Connecticut Light & Power
The Northeast Utilities System

NEW ENGLAND EAST–WEST SOLUTION

THE CONNECTICUT PORTION

OF THE INTERSTATE RELIABILITY PROJECT

BY

THE CONNECTICUT LIGHT AND POWER COMPANY

VOLUME 1A: ALTERNATIVE ANALYSES, INCLUDING ROUTE VARIATIONS
APPLICATION DIRECTORY
GLOSSARY

DECEMBER 2011

Connecticut Light & Power
The Northeast Utilities System

NEW ENGLAND EAST–WEST SOLUTION

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Connecticut Light & Power
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NEW ENGLAND EAST–WEST SOLUTION

SECTION 11

ALTERNATIVES ANALYSES: INTRODUCTION

11. ALTERNATIVES ANALYSES: INTRODUCTION

The proposed Interstate Reliability Project is the result of a comprehensive evaluation process, conducted over more than six years, by ISO-NE, National Grid, and CL&P. This process began with a determination of the need for the Project, continued with the identification and analysis of alternative transmission and non-transmission solutions for addressing the need, and subsequently included the examination of specific alternative routes and sites for the proposed transmission facilities.

This volume provides a compendium of the alternatives analyses that led to the selection of the Project, as presented in Volume 1. Specifically, the volume describes the following alternatives:

- **No Action Alternative (Section 12)**. Under this alternative, the Interstate Reliability Project would not be developed and the Southern New England electric transmission system would not be improved.

- **System Alternatives (Section 13)**. This section describes the non-transmission and transmission system alternatives that were identified and evaluated to meet the identified need. System alternatives considered included distributed generation, generation, potential use of new technology, demand-side energy management alternatives and transmission system options in Connecticut, Rhode Island, and Massachusetts. As a result of these analyses, a 345-kV transmission solution was selected that would connect CL&P's Card Street Substation, CL&P's Lake Road Switching Station, National Grid's West Farnum Substation, and National Grid's Millbury Switching Station.

- **Transmission Line Route / Configuration Alternatives (Section 14)**. After the preferred system alternative was selected for the Interstate Reliability Project, CL&P conducted detailed studies to identify and evaluate potential routes and configurations for the Connecticut portion of the proposed 345-kV transmission lines. These alternatives all necessarily had to interconnect CL&P's Card Street and Lake Road stations with the National Grid facilities. This section explains how CL&P identified and analyzed potential overhead and underground configurations and routes for the proposed 345-kV transmission facilities and why the particular facilities that comprise the Connecticut portion of the proposed Interstate Reliability Project were selected.

- **Potential Variations to the Proposed Transmission Line Configuration and Route (Section 15)**. CL&P prefers the Proposed Route and overhead transmission line configurations as described in Volume 1.[1] However, during the alternatives analysis process, six route variations and transmission line configurations were identified that could potentially be developed, replacing certain segments of the Proposed Route or overhead line design. This section presents detailed technical information, impact analyses, and estimated costs for each variation, as well as an assessment of each variation compared to the portion of the Proposed Route that would be replaced. The Volume 9 and 11 maps include environmental data for each variation, at a comparable level of detail to that presented for the Proposed Route.

- **Proposed Substation and Switching Station Modifications: Alternatives Review (Section 16)**. The proposed Project would require minor modifications to interconnect CL&P's existing stations (i.e., Card Street Substation and Lake Road Switching Station) to the new 345-kV transmission lines, as well as a modification at Killingly Substation to provide two support structures for one new line as it passes through the substation. This section reviews why there are no practical siting alternatives to the proposed modifications to these existing stations.

[1] As discussed in Volume 1, Section 10, in the Mansfield Hollow area, CL&P would be prepared to construct the new 345-kV line either as proposed (i.e., using the Proposed Configuration involving an expanded ROW) or pursuant to one of two other identified configuration options (i.e., the No ROW Expansion Option or the Minimal ROW Expansion Option).

SECTION 12

NO ACTION ALTERNATIVE

12. NO ACTION ALTERNATIVE

Under the No Action Alternative, no improvements to the existing electric supply system serving Southern New England to address the needs served by the Interstate Reliability Project would be made.

The No Action Alternative was rejected because it would not resolve the regional electric reliability problems that ISO-NE and the transmission system owners have been studying for more than six years. Under the No Action Alternative, the electric supply system in the region, particularly in Connecticut, Rhode Island, and Massachusetts, would not comply with national and regional reliability standards and criteria.

In addition, the No Action Alternative would be inconsistent with ISO-NE's determination that the Interstate Reliability Project is needed to fully integrate generation resources with loads throughout Southern New England by relieving existing transmission constraints on the transfer of power from both east-to-west and west-to-east across the region. Furthermore, under the No Action Alternative, the thermal and voltage reliability criteria violations that presently exist in Rhode Island at current load levels would continue and could be exacerbated by future increases in power demand. Finally, in the absence of the development of the Interstate Reliability Project, the Southern New England electrical system would lack the long-term flexibility to dispatch existing and future generation resources efficiently and reliably.

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SECTION 13

SYSTEM ALTERNATIVES

13. SYSTEM ALTERNATIVES

This section complies with the provision in the Council's *Application Guide* (April 2010), which requires an applicant to identify "system alternatives and the advantages and disadvantages of each." First, transmission system alternatives are discussed in Section 13.1, which describes the multi-year process by which transmission system planners led by ISO-NE, and including representatives of CL&P and National Grid, developed the optimal transmission solution for the Interstate Reliability Project component of the NEEWS Plan. In the course of that process, many other potential transmission solutions were developed and evaluated. Some of those potential solutions required extensive testing and evaluation before a preferred solution emerged. The potential transmission alternatives that received such close evaluation are identified and described, and the reasons why the proposed Project was selected from them are provided.

Next, in Section 13.2, the evaluation of potential non-transmission system alternatives (NTAs) is discussed. NTAs include the addition of generation resources, often referred to as a "supply-side" measure, and strategies to reduce load, often referred to as demand-side management or "DSM" measures.

13.1 TRANSMISSION ALTERNATIVES

The consideration of transmission system alternatives to meet the need addressed by the Project was conducted in three phases. In the first phase, the ISO-NE Working Group identified several alternative "options" that would meet threshold system performance requirements for the Interstate Reliability Project element of the NEEWS Plan. This work is described generally in Volume 1, Section 2, and is described in detail in the ISO-NE Report entitled *New England East-West Solutions (Formerly Southern New England Transmission Reliability) Report 2, Options Analysis*, which is referred to in this filing as the *2008 Options Analysis*[1]. The *2008 Options Analysis* was issued in April 2008, after drafts had been published for stakeholder comment.

In the second phase, CL&P and National Grid as the Transmission Owners (TOs) conducted detailed analyses to select a preferred option from the alternatives initially identified by the Working Group. This work is described in detail in a report entitled "*Solution Report for the Interstate Reliability Project*," dated August 2008 (the *2008 Initial Solution Report*) and will be briefly summarized in this section.

The third phase occurred after ISO-NE reevaluated the need for the Interstate Reliability Project in 2010 and 2011. As explained in Volume 1, Section 2, and in detail in ISO-NE's report entitled *New England East West Solution (NEEWS) Interstate Reliability Component Updated Needs Assessment* (April 2011) (*2011 Needs Re-analysis*), this reevaluation identified a need for improvements to the Project as then designed, which would provide additional capability for transferring power from West to East across the New England East-West Interface.

Therefore, the ISO-NE Working Group reconsidered how the original options could be adapted to serve the enhanced need identified in the 2011 *Needs Re-analysis* and developed a redesigned solution for the enhanced need.[2] The Working Group's analysis and conclusions were presented to the ISO-NE Planning Advisory Committee on November 30, 2010, and are described in detail in a report by ISO-NE entitled *New England East-West Solution (NEEWS): Interstate Reliability Project Component Updated Transmission Analysis Solution Study Report*. A draft of this report (the *2011 Updated Solution Study Report*) was posted for review by ISO-NE stakeholders on November 22, 2011 and is expected to become

1 Copies of the 2008 *Options Analysis*, and the *2008 Initial Solution Report*, are provided as part of Volume 5 of this Application. These copies have been redacted to protect Critical Energy Infrastructure Information (CEII). Complete copies will be provided to the Council and qualified participants in the proceeding on this Application pursuant to a protective order that CL&P expects will be entered in the proceeding.

2 For this task, the original ISO-NE Working Group composed of planners from ISO-NE, NUSCO, and National Grid (*see*, Vol. 1, sec. 2.4.1) was expanded by the inclusion of planners from NSTAR, a Massachusetts electric public utility which owned facilities that could have been affected by some of the alternative configurations to be considered.

final on December 23, 2011. When that report has been published and redacted to protect CEII, CL&P will supplement this Application by filing copies with the Council and serving copies on the participants in the proceeding to be held on this Application. Un-redacted copies will be available to participants in the Council proceedings pursuant to a protective order and to other qualified recipients who enter into confidentiality agreements.

13.1.1 The Working Group's 2008 *Options Analysis*

The 2008 *Options Analysis* identified five options as meeting the basic performance requirements that had been identified in the *2008 Needs Analysis* for the Interstate Reliability Project component of NEEWS - strengthening the ties between the southern New England states and increasing the ability to move power between eastern and western New England and into the State of Connecticut. These five options were briefly described as follows:

- **Interstate Option A –** A new 345-kV transmission line from the Millbury Switching Station in Millbury, Massachusetts to the West Farnum Substation in North Smithfield, Rhode Island, to the Lake Road Switching Station in Killingly, Connecticut, and then to the Card Street Substation in Lebanon, Connecticut.

- **Interstate Option B** – A new 345-kV transmission line from the West Farnum Substation to the Kent County Substation in Warwick, Rhode Island and then to the Montville Substation in Montville, Connecticut. (The 345-kV transmission line from the West Farnum Substation to the Kent County Substation is part of the Rhode Island Reliability Project.)

- **Interstate Option C –** A new 345-kV transmission line from the Millbury Switching Station to the Carpenter Hill Substation in Charlton, Massachusetts and then to the Manchester Substation in Manchester, Connecticut. This plan also required a new 345-kV line from Sherman Road Switching Station to West Farnum Substation to completely address all the needs identified.

- **Interstate Option D –** A new 345-kV transmission line from the Millbury Switching Station in Millbury, Massachusetts to the Carpenter Hill Substation in Charlton, Massachusetts and then to the Ludlow Substation in Ludlow, Massachusetts. The plan also includes a line from the Ludlow Substation to the Agawam Substation in Agawam, Massachusetts to the North Bloomfield Substation in Bloomfield, Connecticut. (The 345-kV transmission line from the Ludlow Substation to the Agawam Substation to the North Bloomfield Substation was part of the Greater Springfield Reliability Project component.). This plan also required a new 345-kV line from Sherman Road Switching Station to West Farnum Substation and reconductoring/rebuilds of an existing 345-kV line from Sherman Road to the Connecticut/Rhode Island border and from Ludlow Substation to Manchester Substation to completely address all the needs identified.

- **Interstate Option E –** A new 1,200-MW high-voltage direct-current (HVDC) transmission line between the Millbury Switching Station in Millbury, Massachusetts and the Southington Substation in Southington, Connecticut. This plan also required a new 345-kV line from Sherman Road Switching Station to West Farnum Substation to completely address all the needs identified.

The above descriptions of the five options include only the major new or rebuilt facilities that were added with each option. The *2008 Options Analysis* recognized that each of these five Interstate Reliability Project options would have to meet a set of threshold system objectives, but also that each option "offer[ed] different advantages and disadvantages compared with the other options in terms of system performance." The *2008 Options Analysis* did not consider the cost, constructability, or routing aspects of each option.

13.1.2 The Transmission Owners' *2008 Initial Solution Analysis*

The TOs further analyzed the five original options in detail as described in the *2008 Initial Solution Report.* In the course of this analysis, the TOs identified two distinct routes for one of the electrical options (Option C), so that the total number of options evaluated became six. Figure 13-1 illustrates these six Interstate Options. A compressed summary of the TO's analysis of these six Options, which is set forth in detail in the *2008 Initial Solution Report,* is provided here.

Each alternative solution was first evaluated based on its ability to meet threshold planning and operating objectives and its projected capital cost. Then, the TO's analyzed how the locations of each set of the proposed new transmission facilities would potentially affect the human and natural environments. Winnowing down these options did not require the development of equally detailed routing, constructability, and environmental information for all options. Where technical and/or cost analyses were sufficient to eliminate an option, a full environmental analysis was not required.

Figure 13-1: Location Maps of Six Interstate Options

Interstate Option A

Interstate Option B

Interstate Option C-1

Interstate Option C-2

Interstate Option D

Interstate Option E

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During the evaluation process, Option E, the HVDC solution, was the first option to be eliminated, on grounds of system integration limitations, performance disadvantages, and excessive cost. Being an HVDC facility, this option provides very little flexibility in terms of expandability because any expansion of an HVDC system would involve an additional converter station. This solution was ranked fourth amongst the five major alternatives in thermal and voltage performance, indicating that it had lesser longevity.

Option B would include a new 345-kV line from Kent County, Rhode Island to Montville, Connecticut, paralleling the coastal area. This option was eliminated from consideration due to inferior system benefits and higher cost. Compared to the other five options, Option B had the greatest number of highly loaded lines and low system voltages after contingencies. This option also had the smallest increase in N-1 transfer capability into Connecticut and across the East-West interface. All of these factors led to this option being eliminated from consideration.

After the initial elimination of Options B and E, the remaining three options (i.e., Option A, Option C, and Option D) were analyzed. All three options were among the top three in terms of thermal loading, voltage performance, and ability to transfer more power into Connecticut and western New England.

Option A was recognized as a likely preferred solution because of the following factors.[3]

- It comfortably exceeded the objective design criteria or "targets" of the *2008 Needs Analysis,* and its system performance, measured by these metrics, was substantially equivalent to or better than that of the other AC options.
- It reinforced the electrical connection between Massachusetts and Rhode Island and between Connecticut and Rhode Island for the benefit of all, providing each with more access to competitive power markets and potential access to renewable energy sources.
- It improved access to newer, more efficient generation resources in southeastern Massachusetts – an area known to have excess generation.

[3] Some of these factors (e.g. construction on existing rights-of-way) are not unique to Option A.

- By extending to Millbury, it created a platform for accessing lower cost, low-emission, and renewable generation sources in Northern New England and Canada.
- It also provided access to the natural gas pipeline paths in northeastern Connecticut, northern Rhode Island and southern Massachusetts, near where future generation is proposed.
- It established a new supply source to Rhode Island, thereby increasing the reliability of the Rhode Island system.
- It established a 345-kV loop around several large generators in central Massachusetts, by connecting National Grid's Millbury Switching Station with its West Farnum Substation and with NSTAR's West Medway Substation, thereby improving the reliability of the supply from those sources.
- By providing a second 345-kV source to the Lake Road Switching Station, Option A was expected to make all units at Lake Road Generating Station in Killingly eligible to be considered as fulfilling Connecticut's resource requirement.
- It was preferred by system operations personnel.
- It could be constructed for almost its entire length within existing transmission line rights-of-way.
- The Connecticut segment of the project would not be adjacent to numerous facilities or land uses that would trigger the rebuttable "underground presumption" of section 16-50p (i) of the General statutes.
- It was the least costly of all of the options.

A detailed review of the advantages of Option A is provided in Section 2.3.1 and Appendix 3 of the *2008 Initial Solution Report.*

For most of its length, Option C-1 would have been aligned on a new ROW parallel and adjacent to Interstate 84 in southern Massachusetts and Connecticut. Due to developments adjacent to Interstate 84, Option C-1 was found to be difficult to construct and extremely costly. Option C-2, involving the use of existing transmission line ROWs between the Carpenter Hill, Ludlow, and Manchester Substations, was subsequently evaluated.

Option D was found to be impractical in the form envisioned in the *2008 Options Analysis*. It turned out to be more practical to add a new 345-kV line between Ludlow and Manchester, rather than to rebuild the existing line. With that modification, Option D was virtually indistinguishable from Option C, except for its new line connection to Ludlow Substation.

Option C-2 was evaluated in detail, because its performance and cost were close to that of Option A. Ultimately, a comparative analysis of Option A and Option C-2 showed that, although both potential solutions had merit, Option A performed better, cost less, and crossed fewer environmentally-sensitive and densely populated areas. (*See*, *2008 Initial Solution Report,* §2.8, App. 3) Accordingly, in the *2008 Initial Solution Report,* Option A was selected as the preferred transmission solution.

13.1.3 Redesign of Selected Original Options to Address the Enhanced Need

To address the enhanced need identified by the *2011 Needs Re-analysis,* the Working Group re-considered, and in some cases redesigned, the options evaluated in the original *2008 Options Analysis* and selected a variation of the original Option A as the preferred option. This work is described in detail in the *2011 Updated Solution Study Report*, and is summarized in the remainder of this Section 13.1.

The Working Group first considered which of the original five options appeared, by inspection, to be likely to be adaptable to meet the enhanced need cost effectively.

Option B did not add a line into Massachusetts and the new need identified in the *2011 Needs Re-analysis* indicated a need to bolster the transmission system into eastern New England. Thus, to make Option B a viable alternative, more transmission upgrades would have to be added to the original Option B. Since Option B was already a more expensive alternative, adding more upgrades to that plan would make that option an even less desirable alternative. Similarly, the cost and relative inflexibility of the HVDC solution (Option E) still made it an inferior choice to Options A and C-2.

Accordingly, the Working Group came to the conclusion that there was nothing in the updated needs analysis that altered the previous analysis that had eliminated Option B, Option C-1, Option D, and Option E from consideration. The significant differences in cost and/or system performance between these options, on the one hand, and the original Option A and Option C-2 on the other hand were decisive. The additional cost and impacts of the relatively modest modifications needed to meet the enhanced system need would not offset the difference that existed: therefore Options B, C-1, D, and E were not analyzed further. However, because the system performance and cost of Option C-2 had been a close competitor of Option A, Option C-2 was reconsidered in detail, along with Option A.

Both Option A and Option C-2 were redesigned to meet the requirements of the updated needs analysis. In an iterative process, the original configurations were modified by the additions or changes that the planners anticipated would improve the capability of the Southern New England transmission system to move power from west to east across the New England East-West interface. In addition, some of the original components of each plan were reviewed. System performance with those modifications in place was then analyzed by power-flow simulations in accordance with applicable reliability standards and criteria, using inputs consistent with the *2011 Needs Re-analysis.*

With the incorporation of modifications to meet the requirements of the *2011 Needs Re-analysis*, the original Option C-2 was designated Option C-2.1. Similarly, based on the *2011 Needs Re-analysis*, four distinct variants of the original Option A were identified: these variants are designated Options A-1 through A-4. The following sections describe each of these options.

In addition to the components listed for each option, all of them assume the construction of certain upgrades of NSTAR, NU, and Connecticut Municipal Electric Cooperative (CMEEC) facilities for which a need was identified in the 2011 *Needs Reanalysis*[4]. These upgrade projects are being advanced independently of the Project and already have PPA approval. Accordingly, they are not further considered in comparisons of the Interstate solution options.

13.1.3.1 Option C-2.1

As redesigned to meet the enhanced need identified in the *2011 Needs Re-analysis,* Option C-2.1 includes the construction of a new 345-kV switchyard at Carpenter Hill, whereas the original Option C-2contemplated only the installation of a second autotransformer at Carpenter Hill. Option C-2.1 thus consists of a new 345-kV transmission line from Millbury Switching Station to a new Carpenter Hill Substation to Manchester Substation. Figure 13-2 illustrates the primary 345-kV components of Option C-2.1.

13.1.3.2 The Option A Variants

The four "A" series options all contain the same 345-kV construction plan east from Card Street Substation within Connecticut, which is essentially identical to that of original Option A except that one element of the original configuration has been deleted.[5] To meet the new requirements based on the needs re-analysis, the components of the original Option A had to be modified only in Rhode Island and Massachusetts, as illustrated by Figure 13-3.

4 NSTAR – Reconductor a 1.2-mile section of the 345-kV 336 line (ANP Blackstone to NEA Bellingham tap) and upgrade terminal equipment at the West Medway Substation to 3000-A rated equipment. CL&P/CMEEC – Eliminate the sag limit on the thermal rating of the 115-kV 1410 Line (Montville to Buddington) in Connecticut

5 The new A Options do not include the construction of the 1-mile "310 Line Loop" and the associated expansion of the Card Street Substation that was proposed as part of the original Option A. However, the reason for withdrawing that construction from the Project is unrelated to the redesign of the Project to meet the updated need.

Figure 13-2: Location of Option C-2.1

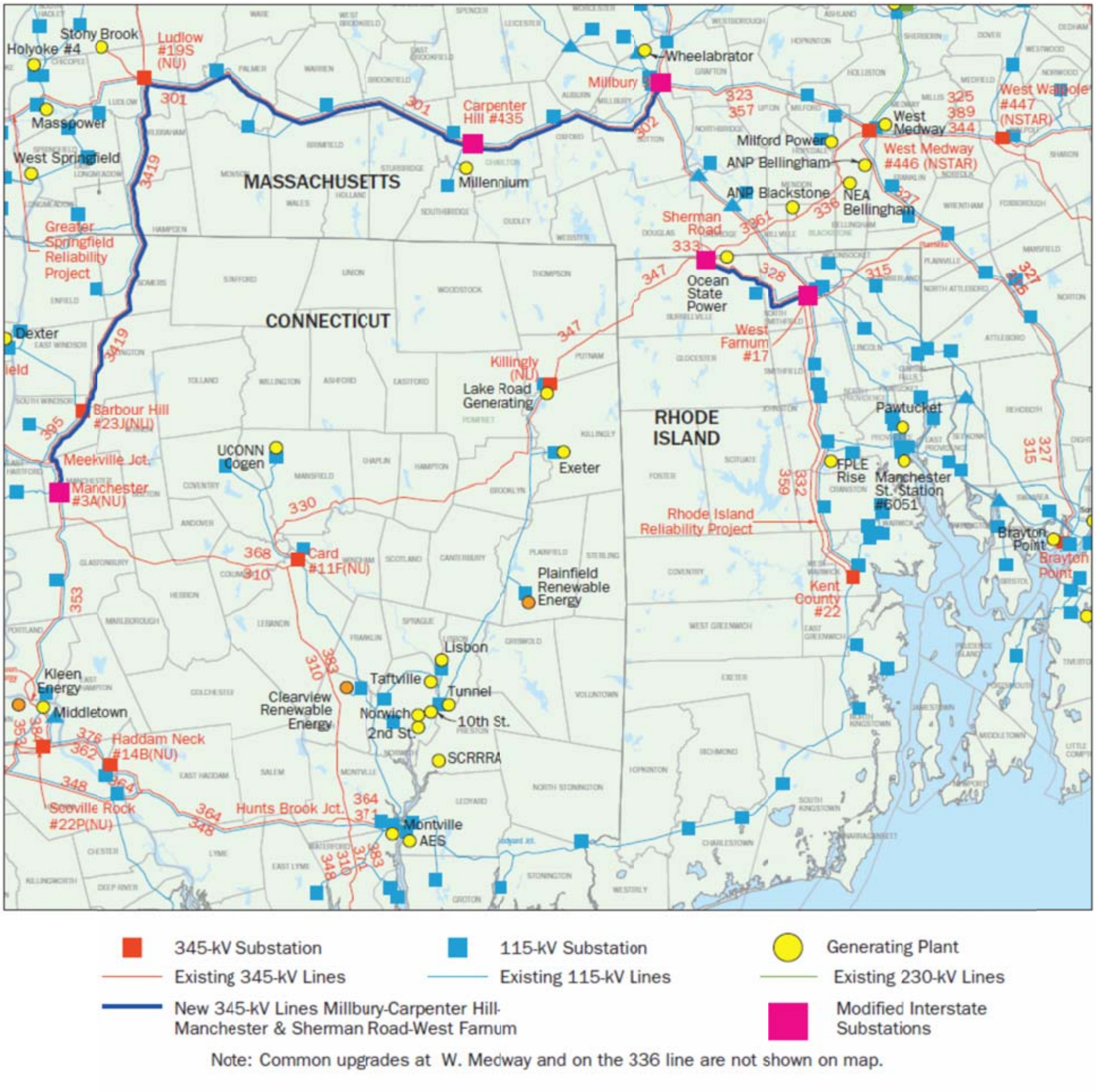
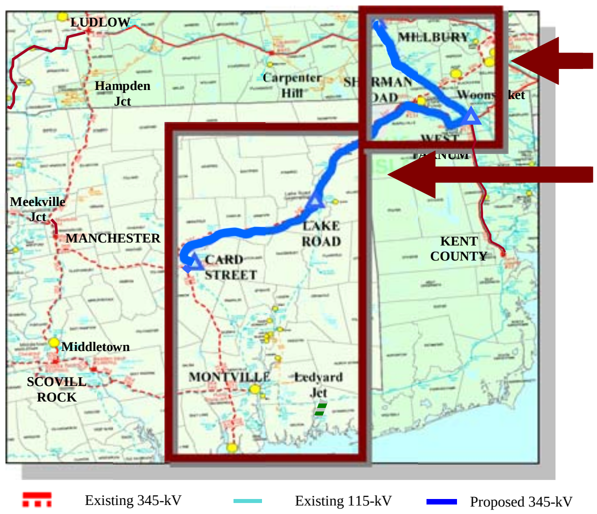


Figure 13-3: Location of Option A Variations



- All 345-kV Option A variations are in this area of MA and RI
- All variations include the same CT components:

Although each of the four variations of Option A has a slightly different configuration in Massachusetts and Rhode Island, they all contain three primary components:

1. A new 345-kV line from Card Substation in Lebanon, Connecticut to the Lake Road Switching Station in Killingly, Connecticut
2. A new 345-kV line from West Farnum Substation in Rhode Island to the Lake Road Switching Station in eastern Connecticut. (In one A option this line would loop in and out of the Sherman Road Switching Station enroute.)
3. A new 345-kV line from the Millbury Switching Station in central Massachusetts to either the West Farnum Substation or the Sherman Road Switching Station in Rhode Island.

The following reviews the components of each of the four A options in Massachusetts and Rhode Island, the only states in which they differ:

Option A-1

Within Massachusetts and Rhode Island, the key elements of Option A-1 include:

- A new 17.7-mile, 345-kV transmission line from the Connecticut border to the West Farnum Substation, located within existing 345-kV transmission ROWs (347 Line and 328 Line);

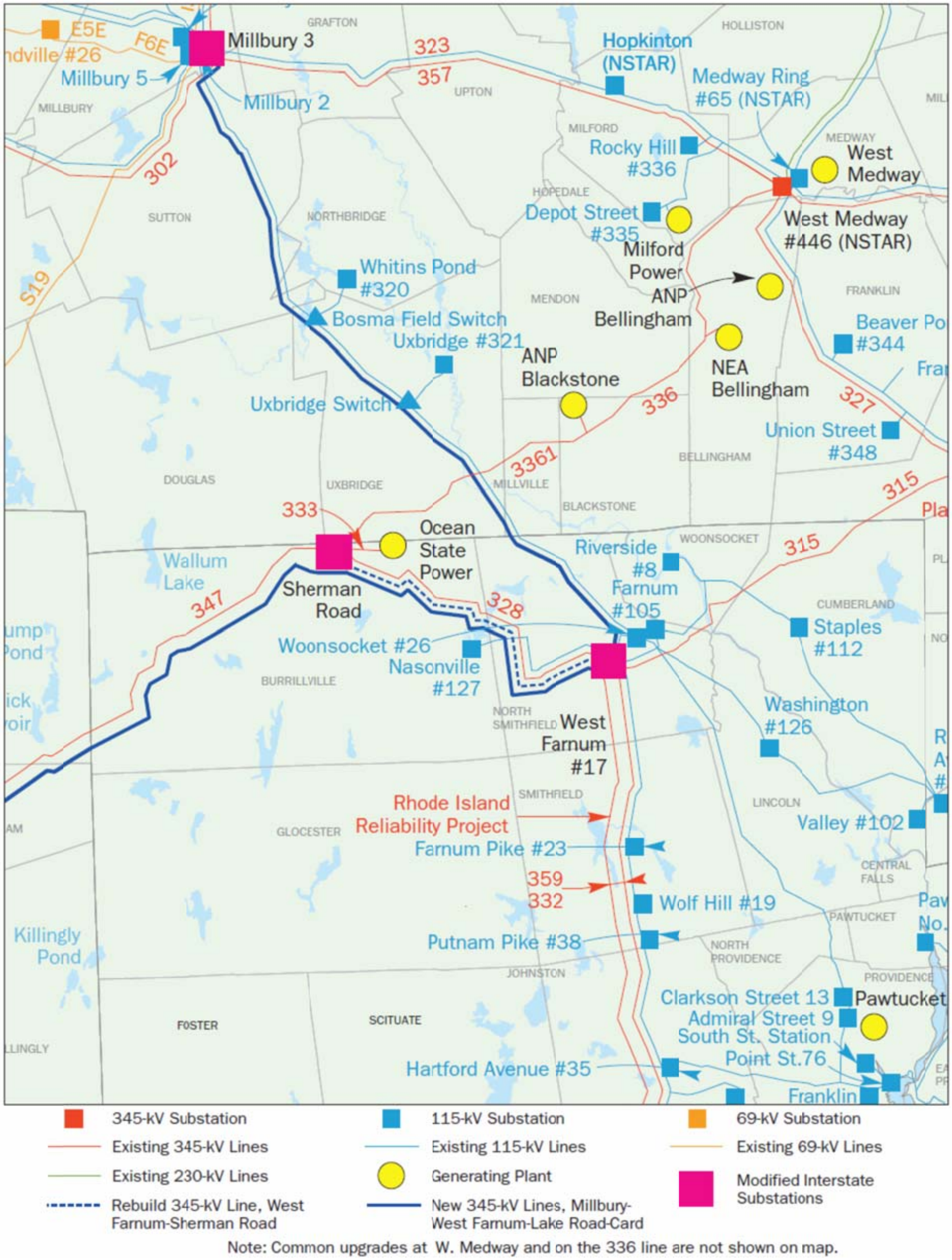
- A new 20.2-mile, 345-kV transmission line from the West Farnum Substation to the Millbury Switching Station within an existing transmission ROW (115-kV Q-143/R144 Lines);

- Rebuilding the existing 9-mile, 345-kV line on the ROW between Sherman Road and West Farnum (328 Line); and

- A new 345-kV AIS switchyard at Sherman Road, and retirement of the existing Sherman Road Switching Station.

Figure 13-4 illustrates the Rhode Island and Massachusetts segments of Option A-1.

Figure 13-4: Option A-1 Elements in RI and MA



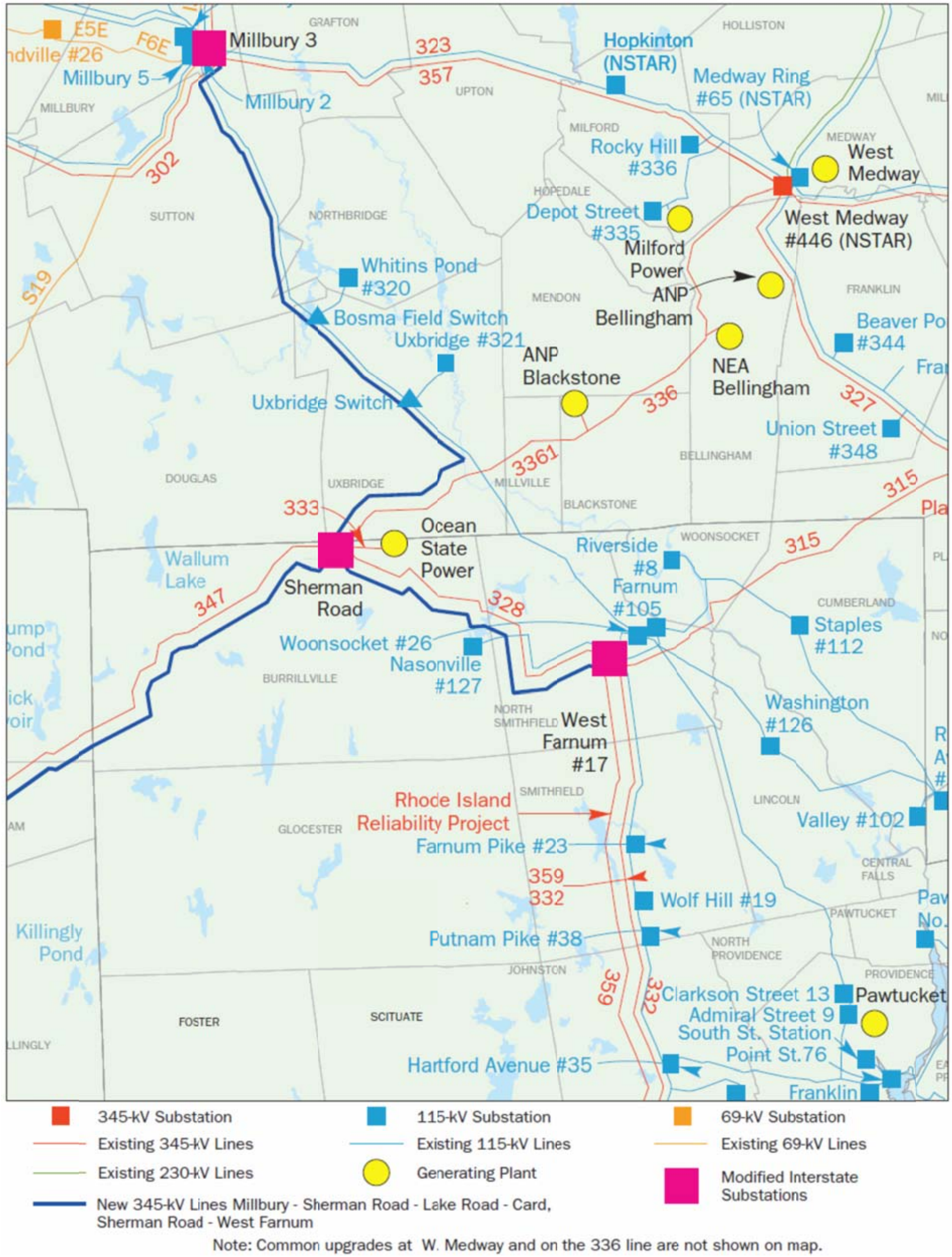
Option A-2

Within Massachusetts and Rhode Island, the key elements of Option A-2 include:

- A new 8.7-mile, 345-kV transmission line from the Connecticut/Rhode Island border to the Sherman Road Switching Station, located within an existing 345-kV transmission ROW (347 Line);
- A new 9-mile, 345-kV line on the ROW between the Sherman Road Switching Station and the West Farnum Substation, located within an existing 345-kV transmission ROW (328 Line);
- A new 17.7-mile, 345-kV transmission line from the Sherman Road Switching Station to the Millbury Switching Station, located partially within a ROW occupied by NSTAR's 345-kV 3361 Line, and partially within National Grid's existing transmission ROW (115-kV Q-143/R144 Lines);
- A new 345-kV GIS switchyard at Sherman Road, and retirement of the existing Sherman Road Switching Station; and
- Rebuilding the 0.2-mile, 345-kV transmission line from Sherman Road Switching Station to Ocean State Power in Burrillville, Rhode Island.

