz MF based on demonstrated health effects. Nor are there any such standards world-wide. Among those international agencies that provide guidelines for acceptable MF exposure to the general public, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) established a level of 833 mG, based on an extrapolation from experiments involving transient neural stimulation by MF at much higher exposures. Using a similar approach, the International Committee on Electromagnetic Safety (ICES) calculated a guideline of 9,040 mG for exposure to workers and the general public (ICNIRP, 1998; ICES/IEEE, 2002). This situation reflects the lack of credible scientific evidence for a causal relationship between MF exposure and adverse health effects.

In November 2010, ICNIRP updated its guidelines. The new guideline establishes 2,000 mG as an acceptable exposure level for the general public replacing the previous 1998 exposure guideline of 833 mG. (See "ICNIRP Statement- Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz). Health Physics 99(6):818-836; 2010" http://www.icnirp.org/documents/LFgdl.pdf and "Fact Sheet on the Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz) Published in Health Physics 99(6):818-836;2010" http://www.icnirp.org/documents/FactSheetLF.pdf at www.icnirp.org.)

Ill. Policy of the Connecticut Siting Council

The Council recognizes that a causal link between power-line MF exposure and demonstrated health effects has not been established, even after much scientific investigation in the U.S. and abroad. Furthermore, the Council recognizes that timely additional research is unlikely to prove the safety of power-line MF to the satisfaction of all. Therefore, the Council will continue its autious approach to transmission line siting that has guided its Best Management Practices since 1993. This continuing policy is based on the Council's recognition of and agreement with conclusions shared by a wide range of public health consensus groups, and also, in part, on a 2006 review which the Council commissioned as to the weight of scientific evidence regarding possible links between power-line MF and adverse health effects[1].

Under this policy, the Council will continue to advocate the use of effective no-cost and low-cost technologies and management techniques on a project-specific basis to reduce MF exposure to the public while allowing for the development of efficient and cost-effective electrical transmission projects. This approach does not imply that MF exposure will be lowered to any specific threshold or exposure limit, nor does it imply MF mitigation will be achieved with no regard to cost

The Council has developed its precautionary guidelines in conjunction with Section 16-50p(i) of the Connecticut General Statutes, enacted by the General Assembly to call special attention to their concern for children. Subject to technological feasibility, the Act restricts the siting of overhead 345-kV transmission lines in areas where children congregate. These restrictions cover transmission lines adjacent to "residential areas, public or private schools, licensed child day-care facilities, licensed youth camps, or public playgrounds."

Developing Policy Guidelines

One important way the Council seeks to update its Best Management Practices is to integrate policy with specific project development guidelines. In this effort, the Council has reviewed the actions of other states. Most states either have no specific guidelines or have established arbitrary MF levels at the edge of a right-of-way that are not based on any demonstrated health effects. California, however, established a no-cost/low-cost precautionary-based EMF policy in 1993 that was re-affirmed by the California Public Utilities Commission in 2006. California's policy aims to provide significant MF reductions at no cost or low cost, a precautionary approach consistent with the one Connecticut has itself taken since 1993, consistent with the conclusions of the major scientific reviews, and consistent with the policy recommendations of the Connecticut Department of Public Health and the WHO. Moreover, California specifies certain benchmarks integral to its policy. The benchmark for "low-cost/no-cost" is an increase in aggregate project costs of zero to four % The benchmark for "significant MF reduction" is an MF reduction of at least 15 % With a policy similar to Connecticut's, and concrete benchmarks as well, California offers the Council a useful model in developing policy guidelines.

[1] Current Status of Scientific Research, Consensus, and Regulation Regarding Potential Health Effects of Power-Line Electric and Magnetic Fields (EMF) http://www.ctgov/csc/lib/csc/emf_bmp/emf_report.pdf

No-Cost/Low-Cost MF Mitigation

The Council seeks to continue its precautionary policy, in place since 1993, while establishing a standard method to allocate funds for MF mitigation methods. The Council recognizes California's cost allotment strategy as an effective method to achieve MF reduction goals; thus, the Council will follow a similar strategy for no-cost/low-cost MF mitigation.

The Council directs the Applicant to initially develop a baseline Field Management Design Plan that depicts the proposed transmission line project designed according to standard good utility practice and incorporating "no-cost" MF mitigation design features. The Applicant shall then modify #le this base design by adding low-cost MF mitigation design features specifically where portions of the project are adjacent to residential areas, public or private schools, licensed child day-care facilities, licensed youth camps, or public playgrounds. The overall cost of low-cost design features are to be calculated at four % of the initial Field Management Design Plan, including related substations. The best estimates of total project costs that are worked out during the Council proceedings should be employed, with the amounts proposed to be incurred for MF mitigation excluded. It is important to note that the four % guideline is not an absolute cap, because the

Council does not want to eliminate prematurely a potential measure that might be available and effective but would cost more than the four %, or exclude arbitrarily an area adjacent to the ROW that might be suitable for MF mitigation. Nor is the four % an absolute threshold, since the Council wants to encourage the utilities to seek effective field reduction measures costing less than four %. In general, the Council recognizes that projects can vary widely in the extent of their impacts on statutory facilities, necessitating some variance above and below the four % figure.

The four % guideline for low-cost mitigation should aim at a magnetic field reduction of 15 % or more at the edge of the utility's ROW. This 15 % reduction should relate specifically to those portions of the project where the expenditures would be made. While experience with transmission projects in Connecticut since 1993 has shown that no-cost/low-cost designs can and do achieve reductions in MF on the order of 15 %, the 15 % guideline is no more absolute than the four % one, nor must the two guidelines be correlated by rote. The nature of guidelines is to be constructive, rather than absolute.

The Council will consider minor increases above the four % guideline if justified by unique circumstances, but not as a matter of routine. Any cost increases above the four % guideline should result in mitigation comparably above 15 %, and the total costs should still remain relatively low.

Undergrounding transmission lines puts MF issues out of sight, but it should not necessarily put them out of mind. After all, soils and other fill materials do not shield MF; rather, MF is reduced by the underground cable design (refer to page 9 for further information). However, special circumstances may warrant some additional cost in order to achieve further MF mitigation for underground lines. The utilities are encouraged, prior to submitting their application to the Council, to determine whether a project involves such special circumstances. Note that the extra costs of undergrounding done for purposes other than MF mitigation should be counted in the base project cost and not as part of the four % mitigation spending.

Additionally, the Council notes two general policies it follows in updating its EMF Best Management Practices and conducting other matters within its jurisdiction. One is a policy to support and monitor ongoing study. Accordingly, the Council, during the public hearing process for new transmission line projects, will consider and review evidence of any new developments in scientific research addressing MF and public health effects or changes in scientific consensus group positions regarding MF. The second Council policy is to encourage public participation and education. The Council will continue to conduct public hearings open to all, update its website to contain the latest information regarding MF health effect research, and revise these Best Management Practices to take account of new developments in MF health effect research or in methods for achieving no-cost/low-cost MF mitigation.

During its review of two recent transmission-line projects-Docket No. 424, approved December 27, 2012 and Docket No. 435, approved September 5, 2013-the Council pursued its policy of monitoring research on EMF.

In Council Docket No. 424 the document titled, *"Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health: Interstate Reliability Project, June 10, 2011"* was centered around the WHO 2007 report examining reports or scientific statements regarding the potential health effects of ELF-EMF over the past previous five years. In Council Docket No. 435 the document titled, *"Update of Research on Extremely Low Frequency Electric and Magnetic Fields and Health May 1, 2011- July 31, 2012 Stamford Reliability Cable Project August 30, 2012"* provides a bibliography of peer-reviewed national and international research and reviews. In general, the conclusions of these two documents are consistent with the scientific consensus articulated by the WHO and other scientific organizations and have not found any *consistent* associations with regard to ELF EMF exposure and any type of cancer or disease, except childhood leukemia, nor have they concluded that there is a cause-and-effect link with any health effect, including childhood leukemia.

Applying its policy of encouraging public participation and education the Council will continue to require that notices of proposed overhead transmission lines provided in utility bill enclosures pursuant to Conn. Gen. Slats. §16-50/(b) state the proposed line will meet the Council's Electric and Magnetic Fields Best Management Practices, specifying the design elements planned to reduce magnetic fields. The bill enclosure notice will inform residents how to obtain siting and MF information specific to the proposed line at the Council's website; this information will also be available at each respective town hall. Phone numbers for follow-up information will be made available, including those of DPH and utility representatives. The project's final post-construction structure and conductor specifications, including calculated MF levels, shall also be available at the Council's website and each respective town hall.

Finally, we note that Congress has directed the Department of Energy (DOE) periodically to assess congestion along critical transmission paths or corridors and apply special designation to the most significant ones. Additionally, Congress has given the Federal Regulatory Commission supplemental siting authority in DOE-designated areas. This means the Council must complete all matters in an expeditious and timely manner. Accordingly, the cooperation of all parties will be of particular importance in fulfilling the policies set forth above.

IV. MF Best Management Practices: Further Management Considerations

The Council's EMF Best Management Practices will apply to the construction of new electric transmission lines in the State, and to modifications of existing lines that require a certificate of environmental compatibility and public need. These practices are intended for use by public service utilities and the Council when considering the installation of such new or modified electric transmission lines. The practices are based on the established Council policy of reducing MF levels at the edge of a right-of-way (ROW), and in areas of particular interest, with no-cost/low-cost designs that do not compromise system reliability or worker safety, or environmental and aesthetic project goals.

Several practical engineering approaches are currently available for reducing MF, and more may be developed as technology advances. In proposing any particular methods of MF mitigation for a given project, the Applicant shall provide a detailed rationale to the Council that supports the proposed MF mitigation measures. The Council has the option to retain a consultant to confirm that the Field Management Design Plan and the proposed MF reduction strategies are consistent with these EMF Best Management Practices.

A. MF Calculations

When preparing a transmission line project, an applicant shall provide design alternatives and calculations of MF for pre-project and post-project conditions, under 1) peak load conditions at the time of the application filing, and 2) projected seasonal maximum 24-hour average current load on the line anticipated within five years after the line is placed into operation. This will allow for an evaluation of how MF levels differ between alternative power line configurations. The intent of requiring various design options is to achieve reduced MF levels when possible through practical design changes. The selection of a specific design will also be affected by other practical factors, such as the cost, system reliability, aesthetics, and environmental quality.

MF *values* shall be calculated from the ROW centerline out to a distance of 300 feet on each side of the centerline, at intervals of 25 feet, including at the edge of the ROW. In accordance with industry practice, the calculation shall be done at the location of maximum line sag (typically mid- span), and shall provide MF *values* at 1 meter *above* ground *level,* with the assumption of flat terrain and balanced currents. The calculations shall assume "all lines in" and projected load growth *five* years beyond the time the lines are expected to be put into operation, and shall include changes to the electric system approved by the Council and the Independent System Operator- New England.

As part of this determination, the applicant shall provide the locations of, and anticipated MF *levels* encompassing, residential areas, private or public schools, licensed child day care facilities, licensed youth camps, or public playgrounds within 300 feet of the proposed transmission line. The Council, at its discretion, may order the field measurement of post-construction MF values in select areas, as appropriate, and compare and contrast projected *values* with actual measured *values*.

B. Buffer Zones and limits on MF

As enacted by the General Assembly in Section 4 of Public Act No. 04-246, a buffer zone in the context of transmission line siting is deemed, at minimum, to be the distance between the proposed transmission line and the edge of the utility ROW. Buffer zone distances may also be guided by the standards presented in the National Electrical Safety Code (NESC), published by the Institute of Electrical and Electronic Engineers (IEEE). These standards provide for the safe installation, operation, and maintenance of electrical utility lines, including clearance requirements from vegetation, buildings, and other natural and man-made objects that may arise in the ROW. The safety of power-line workers and the general public are considered in the NESC standards. None of these standards include MF limits.

In assessing whether a right-of-way provides a sufficient "buffer zone," the Council will emphasize compliance with its own Best Management Practices, but may also take into account approaches of other states, such as those of Massachusetts, New York, and Florida.

Since 1985, the Massachusetts Energy Facilities Siting Board (EFSB) has used an edge-of-ROW *level* of 85 mG as a benchmark for comparing different design alternatives. This benchmark, however, has not served as a generally applicable standard or guide. Rather, in particular cases since 1985 where a proposed transmission line has caused public concern, such as in densely populated areas and near schools, EFSB has "encouraged the use of practical and cost-effective design to minimize magnetic fields along transmission ROW. The EFSB requires EMF mitigation which in its judgment is consistent with minimizing cost" (Massachusetts Energy and Environmental Affairs Case No. EFSB 08-2/08-105/08-106:page 84) This approach is similar to Connecticut's.

Massachusetts has not adopted any generally applicable standards or guidelines concerning transmission facility magnetic fields. However, since 1985, the EFSB has considered projected magnetic field exposures in its proceedings for approval of electric transmission lines and substations. Where a transmission line is proposed in densely populated areas and near schools, the EFSB will "require EMF mitigation which in its judgment is consistent with minimizing cost."

New York and Florida have general MF guidelines that are designed to maintain the "status quo", i.e., that fields from new transmission lines not exceed those of existing transmission lines. In 1991, the New York Public Service Commission established an interim policy based on limits to MF. It required new high-voltage transmission lines to be designed so that the maximum magnetic fields at the edge of the ROW, one meter above ground, would not exceed 200 mG if the line were to operate at its highest continuous current rating. This 200 mG *level* represents the maximum calculated magnetic field level for 345 kV lines that were then in operation in New York State. The Council confirms no change to the New York policy.

The Florida Environmental Regulation Commission established a maximum magnetic field limit for new transmission lines and substations in 1989. The MF limits established for the edge of 230-kV to 500-kV transmission line ROWs and the property boundaries for substations ranged from 150 mG to 250 mG, depending on the voltage of the new transmission line and whether an existing 500-kV line was already present. In 2008, the Florida policy was revised to add a provision making the 250 mG magnetic field limit at the edge of the ROW and at substation property boundaries applicable to transmission lines and substations with a nominal voltage greater than 500-kV. Florida limits apply to one meter above ground level under an assumption that the transmission line is operating at its maximum continuous current rating.

Although scientific evidence to date does not warrant the establishment of MF exposure limits at the edge of a ROW, the Council will continue to monitor the ways in which states and other jurisdictions determine MF limits on new transmission lines.

C. Engineering Controls that Modify MF Level

When considering an overhead electric transmission-line application, the Council will expect the applicant to examine the following engineering controls to limit MF in publicly accessible areas: distance, height, conductor separation, conductor configuration, optimum phasing, increased voltage, and underground installation. Any design change may also affect the line's impedance, corona discharge, mechanical behavior, system performance, cost, noise levels and visual impact. The Council will consider all of these factors in relation to the MF levels achieved by any particular engineering control. Thus, utilities are encouraged to evaluate other possible engineering controls that might be applied to the entire line, or just specific segments, depending upon land use, to best minimize MF at a low or no cost.

Consistent with these Best Management Practices and absent any line performance and visual impacts, the Council expects that applicants will propose no-cost/low-cost measures to reduce magnetic fields by one or more engineering controls, including:

Distance

MF levels from transmission lines (or any electrical source) decrease with distance; thus, increased distance results in lower MF. Horizontal distances can be increased by purchasing wider ROWs, where available. Other distances can be increased in a variety of ways, as described below.

Height of Support Structures

Increasing the vertical distance between the conductors and the edge of the ROW will decrease MF: this can be done by increasing the height of the support structures. The main drawbacks of this approach are an increase in the cost of supporting structures, possible environmental effects from larger foundations, potential detrimental visual effects, and the modest MF reductions achieved, unless the ROW width is unusually narrow.

Conductor Separation

Decreasing the distances between individual phase conductors can reduce MF. Because at any instant in time the sum of the currents in the individual phase conductors is zero, or close to zero, moving the conductors closer together improves their partial cancellation of each other's MF. In other words, the net MF produced by the closer conductors reduces the MF level associated with the line. Placing the conductors closer together has practical limits, however. The distance between the conductors must be sufficient to maintain adequate electric code clearance at all times, and to assure utility employees' safety when working on energized lines. One drawback of a close conductor installation is the need for more support structures per mile (to reduce conductor sway in the wind and sag at mid-span); in turn, costs increase, and so do visual impacts.

Conductor Configuration

The arrangement of conductors influences MF. Conductors arranged in a flat, horizontal pattern at standard clearances generally have greater MF levels than conductors arranged vertically. This is due to the wider spacing between conductors found typically on H-frame structure designs, and to the closer distance between all three conductors and the ground. For single-circuit lines, a compact triangular configuration, called a "delta configuration", generally offers the lowest MF levels. A simple vertical configuration -one conductor above another-may cost more and may have increased visual impact. Where the design goal is to minimize MF levels at a specific location within or beyond the ROW, conductor configurations other than vertical or delta may produce equivalent or lower fields.

Optimum Phasing

Optimum phasing applies in situations where more than one circuit exists in an overhead ROW or in a duct bank installed underground. Electric transmission circuits utilize a three-phase system with each phase carried by one conductor, or a bundle of conductors. Optimum phasing reduces MF through partial cancellation. For a ROW with more than two circuits, the phasing arrangement of the conductors of each circuit can generally be optimized to reduce MF levels under typical conditions. The amount of MF cancellation will also vary depending upon the relative loading of each circuit. For transmission lines on the same ROW, optimizing the phasing of the new line with respect to that of existing lines is usually a low-cost method of reducing MF. MF levels can be reduced for a single circuit line by constructing it as a "split-phase" line with twice as many conductors, and arranging the conductors for optimum cancellation. Disadvantages of the split-phase design include higher cost and increased visual impact.

Increased Voltage

MF are proportional to current, so, for example, replacing a 69-kV line with a 138-kV line, which delivers the same power at half the current, will result in lower MF. This could be an expensive mitigation to address MF alone because it would require the replacement of transformers and substation equipment.

Underground Installation

Burying transmission lines in the earth does not, by itself, provide a shield against MF, since magnetic fields, unlike electric fields, can pass through soil. Instead, certain inherent features of an underground design can reduce MF. The closer proximity of the currents in the wires provides some cancellation of MF, but does not eliminate it entirely. Underground transmission lines are typically three to five feet below ground, a near distance to anyone passing above them, and MF can be quite high directly over the line. MF on either side of an underground line, however, decreases more rapidly with increased distance than the MF from an overhead line.

The greatest reduction in MF can be achieved by "pipe-type" cable installation. This type of cable has all of the wires installed inside a steel pipe, with a pressurized dielectric fluid inside for electrical insulation and cooling. Low MF is achieved through close proximity of the wires, as described above, and through partial shielding provided by the surrounding steel pipe. While this method to reduce MF is effective, system reliability and the environment can be put at risk if the cable is breached and fluid is released.

Lengthy high-voltage underground transmission lines can be problematic due to the operational limits posed by the inherent design. They also can have significantly greater environmental impacts, although visual impacts associated with overhead lines are eliminated. The Council recognizes the operational and reliability concerns associated with current underground technologies and further understands that engineering research regarding the efficiency of operating underground transmission lines is ongoing. Thus, in any new application, the Council may require updates on the feasibility and reliability of the latest technological developments in underground transmission line design.

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Appendix 7B
Field Management Design Plan

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Summary and Recommended Design

Eversource reviewed the development along the Proposed Route to determine if there were any areas that should receive attention in a Field Management Design Plan. There is a baseball field along the Proposed Route and two areas along the route that are considered residential areas. Eversource examined several options to reduce magnetic fields in these areas. "No-cost" options such as best phase arrangement were included in the base design and resulted in small reductions or increases of magnetic field levels at the edges of the ROW. Measures that would yield further reductions were studied; however, none of them were "low-cost" options and none produced substantial reductions of magnetic field levels at the ROW edges. Eversource therefore recommends the base design with "no-cost" mitigation measures.

Council's Best Management Practices for Electric and Magnetic Fields

The Connecticut Siting Council provides guidance in developing a FMDP for a proposed project. This guidance is found in the *Connecticut Siting Council's Best Management Practices for Electric and Magnetic Fields*. In this document, the Council prescribes areas for focus in a FMDP and the following guidance for selection of "low-cost" MF management measures.

1. Focus Areas for FMDP – "*The Applicant shall then modify the base design by adding low-cost MF mitigation design features specifically where portions of the project are adjacent to residential areas, public or private schools, licensed child day-care facilities, licensed youth camps, or public playgrounds.*"
2. Low Cost Designs – "*The overall cost of low-cost design features are to be calculated at four percent of the initial project estimated costs, including related substations.*"
3. Target MF Reductions – "*The four percent guideline for low-cost mitigation should aim at a magnetic field reduction of 15 percent or more at the edge of the utility's ROW.*"

Focus Areas for FMDP

Applicants are directed to identify any adjacent "residential areas, public or private schools, licensed child day-care facilities, licensed youth camps or public playgrounds" and to focus mitigation efforts on these areas.

Candidate "Low-Cost" Designs

Applicants are directed to examine costs associated with any field reduction strategies. The BMPs set 4% of total project costs (including substation costs) as a guideline for magnetic field management, which for the project is approximately $2.04 million.

Target Magnetic Field Reductions

The BMPs state “low-cost” mitigation measures should aim to achieve a 15% reduction at the edge of the utility’s right-of-way. Eversource calculated fields out to both edges of the ROW on either side of the proposed transmission line to compare mitigation options.

Focus Areas along Proposed Route

Eversource looked for areas it thought might be considered by the Council to be adjacent “residential areas”. Eversource also referred to the Connecticut Department of Consumer Protection’s online database to identify any licensed child day-care facilities or youth camps near the Proposed Route, and Eversource reviewed the town websites of Watertown, Thomaston, Litchfield and Harwinton for listings of public playgrounds and all schools. Eversource identified Veteran’s Memorial Park in Watertown as the only public playground within 600 feet of the Proposed Route. No licensed child day-care facilities or youth camps were identified within 600 feet of the proposed transmission line.

Eversource also used aerial imagery to look up nearby groups of residences that might be considered adjacent residential areas. Two groups of residences adjacent to each other were identified as areas of focus for a FMDP: Walnut Hill Road in Thomaston and Campville Road in Litchfield.

Veteran’s Memorial Park (Watertown)

Veteran’s Memorial Park in Watertown extends into the project Right-of-Way. However, the cleared area of the park, where the baseball fields are and where children will congregate, is approximately 300 feet away from the proposed Transmission Line. The location of the fields relative to the proposed transmission line is shown in Figure 1 below.

When examining the concept of installing an underground transmission line rather than the proposed overhead line, the average annual magnetic fields at the baseball fields would see a 2.3% reduction, as compared to the fields post construction of the proposed line. This is well below the target of 15% reduction as described in the BMPs. The comparison of calculated magnetic fields is shown in Table 1 below. The small effect of the new line is due to the dominance of the existing 352 circuit in the ROW for electric and magnetic fields as illustrated in Figures 7-23 and 7-26 of the application.

In addition, construction of the new line underground in a different location would introduce a new source of magnetic fields in the location where it was constructed.

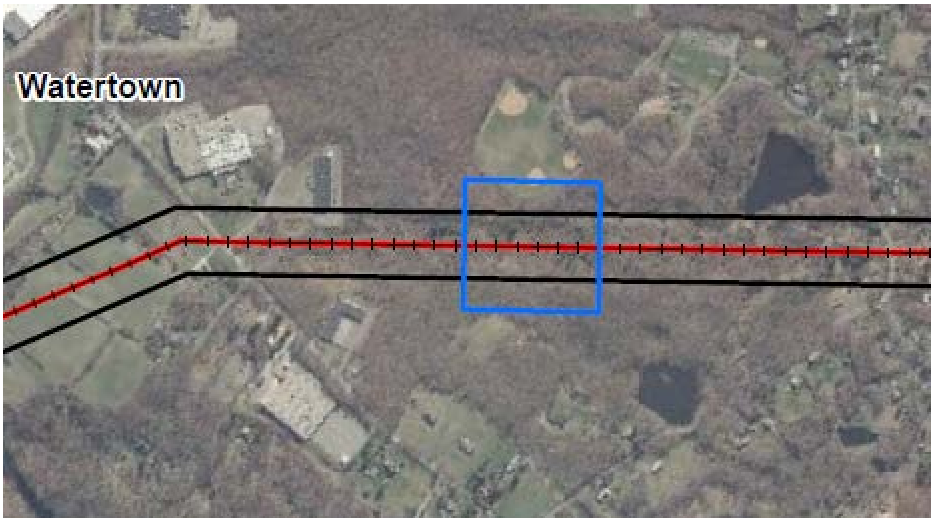

Figure 7B-1: Focus Area A (Veteran's Memorial Park)

Table 7B-1: Calculated Magnetic Fields at Focus Area A (Veteran's Memorial Park)

Distance from Center of Transmission Line to Cleared Area of Baseball Fields at Veteran's Memorial Park (ft)	Calculated Magnetic Fields (mG)		
	Existing Conditions	Post Construction	Post Construction of Underground Alternative Outside of ROW
300	2.99	3.05	2.98

Based on these calculations, Eversource does not recommend applying magnetic field mitigation measures at Veteran's Park in addition to those incorporated in the baseline design of the proposed transmission line.

Walnut Hill Road (Thomaston)

Walnut Hill Road in Thomaston runs perpendicular to the corridor in which the proposed transmission line would reside. There are 12 residences along a section of approximately 1500 feet of Walnut Hill Road along the Proposed Route. Eversource determined this area to be a residential area and decided to examine EMF mitigation on this area. The location of Walnut Hill Road relative to the proposed transmission line is shown in Figure 2 below.

The proposed transmission line reduces average annual magnetic fields at both edges of the right-of-way, as compared to existing conditions. The "no-cost" phasing optimization allows for better cancellation between the existing line and proposed line. Constructing an underground line off of the ROW would not achieve the same reduction as the overhead line, and would introduce a new source of magnetic fields wherever it was built. The pre- and post-construction calculations are shown in Table 2 below.

Figure 7B-2: Focus Area B (Walnut Hill Road)

Table 7B-2: Calculated Magentic Fields at Focus Area B (Walnut Hill Road)

Calculated Magnetic Fields (mG)						
	Left Edge of ROW			Right Edge of ROW		
Section	Existing Conditions	Post Construction	Post Construction of Underground Alternative Outside of ROW	Existing Conditions	Post Construction	Post Construction of Underground Alternative Outside of ROW
Focus Area B (Walnut Hill Road)	7.23	4.23	4.69	6.12	3.92	3.95

Because of the reduction in magnetic fields at both edges of the right-of-way with the proposed transmission line, Eversource does not recommend applying additional magnetic field mitigation measures at this location.

Campville Road (Litchfield)

Campville Road in Litchfield runs perpendicular to the corridor in which the proposed transmission line would reside. There are 19 residences along a section of approximately 3500 feet of Campville Road along the Proposed Route. Eversource determined this area to be a residential area and decided to examine EMF mitigation on this area. The location of Campville Road relative to the proposed transmission line is shown in Figure 3 below.

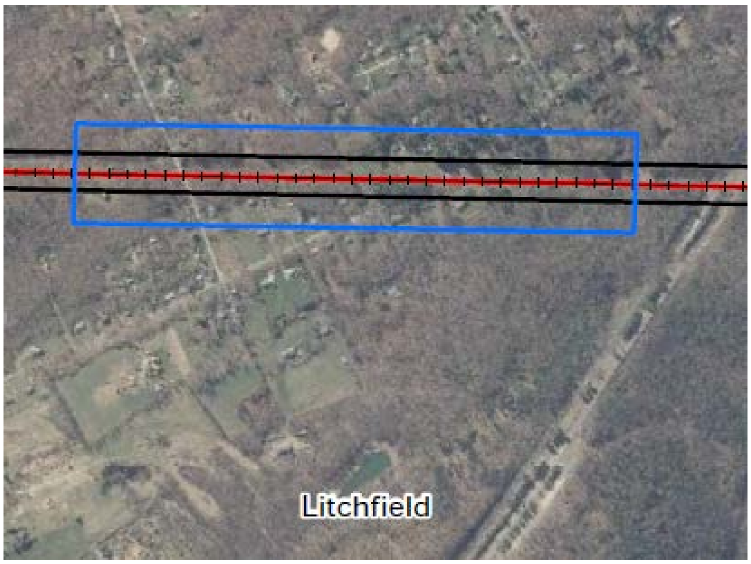

Figure 7B-3: Focus Area C (Campville Road)

The proposed transmission line reduces annual average magnetic fields at the west edge of the right-of-way and slightly increases magnetic fields at the east edge. The greatest reduction at the west edge is a result of the proposed project and transmission line. While magnetic fields do increase at the east edge, the levels are still of a magnitude near background levels. Calculated magnetic fields for this area are shown in Table 3 below.

Table 7B-3: Calculated Magnetic Fields at Focus Area C (Campville Road)

Calculated Magnetic Fields (mG)						
	Left Edge of ROW			Right Edge of ROW		
Section	Existing Conditions	Post Construction	Post Construction of Underground Alternative Outside of ROW	Existing Conditions	Post Construction	Post Construction of Underground Alternative Outside of ROW
Focus Area C (Campville Road)	20.54	12.82	13.28	0.55	1.43	0.42

Because the proposed line would lower magnetic fields on the west edge of the ROW and would barely increase already low fields on the east edge of the ROW, commensurate with background levels, Eversource does not recommend magnetic field mitigation measures in addition to those incorporated in the baseline design of the transmission line.

"No-Cost" Mitigation Measures

The Project's base design incorporates "no-cost" magnetic field reduction measures by arranging the phases of the proposed line to achieve better cancellation with the field from the existing overhead transmission lines.

Conclusion

Based on the magnetic fields resulting from the project's "no-cost" magnetic field reduction measure of optimized phasing, Eversource does not recommend employing additional magnetic field mitigation measures at any of the three Focus Areas. While the magnetic field is slightly higher at Focus Area A with the proposed line compared to an underground line outside of the right-of-way, Veteran's Memorial Park would only see a reduction of 2.3% with the underground line. This reduction is much less than the target 15% reduction described in the BMPs. The magnetic fields at both edges of the right-of-way at Focus Area B experience the greatest reduction with the use of the project's "no-cost" mitigation measure, and while the magnetic fields are slightly increased at the right edge of the ROW at Focus Area C, the levels are still small enough to be considered background levels. Because the proposed transmission line will result in either reductions or very small increases in magnetic fields at the right-of-way edges; and additional "low cost" measures would not achieve substantial further reductions, and could not be implemented within the Council's 4% of project cost guideline, Eversource concludes that mitigation measures in addition to those incorporated in the baseline design of the proposed transmission line are not appropriate for this project.

Appendix 7C

Tabulated Results of Calculated Electric and Magnetic Fields

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Results of Calculated Magnetic and Electric Fields

This appendix includes tabulated results for calculated electric and magnetic fields during annual peak load and the projected seasonal maximum 24-hour average load for pre- and post- construction. This is required as per section IV.A of the Connecticut Siting Council Best Management Practices. Also included are results for the Average Annual Load, which serves as a surrogate that best represents the time weighted average of exposure from the proposed facilities.

Frost Bridge Substation – Purgatory Junction

Table 7C-1: Frost Bridge Substation – Purgatory Junction Calculated Pre-Construction Magnetic Fields (mG)

Distance from Center of Transmission Line (feet)	Calculated Pre-Construction Magnetic Fields (mG)		
	Average Annual Load	Peak Day Average Load	Annual Peak Load
-300	3.02	5.85	4.20
-275	4.29	8.15	6.17
-250	6.65	12.28	9.84
-225	11.73	20.46	17.41
-200	23.54	37.78	34.20
-175	42.96	63.44	60.05
-150	35.84	49.17	47.53
-125	20.70	26.27	25.02
-100	13.82	22.73	19.72
-75	15.63	36.71	45.73
-50	26.43	44.22	81.32
-25	17.23	28.44	52.80
0	24.45	26.60	29.01
25	40.41	37.38	34.33
50	66.86	64.10	60.20
75	125.84	123.99	117.35
100	192.27	193.07	180.60
125	199.38	202.12	187.07
150	145.44	148.59	136.02
175	75.55	78.03	70.16
200	40.89	42.70	37.66
225	24.92	26.30	22.76
250	16.64	17.73	15.08
275	11.86	12.75	10.67
300	8.87	9.61	7.92

Table 7C- 2: Frost Bridge Substation – Purgatory Junction Calculated Post-Construction Magnetic Fields (mG)

Distance from Center of Transmission Line (feet)	Calculated Post- Construction Magnetic Fields (mG)		
	Average Annual Load	Peak Day Average Load	Annual Peak Load
-300	3.05	4.15	4.62
-275	4.29	5.99	6.68
-250	6.65	9.39	10.48
-225	11.73	16.42	18.32
-200	23.54	32.16	35.78
-175	42.96	56.82	62.75
-150	35.84	45.38	49.40
-125	20.70	24.28	25.66
-100	13.82	15.32	14.76
-75	15.63	24.21	22.70
-50	26.43	42.47	41.73
-25	17.23	19.74	18.89
0	24.44	25.12	24.60
25	40.41	42.26	41.86
50	66.86	65.11	64.57
75	125.84	118.45	117.51
100	192.27	178.49	176.93
125	199.38	184.21	182.62
150	145.44	134.00	132.99
175	75.55	69.36	68.87
200	40.89	37.41	37.15
225	24.92	22.73	22.57
250	16.64	15.14	15.03
275	11.86	10.77	10.69
300	8.87	8.03	7.97

Table 7C-3: Frost Bridge Substation - Purgatory Junction Calculated Pre-Construction Electric Fields (kV/m)

Distance from Center of Transmission Line (feet)	Calculated Pre-Construction Electric Fields (kV/m)
-300	0.06
-275	0.08
-250	0.09
-225	0.07
-200	0.23
-175	1.10
-150	0.63
-125	0.09
-100	0.36
-75	0.91
-50	0.37
-25	1.07
0	0.77
25	0.95
50	1.80
75	3.58
100	2.99
125	2.46
150	3.87
175	2.16
200	0.98
225	0.49
250	0.27
275	0.16
300	0.11

Table 7C-4: Frost Bridge Substation – Purgatory Junction Calculated Post-Construction Electric Fields (kV/m)

Distance from Center of Transmission Line (feet)	Calculated Post-Construction Electric Fields (kV/m)
-300	0.07
-275	0.08
-250	0.10
-225	0.07
-200	0.22
-175	1.09
-150	0.62
-125	0.06
-100	0.33
-75	0.90
-50	0.28
-25	0.41
0	0.66
25	0.67
50	1.77
75	3.59
100	3.00
125	2.45
150	3.86
175	2.15
200	0.96
225	0.48
250	0.26
275	0.16
300	0.10

Purgatory Junction – Walnut Hill Junction

Table 7C-5: Purgatory Junction – Walnut Hill Junction Calculated Pre-Construction Magnetic Fields (mG)

Distance from Center of Transmission Line (feet)	Calculated Pre-Construction Magnetic Fields (mG)		
	Average Annual Load	Peak Day Average Load	Annual Peak Load
-300	3.11	4.82	6.25
-275	3.40	5.26	6.84
-250	3.74	5.78	7.52
-225	4.15	6.42	8.35
-200	4.65	7.20	9.37
-175	5.28	8.18	10.64
-150	6.10	9.44	12.28
-125	7.27	11.24	14.63
-100	9.98	15.44	20.09
-75	23.21	35.91	46.73
-50	49.28	46.24	99.23
-25	43.32	67.01	87.21
0	25.50	39.45	51.34
25	16.35	25.30	32.93
50	11.71	18.12	23.58
75	9.03	13.96	18.17
100	7.31	11.31	14.71
125	6.12	9.47	12.33
150	5.26	8.14	10.60
175	4.61	7.13	9.28
200	4.10	6.34	8.25
225	3.69	5.71	7.43
250	3.35	5.19	6.75
275	3.07	4.75	6.18
300	2.83	4.38	5.70

Table 7C-6: Purgatory Junction – Walnut Hill Junction Calculated Post-Construction Magnetic Fields (mG)

Distance from Center of Transmission Line (feet)	Calculated Post-Construction Magnetic Fields (mG)		
	Average Annual Load	Peak Day Average Load	Annual Peak Load
-300	1.98	3.75	3.56
-275	2.16	4.09	3.88
-250	2.37	4.48	4.25
-225	2.61	4.95	4.70
-200	2.91	5.52	5.24
-175	3.28	6.20	5.89
-150	3.71	7.02	6.66
-125	4.23	8.00	7.60
-100	5.38	10.20	9.68
-75	13.68	25.92	24.60
-50	32.79	62.11	58.94
-25	32.21	60.93	57.84
0	24.31	45.89	43.56
25	11.08	20.96	19.88
50	6.71	12.74	12.07
75	5.51	10.46	9.92
100	4.61	8.75	8.29
125	3.92	7.43	7.05
150	3.39	6.43	6.10
175	2.98	5.65	5.36
200	2.65	5.03	4.77
225	2.39	4.53	4.30
250	2.17	4.12	3.91
275	1.99	3.78	3.58
300	1.84	3.48	3.31

Table 7C-7: Purgatory Junction – Walnut Hill Junction Calculated Pre-Construction Electric Fields (kV/m)

Distance from Center of Transmission Line (feet)	Calculated Pre-Construction Electric Fields (kV/m)
-300	0.00
-275	0.01
-250	0.02
-225	0.02
-200	0.04
-175	0.06
-150	0.11
-125	0.23
-100	0.57
-75	1.28
-50	0.50
-25	1.28
0	0.57
25	0.23
50	0.11
75	0.06
100	0.04
125	0.02
150	0.02
175	0.01
200	0.00
225	0.01
250	0.01
275	0.00
300	0.00

Table 7C-8: Purgatory Junction – Walnut Hill Junction Calculated Post-Construction Electric Fields (kV/m)

Distance from Center of Transmission Line (feet)	Calculated Post-Construction Electric Fields (kV/m)
-300	0.00
-275	0.00
-250	0.01
-225	0.01
-200	0.02
-175	0.04
-150	0.09
-125	0.20
-100	0.53
-75	1.25
-50	0.67
-25	1.09
0	0.47
25	0.93
50	0.40
75	0.21
100	0.12
125	0.08
150	0.05
175	0.04
200	0.03
225	0.02
250	0.02
275	0.01
300	0.01

Walnut Hill Junction – Campville Substation

Table 7C-9: Walnut Hill Junction – Campville Substation Calculated Pre-Construction Magnetic Fields (mG)

Distance from Center of Transmission Line (feet)	Calculated Pre-Construction Magnetic Fields (mG)		
	Average Annual Load	Peak Day Average Load	Annual Peak Load
-300	0.72	0.99	1.30
-275	0.93	1.29	1.70
-250	1.25	1.75	2.31
-225	1.78	2.51	3.30
-200	2.70	3.86	5.07
-175	4.52	6.58	8.63
-150	8.82	13.09	17.14
-125	20.54	31.31	40.87
-100	38.17	59.95	77.99
-75	29.83	50.32	65.15
-50	14.52	30.14	38.38
-25	6.11	12.92	16.22
0	2.69	4.22	5.34
25	1.66	1.92	2.51
50	1.18	1.24	1.67
75	0.88	0.94	1.26
100	0.69	0.74	1.00
125	0.55	0.61	0.82
150	0.45	0.50	0.68
175	0.37	0.43	0.57
200	0.32	0.36	0.49
225	0.27	0.31	0.42
250	0.23	0.27	0.37
275	0.20	0.24	0.32
300	0.18	0.21	0.29

Table 7C-10: Walnut Hill Junction – Campville Substation Calculated Post-Construction Magnetic Fields (mG)

Distance from Center of Transmission Line (feet)	Calculated Post-Construction Magnetic Fields (mG)		
	Average Annual Load	Peak Day Average Load	Annual Peak Load
-300	0.51	1.04	0.82
-275	0.65	1.33	1.03
-250	0.85	1.75	1.36
-225	1.18	2.43	1.87
-200	1.74	3.61	2.79
-175	2.85	5.90	4.64
-150	5.46	11.20	9.16
-125	12.82	25.48	22.45
-100	24.52	46.35	45.13
-75	19.27	34.22	39.75
-50	11.33	19.97	29.57
-25	12.60	29.07	24.92
0	18.51	35.28	34.81
25	13.16	22.45	25.26
50	6.39	10.37	12.20
75	3.45	5.51	6.51
100	2.12	3.37	3.94
125	1.43	2.27	2.63
150	1.02	1.64	1.87
175	0.77	1.24	1.40
200	0.60	0.98	1.09
225	0.48	0.79	0.87
250	0.40	0.65	0.71
275	0.33	0.55	0.59
300	0.28	0.47	0.50

Table 7C-11: Walnut Hill Junction – Campville Substation Calculated Pre-Construction Electric Fields (kV/m)

Distance from Center of Transmission Line (feet)	Calculated Pre-Construction Electric Fields (kV/m)
-300	0.01
-275	0.02
-250	0.03
-225	0.05
-200	0.09
-175	0.20
-150	0.47
-125	1.18
-100	0.81
-75	0.66
-50	0.70
-25	0.94
0	0.56
25	0.27
50	0.14
75	0.08
100	0.05
125	0.04
150	0.03
175	0.02
200	0.02
225	0.01
250	0.01
275	0.01
300	0.01

Table 7C-12: Walnut Hill Junction – Campville Substation Calculated Post-Construction Electric Fields (kV/m)

Distance from Center of Transmission Line (feet)	Calculated Post-Construction Electric Fields (kV/m)
-300	0.01
-275	0.02
-250	0.03
-225	0.04
-200	0.09
-175	0.19
-150	0.46
-125	1.16
-100	0.81
-75	0.64
-50	0.47
-25	0.56
0	0.52
25	0.93
50	0.39
75	0.20
100	0.12
125	0.08
150	0.06
175	0.04
200	0.03
225	0.02
250	0.02
275	0.02
300	0.01

Appendix 7D

Research on Extremely Low Frequency Electric and Magnetic Fields and Health

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Health Sciences Practice

Research on Extremely Low Frequency Electric and Magnetic Fields and Health

August 1, 2012 – July 31, 2015

Eversource Energy Transmission Projects Update

Research on Extremely Low Frequency Electric and Magnetic Fields and Health

August 1, 2012 – July 31, 2015

Eversource Energy Transmission Projects Update

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December 4, 2015

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Acronyms and Abbreviations

AC	Alternating current
ALL	Acute lymphoblastic leukemia
ALS	Amyotrophic lateral sclerosis
AMI	Acute myocardial infarction
BMP	Best Management Practices
CI	Confidence interval
CSC	Connecticut Siting Council
CVD	Cardiovascular disease
DMBA	dimethylbenz[a]anthracene
ELF	Extremely low frequency
EMF	Electric and magnetic fields (or electromagnetic fields)
EPA	Environmental Protection Agency
F344	Fischer 344
G	Gauss
GD	Gestational day
GHz	Gigahertz
Hz	Hertz
IARC	International Agency for Research on Cancer
ICES	International Committee for Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation Protection
kV	Kilovolt
kV/m	Kilovolts per meter
mG	Milligauss
NIEHS	National Institute for Environmental and Health Sciences
NRPB	National Radiation Protection Board of Great Britain
OR	Odds ratio
ROW	Right of way
RR	Relative risk
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
TWA	Time weighted average

V/m	Volts per meter
WHO	World Health Organization

Limitations

At the request of Eversource Energy, Exponent prepared this summary report on the status of research related to extremely low-frequency electric- and magnetic-fields and health. The findings presented herein are made to a reasonable degree of scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report for purposes other than project permitting, and any re-use of this report or its findings, conclusions, or recommendations presented herein is at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

The following Executive Summary provides only an outline of the material discussed in this report. Exponent's technical evaluations, analyses, conclusions, and recommendations are included in the main body of this report, which at all times is the controlling document.

Executive Summary

This report was prepared to address the topic of exposure to extremely low frequency (ELF) electric and magnetic fields (EMF) and health for the Connecticut Siting Council (CSC) at the request of Eversource Energy to be filed with Applications for Certificates of Environmental Compatibility and Public Need for projects in preparation at the time of the drafting of this report.

ELF EMF are invisible fields surrounding all objects that generate, use, or transmit electricity. People living in developed countries are almost constantly exposed to ELF EMF in their environments, because electricity is an essential infrastructure of technologically-advanced societies. Sources of man-made ELF EMF include, for example, appliances, wiring in homes, and electric motors, as well as distribution and transmission lines. Section 2 of this report provides information on the nature and sources of ELF EMF, and typical exposure levels.

Research on EMF and health began with the goal of finding therapeutic applications and understanding biological electricity (i.e., the role of electrical potentials across cell membranes and current flows between cells in our bodies). Since the late 1970s, researchers have examined whether EMF from man-made sources can cause short- or long-term health effects in humans using a variety of study designs and techniques. Research on ELF EMF and long-term human health effects was prompted by an epidemiologic study conducted in 1979 of children in Denver, Colorado, which reported that children with cancer were more likely to live near distribution and transmission lines that appeared to be capable of producing higher magnetic-field levels. The results of that study prompted further research on childhood leukemia and other cancers. Childhood leukemia has remained the focus of ELF EMF and health research, although many other diseases have been studied, including other cancers in children and adults, neurodegenerative diseases, reproductive and developmental effects, cardiovascular diseases, and psychological and behavioral effects such as depression or suicide.

Guidance on the possible health risks of all types of exposures comes from health risk assessments (i.e., systematic weight-of-evidence evaluations of the cumulative literature), on a particular topic conducted by expert panels organized by national and international scientific organizations.

The World Health Organization (WHO) published one of the most comprehensive health risk assessments of EMF in the ELF range in 2007 that critically reviewed the cumulative epidemiologic and laboratory research through 2005, taking into account the strength and quality of individual research studies. The public and policy makers should look to the conclusions of reviews such as this, because they are conducted by scientists representing the various disciplines required to understand the topic at hand using validated scientific standards and systematic methods. This WHO report was one of the most recent health agency reviews that informed the CSC when it updated its EMF Best Management Practices (BMP) in 2007. In its revised BMP, issued on February 20, 2014, the CSC further considered the scientific literature up to 2012 based on systematic reviews provided by two documents submitted with previous applications to the CSC.[1]

In a health risk assessment of any exposure, it is essential to consider the type and strength of research studies available for evaluation. Human health studies vary in methodological rigor and, therefore, in their capacity to extrapolate findings to the population at large. Furthermore, all studies in three areas of research—epidemiologic, *in vivo* (experimental whole animal), and *in vitro* (experimental in cells and tissues)—must be evaluated to understand possible health risks. Epidemiologic and *in vivo* studies provide the primary basis for a human health risk assessment, with *in vitro* studies contributing supplementary, secondary information on potential biological mechanisms.

Section 3 of this report provides a summary of the methods used to conduct a health risk assessment. Section 4 provides a summary of the WHO's conclusions with regard to various health outcomes (childhood leukemia and brain cancer, adult breast cancer, brain cancer, leukemia/lymphoma; reproductive and developmental effects; neurodegenerative disease; and cardiovascular disease). Finally, this report contains a systematic literature review and a critical evaluation of all relevant epidemiologic studies in these areas of research and *in vivo* animal studies of cancer published between August 1, 2012 and July 31, 2015 (Section 5).

[1] Docket No. 424, "Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health: Interstate Reliability Project, June 10, 2011"; Docket No. 435, "Update of Research on Extremely Low Frequency Electric and Magnetic Fields and Health May 1, 2011 – July 31, 2012, Stamford Reliability Cable Project, August 30, 2012."

1 Introduction

In response to public concern regarding extremely low frequency (ELF) electric and magnetic fields (EMF) and health, the Connecticut Siting Council (CSC) adopted “EMF Best Management Practices for the Construction of Electric Transmission Lines in Connecticut” (BMP) on December 14, 2007. This BMP was updated on February 20, 2014. The BMP policy is founded on the recognition of consistent conclusions by “a wide range of public health consensus groups,” as well as their own commissioned weight-of-evidence review (CSC BMP, 2014, p. 4). The CSC summarized the current scientific consensus by noting the conclusions of these public health consensus groups, including the most comprehensive review by the World Health Organization (WHO) in 2007, and earlier reviews published by the National Institute for Environmental and Health Sciences (NIEHS) in 1999, the International Agency for Research on Cancer (IARC) in 2002, the Australian Radiation Protection and Nuclear Safety Agency in 2003, the National Radiological Protection Board of Great Britain (NRPB) in 2004, and the Health Council of the Netherlands in 2005.

The WHO report provided the following overall conclusions:

> New human, animal, and in vitro studies published since the 2002 IARC Monograph, 2002 [*sic*] do not change the overall classification of ELF as a possible human carcinogen (WHO, 2007, p. 347).
>
> Acute biological effects [i.e., short-term, transient health effects such as a small shock] have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz that may have adverse consequences on health. Therefore, exposure limits are needed. International guidelines exist that have addressed this issue. Compliance with these guidelines provides adequate protection. Consistent epidemiological evidence suggests that chronic low-intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted (WHO, 2007, p. 355).

The CSC summarized the current scientific consensus as expressed in the above-mentioned reviews as follows: there is limited evidence from epidemiologic studies of a statistical association between estimated, average exposures greater than 3-4 milligauss (mG) and childhood leukemia; the cumulative research, however, does not indicate that magnetic fields are a cause of childhood leukemia, since animal and other experimental studies do not suggest that magnetic fields are carcinogenic and the epidemiologic studies are of limited quality. The CSC also noted the WHO’s recent conclusion with respect to other diseases: “the scientific evidence supporting an association between ELF magnetic field exposure and all of these health effects is much weaker than for childhood leukemia” (CSC BMP, 2014, p. 2).

Based on this scientific consensus, the CSC concluded that proportional precautionary measures for the siting of new transmission lines in the state of Connecticut should include "the use of effective no-cost and low-cost technologies and management techniques on a project-specific basis to reduce MF [magnetic field] exposure to the public while allowing for the development of efficient and cost-effective electrical transmission projects" (CSC BMP, 2014, p. 4).

The BMP also stated that the CSC will "consider and review evidence of any new developments in scientific research addressing MF [magnetic fields] and public health effects or changes in scientific consensus group positions regarding MF" (CSC BMP, 2014, p. 5).

While the initial CSC BMP policies were based largely on the conclusions of the WHO report from 2007, the current BMP, revised in 2014, considers the scientific literature up to 2012 based on systematic reviews provided by two reports submitted as part of previous applications to the CSC.[2]

This Exponent report contains a systematic review and a critical evaluation of the literature, including all relevant epidemiologic studies for various outcomes and *in vivo* studies of carcinogenicity published between August 1, 2012 and July 31, 2015, which were identified in our literature searches. This new report, along with the two previous summaries, provides an analysis of the status of research on ELF EMF inclusive of 2006 through mid-2015.

The studies evaluated in the current and the previous two reports do not provide sufficient evidence to alter the basic conclusion of the WHO: the research does not support the conclusion that ELF EMF at the levels we encounter in our everyday environment are a cause of cancer or any other disease.

There are no national guidelines or standards in the United States to regulate ELF EMF. The WHO recommends adherence to the International Commission on Non-Ionizing Radiation Protection's (ICNIRP) standards or those developed by the IEEE's International Committee for Electromagnetic Safety (ICES) for the prevention of acute, short-term health effects at high exposure levels (ICES, 2002; ICNIRP, 2010). In light of the epidemiologic data on childhood leukemia, these scientific organizations are still in agreement that only no-cost or low-cost interventions to reduce ELF EMF exposure are appropriate.