Figure 13-5 illustrates the Rhode Island and Massachusetts segments of Option A-2.

Figure 13-5: Option A-2 Elements in RI and MA



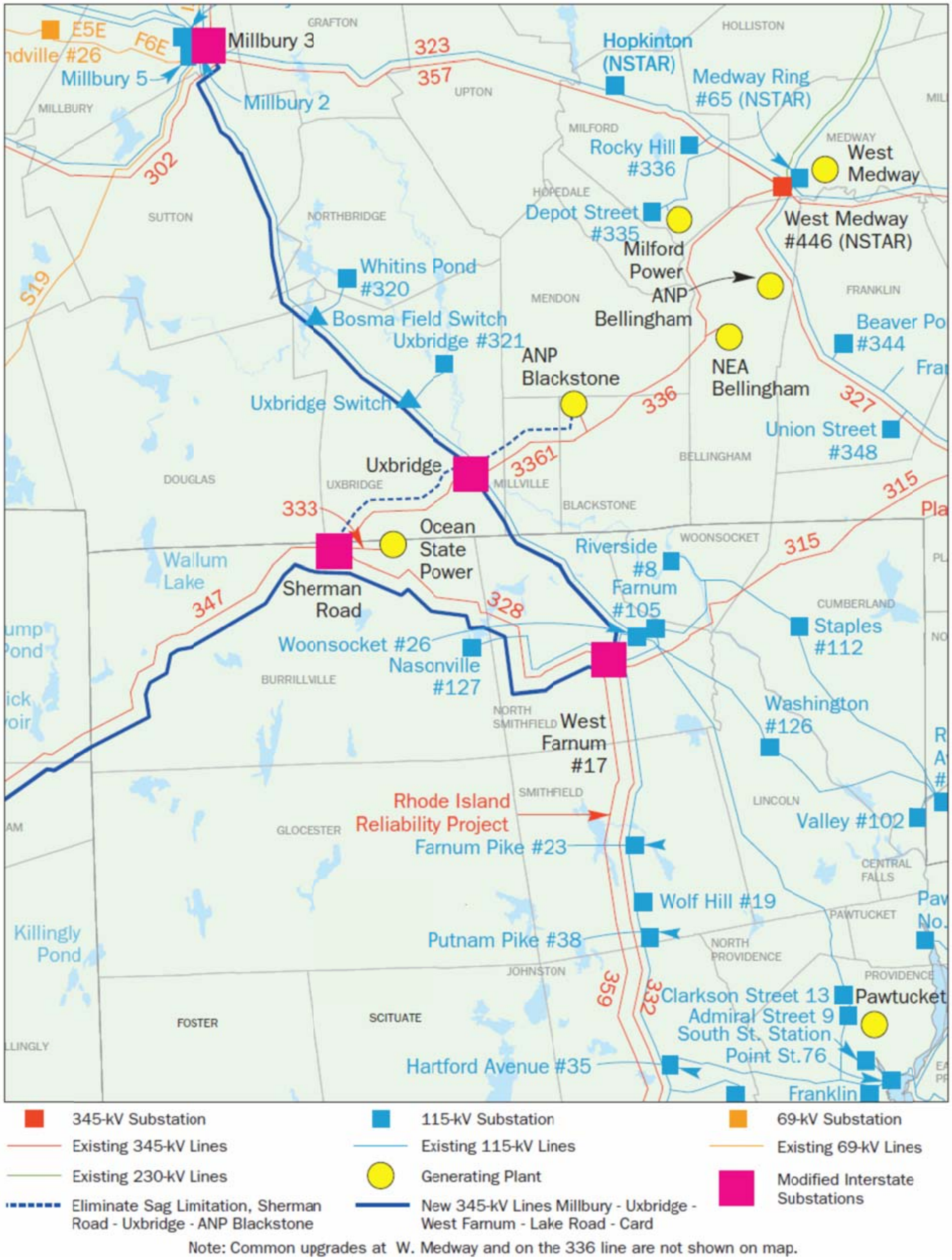
Option A-3

Within Massachusetts and Rhode Island, the key elements of Option A-3 include:

- A new 17.7-mile, 345-kV transmission line from the Connecticut/Rhode Island border to the West Farnum Substation, located within existing 345-kV transmission ROWs (347 Line and 328 Line);
- A new 20.2-mile, 345-kV transmission line from the West Farnum Substation to the Millbury Switching Station within an existing transmission ROW (115-kV Q-143/R144 Lines);
- A new 345-kV switching station in Uxbridge, Massachusetts;
- Increases in conductor height on 8.7 miles of NSTAR’s existing 345-kV line (3361 Line) between Sherman Road, the new Uxbridge Switching Station, and the ANP Blackstone Power Plant; and
- A new 345-kV AIS switchyard at Sherman Road, and retirement of the existing Sherman Road Switching Station.

The Massachusetts and Rhode Island components of Option A-3 are illustrated in Figure 13-6.

Figure 13-6: Option A-3 Elements in RI and MA



Option A-4

Within Massachusetts and Rhode Island, the key elements of Option A-4 include:

- A new 17.7-mile, 345-kV transmission line from the Connecticut/Rhode Island border to the West Farnum Substation, located within existing 345-kV transmission ROWs (347 Line and 328 Line);

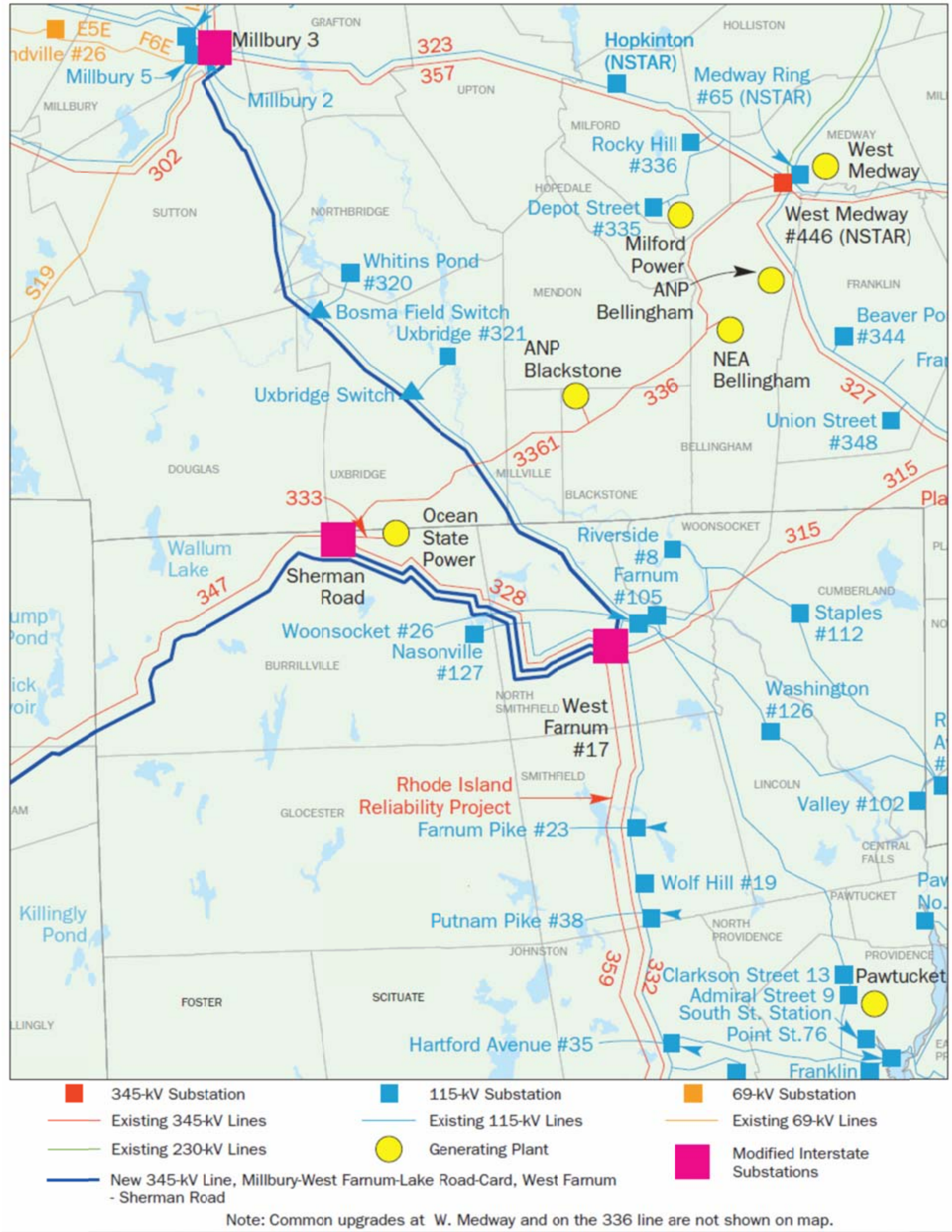
- A second new 9-mile, 345-kV transmission line on the ROW between Sherman Road Switching Station and West Farnum Substation (328 Line);

- A new 20.2-mile, 345-kV transmission line from the West Farnum Substation to the Millbury Switching Station within an existing transmission ROW (115-kV Q-143/R144 Lines); and

- A new 345-kV AIS switchyard at Sherman Road, and retirement of the existing Sherman Road Switching Station.

Figure 13-7 illustrates the Rhode Island and Massachusetts segments of Option A-4.

Figure 13-7: Option A-4 Elements in RI and MA



13.1.4 Comparison of the Redesigned Options

The five redesigned options (i.e., Options A-1 through A-4 and Option C-2.1) were compared on the basis of their system benefits, cost, and potential impacts on the natural and human environments.

13.1.4.1 System Benefits Comparison of the Five Transmission Alternatives

A number of factors were considered in evaluating the performance of each option. These factors ranged from considering the impacts of an option on the power flows across the regional interfaces from west to east and vice versa, and the performance of the southern New England transmission systems in stability, short circuit and Delta P analyses. The analyses performed included:

- **Thermal analysis** – studies to determine the level of steady-state power flows on transmission circuits under base case conditions and following contingency events.
- **Voltage analysis** – studies to determine system voltage levels and performance under base case conditions and following contingency events.
- **Stability analysis** – studies to determine the dynamic performance of electric machines with respect to rotor angle displacement, system voltage stability and system frequency deviations following phase-to-ground faults.
- **Transfer analysis** – studies to determine the capability of the transmission grid to reliably transmit electric power from one area to another area following contingency events.
- **Short-circuit analysis** – studies to determine the short-circuit current levels at system locations and the ability of existing electrical equipment to safely withstand associated forces and to interrupt such currents.
- **Delta P analysis** – studies to determine the torsional impact on the mechanical equipment at a generating station associated with transmission line switching.

In summary, all five options were shown to provide a level of electrical system performance that meets design requirements for satisfying the NERC, NPCC and ISO reliability standards and criteria. In terms of their quantitative improvements in system performance, no option demonstrated a distinct advantage over the others. However, the working group also considered each option’s potential for enhancing system expandability and flexibility. This is an important consideration given that transmission assets typically have long lifetimes that must allow for changing system requirements. 345 kV is the standard high voltage backbone of the New England transmission network, and new345-kV facilities should ideally be located so as to be easily connected to new generation facilities and transmission substations. Option A-1 was found to provide the most expandability and flexibility of all five options. An overall summary of the system benefit comparisons is provided in Table 13-1.

Table 13-1: System Benefit Comparison of Interstate Reliability Project Options

Interstate Options and Needs	Option A-1	Option A-2	Option A-3	Option A-4	Option C-2.1
Improve Eastern New England Import Capability	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Increase in N-1 import capability equivalent to A series; lower increase in N-1-1 import capability
Improve Western New England Import Capability	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Increase in N-1 import capability equivalent to A series; lower increase in N-1-1 import capability
Improve Connecticut Import Capability	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Equivalent increase in N-1 and N-1-1 import capability for all A options	Increase in N-1 import capability equivalent to A series; lower increase in N-1-1 import capability
Number of highly-loaded lines (>90% of LTE)	Marginally higher number of highly-loaded lines	Lowest number of Highly loaded lines	Lowest number of Highly loaded lines	Marginally higher number of highly-loaded lines	Highest number of highly-loaded lines
Impact on Short-Circuit Currents at 345-kV stations	Moderate impact on Short circuit currents	Higher impact on short circuit currents	Higher impact on Short circuit currents	Higher impact on Short circuit currents	Least impact on Short circuit Currents
Impact on Delta P related SPSs	Eliminates Lake Road SPS under All-lines-in Conditions	Eliminates Lake Road SPS under All-lines-in Conditions	Eliminates Lake Road SPS under All-lines-in Conditions	Eliminates Lake Road SPS under All-lines-in Conditions	Does Not Eliminate Lake Road SPS
Flexible System Expandability	High flexibility and Expandability	Lowest expandability and flexibility	Moderate expandability and flexibility	Moderate expandability and flexibility	Low expandability and flexibility

Overall, the A-series options performed better than the C-2.1 option in terms of most of the metrics tested for electric performance evaluation. Within the A-series options, there was none that clearly outperformed the others. However, in terms of system expandability and flexibility, A-1 is preferred over the other A-series options.

13.1.4.2 Cost Comparison of the Five Transmission Alternatives

For each of the five redesigned options, planning-grade cost estimates were prepared using a process consistent with ISO-NE procedures as defined in Planning Procedure No. 4.0. Table 13-2 summarizes these cost estimates for each option.

Table 13-2: Summary of Cost Estimates of Interstate Reliability Project Options ($ million)

	A-1	A-2	A-3	A-4	C-2.1
NU					
Substation Upgrades	$30	$30	$30	$30	$14
Transmission Lines	$221	$221	$221	$221	$295
NU Total	$251	$251	$251	$251	$309
National Grid					
Substations	$101	$138	$145	$118	$150
Transmission Lines	$190	$139	$154	$201	$255
National Grid Total	$291	$277	$299	$319	$405
NSTAR					
Substations	$0	$0	$0	$0	$0
Transmission Lines	$0	$15	$3	$0	$0
NSTAR Total	$0	$15	$3	$0	$0
Interstate Reliability Project Total					
Substations	$131	$168	$175	$148	$164
Transmission Lines	$411	$375	$378	$422	$550
Total	$542	$543	$553	$570	$714

(1) Estimates have a -25% / +50% degree of accuracy

(2) On May 27, 2011, the Federal Energy Regulatory Commission issued an Order authorizing recovery in rate base of 100% of transmission construction work in progress (CWIP) costs for the New England East-West Solution (NEEWS) projects, including the Interstate Reliability Project. Under this Order, CL&P and the New England Power Company (collectively "the Companies") ceased their accrual of AFUDC associated with expenditures on the NEEWS projects on June 1, 2011. The costs presented in Volume 1 for the proposed Project, and in Volume 1A for the proposed Project and potential Project variations, reflect this accounting treatment. However, the Companies have not revised all of the cost estimates used to compare the many potential transmission alternatives discussed in this Section 13, because the substantial effort required to do so would not yield useful information. The comparisons were actually performed on the basis of costs uniformly estimated by assuming AFUDC accounting; recalculating these costs assuming CWIP instead of AFUDC, where applicable, would not materially change the relative ranking of the various options.

While all the A variants were close in cost, the estimate for Option A-1 was the lowest. The cost estimates for all the A variants were substantially lower than the estimate for Option C-2.1. The difference between the highest estimated cost - $714 million for Option C-2.1 – and the lowest estimated cost - $570 million for Option A-1 – was $144 million.

This $144 million is a far greater cost gap than that estimated for original Option C-2 in comparison to original Option A. The increase in that cost difference is explained primarily by the necessity of constructing the new Carpenter Hill 345-kV switchyard and the additional cost for the expansion of the Manchester Substation to accommodate the Option C-2.1 345-kV line, as well as a new Manchester to Meekville Junction 345-kV line segment.

13.1.4.3 Comparison of the Potential Effects on Natural and Human Environment of the Five Transmission Alternatives

CL&P and National Grid compiled and assessed baseline engineering, construction, ROW, and environmental information regarding the four A Option variants and Option C-2.1. Human and natural environment information concerning these options was initially compiled commencing in 2006 (in conjunction with the analyses of the five original Interstate options). Subsequently, after Option C-2 (and later the revised Option C-2.1) and the Option A variations were identified as the options that would best meet the defined need and performance requirements, additional data was compiled, focusing on these system options. Information sources used in the comparative analyses of human and natural environmental resource features included:

- U.S. Geological Survey topographic maps.
- Aerial photography-based maps.
- Geographical Information System (GIS) environmental and land-use data bases.
- Transmission line ROW and existing line characteristics from CL&P and National Grid.

- General field reconnaissance of the 345-kV transmission line routes for each option.

- Review of human and natural environment data compiled by CL&P and National Grid in conjunction with other NEEWS projects.[6]

Using this information, the following factors were applied to compare Option C-2.1 to the Option A variations and also to compare the four Option A variations:

- Miles of new 345-kV transmission line

- New ROW easement acquisition required

- New land acquisition required for substation development or expansion

- Forest vegetation traversed

  - Forested upland

  - Forested wetland

- Wetlands traversed within ROW

- Wetlands altered for substation development or expansion (acres)

- Watercourse crossings

- Habitat for state- or federally-designated species of concern encompassed by ROW and substation sites

- Designated public lands traversed by ROW (federal, state, local parks, forests, trails, recreational areas)

- Residences located within 500 feet of the new 345-kV transmission line centerline

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[6] For example, the Manchester Substation to Meekville Junction segment of Option C-2.1 is the same ROW along which the Council recently approved CL&P's Manchester to Meekville Project (MMP), involving a new 345-kV line. This ROW segment was studied extensively as part of the MMP. Similarly, the Ludlow Substation to Hampden Junction portion of Option C-2.1 was part of the GSRP's Noticed-Alternative route for proceedings before the Massachusetts Energy Facilities Siting Board and thus was investigated thoroughly as part of that siting process. The data resulting from these studies was used as appropriate in the analyses of Option C-2.1 and the Option A variations.

Table 13-3 summarizes the primary elements of options A-1, A-2, A-3, A-4 and C-2.1 as relevant to an evaluation of their comparative environmental effects. Since the A-series options are identical within Connecticut, this analysis focuses on impacts in the states of Massachusetts and Rhode Island.

Table 13-3: Summary of Primary Elements: A-series Options and Option C-2.1 Connecticut, Rhode Island, and Massachusetts

Primary Feature	Option A Series				Option C-2.1
	A-1	A-2	A-3	A-4	
New 345-kV Transmission Line (Miles)	74.7	72.2	74.7	83.7	84.1
Reconductor / Rebuild Existing 345-kV Transmission Lines (Miles)	9	0.2	8.7	0	0
Reconductor / Rebuild /Uprate Existing 115-kV Transmission Lines (Miles)	0	0	0	0	15.4
New Substations/Switching Stations	• New AIS Switching Station at Sherman Road (1)	• New GIS Switching Station at Sherman Road	• New AIS Switching Station at Sherman Road (1) • New 345-kV Switching Station (AIS) at Uxbridge (MA)	• New AIS Switching Station at Sherman Road (1)	• New AIS Switching Station at Sherman Road (1) • New 345-kV switchyard at Carpenter Hill Substation
Modified Substations/Switching Stations	• Upgrade Millbury Switching Station • Modifications to CT Stations (Card Street, Lake Road, Killingly) • Modifications at West Farnum Substation	• Upgrade Millbury Switching Station • Modifications to CT Stations (Card Street, Lake Road, Killingly) • Modifications at West Farnum Substation	• Upgrade Millbury Switching Station • Modifications to CT Stations (Card Street, Lake Road, Killingly) • Modifications at West Farnum Substation	• Upgrade Millbury Switching Station • Modifications to CT Stations (Card Street, Lake Road, Killingly) • New Bay at West Farnum Substation	• Upgrade Millbury Switching Station • Expand Manchester Substation • Modifications at West Farnum Substation

(1) Circuit breaker, bus and other equipment replacements at Sherman Road required by Options A-1, A-3, A-4 and Option C-2.1 could not be accomplished without significant outages and impacts to Ocean State Power. Building a new AIS while leaving the existing station operational during construction is the most practical solution.

Although the variations to the original A Option identified by ISO resulted in four new electrical options, they are all very similar with respect to ROW's as compared to Option C-2.1. Therefore, it was decided to group the four A options in a comparison to C-2.1. For purposes of evaluating potential environmental features along these options, Option C-2.1 was compared to all of the Option A series, based on a range of natural and human environment characteristics. The comparison focused on the length of new 345-kV lines in relation to various natural and human environmental resources along the ROWs in the three states affected by the project: Connecticut, Rhode Island, and Massachusetts. The comparative analysis also considered ROW expansion required and land converted to utility use for substations or switching stations in the three states. Table 13-4 compares the natural and human environment features of Option C-2.1 to the range of these same features for Options A-1, A-2, A-3 and A-4.

Table 13-4: Comparison of Option A Series (A-1 through A-4) and Option C-2.1: New 345-kV Transmission Line and Related Substation and Switching Station Facilities: Connecticut, Rhode Island, and Massachusetts

Feature	A Options (Range for Options A-1 through A-4)	Option C-2.1
New 345-kV Transmission Line Length (Miles)	74.7-83.7	84.3
Length through wetlands (Miles)	5.2-7.0	11.9
Watercourse Crossings (Number)	118-129	177
Upland Forest Traversed (Miles)	36.5-39.1	54.0
Wetland Forest Traversed (Miles)	2.5-3.3	3.3
Parkland Traversed (Miles)	2.7	2.9
Length through Rare, Threatened or Endangered (Listed) Species Habitat (Miles)	14.8-15.2	18.1
Residences within 500 feet of new 345-kV transmission line centerline (Number)	478-536	942
ROW Expansion Required (Estimated Acres)	0-11 (Mansfield Hollow Area, CT)	< 1 (Manchester, CT)
Total Additional Land Development to be Converted to Utility Use for Substations or Switching Stations (Estimated Acres) (*Includes NU / NGrid property outside existing station fence lines and private property)*	4-15 (4 acres: Sherman Road Switching Station, RI) (11 acres: Uxbridge switching station, MA (Option A-3)	3.5 (Carpenter Hill, MA, Manchester, CT)

***Notes*:**

1. *Table compares new 345-kV transmission lines and related substation and switching station modifications that would be required for the A Options and Option C-2.1.*
2. *All linear miles across features are calculated based on the presumed centerline of the new 345-kV transmission line.*
3. *Additional easement acquisition is proposed for the new 345-kV line (all A Options) in Mansfield Hollow (CT); however, NU has also identified design options that would either not require any additional easement or would minimize the amount of easement required.*

Specifically, compared to the four A series Options, Option C-2.1 would involve:

- **Greater impacts in terms of overall vegetation clearing and habitat alteration**. The new 345-kV transmission line required for Option C-2.1 would traverse more miles than any of the new 345-kV lines for the four A-series options.

- **Close to full-width ROW vegetation clearing along some segments.** Between Barbour Hill and Meekville Junction in Connecticut, all vegetation would be cleared to the eastern edge of the ROW. Along the approximately 11 miles between Ludlow Substation and Hampden Junction in Massachusetts, the development of the new 345-kV line along Option C-2.1 would require the use of vertically-configured monopole structures to accommodate the new transmission line within the available easement width. Vegetation clearing to within 20 feet of the limits of the easement would be required.

- **Alignment through or near more areas of known habitat for state- or federally-listed protected species (i.e., threatened, endangered, or special concern species).** Option C-2.1 would traverse or be located within 500 feet of approximately 18.1 miles of such mapped habitat, compared to 14.8-15.2 miles along the Option A series alternatives.

- **Alignment in proximity to substantially more residences.** Portions of Option C-2.1 would traverse through populated areas, resulting in an estimated 942 homes within 500 feet of the centerline of the new 345-kV transmission line. In comparison, the centerline of the new 345-kV line along the four A-series options would be within 500 feet of 478 to 536 homes (in MA, RI and CT).

- **Alignment across more watercourses**. Option C-2.1 would cross 177 streams, compared to 118-129 streams for the four Option As.

- **Requirement of additional transmission line easements**. Both option C.2-1 and the A-series options would involve the development of the new 345-kV transmission lines principally within existing transmission line easements. However, any of the A-series options would potentially require 11 acres of additional easement (i.e., ROW expansion) through 1.4 miles of federally-owned lands in Mansfield Hollow State Park and the Mansfield Wildlife Management Area in the Connecticut towns of Mansfield and Chaplin[7]. Likewise, option C-2.1 would require ROW expansion along the Manchester to Meekville Junction segment in Connecticut. Option C-2.1 also would extend across Wells State Park in Sturbridge, Massachusetts.

Overall, Option C-2.1 would involve greater environmental effects than the Option A series alternatives and thus is not preferred on the basis of human and natural resource factors.

The four A options were then compared to one another. The effects of each of these options in Connecticut are identical, because under any of the four A Options the Connecticut segment is identical. Although the effects of each of the A series options in Rhode Island and Massachusetts were found to be modest, Options A-1 and A-2 were found to have the fewest potential adverse effects and to be quite similar in terms of human and natural environmental characteristics. Option A-1 was found to be

[7] CL&P identified three design options for traversing these federally-owned properties, one of which would not require any additional easement acquisition.

environmentally preferable, in part because it better satisfies specific concerns of state regulatory agencies. Since this comparison does not relate to the proposed Connecticut construction, it is not summarized here.

Conclusion – Transmission Alternatives

Option A-1 emerged from the comparison process as the preferred solution. Although the quantitative measures of electrical performance were similar for all of the Options, the A options provided more system benefits; and among them, Option A-1 had an edge from a system benefit perspective.

Further, the cost estimates indicated the A-series to be less expensive compared to the C-2.1 option. The estimated cost of Option C-2.1 was 25% more than the estimated cost of the most expensive A-series option.

Finally, although the environmental effects of all the A options within Connecticut are identical, Option A-1 was found to be preferable to the others based on a comparison of their effects in Rhode Island and Massachusetts. Accordingly, Option A-1 was selected as the preferred solution by the working group.

13.2 NON-TRANSMISSION ALTERNATIVES

The reliability violations addressed by the Project might theoretically be resolved by adding large amounts of demand and supply resources in Massachusetts, Rhode Island, and Connecticut. Solving reliability problems as if they were simply resource deficiencies does not, however, address the basic problem of transmission facilities that are inadequate to deliver existing resources to the load, or to accommodate significant additions of new resources.

The regional nature of the reliability issues addressed by the Project and the requirement that any solution to them be compatible with the overall solution of the NEEWS Plan makes development of a non-transmission alternative to the Project especially challenging. At a minimum, a non-transmission alternative solution would need to significantly increase resources or reduce load – or both - on each side of the New England interface in order to provide capacity that could be needed under stressed conditions.

In order to determine whether the addition of new demand and/or supply resources could provide a reliability solution equivalent to that of the Project, the effect of such additions must be tested in the same way that the reliability violations were found in the first instance, and in the same way that the proposed transmission improvements have been proven to be a solution: by running power-flow models to determine if violations of reliability standards and criteria have been eliminated by the addition of the extra resources.

Accordingly, CL&P engaged an expert consultant, ICF International, Inc. to perform a Non-Transmission Alternatives (NTAs) study. ICF is a leading management, technology and policy consulting firm that provides advisory and program implementation services to public and private clients in various sectors including Energy, Environment and Transportation. ICF has extensive consulting experience in areas including electric power and renewable energy resources. Its clients include government agencies and utilities. ICF also has consulting experience in the field of electric transmission; specifically, in performing system impact studies and stability studies, and cost-benefit assessments.

ICF evaluated NTAs including generation additions, demand reductions, and combinations of the two in order to determine if there might be a practical and cost-effective non-transmission alternative to the Project. A copy of the ICF report, redacted to eliminate CEII, is provided as part of Volume 5 of this Application. Complete copies will be provided to the Council and to parties and intervenors qualified to receive CEII pursuant to a protective order that CL&P expects will be entered in the proceeding. A high-level summary of ICF's analysis and conclusions is presented in the following sections.

13.2.1 The ICF Analysis

ICF first obtained from ISO-NE the power-flow simulation data used to evaluate the need for the Interstate Reliability Project. It then translated that data so that it would be compatible with ICF's own power-flow simulation software (PSLF), which is different than that employed by ISO-NE (PSSE). ICF ran the ISO-NE power flow cases on its software and determined that the results of the pre-Project power-flow simulations agreed with those of the *2011 Needs Re-analysis* and that the results of its post-Project simulations agreed with those that ISO-NE had obtained in the course of its updated solution analysis.

ICF then projected the generation and demand-side non-transmission resources that could be made available in southern New England within the 5- to 10-year planning horizon (2015 and 2020), and simulated the operation of the New England transmission grid assuming the non-transmission resources were in place in lieu of the Project. Three NTA options were examined – demand-side resources only[8], central generation only, and a combination of generation and demand-side resources. The potential NTA's were tested using power-flow simulations, under assumptions consistent with those ISO-NE used to determine that there was a need for transmission improvements and that the Project would satisfy that need. However, only the performance of the NTAs in eliminating thermal violations was evaluated. Had ICF identified an NTA that would resolve all of the thermal violations addressed by the Project, it would have gone on to determine if it resolved (or aggravated) the pre-Project voltage violations. However, since it found no feasible and practical NTA, such an exercise would have been pointless.

13.2.2 Critical Load Level Analysis and Assessment Of Demand-Side Alternatives

The critical load level (CLL) is the demand level (MW) above which reliability violations begin to occur. Above this load level, upgrades of the electric supply system would need to be made to continue to support demand. ISO-NE has performed CLL analyses in Needs Assessments for other areas of the New England market, notably, in the Needs Assessment for the Vermont/New Hampshire transmission

[8] Distributed generation resources were treated as demand reductions.

system.[9] In the Vermont-New Hampshire study, the ISO determined the CLL for the entire regional market, using a standard power-flow technique to test and document system performance under differing load levels until the point at which no reliability violations occur in the study area is identified. ISO-NE thus pro-rated all loads in ISO-NE downward until the localized Vermont/New Hampshire violations that had been identified at higher loads were eliminated. ICF used a similar approach, but focused on load in southern New England only, to determine the load level in southern New England at which the identified violations resolved by Interstate begin to occur.

Because the reliability violations occur in three different subregions under three different and mutually exclusive dispatch scenarios, ICF determined a CLL for SNE by first determining a sub-regional CLL for each of the three sub-regions – Eastern NE, Western NE and RI – and then combining them to develop an estimate of the Southern New England CLL.

ICF thus made a simplifying assumption that aggregating the sub-regional CLLs will provide a reasonable estimate of the Southern New England CLL. This assumption is supported by the nature of the power-flow cases where reductions in one sub-region have only a small impact on violations in other sub-regions. Further, this assumption is less likely to overstate the required load reduction, as compared to assuming a uniform regional reduction as was done for the New Hampshire/Vermont study, given that in the uniform case, all sub-regions would have to be reduced by a ratio approximately equal to that of the sub-region with the lowest ratio. In addition, ICF performed a CLL analysis for the ISO-NE load zones in Connecticut, which is one of the identified areas of concern with thermal violations and transmission capability limits that will be relieved with the addition of Interstate.

ICF determined that the demand reduction required to achieve the CLL for 2015 was 3,400 MW, which amounts to 15% of the peak load predicted for that year. For 2020, the required demand reduction is

9 VT/NH Critical Load Level Results and Preliminary Transmission Alternatives Under Consideration, ISO New England Planning Advisory Committee, Feb 17, 2011.

5,300 MW, which amounts to 22% of the 2020 predicted peak load. ICF found no practical and feasible demand-side NTA. The load reduction required to address the identified violations far exceeded the estimated maximum potentially available demand-side resources. This deficiency occurred even though ICF's assumptions as to available demand-side resources were very optimistic.

13.2.3 Assessment of Demand-Side Alternatives

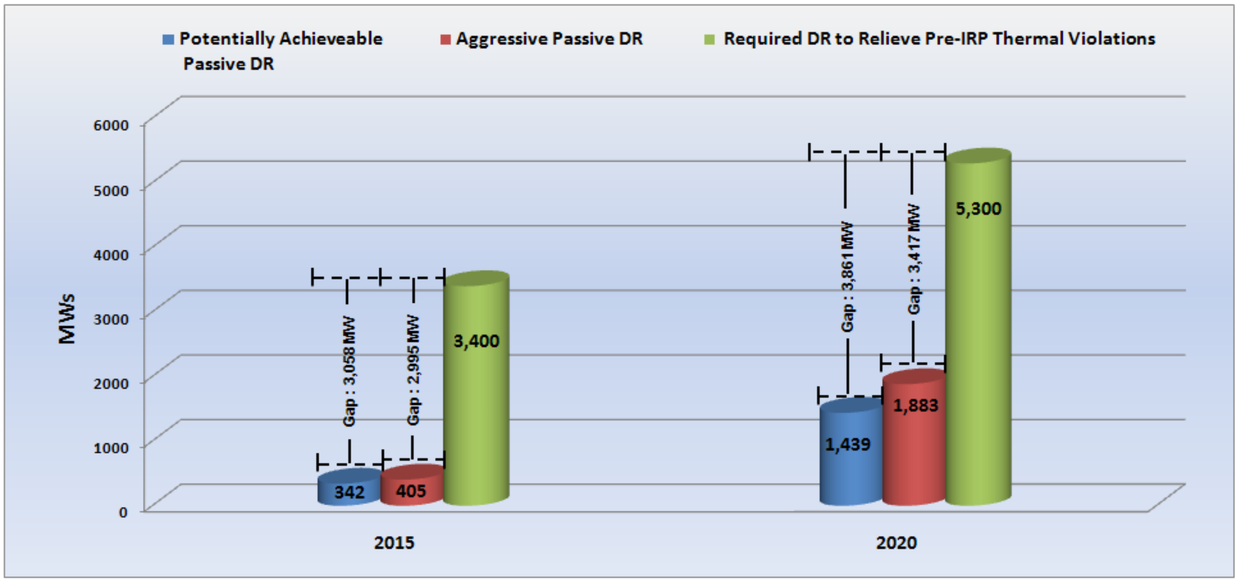
Resources for reducing customer demand are classified as either "passive" or "active." *Passive* demand resources are principally designed to save electric energy use and are in place at all times without requiring direction from the ISO. They include energy efficiency measures and distributed generation. Distributed generation refers to small customer-owned generators the output of which reduces demand for utility-supplied power. *Active*, or demand-response resources, are designed to induce lower electricity use at times of high wholesale prices or when system reliability is jeopardized, by offering customers payments in return for reducing consumption. Most demand resources result from programs sponsored by utilities under regulatory supervision. As such, they are subject to regulatory approvals at the state level, and are also frequently backed with state or ratepayer funding.

Some passive demand resources are accounted for in ISO-NE load forecasts. Others are treated as resources and procured through the ISO Forward Capacity Auction (FCA) process. The base case used to determine the need for the Project included the possible demand measures embedded in the load forecasts and those procured through FCA 4, held in August 2010. ICF assessed the potential of reducing SNE the level of peak demand to the CLL through realizing the potential for incremental demand-side resources in addition to those included in the base case.

ICF first estimated achievable passive resource levels by examining the relevant programs in place in each of three states in the study area and projecting two different potential future resource levels – a Reference Case and an Aggressive Case. The Reference Case assumed that each state would meet its current program goals and that its demand resources would continue to grow at the targeted rate to 2020;

the Aggressive Case assumed that the targeted goals would be significantly exceeded. Neither Case came close to reducing the demand level to the CLL. For instance, the demand reduction from the Aggressive Case provided 405 MW of incremental load reduction in 2015 and 1,883 MW of load reduction in 202. Figure 13-8 illustrates the gap between the CLL and the achievable passive demand resources for filling it:

Figure 13-8: Comparison of Achievable Incremental Passive DR to CLL Load Reduction in Southern New England – 2015 and 2020



After determining that this gap could not be filled with potentially achievable active demand resources, ICF went on to consider generation alternatives.

13.2.4 Assessment of Generation Alternatives

To determine if an NTA solution could be developed from new generation resources, ICF first reviewed the proposed projects in the New England Generation Interconnection Queue (Interconnection Queue) as of April 1st, 2011 to identify potential facilities in Southern New England that could be included in such a solution. The generation resources available in the Interconnection Queue were grouped into three categories based on the likelihood of being constructed:

- **Category 1:** Facilities with completed Interconnection Agreements. These facilities have gone through various studies and all the steps in the approval process and were considered very likely to be developed.

- **Category 2:** Facilities with PPA approval in accordance with Section I.3.9 of the ISO New England Transmission, Markets and Services Tariff, but excluding facilities with completed Interconnection Agreements (Category 1).

- **Category 3:** All facilities in the Interconnection Queue, but excluding facilities with completed Interconnection Agreements (Category 1) and Section I.3.9 approval (Category 2). Units in Category 3 were considered to have the lowest probability of being developed.

A total of 2,850 MW of generation capacity was determined to be listed from the Interconnection Queue, including 427 MW in Category 1, 1,904 MW in Category 2, and 520 MW in Category 3. Although approximately 75% of the generators in the Queue never enter commercial operation, all of this capacity was assumed to be available as needed.

In analyzing each sub-region, generation facilities from Category 1 were added to the 2015 and 2020 base power-flow cases, and the cases were analyzed under N-1 and N-1-1 contingency conditions similar to the needs assessment. The results were compared to those from the needs assessment, and any remaining or new thermal violations were noted. If thermal violations remained in any of the base power-flow cases generation facilities from Category 2 were added to those cases and the contingency analysis and review of results repeated. The process was repeated with Category 3 resources if necessary, that is, if violations persisted after addition of Category 2 resources.

Similar to the CLL approach discussed above, the analysis was performed on a sub-regional basis to isolate the effects of alternate dispatch conditions, and sub-regional results were aggregated to determine the implications for Southern New England.

Two generation addition scenarios were analyzed for 2015. The difference between the scenarios was the capacity added in Western New England. For 2015, the capacity required to resolve violations in Western NE was less than the total capacity available in the sub-region. To ensure that the choice of units would not affect the results of the analysis, ICF tested two different sets of units in Western New England. Within Rhode Island and Eastern New England, the inclusion of all available generation resources was not sufficient to address the violations. The aggregate generation NTA capacity in Southern New England added to the cases in 2015 was 1,302 MW in the first scenario and 1,281 MW in the second. For 2020 all generation capacity in Southern New England available from the Interconnection Queue, totaling 2,850 MW, was added to the power flow cases.

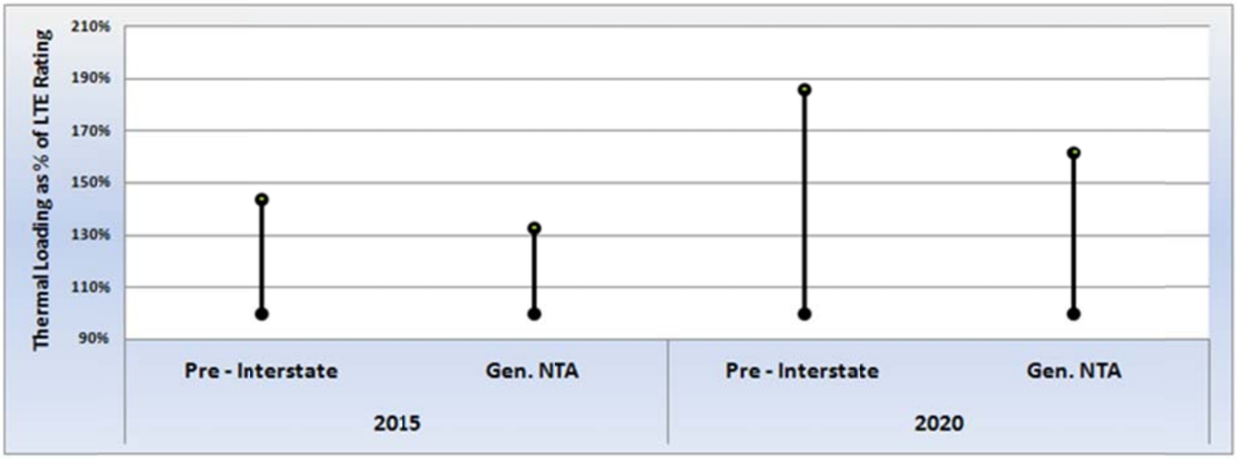
ICF modeled the SNE system with the addition of these generation resources but without the Project. The results of the simulation showed that no feasible generation NTA is available for Southern New England. The generation NTA left unresolved many of the thermal reliability violations addressed by the Project. Table 13-5 summarizes the results of this simulation.

Table 13-5: Summary of Reliability Criteria Violations for Generation NTA

Year	Number of Thermal Violations			Number of Elements Overloaded		
	Needs Assessment	Generation NTA	% Reduction	Needs Assessment	Generation NTA	% Reduction
2015	206	90	56%	20	17	15%
2020	6,029	2,817	53%	53	31	42%

The severity of the thermal violations is shown in Figure 13-9. The generation NTA was more effective in reducing the number of violations than the severity of violations. Many of the most severe overloads still remained. In 2015, some transmission facilities exceeded their thermal limit ratings by 30 percent. In 2020, some violations were more than 60 percent higher than the rating of the facilities.

Figure 13-9: Range of Reliability Criteria Violations in Southern New England – Generation NTA

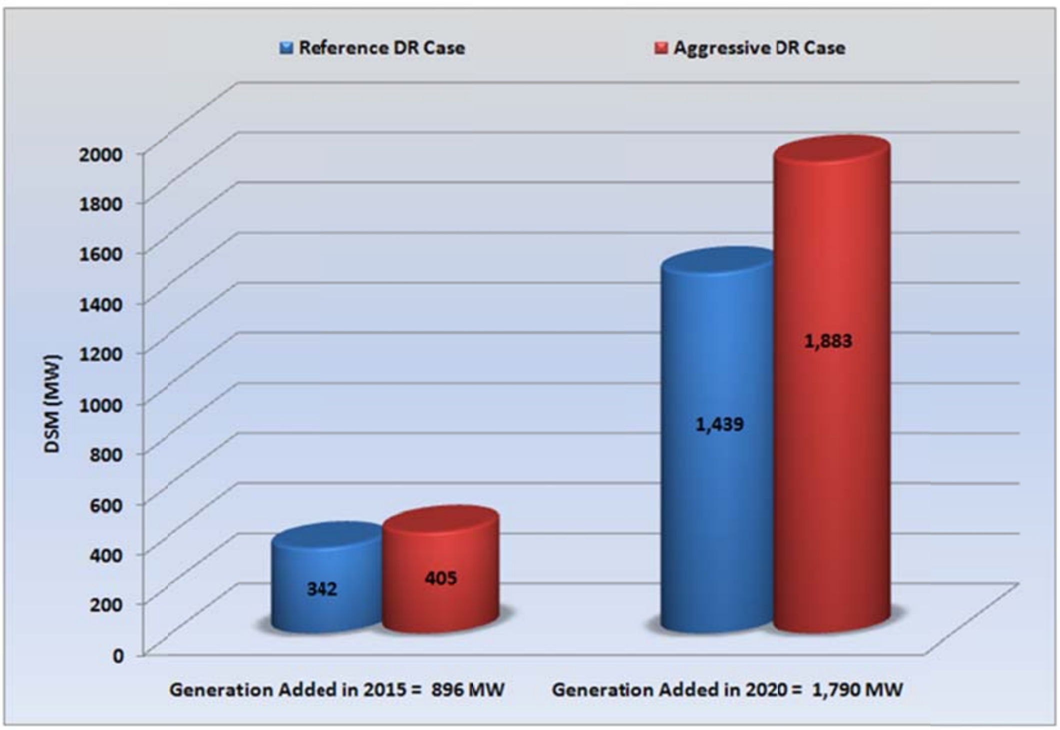


13.2.5 Assessment Of Combined Generation And Demand-Side Alternatives

Following its demand-side-only and generation-only analyses, ICF sought to develop a feasible NTA solution that combined generation with demand-side resources. ICF supplemented the generation NTA with the projected passive demand resources identified it had identified in its demand-side-only analysis to develop a combination generation and passive demand resource NTA. ICF then analyzed the combination to determine if it would provide a feasible NTA solution. Having found that it would not, ICF considered whether the further addition of active DR resources could provide a solution. It determined that it sufficient active DR resources would not be available.

Figure 13-10 shows the incremental amount of generation and passive demand resources used to develop the Combination NTAs. The amounts shown are incremental to the capacity already included in the base power-flow cases prepared by ISO-NE, which include the generation and demand resources that cleared in FCA #4. The identification of generation and demand resources for inclusion in the Combination Cases reflected a refinement to that used in the Generation-Only NTA analysis to account for the interaction of generation resources and demand reductions. In the Combination Case, ICF first assumed the passive demand resources would be available. Next, generation was added in each sub-region in an attempt to address the remaining violations. This resulted in a reduced overall amount of generation resources in the Combination NTA Cases compared to the Generation NTA Cases. In 2015, 896 MW of new generation capacity was added in southern New England. This was combined with 342 MW of passive DR in the Reference Case and 405 MW of passive DR in the Aggressive Case. In 2020, 1,790 MW of new generation capacity was combined with 1,439 MW of Reference Passive DR Case and 1,883 MW in the Aggressive Passive DR Aggressive Case.

Figure 13-10: Incremental Supply and Demand Resources Capacity in Combination NTA Cases



Power-flow simulations assuming the addition of these combinations of resources showed many remaining thermal criteria violations. Multiple contingencies could cause overloads on a single transmission element. The Reference DR Combination NTA reduced the number of thermal violations in 2015 from 206 in the Needs Assessment cases to 77. These include multiple violations on the same element as a result of different contingencies. In 2015, 16 different transmission facilities are overloaded in the Reference DR Combination NTA, compared to 20 in the Needs Assessment. This means that in 2015 multiple contingencies cause 77 violations on 16 facilities when the Reference DR Combination NTA is implemented. In 2020, the violations are reduced from 6,029 in the Needs Assessment cases to 124 in the Reference DR Combination NTA. The overloads in the Combination NTA occurred on 19 transmission elements, compared to 53 in the Needs Assessment. These results are shown in Table 13-6.

Table 13-6: Summary of Reliability Criteria Violations for Reference DR Combination NTA

Year	Number of Thermal Violations			Number of Elements Overloaded		
	Needs Assessment	Combination NTA	Percent Reduction	Needs Assessment	Combination NTA	Percent Reduction
2015	206	77	63%	20	16	20%
2020	6,029	124	98%	53	19	64%

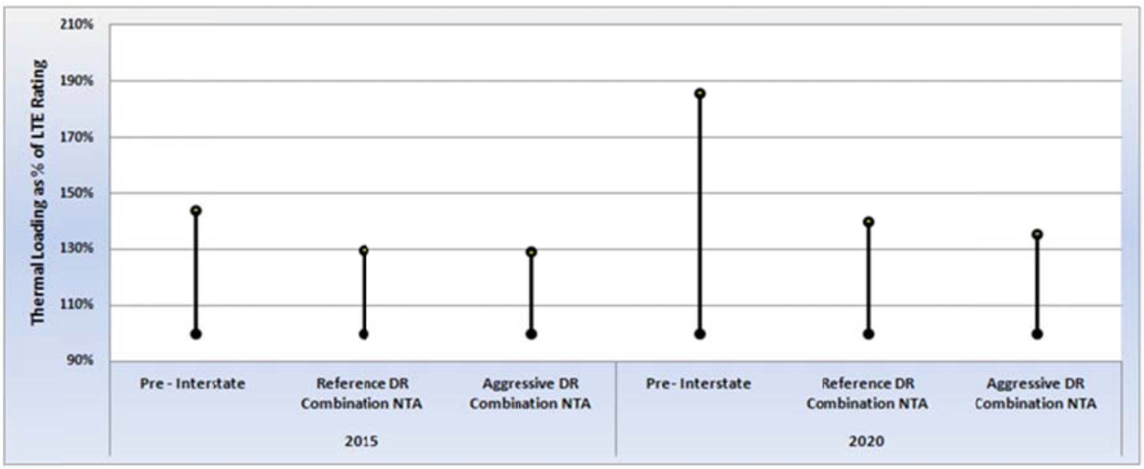
As shown in Figure 13-7, the Aggressive DR Combination NTA slightly reduces the remaining thermal violations as compared to the Reference DR Combination NTA:

Table 13-7: Summary of Reliability Criteria Violations for Aggressive DR Combination NTA

Year	Number of Thermal Violations			Number of Elements Overloaded		
	Needs Assessment	Combination NTA	Percent Reduction	Needs Assessment	Combination NTA	Percent Reduction
2015	206	72	65%	20	15	25%
2020	6,029	84	99%	53	17	68%

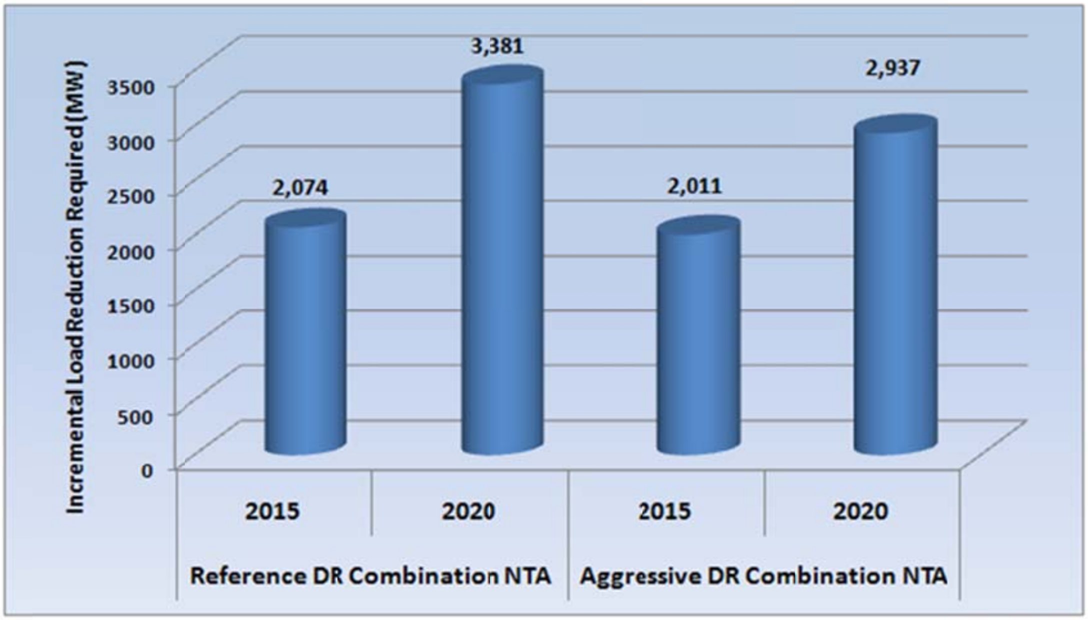
The severity of the thermal violations is shown in Figure 13-11. The combination NTA reduced the number of violations significantly. It was also effective in reducing the severity of violations. However, many severe violations still remained. For example, in all the combination NTAs, some transmission facilities exceeded their limits by approximately 30 percent.

Figure 13-11: Range of Reliability Criteria Violations in Southern New England – Combination NTA



Having determined that a combination of generation assumed to be available by reason of its presence in the Queue and potentially available passive demand resources would not provide a sufficient combination NTA, ICF went on to consider whether the addition of potentially available active demand resources could enable a Combination NTA to provide performance equivalent to that of the Project. As it did in its CLL analysis, ICF determined the additional load reduction required to resolve all the thermal violations that Interstate addresses. ICF then estimated the additional active demand resource capacity that would provide the required load reduction. Figure 13-12 shows the load reduction that would be required from active demand resources to produce a combination NTA solution.

Figure 13-12: Combination Case Incremental Required Load Reduction to Achieve an NTA in Southern NE – 2015 and 2020



Estimating the amount of active demand resources that would be required to achieve this load reduction was challenging. Unlike traditional generators and even energy efficiency measures, active demand resources do not have a long "track record" from which future performance may be projected. Thus, ISO-NE developed an estimated performance factor for "de-rating" active DR in the most recent Forward Capacity Auction (FCA #5) in 2011, but it is considering using a substantially different performance factor for the next auction (FCA #6), which will be held in 2012. Applying each set of factors, ICF calculated the required amount of active demand resources in each sub-region, and then aggregated the sub-regional values to determine the values for southern New England. Table 13-8 presents the amount of active demand resources that would have to be added to the Combination Case assuming Aggressive Passive DR in order to produce an NTA solution.

Table 13-8: Active DR Required to Provide an NTA in the Combination Case assuming Aggressive Passive DR Case

Parameter	Combination NTA 2015			Combination NTA 2020		
	No Derate	FCA #5 Derate	FCA #6 Proposed Derate	No Derate	FCA #5 Derate	FCA #6 Proposed Derate
FCA 5 (2014/15) Qualified Active Demand Response Resources (MW)[1]	1,102					
Incremental Active Demand Resource Required to Eliminate Thermal Violations in the Combination Case (MW)	2,011	3.381	2,745	2,937	4,871	4,083
Total (cumulative) Demand Resource Required (MW)	3,113	1,105	3,847	4,039	5,973	5,185
Average Annual Percentage Growth (%)	182%	0%	249%	24%	33%	29%

1 The qualified resources from FCA #5 are used as a proxy for the total available demand response resources available for the summer of 2014 as of today. Total is shown for the RI, CT, and MA load zones only as the area of concern. The total qualified Real Time Demand Response Resource for all of New England is 1,667 MW. Within RI, CT and MA load zones, 1,207 MW of capacity qualified, of this total, 105 MW were accepted for delist, resulting in qualified Real Time Demand Response Resources of 1,102 MW in southern New England.

In order to achieve these levels of active DR, their annual average growth rate would have to be between 24 and 33 percent to 2020. This is not a realistic target. Accordingly, ICF concluded that potentially available active demand resources could not fill the gap, so that potentially available generation resources and active and passive demand resources are not sufficient to develop a feasible combination NTA solution.

Following this analysis, ICF modeled two sensitivity scenarios. In one, it assumed the Salem Harbor generation plant to be retired, in accordance with an announcement made by the owner and a directive from ISO-NE, both of which occurred after ICF began its work. Under this scenario, the performance of the combination NTA was substantially worse, indicating the potential vulnerability of the NTA to the retirement of existing plants. In the other sensitivity scenario, ICF assumed the addition of a 1,400 MW incremental supply source in Tewksbury. Even that very large resource increment, in addition to the Aggressive DR Combination Case, did not eliminate all of the thermal criteria violations

13.2.6 Implementation Challenges

Given unlimited resources and the necessary time to develop new generation, it might be possible to design a hypothetical NTA for the Interstate project. However, such an NTA would be extremely challenging to implement compared to the Project. This section discusses six NTA implementation challenges.

13.2.6.1 NTA Scope

The hypothetical NTA likely would involve numerous power plants and demand resources at multiple locations. As the number of sub-projects multiply, the potential for unexpected problems in terms of permitting, financing, construction, testing, and operation increase. Approximately 75 percent of the projects in the Interconnection Queue fail to be commercialized. Also, demand-only or combination NTAs would require the co-ordination of many entities, most responding to financial incentives, without experience in or commitment to solving transmission security problems.

In contrast, the Project is a single integrated solution to multiple violations that occur over a broad area of the southern New England electric system. It would employ proven technology and would be administered by ISO-NE, a centralized expert authority. Also, the Project would be constructed by experienced transmission owners.

13.2.6.2 Multi-State Implementation

NTA implementation of the scope required is an especially difficult problem because it involves three states. There are no clearly established and centralized multi-state procedures for NTA implementation. Each state must have the procedures and structures in place to implement the NTA – e.g., contracting, permitting, etc. Also, the states must be able to effectuate long-term contracts with NTA providers, especially providers of supply based NTAs. This is because NTAs will most likely require contracts and programmatic support. Structures and procedures for awarding such contracts do not exist in all of the jurisdictions in which they would likely be needed.

13.2.6.3 Risk of Over-Reliance on Demand Resources

ISO-NE already relies heavily on demand resources. Further reliance on demand resources via a demand-only or combination NTA increases the concerns related to the risks of this reliance:

- In its FCA #5, ISO-NE procured 11 percent of its resource requirements via demand resources. New market rules such as the elimination of the FCM price floor (scheduled for FCA #8 in 2013) and the potential retirement of power plants due to age and/or new environmental restrictions will tend to eliminate supply resources. In a scenario in which excess supply resources were to leave the market (i.e., about 3,700 MW or about 2,400 MW with the potential loss of Vermont Yankee and the loss of Salem Harbor), demand resources would contribute fully 80 percent of ISO-NE local reserves.

- Reliance on demand resources in such a scenario would become more frequent.[10] There may be a risk that the New England region could be exposed to significant attrition of active demand resources by the "fatigue" of being called on extensively and repeatedly in hot weather to decrease load. Under the FCM, interruptible load contracting is for a single year, so that a party who agrees to service interruptions can leave the DSM program on short notice and with little or no financial penalty relative to never having participated. Although there is as yet no body of data by which the effect of this fatigue factor can be documented and measured, it is a serious concern.

- In order to make agreements to accept interrupted service reliable enough for large scale use in an NTA, new program features would most likely be required. These could include longer contract periods with longer notice periods required for withdrawal to accommodate the longer lead time for transmission relative to generation; greater penalties for non-performance; technology to allow system operators to interrupt service to a participant without relying on the participant's voluntary compliance; and greater evergreen provisions (e.g., legal provisions to obligate the new owner of a contracted house or business to honor the contract).

13.2.6.4 Capital Costs

Even though no feasible NTA was found, ICF estimated the capital costs of the inadequate NTA's that it tested. The Combination NTA had capital costs of at least $15 billion or roughly 30 times the cost of the Interstate Project.

[10] In the event of a contingency, additional resources are required. To the extent that NTA resources are supply, then the region is less reliant on demand resources – e.g., active DR is not used. Conversely, if NTA resources are all demand resources, then the demand resource usage will be added to the amount and frequency of demand resources called upon separate from the existence of a contingency.

13.2.6.5 Supply NTA Volatility Risk

Supply NTAs (new generation) would likely involve Contracts For Differences under which the ratepayers undertake to make up the shortfall that may occur if a new plant's revenue requirements exceed its market-based earnings in the ISO-NE markets. That is, whatever the estimated capital costs for the supply component of an NTA are, its actual cost will most likely be subject to substantial variability because it will be subject to market volatility.

13.2.6.6 NTA Cost Allocation versus Interstate Cost Allocation

The ISO-NE-wide transmission planning process that concluded Interstate is needed will likely result in a region-wide allocation of transmission costs based on each state's share of New England's load. There is no equivalent mechanism for allocating the costs of the many components of an NTA.

13.2.6.7 New ISO-NE Rules Make NTAs Even Less Practical

Between February 2010 and April 2011, ISO-NE, FERC, NEPOOL and others were involved in a process that changed the FCM rules.[11] The process was focused on improving price signals in ISO-NE. One effect of the rule change is that NTAs became less economically attractive to regulators and consumers because the new rules eliminate or greatly decrease the potential for the NTA to depress the FCM price. A second effect was to create greater emphasis on the ability to transmit power across zones in ISO-NE in order to maintain reliability and to moderate FCM price changes. This occurred due to the following changes:

- Retirements became more likely due to the forthcoming elimination of the FCM price floor which maintained excess capacity in ISO-NE in previous FCAs.
- Retirements also became more feasible due to the forthcoming implementation of a "model all zones all the time" policy. Previously, only import and export constrained zones were separately modeled apart from the region as a whole, and generation owners could not respond to lower prices and decide to retire during the forward capacity auction.

[11] The rules and their changes are discussed in detail in Appendix F of the ICF Report. Final implementation is scheduled for FCA #8, or earlier.

- Local zonal capacity requirements are being increased via a new approach to setting local supply sourcing minimums.

13.2.7 Conclusion – Non-Transmission Alternatives

No feasible or practical NTA to the Interstate Reliability Project was identified, in spite of a diligent evaluation. ICF's work did show, however, that any hypothetical NTA that could be identified would be unprecedented in scope, immensely costly, difficult or impossible to implement, and less flexible and robust in operation than the proposed transmission solution.

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SECTION 14

TRANSMISSION LINE ROUTE / CONFIGURATION ALTERNATIVES

14. TRANSMISSION LINE ROUTE / CONFIGURATION ALTERNATIVES

14.1 ROUTING OBJECTIVES AND ALTERNATIVE ROUTE ANALYSIS PROCESS

After the Interstate Reliability Project (designed as new 345-kV transmission lines to connect CL&P's Card Street Substation, CL&P's Lake Road Switching Station, National Grid's West Farnum Substation, and National Grid's Millbury Switching Station) was selected as the preferred transmission system solution (according to the process described in Section 13), both CL&P and National Grid identified and evaluated alternative routes and configurations for the new transmission lines. All of the potential alternative routes for the new 345-kV transmission lines necessarily had to interconnect the two substations and two switching stations that are the backbone of the Interstate Reliability Project. This section describes the approach that CL&P used to identify and evaluate route alternatives for the proposed 345-kV transmission lines in Connecticut.

14.1.1 Routing Objectives

As part of the alternatives analysis process for the Connecticut portion of the Interstate Reliability Project, CL&P applied an established set of route selection objectives in order to identify and compare potential routes for the new 345-kV transmission lines between the Card Street Substation and the Lake Road Switching Station, and from Lake Road Switching Station to National Grid's new 345-kV transmission line at the Connecticut / Rhode Island border. CL&P's defined line routing objectives, which are listed in Table 14-1, include the following overarching goals:

- The selection of cost-effective and technically feasible solutions to achieve the required transmission system reliability improvements and to interconnect the specified substations and switching stations; and

- The avoidance, minimization, or mitigation of adverse environmental, cultural, and economic effects.

Table 14-1: CL&P 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, highways, railroads, pipelines)
- 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

14.1.2 Alternative Route Analysis Process

CL&P applied the transmission line route selection objectives to identify potential 345-kV transmission line route alternatives involving both overhead and underground configurations. These potential route alternatives were then examined, using CL&P's route evaluation criteria for overhead transmission lines (as discussed in Section 14.2) and underground transmission cables (as discussed in Section 14.3), 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 configuration types.

As the first step in the alternative route analyses, CL&P[1] identified major, geographically distinct, route alternatives (both within or adjacent to existing ROWs and along potential new ROWs) for the proposed 345-kV transmission lines between Card Street Substation, Lake Road Switching Station, and the

[1] The alternative routes were identified and evaluated by a team consisting of CL&P staff, as well as specialized engineering and environmental consultants. This team conducted field reconnaissance, performed baseline data collection, and reviewed aerial photography to determine the characteristics of each route alternative and to assess each in terms of CL&P's objectives and route evaluation criteria.

National Grid ROW at the Connecticut / Rhode Island border. The initial investigation of potential alternative line routes involved the review of CL&P records, road atlases, and USGS topographic maps to identify existing linear corridors (e.g., highways, pipelines, transmission lines, and railroads) in the Project region. Aerial photographs of the Project region also were reviewed for potential new transmission line routes (e.g., not along existing utility or road corridors), as well as 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) along the alternative routes under consideration.

As a result of these initial investigations, the following potential route/configuration alternatives were identified and then evaluated for the proposed 345-kV facilities:

- Alignment of the proposed 345-kV transmission lines in an overhead configuration along CL&P's existing ROWs between Card Street Substation, Lake Road Switching Station, and the Connecticut / Rhode Island border.

- Alignment of an underground 345-kV cable system within CL&P's existing ROWs between Card Street Substation, Lake Road Switching Station, and the Connecticut / Rhode Island border.

- Development of the 345-kV facilities, in either overhead line or underground cable-system configurations, along new ROWs, which would require the acquisition of utility easements from numerous landowners.

- Collocation of the proposed 345-kV transmission facilities, using either overhead lines or underground cables, adjacent to or within other existing linear corridors in the Project area, including railroads, pipelines, and public roads.

- Development of the proposed 345-kV transmission lines predominantly overhead along CL&P's existing transmission line ROWs, except for certain segments of the lines where underground cable-route variations or overhead line-route variations were identified to minimize potential adverse effects on environmental resources, residential areas, community facilities, or other land uses.

CL&P evaluated each of these potential route alternatives, using the criteria identified in Sections 14.2.1 (for overhead transmission lines) and 14.3.1 (for underground transmission cable systems). Some of the route alternatives were quickly found to be impractical because of overriding environmental issues, engineering constraints, or cost factors. Other alternatives 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 14.2.2 and 14.3.3 for discussions of alternative overhead and underground line routes that were eliminated from consideration.)

Based on this evaluation process, CL&P identified the preferred alternative as all-overhead 345-kV transmission lines, aligned along CL&P's existing transmission line ROWs, between Card Street Substation and Lake Road Switching Station, and from there to the Connecticut / Rhode Island border (i.e., the "Proposed Project"). Subsequently, CL&P performed more detailed engineering and environmental investigations to assess and refine the location of the proposed transmission line structures within these ROWs.

In addition, CL&P examined locations along the ROWs where different transmission line configurations (i.e., different overhead line structure types or underground cable systems) or different routes (i.e., alignments outside of the existing CL&P ROWs) merited consideration. These studies led to the identification and comparative assessment of six transmission line-route variations, consisting of both underground and overhead line configurations along certain segments of the Proposed Project ROWs. These route variations, which are discussed in Section 15, were identified as potentially feasible alternatives to avoid or mitigate potential effects to environmental resources or to existing developments near the ROWs.

During the alternatives analysis process, CL&P also identified design options for the location of the new 345-kV transmission line across the 1.4-mile segment of federally-owned property in the Mansfield Hollow area. These options, which involve different transmission line structure and ROW width configurations, all represent feasible approaches for installing the new 345-kV line across the federally-owned properties. Depending on approvals from the Council and the USACE, CL&P would be prepared to use any one of these options. Accordingly, the design options are discussed in Volume 1, Section 10.

In addition, overhead transmission line design alternatives involving vertical or delta conductor configurations on steel-monopole structures, instead of H-frame structures, were identified in five specific locations (referred to as EMF BMP “focus areas”) along the Proposed Route. These areas are identified and discussed in Volume 1, Section 7. After evaluation of these five focus areas, CL&P incorporated steel monopoles into the proposed 345-kV line configuration in three of the focus areas. In the remaining two focus areas, H-frame line was determined to represent the BMP design.

14.2 OVERHEAD TRANSMISSION LINE ROUTES: ALTERNATIVE ANALYSIS

14.2.1 Route Evaluation Criteria

Along with the route selection objectives listed in Table 14-1, CL&P 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 this 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 Volume 1, Section 4 for information regarding overhead transmission line construction and ROW vegetation management procedures.)

Taking these issues into account, CL&P gives primary consideration to the criteria listed in Table 14-2 when evaluating potential routes for a new overhead 345-kV transmission line. These overhead line routing criteria were applied to examine and compare alternative overhead line routes for this Project.

14.2.2 Alternative Line Routes Considered but Eliminated

CL&P identified and reviewed numerous overhead transmission line-route options, ranging from the development of the proposed 345-kV lines on new ROWs to the use of various existing linear corridors, to interconnect Card Street Substation and Lake Road Switching Station with National Grid's facilities in Rhode Island. However, most of these alternative routes were eliminated from detailed consideration because they were found to be unsuitable for the development of the new transmission lines due to factors such as engineering constraints, geographic location, or potential for significant environmental, social, or economic effects.

The following subsections identify the major route alternatives that were initially identified as viable options for the alignment of the proposed 345-kV transmission lines, and then subsequently eliminated from consideration. Figure 14-1 illustrates the general location of these alternative routes. (Note: Figure 14-1 generally identifies the locations of both overhead and underground line-route alternatives that were initially identified.)