This policy approach is consistent with the recommendation of the CSC for the use of effective no-cost and low-cost technologies to reduce the public's magnetic-field exposure. While the large body of existing research does not indicate any harm associated with ELF EMF exposure, research on this topic will continue to reduce remaining scientific uncertainty.

[2] Docket No. 424. "Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health: Interstate Reliability Project, June 10, 2011"; Docket No. 435. "Update of Research on Extremely Low Frequency Electric and Magnetic Fields and Health May 1, 2011 – July 31, 2012 Stamford Reliability Cable Project, August 30, 2012."

2 Extremely Low Frequency Electric and Magnetic Fields: Nature, Sources, Exposure, and Known Effects

Nature of ELF EMF

Electricity is transmitted as current from generating sources to high-voltage transmission lines, substations, distribution lines, and then finally to our homes and workplaces for consumption. The vast majority of electricity is transmitted as alternating current (AC), completing full cycles of direction changes 60 times per second (i.e., a frequency of 60 Hertz [Hz]) in North America. ELF EMF from these AC sources is often referred to as power-frequency EMF.

Everything that is connected to our electrical system (i.e., power lines, appliances, and wiring) produces ELF EMF (Figure 1). Electric fields and magnetic fields are both properties of the space near these electrical sources. Forces are experienced by objects capable of interacting with these fields; electric charges are subject to a force in an electric field, and moving charges experience a force in a magnetic field.

- **Electric fields** are the result of voltages applied to electrical conductors and equipment. The electric field is expressed in measurement units of volts per meter (V/m) or kilovolts per meter (kV/m), where 1 kV/m = 1,000 V/m. Conducting objects including fences, buildings, and our own skin and muscle easily block electric fields. Therefore, certain appliances within homes and workplaces are the major source of electric fields indoors, while power lines are the major source of electric fields outdoors.

- **Magnetic fields** are produced by the flow of electric currents. Unlike electric fields, however, most materials (including the earth) do not readily block magnetic fields. The strength of a magnetic field is expressed as magnetic flux density in units of gauss (G) or mG, where 1 G = 1,000 mG.[3] The strength of the magnetic field at any point depends on characteristics of the source, including (in the case of power lines) the arrangement of conductors, the amount of current flow, and distance from the conductors.

Sources and exposure

The intensity of both electric fields and magnetic fields diminishes with increasing distance from the source. For example, higher EMF levels are measured close to the conductors of distribution and transmission lines and decrease rapidly with increasing distance from the conductors. Transmission line EMF generally decreases with distance from the conductors in proportion to the square of the distance, creating a bell-shaped curve of field strength to either side of the line.

Since electricity is such an integral part of our infrastructure (e.g., transportation systems) and our homes and businesses, people living in modern communities are surrounded by these fields (Figure 1). While EMF levels decrease with distance from the source, any home, school, or

[3] Scientists also refer to magnetic flux density at these levels in units of microtesla. Magnetic flux density in mG units can be converted to microtesla by dividing by 10 (i.e., 1 mG = 0.1 microtesla).

office tends to have a background EMF level as a result of the combined effect of the numerous EMF sources present in these locations.

Figure 1. Common sources of ELF EMF in the home (appliances, wiring, currents running on water pipes, and nearby distribution and transmission lines).

Figure 2 outlines typical EMF levels measured in residential settings and occupational environments (all of which contribute to a person's background EMF level) compared to typical EMF levels measured at a typical transmission line's right-of-way (ROW).[4] In general, the background magnetic-field level as estimated from the average of measurements throughout a house away from appliances may range up to approximately 5 mG, while levels can be hundreds of mG in close proximity to appliances. Background levels of electric fields range from 10-20 V/m, while appliances produce levels up to several tens of V/m (WHO, 1984).

Experiments have yet to show which aspect of ELF EMF exposure, if any, may be relevant to biological systems. The most commonly used metric of EMF exposure for health research is long-term, average personal exposure, which is the average of all exposures to the varied electrical sources encountered in the many places we spend our days and nights. As expected, this exposure is different for every person and is difficult to approximate. Exposure assessment is a source of uncertainty in epidemiologic studies of ELF EMF and health (WHO, 2007). Some basic conclusions drawn from surveys of the general public's exposure to magnetic fields are:

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[4] The fields from underground transmission lines are not included in this figure because they are a rare source of EMF exposure. The magnetic field over buried conductors can be as high, or even higher, than an overhead line, but the magnetic field will diminish more quickly with distance. No electric field will be produced above ground by underground cables.

- *Residential sources of magnetic-field exposure:*
    - Residential magnetic-field levels are caused by currents carried by nearby transmission and distribution systems, pipes or other conductive paths, and electrical appliances (Zaffanella, 1993).
    - The highest magnetic-field levels are typically found directly next to appliances (Zaffanella, 1993). NIEHS (2002) identified field levels at various distances from a number of common appliances in the home—the highest reported measured values at 6-inches from selected appliances were as follow: can opener, 1,500 mG; dishwasher; 200 mG; electric range, 200 mG; and washing machine, 100 mG; to name a few.
    - Several parameters affect personal magnetic-field exposures at home: residence type, residence size, type of water line, and proximity to overhead power lines. Persons living in small homes, apartments, homes with metallic piping, and homes close to three-phase electric power distribution and transmission lines tended to have higher at-home magnetic-field levels (Zaffanella and Kalton, 1998).
- *Personal magnetic-field exposure:*
    - A survey of approximately 1,000 randomly selected persons in the United States who wore a magnetic field meter that recorded the magnetic field twice each second reports that the average of all measurements taken over 24-hours, i.e., their time-weighted average (TWA) exposure, is less than 2 mG for the vast majority of persons (Zaffanella and Kalton, 1998).[5]
    - In general, personal magnetic-field exposure is greatest at work and when traveling (Zaffanella and Kalton, 1998).
- *Workplace magnetic-field exposure*
    - Some occupations (e.g., electric utility workers, sewing machine operators, telecommunication workers, industrial welders) have higher exposures due to work near equipment with high ELF EMF levels (NIEHS, 2002).
- *Power-line magnetic-field exposure*
    - The EMF levels associated with power lines vary substantially depending on their configuration and current load, among other factors. At a distance of 300 feet and during average electricity demand, however, the magnetic-field levels from many transmission lines are often similar to the background levels found in most homes (Figure 2).

[5] TWA exposure is the average exposure over a given specified time period (i.e., an 8-hour workday or a 24-hour day) of a person's exposure to a chemical or physical agent. The average is determined by sampling the exposure of interest throughout the time period.

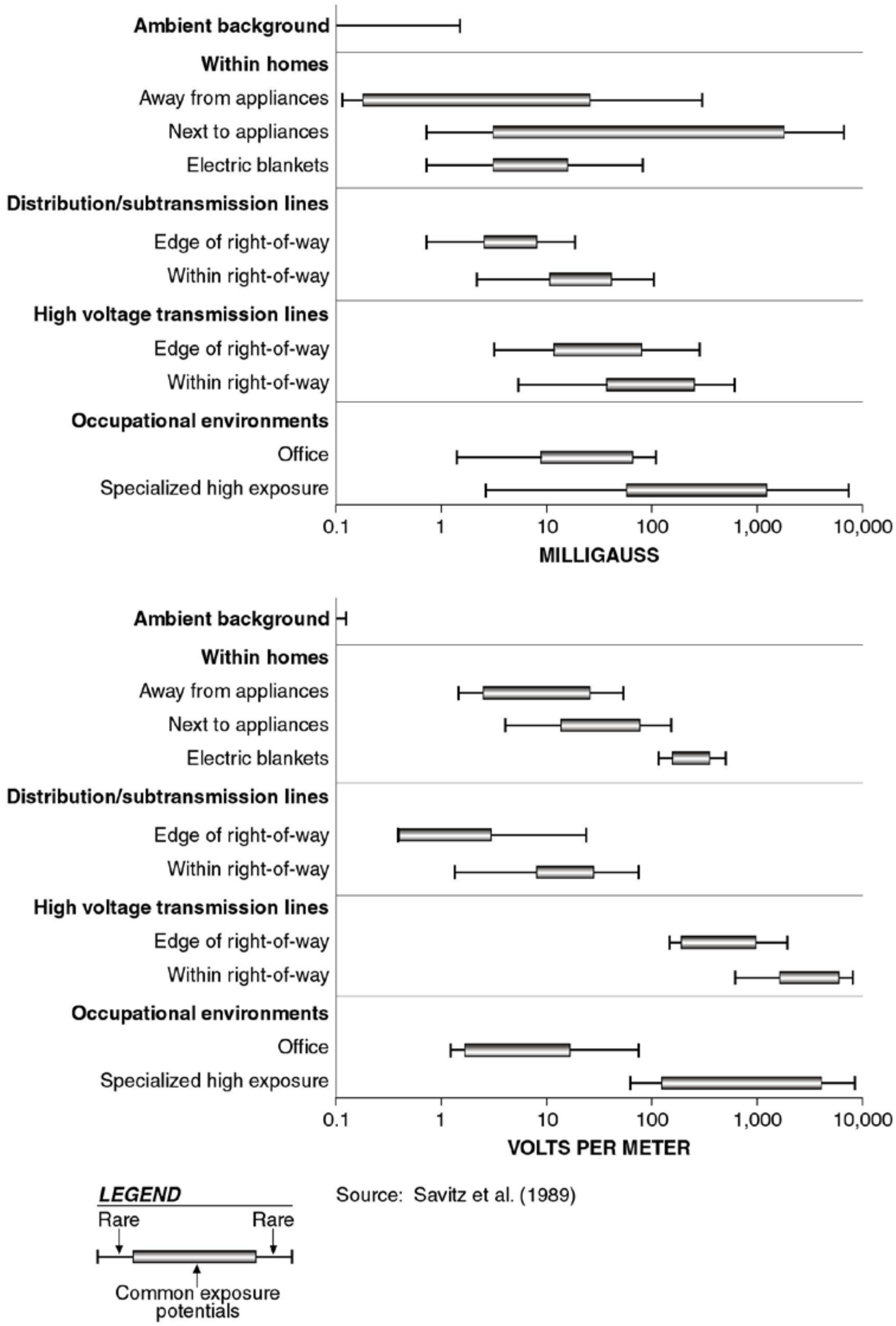

Figure 2. ELF magnetic field (upper panel) and electric field (lower panel) levels in various environments.

Known effects

There is a greater opportunity for long-term exposure to magnetic fields since electric fields are effectively blocked by common conductive objects. For this reason, among others, research on long-term health effects has focused on magnetic fields rather than electric fields.

Like virtually any exposure, adverse effects can be expected from exposure to very high levels of ELF EMF. If the current density or electric field induced by an extremely strong magnetic field exceeds a certain threshold, excitation of muscles and nerves is possible. Also, strong electric fields can induce charges on the surface of the body or ungrounded objects that can lead to small shocks (i.e., micro shocks) when discharged. These effects have no long-term damage or health consequences. Limits for the general public and workplace have been set to prevent these effects, but there are no real-life situations where these levels are exceeded on a regular basis.

Two international scientific organizations, ICNIRP and ICES, have published guidelines for limiting public exposure to ELF EMF to protect against these acute effects (ICES, 2002; ICNIRP, 1998, 2010). These guidelines were developed following weight-of-evidence reviews of the literature, including epidemiologic and experimental evidence related to both short-term and long-term exposure. Both reviews concluded that the stimulation of nerves and the central nervous system could occur at very high exposure levels immediately upon exposure, but that the research did not suggest any long-term health effects.

The ICNIRP guideline states that exposure to magnetic fields should be below 2,000 mG for the general public and 10,000 mG for workers "[to] provide protection against all established adverse health effects" (ICNIRP, 2010). The ICES recommends a maximum permissible magnetic-field exposure of 9,040 mG for the general public (ICES, 2002). For reference, in a survey by Zaffanella and Kalton (1998), only about 1.6% of the general public experienced exposure to magnetic fields of at least 1,000 mG during a 24-hour period.

The ICNIRP's screening value for exposure to 60-Hz electric fields for the general public is 4.2 kV/m and the ICES screening value is 5 kV/m. Both organizations allow higher exposures if it can be demonstrated that exposures do not produce electric fields within tissues that exceed basic restrictions on internal electric fields.

Table 1. Reference levels for whole body exposure to 60-Hz fields: general public

Organization recommending limit	Magnetic fields	Electric fields
ICNIRP restriction level	2,000 mG	4.2 kV/m
ICES maximum permissible exposure	9,040 mG	5 kV/m 10 kV/m[a]

[a] This is an exception within transmission line ROWs because people do not spend a substantial amount of time at these locations and very specific conditions are needed before a response is likely to occur (i.e., a person must be well insulated from ground and must contact a grounded conductor) (ICES, 2002, p. 27).

The literature over the past few years includes a number of studies of workers with the potential for high field exposures that characterize occupational exposure and evaluate compliance with standards. They include a study of spot measurements of EMF during work tasks at 110-kV switching and transforming stations in Finland to evaluate compliance with ICNIRP reference levels (Korpinen et al., 2011a) and a study of occupational electric field exposure at the same 110-kV switching station that evaluated compliance with the European Union's Directive 2004/40/EC (Korpinen et al., 2012); 3-hour TWA magnetic-field measurements of dentists and spot measurements near dental equipment in Taiwan (Huang et al., 2011); spot measurements and personal monitoring of magnetic fields in hospital personnel in Spain (Ubeda et al., 2011); spot measurements and personal monitoring of magnetic fields in railway workers in Italy (Contessa et al., 2010); and a study of electric fields, current densities, and contact currents at a 400-kV substation in Finland (Korpinen et al., 2011b). More recent publications reported measured magnetic-field values inside 110-kV substations in Finland and the Ukraine (Korpinen and Pääkkönen, 2015; Okun et al., 2014). The highest measured field levels were 2,500 and 4,200 mG in the two papers, respectively, in the immediate vicinity of busbars and cables. In general, the measured magnetic fields in these studies were below the occupational reference values of ICNIRP. At some locations within substations, worker exposure to electric fields could exceed the reference level (Korpinen et al., 2011b, 2012), but the induced current density in the central nervous system did not exceed the ICNIRP basic restriction value.

3 Methods for Evaluating Scientific Research

Science is more than a collection of facts. It is a method of obtaining information and of reasoning to ensure that the information and conclusions are accurate and correctly describe physical and biological phenomena. Many misconceptions in human reasoning occur when people casually interpret their observations and experience. Therefore, scientists use systematic methods to conduct and evaluate scientific research and assess the potential impact of a specific agent on human health. This process is designed to ensure that more weight is given to those studies of better quality and studies with a given result are not selected out from all of the studies available to advocate or suppress a preconceived idea of an adverse effect. Scientists and scientific agencies and organizations use these standard methods to draw conclusions about the many exposures in our environment.

Weight-of-evidence reviews

The scientific process entails looking at *all* the evidence on a particular issue in a systematic and thorough manner to evaluate if the overall data present a logically coherent and consistent picture. This is often referred to as a weight-of-evidence review, in which all relevant studies are considered together, giving more weight to studies of higher quality and using an established analytic framework to arrive at a conclusion about a possible causal relationship. Weight-of-evidence reviews are typically conducted within the larger framework of health risk assessments or evaluations of particular exposures or exposure circumstances that qualitatively and quantitatively define health risks. Weight-of-evidence and health risk assessment methods have been described by several agencies, including the IARC, which routinely evaluates substances such as drugs, chemicals, and physical agents for their ability to cause cancer; the WHO International Programme for Chemical Safety; and the US Environmental Protection Agency (EPA), which set guidance for public exposures (USEPA, 1993; WHO, 1994; USEPA, 1996; Rooney et al., 2014; OHAT, 2015). Two steps precede a weight-of-evidence evaluation: a systematic review to identify the relevant literature and an evaluation of each study to determine its strengths and weaknesses.

The following sections discuss important considerations in the evaluation of human health studies of ELF EMF in a weight-of-evidence review, including exposure considerations, study design, methods for estimating risk, bias, and the process of causal inference. The purpose of discussing these considerations here is to provide context for the later weight-of-evidence evaluations.

EMF exposure considerations

Exposure assessment methods range widely in studies of EMF. These methods include the classification of residences based on the relative capacity of nearby power lines to produce magnetic fields (i.e., wire code categories); occupational titles; calculated magnetic-field levels based on job histories (e.g., a job-exposure matrix); residential distance from nearby power lines; spot measurements of magnetic-field levels inside or outside residences; 24-hour and 48-hour measurements of magnetic fields in a particular location in the house (e.g., a child's bedroom);

calculated magnetic-field levels based on the characteristics of nearby power installations; and, finally, personal 24-hour and 48-hour magnetic-field measurements.

Each of these methods has strengths and limitations (Kheifets and Oksuzyan, 2008). Since magnetic-field exposures are ubiquitous and vary over a lifetime as the places we frequent and the sources of EMF in those places change, determining valid estimates of personal magnetic-field exposure is challenging. Furthermore, without a biological basis to define a relevant exposure metric (e.g., average or peak exposure) and a defined critical period for exposure (e.g., *in utero* or shortly before diagnosis), relevant and valid assessments of exposure are problematic. Exposure misclassification is one of the most significant concerns in epidemiologic studies of ELF EMF.

In general, long-term personal exposure measurements are the metric recommended by most epidemiologists to estimate exposure in their studies. Changes in the study subjects' behavior or environment that may be related to the disease under investigation, however, could potentially result in misclassification of the exposure when personal measurements are conducted following disease development. Other methods are also subject to exposure misclassification because they may not be strong predictors of long-term exposure and do not take into account all magnetic-field sources.

EMF can be estimated indirectly by assigning an estimated amount of EMF exposure to an individual based on calculations considering nearby power installations or a person's job title. For example, a relative estimate of exposure could be assigned to all machine operators based on historical information on the magnitude of the magnetic field produced by the machine. Indirect measurements are not as accurate as direct measurements because they do not contain information specific to that person or the exposure situation. In the example of machine operators, the indirect measurement may not account for how much time any one individual spends working at that machine or any potential variability in magnetic fields produced by the machines over time, and occupational measurements do not take into account the worker's residential magnetic-field exposures.

While an advance over earlier methods, job-exposure matrices still have some important limitations, as highlighted in a review by Kheifets et al. (2009) summarizing an expert panel's findings.[6] A person's occupation provides some relative indication of the overall magnitude of his or her occupational magnetic-field exposure, but it does not take into account the possible variation in exposure due to different job tasks within occupational titles, the frequency and intensity of contact to relevant exposure sources, or variation by calendar time. This was highlighted in a study of 48-hour magnetic-field measurements of 543 workers in Italy in a variety of occupational settings, including: ceramics, mechanical engineering, textiles, graphics, retail, food, wood, and biomedical industries (Gobba et al., 2011). There was significant variation in this study among the measured TWA magnetic-field levels for workers in many of the International Standard Classification of Occupations' job categories, which the authors attributed to variation in industry within the task-defined categories.

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[6] Kheifets et al. (2009) reports on the conclusions of an independent panel organized by the Energy Networks Association in the United Kingdom in 2006 to review the current status of the science on occupational EMF exposure and identify the highest priority research needs.

Types of health research studies

Research studies can be broadly classified into two groups: 1) epidemiologic observations of people and 2) experimental studies conducted on humans, animals (*in vivo*), and cells and tissues (*in vitro*) in laboratory settings.

Epidemiologic studies investigate how disease is distributed in populations and what factors influence or determine this disease distribution (Gordis, 2000). Epidemiologic studies attempt to establish causes for human disease while observing people as they go about their normal, daily lives. Such studies are designed to quantify and evaluate the associations between disease and reported exposures to environmental factors.

The most common types of epidemiologic studies in the EMF literature are case-control and cohort studies. In case-control studies, the exposures of people with and without the disease of interest are compared. Often, people are interviewed or their personal records (e.g., medical records or employment records) are reviewed in order to establish the exposure history for each individual. The exposure histories of the diseased (case) and non-diseased (control) populations are compared to determine whether any statistically significant differences in exposure histories exist. A difference in the exposure of the case and control populations may suggest an association between the exposure and the disease. In cohort studies, on the other hand, individuals within a defined cohort of people (e.g., all persons working at a utility company) are classified as exposed or non-exposed and followed over time for the incidence of disease. Researchers then compare disease incidence in the exposed and non-exposed groups and so can directly estimate exposure related risks.

Experimental studies are designed to test specific hypotheses under controlled conditions and are vital to assessing cause-and-effect relationships. An example of a human experimental study relevant to this area of research would be a study that measures the impact of magnetic-field exposure on acute biological responses in humans, such as hormone levels. These studies are conducted in laboratories under controlled conditions.

In vivo and *in vitro* experimental studies are also conducted under controlled conditions in laboratories. *In vivo* studies expose laboratory animals to very high levels of a chemical or physical agent to determine whether exposed animals develop cancer or other diseases at higher rates than unexposed animals, while attempting to control other factors that could possibly affect disease rates (e.g., diet and genetics). *In vitro* studies of isolated cells and tissues are also important because they can help scientists understand biological mechanisms as they relate to the same exposure in intact humans and animals.

The results of experimental studies of animals, and particularly those of isolated tissues or cells, however, may not always be directly extrapolated to human populations. In the case of *in vitro* studies, the responses of cells and tissues outside the body may not reflect the response of those same cells if maintained in a living system, so their relevance cannot be assumed. Therefore, it is both necessary and desirable to explore agents that could present a potential health threat in epidemiologic studies as well.

Both of these approaches—epidemiologic and experimental laboratory studies—have been used to evaluate whether exposure to EMF has any adverse effects on human health. Epidemiologic studies are valuable because they are conducted in human populations, but they are limited by their non-experimental design and typical retrospective nature. In epidemiologic studies of EMF, for example, researchers cannot control the amount of individual exposure to EMF, the contribution from different field sources, how exposure occurs over time, or individual behaviors that could affect disease risk, such as diet or smoking. In valid risk assessments of EMF, epidemiologic studies are considered alongside experimental studies of laboratory animals, while studies of isolated cells and tissues are generally acknowledged as being supplementary.

Estimating risk

Epidemiologists measure the statistical association between exposures and disease in order to estimate risk. In this context, risk simply refers to an exposure that is associated with a health event and does not imply that a causal relationship has been established.[7] This brief summary of risk is included to provide a foundation for understanding and interpreting statistical associations in epidemiologic studies as risk estimates.

Two common types of risk estimates are absolute risk and relative risk (RR). Absolute risk, also known as incidence, is the amount of new disease that occurs in a given period of time. For example, the absolute risk of invasive childhood cancer in children ages 0-19 years for 2004 was 14.8 per 100,000 children (Ries et al., 2007). RR estimates are calculated to evaluate whether a particular exposure or inherent quality (e.g., EMF, diet, genetics, race) is associated with a disease outcome. This is calculated by looking at the absolute risk in one group relative to that in a comparison group. For example, white children in the 0-19 year age range had an estimated absolute risk of childhood cancer of 15.4 per 100,000 in 2004, and African American children had an estimated absolute risk of 13.3 per 100,000 in the same year. By dividing the absolute risk of white children by the absolute risk of African American children, we obtain a RR estimate of 1.16. This RR estimate can be interpreted to mean that white children have a risk of childhood cancer that is 16% greater than the risk of African American children. Additional statistical analysis is needed to evaluate whether this association is statistically significant, as defined in the following sub-section.

It is important to understand that risk is estimated differently in cohort and case-control studies because of the way the studies are designed. Traditional cohort studies can provide a direct estimate of RR, while case-control studies can only provide indirect estimates of RR, called odds ratios (OR). For this reason, among others, cohort studies usually provide more reliable estimates of the risk associated with particular exposures. Case-control studies are more common than cohort studies, however, because of they are less costly and more time efficient.

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[7] The following definition is provided of a risk factor in a dictionary of epidemiology terms: "…an aspect of personal behavior or lifestyle, an environmental exposure, or an inborn or inherited characteristic, that, on the basis of epidemiological evidence, is known to be associated with health-related condition(s) considered important to prevent" (Last, 2001, p. 160).

Thus, the association between a particular disease and exposure is measured quantitatively in an epidemiologic study as either the RR estimate (cohort studies) or OR (case-control studies). The general interpretation of a RR estimate equal to 1.0 is that the exposure is not associated with the occurrence of the disease. If the RR estimate is greater than 1.0, the inference is that the exposure is associated with an increased incidence of the disease. On the other hand, if the RR estimate is less than 1.0, the inference is that the exposure is associated with a reduced incidence of the disease. The magnitude of the RR estimate is often referred to as its strength (i.e., strong vs. weak). Stronger associations are given more weight because they are less susceptible to the effects of bias.

Statistical significance

Statistical significance testing provides an idea of whether or not a statistical association is caused by chance alone, i.e., whether the association is likely to be observed upon repeated testing or whether it is simply a chance occurrence. The terms “statistically significant” or “statistically significant association” are used in epidemiologic studies to describe the tendency of the level of exposure and the occurrence of disease to be linked, with chance alone as an unlikely explanation. Statistically significant associations, however, are not automatically an indication of cause-and-effect, because the interpretation of statistically significant associations depends on many other factors associated with the design and conduct of the study, including, how the data were collected and the size of the study. Statistical significance testing in itself does not provide any information on potential sources of systematic error or bias in the study.

Confidence intervals (CI) are typically reported along with RR and OR values. A CI is a range of values for an estimate of effect that has a specified probability (e.g., 95%) of including the true estimate of effect; CIs evaluate statistical significance, but do not address the role of bias, as described further below. A 95% CI indicates that, if the study were conducted a very large number of times, 95% of the measured estimates would be within the upper and lower confidence limits.

The range of the CI is also important for interpreting estimated associations, including the precision and statistical significance of the association. A very wide CI indicates great uncertainty in the value of the true risk estimate. This is usually due to a small number of observations. A narrow CI provides more certainty about where the true RR estimate lies (assuming no bias in the study). Another way of interpreting the CI is if the 95% CI does not include 1.0, the probability of an association being due to chance alone is 5% or lower and the result is considered statistically significant, as discussed above. Statistical variation, however, while easily estimated, is just one of the sources of uncertainty in the characterization of epidemiological associations. Additional uncertainties may result from bias (e.g., participation, selection, or recall biases) and confounding by alternative exposures. These additional uncertainties are not quantified by statistical testing and the assessment of their influence on the overall interpretation requires expert evaluation of information from outside the studies themselves.

Meta-analysis and pooled analysis

In epidemiologic research, the results of studies with a smaller number of participants may be difficult to distinguish from normal, random variation. This is also the case for sub-group analyses where few cases are estimated to have high exposure levels (e.g., in case-control studies of childhood leukemia and TWA magnetic-field exposure greater than 3-4 mG). Meta-analysis is an analytic technique that combines the published results from a group of studies into one summary result. A pooled analysis, on the other hand, combines the raw, individual-level data from the original studies and analyzes all of the data from the studies together. These methods are valuable because they increase the number of individuals in the analysis, which allows for a more robust and stable estimate of association. Meta- and pooled analyses also are an important tool for quantitatively synthesizing the results of a large group of studies.

The disadvantage of meta- and pooled analyses is that they can convey a false sense of consistency across studies if *only* the combined estimate of effect is considered (Rothman and Greenland, 1998). These analyses typically combine data from studies with different study populations, methods for measuring and defining exposure, and disease definitions. This is particularly true for analyses that combine data from case-control studies, which often use very different methods for the selection of cases and controls and exposure assessment. Therefore, in addition to the synthesis or combining of data, meta- and pooled analyses should be used to understand what factors cause the results of the studies to vary (e.g., publication date, study design, possibility of selection bias), and how these factors affect the associations calculated from the data of all the studies combined (Rothman and Greenland, 1998).

Meta- and pooled analyses are a valuable technique in epidemiology; however, in addition to calculating a summary RR, they should follow standard techniques (Stroup et al., 2001) and analyze the factors that contribute to any heterogeneity between the studies. It is also important to note that potential biases present in the original individual studies will also impact the results of the meta- and pooled analyses.

Bias in epidemiologic studies

One key reason that results of non-experimental epidemiologic studies cannot directly provide evidence for cause-and-effect is the potential presence of bias. Bias is defined as "any systematic error in the design, conduct or analysis of a study that results in a mistaken estimate of an exposure's effect on the risk of disease" (Gordis, 2000, p. 204). In other words, sources of bias are factors or research situations that can mask a true association or cause an apparent association in the study that does not truly exist. As a result, the extent of bias, as well as its types and sources, is one of the most important considerations in the interpretation of epidemiologic studies. Since it is not possible to fully control human populations, perfectly measure their exposures, or control for the effects of all other risk factors, bias will exist in some form in all epidemiologic studies of human health. Experimental studies, on the other hand, more effectively manage bias because of the tight control the researchers have over most study variables.

One important source of bias occurs when a third variable confuses the relationship between the exposure and disease of interest because of its relationship to both. Consider an example of a researcher whose study finds that people who exercise have a lower risk of diabetes compared to people who do not exercise. It is known that people who exercise more also tend to consume healthier diets and healthier diets may lower the risk of diabetes. If the researcher does not control for the impact of diet, it is not possible to say with certainty that the lower risk of diabetes is due to exercise and not to a healthier diet. In this example, diet is the confounding variable.

Cause vs. association and evaluating evidence regarding causal associations

Epidemiologic studies can help suggest factors that may contribute to the risk of disease, but they are not used as the sole basis for drawing inferences about cause-and-effect relationships. Since epidemiologists do not have control over the many other factors to which people are exposed in their studies (e.g., chemicals, pollution, infections) and diseases can be caused by a complex interaction of many factors, the results of epidemiologic studies must be interpreted with caution. A single epidemiologic study is rarely unequivocally supportive or non-supportive of causation; rather, a weight is assigned to the study based on the validity of its methods and all studies (epidemiologic, *in vivo*, and *in vitro*) must be considered together in a weight-of-evidence review to arrive at a conclusion about possible causality between an exposure and disease.

Scientific guidance for assessing the overall epidemiologic evidence for causality was formally proposed by Sir Austin Bradford Hill (Hill, 1965). Hill put forth nine criteria for use in an evaluation of causality for associations observed in epidemiologic studies. These criteria included strength of association, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment, and analogy. Hill cautioned that, while none of these criteria are *sine qua non* of causality, the more the epidemiologic evidence meets these guidelines, the more convincing the evidence is for a potential causal interpretation. The use of these guidelines is recommended after chance is ruled out with reasonable certainty as a potential explanation for the observed epidemiologic association.

In 1964, the Surgeon General of the United States published a landmark report on smoking-related diseases (HEW, 1964). As part of this report, nine criteria, similar to those proposed by Hill for evaluating epidemiologic studies (along with experimental data) for causality, were outlined. In a more recent version of this report, these criteria have been reorganized into seven criteria. In the earlier version, coherence, plausibility, and analogy were considered as distinct items, but are now summarized together because they have been treated in practice as essentially reflecting one concept (HHS, 2004). Table 2 provides a listing of the criteria and a brief description of each.

Table 2. Criteria for evaluating whether an association is causal

Criteria	Description
Consistency	Repeated observation of an association between exposure and disease in multiple studies of adequate statistical power, in different populations, and at different times.
Strength of the association	The larger (stronger) the magnitude and statistical strength of an association is between exposure and disease, the less likely such an effect is the result of chance or unmeasured confounding.
Specificity	The exposure is the single (or one of a few) cause of disease.
Temporality	The exposure occurs prior to the onset of disease.
Coherence, plausibility, and analogy	The association cannot violate known scientific principles and the association must be consistent with experimentally demonstrated biologic mechanisms.
Biologic gradient	This is also known as a dose-response relationship, i.e., the observation that the stronger or greater the exposure is, the stronger or greater the effect.
Experiment	Observations that result from situations in which natural conditions imitate experimental conditions. Also stated as a change in disease outcome in response to a non-experimental change in exposure patterns in population.

Source: Department of Health and Human Services, 2004

The criteria were meant to be applied to statistically significant associations that have been observed in the cumulative epidemiologic literature, i.e., if no statistically significant association has been observed for an exposure then the criteria are not relevant. It is important to note that these criteria were not intended to serve as a checklist; rather, they were intended to serve as a guide in evaluating associations for causal inference. Theoretically, it is possible for an exposure to meet all seven criteria, but still not be deemed a causal factor. Also, no one criterion can provide indisputable evidence for causation, nor can any single criterion, aside from temporality, rule out causation.

In summary, the judicious consideration of these criteria is useful in evaluating epidemiologic studies, but they cannot be used as the sole basis for drawing inferences about cause-and-effect relationships. In line with the criteria of "coherence, plausibility, and analogy," epidemiologic studies are considered along with *in vivo* and *in vitro* studies in a comprehensive weight-of-evidence review. Epidemiologic support for causality is usually based on high-quality studies reporting consistent results across many different populations and study designs that are supported by the experimental data collected from *in vivo* and *in vitro* studies.

Biological response vs. disease in human health

When interpreting research studies, it is important to distinguish between a reported biological response and an indicator of disease. This is relevant because exposure to EMF may elicit a biological response that is simply a normal response to environmental conditions. This response, however, might not be a disease, cause a disease, or be otherwise harmful. There are many exposures or factors encountered in day-to-day life that elicit a biological response, but the response is neither harmful nor does it cause disease. For example, when an individual walks from a dark room indoors to a sunny day outdoors, the pupils of the eye naturally constrict to limit the amount of light passing into the eye. This constriction of the pupil is a biological response to the change in light conditions. Pupil constriction, however, is neither a disease itself, nor is it known to cause disease.

4 The WHO 2007 Report: Methods and Conclusions

The WHO is a scientific organization within the United Nations system whose mandate includes providing leadership on global health matters, shaping health research agendas, and setting norms and standards. The WHO established the International EMF Project in 1996, in response to public concerns about exposure to EMF and possible adverse health outcomes. The project's membership includes 8 international organizations, 8 collaborating institutions, and over 54 national authorities. The overall purpose of the Project is to assess health and environmental effects of exposure to static and time-varying fields in the frequency range 0-300 Gigahertz (GHz). A key objective of the EMF Project was to evaluate the scientific literature and make a status report on health effects to be used as the basis for a coherent international response, including the identification of important research gaps and the development of internationally acceptable standards for EMF exposure.

Methods

As part of their Environmental Health Criteria Programme, the WHO published a Monograph in June 2007 summarizing health research on EMF exposure in the ELF range. The Monograph used standard scientific procedures, as outlined in its Preamble and described above in Section 3, to conduct the review. The Task Group responsible for the report's overall conclusions consisted of 21 scientists from around the world with expertise in a wide range of disciplines. The Task Group relied on the conclusions of previous weight-of-evidence reviews,[8] where possible, and mainly focused on evaluating studies published after an IARC review of ELF EMF (with regard to cancer) in 2002 .

The WHO Task Group and IARC use specific terms to describe the strength of the evidence in support of causality between specific agents and cancer. These categories are described here because, while they are meaningful to scientists who are familiar with the IARC process, they can be confusing and can create an undue level of concern with the general public.

Sufficient evidence of carcinogenicity is assigned to a body of epidemiologic research if a positive association has been observed in studies in which chance, bias, and confounding can be ruled out with reasonable confidence. *Limited evidence of carcinogenicity* describes a body of epidemiologic research where the findings are inconsistent or there are outstanding questions about study design or other methodological issues that preclude making a conclusion. *Inadequate evidence of carcinogenicity* describes a body of epidemiologic research where it is unclear whether the data are supportive or unsupportive of causation because there is a lack of data or there are major quantitative or qualitative issues. A similar classification system is used for evaluating *in vivo* studies and mechanistic data for carcinogenicity.

[8] The term weight-of-evidence review is used in this report to denote a systematic review process by a multidisciplinary, scientific panel involving experimental and epidemiologic research to arrive at conclusions about possible health risks. The WHO Monograph on EMF does not specifically describe their report as a weight-of-evidence review. Rather, they describe conducting a health risk assessment. A health risk assessment differs from a weight-of-evidence review in that it also incorporates an exposure and exposure-response assessment.

Summary categories are assigned by considering the conclusions of epidemiologic and *in vivo* evidence together (Figure 3).[9] Categories include (from highest to lowest risk): known carcinogen; probable carcinogen; possible carcinogen; not classifiable; and probably not a carcinogen. These categories are intentionally meant to err on the side of caution, giving more weight to the possibility that the exposure is truly carcinogenic and less weight to the possibility that the exposure is not carcinogenic. In the IARC classification system, possible carcinogen denotes exposures for which there is limited evidence of carcinogenicity in epidemiologic studies and less than sufficient evidence of carcinogenicity in studies of experimental animals.

	Epidemiology Studies				Animal Studies			
	Sufficient evidence	Limited evidence	Inadequate evidence	Evidence suggesting lack of carcinogenicity	Sufficient evidence	Limited evidence	Inadequate evidence	Evidence suggesting lack of carcinogenicity
Known Carcinogen	✓							
Probable Carcinogen		✓			✓			
Possible Carcinogen		✓				✓	✓	
Not Classifiable			✓			✓	✓	
Probably not a Carcinogen				✓				✓

Sufficient evidence in epidemiology studies—A positive association is observed between the exposure and cancer in studies, in which chance, bias and confounding were ruled out with "reasonable confidence."

Limited evidence in epidemiology studies—A positive association has been observed between the exposure and cancer for which a causal interpretation is considered to be credible, but chance, bias or confounding could not be ruled out with "reasonable confidence."

Inadequate evidence in epidemiology studies—The available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence or absence of a causal association between exposure and cancer, or no data on cancer in humans are available.

Evidence suggesting a lack of carcinogenicity in epidemiology studies—There are several adequate studies covering the full range of levels of exposure that humans are known to encounter, which are mutually consistent in not showing a positive association between exposure to the agent and any studied cancer at any observed level of exposure. The results from these studies alone or combined should have narrow confidence intervals with an upper limit close to the null value (e.g. a relative risk of 1.0). Bias and confounding should be ruled out with reasonable confidence, and the studies should have an adequate length of follow-up.

Sufficient evidence in animal studies—An increased incidence of malignant neoplasms is observed in (a) two or more species of animals or (b) two or more independent studies in one species carried out at different times or indifferent laboratories or under different protocols. An increased incidence of tumors in both sexes of a single species in a well-conducted study, ideally conducted under Good Laboratory Practices, can also provide sufficient evidence.

Limited evidence in animal studies—The data suggest a carcinogenic effect but are limited for making a definitive evaluation, e.g. (a) the evidence of carcinogenicity is restricted to a single experiment; (b) there are unresolved questions regarding the adequacy of the design, conduct or interpretation of the studies; etc.

Inadequate evidence in animal studies—The studies cannot be interpreted as showing either the presence or absence of a carcinogenic effect because of major qualitative or quantitative limitations, or no data on cancer in experimental animals are available

Evidence suggesting a lack of carcinogenicity in animal studies—Adequate studies involving at least two species are available which show that, within the limits of the tests used, the agent is not carcinogenic.

Figure 3. Basic IARC method for classifying exposures based on potential carcinogenicity.

9 *In vitro* research is not described in Figure 3 because it provides ancillary information and, therefore, is used to a lesser degree in evaluating carcinogenicity. *In vitro* studies are classified simply as strong, moderate, or weak.

As of September 2015, the IARC has reviewed close to 1,000 substances and exposure circumstances to evaluate their potential carcinogenicity. About 80% of exposures fall in the categories possible carcinogen (29%) or not classifiable (51%). This occurs because it is nearly impossible to prove that something is completely safe and few exposures show a clear-cut or probable risk, so most agents will end up in either of these two categories. Throughout the history of the IARC, only one agent has been classified as probably not a carcinogen, which illustrates the conservatism of the evaluations and the difficulty in proving the absence of an effect beyond all doubt.

Conclusions

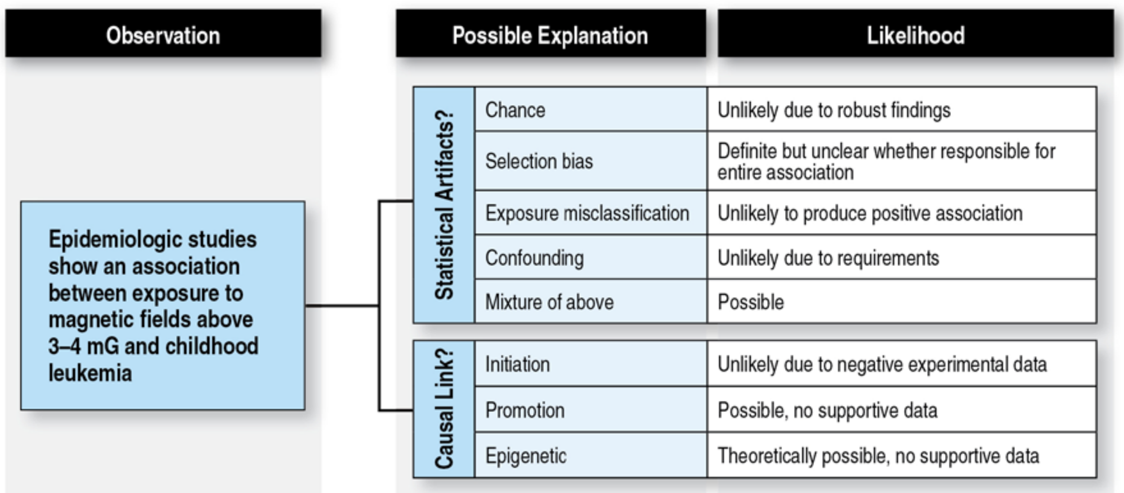
The WHO report provided the following overall conclusions with regard to ELF EMF:

> New human, animal, and *in vitro* studies published since the 2002 IARC Monograph, 2002 [*sic*] do not change the overall classification of ELF as a possible human carcinogen (WHO, 2007, p. 347).
>
> Acute biological effects [i.e., short-term, transient health effects such as a small shock] have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz [kilohertz] that may have adverse consequences on health. Therefore, exposure limits are needed. International guidelines exist that have addressed this issue. Compliance with these guidelines provides adequate protection. Consistent epidemiological evidence suggests that chronic low-intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted (WHO, 2007, p. 355).

With regard to specific diseases, the WHO concluded the following:

Childhood cancers. The WHO report paid particular attention to childhood leukemia because the most consistent epidemiologic association in the area of ELF EMF and health research has been reported between this disease and TWA exposure to high, magnetic-field levels. Two pooled analyses reported an association between childhood leukemia and TWA magnetic-field exposure greater than 3-4 mG (Ahlbom et al., 2000; Greenland et al., 2000); these data, categorized as limited epidemiologic evidence, resulted in the classification of ELF magnetic fields as a possible carcinogen by the IARC in 2002.

The WHO report systematically evaluated several factors that might be partially, or fully, responsible for the consistent association, including: chance; misclassification of magnetic-field exposure; confounding from hypothesized or unknown risk factors; and selection bias (Figure 4). The authors concluded that chance is an unlikely explanation since the pooled analyses had a large sample size and decreased variability. Control selection bias probably occurs to some extent in these studies and would result in an overestimate of the true association, but would likely not entirely explain the observed association. It is less likely that confounding occurs, although the possibility that some yet-to-be identified confounder is responsible for the association cannot be fully excluded. Finally, exposure misclassification would likely result in an underestimate of the true association, although that may not always be the case. The WHO concluded that reconciling the epidemiologic data on childhood leukemia and the negative experimental findings (i.e., no hazard or risk observed) through innovative research is currently the highest priority in the field of ELF EMF research. Given that few children are expected to have average magnetic-field exposures greater than 3-4 mG, however, the WHO stated that the public health impact of magnetic fields on childhood leukemia would likely be minimal, if the association was determined to be causal.



Source: Adapted from Schüz and Ahlbom (2008)

Figure 4. Possible explanations for the observed association between magnetic fields and childhood leukemia.

Fewer studies have been published on magnetic fields and childhood brain cancer compared to studies of childhood leukemia. The WHO Task Group described the results of these studies as inconsistent and limited by small sample sizes. They recommended a meta-analysis to clarify the research findings.

Breast cancer. The WHO concluded that the more recent published studies on breast cancer and ELF EMF exposure were higher in quality compared with earlier studies, and for that reason, they provided strong support to previous consensus statements that magnetic-field exposure does not influence the risk of breast cancer. In summary, the WHO stated "[w]ith these [recent] studies, the evidence for an association between ELF magnetic-field exposure and the risk of female breast cancer is weakened considerably and does not support an association of this kind" (WHO, 2007, p. 9). The WHO recommended no further research with respect to breast cancer and magnetic-field exposure.

Adult leukemia and brain cancer. The WHO concluded, "In the case of adult brain cancer and leukaemia [*sic*], the new studies published after the IARC monograph do not change the conclusion that the overall evidence for an association between ELF [EMF] and the risk of these diseases remains inadequate" (WHO, 2007, p. 307). The WHO panel recommended updating the existing European cohorts of occupationally-exposed individuals and pooling the epidemiologic data on brain cancer and adult leukemia to confirm the absence of an association.

In vivo research on carcinogenesis. The WHO concluded the following with respect to *in vivo* research, "[t]here is no evidence that ELF exposure alone causes tumours. The evidence that ELF field exposure can enhance tumour [*sic*] development in combination with carcinogens is inadequate" (WHO, 2007, p. 10). Recommendations for future research included the development of a rodent model for childhood acute lymphoblastic leukemia (ALL) and the continued investigation of whether magnetic fields can act as a co-carcinogen.

In vitro research on carcinogenesis. The WHO concluded that magnetic-field exposure below 50,000 mG was not associated with genotoxicity *in vitro*. There was some evidence, however, to suggest that magnetic fields above these levels might interact with other genotoxic agents to induce damage. Evidence for an association between magnetic fields and altered apoptosis or expression of genes controlling cell cycle progression was considered inadequate.

Reproductive and developmental effects. The WHO concluded that, overall, the body of research does not suggest that maternal or paternal exposures to ELF EMF cause adverse reproductive or developmental outcomes. The evidence from epidemiologic studies on miscarriage was described as inadequate and further research on this possible association was recommended, although it was designated as low priority.

In vivo research on reproductive and developmental effects. The WHO Task Group concluded that the available *in vivo* studies were inadequate for drawing conclusions regarding the potential effects of magnetic fields on the reproductive system. Furthermore, the Task Group concluded that studies conducted in mammalian models showed no adverse developmental effects associated with magnetic-field exposure.

Neurodegenerative disease. The WHO reported that the majority of epidemiologic studies have reported associations between occupational magnetic-field exposure and mortality from Alzheimer's disease and amyotrophic lateral sclerosis (ALS), although the design and methods of these studies were relatively weak (e.g., disease status was based on death certificate data; exposure was based on incomplete occupational information from census data; and there was no control for confounding factors). The WHO concluded that there is inadequate data in support of an association between magnetic fields and Alzheimer's disease or ALS. The panel highly recommended that further studies be conducted in this area, particularly studies where the association between magnetic fields and ALS is estimated while controlling for the possible confounding effect of electric shocks.

In vivo research on neurological effects. The WHO stated that various animal models were used to investigate possible field-induced effects on brain function and behavior. Few brief, transient responses had been identified.

Cardiovascular disease. It has been hypothesized that magnetic-field exposure reduces heart rate variability, which in turn increases the risk for acute myocardial infarction (AMI). With one exception (Savitz et al., 1999), however, none of the studies of cardiovascular disease morbidity and mortality has shown an association with exposure. Whether a specific association exists between exposure and altered autonomic control of the heart remains speculative and the overall evidence does not support an association. Experimental studies of both short- and long-term exposure indicate that, while electric shock is an obvious health hazard, other hazardous cardiovascular effects associated with ELF EMF are unlikely to occur at exposure levels commonly encountered environmentally or occupationally.

5 Current Scientific Consensus

The following sections identify and describe epidemiologic and *in vivo* studies related to ELF EMF and health published from August 1, 2012 through July 31, 2015. The purpose of this section is to evaluate whether the findings of these recent studies alter the conclusions published by the WHO in their 2007 report, as described in Section 4.

A structured literature search was conducted using PubMed, a search engine provided by the National Library of Medicine and the National Institutes of Health that includes over 15 million up-to-date citations from MEDLINE and other life science journals for biomedical articles (http://www.pubmed.gov). A well-defined search strategy was used to identify literature indexed August 1, 2012 through July 31, 2015.[10] While PubMed contains an extensive database of publications, some studies are indexed well after their publication date. For that reason, there may be studies included in this report that were actually published prior to August 1, 2012, but indexed after that date.

All fields (title, abstract, keywords, among others) were searched with various search strings that referenced the exposure[11] and diseases of interest.[12] A scientist with experience in this area reviewed the titles and abstracts of these publications for inclusion in this evaluation. Only peer-reviewed, epidemiologic studies and pooled- or meta-analyses of 50-Hz or 60-Hz AC ELF EMF and recognized disease entities are included. *In vivo* animal and human studies of 50-Hz or 60-Hz AC ELF EMF are also included, but only on the topic of cancer.

In addition to PubMed, EMF-Portal was also searched for relevant articles published during the same timeframe.[13] EMF-Portal is an extensive online database dedicated to scientific research related to potential effects of EMF. EMF-Portal currently includes over 21,000 publications and over 5,000 research summaries in a searchable format. EMF-Portal is maintained by Aachen University in Germany.

Methodological research is now being pursued in many areas of ELF EMF research to identify the possible impact of certain aspects of study design or biases on the studies' results. Therefore, articles evaluating the impact of methodological aspects of epidemiologic studies in this field are discussed, where appropriate. Systematic review articles of relevant topics are also noted, where appropriate. Studies published prior to the scope of this update are noted in certain circumstances to provide context.

[10] While extensive efforts were made to identify relevant studies, it is possible that some studies reporting on the association between a disease and some measure of EMF exposure were missed. Many occupational and environmental case-control studies of cancer are published, some of which examine a large number of possible exposures; if no reference to EMF is made in the abstract, title, or keywords, for example, these studies may not have been identified using our search strategy. The most informative studies in this field, however, will be identified by our search strategy.

[11] EMF, magnetic fields, electric fields, or electromagnetic.

[12] Cancer (cancer, leukemia, lymphoma, carcinogenesis), neurodegenerative disease (neurodegenerative disease, Alzheimer's disease, amyotrophic lateral sclerosis, or Lou Gehrig's disease), cardiovascular effects (cardiovascular or heart rate), or reproductive outcomes (miscarriage, reproduction, or development).

[13] http://www.emf-portal.de

Epidemiologic studies are evaluated below by outcome (childhood cancer; adult cancer; reproductive or developmental effects; neurodegenerative diseases; and cardiovascular effects), followed by an evaluation of *in vivo* research in the field of cancer. Tables 3-11 list the relevant studies in these areas, including the study's first author and the title of the article.