14.2.2.1 New Right-of-Way Alternative

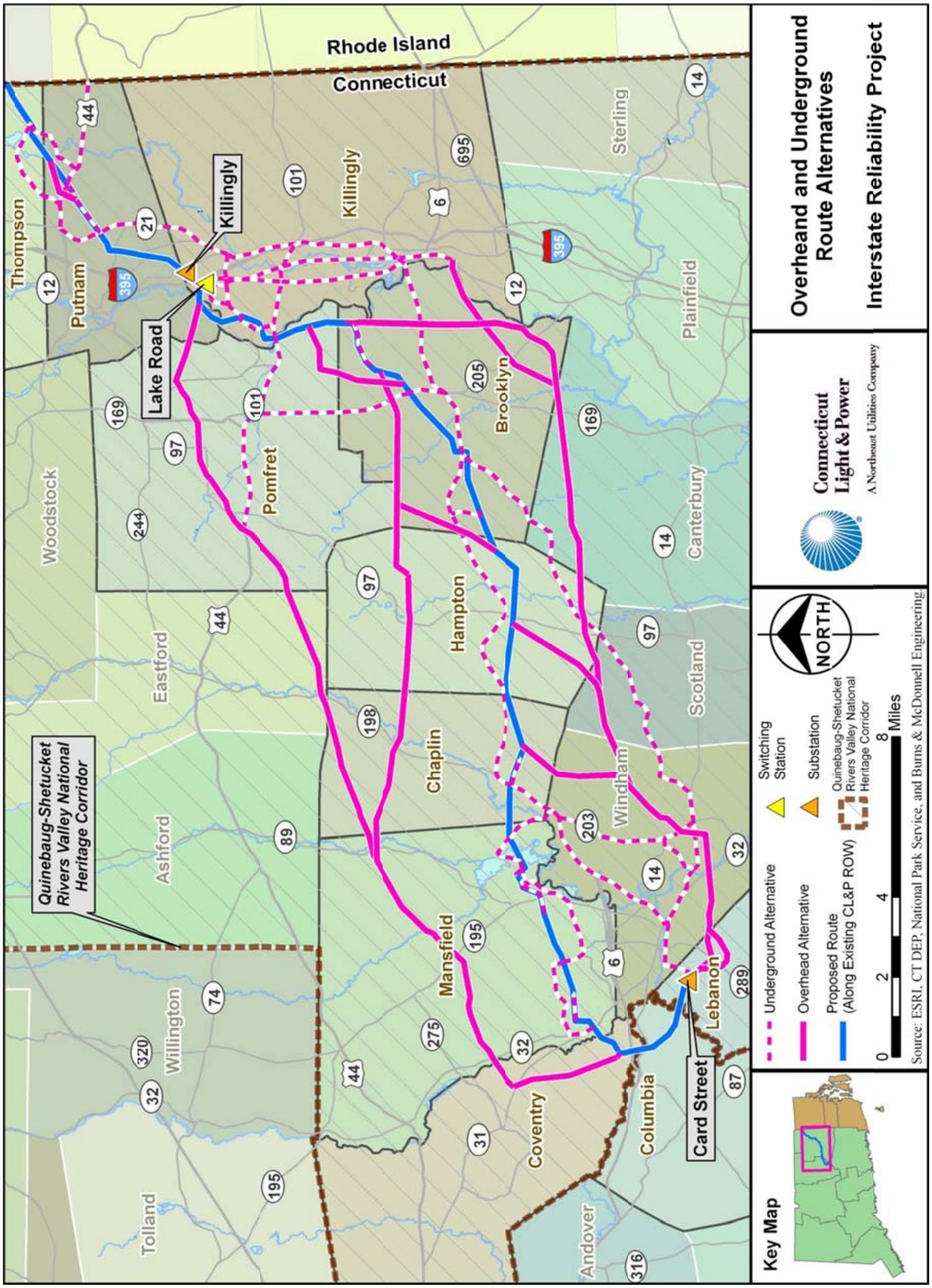
This alternative would involve the development of the overhead 345-kV transmission lines between Card Street Substation, Lake Road Switching Station, and the Connecticut / Rhode Island border along an entirely new ROW (referred to as a "greenfield" corridor) not adjacent to any other existing linear 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 interconnection points.

Table 14-2: Route Evaluation Criteria for Overhead Transmission Line Siting

ROUTING CRITERIA	DESCRIPTION
Availability of Existing ROWs for the New Lines to Follow	The potential collocation of the 345-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 collocation 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.[2] An entirely new 345-kV overhead line route would require a minimum 100-foot-wide ROW to accommodate a line with vertically arranged line conductors and a minimum 150-foot-wide ROW for horizontally arranged line conductors. The placement of the same new 345-kV transmission line on 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 345-kV transmission line. Typically, to accommodate a new 345-kV H-frame transmission line adjacent to an existing transmission line, approximately 90 feet of ROW would have to be cleared of tall-growing woody vegetation and managed in low-growth vegetation. The use of new steel-monopole structures, built adjacent to an existing overhead line of steel-monopole structures, each supporting conductors in a delta configuration, would require approximately 70 feet of new vegetation clearing.
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.
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 CL&P'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 14-1). Further, in Connecticut, statutory provisions[3] discourage the construction of a new 345-kV overhead transmission line "adjacent to" certain land uses (collectively referred to herein as "Statutory Facilities"), including residential areas, private and public schools, licensed child day-care facilities (residential and commercial day-cares), licensed youth camps, and public playgrounds.
Consideration of Visual Effects	Because 345-kV line structures are typically at least 85 feet tall (for an H-frame 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).
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 areas such as parks, wildlife 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.

[2] Connecticut General Statutes Section 16-50p(a)(2)(D)
[3] Connecticut General Statutes Section 16-50p(i)

Figure 14-1: Transmission Line Route Alternatives Initially Identified



However, an entirely new corridor for a horizontally configured (H-frame structures) 345-kV overhead transmission line would require a minimum 150-foot-wide ROW. Even (unrealistically) assuming a minimum straight-line 28-mile distance between Card Street Substation, Lake Road Switching Station, and the interconnection with National Grid's facilities at the Connecticut / Rhode Island border, this alternative route would require the acquisition of more than 500 acres of property for new utility easements.[4]

In addition to these easement acquisition issues, the development of the 345-kV transmission lines along a "greenfield" corridor was determined to be impractical for environmental reasons. For instance, to construct the proposed 345-kV transmission lines, 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 existing ROWs, the creation and maintenance of such a "greenfield" corridor can cause long-term environmental effects (e.g., permanent fill in wetlands due to new access roads and structures, development of a new linear corridor through previously 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 collocation 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. A new "greenfield" 28-mile transmission line ROW also could be inconsistent with the goals of environmental protection within the Quinebaug and Shetucket Rivers Valley National Heritage Corridor, which encompasses 26 towns in northeastern Connecticut. In general, the installation of new transmission line facilities along existing ROWs (e.g.,

[4] Using a vertical (monopole structure) conductor configuration on the new 345-kV line would reduce the ROW width, but would require taller structures.

transmission line ROWs, pipeline corridors, highways, railroads) is environmentally preferable to creating entirely new corridors through properties previously unaffected by linear developments.

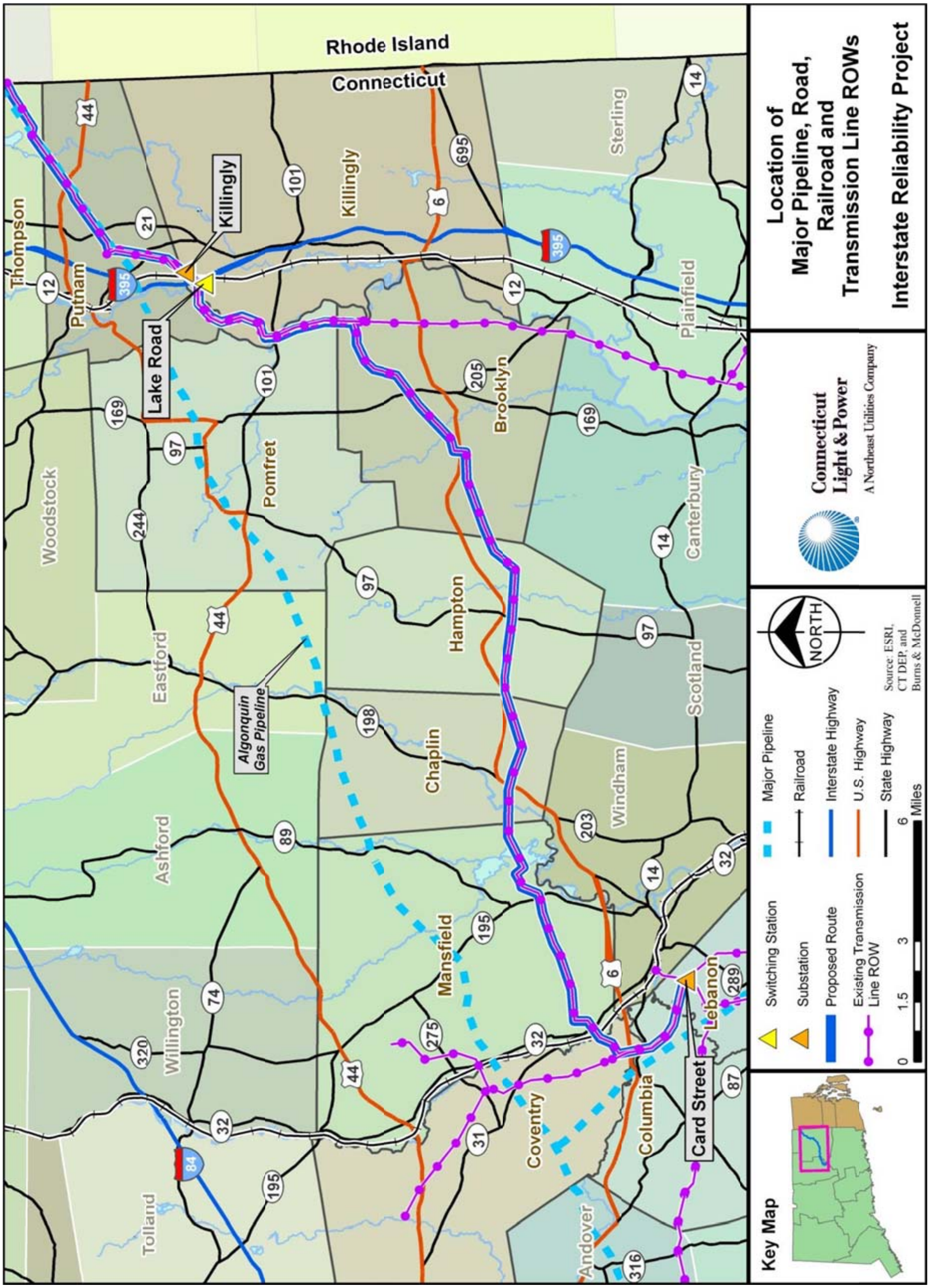
Operation of the new 345-kV transmission lines requires long-term restrictions on land uses within the new ROW. Uses must be compatible with utility operation, and buildings are precluded. For an overhead transmission line, the ROW would have to be managed in low-growing vegetation, although access would only have to be maintained to the transmission line structures.

Overall, the all-new ROW alternative was determined to be impractical based on land use, and environmental considerations. This alternative would not conform to federal and state policies for the collocation of linear corridors to the extent practical and CL&P's acquisition of such easements from private property owners would be both costly and time-consuming.

14.2.2.2 Pipeline Right-of-Way Alternatives

The Algonquin Gas Transmission Company (Algonquin), which is owned by Spectra Energy Transmission, operates the only major natural gas transmission pipeline system within the Project region. Algonquin's natural gas transmission pipelines, which were initially installed more than 30 years ago, extend generally southwest-to-northeast across northeastern Connecticut, traversing the towns of Coventry, Mansfield, Chaplin, Eastford, Pomfret, Putnam, and Thompson (refer to Figure 14-2).

Figure 14-2: Pipeline, Highway, Railroad, and Transmission Line ROWs in the Project Region



After a screening level analysis of this potential route alternative, CL&P determined that the pipeline ROW did not represent a viable option for the location of a new 345-kV transmission line (configured either overhead or as an underground cable system), for the following primary reasons:

- While the pipeline ROW does extend through northeastern Connecticut into Rhode Island, it is not located near the Card Street Substation or Lake Road Switching Station, both of which must be interconnected to National Grid's transmission facilities.

- Even if the pipeline route were closer to the specified substation and switching station facilities that must be interconnected, the unoccupied portion of the pipeline ROW is too narrow to accommodate a new 345-kV transmission line. Instead, new easements parallel to, but outside of, the pipeline ROW would have to be acquired for the transmission line. Numerous homes are located near the pipeline ROW. In order to accommodate the new transmission line adjacent to the pipeline ROW, CL&P would have to obtain easements from private landowners in order to expand the ROW along its entire length. As a result, the new transmission line would be very close to residences, some of which would likely have to be acquired. In addition, the creation of a new utility ROW for the transmission line would affect a variety of environmental resources.

14.2.2.3 Alternative Routes along Highway Rights-of-Way

Northeastern Connecticut has a well-developed network of federal, state, and local roads. This alternative would involve the development of the proposed 345-kV transmission lines in overhead configurations within or adjacent to highway corridors (refer to Figure 14-2). Key considerations in the review of this alternative were the locations of roads in relation to the existing CL&P substations, switching station, and National Grid transmission lines that must be interconnected to meet Project objectives, as well as construction feasibility and potential environmental resource and social effects.

CL&P focused on state and limited access highways as potential routes for the 345-kV overhead transmission lines. Compared to most local roads, state and federal 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.

In order to construct a new overhead, vertically-configured, 345-kV transmission line, a 100-foot-wide ROW would be required.[5] 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 collocation of transmission lines in ConnDOT limited access highways is not permitted except in special circumstances, as provided in ConnDOT's *Utility Accommodation Manual* (2009). In February 2009, CL&P met with ConnDOT to discuss this policy with respect to the potential for the collocation of the proposed 345-kV transmission lines along state and interstate highways for the Project. ConnDOT representatives affirmed that the agency opposes the collocation of transmission lines in state road ROWs, particularly if other routing alternatives, such as the use of existing utility ROWs, are available.

As illustrated in Figure 14-2, the principal highways in the Project area that are aligned in whole or in part in the general direction required for a transmission line route that would interconnect the CL&P substations, switching station, and the National Grid facilities are:

- U.S. Route 6 – extending from Willimantic east through the towns of Brooklyn and Danielson and into Rhode Island (a portion of which is limited access).

- A portion of Interstate 395 – a limited access highway that generally traverses north-to-south through northeastern Connecticut, paralleling the Connecticut / Rhode Island border.

To evaluate the feasibility of using these highway corridors for the proposed 345-kV transmission lines, CL&P conducted field reconnaissance, reviewed USGS topographic maps, and studied aerial photographs. Because ConnDOT policies discourage the collocation of transmission lines linearly along limited access highways unless no other feasible routes are available, the investigations also involved a

[5] Other common configurations of an overhead 345-kV line use shorter structures, but require up to 150 feet of ROW width. Existing highway easement widths vary. As a result, an overhead transmission line could have to be located either within or adjacent to highway property.

review of the areas immediately adjacent to (but outside of the ConnDOT ROWs) along Interstate 395 and the limited access portion of U.S. Route 6.

Based on these analyses, CL&P determined that only limited and discontinuous segments of the highways would potentially meet the requirements for accommodating a new overhead 345-kV transmission line ROW. In general, because portions of all of the highways traverse suburban or urban areas, the development of the transmission line adjacent to the roads would be constrained by residential, commercial, or industrial land uses. Furthermore, wherever the transmission line ROW could not be located within the existing highway easements, new ROW would have to be acquired from private landowners. As a result, no highway corridors were identified that would provide a continuous linear connection between the existing CL&P substations, switching station, and National Grid's facilities.

However, CL&P determined that certain portions of Interstate 395 and U.S. Route 6 merited additional study as alternative routes for the potential alignment of segments of the proposed transmission lines. CL&P's analyses of these highway segments are summarized as follows:

- **Interstate 395.** Although Interstate 395 was dismissed as a viable alignment for the proposed 345-kV transmission lines as a whole (because the highway does not traverse in the west-to-east direction required for the proposed transmission lines), a 6-mile portion of the highway in the Town of Killingly was reviewed as a possible alternative for a segment of the transmission line. This segment extends from the Killingly / Danielson border to CL&P's Lake Road Switching Station. However, this portion of Interstate 395 was determined to be infeasible for use as a transmission line route for several reasons, including the ConnDOT policy of not allowing the collocation of transmission lines longitudinally within the ROWs of any limited-access highway. Other primary factors in eliminating this alternative route segment were the lack of adequate space to accommodate a new overhead transmission line ROW within the highway corridor, potential effects on environmental resources adjacent to the highway ROW (e.g., crossing of the Quinebaug River, potential impacts to wooded areas), and potential effects on adjacent land uses (e.g., the possible need to displace homes and businesses).

- **U.S. Route 6.** U.S. Route 6, a primary east-west transportation corridor, is located approximately 2 miles north of the Card Street Substation. The segment of the highway from the Card Street Substation east to Interstate 395 was evaluated as a potential route alternative for the new 345-kV transmission lines. (In the Town of Killingly, U.S. Route 6 is located approximately 7 miles south of the Lake Road Switching Station and thus does not represent a viable option for a transmission line route to connect to this station.) The primary determinant of construction feasibility was adequate space for a new overhead 345-kV transmission line ROW without having to displace homes or businesses located adjacent to the highway. However, U.S. Route 6 is an important regional transportation corridor and, as a result, a variety of residential, commercial, and industrial uses border the road, most situated within 200 feet of the edge of the road ROW. Because a new overhead line would require between 100 and 150 feet of ROW width (depending on the line configuration), residential and business properties located near U.S. Route 6 would be directly affected. Although the exact widths of the ConnDOT easements along U.S. Route 6 were not specifically researched as part of this routing study, it is likely that CL&P would have to obtain easements from ConnDOT and private landowners adjacent to U.S. Route 6, which would involve substantial property acquisition costs. In addition, the construction of the transmission line could cause temporary and localized adverse effects on some businesses by interfering with customer access and causing general traffic disruptions (e.g., detours, congestion).

The development and operation of an overhead transmission line adjacent to either of these highway ROWs could also affect the aesthetic environment since the new transmission line would be visible both to travelers on the highways and to local residents and business personnel. 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 345-kV transmission line adjacent to these roads would be difficult. Furthermore, compared to structure heights along a typical transmission line ROW, the transmission line structures along a road ROW would likely have to be taller to maintain conductor clearances over the distribution and telephone lines that are presently aligned along the roadways.

Overall, CL&P dismissed all of the highway route alternatives from further consideration as potential overhead transmission line routes due to the significant construction difficulties and constraints, as well as the unacceptable social effects associated with the need to remove homes and businesses. The complexity of construction, the need to follow road ROWs that do not provide direct routes between the substations and switching station that must be electrically linked, 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 existing transmission line ROWs that already directly interconnect such stations.

14.2.2.4 Alternative Routes along Railroad Rights-of-Way

Several railroad lines cross northeastern Connecticut (refer to Figure 14-2). These railroad lines are owned and operated by the Providence & Worcester Railroad and New England Central Railroad, and generally traverse in a north-south direction through the Project area. CL&P investigated whether the new 345-kV line could be aligned along these railroad corridors, as well as whether portions of the railroad corridors could be combined with other existing linear ROWs to create a continuous alternative route for the Project.

However, these investigations revealed that it would be impractical to align the new 345-kV line along any of these existing railroad corridors. None of the railroad corridors are located in the immediate vicinity of the Card Street Substation, Lake Road Switching Station, or National Grid's Rhode Island facilities. As a result, to interconnect the CL&P stations with the National Grid facilities, any transmission line alignment along these existing railroad ROWs would have to be combined with ROW segments along other existing linear corridors or along a "greenfield" ROW. Therefore, any alternative involving alignments along these railroad corridors would be much longer than other routing options and thus would result in higher construction, operation, and maintenance costs.

In addition, the railroad corridors have narrow widths (averaging approximately 50 to 100 feet) and are bordered directly by a variety of land-use developments. In order to construct a new transmission line along these railroad ROWs, CL&P would have to acquire easements on adjacent properties to expand the ROWs. Given the abutting land use development, the acquisition of significant additional property and numerous adjacent homes and businesses would be required. Furthermore, the construction and operation of the 345-kV lines would be complicated by safety concerns associated with work directly adjacent to the active railroad lines, as well as the need for electric transmission line work to avoid conflicts with the railroads' schedules. Given the significant amount of development near the railroad lines, the narrow railroad corridors, and the longer route that would be required, this option was determined to be environmentally, socially, and economically impractical.

14.3 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 (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.

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 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.

Within the past eight years, CL&P has sited and installed underground transmission cable systems as part of the Bethel-Norwalk Project (345-kV and 115-kV transmission cables), Middletown-Norwalk Project (345-kV and 115-kV transmission cables), and the Glenbrook Cables Project (115-kV transmission cables). As a result, CL&P has extensive, recent experience in underground transmission cable routing, construction, and cost analysis.

14.3.1 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. As a result, any potential use of a 345-kV underground cable system instead of a 345-kV overhead transmission line must first give consideration to the key differences between overhead line and underground cable technologies.

Consequently, the siting analysis for underground cable systems involves a two-step process:

- Reviewing key engineering considerations for the selection of appropriate underground cable technology (refer to Section 14.3.1.1); and then
- Applying traditional route evaluation criteria to identify and assess siting options for underground cable systems (Section 14.1.3.2).

The cost of installing and maintaining underground transmission cable systems also is a critical consideration in the alternatives evaluation process and is discussed separately in Section 14.3.1.3.

14.3.1.1 Considerations in Selecting Underground Transmission Technology

A tutorial regarding underground electric power transmission cable systems, included in Appendix 14A, describes underground cable technologies in greater detail. The important differences between underground and overhead 345-kV transmission systems center around the following factors, which are discussed in this section: technical limitations, transmission system operational considerations, power quality concerns, and recovery time from outages (reliability).

Based on its recent experience with transmission cable systems, CL&P identified two cable technologies for consideration for the Project[6]: High Pressure Fluid Filled (HPFF) and Cross-linked Polyethylene (XLPE). The principal characteristics of each of these technologies are:

- **HPFF**. Until recently, HPFF cable was the primary underground technology used for 345-kV underground transmission lines in the United States. This type of cable system involves the use of a dielectric fluid pressurized to a nominal 200 pounds per square inch (psi) within a steel pipe housing the cables, and therefore requires pressurization plants and reservoirs. These reservoirs hold thousands of gallons of dielectric fluid. The fluid system within HPFF cable systems

[6] Appendix 14A describes other cable technologies, which were not deemed practical for this Project.

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.

- **XLPE.** XLPE cables have a water-impervious sheath to keep moisture from entering the extruded, cross-linked polyethylene insulation, and each cable is installed inside a separate duct within a duct bank. No dielectric fluid is involved. Compared to HPFF cables, the XLPE cables have lower electrical losses and significantly higher ratings. XLPE cables have recently experienced more use at 345 kV and over longer distances. CL&P is now operating approximately 25.7 miles of 345-kV XLPE cable systems (six 345-kV cables) as part of the Middletown-to-Norwalk and the Bethel-to-Norwalk projects. In addition, CL&P used XLPE cables (at 115 kV) for the Glenbrook Cables Project, two portions of the Bethel-Norwalk Project, and a 1-mile section of the Middletown-to-Norwalk Project.

As explained further below, based on the capacity required and the success of CL&P's recent underground cable projects, XLPE cable was selected as the preferred cable technology for the Project.

Technical Limitations

Underground transmission cables have typically been used for short distances (less than 5 miles) in urban environments, which characteristically have strong electrical sources (e.g., proximity to generation facilities or multiple transmission lines). Consideration of long lengths of underground 345-kV cables in suburban or rural settings (which usually are remote from strong sources) and the large amounts of cable-charging current associated with the long cable lengths, combined with moderate system strength relative to the cable-charging currents, requires care to prevent damage, disruptions to the transmission system, and potential damage to customer equipment. Proposed 345-kV cable installations must be carefully analyzed by power-system engineers, taking into account the different characteristics of the cables and substation equipment at the cable terminations.

Underground 345-kV cables have much lower current-carrying capability compared to overhead 345-kV transmission line conductors. At 345 kV, to achieve the same power-transfer capacity of a single overhead transmission line, multiple underground cables must be installed (three or more sets of three cables). Thus, a 345-kV underground cable system must consist of multiple sets of cables, and therefore multiple splice vaults at each vault location.

Due to the electrical characteristics of the insulation materials used in underground transmission cables and the proximity of the cables to each other when buried, the capacitive charging currents of an underground cable system are significantly higher than those of overhead lines. For most medium- and long-length underground 345-kV transmission systems, special switching devices and large shunt reactors may be required to compensate for the capacitive charging of the underground cables in order to prevent unacceptably high system voltages during normal operating conditions. These devices add operating complexity, decrease system reliability, require additional land at termination points, and add appreciable cost, especially when multiple cable systems are required.

To connect a 345-kV underground cable segment with an overhead transmission line segment, a line transition station on a 2- to 4-acre site[7] must be constructed at the interconnection location. Within the line transition station, switching equipment may be installed to isolate the underground cables from the overhead line conductors and large shunt reactors, depending upon the underground cable segment's circuit location and its length. (For example, if an underground cable system were used for the Project, a new 345-kV line transition station would have to be constructed near the Connecticut/Rhode Island border at the interconnection with the National Grid overhead 345-kV line.)

When transmission lines or power transformers are switched in a transmission system that has a circuit made up of overhead line and underground cable sections, potential problems can arise because of traveling wave reflections. Switching transient voltages traveling along a line would reflect at points of characteristic impedance change, such as where an overhead line and an underground cable are connected. The voltage reflections can lead to excessive transient voltages, damaging the underground cable itself or other electrical equipment associated with the overhead transmission system.

[7] Site acreage requirements vary based on terrain (e.g., need for grading, site development work). Typically, approximately 1.5 to 2 acres of each 345-kV line transition station site is developed for the above-ground electrical equipment, the overhead and underground lines, and access road. Any remaining land at the site typically would be undeveloped.

Because of these technical considerations and lower electrical impedances of cables, detailed 60-Hertz (Hz) load-flow and harmonic transient voltage studies (refer to the discussion of **Power-Quality Concerns**, below) must be conducted by power-system engineers to determine the maximum length of 345-kV underground cables that could be potentially installed at any location on the transmission grid without adversely affecting the New England transmission system.

Transmission System Operational Considerations

The operation of an all-underground 345-kV cable transmission circuit, or an overhead 345-kV transmission circuit with one or more segments of underground cables, introduces additional transmission system complexity. When a long (more than 5 miles in length) underground cable circuit is initially energized, even though it may not be carrying load, all associated shunt reactors need to be energized to maintain voltages within acceptable levels. When the underground cables start to carry load, the voltage on portions of the system would instantaneously drop until a sufficient amount of shunt reactor compensation can be disconnected. If the shunt reactors are improperly sized or designed, unacceptable voltage swings can occur on the system which can lead to brownouts or blackouts when relays operate to protect the system.

At normal loading, typically only one third of the shunt reactors necessary to maintain the voltages within acceptable levels at the terminals of the underground cable circuit may be required to be in service. For some contingencies on the interconnected transmission system, current flow through the underground cables may instantaneously drop to nearly zero. Because only a portion of the shunt reactors are in service and the remaining portion of the shunt reactors cannot be connected instantaneously to increase their compensation for the capacitive charging of the cables, voltages could rise to unacceptably high levels within portions of the transmission system.

Unlike an all-overhead transmission system, the underground cables introduce a higher level of system operational complexity. System operators must carefully follow a defined sequence of steps when placing an underground cable system in service or removing it from service. They must also be fully aware of the effects of their actions on the transmission system to ensure that voltages remain within acceptable ranges. In critical or emergency situations, the time required to perform these crucial operating steps could be detrimental to the integrated transmission system.

Power-Quality Concerns

When operating underground cables, system engineers need to be concerned with the magnification of harmonic voltages and currents, which are predominantly generated by customer loads and during the energization of three-phase transformers. System harmonic resonances arise for applications of longer cables where the transmission system's local strength is weak or moderate relative to the cable-charging requirement. Low-order harmonic resonances can cause system failures, including cascading outages, and damage to equipment, including power transformers.

Day-to-day switching events, like the energizing and de-energizing of transmission circuits occurring in the normal transmission system operation, can cause amplification of harmonic voltages and currents leading to system component failures and severe power-quality problems. The amplified harmonic voltages and currents can have a detrimental effect on customer equipment and processes. A standard developed by the Institute of Electrical and Electronics Engineers (IEEE) establishes the maximum levels of harmonic voltages and currents allowed to exist on a transmission system at different voltage levels to ensure electric utility and customer equipment and processes are not damaged.

Recovery from Outages

Most faults occurring on an overhead transmission line trip a circuit out of service for only a few seconds because typical faults are temporary, do not cause line damage, and automatic circuit reclosing systems successfully restore the circuit to service. In contrast, when a fault occurs on and trips out a transmission circuit that consists entirely or partially of underground cables, automatic circuit reclosing is not used for fear of causing further damage to an already damaged underground cable. Thus, the circuit outage lasts longer until the cause is found.[8]

Furthermore, compared to an overhead circuit, when a non-temporary fault occurs on a transmission circuit that is entirely or partially comprised of underground cables, significantly more time typically is required to find and then isolate a faulted segment of cable before repairs may commence. Causes of non-temporary faults on all-overhead circuits can be found quickly.

Transmission circuits with multiple short underground cable sections further complicate and extend the time it takes to locate precisely where, within the underground cable segments, the problem exists. Once the problem is located, repair times on an underground cable typically take weeks to complete, compared to hours or a few days to repair most overhead transmission line failures.

Historically, most underground cable-system failures are associated with cable-splice failures or with termination equipment. A long outage of a 345-kV transmission circuit negatively affects system operations and reduces the overall reliability of the transmission system.

14.3.1.2 Route Evaluation Criteria

When performing any analyses of potential underground cable-system routes, CL&P 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 14-3 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.

[8] For example, in 2011, a long outage occurred on one underground 345-kV cable circuit that was installed as part of the Middletown to Norwalk project.

Table 14-3: Route Evaluation Criteria for Underground 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 would be directly affected by the excavations required for the cable system, as well as by the access roads that must be permanently maintained along the underground route. To mitigate such impacts, the cables can be installed for 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 345-kV underground cable system typically requires a minimum 40-foot-wide work area for construction. Additionally, land must be available for burying splice vaults, each approximately 10 feet wide by 10 feet deep and up to 32 feet in length. Such vaults, which must be placed at approximately 1,600-foot intervals along a 345-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 access to adjacent land uses, and potential conflicts with other 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.
Availability of Land for Line Transition Stations	Unless terminated at a substation, underground transmission systems require separate above-ground transition stations at each location where the underground cables interconnect to overhead transmission lines. In general, transition stations require the purchase and conversion of land to industrial (utility) use, and consist of above-ground facilities within a graded, fenced area, similar in appearance to a transmission substation. Routing analyses must consider the availability of land required for transition stations, as well as the environmental and social effects resulting from station development (e.g., surrounding land uses and potential effects on natural resources, cultural resources, neighborhoods, and the visual environment).

14.3.1.3 Cost

Cost is a key consideration in the evaluation of underground cable technology versus overhead technology. The typical costs for constructing an underground 345-kV transmission cable system are five to ten times greater than those for installing an equivalent length of overhead 345-kV transmission line on an existing ROW.

The higher end of this range is reached when line transition stations are required to interconnect overhead and underground cable segments. Each 345-kV line transition station may involve acquisition of land from private property owners (where CL&P-owned land is not available) and costs several million dollars to construct.

In addition, except where underground cable routes can be aligned entirely within highway ROWs or within existing CL&P ROWs where CL&P's easements include underground cable rights, CL&P 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 easement; 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 345-kV cable system. However, for most applications, the percentage difference between overhead and underground system "life cycle" costs (which additionally consider operating and maintenance expenses and electrical losses over the life of the transmission facility) is slightly less than the difference between overhead and underground system capital costs.

The difference in the cost to Connecticut consumers for a 345-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 27% of the New England load; therefore, Connecticut consumers would bear approximately 27% 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 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 borne solely by 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 27% 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 CL&P 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 34 times more than that of the overhead line [(1 x 27%) + (9 x 100%) = 9.27 ÷ 0.27 = 34.3]. The cost multiple can be even larger for Connecticut electric consumers if a section of underground 345-kV transmission line with line transition stations is selected as an alternative to a short segment of overhead line, because the entire cost to construct the line transition stations would be borne solely by CL&P customers.

14.3.2 Construction Considerations and Procedures

Underground cable-system construction requires vastly different procedures and considerations than overhead transmission line construction. This section summarizes the typical underground transmission cable construction procedures that would be used to install an XLPE 345-kV transmission cable system. Such procedures would apply for any length of cable system (i.e., for the installation of an "all-underground cable route" between Card Street Substation, Lake Road Switching Station, and the Connecticut / Rhode Island border, or for smaller segments of transmission line, as discussed in Section 15 for the underground line-route variations).

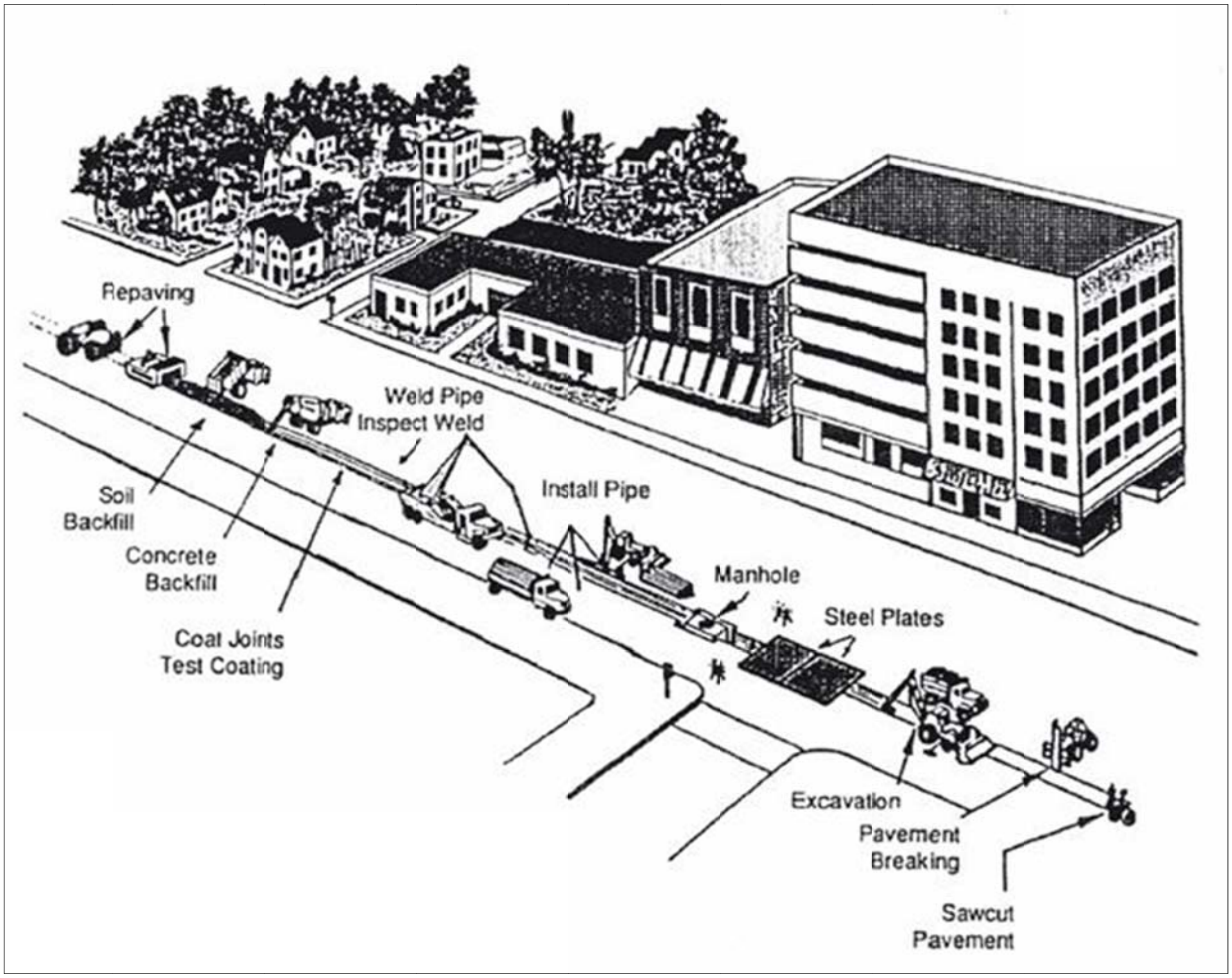
Section 14.3.2.1 explains the typical construction activities and sequence for underground cable-system installation within or adjacent to road ROWs, whereas Section 14.3.2.2 describes how construction procedures would differ for the development of a cable system outside of road ROWs (e.g., along transmission line ROWs or along a "greenfield" utility corridor). Sections 14.3.2.3 through 14.3.2.9 provide details regarding specific underground cable construction considerations (e.g., splice vault locations, erosion controls, traffic management, and 345-kV line transition stations).

14.3.2.1 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 345-kV, nine-cable system installation along or adjacent to a road ROW are illustrated on Figure 14-3 and summarized below.

Figure 14-3: Typical Underground Cable-System Construction within Road ROW



Most of the following activities also apply to underground cable construction outside of road ROWs. (Refer to Section 14.3.2.2 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, worker parking, 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-foot intervals along each circuit cable route, pre-cast concrete splice vaults (one for each circuit) would be installed below ground. Depending on the amount of space, the vaults may be arranged so that vaults are nested together, side-by-side, or staggered linearly along the route. 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, could be significantly closer than the 1,600-foot interval stated above.

  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. Approximately 2.5 feet of fill would be placed as cover on top of each vault. 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 7 to 10 feet deep and approximately 5 feet wide would be excavated within a typical linear 40-foot-wide construction area. This trench would typically be stabilized using trench boxes or another type of shoring.

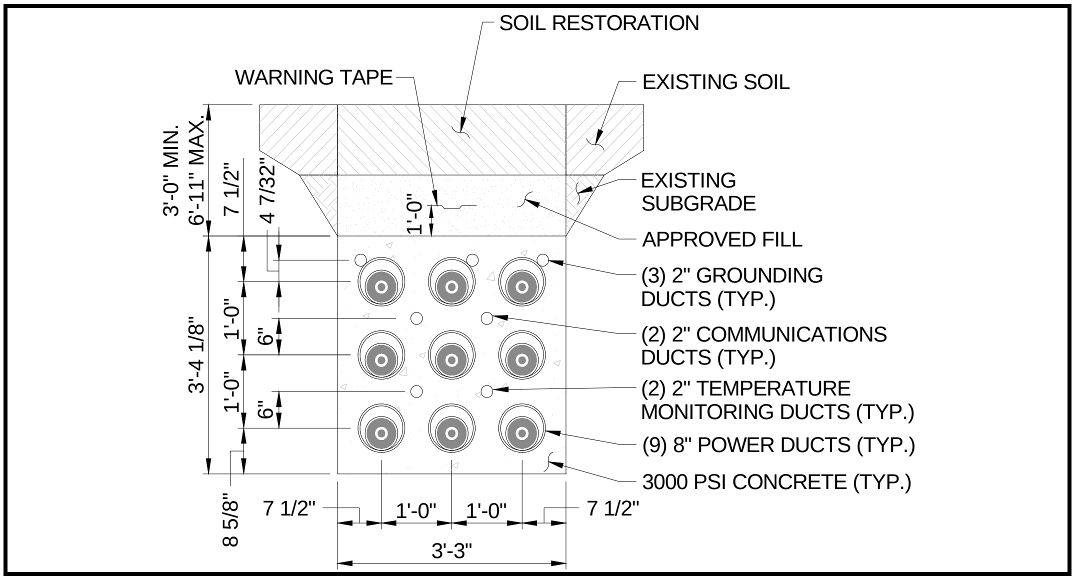
  Excavated material (e.g., pavement, subsoil) would be placed directly into dump trucks and hauled away to a suitable disposal site, or hauled to a temporary storage site for screening/testing prior to final disposal or re-use in the excavations for backfill. If groundwater is encountered, dewatering would be performed in accordance with authorizations from applicable regulatory agencies and may involve discharge to catch basins, temporary settling basins, frac tanks, 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 controlled drilling and 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 would consist of nine 8-inch polyvinyl chloride (PVC) conduits for the XLPE-insulated cables, three 2-inch PVC conduits for the ground-continuity conductors, three 2-inch PVC conduits for the fiber optic relaying cables, and three 2-inch conduits for the temperature-sensing fiber optic cables. Figure 14-4 illustrates a typical 345-kV duct bank cross-section. 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 high-strength concrete. The duct bank would then be backfilled with a low-strength fluidized thermal backfill (FTB) 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 14-4: Typical 345-kV Duct-Bank Cross Section for Nine 345-kV XLPE Cables



- **<u>Duct Swabbing and Testing.</u>** 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.

- **<u>Cable Installation</u>**. 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 10 to 14 days to complete the splices in each vault (three XLPE 345-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 either end of a 345-kV cable system, termination equipment is required. To interconnect a 345-kV cable to overhead transmission facilities, a new 345-kV line transition station is required. Alternatively, if the cable system ends at an existing substation or switching station, the cable terminations can be installed on or adjacent to the station site, depending on the amount of space available. (Refer to Section 14.3.2.9 for additional information regarding transition stations.)

- **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 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 revegetate.

14.3.2.2 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 CL&P's existing overhead transmission line ROWs or pipeline ROWs) or along an entirely new cross-country ("greenfield") ROW, the ROW requirements and typical construction procedures described in Section 14.3.2.1 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**. Generally, CL&P could have to purchase easements from private landowners for an underground cable system, even for transmission cables aligned along its own overhead transmission line ROWs (where the existing easements do not encompass underground transmission systems). Permanent underground easements would have to be acquired.

- **Vegetation Clearing and Grading**. 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.

- **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 20-foot-wide travel area, would likely be developed during the construction phase. The roads would have to be designed 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 14.3.2.4. 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).

14.3.2.3 Splice-Vault Requirements

Due to current-carrying limitations and the assumed underground duct-bank configuration requiring three separate circuits, three 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 345-kV XLPE cables are approximately 10 feet wide by 10 feet deep and up to 32 feet in length (one vault per three XLPE cables).

The installation of each splice vault therefore requires an excavation area approximately 14 feet wide, 13 feet deep, and 36 feet long. At each splice-vault location, pre-cast splice vaults would be installed below ground. Each vault location would consist of three splice vaults. 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., CL&P's overhead transmission line ROWs, pipeline ROWs, railroad ROWs), vaults would be installed within or adjacent to the 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.

14.3.2.4 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 CL&P 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.

14.3.2.5 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 CL&P'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.

14.3.2.6 Special Procedures: Rock Removal (Blasting), Dewatering, Material Handling

Based on a review of the soil and subsurface characteristics in the Project area (refer to Section 5.1 in Volume 1), it is likely that the excavations for any cable system would encounter rock and groundwater in some 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, CL&P would adhere to the same standard procedures as described for the overhead transmission line construction in Volume 1, Section 4. Similarly, dewatering wastewaters and excess excavated soils would be managed pursuant to a *Materials Handling Guideline*, as described for overhead transmission line construction in Section 4; 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.

14.3.2.7 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, CL&P 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, and would prepare a project-specific *Traffic Control Plan*. CL&P also would employ police 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.

14.3.2.8 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 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.

14.3.2.9 Line Transition Station Construction

A line transition station is required whenever an underground 345-kV cable segment of the line connects to an overhead section of the line. As discussed previously, each 345-kV line transition station typically requires about 2 to 4 acres of land, approximately 1.5 to 2 acres of which must be developed for the line transition facilities. The amount of land developed at each site would depend on site-specific topographic features, including the need for grading or filling and access.

To develop a new 345-kV line transition station, CL&P would typically have to purchase land from private owners, unless the station could otherwise be sited on-owned CL&P property. Where underground cable systems terminate at an existing CL&P substation (e.g., the Card Street Substation), the line transition facilities would be developed on the substation property.

Facilities at a line transition station include a line-terminal structure, cable terminator stands, cable terminators, surge arresters, circuit breakers, station service equipment, and a relay/control enclosure that would house the protective relaying systems, Supervisory Control and Data Acquisition (SCADA) equipment, battery systems, etc. Shunt reactors, which resemble large power transformers, may also be required at some line transition stations. Refer to Appendix 15A, Section 15A.2.9, for additional detail regarding 345-kV line transition stations, including representative photographs.

The primary activities required for the construction of a line transition station would include site preparation (e.g., grading, filling), foundation construction (e.g., excavation, form work, concrete placement), installation of components, wiring systems testing and interconnections, clean up and restoration. Temporary erosion and sedimentation controls would be deployed around the work site during the vegetation clearing phase (or when soils are initially disturbed), and would be maintained after the completion of construction until the site is determined to be stabilized (i.e., revegetated or stabilized with gravel or crushed stone).

14.3.3 Alternative Underground Line Routes Considered but Eliminated

Pursuant to the Council's requirements, an applicant proposing an overhead 345-kV electric transmission line must establish that it is "…cost effective and the most appropriate variation based on a life-cycle cost analysis of the facility and underground variations to such facility…"[9] Accordingly, although overhead circuits are the most efficient and reliable method for delivering power over long distances, CL&P

[9] Connecticut General Statutes Section 16-50p(a)(3)(D)

identified and evaluated "all-underground" cable-route alternatives to interconnect Card Street Substation, Lake Road Switching Station, and National Grid's facilities at the Connecticut / Rhode Island border.

As discussed in this section, after considering constructability, cost, and environmental factors, CL&P's analyses determined that none of the "all-underground" cable-system options would be practical for the Project as a whole. However, the use of underground cable systems along select, short segments of the 345-kV transmission line route were considered potentially feasible; these underground line-route variations are described and reviewed in Section 15.

In identifying and evaluating potential "all-underground" routes for the new 345-kV lines between Card Street Substation, Lake Road Switching Station and the Connecticut/Rhode Island border, CL&P applied the routing objectives and technology considerations / evaluation criteria described in Sections 14.1 and 14.3.1, respectively. CL&P also took into consideration the underground cable-system construction requirements detailed in Section 14.3.2 and the environmental and land use characteristics of the Project area.

As described in this section, using these criteria, CL&P subsequently reviewed the viability of underground line-route alternatives along new "greenfield" ROWs, within existing transmission line ROWs, and along road, pipeline, and railroad ROWs. In addition, CL&P also identified and examined two "all-underground" cable-system route alternatives involving a combination of road and CL&P transmission line ROWs to minimize the length of the route between Card Street Substation, Lake Road Switching Station, and the Connecticut / Rhode Island border. The general locations of these "all-underground" route alternatives are depicted on Figure 14-1.

For all of the analyses of underground line-route alternatives, cost and construction schedule would be significant issues. Compared to an overhead 345-kV transmission line configuration, any "all-underground" cable system between Card Street Substation, Lake Road Switching Station, and the

Connecticut / Rhode Island border would require an estimated six to 12 months longer to construct, thereby delaying energization of the Project. In addition, both the capital and life-cycle costs of an underground cable system would be significantly more, by an order of magnitude, than a comparable overhead transmission line.

After examining the various “all-underground” line-route alternatives, CL&P determined that two routes, involving the use of a combination of highway and transmission line ROWs, represented the best of the “all-underground” alignments. One of these routes would primarily use underground cable, but also would include a short segment of overhead line, whereas the other would be aligned entirely underground along road ROWs and CL&P’s ROWs (these routes are described in Sections 14.3.3.5 and 14.3.3.6). CL&P conducted additional studies of these “combined highway/transmission line ROW” underground route alternatives and estimated the life-cycle costs compared to that of the proposed overhead 345-kV transmission lines located within CL&P’s existing ROWs. CL&P determined that the development of the new 345-kV line using either of these underground line routes would be less reliable than the proposed overhead 345-kV transmission lines, would be significantly more costly (with high costs to Connecticut consumers), and would pose environmental and engineering issues.

14.3.3.1 New Right-of-Way Alternative

Similar to the discussion in Section 14.2.2.1 of a new ROW alternative for an overhead transmission line, this alternative would involve the construction and operation of a new 345-kV underground cable system between Card Street Substation, Lake Road Switching Station, and the Connecticut / Rhode Island border 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, CL&P determined that this line-route option would not conform to regulatory guidelines for the collocation of linear corridors to the extent practical, would result in comparatively significant, unavoidable environmental impacts, and would not be cost-effective.

To develop a "greenfield" corridor for a new cross-country (non-street) underground transmission cable system, CL&P would first have to acquire new easements from private property owners along the length of the route. A minimum easement width of 40 feet would be required.[10] Assuming a minimum straight-line 28-mile distance between Card Street Substation, Lake Road Switching Station, and the interconnection with National Grid's facilities at the Connecticut / Rhode Island border, this alternative route would involve the acquisition of approximately 136 acres of property for new utility easements. This property acquisition process would be both costly and time-consuming.

In addition, the development of the 345-kV underground cable system along a "greenfield" corridor would have significantly greater environmental effects than other available 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 (as needed) to create work space for construction equipment, access roads, and for the excavation of the cable duct bank and splice vaults. The continuous trenching required for the duct bank would result in long-term adverse effects to wetlands and watercourses as a direct result of filling (i.e., installing the duct bank and surrounding the conduits with FTB, and creating permanent access roads along the entire ROW). The cable system would have to be installed beneath major rivers (e.g., the Natchaug and Quinebaug rivers) and other 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]).

The development of the cable system along a "greenfield" corridor also would cause long-term environmental effects due to 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 the length of the

[10] 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.

ROW, and other (non-access road) portions of the ROW would have to be maintained in low-growing vegetation.

14.3.3.2 Alternative Routes along Existing Pipeline and Railroad Rights-of-Way

CL&P determined that the alignment of a cable transmission system along either existing pipeline or railroad corridors in the Project region would be impractical for the same general reasons as described for the routing of an overhead 345-kV transmission line (refer to Sections 14.2.2.2 and 14.2.2.4). In particular, because the cable system could not be accommodated within the pipeline and railroad corridors, significant additional easements adjacent to these existing ROWs would have to be acquired.

14.3.3.3 Alternative Routes along Existing Transmission Line Rights-of-Way

At first glance, aligning an underground cable system within CL&P's existing ROWs appears to offer several advantages, such as collocating the underground and overhead transmission lines within the same corridor and facilitating the construction process by avoiding both 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 existing transmission line ROWs is usually less expensive and has the following advantages:

- Duct banks and splice vaults can typically 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, existing transmission line ROWs typically provide the most direct (shortest) route between terminal points. In contrast, underground cable systems along road ROWs must typically follow more circuitous, and typically longer, routes between the same terminal points, and therefore are more expensive to construct and operate.

However, aligning an underground cable system within CL&P's existing overhead transmission line ROWs between Card Street Substation, Lake Road Switching Station, and the Connecticut / Rhode Island border would pose significant construction constraints and, even if feasible, would result in potentially significant, unavoidable, direct impacts to environmental and cultural resources. The terrain and water resources that would have to be crossed (e.g., the Willimantic, Natchaug, and Quinebaug rivers and Mansfield Hollow Lake) would pose difficult, if not insurmountable obstacles in terms of both regulatory approvals and underground cable-system construction.

Environmental impacts would result from the continuous trenching required for the duct banks along the ROWs, the excavations for splice vaults, and the use of construction support areas along the ROWs, 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 122 vault locations would be required for the installation of an underground cable system along the 36.8-mile ROWs between Card Street Substation, Lake Road Switching Station, and the border. 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, and a permanent access road must be developed. Overall, based on the minimum use of a 40-foot-wide work space along the 36.8-mile route, cable-system construction would directly affect a minimum of approximately 175 acres. Additional land would be affected by splice vaults and the temporary equipment and material staging sites.

In addition, a permanent, 20-foot-wide access road would be required along the entire cable route, involving the permanent conversion of approximately 88 acres of land along the ROWs to road use. The access road would traverse approximately 7 miles of wetlands along the ROWs, where the permanent fill would constitute a long-term loss of wetland habitat.[11]

CL&P's existing ROWs in the Project area are wide enough to accommodate the construction and operation of an underground cable system. However, CL&P's easements for overhead transmission lines do not uniformly encompass the use of the ROWs for underground cable installation. In these cases, CL&P would have to purchase additional easement rights for the development of an underground cable system from private landowners. Land also would have to be acquired from private landowners for the development of a line transition station at the Connecticut / Rhode Island border, at the interconnection with National Grid's proposed 345-kV overhead transmission line system.

Further, although CL&P's existing ROWs in the Project area are wide enough to accommodate the construction and operation of cable systems, the terrain and environmental features that are spanned by the existing overhead lines pose severe constraints for underground transmission line construction and operation. These constraints include the following:

- Rough terrain, including steep slopes, embankments, rock outcroppings, and wetlands, all of which would make trenching for the cables and excavating for the splice vaults difficult
- Long and/or steep grades, which could potentially overstress the cable and cable splices
- Excavation through rock, requiring slow and costly mechanical removal or special provisions for blasting
- Long waterway (e.g., Mansfield Hollow Lake, Natchaug River, Quinebaug River) and wetlands crossings, which would involve trenching and direct effects to the water resources or (where practical) the use of costly trenchless cable installation technologies, such as horizontal directional drilling or jack and bore
- Crossings through various state-listed species habitat, as well as areas sensitive for the location of buried archaeological sites

[11] Some of CL&P'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.

For these and cost reasons, the development of an underground 345-kV cable system along CL&P's ROWs was determined to be impractical.

14.3.3.4 Alternative Routes along Highway Rights-of-Way

CL&P 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. CL&P'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 CL&P 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, CL&P typically must obtain easements for splice vaults and the associated cable-duct-bank interconnections from private landowners.

Alternatively, 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, safety, 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 collocation of transmission lines within and parallel to the ROWs of limited access highways.

14.3.3.5 Combination Highway and Transmission Line Rights-of-Way Underground Alternative Route

In addition to evaluating separate alternative underground cable-system alignments along specific types of existing ROWs, CL&P 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 and social effects; and minimizing cable-system costs.[12] Accordingly, as the shortest potential alignment for a cable system between Card Street Substation, Lake Road Switching Station, and National Grid's facilities, CL&P identified a 39.1-mile route that would use a combination of ROWs (road and CL&P transmission line) and would involve a short (1.1-mile) segment of overhead line.

Along this route, the new 345-kV line would consist of approximately 38 miles of underground cable system extending for approximately 36.3 miles along road ROWs and for 1.8 miles along two segments

[12] Note: Any underground 345-kV cable system for the Interstate Reliability Project would be significantly more costly than an overhead 345-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.

of CL&P's existing transmission line ROW. Along the remaining 1.1-mile segment of the route (between a new line transition station in the Town of Thompson and the Connecticut / Rhode Island border), the line would be developed in an overhead configuration. (This alternative assumes that National Grid's new 345-kV line would be overhead and, therefore, the new CL&P 345-kV line would also have to be in an overhead configuration to interconnect with National Grid's facilities at the state border.)

Figure 14-5 illustrates the location of this approximately 39.1-mile combined road / transmission line route alternative. Table 14-4 identifies the public road ROWs and the portions of the CL&P transmission line ROWs along which the route would be aligned.

For this alternative, a new line transition station would be required on the Connecticut side of the Connecticut / Rhode Island border to interconnect to National Grid's overhead 345-kV transmission line (assuming the underground cable route did not continue into Rhode Island). A potential site for this line transition station was identified on property owned by CL&P east of Quaddick Town Farm Road and Elmwood Hill Road in the Town of Thompson. However, to accommodate the line transition station, it is likely that some additional adjacent privately-owned property would have to be purchased.

Line transition facilities also would have to be developed at CL&P's Card Street Substation and Lake Road Switching Station. These line transition facilities would likely require the expansion of both stations beyond the existing station fence lines.

Figure 14-5: Combined Highway and Transmission Line ROWs Underground Alternative Route

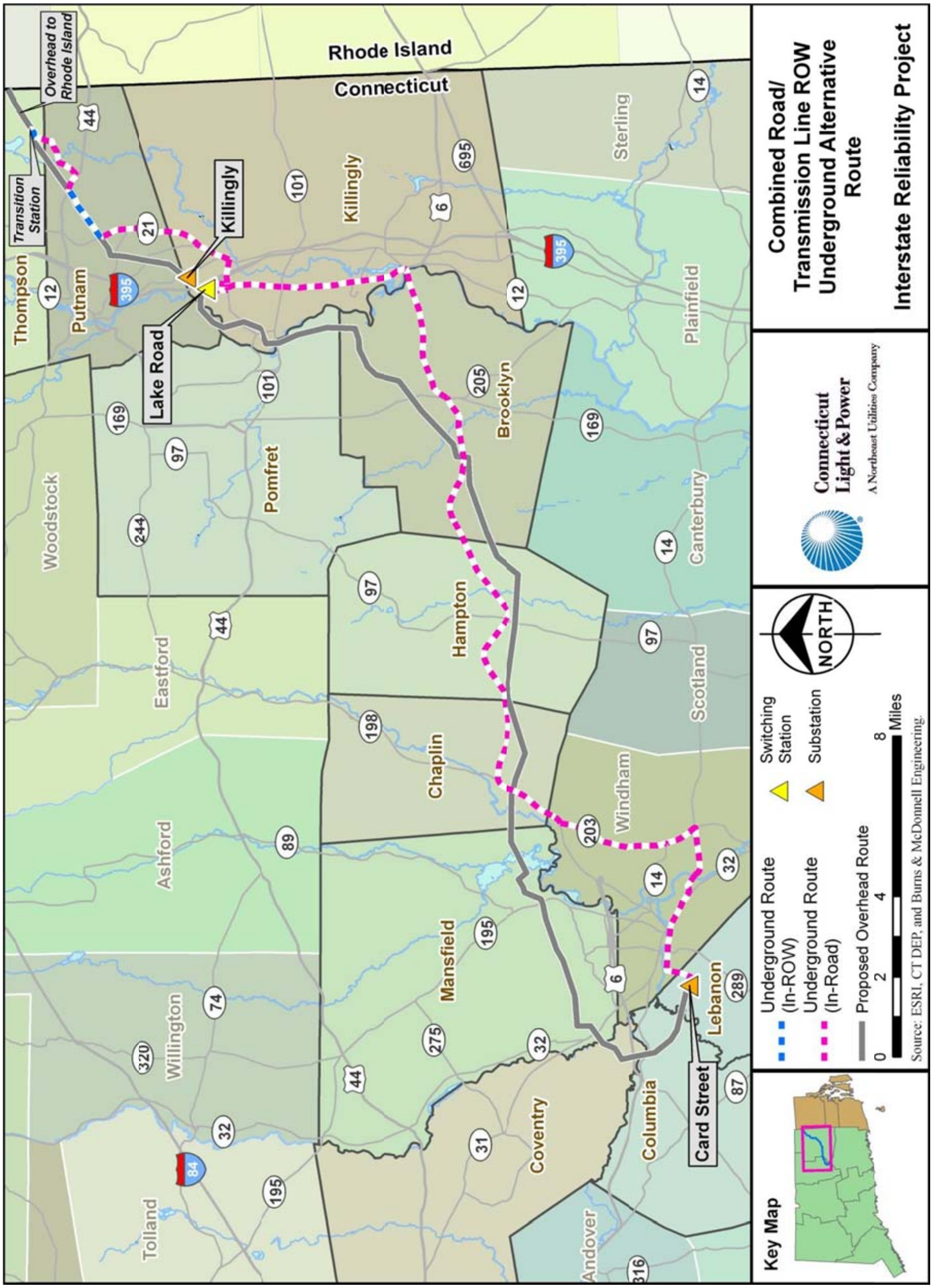


Table 14-4: Summary of ROWs along Combined Highway and Transmission Line ROW Underground Alternative Route

Existing ROW Following (Public Road, CL&P Transmission Line)	Distance (miles)*	Town
UNDERGROUND CABLE SYSTEM		
Card Street Substation to Lake Road Switching Station		
Card Street Substation to Card Street	0.1	Lebanon
Card Street	1.1	Lebanon, Windham
Pleasant Street	1.1	Windham
Windham Road	0.8	Windham
Plains Road	1.9	Windham
State Route 203	3.6	Windham
U.S. Route 6	15.9	Windham, Chaplin, Hampton, Brooklyn, Killingly
Maple Street	1.2	Killingly
Upper Maple Street	3.3	Killingly
Lake Road	0.1	Killingly
Alexander Park Way	0.4	Killingly
Alexander Park Way to Lake Road Switching Station	0.2	Killingly
Lake Road Switching Station to New Line Transition Station		
Lake Road Switching Station to Old Trolley Road	0.2	Killingly
Old Trolley Road	0.4	Killingly
Attawaugan Crossing	0.6	Killingly
Putnam Pike	0.8	Killingly
State Route 21	2.6	Killingly; Putnam
Existing CL&P 345-kV ROW	1.5	Putnam
U.S. Route 44	0.4	Putnam
Munyan Road	1.1	Putnam
State Route 438	0.4	Putnam, Thompson
Existing CL&P 345-kV ROW to Transition Station	0.3	Thompson
Subtotal: Underground Cable System	**38.0**	
OVERHEAD TRANSMISSION LINE		
New Line Transition Station to Connecticut/Rhode Island Border		
Existing CL&P 345-kV ROW	1.1	Thompson
TOTAL	**39.1**	

* Mileage estimates rounded to nearest tenth.

At Card Street Substation, the expansion could be accommodated on CL&P-owned property, but would require vegetation removal and the conversion of presently undeveloped land to utility use. In contrast, CL&P does not own the Lake Road Switching Station site. Depending on the final design for the new 345-kV line transition facilities, CL&P would potentially need to acquire additional property (easements) adjacent to the Lake Road Switching Station. As envisioned in preliminary analyses conducted for this underground line alternative, the switching station would be expanded based on a split-level design, which would require development outside the existing station fence line and would involve tree clearing and grading. In addition, the existing transmission lines at the switching station might need to be reconfigured to avoid the proposed expansion area. The proposed expansion area would be approximately 2 acres.

Routing Considerations

The combined alternative route was selected to maximize, to the extent possible, conformance to CL&P's routine objectives and underground cable-system routing criteria (as summarized in Sections 14.1 and 14.2.1). For example, as Figure 14-5 illustrates, the combined route alternative would follow U.S. Route 6 through the Town of Windham, avoiding Mansfield Hollow Lake, as well as Mansfield Hollow State Park and WMA. However, portions of the underground cable route would be aligned within CL&P's existing ROW in the towns of Putnam and Thompson, thereby decreasing the length of the route compared to using road ROWs in this area.

Using a combination of road and overhead transmission ROWs for the underground cable system would also avoid areas of potentially difficult construction to the extent possible. For example, use of road ROWs would avoid long HDDs or direct trenching to install the cable ducts beneath Mansfield Hollow Lake and large wetlands. The use of road ROWs also would avoid potential visual effects associated with the addition of a second overhead 345-kV transmission line to CL&P's existing ROWs.

A preliminary review of existing easements along the approximately 1.8 miles in the towns of Putnam and Thompson where the underground line-route alternative would be aligned within CL&P's existing transmission line ROW indicates that the majority of the easements do not include underground line rights. As a result, to develop the underground cable system within the 345-kV transmission line ROW along these segments, CL&P would have to acquire additional easement rights from property owners.

The development of the cable system along the highway ROWs and within CL&P's transmission line ROWs would involve the land requirements and construction procedures detailed in Section 14.3.2. If the underground transmission line could not be installed within the road ROWs (due to conflicts with ConnDOT policies, 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 of acquiring easements from private landowners would be significant. Table 14-5 summarizes the key characteristics of the combined underground line-route.

Although this alternative represents CL&P's best-identified combined use of road and transmission line ROWs for the alignment of the all-underground line route (assuming an overhead line connection with National Grid at the state border), cable-system construction in the Project area nonetheless poses constructability issues, and would face environmental and land-use constraints. For example, the underground line route would traverse 15 watercourses, including several large rivers.

Table 14-5: Summary of Key Features: Combined Highway and Transmission Line ROW Underground Alternative Route

Characteristic	Description
ROW / Land	**(Miles / Acres)**
Underground Within or Adjacent to Road ROWs	36.3 miles
Underground Within Transmission Line ROW	1.7 miles
Overhead within Transmission Line ROW	1.1 miles
Line Transition Station (Town of Thompson)	4 acres
Lake Road Switching Station Expansion[13]	2 acres
Total	**39.1 miles / 6 acres of land for stations**
Towns Traversed by Route	**(Miles)**
Lebanon	0.8
Windham	8.2
Chaplin	3.6
Hampton	4.7
Brooklyn	7.2
Killingly	8.1
Putnam	4.9
Thompson	1.6
Highway Characteristics	**% along each lane type**
Four-lane Roads (U.S. Route 6)	4%
Two-lane Roads (State Route 203, Pleasant Street, Maple Street, Upper Maple Street, Hartford Road, Putnam Pike, Thompson Pike)	96%
Adjacent Land Use	**(Percent of Total Route)**
Residential	43%
Commercial	5%
Public	5%
Forested	37%
Undeveloped (Open Land)	9%
Industrial	1%
Total	100%
Watercourse Crossings	**(Number)**
Major crossings (Shetucket River, Merrick Brook, Quinebaug River, Five Mile River), smaller streams	15
Wetlands Adjacent to or Crossed	**(Number)**
Underground Portion along Road ROWs	16
Underground Portion along Transmission line ROW	6
Overhead Portion along Transmission line ROW	4
Railroad Crossings (No.)	**(Name / Number)**
Two	One double track- New England Central One single track – Providence and Worcester

[13] Assumes interconnection to Card Street Substation could be accomplished on CL&P-owned property, but land disturbance outside existing fence line would be required.

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 subsurface crossing method (jack and bore, HDD). In addition, the cable system would have to be installed beneath Interstate 395 and railroads using HDD or jack and bores. The installation of the cable system beneath watercourses, roads, and railroads would 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.

Where the underground cable system would be aligned within CL&P's transmission line ROW in Putnam and Thompson, it would directly affect wetlands, habitat for state-listed species, and various confirmed vernal pools and amphibian breeding habitats. In Putnam, the route would be aligned along CL&P's ROW for 1.5 miles, affecting Wetland Nos. 20-190 through 20-196 (refer to Mapsheets 35 to 37 in Volume 9 and Mapsheets 118 to 124 in Volume 11). In Thompson, the underground cable system would be aligned along CL&P's ROW for 0.3 mile to the potential line transition station east of Elmwood Hill Road; in this area, the route would affect Wetland Nos. 20-204 and -206 and would cross Teft Brook (refer to the Mapsheets 38 and 39 in Volume 9 and Mapsheets in 129 and 130 Volume 11).

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 abut 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 combined highway and transmission line ROW route reflects the optimal “all-underground” cable system between Card Street Substation, Lake Road Switching Station and the National Grid facilities, this alternative is not a practical, cost-effective, or environmentally-sound solution for meeting the Project objectives. Compared to an overhead transmission line configuration using existing CL&P ROWs, the use of the cable system along the combined alternative 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 14.3.1.3, 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 borne by Connecticut consumers alone and that incremental increased cost would be dramatically higher than that of an overhead line. As previously stated, the estimated cost for the construction of the new 345-kV transmission line overhead is $193 million. In comparison, the estimated cost for the combined underground alternative is $1.1 billion. Using these estimates, the probable cost to Connecticut consumers for the development of the all-overhead line (as proposed) in Connecticut would be approximately $61.8 million (27% of the Project’s base design cost, plus preferred EMF BMP design alternatives)[14]. However, after localization of the extra costs for undergrounding, the development of an all-underground cable system would cost Connecticut consumers approximately $950 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 combined route alternative than for an all-overhead 345-kV transmission line, installed along CL&P's ROWs. Specifically, the life-cycle cost for the proposed overhead transmission lines is estimated to be approximately $319 million. For all-underground transmission lines, the life-cycle cost is estimated to be approximately $1.6 billion.

In sum, although identified to minimize, to the extent possible, the effects typically associated with cable-system construction and operation, the combined road and transmission line ROW route alternative between the Card Street Substation and the Connecticut / Rhode Island border 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, the use of this 39.1-mile combined alternative route, including the installation of approximately 38 miles of underground cable system, was eliminated from consideration as a viable option.

[14] This estimate includes the cost of the recommended EMF BMP's in Focus Areas A and D, as described in Volume 1, Section 7, Appendix 7B. It is assumed in this calculation that 100% of the recommended EMF BMPs for these two areas would be included in the Connecticut consumer cost.

14.3.3.6 U.S. Route 44 Underground Variation to Portion of Combination Highway and Transmission Line Rights-of-Way Underground Alternative Route

To accommodate the possibility that National Grid could be required to develop its new 345-kV transmission line in an underground configuration in Rhode Island, CL&P identified and evaluated a route variation to the Combination Highway and Transmission Line ROWs Underground Alternative that would involve the extension of the underground cable system in Connecticut to interconnect with the National Grid facilities at the border. This 2.3-mile route variation would replace the easternmost 2.9 miles of the Combined Highway and Transmission Line ROWs Underground Alternative, and would eliminate an overhead line alignment in the Town of Thompson. With the incorporation of the 2.3-mile underground route variation, the Combination Highway and Transmission Line ROWs Underground Alternative would extend for 38.5 miles and would be an all-underground line.

As illustrated in Figure 14-6, the route variation would diverge from the route of the Combined Highway and Transmission Line ROWs Underground Alternative at the intersection of U.S. Route 44 and Munyan Road in the Town of Putnam, and would continue underground due east along U.S. Route 44 to interconnect with the National Grid underground cable system at the Connecticut / Rhode Island border. Thus, the route variation would be located entirely in the Town of Putnam, and would replace the following segments of the Combined Highway and Transmission Line ROWs Underground Alternative:

- Underground cable system along Munyan Road (1.1 miles), State Route 438 (0.4 mile), and CL&P's existing ROW (0.3 mile).
- The 345-kV line transition station in the Town of Thompson.
- The alignment of the 345-kV line in an overhead configuration along 1.1 miles of CL&P's existing ROW in Thompson.

Table 14-6 summarizes and compares the key features of the Combined Highway and Transmission Line ROWs Underground Alternative with and without this U.S. Route 44 underground route variation.