Childhood leukemia

In 2002, the IARC assembled and reviewed research related to ELF EMF to evaluate the strength of the evidence in support of carcinogenicity. The IARC expert panel noted that, when studies with the relevant information were combined in a pooled analysis, a statistically significant two-fold association was observed between childhood leukemia and estimated exposure to high, average levels of magnetic fields (i.e., greater than 3-4 mG of average 24- and 48-hour exposure). This evidence was classified as limited evidence in support of carcinogenicity, falling short of sufficient evidence because chance, bias, and confounding could not be ruled out with reasonable confidence. Largely as a result of the findings related to childhood leukemia, the IARC classified magnetic fields as a possible carcinogen, a category that describes exposures with limited epidemiologic evidence and inadequate evidence from *in vivo* studies (see Figure 3). The classification of possible carcinogen was confirmed by the WHO in their June 2007 review.

Recent studies (2012 – 2015)

Childhood leukemia continues to be the main focus of ELF EMF epidemiologic research. In recent years, several large case-control studies from France, Denmark, and the United Kingdom have assessed the risk of childhood leukemia in relation to residential proximity to high-voltage power lines (Sermage-Faure et al., 2013; Bunch et al., 2014; Bunch et al., 2015; Pedersen et al., 2014a). The French study used geocoded information on residential addresses and power line locations to examine the risk of childhood leukemia in association with distance to power lines between 2002 and 2007. Overall, the study included 2,779 cases of childhood leukemia and 30,000 control children (Sermage-Faure et al., 2013) and reported no statistically significant increase in leukemia risk with distance to power lines. The authors, however, noted a statistically non-significant risk increase in a sub-analysis within 50 meters of 225-kV – 400-kV lines, but this was based on a small number of cases (n=9). A similar study from Denmark included 1,698 cases of childhood leukemia and 3,396 healthy control children (Pedersen et al., 2014a). The authors reported no risk increases for childhood leukemia with residential distance to power lines. The same authors also evaluated whether consideration of other potential risk factors for childhood leukemia may influence the results for distance to power lines (Pedersen et al., 2014b). No influence of adjustment for socioeconomic status, mother's age, birth order, domestic radon exposure, or traffic-related air pollution was observed in the power-line specific results. While the authors reported a statistical interaction between distance to power lines and radon exposure, they attributed these findings to chance, as these results were based on a small number of cases.

Bunch et al. (2014) reported on a study that updated and extended the 2005 study conducted by Draper et al. in the United Kingdom. The update extended the study period by 13 years, included Scotland in addition to England and Wales, and included 132-kV lines in addition to 275-kV and 400-kV transmission lines. Bunch et al. is the largest case-control study to date—it included over 53,000 childhood cancer cases, diagnosed between 1962 and 2008, and over

66,000 healthy children as controls. Overall, the authors reported no association with residential proximity to power lines with any of the voltage categories. In the overall analysis of the updated data, the statistical association that was reported in the earlier study (Draper et al., 2005) was no longer apparent. An analysis by calendar time indicated that the association was evident only in the earlier decades (1960s and 1970s) but not present in the later decades starting from the 1980s (Bunch et al., 2014). This weakens the argument that the associations observed earlier are due to magnetic-field effects. Population mixing (with potential infectious etiology) has been proposed to explain the associations observed in the earlier years but no empirical data are available in support of this hypothesis (Jeffers, 2014). In a follow up analysis of the same study population, the investigators also examined residential distance to high-voltage underground cables (mostly AC 275 kV and 400 kV) to case and control residences (Bunch et al., 2015). Over 52,000 cases of childhood cancer occurring between 1962 and 2008 in England and Wales, along with their matched controls, were included in these analyses. The authors reported no statistically significant associations or exposure-response trends between childhood leukemia and distance to power lines or calculated magnetic-field levels from the underground cables. The authors concluded that their results further detract from the hypothesis that exposure to magnetic fields explains the associations observed in earlier studies.

The strengths of these studies include their large size and their population-based design that minimized the potential for selection bias. These studies, however, primarily relied on distance to power lines as their main exposure metric, which is known to be a poor predictor of actual residential magnetic-field exposure. The limitations of distance as an exposure proxy also have been discussed by several observers in the scientific literature in the context of the French study (Bonnet-Belfais et al., 2013; Clavel et al., 2013). In addition, Chang et al. (2014) recently provided a detailed discussion of the limitations of exposure assessment methods based on geographical information systems. Swanson et al. (2014a) also concluded, based on their analysis of data from the British study (Bunch et al., 2014), that geocoding information that is not based on exact address but only on post code information is “probably not acceptable for assessing magnetic-field effects” (Swanson et al., 2014a, p. N81).

Epidemiologists from Italy have published two papers that describe the methods and results of a childhood leukemia case-control study and residential exposure to 50-Hz magnetic fields (Magnani et al., 2014; Salvan et al., 2015). In total, 412 leukemia cases under the age of 10 years diagnosed between 1998 and 2001 and 587 controls were included in the study. Exposure to residential ELF magnetic fields was assessed by extended (24 – 48-hr) measurements in the children’s bedroom. Conditional logistic regression was used to calculate RR and adjust for potentially confounding variables. In their analyses, the researchers evaluated a number of exposure metrics (measures of central tendency or peak-exposure measures; continuous or categorical exposures based on measurements during nighttime, weekend, or entire measurement periods). The potential role of residential mobility of the subjects in the observed associations was also assessed. No consistent exposure-response patterns were observed in any of the analyses. The main limitations of the study include the potential for differential participation of controls and cases and differences in participation rates of the study subjects based on their socioeconomic status, which in combination may result in a reference group that is not fully representative of the underlying population at risk. This, in turn, may bias the calculated effect estimates. The low prevalence of highly-exposed subjects (particularly exposure above 3 mG) results in a limitation of the statistical power of the study.

A hospital-based case-control study of EMF and childhood leukemia included 79 cases and 79 matched controls in the Czech Republic (Jirik et al., 2012). Exposure was measured in the participants' homes, in the "vicinity" of the residences, and the participants' schools. No association was reported between the measured magnetic field and leukemia risk. The study was small and provided insufficient information on the methods of case ascertainment, control selection, subject recruitment, and exposure assessment to fully assess its quality.

An even smaller cross-sectional study of 22 cases of childhood ALL and 100 controls from Iran reported a statistically significant association with "prenatal and postnatal childhood exposure to high voltage power lines" (Tabrizi and Bigdoli, 2015, p. 2347). The study, however, would carry very little, if any, weight in an overall evaluation, because of its cross-sectional study design and very small sample size, and due to the complete lack of information on exposure assessment in the study.

A recent pooled analysis (Schüz et al., 2012) aimed to follow up on two earlier studies that, based on small numbers of cases, reported poorer survival among cases of childhood leukemia with increased average exposure to magnetic fields, suggesting the magnetic fields may play a role in the progression in the disease following diagnosis (Foliart et al., 2006; Svendsen et al., 2007). The pooled analysis included exposure and clinical data on more than 3,000 cases of childhood leukemia from Canada, Denmark, Germany, Japan, the United Kingdom, and the United States. The authors reported no association between magnetic-field exposure and overall survival or relapse of disease in children with leukemia after diagnosis.

Researchers also examined the association between occupational exposures of fathers and the risk of childhood leukemia in their children in the United Kingdom (Keegan et al., 2012). The study included a total of 15,785 cases of childhood leukemia diagnosed between 1962 and 2006 and a similar number of matched controls in the analyses. EMF exposure was among the 33 investigated occupational exposures. Occupational EMF exposure of the fathers did not show a statistically significant relationship to leukemia in their children when all types of leukemia, lymphoid leukemia (the most common type), or myeloid leukemia were considered. The authors reported a statistically significant increase for leukemia classified as "other types," which included but 7% of the leukemia cases.

Zhao et al. (2014a) conducted a meta-analysis of nine case-control studies of EMF exposure and childhood leukemia published between 1997 and 2013. The authors reported a statistically significant association between average exposure above 4 mG and all types of childhood leukemia (OR 1.57; 95% CI 1.03–2.4). The meta-analysis relied on published results from some of the same studies included in previous pooled analyses, thus provided little new insight.

Swanson et al. (2014b) investigated the potential role of corona ions from AC power lines in childhood cancer development in a large British epidemiologic study of childhood cancer (Bunch et al., 2014). This work is a follow up on a hypothesis suggesting that charged aerosol particles generated by corona activity might increase exposure to ambient airborne substances leading to increased risk of certain cancers, including childhood cancers. The authors used an improved model to predict exposure to corona ions using meteorological data on wind conditions, power line characteristics, and proximity to residential address. The authors concluded that their results provided no empirical support for the corona ion hypothesis.

Several methodological studies have also examined the potential role of causal and alternative, non-causal explanations for the reported epidemiologic associations. Swanson and Kheifets (2012) proposed that if the biological mechanism explaining the epidemiologic association involves free radicals then, due to the small timescale of the reactions, the effects of ELF EMF and the earth's geomagnetic fields would be similar. Thus, to test this hypothesis the authors evaluated whether the magnitude of the earth's geomagnetic field modifies the effects reported by ELF EMF childhood leukemia studies from various parts of the world. The results were not in full support of the hypothesis. Swanson (2013) examined differences in residential mobility among residents who lived at varying distances from power lines in order to assess if these differences in mobility may explain the statistical association of leukemia with residential proximity to power lines. The study reported some variations in residential mobility, "but only small ones, and not such as to support the hypothesis" (Swanson, 2013, p. N9). A third study evaluated whether selection bias may play a role in the association between childhood leukemia and residential magnetic-field exposure (Slusky et al., 2014). The authors used wire code categories to assess exposure among participant and nonparticipant subjects in the Northern California Childhood Leukemia Study. While the authors reported systematic differences between participant and nonparticipant subjects in both wire code categories and socioeconomic status, these differences did not appear to influence the association between childhood leukemia and exposure estimates. The limitations of the study include the use of wire code categories to assess exposure, which is known to be a poor predictor for actual magnetic-field exposure, and that the study showed no association between magnetic fields and childhood leukemia among the participant subjects.

Recent reviews continue to highlight that the observed epidemiologic association between EMF and childhood leukemia remains unexplained and there are no supportive data from laboratory animal studies or known biophysical mechanisms that could explain a carcinogenic effect (Ziegelberger et al., 2011; Teepen and van Dijck, 2012; Grellier et al., 2014). In contrast, Leitgeb (2014) concluded, based on his combined analysis of 36 childhood leukemia epidemiologic studies, that overall, childhood leukemia is not linked to ELF magnetic field exposure when results from all epidemiologic studies are considered together. He reached his conclusions after plotting ORs as a function of the number of exposed cases and the publication year of the studies. As the analysis is not a conventional meta- or pooled analysis and it does not consider any of the design features and characteristics of the individual studies (e.g., exposure assessment methods, potential sources of bias), no firm conclusion could be drawn based on these results.

Grellier et al. (2014) estimated that, if the association was causal, ~1.5% to 2% of childhood leukemia cases in Europe might be attributable to ELF EMF. They conclude that "this contribution is relatively small and is characterised [*sic*] by considerable uncertainty" (Grellier et al., 2014, p. 61). Authors continue to emphasize that further understanding may be gained by studies of improved methodology and reduced potential for bias and by international and interdisciplinary collaborations (Ziegelberger et al., 2011; Teepen and van Dijck, 2012; Mezei et al., 2014).

Assessment

In summary, while some of the recently published large and methodologically advanced studies showed no association (e.g., Bunch et al., 2014, Pedersen et al., 2014a, 2014b), the association between childhood leukemia and magnetic fields observed in some studies remains unexplained. Thus, the results of recent studies do not change the classification of the epidemiologic data as limited, which is also the assessment of the most recent weight-of-evidence review released in 2015 by the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR).[14]

It should be noted that magnetic fields are just one small area in the large body of research on the possible causes of childhood leukemia. There are many other hypotheses under investigation that point to possible genetic, environmental, and infectious explanations for childhood leukemia, which have similar or stronger support in epidemiologic studies (Ries et al., 1999; McNally and Parker, 2006; Belson et al., 2007; Rossig and Juergens, 2008; Eden, 2010).

Table 3. Relevant studies of childhood leukemia

Author	Year	Study Title
Bunch et al.	2014	Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008.
Bunch et al.	2015	Magnetic fields and childhood cancer: an epidemiological investigation of the effects of high-voltage underground cables
Chang et al.	2014	Validity of geographically modeled environmental exposure estimates
Grellier et al.	2014	Potential health impacts of residential exposures to extremely low frequency magnetic fields in Europe
Jirik et al.	2012	Association between childhood leukaemia and exposure to power-frequency magnetic fields in middle Europe
Keegan et al.	2012	Case–control study of paternal occupation and childhood leukaemia in Great Britain, 1962–2006
Leitgeb	2014	Childhood leukemia not linked with ELF magnetic fields
Magnani et al	2014	SETIL: Italian multicentric epidemiological case-control study on risk factors for childhood leukaemia, non hodgkin lymphoma and neuroblastoma: study population and prevalence of risk factors in Italy
Pedersen et al.	2014a	Distance from residence to power line and risk of childhood leukemia: a population-based case-control study in Denmark
Pedersen et al.	2014b	Distance to high-voltage power lines and risk of childhood leukemia - an analysis of confounding by and interaction with other potential risk factors
Salvan et al.	2015	Childhood leukemia and 50 Hz magnetic fields: findings from the Italian SETIL case-control study
Schüz et al.	2012	Extremely low-frequency magnetic fields and survival from childhood acute lymphoblastic leukemia: an international follow-up study
Sermage-Faure et al.*	2013	Childhood leukaemia close to high-voltage power lines – the Geocap study, 2002–2007
Slusky et al.	2014	Potential role of selection bias in the association between childhood leukemia and residential magnetic fields exposure: a population-based assessment
Swanson	2013	Residential mobility of populations near UK power lines and implications for childhood leukaemia
Swanson and Kheifets	2012	Could the geomagnetic field be an effect modifier for studies of power-frequency magnetic fields and childhood leukaemia?
Swanson et al.	2014a	Relative accuracy of grid references derived from postcode and address in UK epidemiological studies of overhead power lines.

[14] On July 8, 2015, SCENIHR was renamed the Scientific Committee on Health, Environment, and Emerging Risks (SCHEER). Since any publications by this body referenced in this report were published before the name was changed, all citations to their publications will note SCENIHR rather than SCHEER.

Author	Year	Study Title
Swanson et al.	2014b	Childhood cancer and exposure to corona ions from power lines: an epidemiological test.
Tabrizi and Bidgoli	2015	Increased risk of childhood acute lymphoblastic leukemia (ALL) by prenatal and postnatal exposure to high voltage power lines: a case control study in Isfahan, Iran
Teepen and van Dijck	2012	Impact of high electromagnetic field levels on childhood leukemia incidence
Zhao et al.	2014a	Magnetic fields exposure and childhood leukemia risk: a meta-analysis based on 11,699 cases and 13,194 controls
Ziegelberger et al.	2011	Review. Childhood leukemia: Risk factors and the need for an interdisciplinary research agenda
*Comments and Replies on Sermage-Faure et al.:		
Bonnet-Belfais et al.	2013	Comment: childhood leukaemia and power lines--the Geocap study: is proximity an appropriate MF exposure surrogate?
Clavel et al.	2013	Reply: comment on 'Childhood leukaemia close to high-voltage power lines--the Geocap study, 2002-2007'--is proximity an appropriate MF exposure surrogate?

Childhood brain cancer

Compared to the research on magnetic fields and childhood leukemia, there have been fewer studies of childhood brain cancer. The data are less consistent and limited by smaller numbers of exposed cases than studies of childhood leukemia. The WHO review recommended the following:

> As with childhood leukaemia, a pooled analysis of childhood brain cancer studies should be very informative and is therefore recommended. A pooled analysis of this kind can inexpensively provide a greater and improved insight into the existing data, including the possibility of selection bias and, if the studies are sufficiently homogeneous, can offer the best estimate of risk (WHO, 2007, p. 18).

Recent studies (2012 – 2015)

There have been two new publications that examined the potential relationship between residential proximity to overhead and underground transmission lines and childhood brain cancer (Bunch et al., 2014; Bunch et al., 2015). The previously described case-control epidemiologic study by Bunch et al. (2014) also included cases of brain cancer (n=11,968) and other solid tumors (n=21,985) among children in the United Kingdom between 1962 and 2008 in the analysis of overhead power lines. No statistical association was reported in any of the analyses for childhood brain cancer and proximity to overhead lines. In the analyses of residential proximity to high-voltage underground cables (Bunch et al., 2015) in the same study population, the authors report a statistical association for childhood brain cancer with distance, but only in an intermediate category (20 – 49.9 meters), without clear support for an exposure-response pattern. No statistically significant associations were reported with calculated magnetic fields from underground cables.

Assessment

The recent publications by Bunch et al. (2014, 2015) did not report any consistent association between estimated magnetic-field exposure and brain tumors among children. This is in line with the previous assessment that the weight of the recent data does not support an association between magnetic-field exposures and the development of childhood brain cancer (Kheifets et al., 2010; SCENIHR, 2015). The recent data do not alter the classification of the epidemiologic data in this field as inadequate.

Table 4. Relevant studies of childhood brain cancer

Authors	Year	Study Title
Bunch et al.	2014	Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008.
Bunch et al.	2015	Magnetic fields and childhood cancer: an epidemiological investigation of the effects of high-voltage underground cables

Breast cancer

The WHO reviewed studies of breast cancer and residential magnetic-field exposure, electric blanket usage, and occupational magnetic-field exposure. These studies did not report consistent associations between magnetic-field exposure and breast cancer. The WHO concluded that the more recent body of research they reviewed on this topic was less susceptible to bias compared with previous studies, and, as a result, it provided strong support to previous consensus statements that magnetic-field exposure does not influence the risk of breast cancer. Specifically, the WHO stated:

> Subsequent to the IARC monograph [2002] a number of reports have been published concerning the risk of female breast cancer in adults associated with ELF magnetic field exposure. These studies are larger than the previous ones and less susceptible to bias, and overall are negative. With these studies, the evidence for an association between ELF exposure and the risk of breast cancer is weakened considerably and does not support an association of this kind (WHO, 2007, p. 307).

The WHO did not recommend any specific research with respect to breast cancer and magnetic-field exposure.

Recent studies (2012 – 2015)

Researchers in the United Kingdom published a large case-control study that investigated risk of adult breast cancer, leukemia, brain tumors, and malignant melanoma, in relation to magnetic-field exposure and residential distance to high voltage power lines (Elliott et al., 2013). The study included incident cancer cases, including 29,202 female breast cancer cases, from England and Wales diagnosed between 1974 and 2008, and a total of over 79,000 controls between the age of 15 and 74 years. Location of power lines and residential addresses were identified based on data from geographical information systems. Magnetic-field exposure was calculated for each control address and for each case address for the year of and 5 years prior to diagnosis. Risk of female breast cancer showed no association with distance to power lines or with estimated magnetic fields. Following publication, the study received criticism regarding its exposure assessment, exposure categorization, and the potential for confounding (de Vocht, 2013; Philips et al., 2013; Schüz, 2013).

Sorahan (2012) studied cancer incidence among more than 80,000 electricity generation and transmission workers in the United Kingdom between 1973 and 2008. Standardized registration rates were calculated among the workers compared to rates observed in the general population. No statistically significant increases were reported for breast cancer among either men or women. There was no trend for breast cancer incidence with year of hire, years of being employed, or years since leaving employment. The strengths of the study include its prospective nature and its large size. It is, however, limited in exposure assessment because risk was not calculated by magnetic-field exposure levels, and incidence rates were compared to an external reference group.

Koeman et al. (2014) investigated occupational exposure to ELF magnetic fields and cancer incidence in a cohort of about 120,000 men and women in the Netherlands Cohort study. The researchers used a case-cohort approach to analyze their data and identified 2,077 breast cancer cases among women and no breast cancer among men in the cohort. Exposure to ELF magnetic fields was assigned based on job title using a job-exposure matrix. Breast cancer showed no association with the level of estimated ELF magnetic-field exposure, or the length of employment, or cumulative exposure in the exposed jobs.

Li et al. (2013) conducted a nested case-cohort analysis of breast cancer incidence among more than 267,000 female textile workers in Shanghai. The researchers identified 1,687 incidence breast cancer cases in the cohort between 1989 and 2000 and compared their estimated exposure to 4,702 non-cases. Exposure was assessed based on complete work history and a job-exposure matrix specifically developed for the cohort. No association was observed between cumulative exposure and risk of breast cancer regardless of age, histological type, and whether a lag period was used or not. An accompanying editorial opined that this well-designed study further adds to the already large pool of data not supporting an association between ELF EMF and breast cancer (Feychting, 2013). The editorial suggests that further studies on breast cancer "have little new knowledge to add," following the considerable improvement in study quality over time in breast cancer epidemiologic studies, and with the evidence being "consistently negative" (Feychting, 2013, pp. 1046).

Meta-analyses for breast cancer were conducted by Chinese investigators for both female (Chen et al., 2013; Zhao et al., 2014b) and male breast cancers (Sun et al., 2013). The meta-analysis for female breast cancer included 23 case-control studies published between 1991 and 2007. Based on all 23 studies, the authors estimated a slight, but statistically significant association between breast cancer and ELF magnetic-field exposure (OR 1.07; 95% CI 1.02-1.13), which was slightly higher for estrogen receptor positive and premenopausal cancer (OR 1.11) (Chen et al., 2013). The conclusion of the authors that ELF magnetic fields might be related to breast cancer is contrary to the conclusion of the WHO and other risk assessment panels, which may be due to their reliance on earlier and methodologically less advanced studies in the meta-analysis. Zhao et al. (2014b) reported the results of their meta-analysis of 16 case-control epidemiologic studies of ELF EMF and breast cancer published between 2000 and 2007. They reported a weak but statistically significant association, which appeared to be stronger among non-menopausal women. The conclusion of the authors that ELF magnetic fields might be related to breast cancer is contrary to the conclusion of the WHO and other risk assessment panels. Similar to the previous meta-analysis, this may be due to the inclusion of earlier and methodologically less advanced studies in the meta-analysis. Sun et al (2013) conducted a meta-analysis of male breast cancer including 7 case-control and 11 cohort studies. The studies, with one exception that estimated residential exposure, estimated occupational exposure to ELF magnetic fields. The combined analysis showed a statistically significant association between male breast cancer and exposure to ELF EMF (OR 1.32; 95% CI 1.14-1.52). Methodological limitations, the small number of cases in the individual studies, and the potential for publication bias may contribute to the findings.

Assessment

The recent large case-control and cohort studies, which report no association with female breast cancer, add to growing support against a causal role for magnetic-field exposure, both in residential and occupational settings, in breast cancer development. A recent review by SCENIHR (2015) concluded that, overall, studies on “adult cancers show no consistent associations” (p. 158).

Table 5. Relevant studies of breast cancer

Authors	Year	Study
Chen et al.	2013	A meta-analysis on the relationship between exposure to ELF-EMFs and the risk of female breast cancer.
*Elliott et al.	2013	Adult cancers near high-voltage overhead power lines
Feytching	2013	Invited commentary: extremely low-frequency magnetic fields and breast cancer--now it is enough!
Koeman et al.	2014	Occupational extremely low-frequency magnetic field exposure and selected cancer outcomes in a prospective Dutch cohort
Li et al	2013	Occupational exposure to magnetic fields and breast cancer among women textile workers in Shanghai, China
Sorahan et al.	2012	Cancer incidence in UK electricity generation and transmission workers, 1973–2008
Sun et al.	2013	Electromagnetic field exposure and male breast cancer risk: a meta-analysis of 18 studies
Zhao et al.	2014b	Relationship between exposure to extremely low-frequency electromagnetic fields and breast cancer risk: a meta-analysis
*Comment and Replies on Elliot et al.		
De Vocht	2013	Letter to the Editor: Adult cancers near high-voltage power lines
Philips et al.	2013	Letter to the Editor: Adult cancers near high-voltage power lines
Schüz	2013	Commentary: power lines and cancer in adults: settling a long-standing debate?

Adult brain cancer

Brain cancer was studied along with leukemia in many of the occupational studies of EMF. The findings were inconsistent, and there was no pattern of stronger findings in studies with more advanced methods, although a small association could not be ruled out. The WHO classified the epidemiologic data on adult brain cancer as inadequate and recommended (1) updating the existing European cohorts of occupationally-exposed individuals and (2) pooling the epidemiologic data on brain cancer and adult leukemia to confirm the absence of an association.

The WHO stated the following:

> In the case of adult brain cancer and leukaemia, the new studies published after the IARC monograph do not change the conclusion that the overall evidence for an association between ELF [EMF] and the risk of these disease remains inadequate (WHO, 2007, p. 307).

Recent studies (2012 – 2015)

The Elliot et al. (2013) study of residential proximity and magnetic-field exposure from power lines, described above, also included 6,781 brain cancer cases. The risk of brain cancer showed no statistically significant increase with either distance or estimated magnetic-field levels in the study.

Sorahan (2012, 2014a) also examined the incidence of brain cancer in his analyses in the cohort of electricity generation and transmission workers in the United Kingdom. He made both internal comparisons (within the cohort of workers) and external comparisons (to the general population of the United Kingdom) and considered cumulative, recent, and distant occupational exposures to occupational ELF EMF. He reported no increased risk for brain cancer among either men or women. No trend was reported for brain cancer with year of hire, years of employment, years since employment in the study, or with estimates of cumulative, recent, or distant exposure to occupational ELF magnetic fields.

Koeman (2014) identified 160 male and 73 female cases of brain cancer in the Netherlands Cohort Study, described above. No statistically significant risk increase or trend was observed for cumulative ELF magnetic-field exposure among either men or women.

Turner et al. (2014) reported results from the INTEROCC study, which is an international case-control study of brain cancer and occupational exposure to ELF EMF. A total of 3,761 cases of brain cancer and 5,404 controls were included from Australia, Canada, France, Germany, Israel, New Zealand, and the United Kingdom between 2000 and 2004. Exposure was assessed based on individual job history and a job-exposure matrix. There was no association with lifetime cumulative exposure, average exposure, or maximum exposure for either glioma or meningioma. The authors, however, reported an association for both brain cancer types with exposure in the 1 to 4 year time-window prior to diagnosis. A statistical decrease in risk for glioma was also reported in the highest maximum exposure category.

Assessment

Recent studies did not report a consistent overall increase of brain cancer risk with either occupational or residential exposure to ELF EMF. While an association still cannot be ruled out *entirely* because of remaining deficiencies in exposure assessment methods, there is no strong evidence in support of a relationship between magnetic fields and brain cancer. The data remain inadequate as reported earlier (EFHRAN, 2012). As mentioned above, the most recent SCENIHR report (2015) states that, overall, studies on "adult cancers show no consistent associations" (p. 158).

Table 6. Relevant studies of adult brain cancer

Authors	Year	Study
Elliott et al.	2013	Adult cancers near high-voltage overhead power lines
Koeman et al.	2014	Occupational extremely low-frequency magnetic field exposure and selected cancer outcomes in a prospective Dutch cohort
Sorahan	2012	Cancer incidence in UK electricity generation and transmission workers, 1973–2008
Sorahan	2014a	Magnetic fields and brain tumour risks in UK electricity supply workers
Turner et al	2014	Occupational exposure to extremely low frequency magnetic fields and brain tumour risks in the INTEROCC study

Adult leukemia and lymphoma

There is a vast amount of literature on adult leukemia and EMF, most of which is related to occupational exposures. Overall, the findings of these studies are inconsistent—with some studies reporting a positive association between measures of EMF and leukemia and other studies showing no association. No pattern has been identified whereby studies of higher quality or design are more likely to produce positive or negative associations. The WHO subsequently classified the epidemiologic evidence for adult leukemia as "inadequate." They recommended updating the existing occupationally-exposed cohorts in Europe and updating a meta-analysis on occupational magnetic-field exposure.

Recent studies (2012 – 2015)

Elliott et al (2013) included 7,823 cases of adult leukemia and reported no elevated risk or trend in association with distance or estimated magnetic-field exposure from high-voltage power lines in the United Kingdom. In the cohort of electricity power plant and transmission workers in the United Kingdom, Sorahan (2012) reported no increase in risk for leukemia, when compared to the general population of the United Kingdom, either among men or women, and no increasing trend was observed with length of employment. Sorahan also analyzed leukemia risk in relation to estimated occupational exposure to ELF magnetic fields within the cohort of employees; he reported that RR estimates were "unexceptional," and were close to unity for all exposure categories based on cumulative, recent, and distant exposures (Sorahan, 2014b). Sorahan (2014b) reported a statistical association for ALL in a sub-analysis, but attributed this, in the main, to unusually low risk in the reference category.

Koeman et al. (2014) identified 761 and 467 hematopoietic malignancies among men and women, respectively, in the Netherlands Cohort Study. No increases in risk or trend were observed in association with cumulative exposure to ELF magnetic fields among either men or women.

Rodriguez-Garcia and Ramos (2012) reported inverse correlations between acute myeloid leukemia, ALL, and the distance to thermoelectric power plants and high-density power line networks in their study of hematologic cancers in a region of Spain from 2000 to 2005. This study, however, has severe limitations due to the use of aggregated data, rudimentary methods of exposure assessment, and the lack of an adequate comparison group.

Talibov et al. (2015) reported on a large case-control study of acute myeloid leukemia and occupational exposure to ELF EMF and electric shocks. The study included 5,409 cases diagnosed between 1961 and 2005 in Finland, Iceland, Norway, and Sweden and 27,045 controls matched on age, sex, and country. Lifetime occupational exposure to ELF EMF and shocks were assessed with job-exposure matrices based on jobs reported on the censuses. Potential confounding variables, such as work-related exposure to benzene and ionizing radiation, were adjusted for in the analyses. No associations between leukemia and exposure to ELF EMF or electric shocks were reported among either men or women.

Assessment

Recent studies did not provide substantial new evidence in support of an association between EMF and leukemia and lymphoma in adults. While some scientific uncertainty remains on a potential relationship between adult lymphohematopoietic malignancies and magnetic-field exposure because of the remaining deficiencies in study methods, the current database of studies provides inadequate evidence for an association (EFHRAN, 2012; SCENIHR, 2015).

Table 7. Relevant studies of adult leukemia/lymphoma

Authors	Year	Study
Elliott et al.	2013	Adult cancers near high-voltage overhead power lines
Koeman et al.	2014	Occupational extremely low-frequency magnetic field exposure and selected cancer outcomes in a prospective Dutch cohort
Rodriguez-Garcia and Ramos	2012	High incidence of acute leukemia in the proximity of some industrial facilities in El Bierzo, northwestern Spain
Sorahan	2012	Cancer incidence in UK electricity generation and transmission workers, 1973–2008
Sorahan	2014b	Magnetic fields and leukaemia risks in UK electricity supply workers
Talibov et al.	2015	Occupational exposure to extremely low-frequency magnetic fields and electrical shocks and acute myeloid leukemia in four Nordic countries

In vivo studies of carcinogenesis

In the field of ELF EMF research, a number of research laboratories have exposed rodents, including those with a particular genetic susceptibility to cancer, to high levels of magnetic fields over the lifetime of the animals and performed tissue evaluations to assess the incidence of cancer in many organs. In these studies, magnetic-field exposure has been administered alone (to test for the ability of magnetic fields to act as a complete carcinogen), in combination with a known carcinogen (to test for a promotional or co-carcinogenetic effect), or in combination with a known carcinogen and a known promoter (to test for a co-promotional effect).

The WHO review described four large-scale, long-term studies of rodents exposed to magnetic fields over the course of their lifetime that did not report increases in any type of cancer related to the intensity of exposure (Mandeville et al., 1997; Yasui et al., 1997; McCormick et al., 1999; Boorman et al., 1999a, 1999b). The highest intensity studied was 50,000 mG (Yasui et al., 1997). At the time of the WHO report, no directly relevant animal model for childhood ALL had been developed. Some animals, however, develop a type of lymphoma similar to childhood ALL and studies exposing predisposed transgenic mice to ELF magnetic fields did not report an increased incidence of this lymphoma type (Harris et al., 1998; McCormick et al., 1999; Sommer and Lerchl, 2004).

Studies investigating whether exposure to magnetic fields can promote cancer or act as a co-carcinogen used known cancer-causing agents, such as ionizing radiation, ultraviolet radiation, or other chemicals. No effects were observed for studies on chemically-induced preneoplastic liver lesions, leukemia or lymphoma, skin tumors, or brain tumors; however, the incidence of 7,12-dimethylbenz[a]anthracene (DMBA)-induced mammary tumors was increased with magnetic-field exposure in a series of experiments in Germany (Löscher et al., 1993, 1994, 1997; Mevissen et al., 1993a, 1993b, 1996a, 1996b, 1998; Baum et al., 1995; Löscher and Mevissen, 1995; Mandeville et al., 1997), suggesting that magnetic-field exposure increased the proliferation of mammary tumor cells. These results were not replicated in a subsequent series of experiments in a laboratory in the United States (Anderson et al., 1999; Boorman et al., 1999a, 1999b), possibly due to differences in experimental protocol and the species strain. In Fedrowitz et al. (2004), exposure enhanced mammary tumor development in one sub-strain (Fischer 344 [F344] rats), but not in another sub-strain of rats that was obtained from the same breeder, which argues against a promotional effect of magnetic fields.[15]

Two laboratories have reported an increase in genotoxic effects among exposed animals (e.g., DNA strand breaks in the brains of mice at field levels between 100 and 5,000 mG [e.g., Lai and Singh, 2004]). Other investigators have reported no effect of magnetic field exposure and thus did not replicate these results.

In summary, the WHO concluded the following with respect to *in vivo* research on carcinogenesis: "There is no evidence that ELF [EMF] exposure alone causes tumours. The evidence that ELF field exposure can enhance tumour development in combination with carcinogens is inadequate" (WHO, 2007, p. 322). Recommendations for future research included the development of a rodent model for childhood ALL and the continued investigation of whether magnetic fields can act as a promoter or co-carcinogen.

Recent studies (2012 – 2015)

Studies published since Exponent's 2012 update that investigated the potential carcinogenic effects of electric- and magnetic-field exposure in animals are listed in Table 8. As noted above, none of the past large-scale, long-term bioassays of magnetic-field exposures have reported that lifetime exposure to magnetic fields initiate or promote tumor development in rodents. In some other studies, increases of DMBA-initiated mammary tumors in a particular strain of rats exposed to magnetic fields were reported in a single laboratory. To further investigate this phenomenon, Fedrowitz and Löscher (2012) evaluated gene expression in pooled samples of mammary tissue from both F344 rats (magnetic-field susceptible)[16] and Lewis rats (magnetic-field insensitive) following 2 weeks of continuous exposure to 1,000 mG, 50-Hz magnetic fields. Control rats of both strains were sham exposed and analyses were conducted in a blinded manner. Based on a 2.5-fold change in gene expression as the cut-off for establishing an

[15] The WHO concluded with respect to the German studies of mammary carcinogenesis, "Inconsistent results were obtained that may be due in whole or in part to differences in experimental protocols, such as the use of specific substrains" (WHO, 2007, p. 321).

exposure-related response, only 22 of 31,100 gene transcripts were found to be altered with magnetic-field exposure in the two rat strains combined. Genes showing the greatest change in expression in response to magnetic-field exposure in F344 rats (with no change in gene expression observed in Lewis rats) were α-amylase (a 832-fold decrease), parotid secretory protein (a 662-fold decrease), and carbonic anhydrase 6 (a 39-fold decrease).

To follow-up on these findings, Fedrowitz et al. (2012) examined α-amylase activity in mammary tissues collected from the two rat strains in previous experiments. In initial experiments using tissues collected in 2005 through 2006, magnetic-field exposure was associated with increased α-amylase activity in cranial mammary tissues, but not caudal mammary tissues, from both F344 and Lewis rats. Thus, the response did not appear to correlate with the observed rat strain susceptibility to magnetic-field exposure. In later experiments using tissues collected in 2007 through 2008, α-amylase activity in the cranial tissues was unaffected by magnetic-field exposure, but increased in the caudal tissues of F344 rats (and not the tissues of Lewis rats) in response to magnetic-field treatment. Additional experiments looked at α-amylase protein expression and its correlation with tissue differentiation following treatment with diethylstilbestrol. Overall, the findings of this study are contradictory, making interpretation difficult regarding the potential role of α-amylase expression in the observed sensitivity of F344 rats to magnetic-field exposure.

Another recent study (Qi et al., 2015) examined the effects of exposure to 500 mG, 50-Hz magnetic fields on tumor development in mice. The exposures were begun during *in utero* development with 1 week (12 hours per day) exposure of pregnant females and continued for 15.5 months after birth. Controls were not sham-exposed (i.e., in the same exposure apparatus, but with the system turned off) and analyses were not reported to have been conducted in a blinded manner. Further, the exposure apparatus and conditions (including the number of animals per cage and control for potential confounding variables including light, vibration, and noise) were not described. Both male and female offspring were reported to exhibit significantly reduced body weights compared to controls. Tumors were not increased in exposed male mice. The incidence of chronic myeloid leukemia was reported to be significantly higher, however, in exposed females compared to controls. Interpretation of these data is difficult because of the limited experimental detail reported and because overall survival data and the expected background incidence for tumors in these mice were not reported. Further, these data are contradictory to the largely negative large-scale rodent carcinogenesis studies, as reviewed by the WHO (2007).

Other studies investigated the therapeutic potential of high magnetic-field exposures in the treatment of tumors. El-Bialy and Rageh (2013) injected female mice with Ehrlich ascites carcinoma cells, then treated them with 3 mg/kg cisplatin on days 1, 4, and 7, or exposed them to 100,000 mG, 50-Hz magnetic fields for 14 days (1 hour per day), or both. A control group was saline-treated, but not sham exposed to magnetic fields, and analyses were not reported to have been conducted in a blinded manner. Both magnetic-field exposure and cisplatin treatment, alone or in combination, were associated with reduced tumor volume; the strongest response was observed with the combination treatment. This response appeared to be associated with reduced cell proliferation, but also increased DNA damage (as assessed using the Comet and micronucleus assays). In another study (Mahna et al., 2014), female Balb/c mice were injected with spontaneous mouse mammary tumor cells, followed by exposure to 150,000 mG, 50-Hz magnetic fields for 10 minutes per day for 12 days. Other groups of animals were exposed to the magnetic field and also to electrochemotherapy, which is a combination of chemotherapy with pulsed electric current applied to the skin in an attempt to increase permeability of cancers cells to drugs, thus to increase the drugs' efficiency. A sham-exposed control group was included, but analyses were not reported to have been conducted in a blinded manner. Magnetic-field exposure alone or in combination with the other treatments was reported to reduce tumor volume. Although these studies suffer from various limitations, the results suggest that magnetic-field exposure may have therapeutic applications in the treatment of tumors. Field strengths, however, were relatively high in the studies, and it is possible that the observed response was due to an induced electric field.

Several recent studies examined the genotoxic potential of magnetic-field exposure. Miyakoshi et al. (2012) continuously exposed 3-day old rats to 100,000 mG, 50-Hz magnetic fields for 72 hours, treated them with 5 or 10 mg/kg bleomycin, or both; control animals were sham exposed (with the exposure system turned off). Brain astrocytes were then examined in culture for the presence of micronuclei. In other experiments, the animals were treated as just described, but also administered tempol, an antioxidant. Magnetic-field exposure alone or in combination with 5 mg/kg bleomycin appeared to have no effect on micronuclei formation, but was reported to increase the frequency of micronuclei resulting from co-treatment with 10 mg/kg bleomycin. Tempol co-exposure was reported to reduce micronuclei formation, suggesting a role for activated oxygen species in their formation. In a study by Villarini et al. (2013), male mice were exposed to 1,000 to 20,000 mG, 50-Hz magnetic fields for 7 days (15 hours per day), then sacrificed immediately after exposure or 24 hours later. The striatum, hippocampus, and cerebellum were evaluated for DNA damage using the Comet assay. Control mice were sham-exposed (with the exposure system turned off); mice exposed to whole-body X-irradiation served as DNA-damage positive controls. Further, the Comet assay data were evaluated in a blinded manner. Mice exposed to 10,000 or 20,000 mG, but not lower strength magnetic fields, showed evidence of DNA fragmentation in the brain tissues when sacrificed immediately following exposure. By 24 hours post-exposure, however, the levels of DNA fragmentation were back to baseline, indicating either that any associated DNA damage was reversible or that the fragmentation was an indicator of apoptosis, which disappeared as the apoptotic cells were removed during the 24-hour recovery period. Male mice were exposed to 2,000 mG, 50-Hz magnetic fields for 7, 14, 21, or 28 days in a study by Alcaraz et al. (2014). No sham-exposed controls were included. Mice exposed to 50 centi-Gray of X-rays were included as positive controls and analyses were conducted in a blinded manner. The authors reported an increase in micronuclei (i.e., small nucleus-like structures containing DNA indicative of a chromosomal break) in bone marrow erythrocytes 24 hours after magnetic-field exposure. The increase was not duration-dependent, however, and was substantially lower than that induced by X-irradiation.

Wilson et al. (2015) examined the effect of exposure to 100 mG, 1,000 mG, or 3,000 mG, 50-Hz magnetic fields for 2 or 15 hours on the gene mutation frequency in sperm and blood cells in mice. Sham-exposed mice were included as negative controls, while mice exposed to 1 Gray of X-irradiation were included as positive controls. Mutation frequencies in blood cells among magnetic-field exposed mice were similar to those of the negative controls at 12 weeks after exposure. Mutation frequencies in sperm cells were slightly, but significantly, increased among magnetic-field exposed mice, although not in a dose- response-related pattern. In contrast, X-irradiation significantly increased the mutation frequency in both cell types.

Saha et al. (2014) studied DNA double-strand breaks in the embryonic neuronal stem cell compartment of mouse embryos following exposure to 1,000 mG, 50-Hz magnetic fields for 2 hours on gestational day (GD) 13.5 or with continuous or intermittent exposure (5 minutes on, 10 minutes off) to a 3,000 mG magnetic field for 15 hours starting on GD 12.5. The study included sham-exposed controls as well as multiple positive control groups exposed to 10-200 milli-Gray of X-irradiation on GD 13.5. Using appropriate statistical methods to account for litter effects, Saha et al. (2014) reported no increase in double-strand breaks in DNA in the groups exposed to magnetic fields. In a follow-on study (Woodbine et al., 2015), the same group of researchers using the same experimental system then assessed whether concomitant exposure to magnetic fields and X-rays, which are known to alter the rate of repair of DNA double-strand breaks, would have an effect. The mouse embryos were exposed on GD 13.5 to 3,000 mG, 50-Hz for 3 hours before and up to 9 hours after exposure to 100 milli-Gray of X-rays. Controls were exposed to X-rays, but sham-exposed to magnetic fields. Additional controls included unexposed mice; X-ray-only exposed mice; magnetic-field-only, sham-exposed mice; and X-ray-only sham-exposed mice. Sham treatments had no effect on the number of DNA double-strand breaks observed. X-irradiation significantly increased the number of DNA double-strand breaks at 1 hour post-exposure; these decreased to control levels by 6 to 11 hours post-exposure as the DNA double-strand breaks were repaired. Magnetic-field exposure had no effect on the response observed following X-irradiation, indicating that magnetic fields did not affect the DNA repair process under the conditions of the study. The data from this study were assessed in a blinded manner and using the litter as the statistical unit of analysis; however, the number of maternal animals per group was relatively small (n=1-4/group).

Korr et al. (2014) continuously exposed mice for 8 weeks to 1,000 mG or 10,000 mG, 50-Hz magnetic fields. Controls were not sham-exposed, but maintained in the same room as the magnetic-field-exposed animals. At the end of the exposure period, the animals were injected with radiolabeled thymidine to look for DNA single-strand breaks and unscheduled DNA synthesis in the liver, kidneys, and brain using an autoradiographic method. A slight reduction in mitochondrial DNA synthesis was observed in the epithelial cells of the kidney collecting ducts at 1,000 mG, but no increase in DNA single-strand breaks was observed. At 10,000 mG, a slight reduction in unscheduled DNA synthesis (likely related to reduced mitochondrial DNA synthesis) was observed in the epithelial cells of the choroid plexus of the brain’s fourth ventricle and the kidney collecting duct, but again, there was no difference in the degree of DNA single-strand breaks observed between treated and control animals. These investigations were conducted in a blinded manner.

Two recent studies examined DNA damage in human subjects exposed to EMF. Tiwari et al. (2015) investigated the level of DNA damage in the peripheral blood lymphocytes of 142 workers exposed to EMF; these subjects were employed for at least 2 years (and for a mean of 9 years) at a 132-kV high-voltage electrical substation in India. The exposed subjects were matched with a non-exposed group of 151 individuals of similar socioeconomic status. However, the authors did not report how the control subjects were identified. The analyses did not consider or control for the potential confounding effect of other occupational exposures that may be encountered in the workplace. DNA damage was assessed in both sample populations using the alkaline Comet assay and coded examination of slides; other parameters related to plasma epinephrine concentrations, lipid peroxidation, and nitric oxide expression levels were also assessed. Although the Comet tail length exhibited a slightly larger range in the exposed group than in the non-exposed group, there was no significant difference between the two groups in the degree of DNA damage observed.

In another study of human subjects (Villarini et al., 2015), DNA damage was again assessed using the alkaline Comet assay, but the evaluation extended to three different parameters related to DNA damage. The exposed group included 21 electric arc welders exposed to EMF as well as various metal fumes as a result of their occupation. The control group included 21 non-exposed individuals of similar age, residence, and smoking status. Magnetic-field exposure was measured in the exposed individuals using personal dosimeters that were worn for a single work shift and found to average 78 mG; magnetic-field exposure was not assessed in the non-exposed controls. Comet tail length was similar in both the welders and controls; however, the welders exhibited significantly lower tail intensity and tail moment values than did controls, suggesting that they had a lower degree of DNA damage than the controls. The authors suggested that this unexpected finding may be related to the type of DNA damage that might occur. Welders are exposed to various metal fumes, including chromium and nickel, both of which are able to induce DNA-protein cross-links. The DNA-protein cross-links might reduce the amount of DNA available to migrate as the tail in a Comet assay, thereby resulting in reduced Comet tail parameters.

A well-designed double-blind study (Kirschenlohr et al., 2012) examined gene expression in the white blood cells of 17 pairs of human subjects following exposure to a 620 mG, 50-Hz magnetic field on four different days (2 hours per day) over 2 weeks. On each exposure day, one member of each pair was exposed to the magnetic field and the other either exposed to sham conditions (with the current passing through the two coils of the exposure apparatus in opposing directions so that the magnetic field was cancelled, but the total current remained the same) or not exposed. On the next day, the exposures were reversed (the previously exposed subject was sham exposed or not exposed, and vice-versa). Blood samples were collected just prior to and following exposures, as well as at multiple times throughout the exposure period. Gene expression in one set of the collected blood samples (collected in week 1) was determined via microarray analysis with an emphasis on genes previously reported to respond to EMF exposure (i.e., immediate early genes involved in stress, inflammatory, and proliferative and apoptotic responses). The samples collected just prior to exposure were used as reference samples. Any indications of a possible positive finding were verified using the second set of collected blood samples. Based on their analyses, the study investigators reported that no genes showed a consistent response to magnetic-field exposure.

In a similarly well-conducted study, Kabacik et al. (2013) looked for changes in the expression of genes in the bone marrow of juvenile mice exposed to a 1,000 mG, 50-Hz magnetic field for 2 hours. The premise for conducting this research was that many types of leukemia are derived from cells in the bone marrow; thus, changes in gene expression in the bone marrow may relate to the development of these cancers. Control mice were sham-exposed and the experiment repeated in multiple groups of exposed and unexposed mice. In order to confirm consistent changes with exposure, gene expression in these replicate samples was analyzed in a blinded manner using multiple methods and in different laboratories. Again, no consistent changes in gene expression in response to magnetic-field exposure were found.

Assessment

A single new animal bioassay of long-term magnetic-field exposure as a possible carcinogen has been conducted since the last update. This study reported increased chronic myeloid leukemia in female, but not male mice, exposed to magnetic fields from prior to birth through 15.5 months of age—a finding that conflicts with those of the other large-scale rodent bioassays reviewed by the WHO in 2007. Further, the new bioassay suffers from substantial methodological and reporting flaws which affect its weight in the overall assessment.

In addition to this study, various shorter-term studies have been conducted to investigate the potential genotoxicity of magnetic-field exposure and its possible effects on gene expression in cells associated with cancer in humans. Many of these studies suffer from various methodological deficiencies, including small samples sizes, the absence of sham-exposure treatment groups, and analyses that were not conducted in a blinded manner. Further, consistency across the body of studies is commonly lacking in terms of the exposures applied, the cell types assessed, and the specific parameters evaluated. These studies do not change the WHO's conclusion that the overall evidence from *in vivo* studies does not support a role of EMF exposures in direct genotoxic effects.

Two particularly well-conducted studies evaluated potential differences in gene expression resulting from magnetic-field exposure. These studies employed sham exposures, replicate samples, and blinded analyses using multiple experimental methods of measuring gene expression in multiple laboratories; they also took into consideration the potential statistical power of the studies. Neither of these studies reported consistent changes in gene expression due to magnetic-field exposure.

Two studies looked at the possible anti-carcinogenic therapeutic potential associated with high magnetic-field strengths, an area for which more research is still warranted to address the influence of potential confounding variables on observed outcomes. Overall, the *in vivo* studies published since the last update do not alter the previous conclusion that there is inadequate evidence of carcinogenicity due to ELF EMF exposure.

Table 8. Relevant *in vivo* studies related to carcinogenesis

Authors	Year	Study
Alcaraz et al.	2014	Effect of long-term 50 Hz magnetic field exposure on the micronucleated polychromatic erythrocytes of mice.
El-Bialy and Rageh	2013	Extremely low-frequency magnetic field enhances the therapeutic efficacy of low-dose cisplatin in the treatment of Ehrlich carcinoma
Fedrowitz and Löscher	2012	Gene expression in the mammary gland tissue of female Fischer 344 and Lewis rats after magnetic field exposure (50 Hz, 100 µT) for 2 weeks
Fedrowitz et al.	2012	Effects of 50 Hz magnetic field exposure on the stress marker α-amylase in the rat mammary gland
Kabacik et al.	2013	Investigation of transcriptional responses of juvenile mouse bone marrow to power frequency magnetic fields
Korr et al.	2014	No evidence of persisting unrepaired nuclear DNA single strand breaks in distinct types of cells in the brain, kidney, and liver of adult mice after continuous eight-week 50 Hz magnetic field exposure with flux density of 0.1 mT or 1.0 mT
Mahna et al.	2014	The effect of ELF magnetic field on tumor growth after electrochemotherapy.
Miyakoshi et al.	2012	Tempol suppresses micronuclei formation in astrocytes of newborn rats exposed to 50-Hz, 10-mT electromagnetic fields under bleomycin administration
Qi et al.	2015	Effects of extremely low-frequency electromagnetic fields (ELF-EMF) exposure on B6C3F1 mice
Saha et al.	2014	Increased apoptosis and DNA double-strand breaks in the embryonic mouse brain in response to very low-dose X-rays but not 50 Hz magnetic fields.
Tiwari et al.	2015	Epinephrine, DNA integrity and oxidative stress in workers exposed to extremely low-frequency electromagnetic fields (ELF-EMFs) at 132 kV substations
Villarini et al.	2013	Brain hsp70 expression and DNA damage in mice exposed to extremely low frequency magnetic fields: Adose-response study
Wilson et al.	2015	The effects of extremely low frequency magnetic fields on mutation induction in mice.
Woodbine et al.	2015	The rate of X-ray-induced DNA double-strand break repair in the embryonic mouse brain is unaffected by exposure to 50 Hz magnetic fields

Reproductive/developmental effects

Over a decade ago, two studies received considerable attention because of a reported association between peak magnetic-field exposure greater than approximately 16 mG and miscarriage: a prospective cohort study of women in early pregnancy (Li et al., 2002) and a nested case-control study of women who miscarried compared to their late-pregnancy counterparts (Lee et al., 2002).