The incorporation of this route variation into the Combined Highway and Transmission Line ROWs Underground Alternative would increase the length of the underground cable-system route by 0.5 mile, but would decrease the total route length by 0.6 mile (i.e., 38.5 miles vs. 39.1 miles). In addition, the use of the route variation would eliminate the costs and environmental effects associated with developing a 345-kV line transition station in Thompson.

However, this all-underground route would have the same issues as described in Section 14.3.3.5 and would be significantly more costly than an overhead line built along CL&P's existing ROWs. Specifically, although this all-underground route would not involve a line transition station in Connecticut or a segment of overhead transmission line, it would require approximately 0.5 additional mile of underground transmission line to the Connecticut / Rhode Island border. Given the cost of underground cable construction, this all-underground route (i.e., the U.S. Route 44 Variation to the Combined Highway and Transmission Line ROWs Underground Alternative) is estimated to cost approximately $1.1 billion. In other words, the cost of this all-underground option would be generally comparable to the Combined Highway and Transmission Line ROWs Underground Alternative involving the development of the 345-kV line transition station and a segment of overhead transmission line.

Figure 14-6: Combined Highway and Transmission Line ROWs Underground Alternative Route: U.S. Route 44 Variation

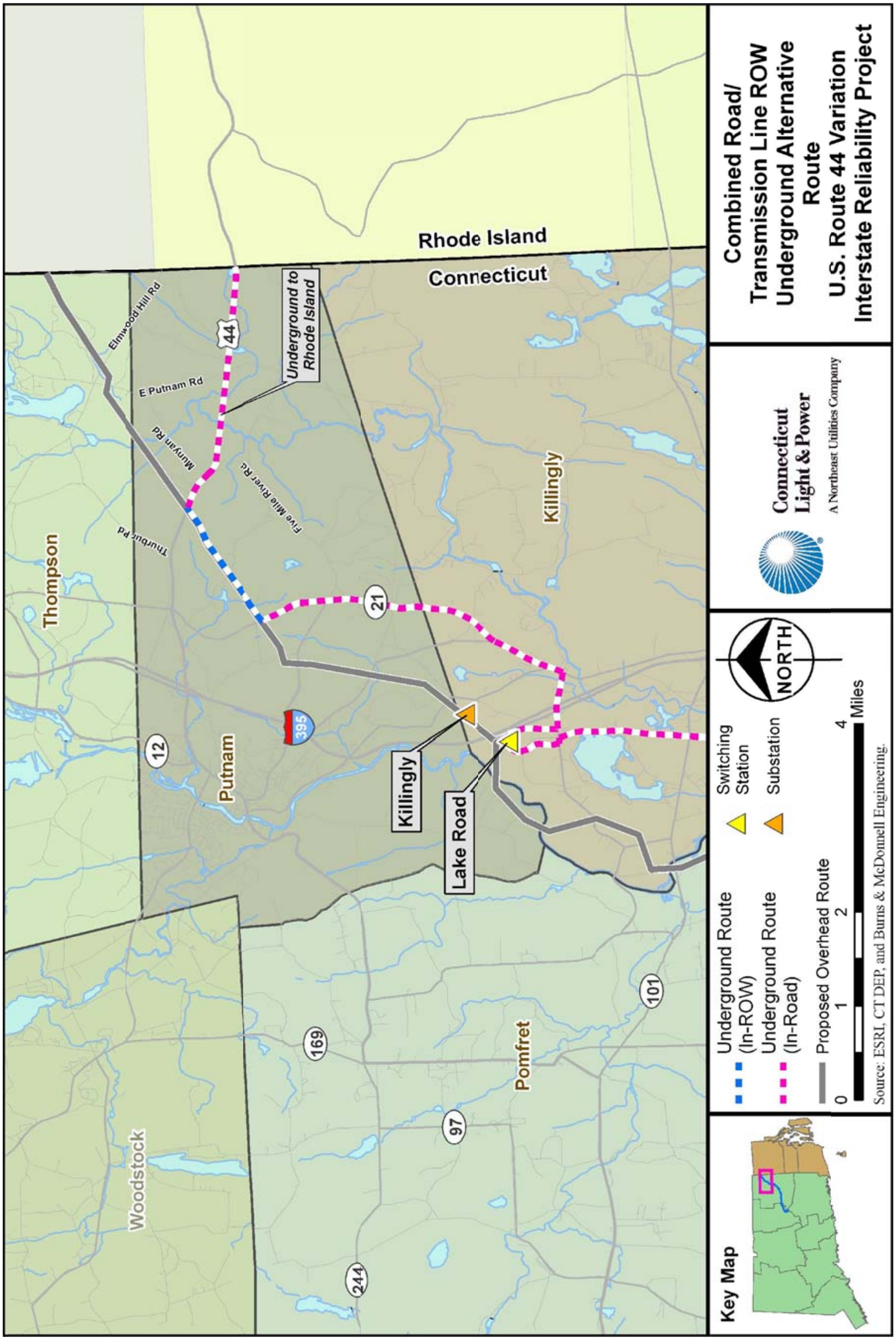


Table 14-6: Comparative Summary of Key Features: Combined Highway and Transmission Line ROW Underground Alternative with and without U.S. Route 44 Underground Variation

Characteristic	Description	
	Combined Route	**Combined Route with U.S. Route 44 Variation**
ROW / Land	**(Miles / Acres)**	**(Miles / Acres)**
Underground Within or Adjacent to Road ROWs	36.3 miles	37.1 miles
Underground Within Transmission Line ROW	1.7 miles	1.4 miles
Overhead within Transmission Line ROW	1.1 miles	0
Line Transition Station (Town of Thompson)	4 acres	0
Lake Road Switching Station Expansion	2 acres	2 acres
Total	**39.1 miles / 6 acres of land for line transition station**	**38.5 miles / 2 acres for line transition station**
Towns Traversed by Route	**(Miles)**	**(Miles)**
Lebanon	0.8	0.8
Windham	8.2	8.2
Chaplin	3.6	3.6
Hampton	4.7	4.7
Brooklyn	7.2	7.2
Killingly	8.1	8.1
Putnam	4.9	5.9
Thompson	1.6	0
Highway Characteristics	**% along each lane type**	**% along each lane type**
Four-lane Roads (U.S. Route 6)	4%	4%
Two-lane Roads (State Route 203, Pleasant Street, Maple Street, Upper Maple Street, Hartford Road, Putnam Pike (U.S. Route 44)	96%	96%
Adjacent Land Use	**(Percent of Total Route)**	**(Percent of Total Route)**
Residential	43%	45%
Commercial	5%	5%
Public	5%	4%
Forested	37%	36%
Undeveloped (Open Land)	9%	9%
Industrial	1%	1%
Total	100%	100%
Watercourse Crossings	**(Number)**	**(Number)**
Major crossings (Shetucket River, Merrick Brook, Quinebaug River, Five Mile River)	15	15 Mary Brown Pond / Keach Brook), Brown Brook)
Wetlands Adjacent to or Crossed	**(Number)**	**(Number)**
Underground Portion along Road ROWs	16	18
Underground Portion along Transmission line ROW	6	6
Overhead Portion along Transmission line ROW	4	n/a
Railroad Crossings (No.)	**(Name / Number)**	**(Name / Number)**
Two	One double track- New England Central One single track – Providence and Worcester	

14.4 JUSTIFICATION FOR THE SELECTION OF THE PROPOSED TRANSMISSION LINE ROUTE AND CONFIGURATION

After considering various alternative technologies and routes for the Project, CL&P identified overhead line designs as the preferred configuration for the new 345-kV lines and the use the existing transmission line ROWs as the preferred alignment for the new 345-kV lines between Card Street Substation, Lake Road Switching Station, and the Connecticut / Rhode Island border. CL&P determined that the Proposed Route for the installation of the new overhead 345-kV transmission lines meets all Project objectives and represents the most cost-effective, least environmentally damaging practical alternative.

The Proposed Route and proposed overhead line design represents the optimal Project configuration for the following reasons:

- **Availability of Existing ROW**. Along approximately 96% of the Proposed Route, the new overhead 345-kV lines would be located within CL&P's existing ROWs, which have sufficient un-utilized space to accommodate the new lines without requiring relocation of the existing lines or the acquisition of additional easements. Along the remaining 4% (approximately 1.4 miles) of the Proposed Route, CL&P's existing ROW (through the federally-owned Mansfield Hollow properties) is only 150 feet wide. To allow the installation of the new 345-kV line using structure types similar to those of the existing 345-kV line, CL&P proposes to acquire additional easements from the USACE across these ROW segments. However, CL&P has identified configuration options for aligning the new 345-kV line across the 1.4 miles that would involve minimal or no additional ROW acquisition from the federal government. (These design options for the Mansfield Hollow area are discussed in Volume 1, Section 10.)

- **Environmental Effects.** With the exception of the additional ROW easement that could be associated with the 1.4 miles of federally-owned property in the Mansfield Hollow area, the proposed lines would be aligned entirely within CL&P's existing ROWs, which are already devoted to utility use. Although incremental effects to site-specific environmental resources would occur as a result of the construction and operation of the proposed 345-kV transmission lines within these ROWs, the development of the new 345-kV transmission lines along this existing corridor would be consistent with federal, state, and local land use policies and would minimize long-term adverse environmental impacts.

- **EMF BMPs.** The proposed overhead transmission line design incorporates BMPs, as described in Volume 1, Section 7.

- **Cost.** The Proposed Route and overhead line design represent the most cost-effective alternative to Connecticut consumers.

Therefore, the Council should certify the Project along the Proposed Route, specifically the construction and operation of the new 345-kV overhead transmission lines, configured as proposed by CL&P. In the case of the 1.4 miles across the federally-owned properties in Mansfield Hollow, CL&P is prepared to develop the new 345-kV line using any of the design configurations (expanded easement or no easement expansion), in accordance with approvals by the USACE and the Council.

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Appendix 14A – Tutorial Underground Electric Power Transmission Cable Systems

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TUTORIAL

UNDERGROUND ELECTRIC POWER TRANSMISSION CABLE SYSTEMS

Brian Gregory BSc, CEng, FIEE, MIEEE
David Notman BSc, CEng, MIEE

Cable Consulting International
www.cableconsulting.net

Contents

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INTRODUCTION

This tutorial explains in a non technical way what an underground cable is, what it does, how it is installed, the types of cable systems that are available and how they affect me, the reader. The intent of this tutorial is to give a background understanding and not to compare the merits of each method of power transmission and each design of cable. Each design has advantages and disadvantages, many of them being highly technical.

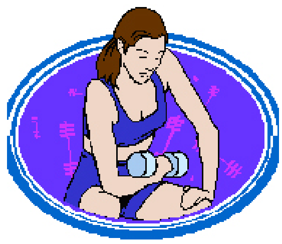
WHAT IS ELECTRIC POWER?

Power is the rate at which work is performed. Work is something like boiling water, moving a locomotive on a railroad or lifting a weight in the gym. The faster the work is done, the higher the power that is expended.

A person who lifts a weight ten times in ten seconds does the same amount of work as a person who takes twenty seconds but the first person generates twice the amount of power.

Power is measured in Watts (after James Watt, the Scottish Engineer who is famous for improving the steam engine).

Electric power is generated in power plants and is transported into homes, shops and factories by means of overhead lines and underground cables. It is then converted into heat, light, movement, etc. An example of conversion is in a refrigerator where electric power is converted to keep food cool.



The faster the weight is lifted, the higher the power

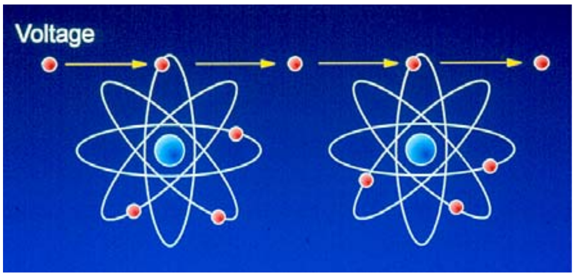
When electric power is transported within a town or street it is called ‘power distribution’.

When it is transported over long distances from the power plants to a town it is called ‘power transmission’.

This tutorial will concentrate on power transmission.

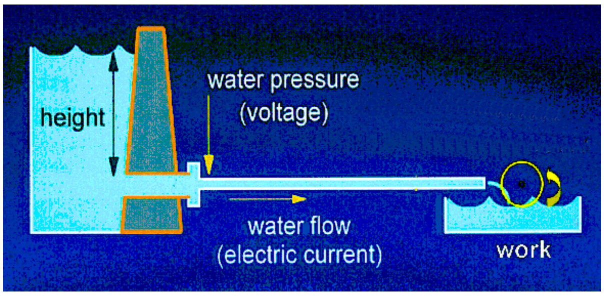
Electric power is carried by the flow of current (electrons moving from one atom to the next) along a conductor or wire.

The current is pushed along the conductor by voltage.



The voltage causes the current to flow

A good way to look at things is to consider water flowing from a reservoir behind a dam. Voltage is equivalent to the depth of water (the water pressure). Current is equivalent to the flow of water from the reservoir through the pipe.



The water pressure forces the water to flow and turn the wheel

Power is calculated by multiplying the voltage by the current.

Voltage is created by the power plant and it is always present in the conductor.

When the user at the far end of the conductor (at home or in a factory) throws a switch, the voltage pushes the current into the domestic or industrial appliance that has been switched on. Energy is then converted at the power plant from fossil fuel, nuclear fuel, water or wind into electric power and permits current to flow through to the appliance. At the appliance, the power is converted into heat (to keep you warm), cold (air conditioning to keep you cool) or movement (to turn your vacuum cleaner motor).

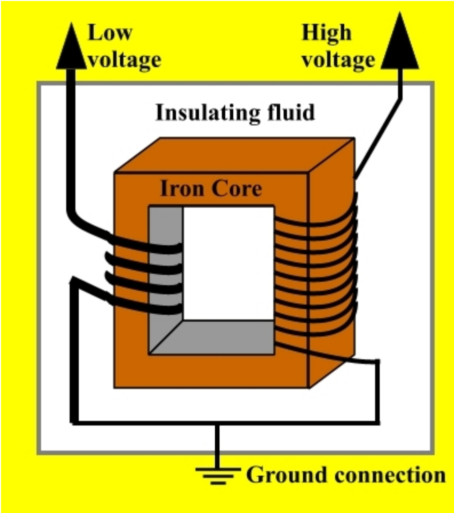
There are two types of electric power transmission. The first uses alternating current (AC) transmission and the second uses direct current (DC) transmission. In an AC system, the current flows to and fro in a push-pull fashion sixty times a second. Its main advantage is that transformers can be used.

Transformers permit voltage to be converted, ‘transformed’, from low values to high values and vice versa.

Transformers allow us to move large amounts of power in a highly efficient way at very high voltages along transmission lines and cables. The voltage is then transformed down so the power serves homes at a much lower and safer voltage.

AC systems are used for the majority of power transmission systems throughout the world.

Small transformers are used in the home, with an example being inside a cell phone charger, where 110 Volt household voltage is transformed down to around 6 Volts.

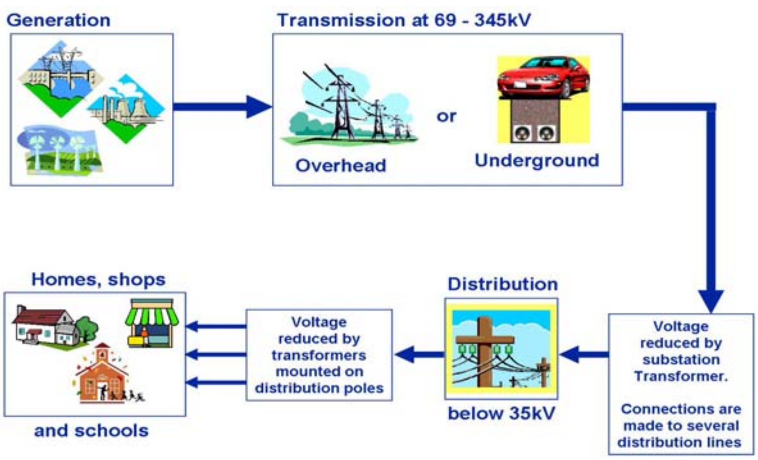


A transformer is used to increase or decrease voltage

In a DC system, the current flows in one direction only and transformers cannot be used. Converter stations are used to convert DC to AC but these are large and expensive so it is impractical to tap off power along the route. DC systems are generally used for specialized technical applications, such as long length undersea power connections and connections between independent AC power systems. This tutorial considers AC systems.

WHAT IS AN AC POWER SYSTEM?

An AC system typically comprises power plants, transformers, switches, circuit breakers, overhead lines and underground cables.



Basic electric power system

When power is transferred at voltages of 69,000 Volts, 115,000 Volts; 230,000 Volts; 345,000 Volts and above, this is known as power transmission.

Transmission voltages are usually expressed in terms of kilovolts, shortened to kV. One kV is equal to one thousand Volts. The voltages stated in the previous paragraph can be written as 69kV, 115kV, 230kV and 345kV. To give a comparison, 345kV is over 1,000 times higher than the voltage of 110 Volts that is used in peoples' homes.

A transmission circuit is usually comprised of three parallel overhead lines or underground cables. The underground cables can be three separate cables or three cables within a common pipe. Each of the three lines or cables must be in operation for the circuit to work properly.

Three parallel lines or cables are required to form a circuit

HOW IS AC POWER TRANSMITTED?

Power can be transmitted overhead by means of overhead lines or underground by means of cables.

The majority of circuits use only overhead lines, some use both overhead lines and underground cables and only a few use cables only. This mixture is somewhat similar to a railroad which is above ground outside a city and underground in dense urban areas.

The first choice of a utility is usually to install circuits overhead as this is the most efficient and reliable. There are technical problems that prevent underground cable circuits from carrying power efficiently over long distances. These can be overcome by installing additional equipment at regular distances along the route. These pieces of equipment are called "reactors" and they allow the cable system to carry more power.

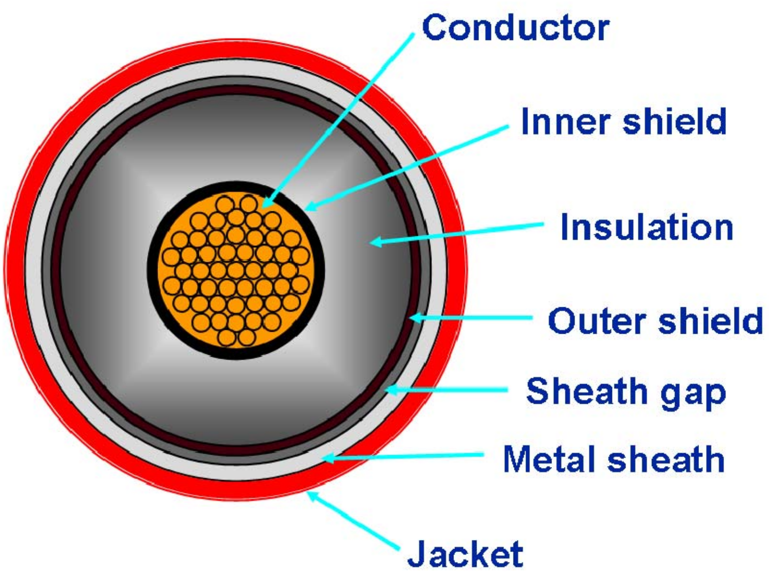
Underground cable transmission systems may be used when it is impractical or undesirable to use overhead lines. Cables might be used in the following situations:

- a water crossing
- a bridge crossing
- a tunnel
- a densely populated area of a city
- next to an airport
- an area of outstanding scenic beauty

This tutorial describes the proven types of underground cable systems that are in use throughout the world.

WHAT IS AN UNDERGROUND POWER TRANSMISSION CABLE?

A power cable provides the means to carry current from one location to another. It is circular in shape. The voltage is contained within the cable so none escapes by sparking across to the ground.



Typical cable construction

The conductor carries the electric current. The current causes the conductor to heat up to a temperature of around 195 degrees Fahrenheit when the cable is working at its maximum capacity. The installation design must allow for this heat to escape to the surroundings.

The inner shield provides a good, smooth, surface for the insulation to sit on.

The insulation prevents the voltage from sparking to ground. The plastic covering on an extension cord for a domestic appliance does the same thing so you don't get an electric shock or short circuit the house supply.

The outer shield further ensures that none of the voltage escapes.

Depending on the cable type, the sheath gap is either filled with fluid or wrapped with swellable tapes to prevent the flow of water along the cable if it is damaged.

The metal sheath keeps the cable completely sealed, it prevents water from entering the cable and, in some types of cable, it prevents the filling fluid from escaping from the cable. The metallic sheath also has some important electric uses.

When included in the design of a cable, the jacket prevents the metal sheath from being corroded by water and salts in the surrounding soil. It is also used to insulate the metal sheath from ground, something that is important in the electric design of a system.

Cables can be manufactured in long lengths of several miles but can only be transported by road or rail in comparatively short lengths (1500 – 2000 feet, typically). A difficult installation terrain, such as a steep or winding route, may mean it is only practical to install short lengths.


Reels of cable are transported by large trucks

The cables are transported from the factory to the construction site on large and heavy reels.

The reel lengths are joined together end to end by connectors called joints (sometimes called splices). These and cable terminations (sometimes called potheads) are described in more detail in the next section.

The main requirements of a power cable are reliability and safety. The cables are installed underground in a hostile environment and are inaccessible for visual inspection during their service lives. A cable system is normally designed to have a prospective life of 40 years.

UNDERGROUND POWER CABLE ACCESSORIES

The joints that are used to connect reel lengths together and the terminations that are used to connect the cable system to switchgear, transformers, reactors and overhead lines are called accessories.

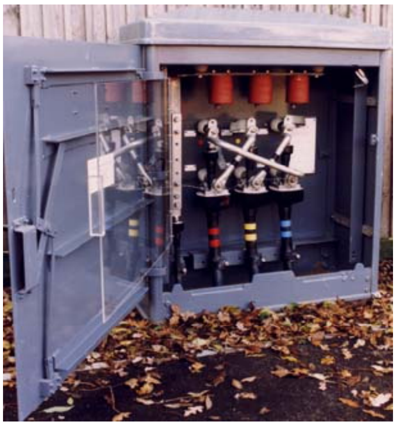
Joints near completion in a joint bay, they will later be buried with soil up to street level

Transition stations are used to connect lines and cables together

The locations where underground cable terminations are connected onto overhead lines are called transition stations.

These accessories are every bit as important as the cable and are recognized as being the weakest link in the cable system in terms of reliability.

All the accessories must be assembled by hand on the construction site without the advantages of being in a clean, dry, factory.



A kiosk used to make electrical connections to ground

Other accessories, such as ground connection boxes, alarm systems, monitoring systems and communication cables are also necessary.

Together, cables and accessories comprise a cable system.

WHAT ARE THE DIFFERENT TYPES OF TRANSMISSION CABLE SYSTEMS?

With the exception of a very small number of special circuits operating at 525kV, 345kV is the highest voltage for underground cables in the USA. Underground circuits at 345kV require advanced technology and each individual circuit must be custom designed and manufactured to suit the particular application. These cable systems cannot be purchased "off the shelf".

Several different types of cable systems are in use throughout the world. Each system has advantages and disadvantages. For any given project, the most appropriate type of system must be selected by a utility after they have taken due account of their own technical and commercial requirements together with the views of the general public, land owners, local and state government, and other interested parties.

In this section the various types of cable systems are described and their main advantages and disadvantages are given. Where systems are not suitable for use at 345kV, this is indicated.

High Pressure Fluid Filled Systems

High pressure fluid filled is usually shortened to HPFF.

Here the three individual cables, called cores, necessary to form a circuit are installed in a steel pipe.

The pipe is first installed in lengths of up to 40 ft and these are welded together in sections that are typically 1500ft long. The three cables are then pulled into the pipe.

The joints that are necessary to join individual reel lengths together are installed in chambers in the ground called splicing vaults that are up to 30 feet long.

At the end of the process, the pipe is filled with a filling fluid and is then pressurized with pumps to around 200 pounds per square inch to achieve full insulation strength.

The key elements of each HPFF cable core are:

Conductor:	This is made from many small copper or aluminum wires that are twisted together.
Insulation and shields:	Many layers of thin tapes measuring less than one hundredth of an inch thick and less than one inch wide are wound onto the conductor in the factory. The layers of tape are applied until the insulation is around one inch thick. Carbon or metalized paper tapes are used as shields to maintain the circularity of the conductor and around the outside of the

insulation to contain the electric field within the insulation. Metal and plastic tapes are also applied over the outer shield.

Two types of insulating tape are available:

- high quality paper that has been washed, treated and dried to remove any impurities and moisture or
- a sandwich of paper-polypropylene-paper (PPP). Polypropylene is a plastic with good electric, mechanical and temperature capability.

Cores insulated with PPP are up to 60% smaller than cores insulated with paper. Also, PPP cores are electrically more efficient than paper cores and so the cost of transferring power is reduced. Today, PPP is the preferred choice of insulating tape.

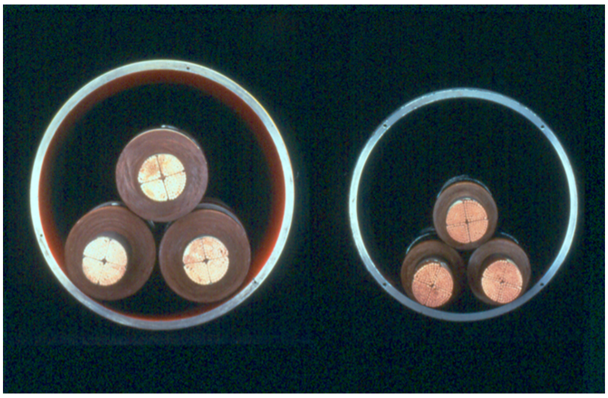
Filling fluid: The tapes are only one part of the insulation. The other part is provided by the fluid that is used to fill the steel pipe after the completion of installation. The fluid permeates through and between the insulating tapes and fills up the gaps and spaces between the tapes.

Skid wires: These are thin D shaped wires, about ¼" across, which are wrapped round each core in an open spiral. Their purpose is to protect the core when it is installed into the pipe, allowing it to 'skid' over the surface of the pipe.

Main Advantages

- HPFF cable systems are a mature technology and have a proven reliability. They provide the backbone of America's underground power transmission systems and many hundreds of miles have been installed since the 1950's in circuit lengths of up to around 15 miles.

- Steel pipes can be laid quickly in short lengths. This means that it is only usually necessary to keep trenches of about 40-60 feet long open at any one time during installation. Sometimes, when obstacles need to be bypassed, much longer trench lengths are necessary. The cable cores are pulled into the pipe after installation of the whole pipe length is complete.



Typical HPFF cable constructions inside steel pipes. Paper insulation is applied to the cores on the left and PPP insulation to those on the right

- Local manufacturing, installation

and maintenance expertise is readily available in the USA.

- Steel pipes provide good, but not perfect, mechanical protection to the cable cores in the event of a ‘dig-in’ by a contractor digging up the roadway.

- Steel pipes reduce the magnetic field effects that are generated by the cable cores.

- The splicing vaults that are used to house the cable joints allow access to the joints for maintenance.

- Long circuit lengths can be easily tested during circuit commissioning. Suitable test equipment is readily available in the USA.

- Cable cores can be pulled out and replaced through the splicing vaults without the need to dig up the road.

Main Disadvantages

- If a leak occurs in the steel pipe, fluid will leak out into the surrounding soil. (Monitoring systems can be used to give an early indication of the presence of a leak).

- The filling fluid is at high pressure, it is stored in large reservoirs situated at various points along the cable route and can flow easily and quickly to the point of any leak.

- Steel pipes will corrode if they come into contact with water and salts in the soil, just like a car kept at the coast will rust quickly. If the protection over the surface of the pipes is damaged, corrosion is likely to occur and, eventually, the corrosion will travel through the pipe wall and result in a fluid leak. Special equipment is necessary to reduce the risk of corrosion. Corrosion is seldom a problem in a properly designed and installed system.

- Cable cores are free to move and slide within the steel pipe. Special design measures must be taken on routes with steep slopes in order to prevent cable damage. The severity of a slope may mean that a HPFF system can not be used at all.

- Some North American utilities are now installing XLPE systems in preference to HPFF at transmission voltages up to 345kV. If this trend continues the availability of HPFF spares and expertise could become a longer term problem.

High Pressure Gas Filled Systems

High pressure gas filled is usually shortened to HPGF.

HPGF systems are similar to HPFF systems with the key difference being that the steel pipe is filled with nitrogen gas at 200 pounds per square inch rather than a filling liquid.

Main Advantages

- A leak of nitrogen gas from the steel pipe has a far lower environmental impact than a leak of filling fluid.
- Nitrogen gas is readily available and does not require any special formulation.
- Nitrogen gas is non-flammable so there is not a fire risk if a cable system is installed in a tunnel or substation.

Main Disadvantage

- An HPGF system is relatively weak electrically (because the nitrogen gas is not as good an insulator as fluid) and so HPGF systems are limited to voltages of 230kV and under. They are not suitable for 345kV so this tutorial will not consider these further. Dropping the power transmission voltage to 230kV or below is not usually a practical option as this would increase the current to be carried by 50% and twice the number of cables would be required to carry the same amount of power. The power transmission would be less efficient.

Self Contained Fluid Filled Systems

Self contained fluid filled is usually shortened to SCFF cable.

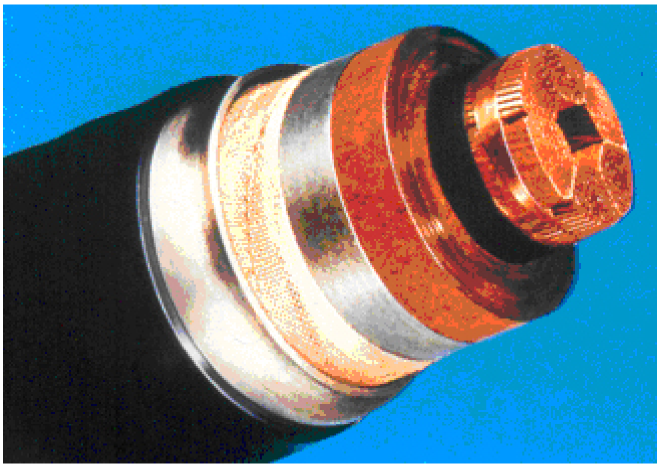
SCFF cables are sometimes also called low pressure fluid filled cables (LPFF).

Three single core cables are necessary to form a circuit.

The cables are buried directly in the ground.

For installation, a trench at least as long as the cable reel length is excavated and the cables are individually pulled into the trench. The open trench may be 1500 to 3000ft long.

Each individual cable comes filled with a fluid.



Typical SCFF cable construction

Joints, which are also buried direct in the ground, are used to connect the reel lengths together.

After installation, the filling fluid is pressurized up to 75 pounds per square inch.

The key elements of each SCFF cable are:

Conductor:	This is similar to the conductor used in HPFF cables. The main difference is that a hole, about ½" in diameter, is present in the center of the conductor to allow the filling fluid to flow from one end to the other when the cable heats and cools.
Insulation and shields:	These are similar to the insulation and shields used in HPFF cables. As with HPFF, the paper or PPP tapes are only one part of the insulation. The other part is provided by the filling fluid that is contained within the cable.
Metal sheath:	This is a tube made from lead or aluminum that is applied over the insulation by means of a process called extrusion. The purpose of the sheath is to prevent the filling fluid from leaking out of the cable and to prevent air or water from leaking into the cable. It also has several important electric functions.
Jacket:	This is a tube made from polyethylene or PVC that is applied over the metal sheath by an extrusion process.

Main Advantages

- SCFF cable systems are a mature technology and have a proven reliability. Outside of America, they provide the backbones of the power transmission systems in most European, Middle Eastern and Asian countries. Many thousands of miles have been installed since the 1960's.
- SCFF systems are buried direct in the ground. This and the use of special anchor joints means that cable movement on steep slopes can be prevented.
- The three cables can be spaced apart in the ground giving improved heat dissipation to the ground surface.
- Long circuit lengths can easily be tested during circuit commissioning. Suitable test equipment is readily available in the USA.

Main Disadvantages

- If a leak occurs in the metal sheath, fluid will leak out into the surrounding soil. (Monitoring systems can be used to give an early indication of the presence of a leak).

- At the higher transmission voltages, where conductor sizes tend to be large and generate high mechanical forces, SCFF systems are not suitable for installation inside long lengths of ducts or pipes as the metal sheath may fatigue and fail.

- Long lengths of trench must be open for longer periods. Long trench lengths present a safety hazard particularly for trenches dug in busy streets. Also, traffic disruption may occur.

- Fluid reservoirs must be installed at regular intervals along the route to allow for expansion and contraction of the filling fluid.

- Corrosion of the cable sheath will result in fluid leaks so regular maintenance testing is necessary, requiring the circuit to be switched out of service.

- The spacing necessary to allow good heat dissipation may result in a wider trench and in higher magnetic fields.

- Special grounding techniques are necessary. These require connection boxes or kiosks to be installed. They must be maintained regularly. The boxes and kiosks must be designed and located to protect the public from the effects of a cable system fault.

- SCFF cable systems are not manufactured in the USA and are not regularly installed by USA based contractors. There is, therefore, very little specialist installation and operational expertise available within the USA.

- Many European and Asian manufacturers of SCFF systems have switched from the production of SCFF to XLPE cable systems. The last large scale production facility in Europe is now being closed. The availability of SCFF spares and expertise in the future is likely to be a problem.

Cross Linked Polyethylene Systems

Cross linked polyethylene is usually shortened to XLPE.

XLPE cables are also called extruded or solid insulation cables. A technical term used to describe the insulation is 'dielectric'.

Three single core cables are necessary to form a circuit.

The cables may be buried directly in the ground or pulled into individual non metallic pipes or ducts.

For installation, either a trench at least as long as the cable reel length is excavated and the cables are pulled into the trench, or individual ducts, usually manufactured from a plastic material, are laid in short lengths and joined together before the cables are pulled into them.

Each individual cable is dry inside and is not filled with a fluid.

Joints are used to connect the reel lengths together and are located in splicing vaults, or encased in conduit or buried direct in the ground.

XLPE systems have a proven reliability at voltages up to 161kV. At higher, power transmission, voltages, their use is relatively recent.

The key elements of each XLPE cable are:

Typical XLPE cable construction

Conductor: This is similar to the conductor used in HPFF cables.

Insulation and shields: The XLPE insulation is extruded over the conductor together with the inner (underneath) and outer (over) shields by means of a process called triple extrusion. Squeezing toothpaste out of a tube is a form of extrusion. Some grocery bags that are supplied by supermarkets are made from polyethylene. The crosslinking process links individual polyethylene molecules together and has the effect of increasing the melting point of the insulation. This allows the XLPE cable to operate at the same higher temperature as HPFF and SCFF cables and thus carry a similar power level.