These two studies improved on the existing body of literature because average exposure was assessed using 24-hour personal magnetic-field measurements (earlier studies on miscarriage were limited because they used surrogate measures of exposure, including visual display terminal use, electric blanket use, or wire code data). The Li et al. study was criticized by the NRPB *inter alia* because of the potential for selection bias, a low compliance rate, measurement of exposure after miscarriages, and the selection of exposure categories after inspection of the data (NRPB, 2002).

Following the publication of these two studies, however, a hypothesis was put forth that the observed association may be the result of behavioral differences between women with healthy pregnancies that went to term (i.e., less physically active) and women who miscarried (i.e., more physically active) (Savitz, 2002). It was proposed that physical activity is associated with an increased opportunity for peak magnetic-field exposure, and the nausea experienced in early, healthy pregnancies and the cumbersomeness of late, healthy pregnancies would reduce physical activity levels, thereby decreasing the opportunity for exposure to peak magnetic fields. This hypothesis received empirical support from studies that reported consistent associations between activity (mobility during the day) and various metrics of measures of peak magnetic-field exposure (Mezei et al., 2006; Savitz et al., 2006; Lewis et al., 2015). These findings suggest that the association between maximum magnetic-field exposure and miscarriage is due to differing activity patterns of the cases and controls, not to an effect of the magnetic field on embryonic development and viability. Furthermore, nearly half of women who had miscarriages reported in the cohort by Li et al. (2002) had magnetic-field measurements taken after miscarriage occurred, when changes in physical activity may have already occurred, and all measurements in Lee et al. (2002) occurred post-miscarriage.

The scientific panels that have considered these two studies concluded that the possibility of this bias precludes making any conclusions about the effect of magnetic fields on miscarriage (NRPB, 2004; FPTRPC, 2005; WHO, 2007). The WHO concluded, “There is some evidence for increased risk of miscarriage associated with measured maternal magnetic-field exposure, but this evidence is inadequate” (WHO, 2007, p. 254) and recommended further epidemiologic research.

Recent studies (2012-2015)

Three epidemiologic studies investigated the relationship between ELF magnetic-field exposure and miscarriage or stillbirth. A study in China (Wang et al., 2013), identified 413 pregnant women at 8 weeks of gestation between 2010 and 2012. The researchers measured magnetic-field levels at the front door and the alley in front of the participants’ homes. No statistically significant association was seen with average exposure at the front door, but the authors reported an association with maximum magnetic-field values measured in the alleys in front of the homes. Magnetic-field levels measured at the front door are very poor predictors of home and personal exposure, thus the study provides only a limited contribution to current knowledge.

A study from Iran (Shamsi Mahmoudabadi et al., 2013) reported results of a hospital-based case-control study that included 58 women with spontaneous abortion and 58 pregnant women. The measured magnetic-field levels reported a statistically significant increase among the cases compared to controls. The study provides little weight to an overall assessment, however, due to limited information provided on subject recruitment, exposure assessment, type of metric used and potential confounders, and the small number of subjects.

A Canadian study (Auger et al., 2012) investigated the association between stillbirth and residential proximity to power lines. The authors identified over 500,000 births and 2,033 stillbirths in Québec and determined distance between postal code at birth address and the closest power line. No consistent association or trend was reported between stillbirth and residential distance. Reliance on distance to power lines and using the postal code for address information is a major limitation of the study’s exposure assessment.

Two studies examined various birth outcomes in relation to ELF EMF exposure. A study from the United Kingdom investigated birth outcomes in relation to residential proximity to power lines during pregnancy between 2004 and 2008 in Northwest England (de Vocht et al., 2014). The researchers examined hospital records of over 140,000 births and distance to the nearest power lines were determined using geographical information systems. The authors reported moderately lower birth weight within 50 meters of power lines, but observed no statistically significant increase in risk of any adverse clinical birth outcomes (such as preterm birth, small for gestational age, or low birth weight). The limitations of the study include its reliance on distance for exposure assessment and the potential for confounding by socioeconomic status as also discussed by the authors. A follow-up analysis of the same data suggested that the observed association in the de Vocht et al. (2014) study, at least partially, could be due to confounding and missing data (de Vocht and Lee, 2014).

A study from Iran reported no association between ELF EMF and pregnancy and developmental outcomes, such as duration of pregnancy, birth weight and length, head circumference, and congenital malformations (Mahram and Ghazavi, 2013). The study, however, provided little information on subject selection and recruitment, thus it is difficult to assess its quality.

An Italian study reported that blood melatonin levels showed a statistically significant increase among 28 newborns 48 hours after being taken from incubators with assumed elevated ELF EMF exposure, but not among 28 control newborns who were not in incubators (Bellieni et al., 2012). Neither the before nor the after values were statistically different from each other in the two groups (incubator vs. control), however, thus the clinical significance of the findings, if any, is unclear.

A cross-sectional study conducted in China examined correlations between magnetic-field exposure and embryonic development (Su et al., 2014). The study population was comprised of 149 pregnant women who were seeking induced termination of pregnancy during the first trimester. Exposure to EMF was assessed using personal 24-hour measurements within four weeks of the termination. Embryonic bud and sac lengths were determined by ultrasound prior to the termination. Since exposure to magnetic fields was measured following the termination of the pregnancy, the examiner completing the ultrasound examination could not be aware of the measured field levels. An association between maternal daily magnetic-field exposure and embryonic bud length was reported. The study provides little, if any weight in a weight-of-evidence assessment due to its severe limitations, the most important of which are the cross-sectional design of the study and the lack of consideration of gestational age, which is a major determinant of embryonic bud length.

Assessment

The recent epidemiologic studies on pregnancy and reproductive outcomes provided little new insight in this research area and do not change the classification of the data from earlier assessments as inadequate. The recent review by (SCENIHR, 2015) concluded that "recent results do not show an effect of ELF MF [magnetic field] exposure on reproductive function in humans."

Table 9. Relevant studies of reproductive and developmental effects

Authors	Year	Study
Auger et al.	2012	Stillbirth and residential proximity to extremely low frequency power transmission lines: a retrospective cohort study
Bellieni et al.	2012	Is newborn melatonin production influenced by magnetic fields produced by incubators?
de Vocht and Lee	2014	Residential proximity to electromagnetic field sources and birth weight: Minimizing residual confounding using multiple imputation and propensity score matching
de Vocht et al.	2014	Maternal residential proximity to sources of extremely low frequency electromagnetic fields and adverse birth outcomes in a UK cohort
Mahram and Ghazavi	2013	The effect of extremely low frequency electromagnetic fields on pregnancy and fetal growth, and development
Shamsi Mahmoudabadi et al.	2013	Exposure to Extremely Low Frequency Electromagnetic Fields during Pregnancy and the Risk of Spontaneous Abortion: A Case-Control Study
Su et al.	2014	Correlation between exposure to magnetic fields and embryonic development in the first trimester
Wang et al.	2013	Residential exposure to 50 Hz magnetic fields and the association with miscarriage risk: a 2-year prospective cohort study

Neurodegenerative diseases

The WHO panel concluded that there is inadequate data in support of an association between magnetic fields and Alzheimer's disease or ALS. The panel recommended more research in this area using better methods; in particular, studies that enrolled incident Alzheimer's disease cases (rather than ascertaining cases from death certificates) and studies that estimated electrical shock history in ALS cases were recommended. Specifically, the WHO concluded, "When evaluated across all the studies, there is only very limited evidence of an association between estimated ELF exposure and [Alzheimer's] disease risk" (WHO, 2007, p. 194) and "overall, the evidence for an association between ELF exposure and ALS is considered inadequate" (WHO, 2007, p. 206).

Recent studies (2012 – 2015)

A population-based case-control study (Frei et al., 2013) examined the relationship between residential distance to power lines and neurodegenerative diseases covering the entire population of Denmark between 1994 and 2010. Distance from the nearest power line to the residential address for all newly-reported cases and matched controls were determined using geographical information systems. Overall, none of the investigated diseases, including Alzheimer disease and other types of dementia, ALS, Parkinson's disease, or multiple sclerosis was related to residential proximity to power lines. The inclusion of newly-diagnosed cases from hospital discharge records represents a significant methodological improvement over mortality studies. The study, however, was limited by the methods used for the exposure assessment.

Seelen et al. (2014) conducted a population-based case-control study including 1,139 ALS cases diagnosed in the Netherlands between 2006 and 2013 and 2,864 frequency-matched controls. Case and control addresses were geocoded and the shortest distance to the nearest high-voltage power line (50 – 380 kV) was determined. No statistically significant associations were reported for ALS with residential proximity to power lines with any of the included voltages. A combined analysis of the current results with two previously published studies (Marcilio et al., 2011; Frei et al., 2013) resulted in an overall OR of 0.9 (95% CI 0.7-1.1) for living within 200 meters of a high-voltage power line. Reconstruction of lifetime residential history represents a methodological improvement of the current study. The main limitation, similarly to previous power-line studies, is the use of distance to power lines as a surrogate for magnetic-field exposure.

Data from the Swiss National Cohort study was used to examine the relationship between occupational exposure to EMF and electric shocks and ALS mortality from 2000 to 2008 (Huss et al., 2014). Occupations reported at the 1990 and 2000 censuses along with job-exposure matrices were used to estimate exposure. A total of 2.2 million subjects were included in the analyses with available data from both censuses. Among these, 278 cases of ALS were identified. The authors reported an association with medium and high estimates of ELF EMF exposure, but not with estimates of exposure to electric shocks. Yu et al. (2014) reported results of a small case-control study of ALS, including 66 cases and 66 controls, examining various lifestyle, environmental, and work-related variables as potential risk factors. Their results on occupational exposure to EMF, however, cannot be interpreted because of a severe error of combining estimates of ionizing and non-ionizing radiation exposures in their analysis.

In a study of 3,050 Mexican Americans, aged 65+, enrolled in Phase I of the Hispanic Established Population for the Epidemiologic Study of the Elderly study, the association between severe cognitive dysfunction and occupational ELF magnetic-field exposure was examined (Davanipour et al., 2014). Information on occupational history, and socio-demographic variables were obtained by in-person interviews. Occupational exposure to magnetic fields was classified as low, medium, and high. The mini-mental state exam was used to evaluate cognitive function. Cognitive dysfunction was defined as an exam score below 10. The study is a cross-sectional survey, even though the authors describe it as a population-based case-control study. The authors report a statistically significant association between estimated occupational magnetic-field exposure and severe cognitive dysfunction. The reported association is, however, difficult to interpret due to the number of severe limitations of the study; including the cross-sectional design, the lack of clear clinical diagnosis for case-definition, and the rudimentary assessment of exposure to occupational EMF.

Koeman et al. (2015) analyzed data from the Netherlands Cohort Study, a longitudinal follow-up study of approximately 120,000 men and women enrolled in 1986, to study the relationship between various occupational exposures and non-vascular dementia. Between 1986 and 2003, 798 male and 1,171 female cases were identified. Lifetime occupational history was obtained by questionnaire. Based on occupational titles and with the use of various job-exposure matrices, occupational exposures to solvents, pesticides, metals, ELF magnetic fields, electric shocks, and diesel exhaust were assessed. No association was reported for exposure to electric shocks. The authors reported moderate, but statistically non-significant, associations for the highest estimates of exposures to metals, chlorinated solvents, and ELF magnetic fields. The association for ELF fields, however, showed no exposure-response relationship based on cumulative exposure and the authors concluded that the association observed for ELF magnetic fields and solvents might be attributable to confounding by exposure to metals.

Brouwer et al. (2015) identified cases of Parkinson's disease between 1986 and 2003 in a cohort of approximately 120,000 adults (i.e., the Netherlands Cohort Study, noted above). They assessed occupational exposure to EMF and electric shocks among the study subjects using job-exposure matrices. Based on a total of 609 cases of Parkinson's disease, the authors concluded that their results generally do not provide strong support for an association with EMF or electric shocks. A hospital-based case-control study in the Netherlands included 444 cases of Parkinson's disease and 876 matched controls (van der Mark et al., 2014). Occupational exposure to EMF and electric shocks was assessed using work history and a job-exposure matrix. No associations were reported between any of the exposure metrics and Parkinson's disease.

Weak to no evidence of an association was presented in recent meta-analyses of occupational exposure to ELF magnetic fields and neurodegenerative disease (Zhou et al., 2012; Vergara et al., 2013; Capozzella et al., 2014; Huss et al., 2015); hence, the authors concluded that potential within-study biases, evidence of publication bias, and uncertainties in the various exposure assessments greatly limit the ability to infer an association, if any, between occupational exposure to magnetic fields and neurodegenerative disease. In sum, these recent meta-analyses provide no convincing evidence of a relationship between ELF magnetic fields and neurodegenerative disease.

It has been previously suggested that the weak and inconsistent association between ELF EMF and ALS might be explained by electric shocks in occupational environments. Several recent studies, however, addressed the issue of the potential role of electric shocks in the development of neurodegenerative and neurological diseases, but none of them presented convincing evidence for an association (Das et al., 2012; Grell et al., 2012; Vergara et al., 2015; van der Mark et al., 2014).

Assessment

The recent studies continue to be limited by uncertainties about the estimates of magnetic-field exposure. Further research in this area will be needed to address the limitations of research to date on neurodegenerative disease. The most recent SCENIHR report (2015) concluded that newly published studies "do not provide convincing evidence of an increased risk of neurodegenerative diseases, including dementia, related to ELF MF [magnetic field] exposure" (SCENIHR, 2015, p. 186).

Table 10. Relevant studies of neurodegenerative disease

Authors	Year	Study
Brouwer et al	2015	Occupational exposures and Parkinson's disease mortality in a prospective Dutch cohort
Capozella et al.	2014	Work related etiology of amyotrophic lateral sclerosis (ALS): a meta-analysis
Das et al.	2012	Familial, environmental, and occupational risk factors in development of amyotrophic lateral sclerosis
Davanipour	2014	Severe cognitive dysfunction and occupational extremely low frequency magnetic field exposure among elderly Mexican Americans
Frei et al.	2013	Residential distance to high-voltage power lines and risk of neurodegenerative diseases: a Danish population-based case-control study
Huss et al.	2014	Occupational exposure to magnetic fields and electric shocks and risk of ALS: The Swiss National Cohort
Huss et al.	2015	Extremely Low Frequency Magnetic Field Exposure and Parkinson's Disease--A Systematic Review and Meta-Analysis of the Data
Grell et al.	2012	Risk of neurological diseases among survivors of electric shocks: a nationwide cohort study, Denmark, 1968-2008
Koeman et al.	2015	Occupational exposures and risk of dementia-related mortality in the prospective Netherlands Cohort Study
Seelen et al.	2014	Residential exposure to extremely low frequency electromagnetic fields and the risk of ALS
Van der Mark et al.	2014	Extremely low-frequency magnetic field exposure, electrical shocks and risk of Parkinson's disease
Vergara et al.	2013	Occupational exposure to extremely low-frequency magnetic fields and neurodegenerative disease: A meta-analysis
Yu et al.	2014	Environmental risk factors and amyotrophic lateral sclerosis (ALS): a case-control study of ALS in Michigan
Zhou et al.	2012	Association between extremely low-frequency electromagnetic fields occupations and amyotrophic lateral sclerosis: A meta-analysis

Cardiovascular disease

It has been hypothesized that magnetic-field exposure reduces heart rate variability, which in turn is a marker of increased susceptibility for AMI. In a large cohort of utility workers, Savitz et al. (1999) reported an increased risk of arrhythmia-related deaths and deaths due to AMI. Previous and subsequent studies did not report a statistically significant increase in cardiovascular disease mortality or incidence related to occupational magnetic-field exposure (WHO, 2007). The WHO concluded, “Overall, the evidence does not support an association between ELF exposure and cardiovascular disease” (WHO, 2007, p. 220).

Recent studies (2012 – 2015)

One study from the Netherlands evaluated the relationship between occupational exposure to ELF EMF and cardiovascular disease mortality (Koeman et al., 2013). The study identified more than 8,000 cardiovascular deaths among the more than 120,000 men and women in the Netherlands Cohort Study during a 10-year period. Occupational exposure was determined by linking occupational histories to an ELF-magnetic-field job-exposure matrix. The authors reported no association between cumulative occupational ELF-magnetic-field exposure and cardiovascular mortality or death due to any of the subtypes of cardiovascular disease. The authors concluded that their results add “to the combined evidence that exposure to ELF-MF [magnetic fields] does not increase the risk of death from CVD [cardiovascular disease]” (Koeman et al., 2013, p. 402).

Assessment

The recent study reported no association between ELF magnetic fields and cardiovascular disease, thus confirming earlier conclusions about the lack of an association between magnetic fields and cardiovascular disease.

Table 11. Relevant studies of cardiovascular disease

Authors	Year	Study Title
Koeman et al.	2013	Occupational exposure to extremely low-frequency magnetic fields and cardiovascular disease mortality in a prospective cohort study

6 Reviews by Scientific Organizations

Several reports with regard to the possible health effects of ELF EMF have been published by national and international scientific organizations since 2012 (NZMH, 2015; SCENIHR, 2015; SSM, 2013, 2014, 2015). Although none of these documents represents a cumulative weight-of-evidence review of the depth of the WHO review published in June 2007, their conclusions are of relevance. In general, the conclusions of these reviews are consistent with the scientific consensus articulated in Sections 4 and 5. The most comprehensive recent scientific review was published by SCENIHR in 2015, which updated the previous report on potential health effects of EMF issued by the same committee in 2009 (SCENIHR, 2009). The conclusions of the 2015 SCENIHR review are consistent with earlier comprehensive reviews, most notably the WHO review discussed in detail above. SCENIHR (2015) did not conclude that the available scientific evidence confirms a causal link between any adverse health effects (including both cancer and non-cancer health outcomes) and EMF exposure. With respect to epidemiologic results of childhood leukemia, the review concludes that: "… no mechanisms have been identified and no support is existing [*sic*] from experimental studies that could explain these findings, which, together with shortcomings of the epidemiological studies prevent a causal interpretation" (SCENIHR, 2015, p. 7).

The WHO and other scientific organizations have not found any *consistent* associations with regard to ELF EMF exposure and any type of cancer or disease, except childhood leukemia, nor have they concluded that there is a cause-and-effect link with any health effect, including childhood leukemia (WHO, 2007; SCENIHR, 2009, 2015; EFHRAN, 2010, 2012; ICNIRP, 2010; SSM, 2010; NZMH, 2015).

In summary, over the past decades, reviews published by scientific organizations using weight-of-evidence methods have concluded that the cumulative body of research to date does not support the hypothesis that ELF EMF causes any long-term adverse health effects at the levels we encounter in our everyday environments. An evaluation of current research does not point to better quality or stronger evidence that is sufficient to change the conclusions of these assessments.

7 Summary

A number of epidemiologic and *in vivo* studies have been published on EMF and health since Exponent's 2012 update to the WHO report. The weak statistical association between high, average magnetic fields and childhood leukemia remains largely unexplained and unsupported by the experimental studies. The recent *in vivo* studies confirm the lack of experimental data supporting a leukemogenic risk associated with magnetic-field exposure or other effects on health.

Overall, the current body of research supports the conclusion that there is no association between magnetic fields and adult cancer or cardiovascular disease, although future research is needed to improve methods to estimate exposure. Recent literature does not confirm an earlier suggestion that there is an association between magnetic fields and Alzheimer's disease.

In conclusion, no recent studies provide evidence to alter the conclusion that the scientific evidence does not confirm that ELF EMF exposure is the cause of cancer or any other disease process at the levels we encounter in our everyday environment.

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8. PROPOSED PROJECT SCHEDULE

Figure 8-1 illustrates the key activities in Eversource's proposed schedule for developing the Frost Bridge to Campville Project, including the submission of this Application. The schedule provided in Figure 8-1 does not list the planning activities that Eversource performed on the Project prior to the September 2015 submittal of the Municipal Consultation Filing (MCF), which was required pursuant to the Council's Application process.

Figure 8-1: Frost Bridge to Campville Project – Estimated Timeline

PRIMARY PROJECT ACTIVITY	YEAR (QUARTER)										
	Q3 '15	Q4 '15	Q1 '16	Q2 '16	Q3 '16	Q4 '16	Q1 '17	Q2 '17	Q3 '17	Q4 '17	2018
Municipal Consultation Filing Issued to Towns	■										
Public Open House Period	■										
Siting Application Filed with the CT Siting Council (CSC)		■									
CSC Hearing and Decision (12 months)			■	■	■	■					
CSC Decision						■					
Development & Management (D&M) Plans							■	■			
State & Federal Permitting				■	■	■	■	■			
Construction								■	■	■	■
Project Outreach	■	■	■	■	■	■	■	■	■	■	■

*Note that the construction timeline refers to the installation of the new 115-kV transmission line and substation modifications, and does not necessarily include the completion of all ROW restoration and post-installation activities.

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9. PERMITS, APPROVALS, AND CONSULTATIONS

As part of the Project planning process, Eversource initiated consultations with representatives of the towns that would be traversed by the proposed new 115-kV transmission line along the Proposed Route, as well as with representatives of the federal and state regulatory agencies from whom approvals for the Project would be required. Eversource will continue such proactive consultations as the planning for and review of the Project proceeds. This section identifies the permits and approvals that would be required for the construction and operation of the Project, and summarizes the federal and state agency and municipal consultations that Eversource has conducted to date.

9.1 AGENCY PERMITS AND APPROVALS REQUIRED FOR THE PROJECT

In addition to the Certificate from the Council, the Project will require permits and approvals from other Connecticut and federal agencies. At the federal level, the Project must comply with the Clean Water Act (CWA), the Endangered Species Act and the National Historic Preservation Act. At the state level, along with compliance with the Council's requirements, Eversource will have to obtain Project-specific permits or approvals pertaining to water quality (pursuant to Section 401 of the CWA), stormwater management, threatened and endangered species, and cultural resources. Additional state approvals may be required, depending on the final design of the Project.

Table 9-1 summarizes the federal and state permits and approvals expected to be required for the proposed Project. This summary is based on currently available data concerning the Project, and may be modified as the Project planning, design, and review process moves forward.

Table 9-1: Potential Permits, Reviews, and Approvals Required for the Project

Agency	Certificate, Permit, Review, Approval or Confirmation	Activity Regulated
Federal		
U.S. Army Corps of Engineers (USACE), New England District	Section 404 CWA	Discharge of dredge or fill material into waters of the U.S. (wetlands or watercourses)
U.S. Fish and Wildlife Service	Coordinates with USACE regarding endangered or threatened species (non-marine); provides input to USACE permit application review	Construction or operation activities that may affect federally-listed endangered or threatened species
U.S. Environmental Protection Agency	Provides input to USACE permit application review	Construction or operation activities that may affect water, air, or other resources
U.S. Department of the Interior, National Park Service	Provides input to USACE permit application review	Input regarding Naugatuck River greenway, which extends across USACE property
Advisory Council on Historic Preservation	Involved if significant cultural resource sites would be potentially affected by the Project	Section 106 National Historic Preservation Act compliance; input to USACE permit review, if applicable
Connecticut		
Connecticut Siting Council	Certificate of Environmental Compatibility and Public Need Development & Management Plan approval prior to construction	General transmission line need, siting, construction, environmental compatibility, safety, maintenance, and ROW management procedures
Department of Energy and Environmental Protection (CT DEEP)	401 Water Quality Certification	Conformance to Section 401 of the CWA; Section 401 approval from CTDEEP is required prior to USACE permit issuance
	Water Discharge General Permit	Stormwater management during construction
	Threatened, Endangered, and Special Concern Species	Approval of species-specific mitigation plans as part of Council's process, 401 Water Quality Certification approval
CT DEEP Public Utilities Regulatory Authority	Approval pursuant to CGS Section 16-243	Approval to Energize Lines
State Historic Preservation Office (SHPO)[1]	Approval of proposed Project consistency with the National Historic Preservation Act; comments during Council and USACE processes	Construction and operation activities that may affect archaeological or historic resources.
Connecticut Department of Transportation (ConnDOT)	Encroachment permit	Transmission line crossing of state highways

9.2 FEDERAL AND STATE AGENCY CONSULTATIONS

In conjunction with the overall Project planning, Eversource initiated consultations with the federal and state agencies likely to be involved in the review or approval of the new 115-kV transmission line and related substation modifications. The purpose of these initial consultations was to provide the agencies with preliminary information regarding the proposed Project, and to solicit baseline information concerning the Project area or input concerning potential Project-related issues. Table 9-2 summarizes the federal and state agency consultations conducted to date.

Table 9-2: List of Federal and State Agency Consultations to Date

AGENCY	DATE	AGENCY CONTACT
Federal		
USACE, New England District	7/20/2015	Susan Lee
U.S. Department of Interior - Fish & Wildlife Service	7/30/2015	Jenny Dickson (CT DEEP)
National Park Service	8/17/2015	John Monroe
Connecticut		
CT DEEP – Mattatuck State Forest / Black Rock State Park	8/11/2015	Tammy Talbot
CT DEEP – Natural Diversity Database	5/14/2015 5/19/2015 7/30/2015	Dawn M. McKay Jenny Dickson Laura Saucier
SHPO	8/18/2015	Cathy Labadia

9.3 MUNICIPAL, PUBLIC, AND OTHER CONSULTATIONS

In April of 2015, Eversource initiated consultations with municipal officials in the towns of Watertown, Thomaston, Litchfield and Harwinton in which the proposed Project would be located. The purpose of these consultations was to inform the municipal officials of the proposed Project and solicit their input. In addition, key state elected and regulatory officials, were offered briefings and consulted regarding the proposed Project. Project representatives also presented the project to the Board of Selectman (BOS) meetings in the towns of Thomaston, Litchfield and Harwinton, per the request of the First Selectmen.

Property owners and abutters to the proposed new transmission line were notified about the proposed Project and were offered briefings shortly after the submittal of the MCF in early September. These notifications included a letter introducing the Project, invitations to the Open Houses as well as door-to-door outreach to property owners identified as having proposed construction impacts. Open Houses were held on September 29 and 30, 2015 in Litchfield and Thomaston, respectively. The Open Houses were attended by abutting property owners, municipal officials and state representatives, among other interested parties.

As a result of the proactive outreach during the MCF process, the Project team received feedback from stakeholders about the proposed Project. Multiple property owners in Thomaston, as well as the First Selectman, requested the Project look into changing the design of the structures in the Walnut Hill area (proposed structures 50-60) from a delta configuration to a horizontal configuration, thereby reducing the height of the new structures to be closer in height to the existing tree line. The Project team evaluated this request for a structure design change and determined that only a few of the structures would have the height reduced enough to be below the adjacent tree height. Additionally, the H-frame structures would require more vegetation clearing, additional impacts to wetlands, and would increase Project costs. Therefore, this requested design change is not preferred and is not being incorporated into the proposed Project. Additional information regarding Eversource's evaluation of this suggested line modification is included in Section 12.4.

The Project Team also received two property owner requests for structure relocations to reduce impacts on the abutting properties. These structure relocation requests were evaluated and follow-up meetings were held with the property owners to review the options for relocating the structures. One property owner request for a structure relocation was accommodated. The second property owner requested that two structures be relocated; of these, one of which was changed to the location requested. The other planned structure was relocated in the direction requested, but not to the exact location requested in order to prevent the Project from incurring additional costs associated with revised structure heights to make this relocation feasible. These changes are reflected in the revised Project mapping included in Volume 5.

In addition to requests regarding structure location and configuration changes, a few property owners made specific requests regarding restoration measures for their properties, including requests for stump removal and requests for restoration plantings, among others. Eversource has committed to working with these property owners to address their requests.

This Project outreach process conforms to the Council's MCF requirements. Eversource intends to continue proactive outreach with affected property owners and other stakeholders as the Project moves forward.

Table 9-3 summarizes the primary meetings that Eversource has held to date with municipal officials and state and federal officials.

Table 9-3: Meetings Held To-Date with Municipal Officials, State and Federal Officials, and Other Key Stakeholder Groups

Stakeholder Group	Date of Meeting	Purpose of Meeting
Municipal Officials		
Town of Watertown Town Manager Robert M. Scannell	April 7, 2015	Project Introduction
Town of Thomaston First Selectman Edmond V. Mone	April 8, 2015	Project Introduction
Town of Litchfield First Selectman Leo Paul	April 9,2015	Project Introduction
Town of Harwinton First Selectman Michael R. Criss	April 8, 2015	Project Introduction
Town of Litchfield Board of Selectmen	May 19, 2015	Project Introduction
Town of Harwinton Board of Selectmen	October 6, 2015	Project Introduction
Town of Thomaston Board of Selectmen	October 6, 2015	Project Introduction
State and Federal Officials		
Congresswoman Elizabeth Esty 5th District	Weeks of April 13 and April 20, 2015	Project Introduction
Senator Chris Murphy	Weeks of April 13 and April 20, 2015	Project Introduction
Senator Richard Blumenthal	Weeks of April 13 and April 20, 2015	Project Introduction
State Senator Clark Chapin 30th District	Weeks of April 13 and April 20, 2015	Project Introduction
State Representative Craig Miner 66th District	Weeks of April 13 and April 20, 2015	Project Introduction
State Representative John Piscopo 76th District	Weeks of April 13 and April 20, 2015	Project Introduction
State Senator Henri Martin 31st District	Weeks of April 13 and April 20, 2015	Project Introduction
State Senator Kevin Witkos 8th District	Weeks of April 13 and April 20, 2015	Project Introduction
Representative Eric Berthel 68th District	Weeks of April 13 and April 20, 2015	Project Introduction
State Senator Robert Kane 32nd District	Weeks of April 13 and April 20, 2015	Project Introduction

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10. SYSTEM ALTERNATIVES

This section complies with the provision in the Council's Application Guide (April 2010) that requires an applicant to identify "system alternatives and the advantages and disadvantages of each." First, in Section 10.1, a "No Action" alternative is briefly discussed. Next, in Section 10.2, transmission system alternatives are discussed. This section describes the process by which a preferred transmission solution for NWCT was developed as part of the GHCC studies. Finally, in Section 10.3, the evaluation of potential non-transmission system alternatives (NTAs) is discussed. NTAs include the addition of generation resources, often referred to as "supply-side" measures, and strategies to reduce load, often referred to as demand-side management or "DSM" measures.

10.1 NO ACTION ALTERNATIVE

Under the no-action alternative, no new transmission facilities would be developed and no improvements would be made to the existing electrical transmission system or to supply or demand resources in NWCT. This alternative was rejected because it would do nothing to correct violations of national and regional reliability standards and criteria; and thus the NWCT sub-area would continue to be at risk for electric outages and Eversource would be exposed to being fined by FERC for its failure to take action to resolve identified criteria violations. Failure to take action to bring the NWCT electric supply into conformity with applicable reliability standards and criteria would also undermine the long-range plan of ISO-NE and Eversource for providing reliable transmission service throughout Connecticut and neighboring states.

10.2 TRANSMISSION ALTERNATIVES

Transmission alternatives are improvements to the transmission system that would resolve reliability problems with different electrical configurations or technologies than those of the preferred solution. As part of the GHCC studies, an ISO-NE Working Group comprised of transmission planners from ISO-NE, Eversource Utilities Service Company, and The United Illuminating Company evaluated transmission alternatives in all of the sub-areas studied, including NWCT.

10.2.1 Process for Developing the NWCT Transmission Alternatives

Using their engineering judgment and knowledge of the Connecticut and New England transmission systems, the Working Group first identified potential transmission solutions and then conducted testing to evaluate their performance. The Working Group's approach to developing potential solutions was to look for ways to strengthen connections to the load pockets, which could be done by adding a new source into the pocket, by improving the elements that would remain in service after N-1-1 contingency events so that they could adequately handle the additional loading, or by eliminating the contingency condition causing the violations (such as by separating the circuits of a double circuit line.) All of the alternative solutions were first evaluated to ensure that the solution components resolved all the target criteria violations identified in the *GHCC Needs Report*. The next step was to compare the alternative solution components in terms of cost, constructability, environmental concerns, and other criteria.

The Working Group presented interim results of this evaluation to the ISO-NE Planning Advisory Committee (PAC) in March, 2014; and presented the preferred solution to the PAC in July, 2014. The PAC is composed of stakeholders, including generator owners, suppliers, load serving entities, energy efficiency entities, state regulators and transmission owners, who are given the opportunity to provide input throughout the study process. The *GHCC Solutions Report*, which explains and justifies the selection of the preferred solution, was published in February, 2015.

In the course of its work, the Working Group determined that the solutions for the several subareas within the greater GHCC area could be analyzed independently of one another, since the needs for the area were largely driven by load-serving issues following the loss of critical 115-kV sources into each subarea.

The potential transmission solutions were tested by simulations using assumptions and procedures consistent with those that had been applied to identify the reliability needs in the study area, with adjustments for changes in system resources and transmission topology that had occurred since the *GHCC Needs Assessment* had been completed. These changes are discussed in detail at pages 15-17 of the *GHCC Solutions Report.*

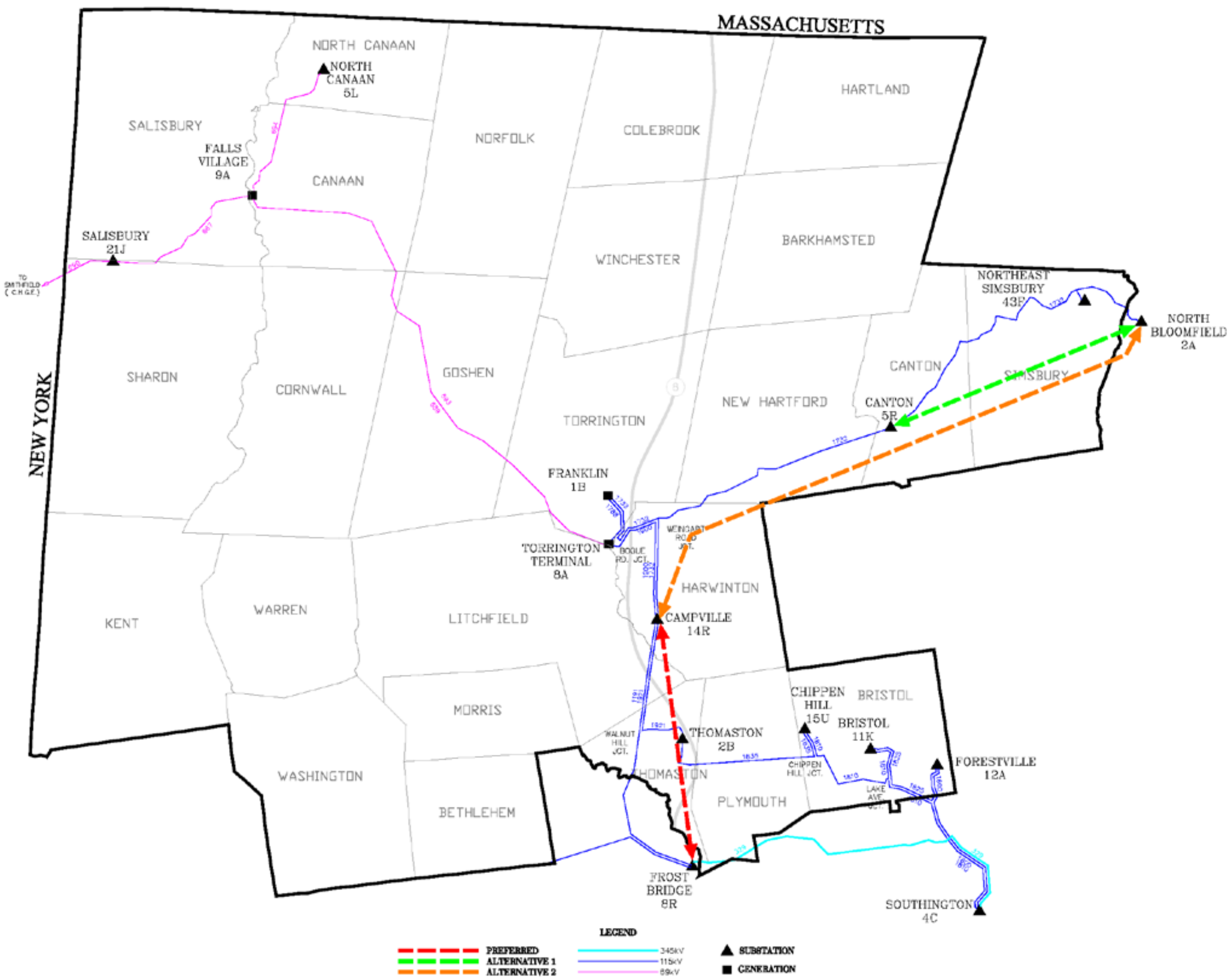
10.2.2 Transmission Alternatives Considered

Having determined that the best way to solve the violations in the NWCT sub-area was to provide a new 115 kV source into it, the Working Group considered what the effective terminal locations of such a line were likely to be. The terminal locations outside the NWCT subarea that were considered were the North Bloomfield Substation (located to the east of the NWCT subarea in the Greater Hartford subarea) and Frost Bridge Substation (located in the SWCT subarea, just to the south of the NWCT subarea). Terminal locations within the NWCT sub-area that were considered were the Canton and Campville substations. The potential new 115-kV transmission line connections initially considered were thus:

- North Bloomfield to Canton;
- North Bloomfield to Campville; and
- Frost Bridge to Campville.

Each of these transmission lines would have associated minor upgrades as well. The terminal points of the three lines initially considered are illustrated in Figure 10-1.

Figure 10-1: Alternative Terminations for a New Line into the NWCT Sub-area



10.2.3 Comparison of the Transmission Alternatives

The Working Group quickly dismissed the North Bloomfield to Campville transmission system alternative because of its much greater length, as compared to the North Bloomfield to Canton alternative (approximately 25 vs. 12.8 miles), which made it far more expensive, with more environmental effects. The Working Group accordingly analyzed only the other two alternatives in detail, referring to the Frost Bridge to Campville system as Alternative A and the North Bloomfield to Canton system as Alternative B.

Using load flow simulations, the Working Group identified the full scope of the improvements that would be required for each alternative, as shown in Table 10-1:

Table 10-1: Northwestern Connecticut Subarea Solution Alternatives

<table>
<tr><th>Component ID</th><th>Description</th><th>Included in Alternative A</th><th>Included in Alternative B</th></tr>
<tr><td>1</td><td>Add a new 10.4-mile, 115-kV line from Frost Bridge to Campville and associated terminal equipment</td><td>Y</td><td></td></tr>
<tr><td>2</td><td>Add a new 12.8-mile, 115-kV-line from North Bloomfield to Canton and associated terminal equipment</td><td></td><td>Y</td></tr>
<tr><td>3</td><td>Separation of 115-kV DCT corresponding to the Frost Bridge to Campville (1191) line and the Thomaston to Campville (1921) line and add a breaker at Campville 115-kV substation</td><td>Y</td><td></td></tr>
<tr><td>4</td><td>Upgrade terminal equipment on the 115-kV line between Chippen Hill and Lake Avenue Junction (1810-3)</td><td rowspan="2">Y</td><td rowspan="2">Y</td></tr>
<tr><td>5</td><td>Reconductor the 115-kV line between Southington and Lake Avenue Junction (1810-1) – 5.2 miles</td></tr>
<tr><td>6</td><td>Add a 25.2 MVAR capacitor at Campville Substation</td><td></td><td>Y</td></tr>
</table>

10.2.3.1 Comparative Performance

Both alternative solutions would resolve the thermal and voltage criteria violations in their respective study sub-areas, with the following exceptions, which will be separately addressed: (a) criteria violations related to the loss of certain distribution voltage transformers at substations in the sub-area, which Eversource will address separately with local upgrades; and (b) violations associated with the 69-kV system in NWCT, including the No. 690 line between the Smithfield Substation in Amenia, New York and the Salisbury Substation in Salisbury, Connecticut. These issues will be resolved separately by a joint effort of ISO-NE and the New York ISO.

The study results are discussed in detail in the *GHCC Solutions Study*. Although both alternatives would solve the same criteria violations, the voltage performance of the Frost Bridge to Campville line (Alternative A) was better than that of the North Bloomfield to Canton line (Alternative B) in that Alternative B required additional reactive support to be installed at Campville in order to boost voltages in the area under certain conditions.

10.2.3.2 Comparative Cost

The cost of Alternative B was determined to be much higher than that of Alternative A, the preferred alternative. The unique elements of Alternative A were estimated to cost approximately $51 million in 2017 dollars, whereas the cost of the unique elements of Alternative B were estimated to cost approximately $74 million. In addition, each alternative required common elements with an estimated cost of approximately $12 million, thus making the overall cost comparison, approximately $63 million for Alternative A and approximately $86 million for Alternative B.

The elements common to both alternatives were those listed as Items (4) and (5) in Table 10-1 above. The comparison of the estimated costs of the unique elements was as shown in Table 10-2:

Table 10-2: Cost Estimates of Unique Components of NWCT Solution Components

ID	Solution Component	Cost ($M)	Included in Alternative A	Included in Alternative B
1	Add a new 10.4-mile, 115 kV-line from Frost Bridge to Campville and associated terminal equipment	45.5	Y	
2	Add a new 12.8-mile, 115-kV line from North Bloomfield to Canton and associated terminal equipment	66.9		Y
3	Separation of 115-kV DCT corresponding to the Frost Bridge to Campville (1191) line and the Thomaston to Campville (1921) line and add a breaker at Campville 115-kV Substation	5.5	Y	
6	Add a 25.2 MVAR capacitor at Campville Substation	7.0		Y
	Solution Alternative Totals ($M)		**51.0**	**73.9**

This difference in cost was due to a number of factors, including Alternative B's more extensive and costly substation improvements and longer length. In addition, the Alternative B estimate included higher labor and material costs and a greater contingency allowance because the North Bloomfield to Canton ROW was estimated to include approximately 6 times more wetlands than the Frost Bridge to Campville ROW.

10.2.3.3 Comparative Environmental and Social Effects

Compared to the Frost Bridge to Campville transmission line, a new 115-kV transmission line between North Bloomfield and Canton would be approximately 24% (2.3 miles) longer; would extend through generally more densely populated areas; and would cross more wetlands. As a result, the North Bloomfield to Canton line would result in comparatively greater potential environmental and social impacts than the Frost Bridge to Campville line.

For example, the Frost Bridge to Campville ROW extends primarily through undeveloped or sparsely populated areas; only 55 residences are located within 300 feet of the centerline of the new transmission line route. In comparison, the centerline of the North Bloomfield to Canton 115-kV line would be within 300 feet of approximately 207 homes.

The North Bloomfield to Canton line ROW also would affect six times as many wetland resources as the Frost Bridge to Campville line. Assuming a 90-foot-wide ROW would be involved in the construction of the new 115-kV line along either route and based on a review of National Wetlands Inventory mapping, the North Bloomfield to Canton line would impact approximately 13 acres of wetlands, whereas the Frost Bridge to Campville line would affect approximately 2.2 acres of wetlands. Based on these significantly greater potential adverse effects on water resources, a new line along the North Bloomfield to Canton ROW would not be considered the least environmentally damaging practical alternative, pursuant to the Clean Water Act, and thus also would be difficult to permit, given the availability of the Frost Bridge to Campville alternative.

10.2.3.4 Conclusion

As compared to Alternative B, Alternative A would cost less, perform slightly better, and have fewer environmental and social impacts. Accordingly, Eversource has selected Alternative A as preferred and is proposing its major elements in this proceeding.

10.3 NON-TRANSMISSION ALTERNATIVES (NTA)

As part of its examination of electric system needs and solutions in the Greater Hartford, Manchester / Barbour Hill, Middletown, and NWCT subareas, ISO-NE conducted two studies to identify hypothetical solutions to the identified needs that would not require expansion of the regulated transmission system. Because these non-transmission solutions could, at least potentially, be implemented by participants in competitive markets, ISO-NE referred to them as “Market Resource Alternatives” (MRAs). Pursuant to the ISO-NE Open Access Transmission Tariff, transmission owners such as Eversource are obliged to pursue regulated transmission solutions to address system needs only where the needs are not addressed by market forces. The ISO-NE MRA studies served as a signal to private developers of a potential need for such market alternatives.

In the MRA studies, ISO-NE evaluated the effects of adding new demand side and supply side resources in the same way that it evaluated system needs and transmission solutions – by running power-flow simulations to determine if the target reliability criteria violations could be eliminated by the addition of the extra resources or reductions in load. After extensive studies and testing, ISO-NE presented to the PAC the results of two separate MRA studies, one of which considered exclusively demand-side alternatives, and the other supply-side alternatives. These studies identified MRAs for each of the four GHCC subareas.

The ISO-NE MRA analyses identified quantities of injections of power into the electrical system or load reductions that would be required at particular electrical locations in order to obviate the need for regulated transmission improvements. However, ISO-NE did not determine the types of resources and technology that could, in reality, provide such injections or reductions of demand at each location. Such a determination requires consideration of the suitability of the available technologies for the particular application, including performance characteristics, cost, land requirements and access to cooling water (if necessary), availability of fuel supplies, and other factors for developing and bringing to commercial operations a new demand reduction program or supply-side resource. The ISO-NE MRA studies also did not undertake to estimate the cost of the NTA solutions compared to the cost of the transmission solution.

Accordingly, Eversource engaged an expert consultant, London Economics International, LLC (LEI), to study of non-transmission alternatives to the preferred transmission solution for the NWCT sub-area identified in the GHCC *Solutions Report*, which includes the proposed transmission improvements that are the subject of this document. LEI is a consulting firm with expertise in analyses of the New England power markets, including economic evaluations, simulation modeling, asset valuation, price forecasting, and market design.

Using the ISO MRA analyses as the point of departure for its investigations, LEI considered the potential technology that could deliver the requisite energy injections to satisfy the reliability needs of the local areas, the associated costs of the NTA technology, and practical feasibility of the least-cost NTA solution. The results of LEI's studies, as well as a detailed description of their analyses, are contained in a report (LEI Report), a copy of which is included in Volume 4.

As detailed in the LEI Report, the ISO-NE analyses showed that an NTA for the NWCT sub-area would require an injection of 48 MW of energy at Torrington Substation and 181 MW of energy at Campville Substation, or commensurate reductions in the loads served at these substations. Based on these ISO-NE analyses, LEI then consideredwhat actual supply-side and demand-side resources would be capable of providing these injections or reductions and selected hypothetical, technically feasible NTA technologies for cost analysis. LEI considered technically "feasible" technologies to be those that would address the reliability need and could be hypothetically implemented based on planning criteria and technology-specific operating profiles.

As technically feasible NTA technologies at the Torrington and Campville substation locations, LEI identified peaker aeroderivative turbines (turbines modelled on turbojet fans), Combined Cycle Gas Turbines ("CCGT"), energy storage, fuel cells, and passive demand response (energy efficiency). Next, LEI assessed whether these technically feasible NTAs could be cost-effective or practical.

First, with the assistance of Eversource personnel responsible for energy efficiency programs, LEI identified the maximum incremental demand response that could likely be implemented at each of the two substation locations, in addition to what is currently planned to be implemented pursuant to the ISO-NE Forward Capacity Market, and above and beyond what is forecast by ISO-NE to occur on the basis of current utility programs for DSM and energy efficiency. Given the projected net load at each substation, the maximum likely achievable incremental demand response was modest – 10 MW at Campville Substation and 2 MW at Torrington Substation. Taking into consideration this incremental demand response, LEI then employed industry-standard levelized costing principles to select from the group of technically feasible NTA technologies, components to supply the large remaining balance of the requirements for each substation (i.e., 171 MW at Campville and 46 MW at Torrington).

Based on operational factors and the balance of the requirements for each substation, LEI concluded that the best solution would be to construct a 180 MW combined-cycle natural gas fueled turbine generator (CCGT) at Campville and 54 MW of aeroderivative peaking generation units at Torrington. Table 10-3 summarizes the total requirements and technically feasible NTA technologies, by substation.

Table 10-3: List of Qualified Technologies and Requirements for Each Substation

Substations	Torrington	Campville
Requirements at substation (MW)	48	181
NTA Technologies	-	-
Energy Efficiency (MW)	2	10
CCGT (MW)	-	180
Aeroderivative peaker (MW)	54	-

LEI then computed the net direct cost to Connecticut ratepayers of this least-cost NTA portfolio by deducting from the NTA's gross annual costs the projected average annual market-related revenues that the NTAs could be projected to earn. The total net direct cost to ratepayers of this least cost technically feasible NTA solution for NWCT was estimated to range from $22 million to $36 million a year, not including the cost of constructing lateral pipelines to reach the nearest existing natural gas pipeline supply, or any transmission system upgrade costs required to implement the NTA technologies. Furthermore, the costs are not inclusive of any locational premiums associated with developing and building in Connecticut as opposed to more generally in New England. In contrast to this minimum annual cost of $22 million to $36 million, Connecticut ratepayers' share of the revenue requirement associated with the NWCT transmission solution would be approximately $2.7 million per year. This enormous cost differential compelled the conclusion that an NTA would not provide a practical alternative to the transmission solution and to terminate the analysis.

If the NTA identified by LEI were to be considered further, it would be necessary to test it in the same manner as the transmission solution was tested in the ISO-NE solution study. In such a study, a generation dispatch would be constructed that would assume one or two of the most critical units in the NWCT sub-area to be out of service and that approximately 80% of the fast start units in the subarea (which would include the aeroderivative units at Torrington) would come on when requested. The results of this study could have indicated that additional capacity beyond that included in the LEI NTA would be necessary to provide, with the required degree of reliability, the injection quantities determined by the ISO-NE MRA studies to be necessary.

Such further studies would also have to evaluate a full range of the non-economic costs and benefits of the NTAs, compared to those of the transmission solution. For instance, the environmental effects of the NTAs (e.g., noise impacts and air emissions from the aeroderivative and CCGT plants) would have to be specifically determined and subsequently compared to those of the transmission alternative, which are extensively described in this document (refer to Section 6). In addition, forward-looking simulation modeling would have to be performed to assess the relative longevity of both the transmission solution and the potential NTA technologies, and to compare the various services and other benefits that each could provide.

However, the cost difference between the NTA and transmission solutions in this case is decisive, illustrating that an NTA solution in this case is economically impractical. Indeed, the economic impracticality of the NTA solution here is suggested by the fact that no one has proposed to implement such an NTA for the NWCT sub-area since ISO-NE identified potential MRAs for the GHCC projects in 2012. Pursuant to the ISO-NE Open Access Transmission Tariff, since no market solution for a reliability need has been implemented, Eversource is required to proceed with a “backstop” regulated transmission solution, as proposed in this document.