Metal sheath: This is similar to the metal sheath used in SCFF cables. As the metal sheath does not have to contain a pressurized filling fluid, a number of alternative, less robust, types of metal sheath are available for some applications.

Jacket: This is similar to the jacket used in SCFF cables.

Main Advantages

- The insulation is electrically efficient, so relatively long underground circuits can be installed which helps to keep the cost down.
- XLPE systems don't contain fluid so the environmental effects of leaks are not a problem. Fluid system maintenance is not necessary.

- XLPE systems do not burn as readily so there is a reduced risk of fire spread in tunnels and sub-stations.

- There is now a greater number of suppliers with a manufacturing capability for 345kV XLPE cable than those who manufacture other cable types.

Main Disadvantages

- Reliable, long term, service experience is still being proven. At power transmission voltages, XLPE cable systems were developed after the other types of systems discussed in this tutorial. The first long length system at 345kV or at higher voltages was not commissioned until the mid 1990's. The circuit length was 7.5 miles.

- XLPE technology was held back by difficulties in producing and assembling reliable accessories (joints and terminations). Different designs and materials are in use around the world and manufacturers are still improving them. As with other cable types, the accessories are recognized as the weakest link.

- In the event of undetected damage to the metal sheath, moisture can enter the XLPE insulation and weaken it. Premature cable failure is likely.

- XLPE cables are larger in diameter as a thicker layer of insulation is required. Reel lengths tend to be shorter and sometimes the number of joints has to be increased.

- 345kV XLPE cables and accessories are not yet manufactured in the USA, although this is expected to change. The expertise of USA based installation contractors is growing with time.

- International standards require long term proving tests to be carried out on each new design of XLPE cable system. These can be up to one year long and thereby increase project lead time.

- The manufacture of XLPE cable is slower than other types and so longer project lead times are required.

- Cable circuits are tested at a high voltage before being energized. Special equipment comprising an HV AC voltage generator is required to test an XLPE cable system, this being significantly larger and more complex than equipment used for other cable types.

- The installation of self-contained XLPE cables in three plastic ducts instead of one steel pipe increases the magnetic field effects and complexity of the grounding equipment compared to HPFF systems.

Ethylene Propylene Rubber Systems

Ethylene propylene rubber is usually shortened to EPR.

EPR cables are also called extruded or solid insulation cables.

Three single core cables are necessary to form a circuit.

The cables are either buried directly in the ground or pulled into non-metallic pipes.

For installation direct in the ground, a trench at least as long as the cable reel length is excavated and the cables are pulled into the trench.

Each individual cable is dry inside and is not filled with a fluid.

Joints, which are either buried direct in the ground or installed in splicing vaults, are used to connect the reel lengths together.

Main Advantages

- EPR systems are more resistant to water and can be exposed to water for a longer time without a metallic sheath.
- EPR cable is more flexible and can be bent into tighter locations without damage.
- EPR systems can carry a higher overload under emergency situations with less risk of damage.

Main Disadvantage

- EPR is electrically less efficient than XLPE insulation and so cable systems are usually limited to voltages of 150kV and under. They are not suitable for 345kV so will not be considered further in this tutorial.

NEWER TYPES OF TRANSMISSION SYSTEMS

Newer types of transmission systems, which are still at the proving stage, are gas insulated lines (GIL) and superconducting cables.

A GIL system comprises three aluminum alloy pipes each some 2 feet in diameter and 40 feet long. A solid tubular aluminum conductor is inserted into each pipe. Many pipes are then welded or bolted together. GIL has the advantage that higher levels of power can be carried over longer distances because of the larger size of the conductor and pipe.


GIL installed on short stilts (diagrammatic representation only)

The pipes can be installed above ground on stilts, in a tunnel or they can be direct buried underground. After installation, the pipe is filled with an insulating gas.

To date, little long length GIL has been installed worldwide. These installations have been above ground in power plants or in tunnels. Only short, trial, lengths have been installed direct buried underground.

Underground, long length GIL systems do not have a proven reliability and service life.

Above ground, GIL systems present a considerable visual impact. Where GIL is direct buried in the ground, there is concern over the additional mechanical stresses that will arise in the aluminum pipes. Aluminum is a metal that corrodes easily and the protection of direct buried pipes is extremely important.

Superconducting cable systems use the property that at low temperatures some materials have no electric resistance. This allows high levels of current to flow in a smaller conductor. These systems have to be kept extremely cold by having liquid helium or nitrogen pumped through them at a temperature down to as low as minus 450 degrees Fahrenheit and they have to be thermally insulated from their surroundings within a vacuum filled tubular layer. Superconducting transmission systems are at the prototype stage with some short length service connections recently installed and under evaluation in the US. The superconducting system is a high technology solution which is still evolving and which does not yet have a proven reliability and service life.

HOW ARE CABLE SYSTEMS INSTALLED?

HPFF Systems

First of all the steel pipes are installed in the trench. The pipes are installed at a depth of around 4 feet. Each pipe section is about 40 feet long and the individual sections are welded together and x-rayed to ensure the quality of the weld.

Pipe installation moves progressively along the route and it is only necessary to keep a short section of trench open at any one time. Trench lengths of 200 feet are possible. This minimizes disruption to pedestrians, traffic, landowners and so on.

The pipe trench is either part filled with concrete, soil that was removed from the trench, or with a special material, called thermal backfill, which helps remove the heat from the cables.

After installation of the pipe, the three reel lengths of cable core are pulled into the pipe together. The inside of the pipe and the welded pipe joints must be smooth so that the skid wire protected cable cores can slide easily and prevent damage to the cores.

Splicing vaults can measure up to 8 feet wide, 8 feet deep and up to 30 feet long and are constructed to allow individual cable reel lengths to be connected together.

The joints that are used to connect the reel lengths together are installed in the splicing vaults. A larger steel casing is then welded to the steel pipes thereby sealing the joints into the pipe system.

At each end of the route, terminations are connected onto the ends of the three cable cores to allow them to be connected to switches, transformers or overhead lines.

Pumping stations are positioned periodically in long routes to house fluid reservoirs and associated pumping equipment. These reservoirs permit thermal expansion and contraction of the fluid.

Filling fluid is pumped into the steel pipe after completion of joint and termination installation and is pressurized to around 200 pounds per square inch. In some applications the fluid is circulated to cool hot spots along the cable.

Finally, the circuit is tested and is put into service.

SCFF Systems

Open cable trench

SCFF systems are most suited to direct burial in the ground.

A trench length at least equal to the reel length, around 1,500 – 2,000 feet, must be open. Trenches are typically 3-4 feet deep and 3-4 feet wide. Wooden boards or steel shuttering are installed along the trench length to prevent collapse.

Three cables are pulled in one after the other. Often a technique, called 'bond pulling', is necessary whereby each cable is supported by a tensioned wire rope as it is pulled in so that it is not stretched or crushed.

After the cables are pulled in, the trench is filled with either the soil that was removed or with thermal backfill, if help to remove heat from the cables is necessary.

A buried joint bay during the backfill operation

Cable joints are then installed in pits containing a concrete base. These pits are sometimes called joint bays and typically measure 9 feet wide, 6 feet deep and 24 feet long. A large tent or building is erected over the pit. A clean working environment is established and the inside may be air conditioned.

Joint bays cannot be backfilled until two consecutive cable section lengths have been pulled in and connected together. The joints have to be sealed inside a waterproof casing and also protected from loads arising from the soil and road surface.

115kV cable system terminations

Terminations are connected to the cable ends at the ends of the route in order to allow them to be connected to switches, transformers or overhead lines.

SCFF systems operate at a maximum pressure of 75 pounds per square inch. Sectionalizing joints, called stop joints, are used to limit fluid pressures along a steep route. These joints also anchor the cable system mechanically in order to prevent movement downhill.

Fluid reservoirs to permit expansion and contraction of the filling fluid must be buried in the ground next to stop joints and at the ends of the route.

Finally, the circuit is tested and is put into service.

High voltage test set connected to SCFF terminal

Pit housing fluid feed tanks

XLPE Systems

XLPE systems up to 345kV are suited both to direct burial in the ground and for installation in ducts (one cable) and pipes (three cables).

Installation of direct buried XLPE systems is similar to installation of SCFF systems.

As with other cable types joints and terminations are the weakest link and must be installed in a carefully controlled ultra-clean environment. XLPE joints are highly complex to manufacture and special care and techniques are necessary during assembly.

Anchor joints are required to secure the cable system from moving in special situations.

Connecting XLPE cables together in an ultra-clean environment within a buried joint bay

Transition joints are becoming available that will permit new XLPE cable to be electrically connected to existing types of fluid filled cable, whilst completely segregating the fluid filling.

Some designs of XLPE termination must be filled with insulating oil.

It may be necessary to insert intermediate substations in longer circuits to separate them into short lengths and so permit the cable system to be voltage tested prior to commercial operation.

MAINTENANCE AND REPAIR

The technology used for HPFF and SCFF systems is mature and well proven. Provided systems are designed, manufactured, installed and maintained properly, a long, reliable, service life should follow. XLPE systems are still accumulating service experience. Manufacturers are investing heavily into XLPE systems and this gives confidence that, in time, designs should evolve and reliability should match that of HPFF and SCFF systems.

Maintenance

Regardless of the type of cable system, routine maintenance is necessary to keep it in as good a condition as possible. This will help to prevent unexpected failures.

Each system has its own specific, detailed, maintenance requirements but these can be generalized as follows:

- A regular patrol along the cable route to look for evidence of anything that may indicate the system has been or is likely to be damaged. Roadworks by another utility is a good example.
- A regular inspection of all exposed pipework and pressure gauges to look for any signs of fluid leakage.
- Regular testing of ground bonding connections, alarm connections, corrosion protection systems (including cable jackets) and surge limiters that protect the cable system from lightning strikes and other abnormal electric events.

Fluid pipe and gauge inspection

Repair

In the event of a failure of a cable system component, a system repair will be necessary.

Failure of a minor item may mean that a repair can be carried out while the circuit remains in service.

Failure of a major component, such as the cable itself, the metal sheath, the jacket, a joint, a termination or a grounding connection will mean that the system must be taken out of service to permit the repair to be carried out safely.

Fault location and repair times will range from one week (a jacket repair, for example) through several weeks to more than a month (a failed cable or joint, for example).

In the event of a failure, a utility must do everything reasonable to limit further system or environmental damage.

The failure must first be located. Electronic location techniques are used as the cable system is buried and cannot be inspected visually. This can take several days. Any other adjacent equipment (transformers, switches, etc) must also be examined to check for damage.

After successful location, the most appropriate repair solution must be established. This may mean that a specialist from the supplier of the cable, joint or termination must visit the site.

Each cable system is designed specially for each utility and a supplier is not likely to have spare parts in stock. Manufacturing times are a few months and so each utility should hold its own set of spares. Typically a utility will hold a spare reel of cable, two spare joints and one spare termination.

Skilled personnel must be available to carry out the repair.

A transmission cable system is designed to have a service life of 40 years. It therefore follows that spare parts, materials and tools must be available over the service life. In selecting a particular cable system type a utility must ensure, as far as they can, that direct spares or suitable substitutes remain available.

HOW DO CABLE SYSTEMS AFFECT ME?

As part of the project planning process, the utility will have negotiated the right to install the cable circuit with local authorities, land owners, etc. Often, in the countryside, a dedicated right-of-way will be granted that gives a utility the right to install cables or overhead lines and to access them for maintenance and repair purposes. The right-of-way is effectively a continuous path of land that is leased to the utility.

In towns and cities, it is not usually practical to dedicate a right-of-way to a utility as other utilities often have to install their services in close proximity and the public need to be given access to roadways after the completion of installation.

During installation, trenches will have to be excavated. Depending on the number of circuits being installed, an access width of up to 36 feet may be necessary. Traffic flow may be disrupted and, on some occasions, partial or total temporary street closures will be necessary.

Also, as part of the project siting process, an environmental impact analysis is typically performed. This will have covered installation, in-service operation and repair and maintenance of the cable system.

During Installation

During installation as much work as possible, such as trench excavation, splicing vault construction and the storage of excavated soil, will be performed within the right-of-way or the area negotiated with a town or city authority. However, additional areas will probably be required and these will be negotiated on a case by case basis.

At all times during installation, public safety is paramount and, by means of a risk analysis process, all risks will be identified, analyzed, quantified and measures adopted to minimize each risk and its effects. A typical example is the construction of a splicing vault. This will be protected by crash barriers, signs warning about the presence of the splicing vault will be posted and the splicing vault location will be lit at night. In some circumstances, security guards will be employed.

Installation will typically progress at a rate of about one mile per month and will move progressively along the route so not all parts will be affected all of the time.

The key areas with the greatest impact are as follows:

- Increased construction traffic. Large, heavy trucks will need to access the construction site. Drivers will be instructed to only use approved access routes. Wheel washing and measures to minimize dust will be employed. In particular, increased traffic will result from
  - Trucks carrying excavating machines.
  - Trucks carrying cable reels, transformers and switches.
  - Trucks taking away excavated soil and returning with concrete and thermal backfill.
  - Cars and pickups carrying engineers and construction workers.

Three reels of cable are parked in the street ready to be pulled into a steel pipe

Installation of ducts to house the cables that will cross the river

- Open trenches and splicing vaults or joint bays
  - If a HPFF pipe or XLPE duct system is being installed, trenches up to 200 feet will be opened. Depending on trench length, excavation, pipe installation and backfill of 1-4 trenches can take place in less than a day. Work will proceed along the route by completing adjacent short trench sections.

  - Each splicing vault will be installed in less than a week. Cable pulling of three lengths of 1,500- 2,000ft of cable will take place in less than a day. Jointing work will continue inside the splicing vault for around 2-3 weeks.

  - If a SCFF or XLPE buried direct system is being installed, trenches of up to 2000 feet will have to be opened in one operation. The excavation, cable laying and backfilling cycle takes about 2 weeks. Each vault will have to be open for joint assembly and backfill for an additional period of 2-3 weeks.

Temporary trench reinstatement

  - Once trenches and splicing vaults have been filled in, the road surface will be 'reinstated' to its original condition. Reinstatement is usually a two stage process; temporary reinstatement to allow the filling to settle followed by permanent reinstatement which can be several months later depending upon the road surface type.

- Access to vehicular traffic and pedestrians. Access will inevitably be restricted during construction of those parts of the route passing alongside and underneath roads and sidewalks. On a long length route of tens of miles the work may occupy a period of many months to over a year. Work will proceed at different locations along the route at the same time. The schedule of work and necessary measures are agreed in advance with the appropriate State, City and Town Traffic Departments. Examples of the impacts and measures that may be taken to ease access are:

  - An open trench will be fenced off and lit at night. The trench will be typically 3-4 feet wide for HPFF pipe and XLPE duct installations comprising 3-6 cables and also for XLPE and SCFF buried direct installations comprising 3 cables. For XLPE and SCFF direct buried installations of 6 cables, either the trench width will be increased to 4-6 feet or a second trench excavated. Sufficient additional road width must be allowed to permit the excavated soil to be stored, removed and replaced.

– Access must also be provided for the excavation machines and trucks. This is likely to require that one lane of the road be closed and temporary traffic lights be used to control traffic flow.

Ducts being positioned in a deep trench before pouring concrete

– When two trenches are to be installed under opposite sides of the road, one section length of pipes, ducts or cables will be completely installed and the road surface reinstated before the trench on the opposite side is opened.

– Typically, vehicles can not be parked along the roadside during trenching operations.

– The time that a trench may be open depends upon a number of factors, including the weather. The presence of other buried services in the ground, such as water pipes, gas pipes, water drains, communication cables and domestic electricity cables will require that the trench be excavated to a greater depth using hand tools. The presence of a high water table will require that the trench be continuously pumped dry. Loose, running ballast will require special measures to support the trench walls. Rock and concrete will require special cutting and drilling equipment.

– In some locations it may be necessary to lay the cable close to, or under, a sidewalk. A fenced off safe passage is then provided for pedestrians.

– The crossings of major road intersections and civil constructions such as bridges and tunnels will require special arrangements. The trench may be opened at night requiring that either the lane or road be temporarily closed. One possibility is to lay pipes or ducts and to quickly reinstate the road surface such that the cables can be pulled under the intersection at a later date without the need to interrupt traffic.

– At certain intersections steel plates may be laid to bridge the trench.

– Access to domestic and public premises for vehicles and pedestrians may be provided across the trench by a temporary crossing if access is to be restricted for a prolonged period.

– Special measures are taken to provide access for emergency vehicles to public premises such as hospitals, schools and fire and police departments.

– In some special circumstances, as an alternative to temporary trench crossings, unrestricted access can be achieved by the use of pipe-jack tunnels, miniature tunnels or by directional drilling. However these techniques have technical limitations dependent on the location and type of cable.

– The installation of joints in either splicing vaults (HPFF pipe and XLPE duct cables) or bays (XLPE and SCFF buried direct cables) requires the excavation of a wider and deeper hole than the trench. The construction time for the splicing vault and the installation time for the joints is significantly longer than for the trench and cables. Wherever possible a location for the splicing vault is chosen to reduce the disruption to vehicular and pedestrian access.

Ducts entering a single, pre-cast concrete splicing vault

– In applications where two parallel configurations of six cables are required, combinations of double length splicing vaults and double width splicing vaults may be selected to separate the joints for maintenance purposes.

– To reduce site construction time the splicing vaults may be prefabricated in pre-cast concrete and transported to site and lowered into position using large trucks and cranes. The traffic flow may require to be halted during this activity.

– Jointing activities will take 2-3 weeks. It is usual during this time to cover the two access positions in the roof of the splicing vault chamber by small tents, small temporary buildings or special vehicles. A joint bay in a buried direct system has to remain open for this period and it will be necessary to completely weatherproof it with a large sealed tent, large temporary building or a custom designed shipping container. An additional period of 1 week may be required to remove the temporary building from the bay and to reinstate the road surface. It will be necessary for the specialist support vehicles to park along the road during the jointing period. The support vehicles will also include electricity generators for air conditioning equipment, pumps, lighting and power tools as well as washing and changing facilities for the jointers.

– During cable installation it will be necessary to park three large trucks next to the splicing vaults and use a crane to lift the large and heavy cable reels onto axle stands that will permit them to rotate. Traffic flow may require to be halted during this activity. Powered winches are located at the next splicing vault or joint bay to pull the three cables into position. A number of workers and vehicles are necessary during this activity, which will usually be completed within 1-2 days.

Reel being prepared for cable pulling

- Construction work may be performed at night and covered with steel plates during the day.

- Plants and animals. There is likely to be some disruption to the local ecosystem. Any plants or flowers that are covered by any preservation order will be identified and through consultation with the right representative bodies, a plan will be put into place to mitigate any environmental impact. The same is true for animals.

- Noise from construction machinery. This may be minimized by the use of acoustic shielding where necessary.

- Visual impact. This can be minimized by the use of appropriate screening.

In Service

In service, the cable route will be completely hidden. The tops of trenches and splicing vaults or joint bays will be covered with a surface that best blends in with the surrounding surfaces. This could be grass, concrete or tarmac.

At certain locations, small kiosks or boxes that house grounding equipment and filling fluid monitoring equipment will be present. In a duct system these are usually located out of sight inside the splicing vault.

Kiosk containing ground connection links

The key areas with the greatest impact are as follows:

- Visual impact.
  - Apart from boxes or kiosks there will be very little visual impact along the length of the route. In the photograph, 12 SCFF transmission cables cross this farmer's field in the UK.

    Kiosks protected by a fenced enclosure can be seen in the middle of the field.

Only the fenced enclosure is evidence that 12 transmission cables cross this land

  - At the ends of the route in transition stations, where the terminations connect onto transformers, switches or overhead lines, secure fenced yards will be necessary.
  - Depending on the circuit configuration, it is possible that smaller yards will be necessary at one or two points along the route.

- Boxes and kiosks. These will only be visible when it is not possible to house them underground. The electric design of SCFF and XLPE circuits requires that any accessories are connected to the cable system at no greater a distance than 30 feet. All boxes and kiosks will be of a strong steel construction and will be locked to prevent unauthorized access. They will be located in a position where accidental damage by the public is minimized.

Transition stations where cable terminations are connected to overhead lines

- Fluid leaks. The filling fluids contained in HPFF and SCFF cables are not listed in the Environmental Protection Agency's hazardous waste regulations. They also do not trigger any of the four criteria (corrosivity, reactivity, ignitibility and toxicity) for determining the status of those wastes not specifically listed by the EPA.

  One fluid, alkylbenzene contains a benzene ring. It is considered to have a low toxicity. A water soluble form of alkylbenzene is used in household detergents.

If ingested at full strength by humans, it can cause nausea. It is non-carcinogenic and has no adverse reproductive effects.

Kiosk containing pressure gauges and fluid leak alarms

Cable filling fluid is classified as a non-indigenous substance by the State of Connecticut and the State has a formalized program to remediate releases. The Remediation Standard Regulations (RCSA 22a-133k-1, 22a-430) place a high level of scrutiny on the cleanup of contamination. The State also administers a permitting program to prevent future releases.

Cable systems are monitored so that the presence of a leak is indicated as early as possible.

It is in the best interest of all parties that HPFF and SCFF systems are designed and installed to be as leak tight as possible.

- Magnetic fields. When power flows along an overhead line or underground cable conductor, an electric and a magnetic field are generated. In an overhead line both fields spread out from the conductors, and progressively reduce in strength as the distance from the conductor increases.

  In a cable, the electric field is completely screened by the outer shield and the metallic sheath and does not spread out into the surrounding environment. Only the magnetic field spreads out. The magnetic field decreases in strength as the distance from the cable increases.

  For SCFF and XLPE systems, the installation configuration of the cables has an effect on the magnitude of the magnetic field and how fast it drops off. The magnetic field strength at the ground surface can be reduced by burying the cables deeper and closer together.

  Whenever practical the configuration that produces the lowest field will be used. It should be noted, however, that some configurations may severely restrict the cables' capability to transfer sufficient power and may not be suitable.

- Plants and animals. When carrying maximum power, the cable conductor reaches a temperature of around 195 degrees Fahrenheit. The temperature drops as the distance from the conductor increases but there will be some localized heating of the soil in the immediate vicinity of the cables. Such additional heating would normally have reduced to zero some 12 to 15 feet away from the cables.

In some locations the local temperature increase may result in the moisture content of the surrounding soil decreasing, so some plants and animals may be affected by the temperature and a lack of moisture.

- Noise from transition stations. Sometimes a low pitched 'hum' can be heard to come from transition stations when transformers are present. This effect is minimized by installing transformers on anti-vibration pads and by the use of acoustic baffles.

- Risk of damage by contractors and other utilities. There is a risk to cable circuits from dig-ins. Detailed 'as installed' route plans will be made available to a central agency ("Call Before You Dig" in Connecticut) so the location of cables can be identified in the future.

Transmission circuit warning sign

Warning signs may be placed at discrete locations.

Portable scanners are available for use by contractors and are called Cable Avoidance Tools. These detect the magnetic field from a cable circuit and warn of its presence.


Protection and warning signs over buried cables

If someone commences digging without taking sensible precautions, they will find that the cable circuits are covered with warning tapes, steel plates or concrete slabs that state 'Caution Electricity' or something similar.

They may also find that the cable trenches have been filled with a type of concrete for heat dissipation reasons.

The likelihood of from dig-in damage is therefore small.

- Plowing restrictions on farmland. Cables buried across farmland may restrict the depth to which a farmer may operate a plough. Prior to installation, the depth of the cables would have been agreed with the farmer.

During Maintenance and Repair

Regular patrols are necessary to check the cable route for damage and to check all HPFF and SCFF connections are leak tight. Access to boxes or kiosks will be necessary but as checks are carried out annually the impact is likely to be small.

The impact will be similarly small during routine maintenance tests on the cable system's grounding connections and during minor system repairs.

In the event that a major system repair becomes necessary, such as a failed cable or joint, significant disruption in the vicinity of the failure site can be expected. Localized trench, splicing vault or joint bay excavations may be necessary and, in some circumstances it will be necessary to install a new length of cable. For HPFF systems in pipes and XLPE systems in ducts this can be achieved without trench excavation as the new cable core can be pulled into the existing pipe or duct.

TUTORIAL SUMMARY

- Underground cable transmission systems may be used when it is impractical or undesirable to use overhead lines, however there are technical limitations that prevent underground cables carrying power over long distances.

- Transmission cables are installed underground in a hostile environment where they are inaccessible for visual inspection and easy maintenance. The main cable requirements are therefore safety and reliability during a long service life.

- A choice of cable types exists for transmission voltages up to 345kV. At this high voltage level the cable systems are custom designed to suit each application and the highest levels of technology and quality are required.

- XLPE (extruded crosslinked polyethylene) is the newest type of transmission cable. XLPE is now being selected as the preferred cable type for the majority of applications worldwide. The main advantages are that it is electrically efficient and does not contain fluid. Service experience is still being accumulated to demonstrate reliability and service life. In particular the accessories that connect and terminate the XLPE cable lengths, are evolving in design to improve performance. The more mature and highly evolved cable types, with a demonstrated reliable service life, are now being superseded. Examples are HPFF cable (high pressure fluid filled) installed in a steel pipe and SCFF cable (self contained fluid filled) installed directly in the ground.

- Careful installation and protection of the cables is every bit as important as the cable design and manufacture, as the cables can initially be damaged during pulling in and jointing operations and later by third party dig-ins.

- Some disruption to pedestrian and traffic flow and some effect to the environment is inevitable during the comparatively long construction period when trenches are dug and cables and joints are installed. However these can be reduced with responsive project planning and co-operation with the appropriate public bodies.

- Regular maintenance in the form of diagnostic monitoring of the underground cable and visual inspection of the above ground equipment is important in reducing the need to re-excavate and repair the cable; the circuit outage times for which would be long.

- Careful selection of the cable and installation type, the cable manufacturer and the installation contractor, together with good project management, will lay a sound foundation for a reliable and long service life.

SECTION 15

POTENTIAL TRANSMISSION LINE ROUTE VARIATIONS

15. POTENTIAL TRANSMISSION LINE ROUTE VARIATIONS

15.1 INTRODUCTION AND SUMMARY

15.1.1 Overview of the Route Variations

As part of the process that led to the selection of the line design and route for the proposed Project, CL&P evaluated six 345-kV transmission line-route variations (two with overhead line configurations and four with underground line configurations[1]). As illustrated on Figure 15-1, the six route variations are:

- Mansfield Underground Variation
- Mount Hope Underground Variation
- Brooklyn Overhead Variation
- Brooklyn Underground Variation
- Willimantic South Overhead Variation
- Willimantic South Underground Variation

Each of these route variations represents a potential alternative to the construction of the proposed overhead 345-kV transmission line along certain segments of CL&P's existing ROWs. Although CL&P prefers to develop the proposed Project as described in Volume 1, the route variations discussed in this section were determined to be potentially feasible to construct and operate. However, compared to the portions of the proposed overhead transmission line route that these variations would replace, CL&P found each of the variations less desirable due to constructability, engineering, environmental, social, and/or cost factors.

1 While CL&P eliminated an "all-underground" cable system route from consideration for the reasons discussed in Section 14, shorter underground cable segments were evaluated as potential variations to portions of the proposed overhead transmission line route or overhead line design. For the purposes of this discussion, "route variation" or "variation" denotes either a potential alternative alignment to a segment of the proposed Project (i.e., the overhead 345-kV line along CL&P's existing ROWs) or a potential transmission line configuration alternative (e.g., underground cable) within CL&P's existing ROWs. Different overhead line types for EMF BMPs and for the alignment across the federally-owned properties in the Mansfield Hollow area are addressed in Volume 1, Sections 7 and 10, respectively.

Figure 15-1: Proposed Route and Route Variations

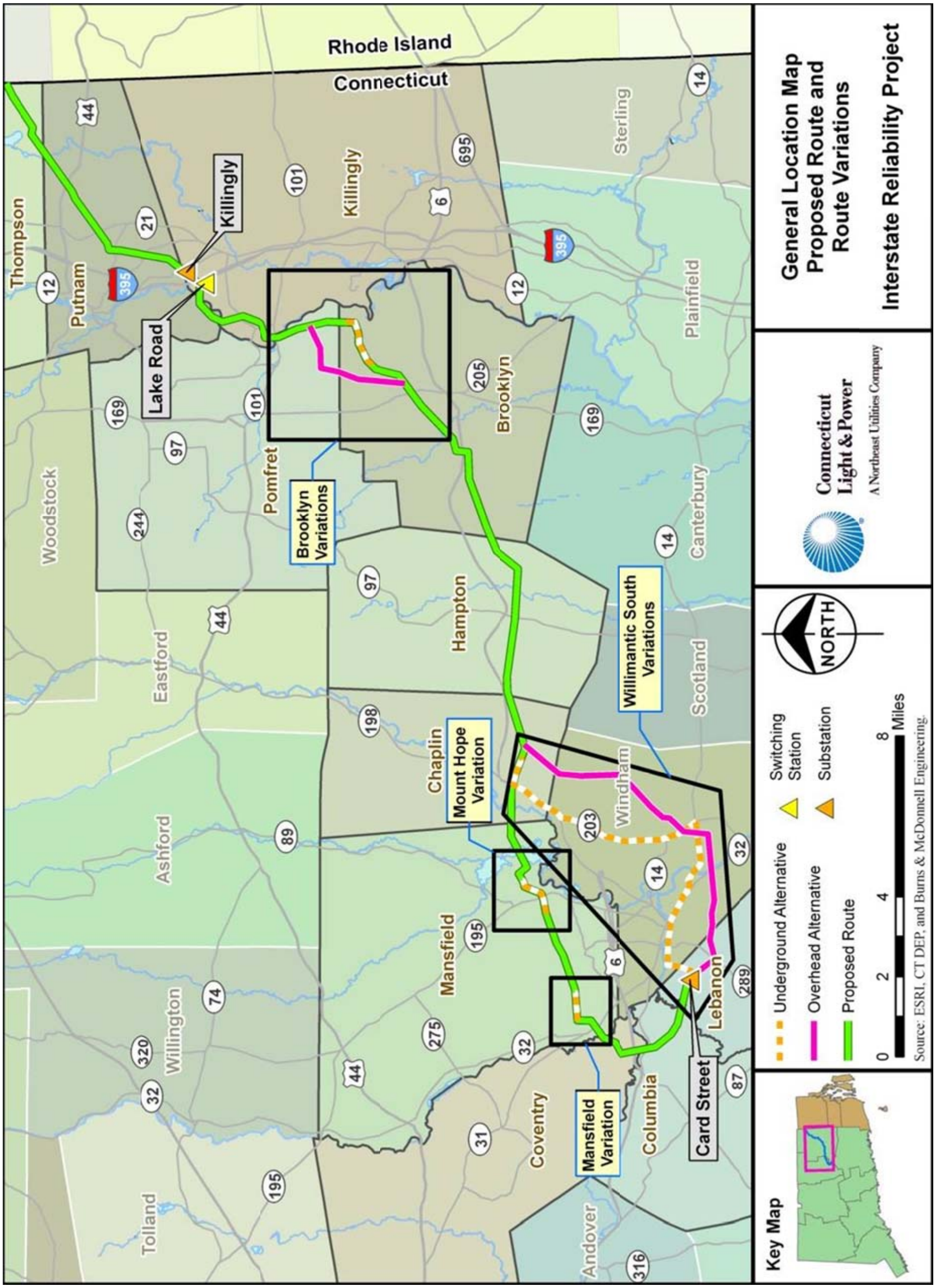


Table 15-1 summarizes the purpose of the six route variations, as well as the location and configuration of the variations in relation to the portions of the proposed overhead transmission line configuration or Proposed Route that each would replace. As this table shows, the six variations were identified as possible alignment or transmission line configuration alternatives for two principal reasons:

- To avoid routing the new 345-kV transmission line overhead on either the existing ROW or on an expanded ROW through the 1.4 miles of federally-owned properties in the Mansfield Hollow area (towns of Mansfield and Chaplin); or
- To avoid routing the new 345-kV transmission overhead along the Proposed Route in the event that Statutory Facilities, as defined pursuant to the Connecticut General Statutes Section 16-50p(i), may be determined by the Council to be located adjacent to the Proposed Route in certain locations.

Alternatives to Avoid the Mansfield Hollow Area. Both the Willimantic South Overhead Variation and the Willimantic South Underground Variation represent potential alternatives to the alignment of the proposed overhead transmission line along CL&P's existing 150-foot-wide ROW across the federally-owned properties in the towns of Mansfield and Chaplin (i.e., across Mansfield Hollow Lake, Mansfield Hollow State Park, and the Mansfield Hollow WMA). As part of the proposed Project, CL&P proposes to expand the existing 150-foot-wide ROW through these federally-owned properties, requiring the acquisition of approximately 11 additional acres of easement from the federal government.

As described in Volume 1 and illustrated on the Volume 9 maps, CL&P proposes to expand the ROW by 55 feet through the federally-owned properties in the Town of Mansfield and by 85 feet across the federally-owned properties in the Town of Chaplin. The differences in the proposed easement expansion widths relate to the proposed use of steel monopoles (to match the existing steel monopoles used for the 330 Line) along the ROW in Mansfield and the use of H-frames (to match the existing H-frames) along the ROW in Chaplin.

Table 15-1: Summary of Variations

Route Variation	Purpose of the Variation	Principal Route Variation Characteristics		
		Length (Miles)	**Town(s)**	**Transmission Line Configuration and ROW Location**
Mansfield Underground Variation	Alternative for consideration in the event that Statutory Facilities, as defined pursuant to the Connecticut General Statutes § 16-50p(i), may be determined by the Council to be located adjacent to the proposed overhead 345-kV transmission line. Would replace 0.7 miles of the proposed overhead transmission line route.	0.7 mile	Mansfield	Underground 345-kV cable system, within existing 300-foot-wide CL&P ROW; two line transition stations within and adjacent to ROW. Cable system would generally be offset approximately 15 feet from the outside conductor of CL&P's existing 345-kV line (i.e., the 330 Line)
Mount Hope Underground Variation	Same as the Mansfield Underground Variation. Potential Statutory Facilities include Mount Hope Montessori School, Green Dragon Day Care, and Come Play with Me Day Care. Would replace 1.1 miles of the proposed overhead transmission line route.	1.1 miles	Mansfield	Underground 345-kV cable system, within existing CL&P ROW; two line transition stations within and adjacent to ROW. Cable system would generally be offset approximately 15 feet from the outside conductor of CL&P's existing 345-kV line (i.e., the 330 Line)
Brooklyn Underground Variation	Same as the Mansfield Underground Variation. Would replace 1.3 miles of the proposed overhead transmission line route and avoid a residential child day care near Church Street.	1.4 miles	Brooklyn	Underground 345-kV cable system, within existing CL&P ROW; two line transition stations within and adjacent to ROW. Cable system would generally be offset approximately 15 feet from the outside conductor of CL&P's existing 345-kV line (i.e., the 330 Line)
Brooklyn Overhead Variation	Same as the Mansfield Underground Variation. Would replace 3.3 miles of the proposed overhead transmission line route and would avoid a residential child day care near Church Street.	3.3 miles	Brooklyn Pomfret	Overhead line on new "greenfield" 150-foot-wide ROW, easements for which would have to be acquired from private landowners
Willimantic South Underground Variation	Alternative for consideration to avoid following CL&P's existing ROW across Mansfield Hollow State Park, Mansfield Hollow Lake, and portions of the Mansfield Hollow WMA located in the towns of Mansfield and Chaplin. Would replace 11.5 miles of the proposed overhead transmission line route.	10.7 miles	Lebanon Windham Chaplin	Underground 345-kV cable system, within or adjacent to public roads except for a 0.6–mile underground segment along CL&P's existing transmission line ROW in Chaplin; one new line transition station on eastern end of cable system (western terminus would be on Card Street Substation property)
Willimantic South Overhead Variation	Same as Willimantic South Underground Variation. Would replace approximately 12 miles of the proposed overhead transmission line route along CL&P's existing ROWs with new overhead line ROW.	9.4 miles	Lebanon Windham Chaplin	Overhead line on a new "greenfield" 150-foot-wide ROW, easements for which would have to be acquired from private landowners.