11. TRANSMISSION LINE ROUTE / CONFIGURATION ALTERNATIVES

11.1 ROUTING OBJECTIVES AND ALTERNATIVE ROUTE ANALYSIS PROCESS

After the Project (a new 115-kV transmission line to connect Frost Bridge and Campville substations) was selected as the preferred transmission system solution, Eversource identified and evaluated alternative routes and configurations for the new transmission line. All of the potential alternative routes for the new 115-kV transmission line necessarily had to interconnect the two substations, as required to achieve the Project's technical objectives. This section describes the approach that Eversource used to identify and evaluate route alternatives for the proposed 115-kV transmission line and, from among these alternatives, select the preferred route and design for the Project.[95]

11.1.1 Routing Objectives

For the alternatives analysis, Eversource applied an established set of route selection objectives to identify and compare potential routes for the new 115-kV transmission line between Frost Bridge Substation and Campville Substation. These defined line routing objectives, which are listed in Table 11-1, include the following overarching goals:

- The selection of a cost-effective and technically feasible solution to achieve the required transmission system reliability improvements and to interconnect the specified substations; and
- The avoidance, minimization, or mitigation of adverse environmental and cultural effects and minimizing impacts to the community to the extent possible.

[95] There are no feasible "routing" alternatives to the proposed separation of the existing 1191 and 1921 Lines at the Naugatuck River crossing. An alternative transmission line structure configuration was considered for the circuit separation and is discussed in Section 12.

Table 11-1: Eversource Transmission Line Route Selection Objectives

- Comply with all statutory requirements, regulations, and state and federal siting agency policies
- Maximize the reasonable, practical, and feasible use of existing linear corridors (e.g., transmission line, highway, railroad, pipeline rights-of-way)
- Minimize adverse effects to sensitive environmental resources
- Minimize adverse effects to significant cultural resources (archaeological and historical)
- Minimize adverse effects on designated scenic resources
- Minimize conflicts with local, state and federal land use plans and resource policies
- Minimize the need to acquire property by eminent domain
- Maintain public health and safety
- Achieve a reliable, operable and cost-effective solution

11.1.2 Alternative Route Analysis Process: Overview and Summary

Eversource applied the transmission line route selection objectives to identify potential 115-kV transmission line route alternatives involving both overhead and underground configurations. These potential route alternatives were then examined, using Eversource's route evaluation criteria for overhead transmission lines (as discussed in Section 11.2) and underground transmission cables (as discussed in Section 11.3), to assess the viability of each option based on operability and reliability, technical feasibility, potential effects on property, potential effects on environmental and cultural resources, and cost. Because overhead and underground transmission line construction and operation are inherently different, the emphasis placed on some of the route evaluation criteria in the analysis of potential route options varied for these two line designs.

As the first step in the alternative route analyses, Eversource[96] reviewed the general region between Frost Bridge Substation and Campville Substation to identify major, geographically distinct, existing linear corridors (e.g., railroad, road, pipeline, transmission line ROWs) for further investigation. The Project

[96] The alternative routes were identified and evaluated by a team consisting of Eversource staff, as well as specialized engineering and environmental consultants. This team conducted field reconnaissance, performed baseline data collection, prepared cost estimates, and reviewed aerial photography to determine the characteristics of each route alternative and to assess each in terms of the Project objectives and Eversource's route evaluation criteria.

region was also reviewed to determine the potential viability of new "greenfield" routes (i.e., not adjacent to any existing corridors) for the new transmission line.

The initial examination of potential alternative line routes involved the review of Eversource records regarding transmission line ROWs, road atlases, USGS topographic maps, Google Earth® and similar databases. Aerial photography of the Project region was also reviewed to identify general land uses and environmental features (e.g., vegetative communities, water resources, major designated recreational areas, and developed residential, commercial, and industrial areas).

Using this baseline information and reconnaissance of the Project region, Eversource identified and reviewed various existing linear corridors to determine if the new 115-kV line could be co-located within or adjacent to such ROWs. Existing corridors reviewed included State Routes 8, 848, 254, 807, 262, and 109; local roads; Eversource's existing transmission line ROWs; and railroads. In addition, Eversource assessed regional topographic and land use conditions to determine whether a new 115-kV transmission line could be practically developed along an entirely new ROW.

Eversource evaluated each potential route alternative using the criteria identified in Sections 11.2.1 (for overhead transmission lines) and 11.3.1 (for underground transmission cable systems). As a result of these route evaluations, most of the alternatives were quickly found to be impractical because of overriding environmental issues, lack of easements or property, engineering constraints, and/or cost factors, or were determined to be infeasible after field reconnaissance and closer investigation of potential environmental, social, and cultural effects, engineering concerns, or costs. (Refer to Sections 11.2.2 and 11.3.3 for discussions of alternative overhead and underground line routes that were eliminated from further consideration.)

Based on this evaluation process, Eversource identified three route alternatives for further consideration:

a. **Overhead 115-kV Transmission Line within Existing ROW**. Alignment of the proposed approximately 10.4-mile 115-kV transmission line in a predominantly overhead configuration within Eversource's existing ROW between Frost Bridge Substation and Campville Substation. There is sufficient space to accommodate the new transmission line within Eversource's existing ROW, without having to acquire new easements.

b. **Underground 115-kV Transmission Cable System along Road ROWs**. Development of approximately 11.2 miles of 115-kV transmission line, predominantly in an underground configuration (cable system) within or adjacent to existing road ROWs between the two substations. This route alternative would be constructed entirely underground, except for an approximately 0.2-mile overhead line segment extending from the Frost Bridge Substation, east across the Naugatuck River to Waterbury Road (State Route 262/848). The overhead line segment would be located primarily on new ROW but between two existing overhead ROWs and would avoid a difficult underground cable installation beneath the Naugatuck River.

c. **Underground 115-kV Transmission Cable System along Road ROWs with Overhead 115-kV Transmission Line Segment in Litchfield / Harwinton.** Development of approximately 9.8 miles of new 115-kV transmission line, predominantly in an underground configuration (cable system), as described in (b), except that the northern end of the route would transition to an overhead configuration in the Town of Litchfield and would be aligned within Eversource's existing ROW for approximately 1.8 miles across State Route 8 and the Naugatuck River to the Campville Substation. Overall, this route alternative would consist of approximately 7.8 miles of underground transmission cable and 2 miles of overhead transmission line.

These three route alternatives are illustrated on Figure 11-1. As described in Sections 11.2 and 11.3, Eversource conducted more detailed analyses of each of these alternatives, taking into consideration environmental and social impacts, constructability, and cost, among other factors. Subsequently, from among these alternatives, for the reasons described further below, Eversource identified the preferred Project alternative as a predominantly overhead 10.4-mile 115-kV transmission line, aligned within Eversource's existing transmission line ROW between Frost Bridge Substation and Campville Substation.

11.2 OVERHEAD TRANSMISSION LINE ROUTES: ALTERNATIVES ANALYSIS

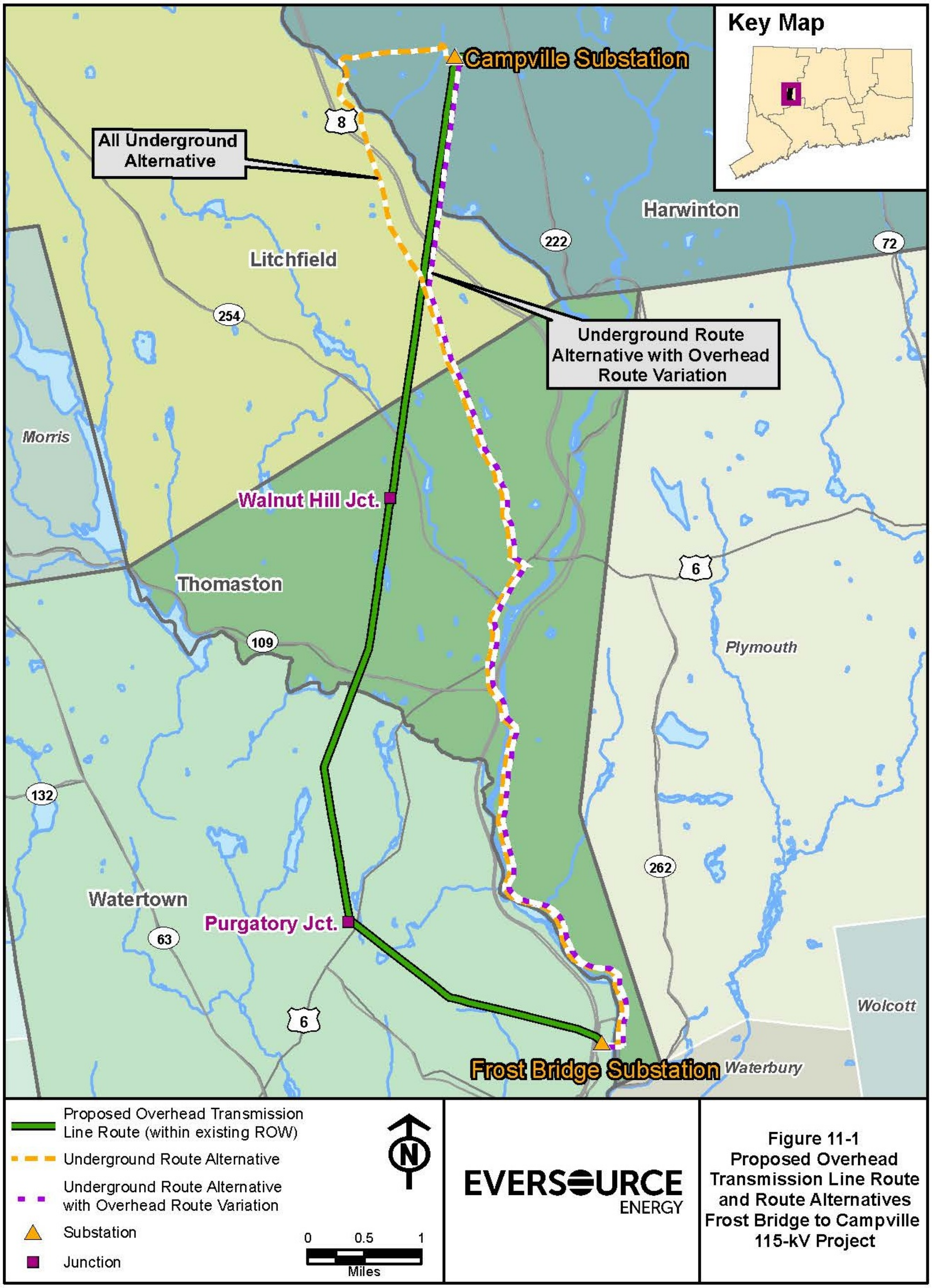
11.2.1 Route Evaluation Criteria

Along with the route selection objectives listed in Table 11-1, Eversource applied an established set of route evaluation criteria to identify and compare potential overhead transmission line routes. These standard route evaluation criteria, as described below, were used to locate and assess alternative overhead transmission line routes for the proposed Project.

Overhead transmission lines allow some design flexibility, provided that a continuous ROW of adequate width is available. Individual transmission line structures often can be located to avoid, or to allow the conductors to span over, sensitive environmental areas (e.g., wetlands, watercourses and lakes, steep slopes, important wildlife habitat).

Overhead lines require ROWs within which certain land uses (such as building a new permanent structure) are precluded and along which vegetation must be managed to prevent tall-growing trees within conductor zones. (Refer to Section 4 for information regarding overhead transmission line construction and ROW vegetation management procedures.)

Figure 11-1: Proposed Overhead Transmission Line Route and Route Alternatives



Taking these factors into account, Eversource gives primary consideration to the criteria listed in Table 11-2 when evaluating potential routes for a new overhead 115-kV transmission line. These overhead line routing criteria were applied to examine and compare alternative overhead line routes for the Project.

11.2.2 Alternative Overhead Line Routes Considered but Eliminated

In addition to the alignment of the new 115-kV transmission line within the existing ROW between Frost Bridge and Campville substations, Eversource identified and reviewed a number of overhead transmission line-route options. These included the development of the new 115-kV line on a new ROW and within or adjacent to existing linear corridors in the Project region, including State Routes 8, 848, 254, 807, 262, and 109; local roads; and the Naugatuck Railroad Company railroad corridor (which is leased from ConnDOT) along the Naugatuck River.

However, as summarized below, all of these potential alternative routes were eliminated from detailed consideration because they were found to be unsuitable for the development of a new transmission line due to factors such as engineering constraints, geographic location, lack of easements or property owned in fee, and/or potential for significant environmental, social, or economic effects.

11.2.2.1 New Rights-of-Way Alternative

This alternative would involve the development of the new overhead 115-kV transmission line between Frost Bridge Substation and Campville Substation along an entirely new ROW (referred to as a "greenfield" corridor) not adjacent to any other existing linear corridors. In the absence of any environmental, social, or engineering constraints, such a "greenfield" corridor could provide the shortest, straight-line alignment between the required substation interconnection points.

However, an entirely new corridor for the 115-kV overhead transmission line would have to be aligned to avoid both developed areas and constraints posed by topography. Assuming the use of a delta structure configuration (refer to Table 11-2), a minimum 90-foot-wide ROW width would be required. Even (unrealistically) assuming a minimum straight-line 8.8-mile distance between Frost Bridge Substation, this alternative route would require the acquisition of easements applicable to more than 96 acres of property for the new overhead transmission line.[97]

[97] Using a vertical (monopole structure) conductor configuration on the new 115-kV line would reduce the ROW width, but would require taller structures.

Table 11-2: Route Evaluation Criteria for 115-kV Overhead Transmission Line Siting

ROUTING CRITERIA	DESCRIPTION
Availability of Existing ROWs for the New Line to Follow	The potential co-location of the 115-kV transmission facilities along existing ROWs where linear uses are already established (e.g., transmission lines, highways, railroads, pipelines) is a primary routing consideration. The co-location of linear utilities within existing utility corridors is strongly favored by the Federal Energy Regulatory Commission's *Guidelines for the Protection of Natural, Historic, Scenic, and Recreational Values in the Design and Location of Rights-of-Way and Transmission Facilities*, with which any electric transmission line approved by the Council must be consistent.[98] **New ROW**. The ROW width required for an entirely new 115-kV overhead line route would vary depending on the type of transmission line structure, which affects the conductor clearance required from vegetation. Typically, a line with a delta configuration would require a minimum 90-foot-wide ROW, a line with a horizontal (H-frame) configuration would require a, 100-foot-wide ROW, and a line with a vertical configuration would require a 70-foot-wide ROW. **Existing ROW.** The placement of a new 115-kV transmission line within an existing corridor (parallel to existing transmission lines) may require a lesser expansion of an existing ROW or may not require any additional ROW at all, providing that the existing ROW is wide enough and has sufficient un-used space for the new 115-kV transmission line. Typically, to accommodate a new 115-kV delta transmission line adjacent to an existing H-frame or delta 115-kV transmission line, approximately 50 feet of additional ROW would be required. Aligning a new 115-kV H-frame adjacent to an H-Frame or delta 115-kV transmission line would require approximately additional 60 feet. A new vertically-configured 115-kV line, located adjacent to an existing 115-kV line, supported on H-frame or delta structures, would require only an additional 30 feet of ROW.
Engineering Considerations	Whether on existing or new ROWs, the terrain and location of the transmission line route and constructability issues must be considered since both may have a significant bearing on cost and effects on environmental resources. Among the constructability factors considered is the ability to avoid or minimize the location of structures along steep slopes or embankments, in areas of rock outcroppings, or within environmentally sensitive areas, such as wetlands. Engineering requirements for the transmission line and access roads (as necessary) to cross streams, railroads, and other facilities are also assessed. Terrain and access constraints (e.g., side slopes, rugged topography) due to extreme side slopes are assessed.
Avoidance or Minimization of Conflicts with Developed Areas	Where possible, it is preferable to avoid or minimize conflicts with residential, commercial, and industrial land uses such as homes, businesses, and airport approach zones. One of Eversource's primary routing objectives for any proposed transmission line is to minimize the need to acquire (by condemnation or voluntary sale) homes or commercial buildings to accommodate the new transmission facilities (refer to Table 11-1).
Consideration of Visual Effects	Because 115-kV transmission line structures range from 45 to 155 feet tall (depending on structure configuration), structure visibility is a design consideration. In recognition of public opinion regarding structure visibility, it is desirable to avoid placing structures in areas of visual or historic sensitivity; to consider designs for minimizing structure height; and to assess the potential visual effects of removing mature trees along ROWs, as required to conform to electrical clearance requirements (i.e., the potential implications of removing trees that provide vegetative screening). Vertical structures typically have the greatest visibility effects. However, structure visibility effects are incremental if new overhead lines are placed within existing ROWs along which overhead transmission lines are already part of the visual landscape.
Avoidance or Minimization of Environmental Resource Effects	In accordance with federal, state, and municipal environmental protection policies, the avoidance or minimization of new or expanded corridors through sensitive environmental resource or recreation areas such as parks, wildlife management areas, and wetlands is desired.
Accessibility	An overhead line must be accessible to both construction and maintenance equipment. Although access along the entire overhead line route is typically not needed, vehicular access to each structure location from some access point is required.

98 CGS Section 16-50p(a)(3)(D)

In addition to these easement acquisition issues, the development of the 115-kV transmission line along a "greenfield" corridor was determined to be impractical for environmental reasons. For instance, to construct the proposed 115-kV transmission line, the majority of the vegetation along the "greenfield" corridor would have to be removed and access roads would have to be created within the new ROW. Compared to the use of an existing ROW, the creation and maintenance of such a "greenfield" corridor can cause greater environmental impacts (e.g., permanent fill in wetlands due to new access roads and structures, development of a new linear corridor through undisturbed forested communities, crossings of water resources, and preclusion of certain other land uses within the corridor).

In addition, the creation of a new transmission line corridor, when existing ROWs are available and practical to use, does not conform to federal and state policies regarding the co-location of linear facilities, and likely would not conform to federal criteria (pursuant to the Clean Water Act) for selecting the "least environmentally damaging practical alternative" to avoid or minimize adverse effects to water resources and other environmental and cultural resource features. In general, the installation of new transmission line facilities along existing ROWs (e.g., transmission line ROWs, pipeline corridors, highways, railroads) is environmentally preferable to creating entirely new corridors through properties previously unaffected by linear developments.

Operation of the new 115-kV transmission line within a new ROW would require restrictions on property owners' land uses. Specifically, land uses within the ROW would be limited to those that are compatible with the transmission facilities and utility operation; buildings and other uses would be precluded. For an overhead transmission line, the ROW would have to be managed in low-growing vegetation, and access to the transmission line structures would typically be required.

Overall, the all-new ROW alternative was determined to be impractical based on existing land use, and environmental considerations and the ready availability of a viable alternative (i.e., the use of Eversource's existing ROW). The all-new ROW alternative would not conform to federal and state policies for the co-location of linear corridors to the extent practical and Eversource's acquisition of such easements from private property owners would be both costly and time-consuming.

11.2.2.2 Alternative Routes along Highway Rights-of-Way

This alternative would involve the development of the new 115-kV transmission line between Frost Bridge and Campville substations in overhead configurations within or adjacent to highway corridors, including State Route 8 (a limited access highway) and local roads. Key considerations in the review of this alternative were the locations of roads in relation to the existing two substations that must be interconnected, as well as construction feasibility and potential environmental resource and social effects.

State Route 8: Limited Access State Highway. State Route 8 was reviewed as a potential route for the new 115-kV line because, compared to most local roads, state highways typically have wider ROWs, including undeveloped areas outside of paved travel lanes, where land may be available to accommodate an overhead transmission line. This situation is particularly true of limited-access highways such as State Route 8.

Generally, in order to construct a new overhead, delta-configured, 115-kV transmission line, a 90-foot-wide ROW would be required.[99] Along state highways, if an agreement could be reached with ConnDOT to share the outer portion of a highway ROW with an aerial easement, the required new ROW width could be reduced.

However, longitudinal co-location of transmission lines in ConnDOT limited access highway corridors is not permitted except in special circumstances, as provided in ConnDOT's *Utility Accommodation Manual* (2009). On April 9, 2015, Eversource met with ConnDOT to discuss this policy, with respect to the potential for the co-location of new 115-kV transmission line(s) along state highways. ConnDOT representatives affirmed that the agency opposes the co-location of transmission lines in state road ROWs, particularly if other routing alternatives, such as the use of existing utility ROWs, are available.

In addition to ConnDOT's policy against the co-location of transmission lines within its highway ROWs, the State Route 8 corridor would pose particular challenges for the development of a new transmission line because of the steep topography, bedrock outcrops, and numerous water resources (including reservoirs) adjacent to the highway. Further, because portions of State Route 8 extend through suburban or urban areas, the development of the transmission line adjacent to the highway would be constrained by

[99] Other common configurations of an overhead 115-kV line use shorter structures, but would require a wider ROW (e.g., up to 150 feet). Existing highway easement widths vary. As a result, depending on the actual widths of a state highway corridor, an overhead transmission line could have to be located either within or adjacent to highway property.

residential, commercial, or industrial land uses. Wherever the transmission line ROW could not be located within the highway easement, new ROW would have to be acquired from private landowners. In addition, the linear alignment of an overhead transmission line along State Route 8, would be highly visible, affecting the aesthetic environment.

- **Local Road and Other State Highway ROWs.** The alignment of the new 115-kV transmission line within or adjacent to local road ROWs or other state highways (not limited access, typically two-lane) poses similar constraints. For example, the primary determinant of construction feasibility was adequate space for a new overhead 115-kV transmission line ROW without having to displace homes or businesses located adjacent to the highway.

The development and operation of a new overhead transmission line adjacent to either two-lane state highways or local road ROWs also would affect the aesthetic environment because the new transmission line would be visible both to travelers on the highways and to local residents and business patrons. Additionally, while overhead electric distribution lines and telephone lines can be configured to follow winding roads, high voltage transmission lines are designed for mostly straight-line, longer-span construction. As a result, the design and construction of a new 115-kV transmission line adjacent to these roads would be both technically difficult and costly, and would result in potentially significant land use and environmental impacts (e.g., as a result of the removal of vegetation adjacent to road ROWs to achieve mandated conductor clearances, possible need to acquire new utility easements from private landowners, depending on the width of the road ROWs). Further, compared to structure heights along a typical transmission line ROW, the transmission line structures along a local road ROW would likely have to be taller to maintain conductor clearances over the distribution and telephone lines that are presently aligned along the roads.

Summary. Overall, Eversource dismissed all of the highway route alternatives from further consideration as potential overhead transmission line routes for the Project due to inconsistency with ConnDOT policies; significant construction difficulties and constraints; and the unacceptable social effects associated with the need to remove homes and businesses where a new ROW could not be located within the highway corridor. The complexity of construction, the need to follow road ROWs that do not provide direct routes between the substations that must be interconnected, and the amount of land acquisition required also would result in comparatively higher costs than would the development of an overhead line within the unused portions of Eversource's existing transmission line ROW that already extends directly between Frost Bridge and Campville substations.

11.2.2.3 Alternative Route along Railroad Rights-of-Way

Within the Project region, the only railroad corridor in the vicinity of Frost Bridge and Campville Substations is aligned adjacent to the Naugatuck River. ConnDOT owns this railroad track, which in the Project area, extends from Waterbury to Torrington. ConnDOT leases the portion of the track between Waterbury (Waterville area) and Thomaston to the Railroad Museum of New England (RMNE), a not-for-profit educational and historical organization based in Thomaston. The RMNE operates the Naugatuck Railroad as a heritage railway, using historic train equipment and offering excursions for recreational / scenic purposes within the Naugatuck River valley. The RMNE trains operate between Thomaston Railroad Station to Waterbury, from April through December.

Portions of the railroad corridor are also being investigated as part of a greenway trail system along the Naugatuck River. In addition, the train tracks extend through densely populated portions of Thomaston and other towns, and are adjacent to the Naugatuck River. Further, the train tracks traverse beneath Reynolds Bridge, an open-span concrete arch bridge constructed over the Naugatuck River in 1928; this bridge is listed on the NRHP because it was the longest bridge of its kind built by the then-Connecticut State Highway Department.

Given the current use of the Thomaston-Waterbury portion of railroad corridor for scenic excursions, the presence of the NRHP-listed Reynolds Bridge, and the land use developments adjacent to the railroad corridor in Thomaston and elsewhere, the alignment of a new overhead 115-kV transmission line along the ConnDOT / Naugatuck Railroad ROW was quickly determined to be impractical based on overriding environmental, social, constructability, and cost considerations.

11.2.2.4 Alternative Routes along Other Transmission Line Rights-of-Way

Eversource reviewed its existing transmission line ROWs in the vicinity of Frost Bridge Substation and Campville Substation to assess whether the new 115-kV line could practically be constructed within ROWs other than the Proposed Route (which extends west and then north-northeast between the two substations). Three other ROWs (occupied by 115- and 345-kV lines) extend into Frost Bridge Substation from the south, southeast, and east. However, none of these ROWs, individually or in combination, extend north toward Campville Substation, which is presently interconnected to only one existing ROW from the south (i.e., the Proposed Route) and one 115-kV ROW that extends out of the substation to the north. Consequently, the use of any other transmission line ROWs for the new 115-kV line was determined to be infeasible.

11.3 UNDERGROUND TRANSMISSION LINE-ROUTE ALTERNATIVES

The vast majority of transmission lines in Connecticut and in the United States consist of overhead lines. However, underground transmission cable systems, consisting of both buried electric cables and splice chambers[100] (or "splice vaults", which are required at specified intervals along a cable route), may warrant consideration when overhead lines are impractical due to site-specific environmental, social, construction, or regulatory factors, and in the rare case where there is not a large cost difference between overhead and underground alternatives.[101] Within the past 12 years, Eversource has sited and installed underground transmission cable systems in Connecticut as part of the Bethel-Norwalk Project (345-kV and 115-kV transmission cables), Middletown-Norwalk Project (345-kV and 115-kV transmission cables), the Glenbrook Cables Project (115-kV transmission cables), and the Stamford Cables Project (115-kV transmission cables). As a result, Eversource has extensive, recent experience in underground transmission cable routing, construction, and cost analysis.

11.3.1 Cable Technology Considerations and Route Evaluation Criteria

Underground cable systems and overhead transmission lines represent different technologies for transporting power. In a given system application, one of these line types may not be practical to use, given specific project considerations such as the length of the transmission line to be installed, terrain, availability of ROWs, urbanization, etc. In addition, there are many technical issues with respect to the installation of underground cables in a predominantly overhead system, such that extensive technical studies by power-system engineers may be required to determine the feasibility of a particular underground installation. In this case, power system studies that would be required to analyze the performance and possible technical limitations of an underground system were not performed. Rather, the practicality of the identified underground alternative was assumed for the purpose of further economic and routing analysis.

11.3.1.1 Selection of Underground Transmission Cable Technology

There are two distinct types of 115-kV underground cables that are in common use in the Eversource transmission system: High Pressure Fluid Filled (HPFF) and XLPE (which is the type of cable planned

[100] Appendix 11A describes the components of a 115-kV cable system, as well as cable system construction procedures.

[101] The typical costs for constructing an underground 115-kV transmission cable system are five to ten times greater than those for installing an equivalent length of overhead 115-kV transmission line within an existing transmission line ROW. Cost considerations are discussed separately in Section 11.3.1.4.

for the 0.1-mile segment of the Proposed Route exiting the Frost Bridge Substation). The principal characteristics of each of these technologies are:

- **HPFF.** HPFF cable was traditionally the primary underground technology used for 115-kV underground transmission lines in the United States. Three individual cables, called cores, are used to form a circuit. The cores are encased in a steel pipe that is filled with insulating fluid and then pressurized to a nominal 200 pounds per square inch (psi), which requires pressurization plants and reservoirs. These reservoirs hold thousands of gallons of insulating fluid.
- **XLPE**. XLPE cables are the newer technology. Here again, three single cores are necessary to form a circuit. However, they are installed separately, often within individual ducts, usually made from a plastic material. Each XLPE core is surrounded with a solid insulating material rather than fluid, and the insulating material is protected by a water-impervious sheath. No insulating fluid is involved.

HPFF and XLPE cables are both reliable at 115-kV, but each has different features and requirements that are considered in choosing between them when either is suitable for a given application.

For example, HPFF cables can be provided in longer lengths, such that fewer splice vaults and cable splices are necessary, resulting in lower construction costs compared to XLPE cables. HPFF cable systems also have the ability to circulate the dielectric fluid to smooth out (mitigate) hot spots along the cable route, effectively increasing the circuit capacity. This provides an advantage over XLPE cable systems when the cable system is aligned parallel to existing heat sources (i.e., existing distribution circuits near substations, capable of de-rating the circuit). In addition, for many applications, the cost of HPFF cables will be lower.

However, the fluid system within HPFF cable systems requires more maintenance and planned outages than XLPE cable systems. In addition, HPFF cables have higher electrical losses, lower capacity for equivalent size conductors, and much higher capacitive charging requirements. Further, over rugged terrain with variable topography, such as characterizes the Project area, the ability to maintain the required pressure in the HPFF cable system would be difficult.

Based on the capacity required for the Frost Bridge to Campville solution and Eversource’s experience on recent underground cable projects, XLPE cable was selected as the preferred cable technology for the underground route analyses for the Project.

11.3.1.2 Route Evaluation Criteria

Compared to overhead transmission lines, an underground cable system requires a narrower ROW. However, an underground cable system entails a continuous trench and the installation of underground splice vaults, both of which must remain completely accessible by large vehicles for utility maintenance purposes. Environmentally sensitive areas, such as wetlands and streams, cannot be spanned as with overhead lines. Careful siting is required to avoid or minimize significant effects to environmental resources and other utilities as a result of trenching activities, as well as to ensure that the cable system is immediately accessible in the event that maintenance is required during the operation of the facility.

When performing analyses of potential underground cable-system routes, Eversource typically applies a set of standard routing criteria, reflecting the consideration of environmental, social, construction, engineering, and economic factors. Given typical cable-system design, installation, and maintenance considerations, the criteria summarized in Table 11-3 are factored into the identification and evaluation of potential underground cable-system route alternatives. Cost, as described separately in the following section, also is a critical factor in the consideration of underground cable systems.

Table 11-3: Route Evaluation Criteria for Underground 115-kV Transmission Cable-System Siting

ROUTING CRITERIA	DESCRIPTION
Environmental Considerations	Underground cables are preferably sited away from, rather than through, significant environmental resources. Whereas an overhead transmission line can span wetlands, watercourses, vegetation, rock outcroppings and, steep slopes, the installation of an underground cable system requires the excavation of a continuous trench. The operation of the cable system requires continuous permanent access along the entire route so that any splice vault or portion of the cable duct bank can be reached by heavy equipment as necessary for maintenance and repairs. Therefore, any sensitive environmental resources (such as watercourses, wetlands, or endangered species habitat) located along an underground cable route may be directly affected by the excavations required for the cable system. To mitigate such impacts, the cables can be installed, for relatively short distances, beneath these resources using subsurface construction technology, such as jack and bore or horizontal directional drilling, but at great expense. Existing public road corridors are usually considered for the installation of underground cables in preference to overland electric transmission line ROWs. Road corridors typically provide continuous permanent access along the underground cable route and often are characterized by gradual slopes. However, when sited in or adjacent to roadways, underground cables must avoid conflicts with existing underground utilities. Furthermore, alignment of underground cables along road ROWs may pose other potential environmental issues, such as excavation through areas of contaminated groundwater or soils; traffic congestion; difficult crossings of watercourses and wetlands that the roads traverse or bridge; and disturbance to vegetation and land uses adjacent to the roads (due to construction staging, heavy equipment operation, etc.).
Engineering Considerations	Steep terrain poses serious problems for underground cable construction and may cause down-hill migration and overstressing of the cable and cable splices (the point where two cables are physically connected together). Accordingly, one of the primary engineering objectives for an underground cable system is to identify routes that are relatively straight, direct, and have gradual slopes and inclines to minimize construction and maintenance costs, and to avoid downhill cable migration.
Availability of Useable ROW	A new 115-kV underground XLPE cable system typically requires a minimum 30-to-40-foot-wide work area for construction. Additionally, land must be available for burying splice vaults, each of which is approximately 9 feet wide by 9 feet deep and up to 24 feet in length. The installation of each vault would typically require an excavation of 13 feet wide, 13 feet deep, and 30 feet in length. Such vaults, which must be placed at approximately 1,600-to-2000 foot intervals along a 115-kV cable route, are required to allow the individual cable lengths to be spliced together and also must be accessible, via manholes, for cable-system maintenance and repair. Due to constraints posed by buried utilities within road travel lanes or conflicts with public highway use policies, vaults must sometimes be located beneath road shoulders or on private lands adjacent to public road corridors.
Social Considerations	Cable construction requires considerable time and results in noise, disruptions to traffic and impediments to access to adjacent land uses, and potential conflicts with existing in-ground utilities. Consequently, where possible, a routing consideration is to limit the length of cable installation through densely developed residential areas and central business districts. These social effects must be carefully considered and balanced against the potential lesser effects of constructing and operating overhead line segments in comparable areas.

11.3.1.4 Cost

Cost is a key consideration in the evaluation of underground cable technology versus overhead technology. As noted previously, the typical costs for constructing an underground 115-kV transmission cable system are five to ten times greater than those for installing an equivalent length of overhead 115-kV transmission line on an existing ROW.

In addition, except where underground cable routes can be aligned entirely within highway ROWs, on Eversource property, and/orwithin existing Eversource ROWs where Eversource's easements include underground cable rights, Eversource would have to acquire new easement rights from private landowners for the installation and operation of the cable system. Along state highway ROWs, ConnDOT policy requires the locations of splice vaults outside of the highway ROW; as a result, for any cable systems aligned along state roads, easements from private landowners would be required to accommodate the splice vaults and the interconnecting portions of the duct bank.

As a result, where existing ROWs have sufficient space to accommodate a new overhead transmission line or can be expanded for comparatively low cost, the capital costs of building the overhead transmission line are significantly less than the costs of building a comparable underground 115-kV cable system.

The difference in the cost to Connecticut consumers for a 115-kV underground cable system, compared to an overhead line, is even greater because of federal tariff provisions. Because this Project is expected to qualify for inclusion in New England regional transmission rates, the Project costs would be shared by consumers throughout New England, based on each electric transmission company's share of the regional electric load. Connecticut accounts for approximately 25% of the New England load; therefore, Connecticut consumers would bear approximately 25% of the Project cost included in regional rates.

Recovery of Project costs through regional rates, however, is not automatic. Only costs determined by ISO-NE to be eligible for regionalization according to specific tariff provisions would be included in regional rates. Experience has shown that where a transmission line (or a line segment) that would normally be constructed overhead, in conformity with good utility practice, is instead constructed underground, ISO-NE typically does not allow the extra costs of underground line construction to be included in regional rates. Instead, such extra costs are "localized" and must be recovered solely from consumers in the area in which the underground system is situated.

In Connecticut, the effect of localizing excess underground cable costs is that in-state consumers would bear approximately 25% of the cost of an overhead line (or segment), plus 100% of the difference between that cost and the cost of an underground cable system. For example, if Eversource were to build an all-underground line that cost 10 times more than a comparable overhead line (constructed in accordance with standard good utility practice), the cost to Connecticut consumers for the underground cable system could be 37 times more than that of the overhead line [(1 x 25%) + (9 x 100%)] = (9.25 ÷ 0.25) = 37.0

11.3.2 Construction Considerations and Procedures

Underground cable-system construction requires vastly different procedures and considerations than overhead transmission line construction. Such systems are most often located within or adjacent to public roads, which provide both a linear corridor for the cable route and roadway access along the entire cable system for construction and maintenance. Appendix 11A describes the construction procedures that would typically be used to install an underground XLPE 115-kV transmission cable system[102]. The appendix includes the following information:

- The typical construction activities and sequence for underground cable-system installation within or adjacent to road ROWs;
- The different construction procedures that would be required to develop a cable system outside of road ROWs (e.g., along transmission line ROWs or along a "greenfield" utility corridor);
- The typical requirements for equipment staging areas, as well as the dimensions for cable trenches and splice vaults; and
- Data regarding specific underground cable construction considerations (e.g., splice vault locations, erosion controls, traffic management).

11.3.3 Alternative Underground Line Routes Considered but Eliminated

Although overhead circuits are the most efficient and reliable method for delivering power over long distances, Eversource identified and reviewed, using the routing objectives, technology considerations, and evaluation criteria described in Sections11.2.1 and 11.3.1, respectively, several underground cable-route alternatives to interconnect Frost Bridge Substation and Campville Substation. As summarized in this section, after considering constructability, cost, and environmental factors, most of the "all-

[102] Section 4.2 describes underground cable construction procedures as applicable to the short (0.1-mile) segment of XLPE cable that will be installed within and adjacent to Frost Bridge Substation. Appendix 11A provides additional information regarding construction procedures for longer cable systems, which are typically aligned within road ROWs, but may also be situated in greenfield areas or within other types of ROWs.

underground" cable-system options initially identified were quickly eliminated from further consideration due to significant cost, constructability, and environmental issues. The underground routes considered but eliminated from further consideration included cable system alignments along State Route 8, along the Naugatuck Railroad, and within Eversource's existing transmission line ROW between Frost Bridge and Campville substations (refer to Sections 11.3.3.1 through 11.3.3.4).

In addition to these potential underground cable routes that were quickly eliminated from consideration, Eversource identified and further reviewed two routes between Frost Bridge and Campville substations: (1) an "all underground" cable system along state and local roads; and (2) a variation of the "all-underground" route, which also would include a segment of overhead line within Eversource's existing ROW between Campville Road (Town of Litchfield) and the Campville Substation. For these two route alternatives, which are described in Sections 11.3.3.5 and 11.3.3.6, Eversource conducted additional studies and estimated the life-cycle costs compared to that of the overhead 115-kV transmission line proposed for the Project.

Eversource determined that the development of the new 115-kV line using a cable system installed along either of these underground line routes would be less reliable than the proposed overhead 115-kV transmission line, would be significantly more costly (by an order of magnitude, with high costs to Connecticut consumers), and would pose environmental and engineering issues. Further, either route alternative would add an estimated six to 12 months to the construction period, thereby extending construction impacts, increasing costs, and delaying energization of the Project.

11.3.3.1 New Rights-of-Way Alternative

Similar to the discussion in Section 11.2.2.1 of a new ROW alternative for an overhead transmission line, this alternative would involve the construction and operation of a new 115-kV underground cable system between Frost Bridge Substation and Campville Substation along a "greenfield" corridor, not within or adjacent to any existing roads or other linear corridors. As was the case for the corresponding overhead transmission line "greenfield" ROW alternative, Eversource's initial review determined that this underground line-route option would not conform to regulatory guidelines for the co-location of linear corridors to the extent practical, would result in comparatively significant, unavoidable environmental impacts, and would not be cost-effective. As a result, Eversource eliminated this option from any further consideration. The following briefly reviews the key constraints to any underground "greenfield" route.

To develop a "greenfield" corridor, for a new cross-country (non-street) underground transmission cable system, Eversource would first have to acquire new easements from private property owners along the entire length of the route. A minimum easement width of 40 feet would be required.[103] This property acquisition process would be both costly and time-consuming.

Moreover, the development of the 115-kV underground cable system along a "greenfield" corridor would be considerably more costly and result in significantly greater environmental effects than other potential route alternatives. To install the cable system, all of the vegetation along the "greenfield" corridor would have to be cleared and the entire corridor would have to be graded to create work space for construction equipment, access roads, and for the excavation of the cable duct bank and splice vaults. Given the rugged terrain and bedrock in the Project region, extensive grading (and likely blasting), representing permanent topographic changes, would be required to install the continuous trench for the cables and to excavate the splice vaults.

The continuous trenching needed for the duct bank would result in adverse effects to wetlands and watercourses as a direct result of filling (i.e., installing the duct bank and surrounding the conduits with FTB). In addition, permanent access roads would be required along the ROW to access splice vaults for maintenance. The cable system would have to be installed beneath watercourses using either conventional trenching (which would result in direct disturbance to the stream beds and water quality impacts) or more costly subsurface installation methods (e.g., jack and bore, horizontal directional drilling [HDD]) that would minimize direct impacts to the stream beds.

The development of the cable system along a "greenfield" corridor also would require the conversion of previously undisturbed forested wetland habitats to scrub-shrub communities, development of a new ROW through upland forest, preclusion of certain land uses within the corridor, and potential direct disturbance to archaeological sites. For the operation of the underground cable system, permanent access roads would have to be maintained along most of the length of the ROW in order to maintain access to all splice vaults, and other (non-access road) portions of the ROW would have to be managed in low-growing vegetation.

[103] This easement would be required for the construction and subsequent operation and maintenance of the cable system. Additional easements would be required for property on which splice vaults would be located.

11.3.3.2 Alternative Underground Route along Existing Railroad Rights-of-Way

Eversource determined that the alignment of a cable transmission system along the ConnDOT / Naugatuck Railroad corridor would be impractical for the same general reasons as described for the routing of an overhead 115-kV transmission line (refer to Section 11.2.2.2).

11.3.3.3 Alternative Underground Route along Existing Transmission Line Right-of-Way

At first glance, aligning an underground cable system within Eversource's existing ROW between Frost Bridge and Campville substation appears to offer some advantages, in terms of not only co-locating the underground and overhead transmission lines within the same corridor, but also avoiding underground cable construction conflicts with other buried utility lines and the potential for traffic congestion and similar public nuisance issues that are caused by underground cable-system construction within or adjacent to public roads. Compared to an in-road cable system, underground cable construction within an existing transmission line ROW is usually less expensive and typically has the following advantages:

- Duct banks and splice vaults can be installed at uniform depths because buried utilities are only encountered at road crossings;
- No special construction design and scheduling is required to maintain traffic flow patterns or to avoid construction conflicts with adjacent land uses; and
- Construction does not require road pavement removal or replacement.

In addition, because the existing transmission line ROW already extends between the Frost Bridge and Campville substations, it would provide the most direct (shortest) route between these two terminal points. In contrast, an underground cable system following road ROWs must follow more circuitous, and longer, routes between the two substations, and therefore are more expensive to construct and operate.

However, aligning an underground cable system within Eversource's existing overhead transmission line ROW between Frost Bridge and Campville substations is not feasible due to the extreme terrain (extensive bedrock outcrops, shallow depth to bedrock, steep slopes, and continuous access constraints) and water resources that would have to be crossed. These areas would pose difficult, if not insurmountable, obstacles in terms of underground cable-system construction.

Environmental impacts would result from the continuous trenching required for the duct banks along the ROW, the excavations for splice vaults, and the use of construction support areas along the ROW, such as material staging sites and crane pads for the vault installations. Assuming the placement of splice vaults at intervals of approximately 1,600 feet, an estimated 35 vault locations would be required for the installation of an underground cable system along the 10.4-mile ROW between Frost Bridge Substation and Campville Substation.

The construction of the duct bank would involve not only continuous trenching, but also the use of an estimated 40-foot-wide construction work space along the length of the ROWs. Within this construction work space, all vegetation would have to be removed, grading and filling would have to be performed as necessary, and a construction access road must be developed. Overall, based on the minimum use of a 40-foot-wide work space along the 10.4-mile route, cable-system construction would directly affect a minimum of approximately 50 acres; some of this acreage is already managed in low growth vegetation for compatibility with the existing overhead transmission lines in the corridor. Additional land would be affected by splice vaults and the temporary equipment and material staging sites.

In addition, a permanent, typically 20-foot-wide access road would typically be required along the cable route. Some of Eversource's existing on-ROW access roads could likely be used. However, all of these roads would likely have to be improved to provide a permanent, contiguous road adjacent to the cable system. The access road would traverse wetlands along the ROWs, where the permanent fill would constitute a long-term loss of wetland habitat.

Furthermore, Eversource's easements for overhead transmission lines along the ROW do not uniformly encompass the use of the ROW for underground cable installation. In these cases, Eversource would have to purchase additional easement rights for the development of an underground cable system from private landowners.

For these and cost reasons, the development of an underground 115-kV cable system within Eversource's ROW was determined to be impractical.

11.3.3.4 Alternative Routes along Highway Rights-of-Way

Eversource investigated possible cable-system alignments along various road ROWs in the Project area. In-road alignments for underground cable systems usually offer environmental advantages, particularly if the underground cable construction can be confined principally to paved or previously disturbed portions of the road ROWs. As a result, compared to underground line construction in overhead transmission line ROWs, in-road cable-system construction would typically affect fewer environmental resources (e.g., forested areas, wetlands) and fewer cultural resources.

To install the underground cable system within road ROWs, an approximately 40-foot-wide working area would be required adjacent to or within the existing highway travel lanes. The exact location of the cable system would depend on agreements with ConnDOT (for state highways) or local highway authorities. Eversource's recent 345-kV and 115-kV underground cable systems have been installed primarily along non-limited access state road ROWs. An encroachment agreement must be negotiated between Eversource and ConnDOT for the use of the road ROWs. For the most part, although the cable duct banks may be aligned beneath the highway pavement, ConnDOT does not permit the location of splice vaults within paved road ROWs. As a result, Eversource typically must obtain easements for splice vaults and the associated cable-duct-bank interconnections from private landowners.

If the underground cable system could not be installed within public road ROWs, the availability of land for a transmission line easement, without having to displace homes or businesses located adjacent to the highways, would be a major concern. Furthermore, the costs and schedule of acquiring easements for the cable system from private landowners would be significant.

Key construction, engineering, maintenance, and environmental issues related to the identification and evaluation of potentially viable routes for an underground cable system within or adjacent to public road ROWs in the Project region included:

- Presence of road embankments and elevated portions of road ROWs, which would make cable-system excavations difficult.
- Presence of areas of rock, where excavation would potentially require highway closures for blasting.
- Location of wetlands and waterways adjacent to or crossed by the road ROWs, beneath which the underground cable system would have to be buried.
- Construction and future maintenance activities causing traffic delays and congestion.
- ConnDOT policy of not allowing co-location of transmission lines within and parallel to the ROWs of limited access highways.
- Taking these factors into consideration, an alignment of an underground cable system within or adjacent to State Route 8 was quickly eliminated from consideration due to insurmountable cost, constructability, and environmental constraints. The two potential routes involving underground cable systems that Eversource evaluated in greater detail are illustrated on Figure 11-1 and discussed in Sections 11.3.3.5 and 11.3.3.6.

11.3.3.5 Road Rights-of-Way Underground Alternative Route

Eversource assessed the alignment of the new 115-kV transmission line, as an underground cable system, along various road ROWs. Roads were investigated for the potential cable system, taking into consideration the objectives of minimizing the overall length of the route, avoiding or minimizing adverse environmental and social effects; and minimizing cable-system costs.[104] Accordingly, Eversource identified an 11.2-mile route that would use a combination of state and local road ROWs to optimize the alignment of the cable system (refer to Figure 11-1 and to Table 11-4, which identifies the public road ROWs along which the route would be aligned).[105]

Table 11-4: Summary of ROWs along Road ROWs Underground Alternative Route

Existing ROW Followed by Underground Route	Distance (miles)*	Town
Frost Bridge Substation to Campville Substation		
OVERHEAD TRANSMISSION SEGMENT		
Frost Bridge Substation (Overhead tap across the Naugatuck River)**	0.2	Watertown/Thomaston
UNDERGROUND CABLE SYSTEM		
Waterbury Road (State Routes 262, 848, and 254)	3.8	Thomaston
Waterbury Road (State Hwy 254)	0.2	Thomaston
South Main Street (State Routes 254 and 807)	1.0	Thomaston
Clay Street	0.6	Thomaston
High Street Extension	1.3	Thomaston
Campville Road	2.6	Litchfield
Northfield Road	0.2	Litchfield/Harwinton
Valley Road	0.1	Harwinton
Campville Hill Road	1.0	Harwinton
Wildcat Hill Road	0.1	Harwinton
Campville Substation (Access Road)	0.1	Harwinton
TOTAL	**11.2**	

** Near existing overhead ROW
* Mileage estimates rounded to nearest tenth.

[104] Note: Any underground 115-kV cable system for the Project would be significantly more costly than an overhead 115-kV line. Consequently, the goal in the underground cable-route alternatives evaluation was to identify the most potentially desirable underground cable alignment - that is, the route that would minimize the costs and environmental and social effects compared to other cable routing options.

[105] The use of this underground route alternative would avoid the alignment of a new 115-kV transmission line along Eversource's existing ROW; however, as part of the Project, the 1191 and 1291 Line circuits would still be separated along the Eversource ROW at the Naugatuck River crossing. This work would require construction activities along the Eversource ROW from approximately State Route 8 in the Town of Litchfield northeast to the Valley Road area in the Town of Harwinton.

Along approximately 11 miles of the route, the new 115-kV line would be configured as an underground cable system; the remaining 0.2-mile segment of the route, extending east from Frost Bridge Substation, would be aligned overhead across the Naugatuck River, before transitioning to underground cable.

The alternative route was selected to maximize, to the extent possible, conformance to Eversource's routing objectives and underground cable-system routing criteria. For example, as illustrated in Figure 11-1 and summarized in Table 11-4, the Road ROWs Underground Alternative Route would follow both state and local roads.

The development of the cable system along the highway ROWs would involve the land requirements and construction procedures detailed in Section 11.3.2. If the underground transmission line could not be installed within the road ROWs (due to conflict with ConnDOT policy, etc.), the availability of adjacent land for the installation and operation of the cable system, without having to displace homes or businesses located adjacent to the highways, would be a major concern. Furthermore, the costs and schedule impacts of acquiring easements from private landowners would be significant. Table 11-5 summarizes the key characteristics of the combined underground line-route.

Table 11-5: Summary of Key Features: Road ROWs Underground Alternative Route

Characteristic	Description
ROW / Land	**(Miles)**
Underground Within or Adjacent to Road ROWs	10.9 miles
Underground Within Eversource Property	0.1 mile
Overhead Within Eversource Property or ROW	0.1 mile
Overhead Within New ROW	0.1 mile
Total	**11.2**
Towns Traversed by Route	**(Miles)**
Watertown	0.1
Thomaston	6.9
Litchfield	2.8
Harwinton	1.4
Highway Characteristics	**% along each lane type**
Two-lane State Roads (State Hwys 848, 254 and 807)	45%
Two-lane Local Roads (Clay Street, High Street Ext, Campville Road, Northfield Road, Valley Road, Campville Hill Road, and Wildcat Hill Road)	55%
Adjacent Land Use	**(Percent of Total Route)**
Residential	44%
Commercial	10%
Public	10%
Forested	19%
Undeveloped (Open Land)	4%
Industrial	13%
Total	100%
Watercourse Crossings	**(Number)**
Major crossings (Naugatuck River)	3
100-year floodplain crossings (Naugatuck River)	4,450 linear feet
Wetlands Crossed*	**(Number)**
Underground Portion along Road ROWs	12
Overhead Portion adjacent to Transmission line ROW	1
Railroad Crossings	**(Number)**
ConnDOT and Naugatuck Railroad Company	3

*Wetland crossings identified based on the review of publically available GIS data, typically underestimates wetland resources.

The cable system would have to be installed across all of the watercourses using methods such as a bridge attachment (if the bridges have the design capacity to handle the weight of the cable system and if ConnDOT permits the attachment) or a trenchless crossing method (jack and bore, HDD). In addition, the cable system would have to also need to be installed beneath State Route 8 and railroads using HDD or horizontal bores. The installation of the cable system beneath watercourses, roads, and railroads would also require substantial staging areas, typically on private property, on either side of the crossing in order to position construction equipment and materials.

Except for the isolated crossings where trenchless technologies (such as HDD or jack and bore) could be used, the cable-system installation would require continuous excavations for the duct banks, as well as excavations for the splice vaults. As described previously, ConnDOT would likely require that splice vaults be located outside of state road ROWs, which would require the acquisition of easements from private property owners and land disturbance on such private property. Furthermore, where the cable system could be installed within the paved portions of the road ROWs, lane closures (resulting in traffic delays), trench dewatering (where groundwater is encountered), and trimming of trees overhanging or adjacent to the ROWs, would be required.

The majority of the road ROWs along which the route would be located were selected because they are generally wide enough to accommodate the construction of a cable system, using lane closures, rather than full road closures. However, these roads also represent important components of the regional highway system. As a result, they generally traverse more developed areas and, in some locations, residential, commercial, and industrial uses about the road ROWs. Such land uses would be affected in areas where the construction or alignment of the cable system would have to occur on private property (e.g., at splice-vault locations, or areas where in-street buried utilities leave no space for the cable system).

Although the road ROW route reflects the optimal “all-underground” cable system between Frost Bridge and Campville substations, this alternative is not a practical, cost-effective, or environmentally-sound solution for meeting the Project objectives. Compared to an overhead transmission line configuration along the existing Eversource ROW, the use of the cable system along the road ROW route would be significantly more expensive and would require substantially more time to construct, delaying the Project’s scheduled energization by at least one year.

As explained in Section 11.3.1.3, most of the costs of constructing an overhead transmission line are expected to be shared with the rest of New England. However, the significantly higher costs of building the same line underground would be expected to be recovered from Connecticut consumers alone and that incremental increased cost would be dramatically higher than that of an overhead line.

As previously stated, the estimated capital cost for the construction of the new 115-kV transmission line overhead is approximately $51 million[106]. In comparison, the estimated initial cost for the road ROW underground alternative is estimated at approximately $328 million. Similarly, the life-cycle cost, which reflects the estimated capital cost and the anticipated maintenance costs of a project over its anticipated useful life, also would be substantially greater for the underground cable system along the road ROW route alternative than for an all-overhead 115-kV transmission line, installed along Eversource's ROW. Specifically, the life-cycle cost for the proposed overhead transmission lines is estimated to be approximately $76 million. For all-underground transmission lines, the life-cycle cost is estimated to be approximately $540 million.

In sum, although identified to minimize, to the extent possible, the effects typically associated with cable-system construction and operation, the road ROW route alternative between the Frost Bridge and Campville substations nonetheless does not represent a practical, cost-effective, or environmentally-sound solution for meeting the Project objectives. Construction of the alternative would be prohibitively costly, would require more time to construct, would disrupt local traffic patterns, would result in potential environmental impacts associated with major watercourse crossings and land use/soil disturbance adjacent to roads, and would be more difficult to operate within the system than a comparable overhead line. For these reasons, this alternative route was eliminated from further consideration as a viable option.

[106] Note: All cost estimates include the approximately $5.5 million for separating the two existing 115-kV circuits in the Naugatuck River crossing vicinity.

11.3.3.6 Overhead Variation to Portion of Road Rights-of-Way Underground Alternative Route

Eversource assessed the combination of both highway and transmission line ROWs to achieve the objectives of minimizing the overall length of the route, avoiding or minimizing adverse environmental effects, and minimizing impacts to the community and cable-system costs.[107] Accordingly, Eversource identified an approximately 9.8-mile route that would consist of:

- The same combination of ROWs (including an underground cable system along approximately 7.8 miles of road ROWs in the towns of Watertown, Thomaston, and Litchfield and the 0.2-mile overhead segment extending east from Frost Bridge Substation[108]) as described for the "all underground" cable system in Section 11.3.3.5; and
- An approximately 1.8-mile segment of Eversource's existing ROW between Campville Road (Town of Litchfield) and Campville Substation, along which the route would be aligned in an overhead configuration.

As illustrated in Figure 11-1, this route variation would diverge from the Road ROWs Underground Alternative Route at the intersection of Eversource's existing ROW and Campville Road in the Town of Litchfield. At this point, the 115-kV line would transition from underground to overhead, following Eversource's existing ROW northeast to the Campville Substation. The configuration of the overhead line segment would be as shown on XS-4 through XS-6 for the proposed Project (refer to Volume 1, Section 3).[109]

Table 11-6 summarizes and compares the key features of this variation compared to the portion of the "all underground" cable route that it would replace. The combined underground / overhead route would have the same issues as described in Section 11.3.3.5 and would be significantly more costly than an overhead line built along Eversource's existing ROW.

As previously stated, the estimated cost for the construction of the new 115-kV transmission line overhead is approximately $51 million. In comparison, the estimated cost for the Road ROW underground alternative would be approximately $264 million. Similarly, the life-cycle cost, which

[107] Note: Any underground 115-kV cable system for the Project would be significantly more costly than an overhead 115-kV line. Consequently, the goal in the underground cable-route alternatives evaluation was to identify the most potentially desirable underground cable alignment - that is, the route that would minimize the costs and environmental and social effects compared to other cable routing options.

[108] The 0.2-mile overhead segment would extend east from Frost Bridge Substation, crossing the Naugatuck River, before transitioning to an underground cable configuration.

[109] Using this route alternative, the construction activities to separate the 1191 and 1291 circuits at the Naugatuck River crossing would be combined with the new 115-kV overhead transmission line work along Eversource's ROW.

reflects the estimated capital cost and the anticipated maintenance costs of a project over its anticipated useful life, also would be substantially greater for the underground cable system along the road ROWs route alternative than for an all-overhead 115-kV transmission line, installed along Eversource's ROW. Specifically, the life-cycle cost for the proposed overhead transmission lines is estimated to be approximately $76 million. For all-underground transmission lines, the life-cycle cost is estimated to be approximately $432 million.

Table 11-6: Comparative Summary of Key Features: Road ROWs Underground Alternative with and without the Litchfield-Harwinton Overhead Variation

Characteristic	Description	
	All Underground Road ROW Route Alternative	**Combined Road ROW Route Alternative with Overhead Variation**
ROW / Land	**(Miles)**	**(Miles)**
Underground Within or Adjacent to Road ROWs	10.9 miles	7.7 miles
Underground Within Eversource Property	0.1 mile	0.1 mile
Overhead Within Eversource Property or ROW	0.1 mile	1.9 miles
Overhead Within New ROW	0.1 mile	0.1 mile
Total	**11.2 miles**	**9.8 miles**
Towns Traversed by Route	**(Miles)**	**(Miles)**
Watertown	0.1	0.1
Thomaston	6.9	6.9
Litchfield	2.8	1.6
Harwinton	1.4	1.2
Highway Characteristics	**% along each lane type**	**% along each lane type**
Two-lane State Roads (State Routes 262, 848, 254 and 807)	45%	35%
Two-lane Local Roads (Clay Street, High Street Ext, Campville Road, Northfield Road, Valley Road, Campville Hill Road, and Wildcat Hill Road)	55%	65%
Adjacent Land Use	**(Percent of Total Route)**	**(Percent of Total Route)**
Residential	44%	33%
Commercial	10%	12%
Public	10%	10%
Forested	19%	28%
Undeveloped (Open Land)	4%	4%
Industrial	13%	13%
Total	100%	100%
Watercourse Crossings	**(Number)**	**(Number)**
Major crossings (Naugatuck River)	3	3
100-year floodplain crossings (Naugatuck River)	4,450 linear feet	930 linear feet
Wetlands Crossed	**(Number)**	**(Number)**
Underground Portion along Road ROWs	12	6
Underground Portion along Transmission line ROW	-	0
Overhead Portion along or adjacent to Transmission line ROW	1	10
Railroad Crossings	**(Number)**	**(Number)**
ConnDOT and Naugatuck Railroad Company	3	3

11.4 JUSTIFICATION FOR THE SELECTION OF THE PROPOSED TRANSMISSION LINE ROUTE AND CONFIGURATION

After considering various alternative technologies and routes for the Project, Eversource identified a predominantly overhead line (with a 0.1-mile segment of underground cable on Eversource property) as the preferred configuration and the use the existing transmission line ROW as the preferred alignment for the new 115-kV line between Frost Bridge and Campville substations. This Proposed Route and configuration meets all Project objectives and represents the most cost-effective, least environmentally damaging practical alternative.

The Proposed Route and line design represent the optimal Project configuration for the following reasons:

- **Maximizes the Use of Existing ROW and Avoids the Need to Acquire Additional Property for Utility Use**. The new overhead 115-kV line would be located entirely within Eversource's existing ROW, which is already devoted to utility use and has sufficient unutilized space to accommodate the new lines without requiring relocation of the existing lines or the acquisition of additional easements.
- **Minimizes Environmental and Land Use Effects.** Although temporary effects to site-specific environmental resources would occur as a result of the construction and operation of the proposed 115-kV transmission line within Eversource's existing ROW, the development of the Project along this existing utility corridor would be consistent with federal, state, and local land use policies and would minimize long-term adverse environmental impacts.
- **Achieves a Reliable, Operable, and Cost-Effective Solution.** The Proposed Route and overhead line design represent the most cost-effective alternative to Connecticut consumers and offer the optimal solution to the defined reliability issues.
- **Avoids Conflicts with Existing Overhead Lines at the Frost Bridge Substation Exit.** The use of the short, 0.1-mile segment of underground XLPE cable system within and adjacent to Frost Bridge Substation provides the most direct exit for the new 115-kV line from the substation, and avoids potential reliability issues that would otherwise have been associated with three new crossings of existing overhead transmission lines.

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APPENDIX 11A - UNDERGROUND CABLE CONSTRUCTION

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INTRODUCTION

This appendix provides information regarding the construction procedures that would generally be used to install an underground XLPE 115-kV transmission cable system. The appendix includes the following information:

- The typical construction activities and sequence for underground cable-system installation within or adjacent to road ROWs;
- The different construction procedures that would be required to development of a cable system outside of road ROWs (e.g., along transmission line ROWs or along a "greenfield" utility corridor);
- Data regarding specific underground cable construction considerations (e.g., splice vault locations, erosion controls, traffic management).

11A.1 General Construction Sequence: Cable Systems in or Adjacent to Road ROWs

Underground transmission cable systems are most often situated within or adjacent to public roads. Public roads provide both linear corridors for the cable route and roadway access along the entire cable system for construction and maintenance. This section summarizes the typical construction activities involved in underground cable installation within or adjacent to roads.

The sequence in which some of these activities are performed depends on site-specific factors and construction scheduling. The types of activities generally involved in a 115-kV cable system installation along or adjacent to a road ROW are summarized below.

Most of the following activities also apply to underground cable construction outside of road ROWs. (Refer to Section 11A.2 for additional information regarding the differences in cable-system installation and operation in non-road areas).

Cable-System Land Requirements and General Sequence

Construction Staging, Storage, and Laydown Areas. Cable-system construction requires construction contractor yard(s), as well as a combination of other staging, storage, and laydown support areas. These areas, which typically would range in size from 2 to 5 acres, would optimally be located on previously disturbed sites and would be selected based on availability and proximity to work locations. Construction support sites near the cable-system route are preferred to facilitate the construction work and to minimize adverse effects on traffic resulting from the movement of equipment and materials to work sites.

Generally, these support sites would be used for construction offices, parking for workers' personal vehicles, equipment staging, the storage of cable-system construction materials (e.g., conduit, trench boxes, backfill), and the temporary storage of excavated materials (e.g., rock, soil, dewatering wastewater).

Install Erosion Controls and Pavement Cutting / Removal. The first step in the construction process would be to deploy appropriate erosion and sedimentation controls (e.g., catch basin protection, silt fence, or straw bales) at locations where pavement or soils would be disturbed. Within roads and other paved areas, the pavement over the cable route and splice vault locations would then be saw-cut and removed.

Excavate and Install Splice Vaults. At approximately 1,600-to-2,000-foot intervals along the cable route, pre-cast concrete splice vaults would be installed below ground. The length of an underground cable section between splice vaults (and therefore the location of the splice vaults) is determined based upon engineering requirements (such as maximum allowable pulling tensions, the cable weight/length that can fit on a reel and be safely shipped, and cross-bonding requirements) and land constraints. The specific locations of splice vaults would be determined during final engineering design, and in some areas, distances between vaults could be significantly less than the typical 1,600-to-2000-foot interval stated above.

The outside dimensions of splice vaults for 115-kV XLPE cables are approximately 9 feet wide by 9 feet high and up to 24 feet long. The installation of each splice vault therefore typically requires an excavation area approximately 13 feet wide, 13 feet deep, and 30 feet long. The actual burial depth of each vault would vary, based on site-specific topographic conditions and on the depth of the adjacent cable sections that must interconnect within the vault (the depth of the cables at any location would be based on factors such as the avoidance of other buried utilities).

For safety purposes, the splice vault excavations would be shored and fenced. Vault sites may also be isolated by concrete (Jersey) barriers or the equivalent. Vault installation within roadways may require the closure of two travel lanes in the immediate vicinity of the vault construction. Each vault would have two entry points to the surface. The splice vaults would be installed at a minimum depth of cover (depth from existing ground surface to top-of-vault) of approximately 2.5 feet. Backfill would be placed on top of each vault to bring the ground surface back to the pre-construction elevation. After backfilling, these entry points are identifiable as manhole covers, which are set flush with the ground or road surface.

Trench and Install Duct Bank. To install the duct bank for the XLPE-insulated cables, a trench approximately 7 to 10 feet deep and approximately 5 feet wide would be excavated within a typical linear 30-to-40-foot-wide construction area. This trench would typically be stabilized using trench boxes or another type of shoring.

Excavated material (e.g., pavement, subsoil) would be placed directly into dump trucks and hauled away to a suitable disposal site, or hauled to a temporary storage site for screening/testing prior to final disposal or re-use in the excavations for backfill. If groundwater is encountered, dewatering would be performed in accordance with authorizations from applicable regulatory agencies and may involve discharge to catch basins, temporary settling basins, frac tanks, surface waters, or vacuum trucks.

Because underground cable installation would involve both the excavation of a continuous trench and areas for splice vaults, it is very probable that rock would be encountered. Such rock would have to be removed using mechanical methods, or possibly mechanical methods supplemented by drilling and controlled blasting. Should drilling and controlled blasting be necessary for the underground cable, it would be performed only pursuant to a plan incorporating multiple safeguards that would be subject to specific approval by the Council, and in consultation with local authorities.

The duct bank system that would be required for this Project, which is a function of both the system voltage and the required loading, would consist of six 6-inch polyvinyl chloride (PVC) conduits for the XLPE-insulated cables, two 6-inch PVC conduits as spare power cable conduits, two 2-inch PVC conduits for the ground-continuity conductors, two 4-inch PVC conduits for the fiber optic relaying cables, and two 2-inch conduits for the temperature-sensing fiber optic cables. Figure 11A-1 illustrates this 115-kV duct bank cross-section[110].

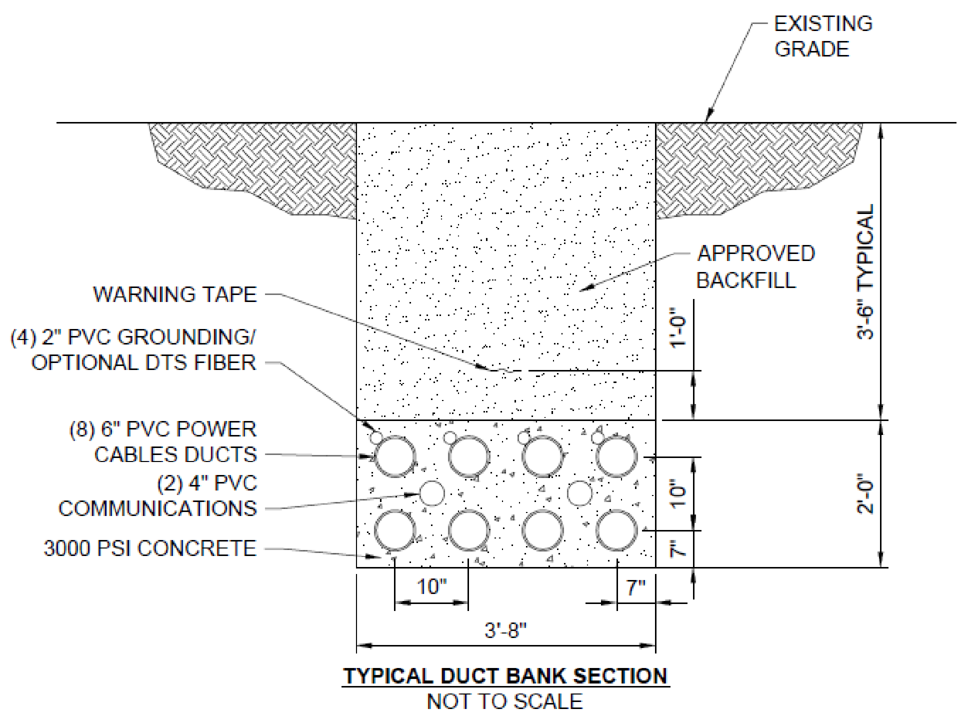
The conduit would be installed in sections, each about 10 to 20 feet long, and would have a bell and spigot connection. Conduit sections would be joined by swabbing the bell and spigot with glue and then pushing the sections together. After installation in the trench, the conduits would be encased in concrete.

[110] An all underground cable alternative necessitates two XLPE-insulated cables per phase (for a total of six cables) unlike the 0.1 mile underground line exit at Frost Bridge Substation, which only requires one XLPE-insulated cable per phase (for a total of three cables). Utilizing one XLPE-insulated cable per phase imposes a maximum installation depth of 8 feet in order to accommodate the required ampacity rating. It cannot be guaranteed that the installation depth along an entirely or predominantly underground route would not be driven deeper by encountered obstacles.

The duct bank would then be backfilled with approved backfill with sufficient thermal characteristics to dissipate the heat generated by the cable system.

Trenching, conduit installation, and backfilling would proceed progressively along the route such that relatively short sections of trench (under favorable conditions, typically 200 feet per crew) would be open at any given time and location. During non-work hours, temporary cover (steel plates) would be installed over the open trench within paved roads to maintain traffic flow over the work area. After backfilling, the trench area would be repaved using a temporary asphalt patch or equivalent. Disturbed areas would be permanently repaved as part of final restoration.

Figure 11A-1: Typical Duct-Bank Cross Section for 115-kV XLPE Cables System and Project Loading



- **<u>Trenchless Duct Installation.</u>** The installation of an underground cable system beneath certain obstacles (such as waterways, railroads, and limited-access highways) where excavating an open trench may present constructability or regulatory issues, may require the use of trenchless construction methods. Trenchless installation involves subsurface excavation to align the cable duct beneath the obstacle in question.

  Two trenchless installation methods are typically used in underground cable construction – horizontal directional drilling (HDD) and horizontal boring. HDD involves the excavation of a bore along a curved path starting and ending near the ground surface on either side of the obstacle. As necessary, the bore path is enlarged from its initial size with successive passes with larger drill heads. Once the final bore path diameter is reached, the pre-assembled conduit package is pulled through. Alternatively, a horizontal bore involves the excavation of a vertical shaft on each side of the obstacle, and then the excavation of a straight, horizontal bore between the two shafts. Various methods exist to accomplish this, including pipe jacking, auger boring, and microtunneling; with the choice of method a function of bore length, size, soil conditions, and presence of ground water.

Any trenchless installation technique involves staging areas on either side of the subsurface crossing. These staging areas, which typically must be at least 0.3 acre on the launching side and 0.1 acre on the receiving side, are required to accommodate the specialized HDD and boring equipment, as well as the materials needed for the subsurface crossing.

- **Duct Swabbing and Testing.** After the vaults and duct bank are in place, the ducts would be swabbed and tested (proofed), using an internal inspection device (mandrel) to check for defects. Mandrelling is a testing procedure in which a ‘pig’ (a painted aluminum or wood cylindrical object slightly smaller in diameter than the conduit) is pulled through the conduit. This is done to ensure the ‘pig’ can pass easily, verifying the conduit has not been crushed, damaged, or installed improperly. After successful proofing, the transmission cables and ground-continuity conductors would be installed and spliced. Cable reels would be delivered by special tractor trailers to the vaults, where the cable would be pulled into the conduit using a truck-mounted winch and cable handling equipment.
- **Cable Installation**. To install each transmission cable and ground-continuity conductor within the conduits, a large cable reel would be set up over a splice vault, and a winch would be set up at one of the adjacent splice-vault locations. The cables and ground-continuity conductors (during separate mobilizations) would then be pulled into their conduits by winching a pull rope attached to the ends of each cable. In a separate pulling operation, the splice vaults would also be used as pull points for installing the temperature-sensing fiber optic cables. Additionally, pull boxes would be installed near the splice vaults for the pulling and splicing operations required for the remaining fiber optic cables.
- **Cable Splicing**. After the transmission cables and ground-continuity conductors are pulled into their respective conduits, the ends would be spliced together in the vaults. Because of the time-consuming and precise nature of splicing high-voltage transmission cables, the sensitivity of the cables to moisture (moisture is detrimental to the life of the cable), and the need to maintain a clean working environment, splicing XLPE-insulated cables involves a complex procedure and requires a controlled atmosphere. The ‘clean room’ atmosphere would be provided by an enclosure or vehicle that must be located over the manhole access points during the splicing process.

  It typically takes 7 to 10 days to complete the splices in each vault (three XLPE 115-kV cable splices in each splice vault). Each cable and associated splice would then be stacked vertically and supported on the wall of the splice vault.
- **Cable Termination**. At each end of a 115-kV cable system, termination equipment is required. This would consist of steel structures on which the cable terminations would be mounted. The duct bank itself would be routed to the termination structure, and the ducts turned to vertical to allow the cables to be pulled up and out of the duct bank and attached to the terminations assemblies. The terminations are typically located with substations on each end of the underground cable system; however, terminations could also be located where an overhead line segment transitions to underground or vice versa.

- **Restoration.** After the installation of the duct banks and splice vaults, disturbed road ROWs or other paved areas (e.g., parking lots) would be restored to appropriate grade levels and re-paved. Sidewalks, curbs, and road shoulder or median areas affected by construction also would be restored. Non-paved areas affected by construction (e.g., vegetated road shoulders, lawns, or other previously vegetated areas disturbed by cable-system construction) would be seeded, mulched, and allowed to vegetate.

11A.2 Additional Requirements for Cable-System Construction Outside of Road ROWs

To install and operate a transmission cable system within or adjacent to non-road ROWs (such as Eversource's existing overhead transmission line ROW) or along an entirely new cross-country ("greenfield") ROW, the ROW requirements and typical construction procedures described in Section 11A.1 would be used, with the following exceptions:

- **Construction Workspace**. Because the cable system would not be aligned along existing roads, the workspace required to construct the system could be wider than 40 feet to accommodate construction equipment, trench excavation, splice vaults, and access roads along the entire cable route. Additional ROW width and temporary construction work spaces also could be needed in certain areas to account for topography and subsurface conditions, which may affect the width of the excavations that would be required to achieve the specified cable and splice vault depths. The required width of the construction workspace would depend on site-specific conditions.
- **Easement Requirements**. Eversource might need to purchase easements from private landowners for an underground cable system installed outside of road ROWs, even for transmission cables aligned along its own overhead transmission line ROW (where the existing easements do not encompass sufficient rights for underground transmission systems). Permanent underground easements would have to be acquired.
- **Vegetation Clearing and Grading**. For any cable system located outside of paved corridors, all vegetation would have to be cleared and removed along the entire width of the construction ROW, which would then have to be graded both to create an access road along the length of the cable route and to achieve appropriate elevations for the installation of the duct banks and splice vaults. Additional construction work spaces, such as in areas of side slopes, wetlands, and adjacent to stream crossings, and temporary construction support areas (e.g., crane pads adjacent to splice vaults, temporary material staging sites) also would have to be cleared and graded as appropriate to site-specific conditions. Because the Project region is characterized by rugged, forested, terrain with bedrock outcrops, shallow depth to bedrock, and multiple water resources (wetlands and streams), the vegetation clearing and grading that would be required to create an acceptable ROW for an underground cable system would involve significant environmental impacts. Extensive hammering and/or blasting would be required to create level grades for work pads and for the cable system ROW, permanently altering topography along the cable route.
- **Access Roads.** Because permanent access would be required along the entire route for cable-system maintenance purposes (i.e., for immediate access to the duct banks and splice vaults), gravel-type roads, with a typical 20-foot-wide travel area, would likely be developed during the construction phase. The roads would have to be constructed to handle all anticipated construction equipment and material deliveries, including trench boxes, concrete trucks, splice vaults, cranes, and cable reel trucks. Access road construction would involve cutting and filling activities (including permanent fill in wetlands along the cable route), as well as the installation of permanent watercourse crossings (e.g., culverts, bridges) as needed.

- **Erosion and Sedimentation Controls.** Because of the soil disturbance along the length of the cable-system route, erosion and sedimentation controls would have to be deployed and maintained both along and across the ROW as necessary to minimize the potential for impacts to adjacent properties and to environmental resources. Soil erosion and sedimentation controls would consist of the measures as summarized in Section 11A.1. Where the ROW intersects public roads, crushed stone anti-tracking pads would have to be installed along the ROW to minimize the amount of soil tracked onto the pavement from construction-related activities.
- **Restoration**. Restoration activities would consist of reseeding and mulching disturbed soil areas. With the exception of the permanent access road, disturbed areas would be allowed to revegetate, but would be managed in low-growth vegetation, consistent with the operation of the underground cable system.

Underground cable-system construction outside of roadway ROWs also typically must address site-specific environmental conditions. For example, wetlands are typically characterized by soils that are relatively poor in terms of thermal characteristics for heat dissipation, compared to granular soils typically found beneath roadways. Organic soils require over-excavation, or the use of different phase spacing within the duct bank. In addition, wetlands and watercourses could pose significant obstacles to underground construction, requiring either direct trenching or costly and time-consuming trenchless duct-bank installation methods (such as jack and bore or horizontal directional drill [HDD], both of which would require potentially extensive staging areas on either side of the water crossing).

11A.3 Splice-Vault Requirements

Due to current-carrying limitations and the assumed underground duct-bank configuration requiring two cables per phase, two separate splice vaults would be required at each cable-splice interval along the length of an underground line. The outside dimensions of a splice vault for 115-kV XLPE cables are approximately 9 feet wide by 9 feet deep and up to 24 feet in length (one vault per three XLPE cables).

The installation of each splice vault therefore requires an excavation area approximately 13 feet wide, 13 feet deep, and 30 feet long. At each splice-vault location, pre-cast splice vaults would be installed below ground. Splice vaults located along, but outside of public road ROWs, require a minimum of 12,000 square feet of permanent easement for future access to perform maintenance and repairs. An additional minimum 4,300 square feet of temporary easement would be required for cable-system construction. Therefore, the construction of each vault would require approximately 0.4 acre (exclusive of access).

Along a cable route, the actual burial depth of each vault would vary, depending on site-specific topographic conditions and the depth of the interconnecting duct bank. For cable systems aligned along roads, the below-grade elevation of the duct banks (and therefore the depth at which vaults must be placed) often depends on the depth required to avoid conflicts with other buried utilities.

Vaults may be installed beneath public road travel lanes or, in order to avoid conflicts with other utilities buried beneath the roads, may be installed in other suitable locations adjacent to roads (e.g., beneath parking lots, sidewalks, road shoulders, road medians). However, in locations where the duct bank extends beneath a road but vaults must be installed off-road, the duct bank may need to cross other parallel buried utilities twice to interconnect each vault, greatly complicating the cable-system design and construction process.

For cable-systems aligned along linear corridors other than road ROWs (e.g., Eversource’s overhead transmission line ROW, railroad ROW), vaults would be installed within or adjacent to these ROWs so as to avoid conflicts with the existing facilities. However, along such ROWs, vault installation may be more difficult due to factors such as unfavorable topographic conditions (e.g., need for grading or filling, presence of rock that must be excavated and removed, dewatering needs, and needs for developing and maintaining suitable access for the heavy construction equipment such as cranes). Extra work areas adjacent to the vaults also would be required for crane pads, which would be needed to place each vault. The crane-pad area required at each splice vault would be approximately 80 feet wide by 130 feet long.

11A.4 Temporary Erosion and Sedimentation Controls

Temporary erosion and sedimentation controls (e.g., silt fence, hay/straw bales, filter socks, inlet and catch basin protection) would be installed as needed prior to or in conjunction with the commencement of cable-system construction activities that would involve soil disturbance. The controls would be installed in compliance with the 2002 Connecticut *Guidelines for Soil Erosion and Sedimentation Control*. The need for, type, and extent of erosion and sedimentation controls would be a function of considerations such as:

- Whether the underground cable route is within or adjacent to road ROWs or along Eversource transmission line or other utility ROWs (for example, catch basin protection would be required for cable-system construction within roads)
- Slope (steepness, potential for erosion) and presence of resources, such as wetlands or streams, at the bottom of the slope
- Type of soil disturbed
- Soil moisture regimes
- Schedule of future construction activities

- Proximity of cleared areas to water resources, roads, or other sensitive environmental resources
- Time of year, as this dictates the types of erosion and sedimentation control methods for a particular area. For example, re-seeding is not typically effective during the winter months. In winter, with frozen ground, controls other than re-seeding (such as wood chips, straw and hay, geotextile fabric, waterbars, or crushed stone) would be used to stabilize disturbed areas until seeding can be performed.
- Extreme weather conditions during or immediately following soil disturbance.

11A.5 Vegetation Clearing (Within / Adjacent to Roads vs. Other Sites)

Only minimum vegetation clearing is typically required for underground cable-system construction within or adjacent to road ROWs. Some landscaping or other vegetation bordering the cable route within roads may need to be removed or trimmed to allow the safe operation of construction equipment, and vegetation also would have to be removed at off-road splice vault locations (unless the vaults are located in paved areas). Similarly, vegetation may be affected by temporary staging or material storage sites.

In contrast, underground cable-system construction within Eversource's transmission line ROWs or other non-roadway corridors would involve the removal of all vegetation within a typical minimum 40-foot-wide construction work area. Additional vegetation clearing would also be needed at the locations of line transition stations, splice vaults, splice vault work (crane) pads, and staging areas.

11A.6 Special Procedures: Rock Removal (Drilling/Blasting), Dewatering, Material Handling

Based on a review of field conditions, it is likely that the excavations for any cable system would encounter rock and groundwater in many locations. Compared to the installation of overhead transmission line structures at defined locations, underground cable construction, which involves both the excavation of a continuous trench and areas for splice vaults, would require substantially more rock digging and removal and would require the management of significantly greater quantities of both dewatering wastewater and excavated soils. All of these excavated materials must be properly disposed.

Generally, rock encountered during underground cable-system construction would be removed using mechanical methods, or mechanical methods supplemented by controlled drilling and blasting. If drilling and blasting are necessary, Eversource would adhere to the same standard procedures as described for the construction of the Proposed Route in Volume 1, Section 4. Similarly, dewatering wastewaters and excess excavated soils would be managed as described in Section 4 for the construction along the Proposed Route ; however, substantially greater quantities of excess soil and dewatering wastewater would be involved in the underground cable-system installation. Further, dewatering could result in discharges to catch basins, sanitary sewers, temporary settling basins, tanker trucks (for eventual off-site transport), or watercourses.

11A.7 Traffic Management

Traffic issues are often of primary concern with respect to the construction of underground cable systems within or adjacent to public road ROWs. The installation of the duct banks and splice vaults typically requires temporary travel lane closures, which would potentially cause traffic disruption, delays, detours, or congestion.

To minimize traffic-related impacts, Eversource would typically coordinate with municipal and state highway authorities regarding peak and non-peak travel times in order to identify construction schedules that would limit potential interference with traffic flow along public roads. Eversource also would employ personnel to direct traffic at construction sites, and would erect appropriate traffic signs and install work area protection measures and signs to clearly denote the presence of construction work zones.

11A.8 Construction Scheduling and Work Hours

Cable-system construction is time-consuming and highly dependent on subsurface conditions. Duct-bank construction could proceed at a rate of only 50 feet / day and the excavation and installation of a splice vault could require a week to complete.

In addition, cable-system construction schedules would depend on the location of the underground route (e.g., within public road travel lanes, near developed land uses, timing for crossing of sensitive environmental resources, such as streams that support fisheries). Where underground cables are routed within public road ROWs, construction work must be coordinated with state or local highway authorities to avoid peak travel times and thus may occur at night. In contrast, in areas where the underground cable system traverses adjacent to residential areas, work would be scheduled during daylight hours, to minimize nighttime noise disturbance to residents.

Cable-system installation beneath watercourses that support fishery resources or that are classified as high quality waters would be performed and scheduled in accordance with CT DEEP and USACE requirements. Often, cables must be installed beneath larger watercourses using trenchless technologies such as horizontal directional drilling or jack and bore. Using either of these techniques, the installation of the duct bank beneath a watercourse typically requires several weeks or months to complete.

12. POTENTIAL TRANSMISSION LINE ROUTE AND CONFIGURATION VARIATIONS

As part of the process that led to the selection of the Proposed Route for the new 115-kV transmission line within Eversource's existing ROW or on Eversource-owned property and a preferred transmission line design for each ROW segment, Eversource also evaluated the following:

- Potentially viable site-specific variations to portions of the Proposed Route, in either overhead or underground configurations; and
- Different overhead configurations (structure types) for the new 115-kV line.

These potential variations are discussed in the following sections.

12.1 ROUTE VARIATIONS: GENERAL

Except for the portion of the route in the vicinity of Frost Bridge Substation (refer to XS-1 and the discussion in Section 12.2), the proposed new transmission line would be aligned entirely within an existing Eversource ROW that has been devoted to utility use (and occupied by other overhead transmission lines) for many years. For these segments of the ROW (i.e., XS-2 through XS-6), no viable alignment variations to the Proposed Route were identified. Compared to the Proposed Route and overhead line design, any route variation outside of the established ROW or in an underground configuration would increase environmental impacts, community impacts, and Project costs.

12.2 FROST BRIDGE SUBSTATION LINE EXIT UNDERGROUND / OVERHEAD ROUTE VARIATIONS

The Frost Bridge Substation presently connects to nine overhead transmission lines (seven 115-kV lines and two 345-kV lines). As a result, Eversource carefully considered options for extending the new 115-kV line out of the substation, with the objective of avoiding or minimizing potential conflicts with these existing overhead lines, existing substation facilities, and planned Project-related substation modifications.

Eversource identified and evaluated three options (including the Proposed Route) for the new 115-kV transmission line exit from Frost Bridge Substation. These options, all of which would be located on Eversource property (spanning Frost Bridge Road, State Route 8, and Echo Valley Road), are as follows:

- **Proposed Route:** The line would exit the substation in overhead configuration to a new transition structure immediately outside of the eastern substation fence line. The line would then transition to underground configuration and traverse through and adjacent to the substation for approximately 0.1 mile to a second new transition structure directly outside of the western substation fence line where the line would return to overhead configuration. After performing comparative engineering, environmental, and cost analyses, Eversource selected and incorporated this alignment and design into the Proposed Route (refer to XS-1, as depicted in Appendix 3A and in Volume 5).
- **Variation 1:** An all-overhead line design that would require the new 115-kV line to exit the substation to the east and then extend around the substation fence line to the north and west.
- **Variation 2:** The line would exit the substation in overhead configuration to a new transition structure immediately outside of the eastern substation fence line. The line would then transition to underground configuration and traverse through the substation for approximately 0.1 mile to a second new transition structure directly outside of the northeast corner of the substation fence. The line would transition back to an overhead configuration and continue to the west, following the same alignment as Variation 1.

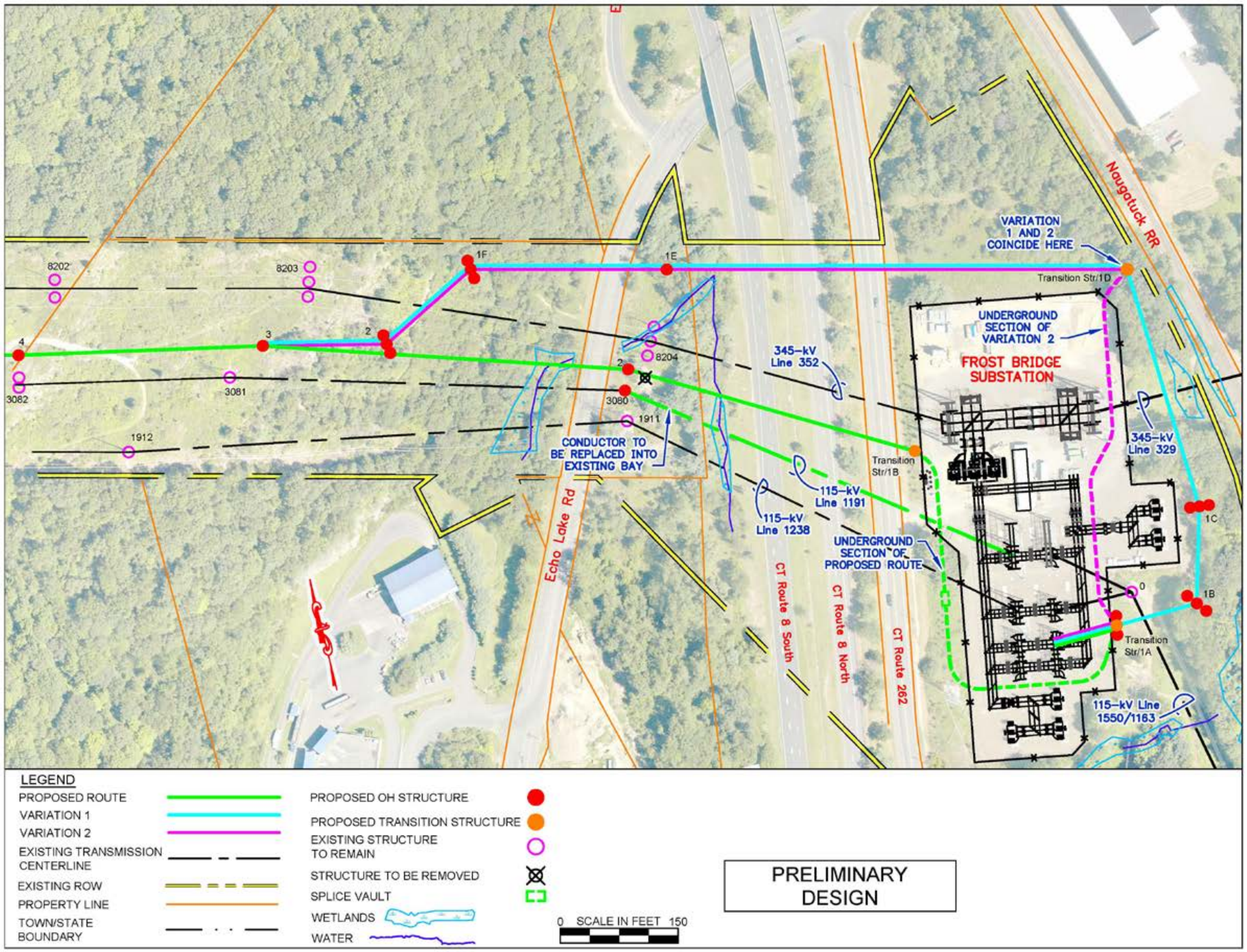
Figure 12-1 illustrates the Proposed Route segment exiting from Frost Bridge Substation, as well as Variations 1 and 2. Table 12-1 summarizes the characteristics of the substation exit along Proposed Route, compared to Variations 1 and 2, each of which is described below.

Table 12-1: Comparison of Proposed Route and Frost Bridge Line Exit Route Variations

Feature	Frost Bridge Proposed Route (XS-1) (West Underground Exit from Substation, then Overhead)	Frost Bridge Route Variation 1 (All Overhead Design; East Exit from Substation)	Frost Bridge Route Variation 2 (North Underground Exit from Substation, then Overhead)
Miles (total)	0.5	0.4	0.4
Miles (Overhead)	0.4***	0.4	0.3
Miles (Underground)	0.1	0	0.1
New Overhead Structures (No.)	4*	7	5*
Water Resources Affected	0	0	0
Creation of New ROW**	No	Yes	Yes

Footnote:
* Includes two transition (UG-OH Transition) structures (one transition structure just outside the southeastern substation fence to transition to the underground cable and one immediately outside the northwestern portion of the substation to transition from an underground to overhead line configuration)
** New ROW would be on Eversource property, but in an area not presently used as an overhead transmission line corridor
*** Includes the replacement of approximately 0.1 mile of the 1191 Line

Figure 12-1: Frost Bridge Substation Line Exit: Proposed Route and Underground / Overhead Route Variations



<u>Variation 1: All-Overhead Line Design</u>. Eversource initially identified this all-overhead line exit design, in keeping with the all-overhead plan for the rest of the new 115-kV line. However, in contrast to the other segments of the Project where the new 115-kV line would be aligned within an Eversource ROW presently occupied by one or more overhead transmission lines, Variation 1 would involve locating the new 115-kV line along a new route (not adjacent to any existing transmission lines).

In order to avoid conflicts with the existing transmission facilities that are located within and interconnect to the substation, using Variation 1, the new 115-kV transmission line would extend out of the southeastern side of the substation in an overhead three-pole configuration. The new transmission line then would be aligned around the eastern and the northern portions of the substation fence line before extending west over Frost Bridge Road, State Route 8, and Echo Lake Road to join the 400-foot-wide Eversource ROW.

As illustrated on Figure 12-1, five new three-pole structures and two new monopole structures (Structures 1A-F, Structure 2) would be required along this 0.4-mile route variation. In addition, this variation would require the new 115-kV line to cross Eversource's existing 345-kV line (i.e. the 352 Line) near Structure 2.

This route variation would place the new 115-kV line on variable terrain upslope of the Naugatuck Railroad and the Naugatuck River and would require the new transmission line to cross Eversource's existing transmission lines that interconnect to Frost Bridge Substation on the east. Due to the topography in this area, considerable cut and fill would be required to establish the access roads and work pads required to install and maintain the new structures. Vegetation would have to be cleared to accommodate these construction activities and, after the installation of the new overhead route segment along Variation 1, would be managed in low-growth species consistent with overhead transmission line operation.

Eversource initially identified Variation 1 as the potentially preferred substation exit option for the new 115-kV line. This overhead line design was included in the MCF as part of the then-Proposed Route, with the caveat that Eversource was in the process of performing additional engineering and constructability analyses of undergrounding the portion of the new 115-kV line within and near the Frost Bridge Substation. Based on the results of these analyses, Eversource determined that the constructability and environmental issues associated with Variation 1 could be avoided by the adoption of the underground cable / overhead configuration as has been incorporated into the Proposed Route.

<u>Variation 2: North Underground Exit from Substation to Overhead.</u> Like the Proposed Route exit from Frost Bridge Substation, Variation 2 would involve a short underground 115-kV transmission cable segment within the substation, as well as an overhead configuration. Using Variation 2, the line would exit the substation in overhead configuration to a new transition structure immediately outside of the substation fence. The line would then transition to an underground cable configuration and traverse through the substation for approximately 0.1 mile to another new transition structure located outside of the northern portion of the substation fence. The line would then transition back to an overhead configuration and extend west across Frost Bridge Road, State Route 8, and Echo Valley Road before reconnecting to the Proposed Route at new Structure 3. From the transition structure, the overhead portion of Variation 2 would follow the same alignment as the western portion of Variation 1 (refer to Figure 12-1).

Variation 2 would require five new transmission line structures (including a transition structure). In addition, using this variation, the new 115-kV line would have to cross the existing 352 Line.

<u>Rationale for Selection of the Proposed Route Line Exit from Frost Bridge Substation</u>

Compared to either Variation 1 or Variation 2, the Proposed Route provides a more direct exit for the new 115-kV line from the Frost Bridge Substation and avoids the need for any crossings of existing transmission lines. In comparison, Variation 1 would require three transmission line crossings, as well as transmission line construction along a new ROW, outside the eastern and northern substation fence, in proximity to the Naugatuck River. Variation 2 would minimize the length of underground cable within the substation, but would require an overhead alignment that would involve a crossing of the 352 Line.

12.3 STRUCTURE CONFIGURATION VARIATIONS

As part of the Project planning process, Eversource evaluated the use of three overhead structure configuration types for the proposed 115-kV transmission line: steel monopoles with either a delta or vertical configuration and steel H-frames. Eversource determined that monopole type structures were preferred rather than H-frames due to constructability, and because the use of monopoles would require less ROW clearing, less environmental impacts, and would be more cost-effective. Specifically, steel monopoles are better suited for installation along the rugged/uneven topography that characterizes most of the Proposed Route. Further, compared to H-frame structures, monopoles require less new vegetation removal to meet conductor clearance requirements to the edge of the vegetation removal. The principal engineering, construction, and environmental factors associated with each of the three structure configurations (delta monopoles, vertical monopoles, and H-frame structures) are described further and summarized in Table 12-2.

Table 12-2: Transmission Line Structure Configuration Variations: Summary of Structure Heights and Additional Vegetation Clearing Required to Expand the Edge of the Managed Portion of the ROW

Cross-Section No.* / Description	Total Row Width (feet)	Monopole Line w/ Delta Configuration	Monopole Line w/ Vertical Configuration	H-Frame Variation Line Configuration
XS-2 (Watertown)	400			
• Structure height (typical)		90 feet	105 feet	75 feet
• Additional vegetation clearing required to expand edge of managed ROW		None	None	None
XS-3 (Watertown & Thomaston)	250			
• Structure height (typical)		90 feet	105 feet	75 feet
• Additional vegetation clearing required to expand edge of managed ROW		45 feet	35 feet	55 feet
XS-4 (Thomaston & Litchfield)	250			
• Structure height (typical)		90 feet	105 feet	75 feet
• Additional vegetation clearing required to expand edge of managed ROW		40 feet	30 feet	50 feet
XS-5 (Litchfield & Harwinton)	250			
• Structure height (typical)		155 feet	170 feet	135 feet
• Additional vegetation clearing required to expand edge of managed ROW		70 feet	70 feet	80 feet
XS-6 (Harwinton)	250			
• Structure height (typical)		90 feet	105 feet	75feet
• Additional vegetation clearing required to expand edge of managed ROW		40 feet	30 feet	50 feet

*Note: This table excludes the segment of the ROW extending northwest from Frost Bridge Substation (XS-1), where the new 115-kV line would be configured underground.
Shading indicates proposed structure configuration.

Steel Monopole Structures

Steel monopoles in delta and vertical configuration were identified as the preferred structure types for the development of the new 115-kV transmission line within the Frost Bridge Substation to Campville Substation ROW. Along the majority of the ROW, Eversource proposes to use delta steel monopole structures to support the new transmission line.

Delta steel monopoles were selected for use along most portions of the ROW because, compared to vertical steel monopole structures, they are shorter (and thus have a lower visual profile) and more cost-effective to install (shorter embedment depths). However, delta steel monopoles will typically require slightly more new forested vegetation removal than vertical steel monopoles.

However, along the 400-foot-wide ROW segment from north of Frost Bridge Substation to Purgatory Junction in the Town of Watertown (refer to XS-2), vertical steel monopoles would be installed to optimize the use of the existing ROW, which already is occupied by three other transmission lines. Similarly, in select locations along other segments of the ROW (i.e., XS-3 through XS-6), vertical steel monopoles are proposed to further minimize environmental impacts (e.g., to avoid a water resource or to minimize clearing within a wetland).

Appendix 12A includes cross-sections depicting the alternative use of vertical monopoles for the new 115-kV line within ROW segments 3 through 6 (i.e., XS-3, XS-4, XS-5, and XS-6).

H-Frame Structures

Cross-sections depicting views of the new 115-kV line supported on H-frame structures are included in Appendix 12B. Compared to either of the proposed monopole designs, steel H-frame structures would present a lower profile. For example, a typical 115-kV H-frame structure would be approximately 75 feet tall, compared to the typical 90-105-foot heights of the delta or vertical monopoles. However, as explained below, compared to the proposed line design, Eversource found the H-Frame line configuration variation less desirable due to constructability, engineering, environmental, and/or cost factors.

One of the existing 115-kV lines that occupy the Project ROW (i.e., the 1191 Line) is currently supported on H-frame structures. In some cases, configuring a new transmission line to match an existing line can be used to minimize incremental visual effects. However, the existing 1191 Line was installed in 1942. As a result, the H-frames used to support that line differ significantly in appearance from modern steel H-frame structures. Specifically, transmission line materials and standards have changed substantially over the last 70 years, and new H-frame structures also would be taller than the existing structures.

In addition, the use of H-frames to support the new 115-kV transmission line would pose engineering and constructability challenges, given the extreme slide slopes and steep topography within the Frost Bridge to Campville ROW. This type of rugged terrain presents construction issues associated with installing and leveling the two poles that are required for each H-frame structure.

Further, compared to the proposed monopoles, use of the wider H-frame structures would require additional forested vegetation clearing along a majority of the ROW (XS-3 through XS-6; refer to Table 12-2). If H-frames were to be used instead of the proposed monopoles along the Proposed Route, an estimated 8.84 additional acres of forest would have to be removed along the ROW to achieve the required conductor clearances, per utility industry standards.

For the above reasons, although H-frame structures may warrant site-specific consideration for short sections of the new 115-kV line, the topographic conditions that characterize most of the ROW make this structure type impractical for overall use for the entirety of the Project.

12.4 H-FRAME STRUCTURE CONFIGURATION VARIATION: TOWN OF THOMASTON

During the MCF process, several property owners in the Town of Thomaston requested that Eversource investigate the use of H-frame structures to install the new 115-kV line along an approximately 1-mile ROW segment generally encompassing new Structures 50 to 60. This portion of the ROW is generally situated north of State Route 109 and south of Walnut Hill Road (refer to the 1”=400 scale Mapsheets 5 and 6 in Exhibit 2, Volume 5). In this area, the ROW is 250 feet wide and is occupied only by the existing 1191 Line.

Lands in the vicinity include the Thomaston Fish and Game Club, a portion of the Mattatuck State Forest, Morton Pond, and private lands. Black Rock State Park is located to the south the ROW segment (i.e., of State Route 109) and Northfield Brook Recreation Area is located to the north (north of State Route 254).

The existing 1191 Line, which is characterized by structures that range from 50 to 80 feet and typically average approximately 60 feet in height, occupies the westernmost portion of the 250-foot-wide ROW along this segment (refer to XS-3 in Appendix 3A of this Volume and in Exhibit 4, Volume 5). The

Thomaston landowners suggested the use of H-Frame structures in this area in order to minimize potential views of the new transmission line structures above the existing tree line. Accordingly, Eversource investigated this configuration variation, taking into consideration constructability, environmental effects (e.g., additional forested clearing, wetlands impacts), visual effects, and cost.

Along this 1-mile portion of the ROW, Eversource proposes to support the new 115-kV line using monopoles that would typically range in height from approximately 66 to 108 feet. In comparison, if H-frame structures are used, structure heights would range from approximately 52 to 90 feet. In this area, the un-used portion of the ROW is sufficiently wide to accommodate the additional land required for H-frame structures.

Table 12-3 summarizes and compares the heights of the proposed monopole structures and the alternative H-frame structure configurations to the approximate height of the existing tree line.

Table 12-3: Summary Comparison of Proposed Monopole and H-Frame Structure Variation Configurations: Structure Heights and Types in Relation to Existing Tree Heights, Structures 50-60 (Thomaston)

New 115-kV Structure No.	Proposed Structure Design (Monopoles)		Alternative Structure Design (H-frame)		Height of Existing Forested Vegetation (Edge of ROW) (feet)
	Structure Type	Structure Height (feet)	Structure Type	Structure Height (feet)	
50	Vertical Running Angle	100	3-Pole Pull-Off	80	68
51	Delta Tangent	108	H-Frame Tangent	84	73
52	Delta Tangent	89	H-Frame Tangent	79	77
53	Delta Tangent	66	H-Frame Tangent	52	65
54	Delta Tangent	84	H-Frame Tangent	66	70
55	Delta Tangent	84	H-Frame Tangent	66	62
56	Delta Tangent	70	H-Frame Tangent	57	53
57	Delta Tangent	84	H-Frame Tangent	66	67
58	Delta Tangent	98	H-Frame Tangent	79	90
59	Delta Tangent	89	H-Frame Tangent	75	79
60	Delta Tangent	98	3-Pole Strain	90	70

Locations where alternative H-Frame structure heights would be lower than existing tree canopy and thus would be potentially screened from some views.

As Table 12-3 illustrates, all of the proposed monopole structures would be visible above the tree line. Of the 11 structures along the H-frame configuration variation, only five would be lower than the existing tree line. Thus, a majority would remain visible to some extent, depending on the vantage point.

Eversource's analyses determined that, in terms of constructability, the new 115-kV line could be supported on H-frames along this 1-mile segment. However, to do so, an additional 10 feet of vegetation (predominantly forested) would have to be removed along the eastern portion of the 1-mile ROW segment in order to maintain appropriate clearances between vegetation and the lower H-frame conductors. Thus, an additional 7.8 acres of forested vegetation would have to be cleared for the construction of the Project, and thereafter maintained in low-growth vegetation consistent with Eversource's ROW vegetation management protocols. Portions of the vegetation clearing would be within wetlands and streams, which would also increase water resource impacts.

Compared to the proposed use of monopole structures, the H-frame variation configuration would be more costly. As a result of construction issues associated with both the additional clearing and the installation of the H-frame structure footings, as well as the need to use strain structures to transition from the monopole to H-frame structure design on either end of this segment, Eversource estimates that the use of the H-frame configuration variation would increase Project costs by approximately $700,000.

In summary, the use of H-frame structures along the 1-mile ROW segment in Thomaston is technically feasible. However, the use of this configuration variation would result in greater impacts to water resources, more forested vegetation removal, and higher costs. Further, a majority of the H-frame structures would still be visible above the tree line. For these reasons, Eversource prefers the proposed Project configuration, using monopoles, along this ROW segment.

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Appendix 12A – Alternate Monopole Configuration Cross-Sections

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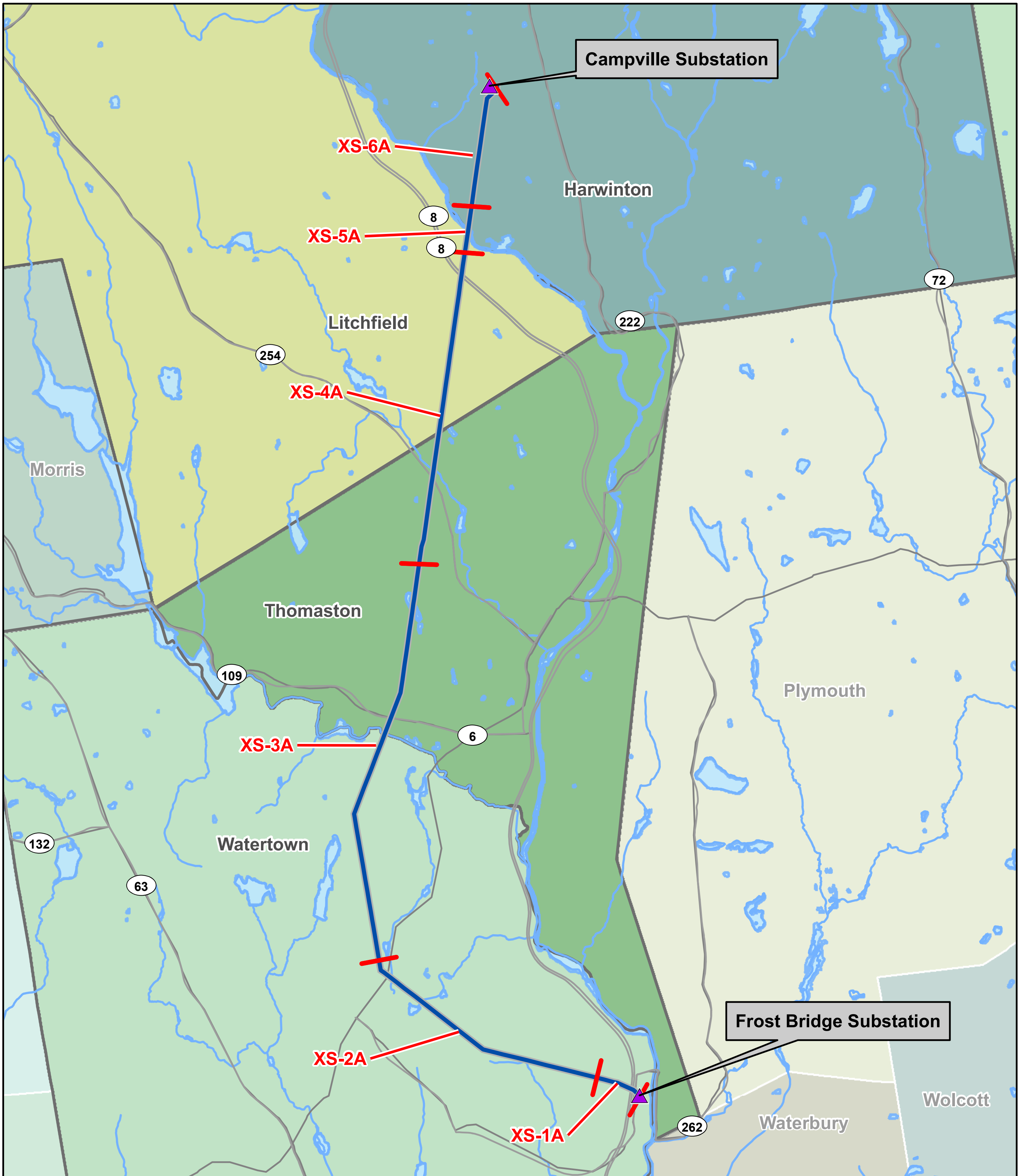

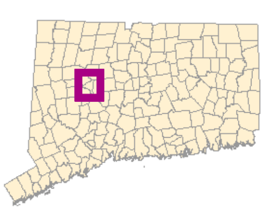

0.5 0.25 0 0.5 1 1.5 Miles

Source: CT DEEP, Tighe & Bond

EVERSOURCE ENERGY

Cross-Section Location Map

Frost Bridge to Campville 115-kV Project

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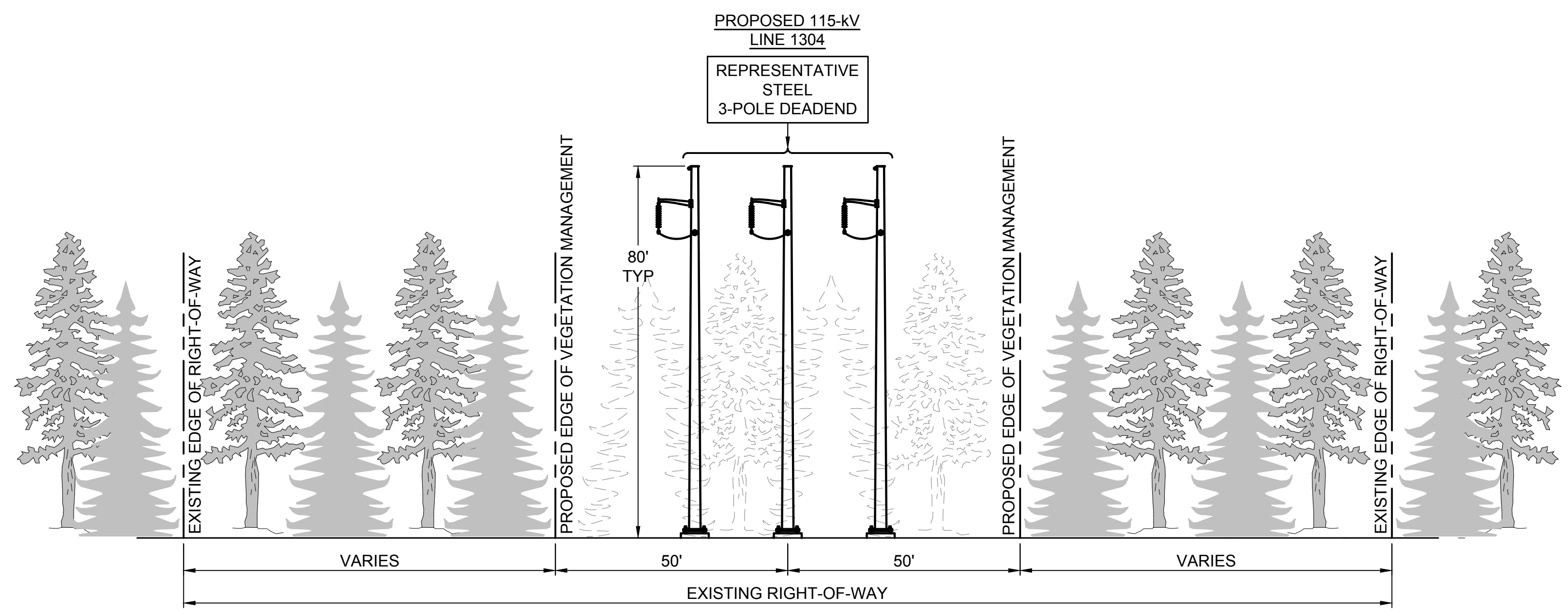


PROPOSED CONFIGURATION

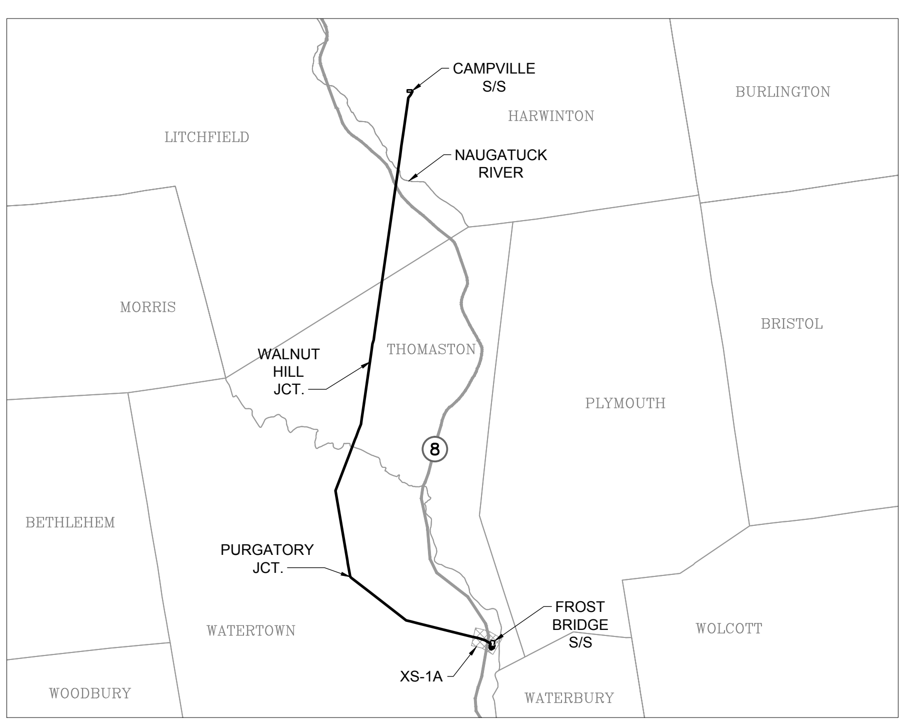
3-POLE DEADEND DESIGN

FROST BRIDGE SUBSTATION
TO
0.4 MILE OUT OF FROSTBRIDGE SUBSTATION

IN THE TOWN OF
WATERTOWN

LOOKING
EAST, NORTH AND WEST

(0.4 MILE)



KEY MAP
NOT TO SCALE

PRELIMINARY
DESIGN

NOTES:

1. NEW TRANSMISSION LINE ALIGNMENT ON EXISTING EVERSOURCE-OWNED PROPERTY.
2. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
3. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL 3-POLE DEADEND STRUCTURES TO BE PLACED ON CONCRETE FOUNDATIONS. TANGENT STRUCTURES WILL UTILIZE DIRECT EMBEDDED FOUNDATIONS, WHILE VERTICAL DEADEND STRUCTURES WILL BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
PROPOSED CROSS SECTIONS
FROST BRIDGE S/S TO 0.4 MILE OUT OF FROST BRIDGE S/S

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO.	XS-1A
P.A. #			

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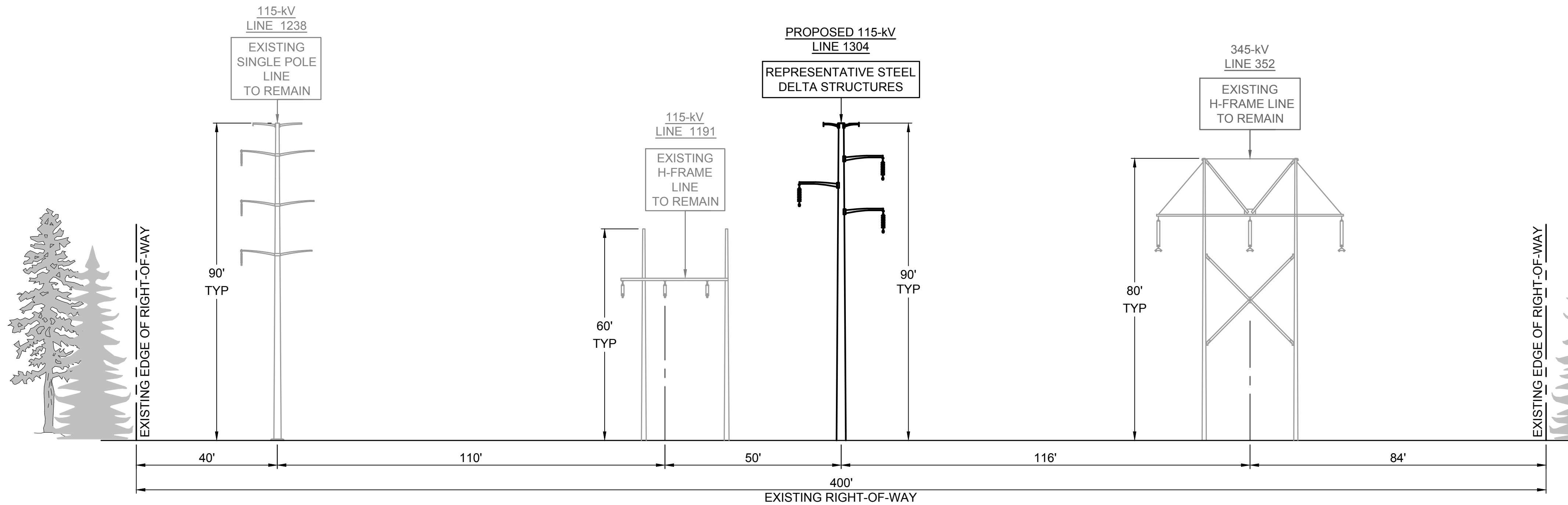


PROPOSED CONFIGURATION

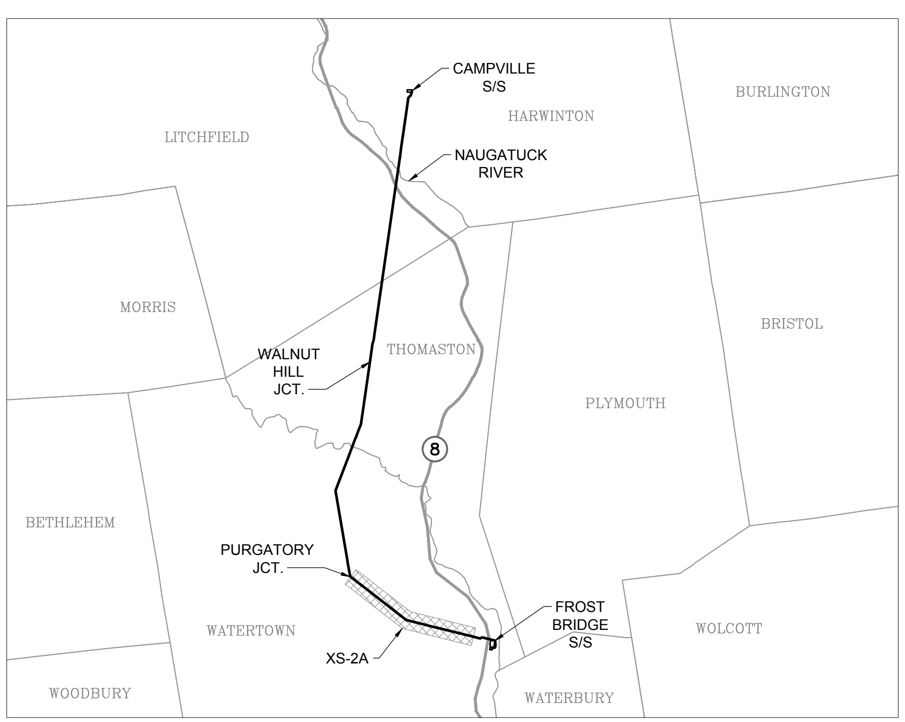
DELTA DESIGN

FROM 0.4 MILES OUT OF FROST BRIDGE S/S
TO
PURGATORY JUNCTION

IN THE TOWN OF
WATERTOWN

LOOKING
WEST

(2.3 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY DESIGN

NOTES:

1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING CONCRETE FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL ALSO BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE VERTICAL CROSS SECTIONS
FROST BRIDGE S/S LINE EXIT TO PURGATORY JCT.

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-2A	
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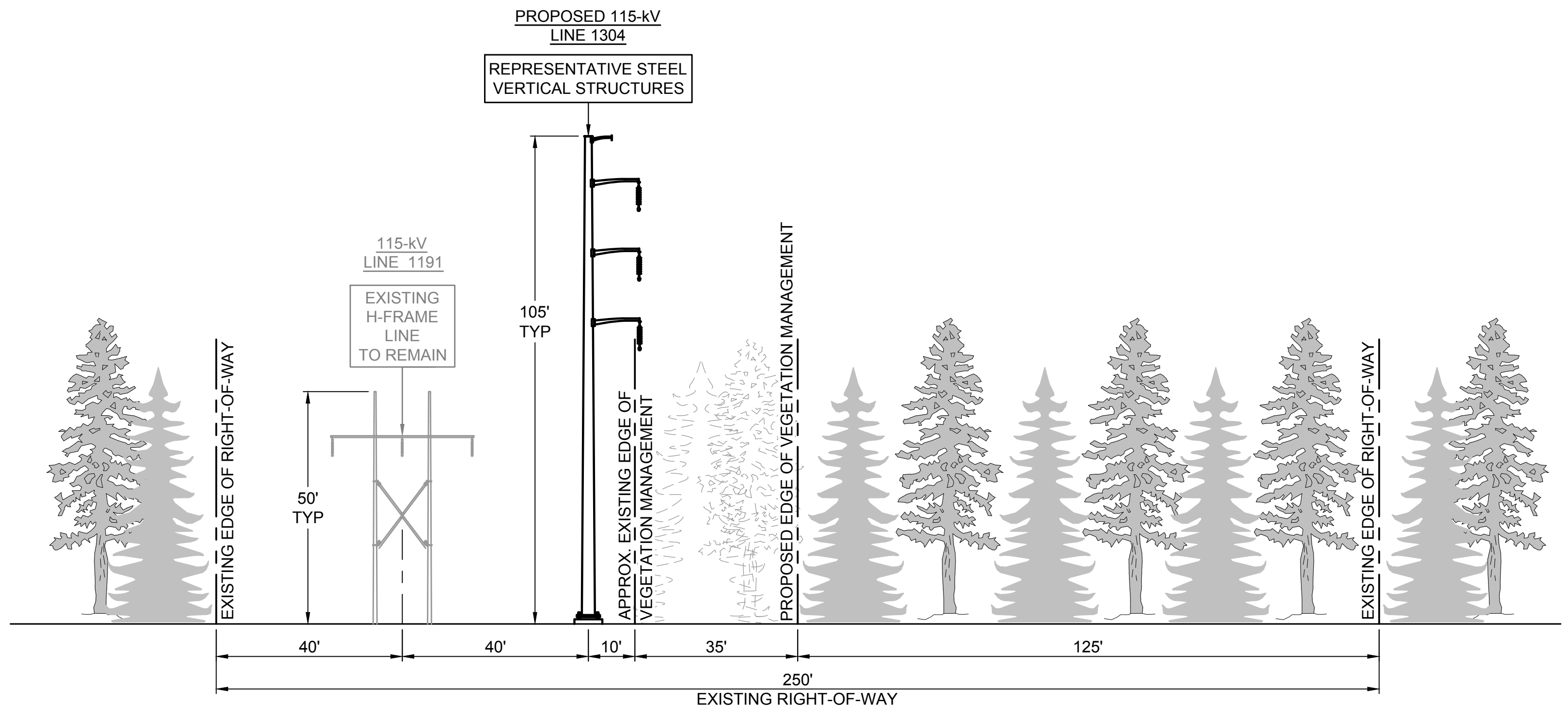


PROPOSED CONFIGURATION

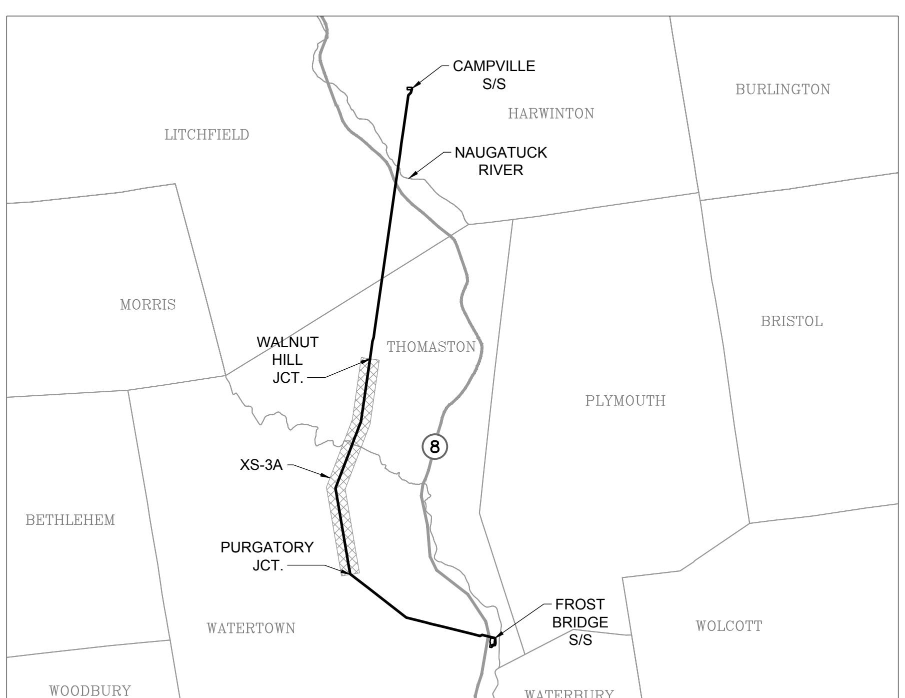
VERTICAL DESIGN

PURGATORY JUNCTION
TO
WALNUT HILL JUNCTION

IN THE TOWNS OF
WATERTOWN & THOMASTON

LOOKING
NORTH

(3.8 MILES)



KEY MAP
NOT TO SCALE

N

PRELIMINARY
DESIGN

NOTES:
1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING CONCRETE FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL ALSO BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE VERTICAL CROSS SECTIONS
PURGATORY JCT. TO WALNUT HILL JCT.

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-3A	
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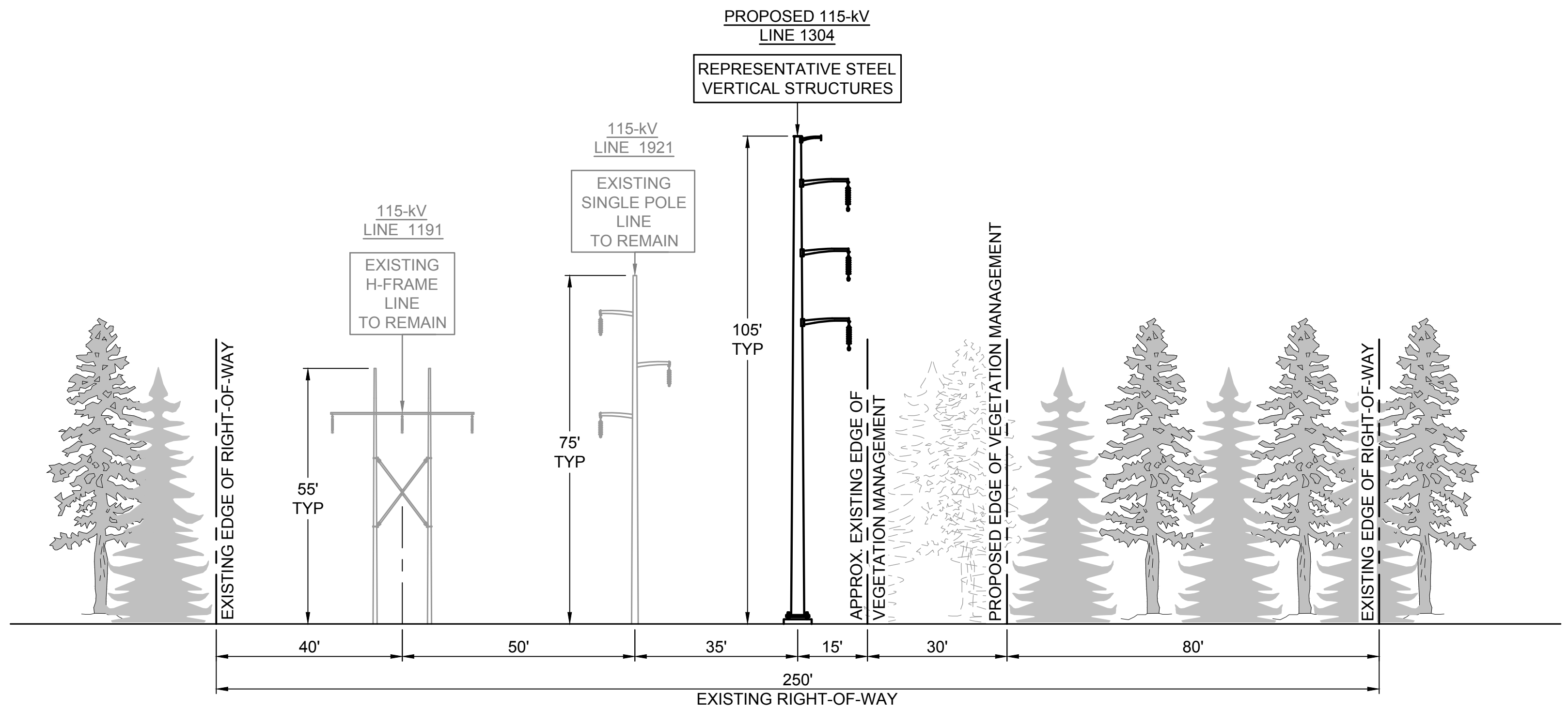


PROPOSED CONFIGURATION

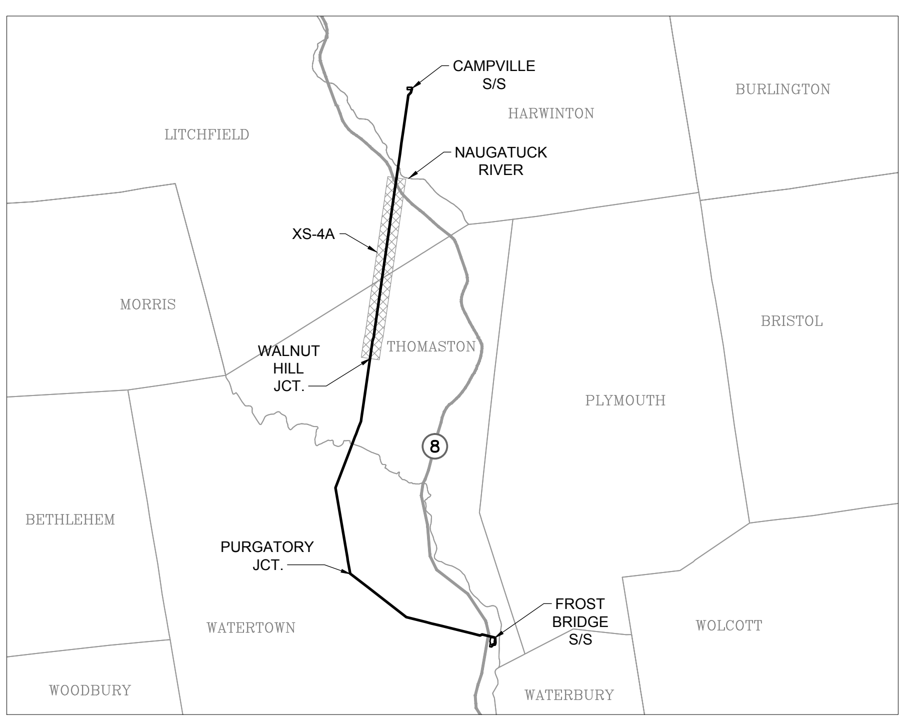
VERTICAL DESIGN

WALNUT HILL JUNCTION
TO
SOUTH BANK OF NAUGATUCK RIVER

IN THE TOWNS OF
THOMASTON & LITCHFIELD

LOOKING
NORTH

(2.5 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY
DESIGN

NOTES:

1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING CONCRETE FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL ALSO BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE VERTICAL CROSS SECTIONS
WALNUT HILL JCT. TO S. BANK OF NAUGATUCK RIVER

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-4A	
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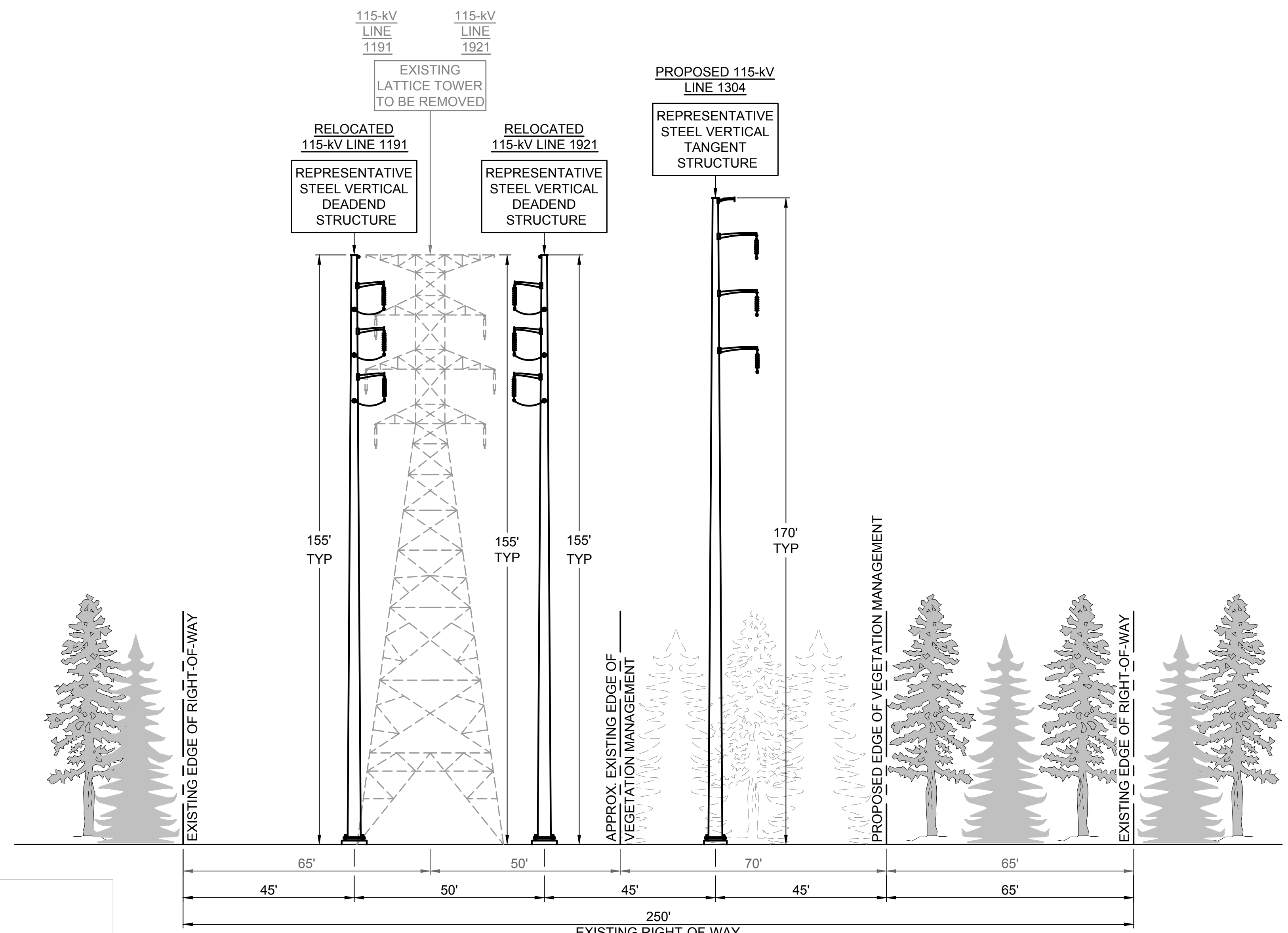


PROPOSED CONFIGURATION

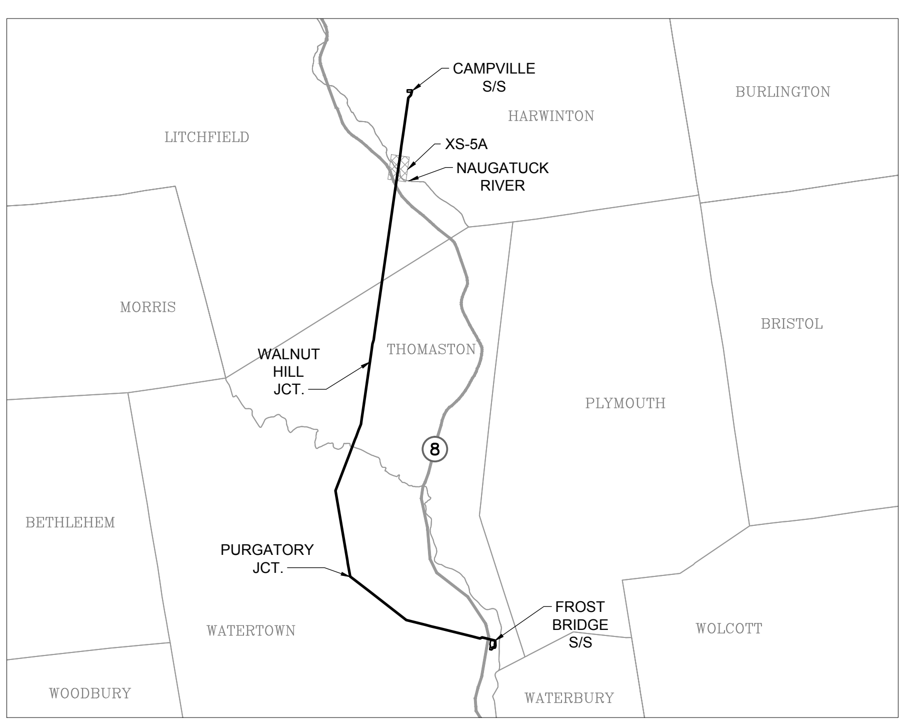
VERTICAL DESIGN

SOUTH BANK OF NAUGATUCK RIVER
TO
NORTH BANK OF NAUGATUCK RIVER

IN THE TOWNS OF
LITCHFIELD & HARWINTON

LOOKING
NORTH

(0.4 MILE)



KEY MAP
NOT TO SCALE

N

NOTES:
1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.

PRELIMINARY DESIGN

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE VERTICAL CROSS SECTIONS
S. BANK OF NAUGATUCK RIVER TO N. BANK OF NAUGATUCK RIVER

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-5A	
P.A. #			

Z:\Clients\TND\NUSC\81960_GHCC\CADD\Design\Frost Bridge-Campville\CADD\Working\Cross Sections\GHCC X-SECT VERTICAL DSGN.dwg (XS-5A) 12-16-2015 09:34 DDL B&McD

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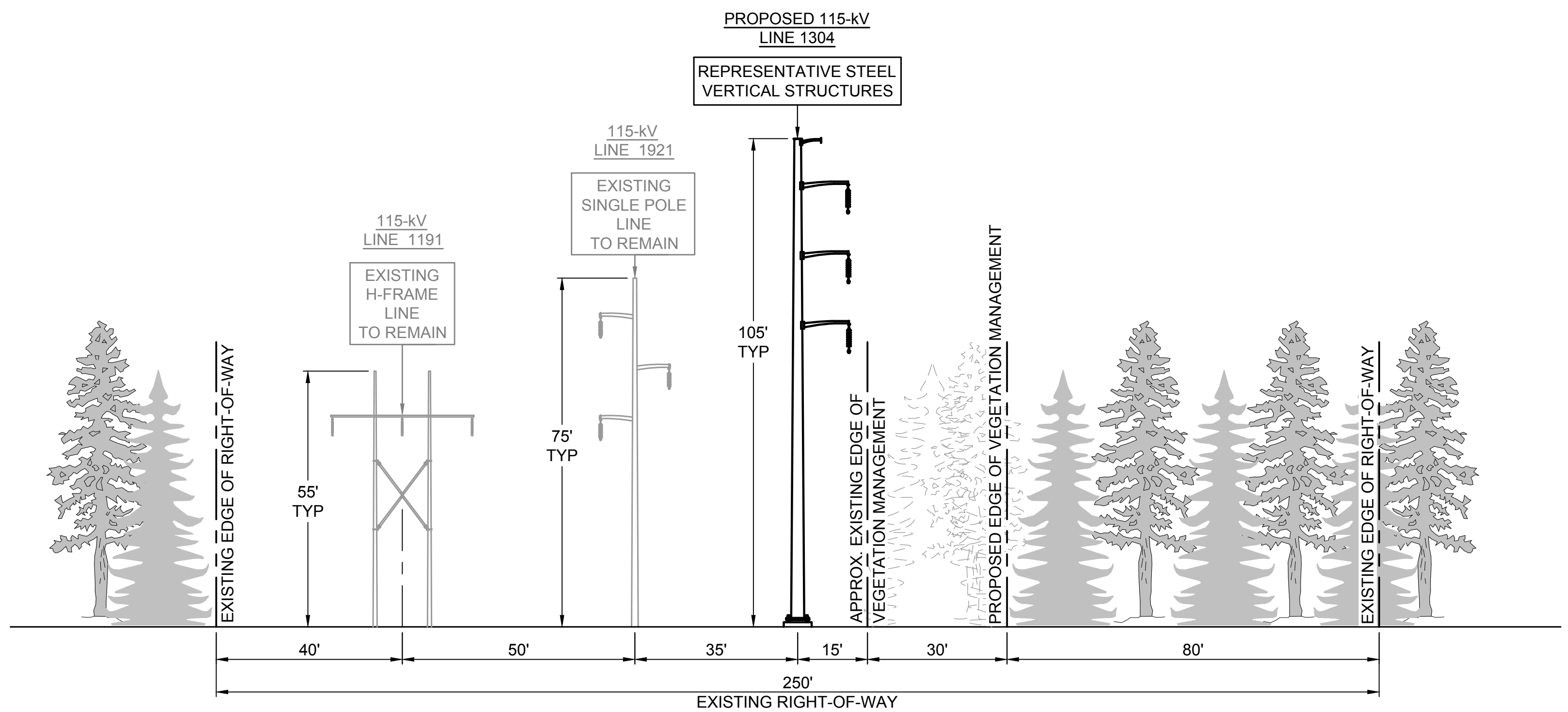


PROPOSED CONFIGURATION

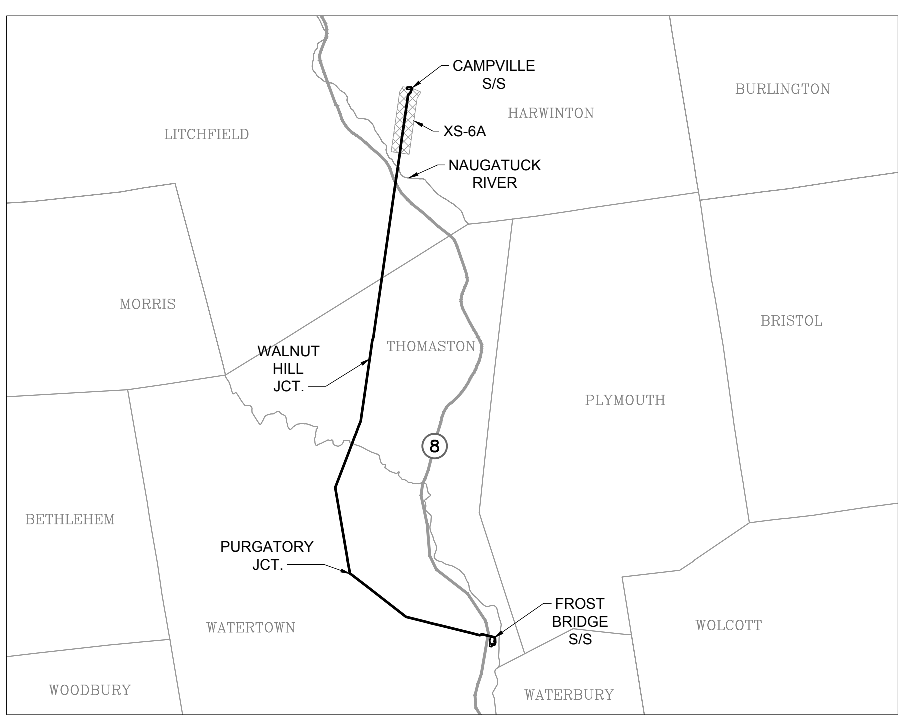
VERTICAL DESIGN

NORTH BANK OF NAUGATUCK RIVER
TO
CAMPVILLE SUBSTATION

IN THE TOWN OF
HARWINTON

LOOKING
NORTH

(1.0 MILES)



KEY MAP
NOT TO SCALE

N

PRELIMINARY
DESIGN

NOTES:

1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING CONCRETE FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL ALSO BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE VERTICAL CROSS SECTIONS
N. BANK OF NAUGATUCK RIVER TO CAMPVILLE SUBSTATION

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-6A	
P.A. #			

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Appendix 12B – H-Frame Configuration Cross-Sections

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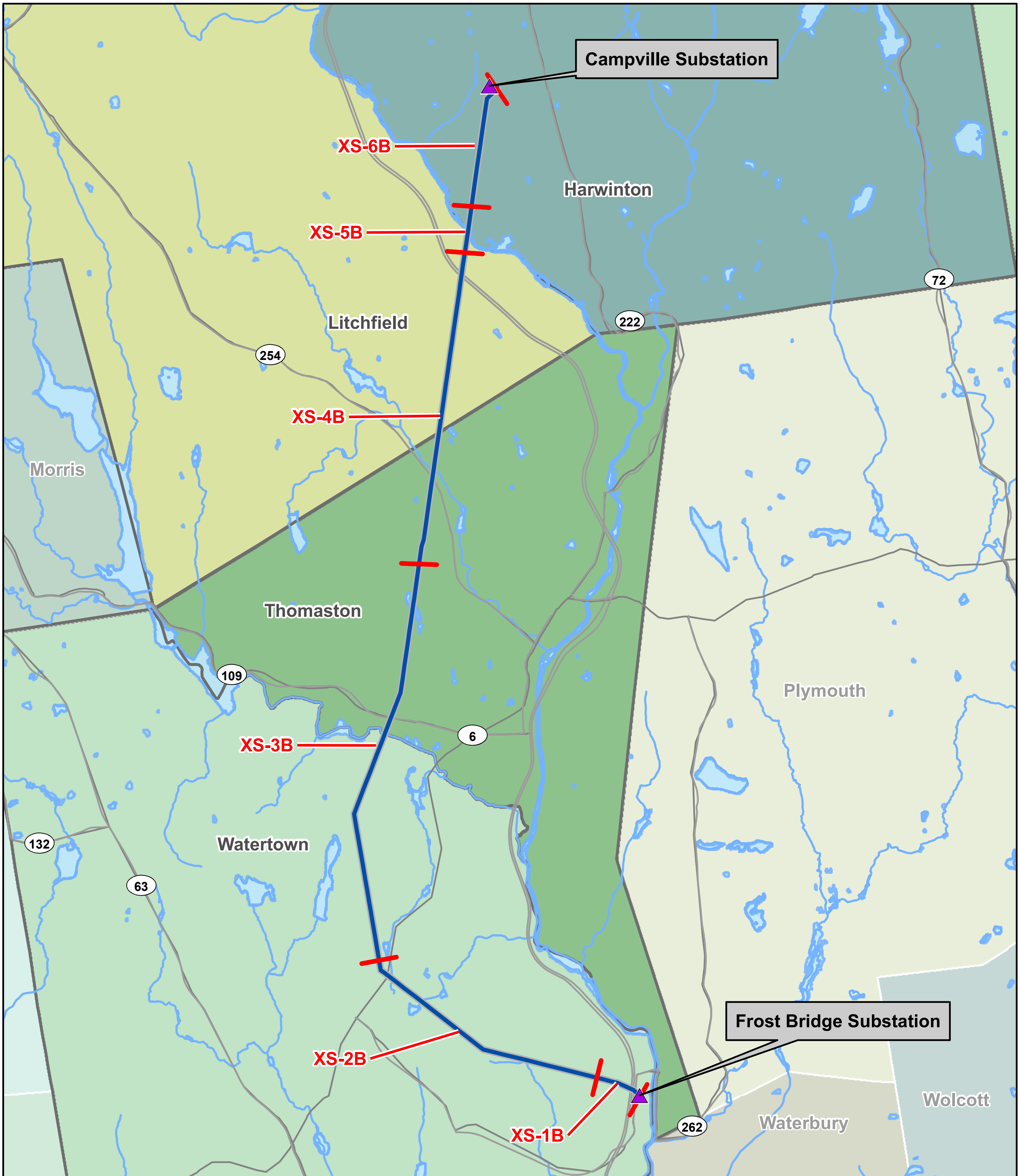

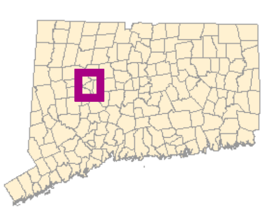

0.5 0.25 0 0.5 1 1.5
Miles

Source: CT DEEP, Tighe & Bond

EVERSOURCE ENERGY

Cross-Section Location Map

Frost Bridge to Campville 115-kV Project

G:\GIS\CT\EversourceEnergy\N0915\N0915_43_FrostbridgetoCampville_HighLevelOverview\MapDocuments\HighLevelOverview\FrostbridgetoCampville_HighLevelOverview_XSections_Letter_Portrait_B_20150903_.mxd

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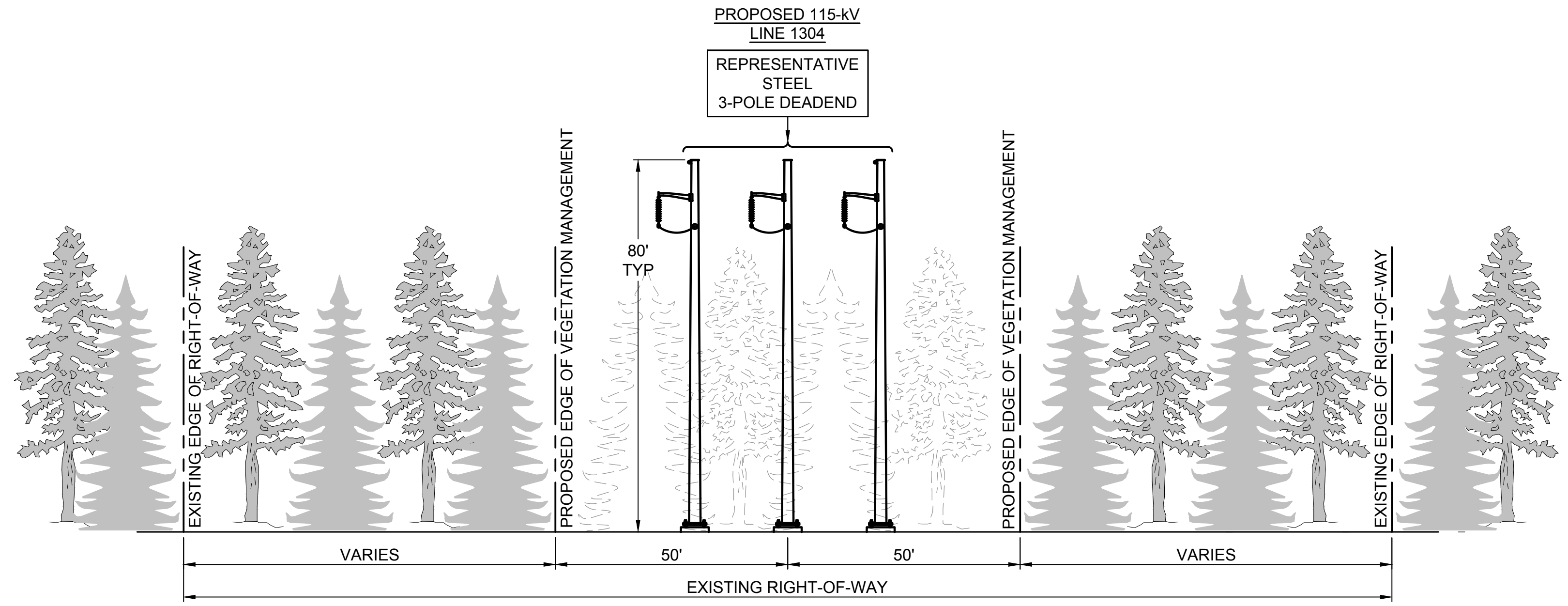


PROPOSED CONFIGURATION

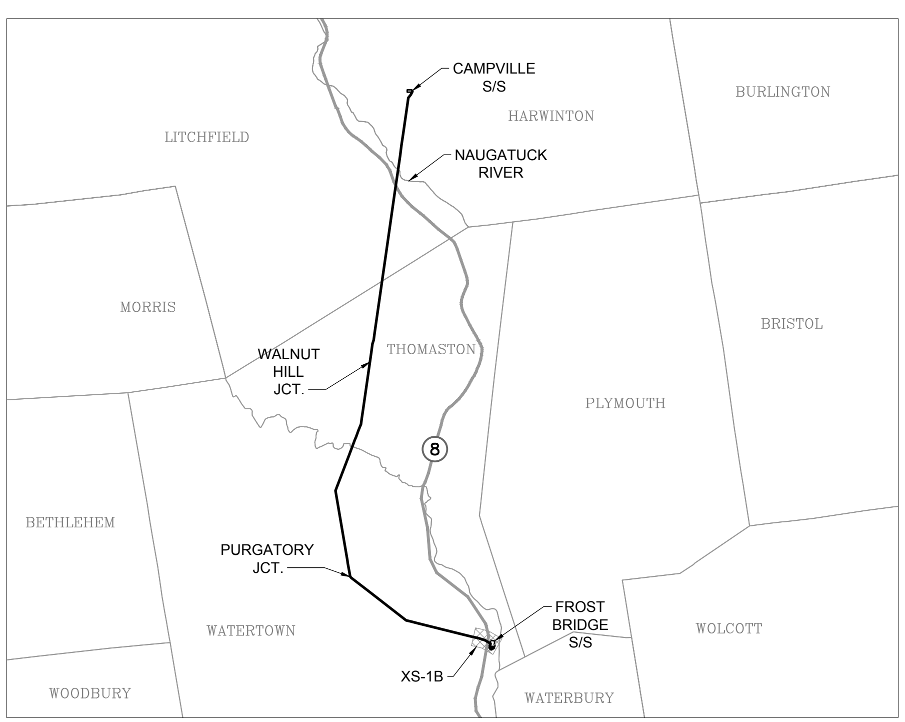
3-POLE DEADEND DESIGN

FROST BRIDGE SUBSTATION
TO
0.4 MILE OUT OF FROSTBRIDGE SUBSTATION

IN THE TOWN OF
WATERTOWN

LOOKING
EAST, NORTH AND WEST

(0.4 MILE)



KEY MAP
NOT TO SCALE

PRELIMINARY
DESIGN

NOTES:

1. NEW TRANSMISSION LINE ALIGNMENT ON EXISTING EVERSOURCE-OWNED PROPERTY.
2. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
3. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL 3-POLE DEADEND STRUCTURES TO BE PLACED ON CONCRETE FOUNDATIONS. TANGENT STRUCTURES WILL UTILIZE DIRECT EMBEDDED FOUNDATIONS, WHILE VERTICAL DEADEND STRUCTURES WILL BE PLACED ON CONCRETE FOUNDATIONS.

TITLE FROST BRIDGE TO CAMPVILLE 115-kV PROJECT PROPOSED CROSS SECTIONS FROST BRIDGE S/S TO 0.4 MILE OUT OF FROST BRIDGE S/S			
BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-1B	
P.A. #			

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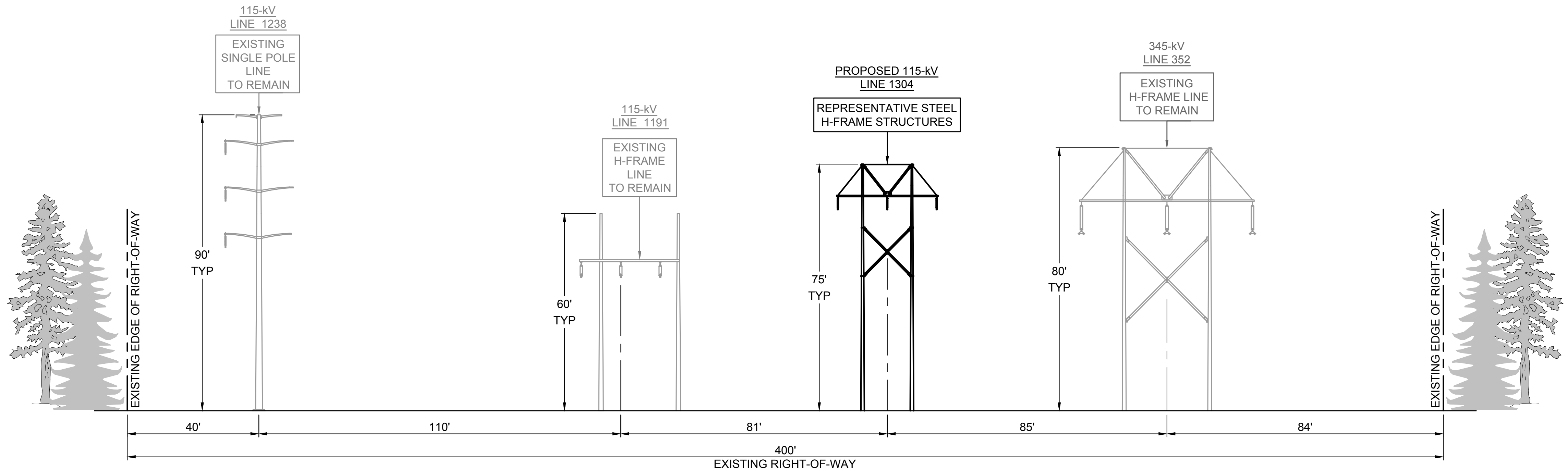


PROPOSED CONFIGURATION

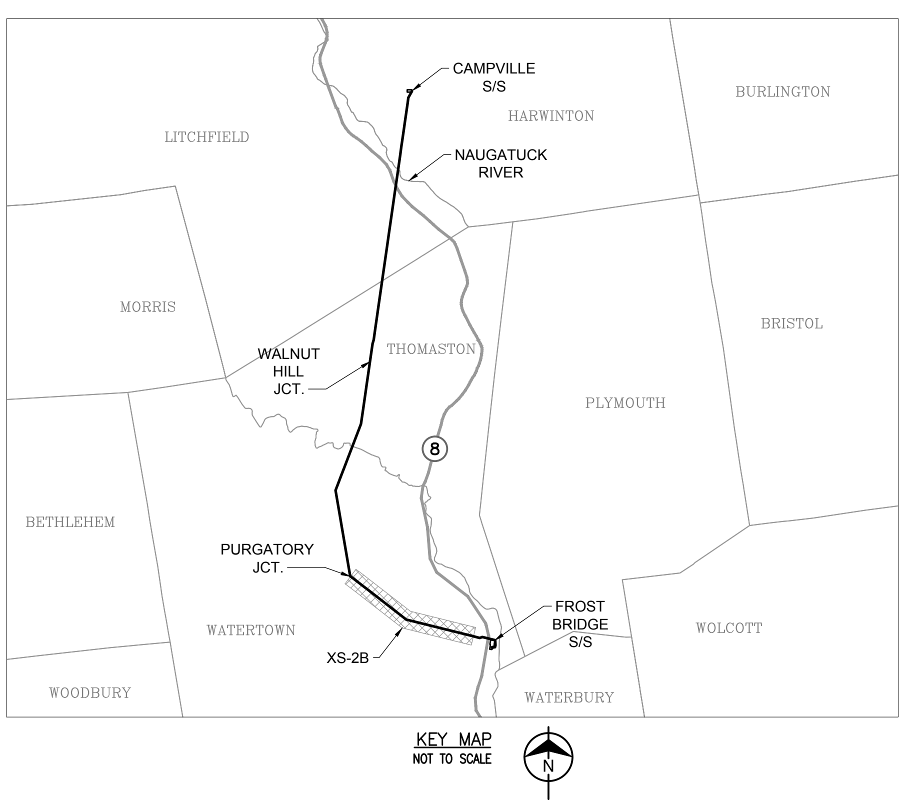
H-FRAME DESIGN

FROST BRIDGE SUBSTATION LINE EXIT
TO
PURGATORY JUNCTION

IN THE TOWN OF
WATERTOWN

LOOKING
WEST

(2.3 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY DESIGN

NOTES:
1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING DIRECT EMBEDDED FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL DIFFER AND BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE H-FRAME CROSS SECTIONS
FROST BRIDGE S/S LINE EXIT TO PURGATORY JCT.

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-2B	
P.A. #			

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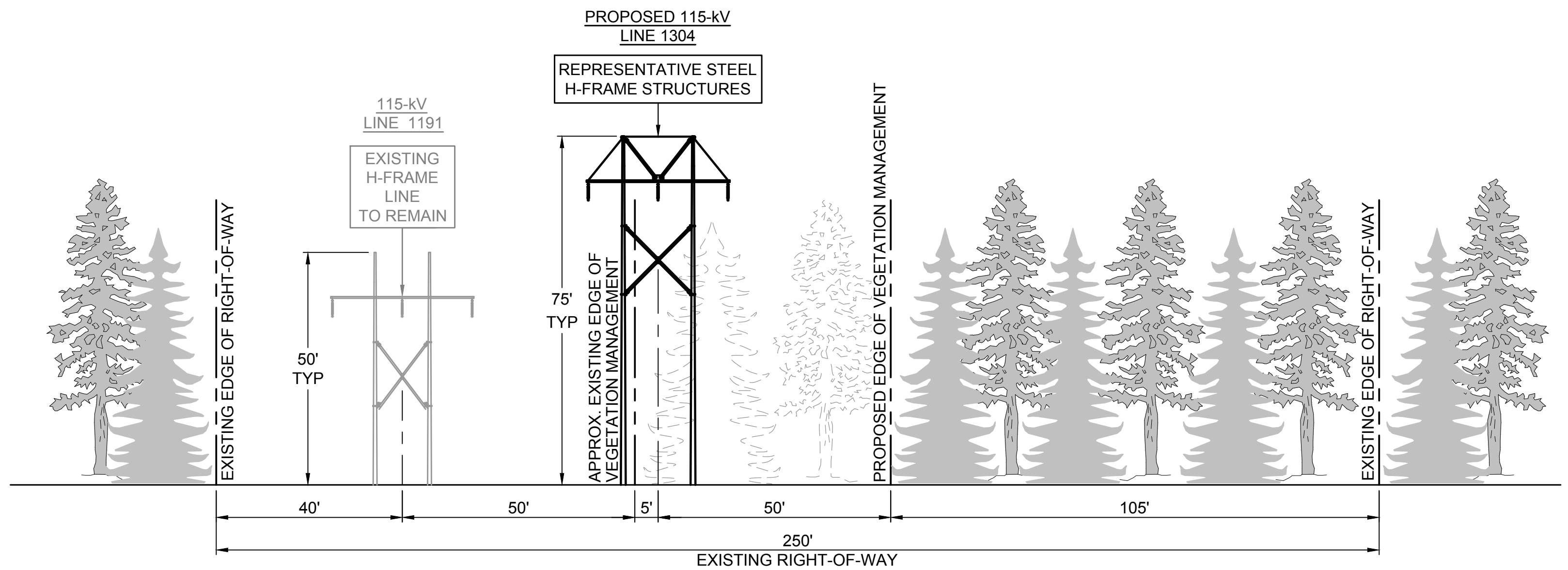


PROPOSED CONFIGURATION

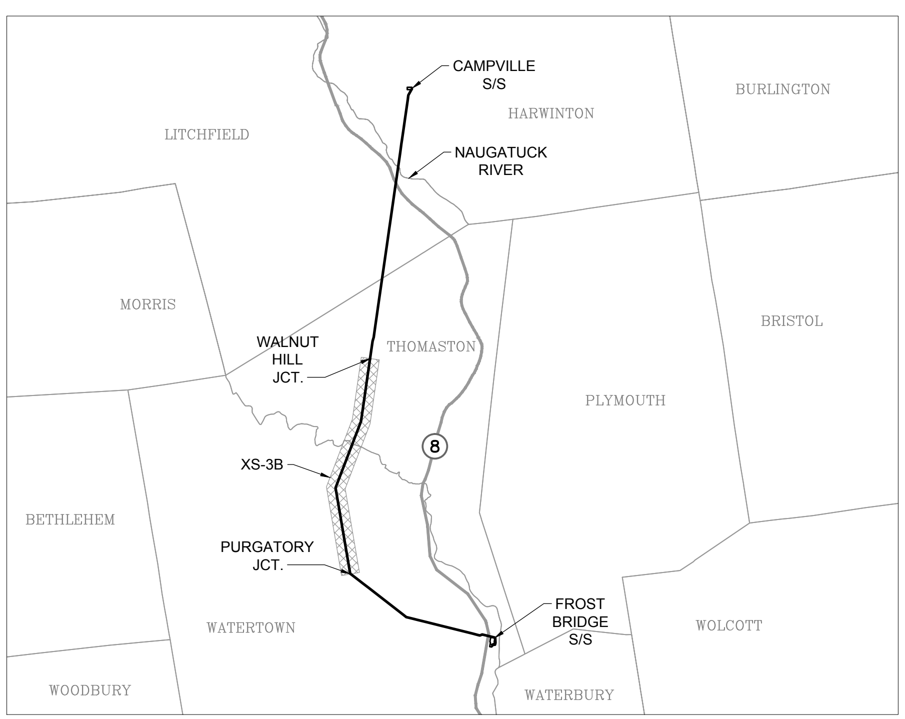
H-FRAME DESIGN

PURGATORY JUNCTION
TO
WALNUT HILL JUNCTION

IN THE TOWNS OF
WATERTOWN & THOMASTON

LOOKING
NORTH

(3.8 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY
DESIGN

NOTES:

1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING DIRECT EMBEDDED FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL DIFFER AND BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE H-FRAME CROSS SECTIONS
PURGATORY JCT. TO WALNUT HILL JCT.

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-3B	
P.A. #			

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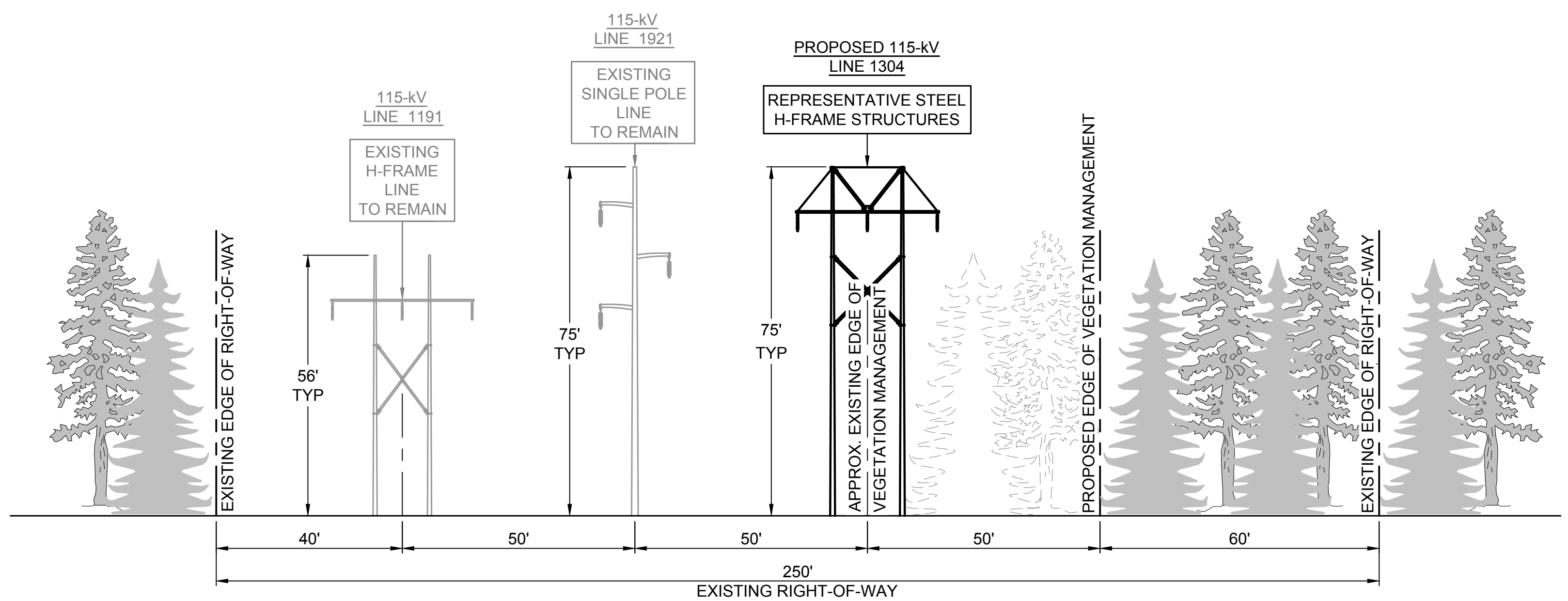


PROPOSED CONFIGURATION

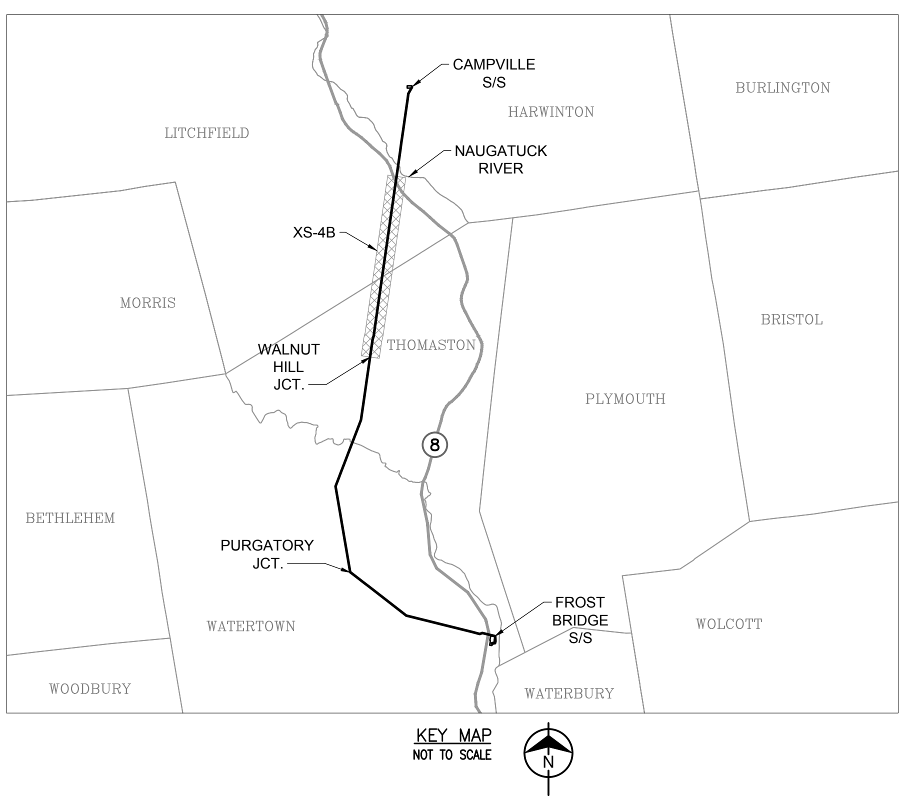
H-FRAME DESIGN

WALNUT HILL JUNCTION
TO
SOUTH BANK OF NAUGATUCK RIVER

IN THE TOWNS OF
THOMASTON & LITCHFIELD

LOOKING
NORTH

(2.5 MILES)



KEY MAP
NOT TO SCALE

PRELIMINARY
DESIGN

NOTES:

1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING DIRECT EMBEDDED FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL DIFFER AND BE PLACED ON CONCRETE FOUNDATIONS.

TITLE FROST BRIDGE TO CAMPVILLE 115-kV PROJECT ALTERNATIVE H-FRAME CROSS SECTIONS WALNUT HILL JCT. TO S. BANK OF NAUGATUCK RIVER			
BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-4B	
P.A. #			

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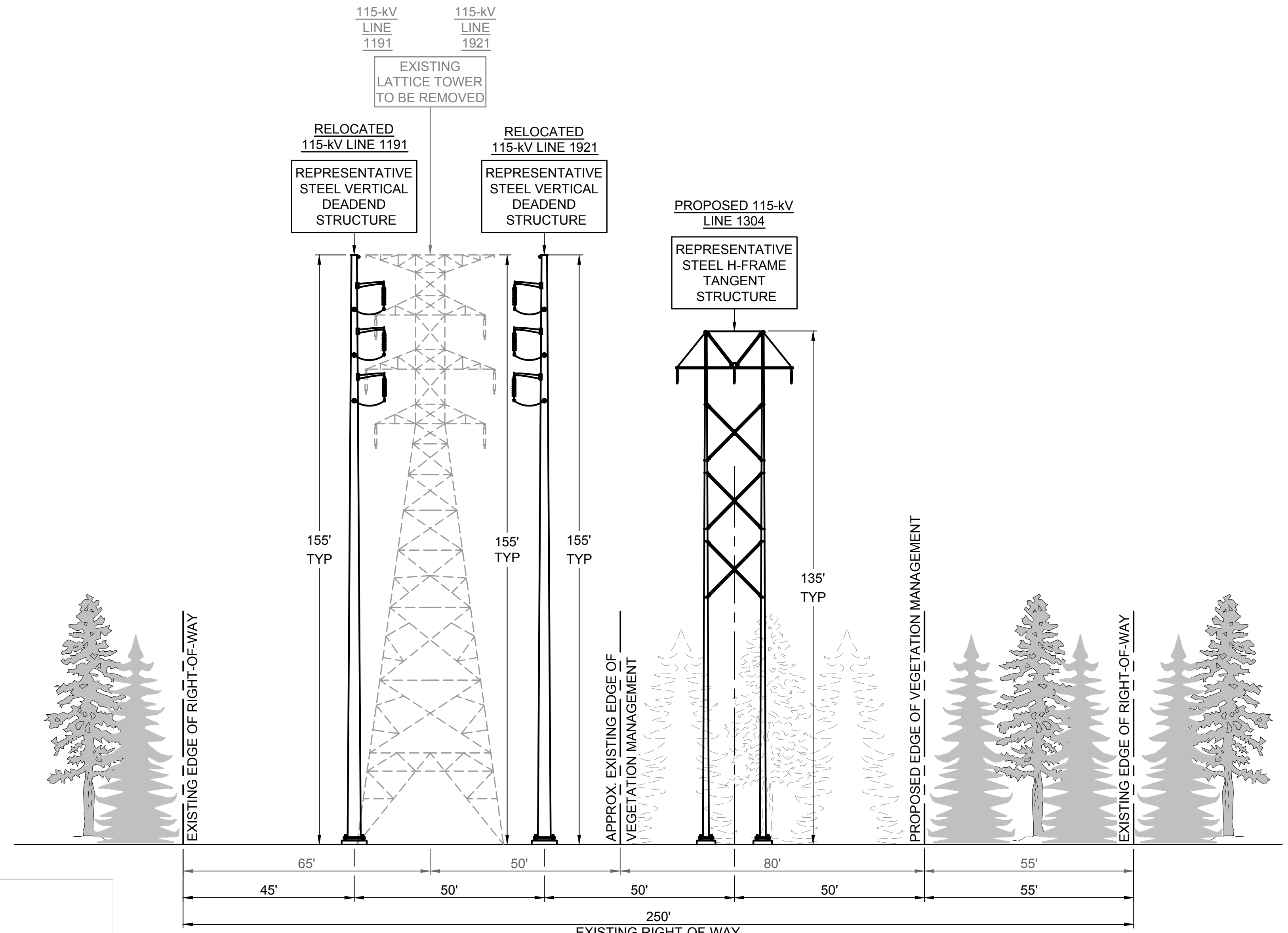


PROPOSED CONFIGURATION

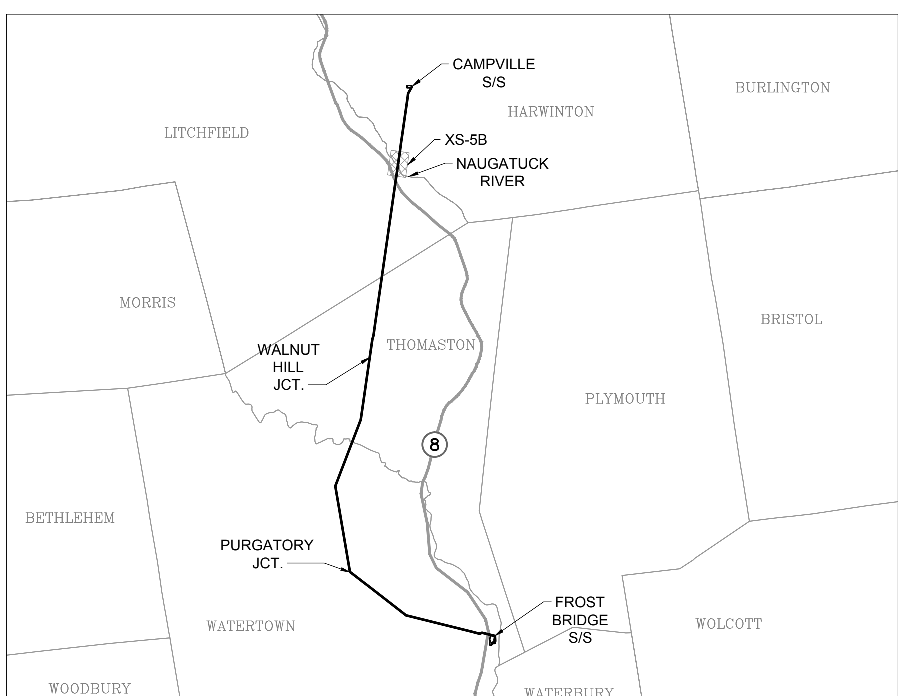
H-FRAME DESIGN

SOUTH BANK OF NAUGATUCK RIVER
TO
NORTH BANK OF NAUGATUCK RIVER

IN THE TOWNS OF
LITCHFIELD & HARWINTON

LOOKING
NORTH

(0.4 MILE)



KEY MAP
NOT TO SCALE

NOTES:
1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.

PRELIMINARY DESIGN

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE H-FRAME CROSS SECTIONS
S. BANK OF NAUGATUCK RIVER. TO N. BANK OF NAUGATUCK RIVER

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-5B	
P.A. #			

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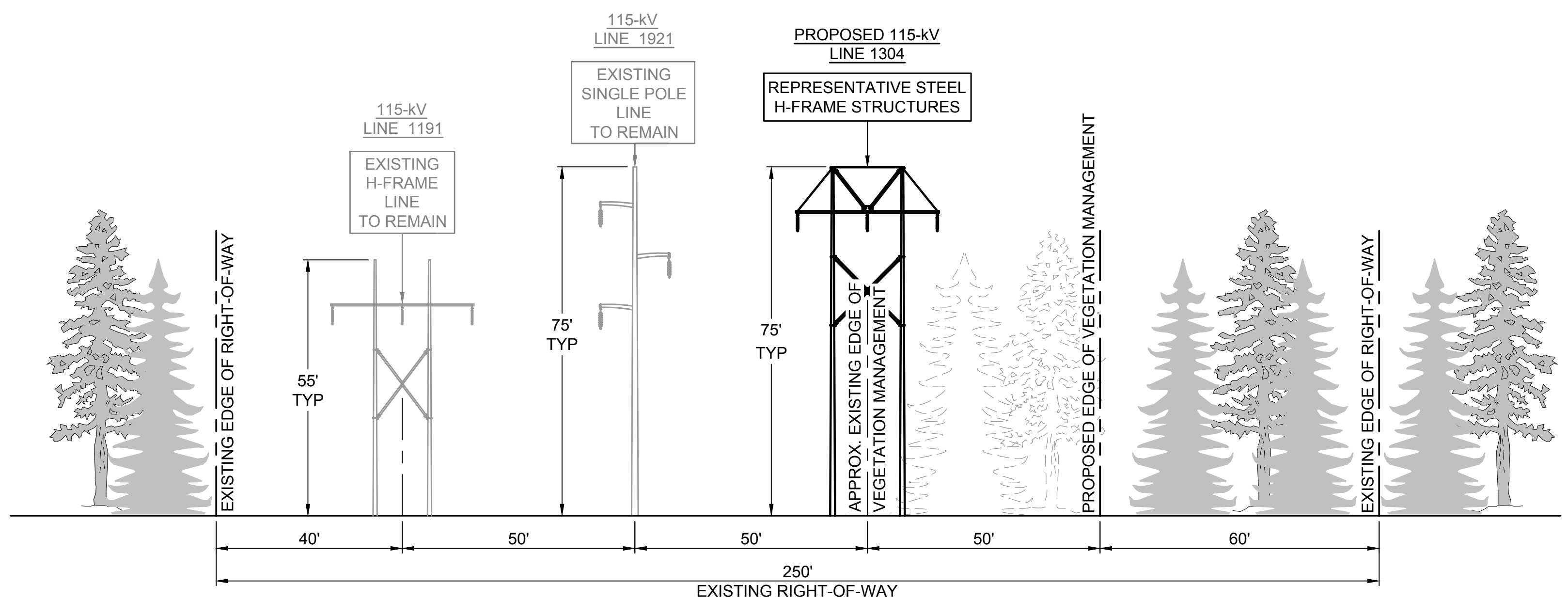


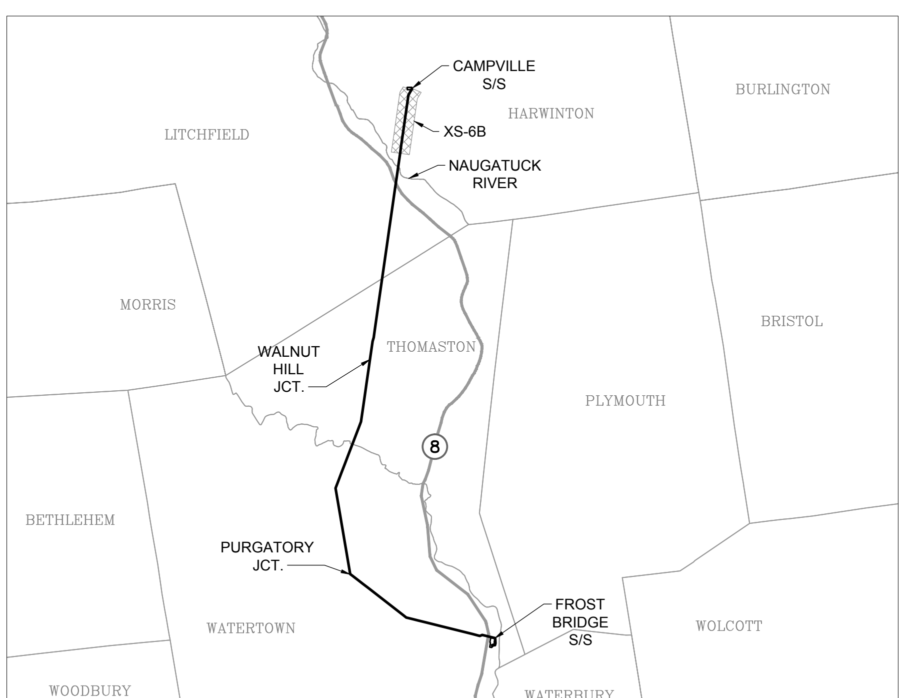
PROPOSED CONFIGURATION
H-FRAME DESIGN

NORTH BANK OF NAUGATUCK RIVER
TO
CAMPVILLE SUBSTATION

IN THE TOWN OF
HARWINTON

LOOKING
NORTH

(1.0 MILES)



KEY MAP
NOT TO SCALE

N

PRELIMINARY DESIGN

NOTES:

1. EXISTING LINES TO REMAIN.
2. PRELIMINARY STRUCTURE SPOTTING IS BASED ON STRUCTURE-FOR-STRUCTURE INSTALLATION.
3. EXISTING VEGETATION MANAGEMENT EDGES ARE TYPICAL.
4. AFTER THE CONDUCTORS HAVE BEEN INSTALLED, A REFERENCE IS ESTABLISHED THAT MAY IDENTIFY ADDITIONAL DANGER TREES OUTSIDE THE INITIALLY CLEARED AREA THAT MIGHT NEED TO BE REMOVED.
5. DEPICTED REPRESENTATIVE STRUCTURES ARE STEEL TANGENT STRUCTURES UTILIZING DIRECT EMBEDDED FOUNDATIONS. ANGLE AND DEADEND STRUCTURES WILL DIFFER AND BE PLACED ON CONCRETE FOUNDATIONS.

TITLE
FROST BRIDGE TO CAMPVILLE 115-kV PROJECT
ALTERNATIVE H-FRAME CROSS SECTIONS
N. BANK OF NAUGATUCK RIVER TO CAMPVILLE SUBSTATION

BY D. LAURSEN	CHKD V. MONTEMURRO	APP	APP
DATE 12/16/15	DATE 12/16/15	DATE	DATE
SCALE NONE	MICROFILM DATE	DWG. NO. XS-6B	
P.A. #			

Z:\Clients\TND\NUSC\81960_GHCC\Design\Frost Bridge-Campville\CADD\Working\Cross Sections\GHCC X-SECT H-FRAME DSGN.dwg (XS-6B) 12-16-2015 09:19 DDL B&McD

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13. PROPOSED SUBSTATION MODIFICATIONS: ALTERNATIVES REVIEW

To meet the Project objectives, the new 115-kV transmission line must extend between and connect to the existing Frost Bridge and Campville substations. As a result, there are no alternative, geographically distinct substation sites that could be developed or modified to achieve the Project objectives. Similarly, for the reasons summarized below, the minor modifications to the Frost Bridge and Campville substations, as proposed, would avoid or minimize environmental impacts and represent the most cost-effective and efficient approach for interconnecting the new 115-kV line to the power grid.

Both the Frost Bridge and Campville substations were developed approximately 90 years ago and each is situated within a larger parcel of Eversource-owned property. Specifically, the 5.7-acre Frost Bridge Substation is situated on a 128-acre Eversource property, whereas the existing 1.7-acre Campville Substation is located within a 42.3-acre Eversource parcel.

The Project modifications to the Frost Bridge Substation would be located within the presently developed, fenced portion of the substation. Although seven existing 115-kV lines currently connect to the Frost Bridge Substation, sufficient space is available within the fenced portion of the station to accommodate all of the equipment required to interconnect the proposed 115-kV transmission line.

However, the proposed modifications to the Campville Substation could not be accommodated entirely within the footprint of the existing substation, which includes both 115-kV and 27.6-kV facilities. As a result, Eversource proposes to expand the developed portion of the substation (extending the existing substation fence) by approximately 0.4 acre. The location of the Campville Substation expansion (i.e., on the east side of the existing station fence) is proposed based on where new Project equipment and a new control house are needed to allow interconnections to the new 115-kV transmission line, which would extend into the substation from the south.

Within the existing Campville Substation, the 115-kV facilities are located on the east side of the yard and the 27.6-kV facilities are situated on the west side of the yard. The substation's two existing energized transformers are located between the 115-kV and 27.6-kV equipment. To accommodate the facilities required to interconnect the proposed 115-kV line while adhering to industry and Eversource standards for equipment (i.e., ring bus) separation, the existing 115-kV portion of the yard must be modified and expanded. Because the existing 115-kV yard is located on the eastern portion of the substation, the most cost-effective and least environmentally intrusive option is to expand the substation to the east, as is proposed.

Alternative locations for the Campville Substation modifications (e.g., outside of the western or southern substation fence lines) would be cost-ineffective, requiring the relocation of the existing transformers and the 27.6-kV equipment. Further, expansion of the substation footprint to the west or south would require the location of the proposed new control house and other new 115-kV equipment closer to Wildcat Hill Road. In contrast, the proposed substation expansion to the east would align the expansion to the back of the existing station, away from Wildcat Hill Road.

14. GLOSSARY AND TERMS

115-kV: 115 kilovolts or 115,000 volts
345-kV: 345 kilovolts or 345,000 volts
AAL: Annual average loads
AC (alternating current): An electric current that reverses its direction of flow periodically. (In the United States this occurs 60 times a second-60 cycles or 60 Hertz.) This is the type of current supplied to homes and businesses.
ACSR: Aluminum Conductor, Steel Reinforced, a common type of overhead conductor.
ACSS: Aluminum Conductor Steel Supported, a common type of overhead conductor.
Ampere: (Amp): A unit measure for the flow (current) of electricity. A typical home service capability (i.e., size) is 100 amps; 200 amps is required for homes with electric heat.
AMSL: Above mean sea level
ANSI: American National Standards Institute
APL: Annual peak load
Arrester: Equipment that protects lines, transformers and equipment from lightning and other voltage surges by carrying the charge to ground. Arresters serve the same purpose as a safety valve on a steam boiler.
ASTM: American Society for Testing and Materials
Auxiliary Transformers: Equipment installed at substations to provide voltage or current information for relaying and/or metering purposes.
BMP: Best Management Practice
BMP Manual: Eversource's Best Management Practices Manual: Connecticut Construction & Maintenance Environmental Requirements (2011). Available via: http://www.transmission-nu.com/contractors/pdf/CT_BMP.pdf
C&D: Conservation and Development (plan)
C&LM: Conservation and Load Management.
Cable: A fully insulated conductor usually installed underground but in some circumstances can be installed overhead.
CCGT: Combined Cycle Gas Turbines
CCRP: Central Connecticut Reliability Project
CCVT: Capacitor coupling voltage transformers
CEII: Confidential Energy Infrastructure Information
CELT: ISO-NE, Forecast Report of Capacity, Energy, Loads and Transmission
Certificate: Certificate of Environmental Compatibility and Public Need (from the Connecticut Siting Council)
CFPA: Connecticut Forests and Park Association
CGS: Connecticut General Statutes
Circuit: A system of conductors (three conductors or three bundles of conductors) through which an electrical current is intended to flow and which may be supported above ground by transmission structures or placed underground.
Circuit Breaker: A switch that automatically disconnects power to the circuit in the event of a fault condition. Located in substations. Performs the same function as a circuit breaker in a home.**CL&P:** The Connecticut Light and Power Company, a legal entity authorized to provide electric transmission and distribution service in Connecticut, now known as Eversource Energy.
CLEAR: Center for Land Use Education and Research
CLL: Critical Load Level
CMEEC: Connecticut Municipal Electrical Cooperative

ConnDOT: Connecticut Department of Transportation

Conductor: A metallic wire, busbar, rod, tube or cable that serves as a path for electric current flow.

Conduit: Pipes, usually PVC plastic, typically encased in concrete, for housing underground power cables.

Contingency: The unexpected failure or outage of a system component, such as a generator, transmission line, circuit breaker, switch or other electrical element

Conversion: Change made to an existing transmission line for use at a higher voltage, sometimes requiring the installation of more insulators. (Lines are sometimes pre-built for future operation at the higher voltage.)

CONVEX: Connecticut Valley Electric Exchange.

Corona: A luminous discharge due to ionization of the air surrounding conductors, hardware, accessories, or insulators caused by a voltage gradient exceeding a certain critical value. Surface irregularities such as stranding, nicks, scratches, and semiconducting or insulating protrusions are usual corona sites, and weather has a pronounced influence on the occurrence and characteristics of overhead power-line corona.

Council: Connecticut Siting Council

CT DEEP: Connecticut Department of Energy and Environmental Protection

CTH: Critical terrestrial habitat

CWA: Clean Water Act (federal)

D&M Plan: Development and Management Plan (required by the Connecticut Siting Council)

dBA: Decibel, on the A-weighted scale.

DBH: Diameter breast height

DC: (direct current): Electricity that flows continuously in one direction. A battery produces DC power.

DCT: Double-circuit transmission line

Deadend Structure: A line structure that is designed to have the capacity to hold the lateral strain of the conductor in one direction

Demand: The total amount of electricity required at any given time by an electric supplier's customers.

DESPP: Department of Emergency Services and Public Protection (Connecticut)

DG: Distributed Generation. Refers to modular electric generation or storage, located near the point of electric use, and generally involves the use of small generators located close to electric demand sources, to decrease end-users' electric purchases and to reduce the need for electricity generated by large, centrally-located power plants and power transport to load centers on transmission lines.

Distribution: Line, system. The facilities that transport electrical energy from the transmission system to the customer.

Disconnect Switch: Equipment installed to isolate circuit breakers, transmission lines or other equipment for maintenance or sectionalizing purposes.

DR: Demand response

DRP: Demand-response program.

DRSP: Demand-response service provider

DSM: Demand side management

Duct: Pipe or tubular runway for underground power cables (see also Conduit).

Duct Bank: A group of ducts or conduit usually encased in concrete in a trench.

DVP: Decoy vernal pool

Electric Field: Produced by voltage applied to conductors and equipment. The electric field is expressed in measurement units of volts per meter (V/m) or kilovolts per meter (kV/m); 1 kV/m is equal to 1,000 V/m.

Electric Transmission: The facilities (69 kV+) that transport electrical energy from generating plants to distribution substations.

EMF: Electric and magnetic fields.

EMF BMPs: Electric and Magnectic Fields Best Management Practices for the Construction of Electri Transmission Lines in Connecticut.

EPA: United States Environmental Protection Agency
EPAct: Electric Policy Act of 2005
ERO: Electric Reliability Organization
ESRI: Environmental Systems Research Institute, Inc. (database of environmental information)
Eversource: also referred to as "the **Company**": The Connecticut Light and Power Company doing business as Eversource Energy.
Eversource Service: Eversource Energy Service Company (formerly, Northeast Utilities Service Company); a company within the Eversource Energy organization that provides services to the public utility subsidiaries, such as Eversource and to the other subsidiaries of Eversource Energy.
FAA: Federal Aviation Administration
Fault: A failure (short circuit) or interruption in an electrical circuit.
FCM: Forward Capacity Market
FEMA: Federal Emergency Management Agency
FERC: Federal Energy Regulatory Commission
FMD: Field Management Design (Plan) (for EMF)
FTB: Fluidized thermal backfill
G: Gauss; 1G = 1,000 mG (milligauss); the unit of measure for magnetic fields.
GHCC: Greater Hartford Central Connecticut
GIS: Geographic Information System
GPS: Global Positioning System
Ground Wire: Cable/wire used to connect wires and metallic structure parts to the earth. Sometimes used to describe the lightning shield wire.
GSRP: Greater Springfield Reliability Project (part of NEEWS)
HAER: Historic American Engineering Record
HDD: Horizontal directional drill
H-frame Structure: A wood or steel structure constructed of two upright poles with a horizontal cross-arm and bracings.
HPFF Pipe Cable System: High-pressure fluid-filled; a type of underground transmission line.
HVDC: High voltage direct current
Hz: Hertz, a measure of alternating current frequency; one cycle/second.
ICES: International Committee on Electromagnetic Safety, a committee of the Institute of Electrical and Electronics Engineers)
ICNIRP: International Council on Non-Ionizing Radiation Protection, a specially chartered independent scientific organization
IEEE: Institute of Electrical and Electronics Engineers
IFR: Instrument Flight Rules
Impedance: The combined resistance and reactance of the line or piece of electrical equipment which determines the current flow when an alternating voltage is applied
Interstate: Interstate Reliability Project (also, IRP)
iPac: Information, Planning, and Conservation System (USFWS)
ISO: Independent System Operator
ISO-NE: Independent System Operator New England, Inc. New England's independent system operator.
kcmil: 1,000 circular mils, approximately 0.0008 sq. in.
kV: kilovolt, equals 1,000 volts
kV/m: Electric field unit of measurement (kilovolts/meter)
Lattice-type Structure: Transmission or substation structure constructed of lightweight steel members.
LEI: London Economics International, LLC
Lightning Shield Wire: Electric cable located to prevent lightning from striking transmission circuit conductors.

Line: A series of overhead transmission structures that support one or more circuits; or in the case of underground construction, a duct bank housing one or more cable circuits.

LMP: Locational marginal pricing

Load: Amount of power delivered as required at any point or points in the system. Load is created by the power demands of customers' equipment (residential, commercial, industrial).

Load Pocket: A load area that has insufficient transmission import capacity and must rely on out-of-merit order local generation.

LOLE: Loss of Load Expectation; a measure of bulk-power system reliability.

LPP: Laminated paper-polypropylene; a type of cable insulation.

LSR: Local Sourcing Requirement

LTE: Long-term Emergency (rating on transmission line)

Magnetic Field: Produced by the flow of electric currents; however, unlike electric fields, most materials do not readily block magnetic fields. The level of a magnetic field is commonly expressed as magnetic flux density in units called gauss (G), or in milligauss (mG), where 1 G = 1,000 mG.

Magnetic Flux Density: See Magnetic Field

Manhole: See Splice Vault

MCF: Municipal Consultation Filing (required by Connecticut Siting Council)

MF: Magnetic field

MHG: Material Handling Guidelines

mG: milligauss (see Magnetic Field)

MRA: Market Resource Alternatives

MVA: (Megavolt Ampere) Measure of electrical capacity equal to the product of the voltage times the current times the square root of 3. Electrical equipment capacities are sometimes stated in MVA.

MVAR: (Megavolt Ampere Reactive) Measure of reactive power.

MW(s): (Megawatt(s)) One megawatt equals 1 million watts, measure of the work electricity can do.

MWh: Megawatt hour

NAAQS: National Ambient Air Quality Standards

NDDB: Connecticut Natural Diversity Data Base (CT DEEP)

NECCOG: Northeastern Connecticut Council of Governments

NEEWS: New England East – West Solution

NEPOOL: New England Power Pool

NERC: North American Electric Reliability Council, Inc. (initially, the National Electric Reliability Council)

NESC: National Electrical Safety Code

NGVD: National Geodetic Survey Datum

NHD: National Hydrography Database

NHPA: National Historic Preservation Act

NPCC: Northeast Power Coordinating Council

NPH: Notice of Presumed Hazard (FAA)

NPS: United States National Park Service

NRCS: Natural Resources Conservation Service (United States Department of Agriculture)

NRHP: National Register of Historic Places

NTAs: Non-transmission alternatives

NU: Northeast Utilities (former name of Eversource Energy)

NHCOG: Northwest Hills Council of Governments

NVCOG: Naugatuck Valley Council of Governments

NWCT: Northwest Connecticut (electric sub-area); includes more than 20 towns

NWI: National Wetlands Inventory

NY-ISO: New York Independent System Operator

OH (Overhead): Electrical facilities installed above the surface of the earth.

OOS: Out-of-service (as in a generating unit or station)
OPGW: Optical groundwire (a shield wire containing optical glass fibers for communication purposes)
PAC: Planning Advisory Committee (ISO-NE)
PDAL: Peak average daily loads
PEM: Palustrine emergent (wetlands)
PFO: Palustrine forested (wetlands)
Phases: Transmission (and some distribution) AC circuits are comprised of three phases that have a voltage differential between them.
POW: Palustrine open water (wetlands)
Protection/Control Equipment: Devices used to detect faults, transients and other disturbances in the electrical system in the shortest possible time. They are customized or controlled per an entity's operational requirements.
PSI: Pounds per square inch
PSS: Palustrine scrub-shrub (wetlands)
PT: Potential transformer
PTF: Pool Transmission Facilities
PUB: Palustrine unconsolidated bottom (wetlands)
PURA: Public Utilities Regulatory Authority (part of CT DEEP)
PVC: Polyvinyl chloride (conduits for XLPE-insulated cable)
Reactive Power: The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current lines and equipment owing to their inductive and capacitive characteristics. Reactive power is provided by generators, synchronous condensers, and capacitors, absorbed by reactive loads, and directly influences electric system voltage. Shunt capacitor and reactor capacities are usually stated in MVAR.
Rebuild: Replacement of an existing overhead transmission line with new structures and conductors generally along the same route as the replaced line.
Reconductor: Replacement of existing conductors with new conductors, but with little if any replacement or modification of existing structures.
RGGI: Regional Greenhouse Gas Initiative
Reinforcement: Any of a number of approaches to improve the capacity of the transmission system, including rebuild, reconductor, conversion and bundling methods.
RFP: Request for Proposal
RIRP: Rhode Island Reliablity Project
ROW: Right-of-Way; as used in this document, a defined strip of land over which Eversource has rights to construct, operate, and maintain electric transmission lines, together with various ancillary rights. Typically, these rights have been conveyed to Eversource by the owner of the underlying land. In some cases, Eversource may own the land itself in fee.
RPS: Renewable Portfolio Standards
RSP: Regional System Plan prepared annually by ISO-NE.
RTE: Rare, threatened and endangered (see also T&E)
RTEP: Regional Transmission Expansion Plan
SCADA: Supervisory Control and Data Acquisition
SGCN: Species of Greatest Conservation Need (as classified by Connecticut's Wildlife Action Plan [WPA])
Shield Wire: See Lightning Shield Wire
SHPO: State Historic Preservation Office
SNE: Southern New England
Splice: A device to connect together the ends of bare conductor or insulated cable.
Splice Vault: A buried concrete enclosure where underground cable ends are spliced and cable-sheath bonding and grounding is installed.
SRHP: State Register of Historic Places

S/S (Substation): A fenced-in yard containing switches, transformers, line-terminal structures, and other equipment enclosures and structures. Adjustments of voltage, monitoring of circuits and other service functions take place in this installation.

Steel Lattice Tower: See Lattice-Type Structure

Steel Monopole Structure: Transmission structure consisting of a single tubular steel column with horizontal arms to support insulators and conductors.

Switchgear: General term covering electrical switching and interrupting devices. Device used to close or open, or both, one or more electric circuits.

Stormwater Pollution Control Plan: Is a sediment and erosion control plan that also describes all the construction site operator's activities to prevent stormwater contamination, control sedimentation and erosion, and comply with the requirements of the Clean Water Act

SWCT: Southwest quadrant of the State of Connecticut

Terminal Points: The substation or switching station at which a transmission line terminates.

Terminal Structure: Structure typically within a substation that ends a section of transmission line.

Terminator: A flared pot-shaped insulated fitting used to connect underground cables to overhead lines

T&E: Threatened and endangered species (see also RTE)

TOs: Transmission owners

Transformer: A device used to transform voltage levels to facilitate the efficient transfer of power from the generating plant to the customer. A step-up transformer increases the voltage while a step-down transformer decreases it.

Transmission Line: Any line operating at 69,000 or more volts.

UG (Underground): Electrical facilities installed below the surface of the earth.

Upgrade: See Reinforcement

USACE: United States Army Corps of Engineers (New England District)

USDA: Unites States Department of Agriculture

USFWS: United States Fish and Wildlife Service

USGS: United States Geological Survey (U.S. Department of the Interior).

VAR: Volt-ampere reactive power. The unit of measure for reactive power.

Vault: See Splice Vault.

VFR: Visual Flight Rules

V/m: volts per meter, kilovolt per meter: 1,000 V/m = 1 kVm; electric field measurement

Voltage: A measure of the push or force that transmits energy

VP: Vernal pool

VPE: Vernal pool envelope

WAP: Wildlife Action Plan (Connecticut)

Watercourse: Rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs, and all other bodies of water, natural or artificial, public or private.

Wetland: An area of land consisting of soil that is saturated with moisture, such as a swamp, marsh, or bog.

WMA: Wildlife Management Area (CT DEEP)

XS: Cross section (drawing)

XLPE: Cross-linked polyethylene (solid dielectric) insulation for transmission