CL&P also identified two other configuration options for building the new 345-kV line across the federally-owned properties. Either of these options, which are detailed in Volume 1, Section 10, could be used to develop the new 345-kV line across the 1.4 miles of federal property:

- **Minimal ROW Expansion Option**. Under this configuration option, to minimize the width of expanded ROW that would be required, CL&P would construct the new 345-kV line using taller vertical structures, which would not be the same as the 330 Line structure designs. Accordingly, the ROW width would increase by 25 feet through the federally-owned properties in the Town of Mansfield and by 35 feet across the federally-owned properties in the Town of Chaplin. A total of approximately 4.8 acres of additional easement would be required from the federal government.

- **No ROW Expansion Option**. This option would not require any additional easements from the federal government. Instead, CL&P would remove and relocate the existing 345-kV line (the 330 Line) across the 1.4 miles of federally-owned property to allow the construction and operation of both the new 345-kV line and the 330 Line within the existing 150-foot-wide ROW. All of the vegetation from the existing 150-foot-wide ROW would have to be removed to rebuild the existing 330 Line and construct the new 345-kV line. In the event that the 150-foot-wide ROW segments cannot be expanded to build the new 345-kV line, CL&P's proposal then is to build this No ROW Expansion Option.

Alternatives for Consideration Should the Council Determine Statutory Facilities to be Adjacent to the Proposed Route. The four remaining variations (i.e., the Mansfield Underground Variation, Mount Hope Underground Variation, Brooklyn Overhead Variation, and Brooklyn Underground Variation) were identified as alternatives for consideration should the Council determine that Statutory Facilities are located adjacent to the proposed overhead 345-kV transmission line in these locations. Connecticut General Statutes Section16-50p(i) designates a group of land uses (collectively called here, for convenience, "Statutory Facilities") that the Council must consider in its review of new electric transmission lines. These land uses are:

- Private or public schools
- Licensed residential child day-care facilities
- Licensed youth camps

- Public playgrounds
- Residential areas

The Council has previously construed "residential areas" to be developed "neighborhoods," not residentially zoned land or sparsely settled rural or semi-rural areas.[2] The law establishes a rebuttable presumption that new electric transmission lines, with a voltage of 345 kV or greater, be constructed underground if they are "adjacent to" Statutory Facilities. This presumption may be overcome by a demonstration that it is infeasible to bury the lines for technical or cost-to-consumer reasons. The Council may, in such a case, approve overhead construction of a 345-kV transmission line adjacent to Statutory Facilities, provided that it would be contained within a buffer zone adequate to protect public health and safety.[3] A ROW that provides line spacings from the ROW edge and ground consistent with generally applicable safety standards may qualify as such a buffer zone.[4] The Council requires that overhead transmission lines be constructed in accordance with its *Electric and Magnetic Field Best Management Practices for the Construction of Electric Transmission Lines in Connecticut* (2007).

There are no youth camps or public playgrounds adjacent to the proposed overhead 345-kV transmission line route. However, based on state registration information gathered at the time of the preparation of this Application, several residential child day-care facilities and a school are located near the proposed 345-kV transmission line ROW in the towns of Brooklyn and Mansfield.[5] Furthermore, although the areas surrounding the Proposed Route are predominantly rural and sparsely settled, several groups of homes are situated near selected portions of CL&P's ROWs. The Council would need to determine whether any of these groups of homes are sufficiently densely developed, integrated and adjacent to the proposed 345-kV line to qualify as a statutory "residential area."

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[2] CSC Docket 272 (Middletown to Norwalk 345-kV Transmission Line), Opinion, April 7, 2007.

[3] Connecticut General Statutes Section 16-50p(i)

[4] Connecticut General Statutes Section 16-50p(i); Docket 272 Opinion at 14; Council's Best Management Practices for Electric and Magnetic Fields, December 14, 2007.

[5] This includes two licensed residential child day-care facilities in Brooklyn; the Mount Hope Montessori School in Mansfield, (which is both a licensed child day-care facility and a school); and two licensed residential child day-care facilities in Mansfield.

Alternatives Initially Considered but Later Eliminated. CL&P's August 2008 Municipal Consultation Filing (MCF) identified two potential route variations (referred to as the Putnam North Overhead and Underground Variations) to the alignment of the proposed 345-kV transmission line along an approximately 0.6-mile segment of the ROW that is within approximately 400 feet of a group of homes along Elvira Heights Court in the Town of Putnam. The nearest of these homes is approximately 115 feet from the eastern ROW edge. Along this ROW segment, the proposed new line would be further separated from these homes by the existing 345-kV line (and by a natural gas transmission pipeline), and thus would not be "adjacent to" them.

As identified in the August 2008 MCF, the Putnam North Overhead Variation would have required the creation of a new "greenfield" ROW for the new 345-kV line and was estimated in 2008 to add $6.3 million to the Project cost. The Putnam North Underground Variation, which would have required two new line transition stations, would have been constructed primarily in public roads, and was estimated in 2008 to add $136.6 million to the Project cost. *See,* 2008 MCF, Vol. 1, pp. VI-26 – VI-28. As explained in Section 15.1.3, subsequent to the issuance of the 2008 MCF, CL&P determined that the Putnam North variations did not merit further consideration, so they are not presented in this Application.

15.1.2 Route Variation Analysis Process

Each of the route variations was examined in terms of engineering and constructability issues, environmental features, social factors, and cost. Baseline information regarding the existing environmental conditions along the route variations was collected using the same approach (e.g., research, GIS analyses, and mapping) as described for the Proposed Route in Volume 1, Section 5. In addition, CL&P performed field reconnaissance of the variations to the extent possible, based on availability of access to the alternative routes.

For each of the variations, CL&P compiled data such as total length; distance through residential, commercial/industrial, and undeveloped land uses; width of existing easements (i.e., roads, overhead transmission line ROWs); the number of wetlands and watercourses crossed; the number of potential Statutory Facilities within 300 feet of the ROW edge; and the number of locations where bedrock could be present at or near the surface. The underground cable system variations were evaluated based on the presence of terrain that could make construction difficult and limit the feasibility of underground cable technology, as well as to examine the need to acquire easement rights for an underground cable system. In addition, for each underground variation, potential sites for the construction and operation of line transition stations were identified and assessed in terms of environmental and constructability factors.[6]

The locations of the six variations are illustrated on the Volume 9 maps, which identify the same types of environmental features along each of the route variations as provided for the proposed Project. Cross-sections for each of the variations are presented in Appendix 15B and also are included on the route variation maps included in Volume 9. Appendix 15B also provides a schematic of typical splice vault layouts along a cable system.

As illustrated on Figure 15-1 and described in this section, because all of the route variations are located either in proximity to the portions of the proposed Project route that they would replace or within the general Project region, certain of the environmental features (e.g., noise characteristics, air quality) along the variations are the same as those described for the proposed Project route in Volume 1. The descriptions presented in this section center on the environmental features along the route variations that differ from those along the proposed Project route or – in the case of the underground variations, within CL&P ROWs – the environmental features along the ROWs that would be affected by the cable system. Sections 15.2 through 15.5 describe the characteristics and potential environmental effects of the development of a 345-kV line segment along each of the six variations. To facilitate a review of the route

[6] As described in Section 14.3, each underground cable system would require land not only for the installation and operation of the cable system (ducts and splice vaults), but also property for the construction and operation of 345-kV line transition stations on either end of the underground cable-segment. An exception is the Willimantic South Underground Variation, which would involve modifications to Card Street Substation on the western end of the variation and the development of one new 345-kV line transition station where the underground line segment would interconnect to the overhead portion at a location along the Proposed Route.

variations that would traverse areas outside of CL&P's existing ROWs (i.e., the Brooklyn Overhead Variation and the Willimantic South Variations), Appendix 15A provides an overview of the environmental effects typically associated both with underground cable systems and overhead transmission line development along road ROWs and new "greenfield" corridors.

In addition, the effects of the construction and operation of a 345-kV line along each variation are compared to the development of the transmission line as proposed (i.e., in an overhead line configuration) along each of the ROW segments that the variations would replace. Conservatively calculated "typical" (2020 annual average load [AAL] case) magnetic field levels associated with the variations and those that would be associated with the proposed overhead line segments that each variation would replace are included in these comparisons.

15.1.2.1 Analysis Issues Common to the Underground Variations

Any of the potential underground line variations would require the development of a 345-kV cable system consisting of cables to be buried within conduits in a trench and connected to sets of splice vaults. The four potential underground variations would involve the alignment of the cable system either within or adjacent to road ROWs or within CL&P's existing ROWs. For each underground variation, 345-kV line transition stations would also be required at the interconnection with the overhead 345-kV transmission line on either end of the underground segment. Construction and operation/maintenance information for underground cable systems is discussed in Section 14.3 and in the tutorial in Appendix 14A.

Based on CL&P's recent experience with underground 345-kV and 115-kV cable system installations, for route variations located along federal and state road ROWs, portions of the cable system (particularly splice vaults) would likely have to be sited on private property adjacent to the roads. Such off-road siting is typically required to avoid conflicts with other buried utilities, to cross beneath waterways, to conform to state highway regulations, etc. However, the detailed engineering studies required to define site-specific off-road splice-vault locations would not be performed until after the initial selection of a route by the Council.

Each of the four potential underground line variations, which would be aligned either along public roadways or within CL&P's ROWs, is readily accessible. As a result, for the Mansfield, Mount Hope, and Brooklyn underground variations and a portion of the Willimantic South Underground Variation, which would be aligned along CL&P's existing transmission line ROWs, the detailed environmental data compiled for the proposed Project (as discussed in Volume 1, Section 5, and illustrated on the Volume 9 maps) was excerpted, as applicable, to describe the environmental features along each potential variation.

For the portions of the Willimantic South Underground Variation that would follow public roads, CL&P conducted drive-by field reconnaissance to verify adjacent environmental conditions. Although environmental features were identified based on this reconnaissance and on the review of published data, no detailed field studies (e.g., wetland/watercourse delineations, vernal pool and amphibian breeding habitat studies, cultural resource field surveys, photo-simulations) were performed. This is because off-road ROW surveys would require permission from private landowners and, more importantly, because the development of the underground variation along road ROWs would likely require the acquisition of easements on private land adjacent to the road ROWs where splice vaults or portions of the cable routes might have to be located. However, the locations of, and site-specific land requirements for splice vaults or other areas where the cable route would have to diverge from the road ROWs would not be determined until detailed engineering design studies are performed. Should the Council approve the Willimantic South Underground Variation (or any other cable system variation along road ROWs), such detailed engineering design, followed by site-specific environmental and cultural resource field surveys, would be required.

15.1.2.2 Analysis Issues Common to the Overhead Route Variations

The two overhead line-route variations (Willimantic South and Brooklyn) would entail the development of the new 345-kV transmission line on new ("greenfield") ROW segments, generally across privately-owned properties. The use of one or both of these overhead line-route variations would involve the construction and operation of the 345-kV transmission lines as detailed for the proposed Project in Volume 1, except that CL&P would have to acquire easements from private landowners along the entire length of the new ROWs and, along these new corridors, a comparatively wider area would have to be cleared of forest vegetation and subsequently managed in low-growth vegetation.

Due to lack of access rights on the privately-owned lands, neither field reconnaissance nor more detailed field investigations (e.g., federal and state jurisdictional wetland delineations, vernal pool and amphibian breeding habitat analyses, cultural resource surveys, photo-simulations) were performed for these overhead line-route variations. However, based on the review of published environmental data, aerial photo-interpretation, and mapping analyses, CL&P determined that neither of these overhead line-route variations would be preferred over the proposed Project. As a result, consultations with private property owners to obtain access to conduct detailed ROW-specific surveys of these variations were not warranted.

If the Council selects one or both of these overhead line-route variations for inclusion in the Project, despite CL&P's initial determinations that these route variations are inferior to the segments of the proposed Project that each would replace, site-specific field environmental and engineering investigations would be required. Such studies would be necessary to refine the siting of the new 345-kV transmission line ROW and to conduct field investigations to identify and assess site-specific environmental conditions and cultural resources within the new ROW segments.

15.1.3 Conclusions Regarding Variations

In general, while each of the six variations would result in some benefits (e.g., placing the new 345-kV line farther from residences or residential day-care facilities, avoiding ROW expansion through the

Mansfield Hollow federal property), compared to the proposed overhead line configuration and route, each would be more expensive, raise potential electric system reliability issues (in the case of the addition of underground cable system segments), result in increased environmental effects, and/or require the acquisition of additional property or easement rights from private landowners. Moreover, underground variations may not result in magnetic field levels along the ROW that are significantly different than what could be accomplished using BMP line-design proposals and would, in some cases, create new sources of magnetic field exposure in other locations.

Either of the two overhead line-route variations would require substantial additional acquisition of private lands for new easements, and would involve the development of a 345-kV overhead line segment on a new "greenfield" ROW. The development of these overhead line-route variations would affect private property not presently devoted to utility use, and therefore would not be consistent with federal and state environmental policies favoring the collocation of utilities on linear corridors.[7] In addition, the development of the overhead line-route variations also would result in significantly greater effects to environmental resources (e.g., removal of forest vegetation, effects on wetlands and watercourses).

In comparing the route variations to the proposed overhead transmission line alignment along CL&P's existing ROWs, particularly in relation to the "underground presumption" of Connecticut General Statutes Section 16-50p(i), comparative estimates of magnetic field levels should be taken into account. In doing so, several different effects must be considered, as summarized below (refer to Volume 1, Section 7 for additional explanation).

[7] For instance, the Council is required to find that the overhead portions of any approved transmission line will be consistent with the FERC's "Guidelines for the Protection of Natural Historic Scenic and Recreational Values in the Design and Location of Rights-of-Way and Transmission Facilities, " Conn. Gen. Statutes Section 16-50p(a)(3)(D)(iii). In order to minimize conflicts between electric transmission ROWs and other land uses, these guidelines specify that "existing rights-of-way should be given priority as locations for additions to existing transmission facilities." *Id.*,1

Building new transmission lines adjacent to, and with the same or closely similar, end points as existing lines of the same voltage (as is proposed for the Card Street Substation to Lake Road Switching Station portion of the Project) has the initial effect of causing two lines to share a current that would otherwise have been carried by the "old" line alone, all else equal. At the same time, the sum of the currents carried by the two lines can be greater than the current that the "old" line would have carried by itself because a system with an additional line can reliably support higher power transfers.[8]

Since magnetic fields are proportional to currents, at equal power-transfer levels, the magnetic fields associated with both the "old" line and the "new" line in this case would be lower than those that would be associated with the "old" line by itself. Moreover, the fields that would be associated with the "old" and "new" lines together would not be cumulative of the fields that each would produce by itself. This is because where a new line is built next to an existing line on the same ROW, there is another important influence on magnetic fields – the cancellation effect. As recognized by the Council's EMF BMPs, the three conductor sets of the new line can be optimally phased so that the magnetic fields from the new line and those from the "old" line would partially cancel one another when, as in this case, their currents would usually be in the same direction. This effect produces lower magnetic fields at and beyond the edge of the ROW that is nearest to the existing line, and it mitigates the increase on the other ROW edge caused by constructing the new line closer to that ROW edge.

The variations encompass overhead line-route variations (i.e., building an overhead segment of the new 345-kV line along a new ROW, separate from CL&P's existing ROWs), in-transmission-ROW underground line variations (i.e., building underground cable segments within CL&P's existing transmission line ROW), and in-road-ROW underground line variations (i.e., building underground cable

8 The proposed 345-kV line from Lake Road Switching Station to West Farnum Substation does not have the same end points as the existing 345-kV line that it would be adjacent to in Connecticut. As a result, these two lines would not share power transfers equally.

segments within or adjacent to road ROWs). Each type of variation has a different effect on magnetic field levels, as described briefly below:

- An overhead line-route variation creates a second linear source of magnetic fields in a different location and shares current with the existing line to essentially the same extent that a new line built in the same ROW would. This scenario typically reduces magnetic field levels along the existing corridor between the Card Street Substation and the Lake Road Switching Station due to the reduction of current in the existing line. In the case of the Project, the existing Card Street to Lake Road line is generally aligned south of the ROW centerline, and the proposed location of the new line is to the north of the ROW centerline. Relocating the proposed line to new ROW would further reduce fields along the northern edge for the most of the Project ROW, relative to the proposed configuration, as the distance between the existing line and that ROW edge remains larger than it would be for the proposed configuration. However, if the proposed line is not constructed adjacent to the existing circuit, field cancellation between the two lines is no longer possible, and field levels may be higher along the ROW edge nearest the existing line.

- An underground line variation, constructed in or adjacent to roads, also creates a second linear source of magnetic fields. Directly over and near the cables, magnetic fields would tend to be elevated, but they would fall off quickly to background levels over rather short distances. Like an off-ROW overhead line segment, an in-street underground line would share current with the existing line on the ROW, but would not provide any cancellation for the magnetic fields associated with that line.

- An underground line segment constructed within the existing overhead transmission line ROW would also share current with the existing line, but would provide no cancellation for the existing line at ROW edges and beyond. Unlike an in-street underground line variation, an underground line installed in an existing transmission line ROW would not create a separate linear source of magnetic field exposure in a different location.

Accordingly, it cannot be assumed that constructing a new line underground, or overhead in a different location, rather than overhead on an existing ROW, would cause a reduction in magnetic fields to which people are exposed. Whether the magnetic field exposures associated with building a new overhead line within a ROW would be greater, lesser, or equivalent to those associated with installing the new line underground or overhead in a different location requires careful analysis and modeling, with inputs that are specific to the particular configurations and systems under consideration.

For instance, since the August 2008 MCF was prepared, CL&P's EMF consultant (Exponent) has estimated the magnetic fields (MF) that would be associated with the lines on the existing Lake Road to

Connecticut / Rhode Island border ROW both with and without the Putnam North Overhead and Putnam North Underground Variations. In its 2008 MCF, CL&P identified these variations as options to aligning the proposed 345-kV line in an overhead configuration along a 0.6-mile segment of ROW near Elvira Heights Court in the Town of Putnam.

The MF calculations have shown that post-construction of the Project, the MF at the east edge of the ROW nearest the Elvira Heights homes would increase, but as the result of higher current flow in the existing 345-kV line, and not because of the lower currents that would flow on the more distant new line. Therefore, relocating the proposed new 345-kV line off of the ROW, either overhead or underground, would not reduce MF, either at the eastern ROW edge proximate to the Elvira Heights homes or at the homes. In fact, because relocating the new line would not reduce the currents that would flow on the existing line, but would negate the cancellation effect of co-locating two lines adjacent to one another, adopting either of the variations would slightly increase MF at the ROW edge near the homes, compared to the MF that would be associated with the Project as proposed.

Accordingly, CL&P is no longer considering the Putnam North Variations. CL&P has, however, identified the approximately 0.6-mile segment of ROW that passes by Elvira Heights Court as a BMP Focus Area (Focus Area E) in its Field Design Management Plan. (Refer to Volume 1, Section 7, Appendix 7B).

15.2 MANSFIELD UNDERGROUND VARIATION

15.2.1 Purpose and Location of the Variation

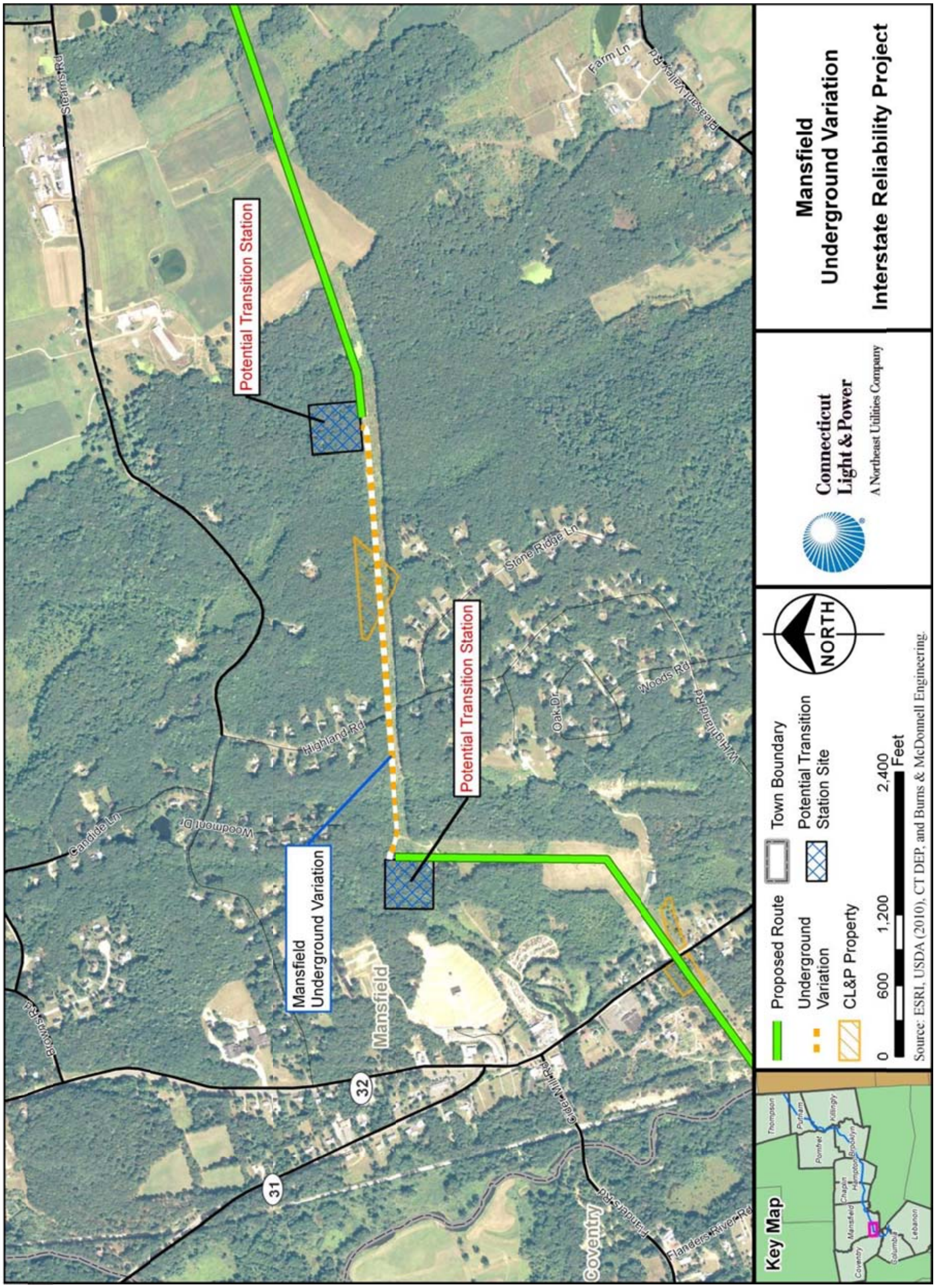
The 0.7-mile Mansfield Underground Variation would involve the alignment of the 345-kV line in an underground cable configuration within CL&P's existing overhead transmission line ROW in the western portion of the Town of Mansfield (refer to Figure 15-2 and to the Volume 9 maps of the variation). The variation was identified as an alternative to developing the new 345-kV line in an overhead line configuration, adjacent to CL&P's existing 345-kV 330 Line, in the vicinity of a group of homes along Highland Road, Woodmont Drive, and Stone Ridge Road.[9]

This 0.7-mile segment of ROW is part of one of the focus areas (Focus Area A) evaluated in CL&P's Field Management Design Plan and along which CL&P proposes to construct an overhead line on delta steel-pole structures rather than on H-frames (refer to Cross-Section [XS]-2 BMP in Volume 1, Appendix 3A and to Volume 1, Section 7, Appendix 7B). The analyses in this section compare the 0.7-mile underground variation to the proposed overhead line design (i.e., with delta steel poles) that would be replaced.

In addition to the alignment of the underground cable system within the CL&P ROW, the variation would involve the construction and operation of two new line transition stations, one at each end of the underground cable route. The western line transition station would be located partially within and adjacent to CL&P's existing ROW, on a parcel of privately-owned land situated southwest of Woodmont Drive. The eastern line transition station, which also would encompass a privately-owned site within and adjacent to CL&P's existing ROW, would be located east of Highland Road and Stone Ridge Road, near Conantville Brook.

[9] Given the limited availability of land in this relatively developed area, no viable overhead line-route variations (outside of the CL&P ROW) were identified.

Figure 15-2: Location of Mansfield Underground Variation



15.2.2 Technical Description (Design, Appearance, Land Requirements, Cost)

The proposed overhead line design and location within the ROW are depicted on XS-2 BMP, as illustrated in Volume 1, Section 3 [Appendix 3A], Volume 9, and Volume 10. The underground route variation, which would replace 0.7 mile of the proposed overhead 345-kV transmission line, would place a cable-system within CL&P's existing ROW, north of and adjacent to the 330 Line.

The underground cable system would consist of nine XLPE cables in a common duct bank (refer to Appendix 15B). Given the short length of this underground segment (0.7 mile), splice vaults would be spaced at closer intervals than the typical 1,600 feet. In particular, at approximately 1,200- to 1,300-foot intervals along the cable route, three separate splice vaults (one for each set of three XLPE cables) would be required. As shown in Appendix 15B, the center of the underground cable duct bank would be offset 15 feet from the outside conductor of the existing 330 Line.

Although the cables of the Mansfield Underground Variation would be located within CL&P's existing ROW, additional properties would have to be acquired for the development of line transition stations at each end of the underground cable system. In addition, CL&P would have to acquire easement rights to install the underground cable system within the overhead line ROW, and would have to purchase between 4 and 8 acres of land for the two line transition station sites.

The capital cost of the Mansfield Underground Variation is estimated at $58.2 million. In comparison, the capital cost for the proposed overhead 345-kV transmission line along this 0.7-mile segment is estimated at $4.7 million.

15.2.3 Construction and Operation/Maintenance Considerations

The construction of the 0.7-mile cable system (duct banks, splice vaults, cable installation) and associated line transition stations would be performed using the methods generally described in Section 14.3.2.

Cable-system installation requires continuous trenching and, as a result, lands along the entire 0.7-mile length of the route would be disturbed.

Assuming the use of a 40-foot-wide construction workspace, approximately 3.6 acres of land, including 0.2 acres for splice vaults outside of the construction workspace, would have to be cleared of all vegetation, and then graded and filled to create a level construction work area to accommodate a construction access road along the length of the cable route. The entire 3.6 acres of disturbed land would be within CL&P's existing 300-foot-wide transmission line ROW. Up to an additional 8 acres of land would have to be acquired (in fee ownership) and subsequently cleared and leveled for the development of the line transition stations at each end of the cable route.

The construction of the cable system would disturb a total of approximately 11.6 acres of land for the installation of the cable duct bank, splice vaults, access road, and line transition stations. An area of approximately 0.25 acres (80 feet[10] x 130 feet) would be required for each of the splice vault sets (each "set" would include three splice vaults). Along the Mansfield Underground Variation, two sets of splice vaults would be required, spaced at intervals of 1,200 to 1,300 feet along the cable route. A 20-foot-wide access road also would have to be developed (or existing access roads would have to be improved) along the length of the 0.7-mile cable route, for use during both construction and operation. To reach this on-ROW access road, equipment and vehicles would most likely have to use Highland Road.

Compared to overhead transmission line installation, underground cable-system construction generally proceeds slowly, and can vary significantly depending on the amount of grading required along the ROW and the type of subsurface conditions encountered during excavations for the duct bank and splice vaults. On average, after clearing and grading are completed along the ROW, trenching could be expected to

[10] Assuming that 40 feet of an 80-foot-wide splice-vault area would be located within the 40-foot-wide duct-bank construction workspace, the remaining 40 feet would extend outside of this work area. Within CL&P's wider easement, the permanent cable system ROW would consist of the 40-foot-wide area, which would include the access road along the duct bank, as well as the additional adjacent areas required for the splice vaults.

progress at approximately 50 to 100 feet per day. Construction of each of the line transition stations can be expected to require approximately 12 to 18 months. As a result, up to 18 months could be required to complete the construction of the cable system, including the line transition stations, along the Mansfield Underground Variation.

The operation of the underground cable system would require a permanent access road to be maintained along the entire length of the route. This road would provide access to both the cable system (i.e., duct banks and splice vaults), as well as to the line transition stations. During the operation of the cable system, access to the on-ROW road (and then to the transition stations) would be via Highland Road.

Each of the line transition stations would consist of an above-ground 345-kV line-terminal structure, a control building, and related equipment to interconnect the underground cable system to the overhead portion of the 345-kV transmission line. The developed portion of the station would be graded, surfaced with crushed stone, and fenced.

15.2.4 Existing Environmental Features

15.2.4.1 Topography, Geology, and Soils

The Mansfield Underground Variation would be aligned along CL&P's ROW on the eastern side of the Willimantic River Valley, in an area where elevations range from approximately 310 feet to 420 feet NGVD. Soil types and approximate depth to bedrock along this route variation are identified in Table 15-2.

Table 15-2: Soils and Soil Characteristics along the Mansfield Underground Variation

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
17 Timakwa and Natchaug	Woody organic material over sandy and gravelly glaciofluvial deposits, and woody organic material over loamy alluvium and/or loamy glaciofluvial deposits and/or loamy till	Yes	--	--	0.0-1.0
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	0.15	--	1.5-2.5
58C Gloucester gravelly sandy loam, 8 to 15%, very stony	Sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
61C, 62C Canton and Charlton, 8 to 15% slopes, very stony; 3 to 15 % slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
85B, 85C, 85D Paxton and Montauk fine sandy loam, 3 to 8% slopes, very stony; 8 to 15% slopes, very stony; 15 to 35% slopes, extremely stony	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	0.20	--	1.5-2.5

Source: USDA Natural Resources Conservation Service, Online Soil Surveys and Geographic Data of Windham County, 2009.

Notes:

1. Erosion Factor (K (dimensionless)): Indicates the erodability of the whole soil, the higher the value, the more susceptible the soil to erosion.
-- No Data Available. No bedrock or water encountered to survey depth.

15.2.4.3 Water Resources

The Mansfield Underground Variation is located within the Thames River drainage basin and the Willimantic River and Natchaug River regional drainage basins. Because the variation would be aligned within CL&P's ROW, adjacent to and north of the existing overhead 330 Line, the same wetlands and watercourses would be traversed as field delineated for the proposed overhead transmission line route along this segment.

The underground variation would traverse two perennial watercourses: S20-7 (tributary to Cider Mill Brook) and S20-8 (tributary to Conantville Brook). Both watercourses, which extend perpendicularly across the ROW, have a water quality classification of A.

Based on the 2008 and 2011 wetland delineation surveys conducted along CL&P's ROWs, seven wetlands are located along the Mansfield Underground Variation. Table 15-3 summarizes the characteristics of these wetlands, including those that provide vernal pool / amphibian habitat (refer to Volume 2 for additional information regarding each wetland).

No wetlands are located on the potential line transition station sites. The wetlands along the 0.7-mile variation consist of scrub-shrub and forest communities. Overall, approximately 0.3 acre of palustrine-forested[11] and 0.6 acre of scrub-shrub wetlands are located within the portion of the CL&P ROW that would be affected by the Mansfield Underground Variation. All of these wetlands would be traversed by the comparable section of the proposed overhead 345-kV transmission line.

[11] **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.

Table 15-3: Delineated Wetlands / Vernal Pools and Wetlands Supporting Amphibian Habitat: Mansfield Underground Variation

Vol. 9 Mapsheet Numbers	Wetland Series Number[1]	Wetland Classification[2]	Relationship to Proposed Underground Route (Feet traversed)[3]	Vernal Pool / Amphibian Breeding Habitat		
				Vernal Pool / Habitat Number[4]	Location along ROWs	Species Observed
1 of 1	W20-38	PSS / PFO	20 feet			
1 of 1	W20-39	PFO / PSS	150 feet			
1 of 1	W20-39A	PSS / PFO	Adjacent			
1 of 1	W20-40	PFO	25 feet			
1 of 1	W20-41	PFO / PSS	85 feet	MA-1-VP	Beneath existing 345-kV line, east of Structure No. 9043 (no impact expected as a result of the underground variation)	Wood frog, spotted salamander
1 of 1	W20-42	PFO / PSS	140 feet			
1 of 1	W20-43	PFO / PSS	510 feet	MA-2-VP MA-3-VP MA-4-VP MA-5-VP MA-6-VP MA-7-VP	Near Structure No. 9045. MA-3-VP and MA-4-VP are separate vernal pools located north of the underground variation, near the northern edge of ROW and north of existing 330 Line Structure No. 9045 MA-7-VP is north of Structure No. 9046 (Underground variation would affect MA-2-VP, MA-5-VP, and MA-6-VP only)	Wood frog; spotted salamander, green frog Wood frog, spotted salamander, fairy shrimp

NOTES:

1. Series No. refers to wetland number designated in the field report (Volume 2) and illustrated on the aerial photographs in Volume 9. The CL&P ROW along which the underground variation would be located is illustrated in Volume 11, Mapsheets 17 through 19 of 134 Vernal pools along this ROW segment also are illustrated on the Volume 11 maps.
2. Wetlands classification according to Cowardin et al 1979; PEM = Palustrine Emergent Wetland; PFO = Palustrine Forested Wetland; PSS = Palustrine Scrub-Shrub Wetland; POW = Palustrine Open Water; PUB = Palustrine Unconsolidated Bottom.
3. "Feet traversed" refers to linear distance crossed by the center of the 345-kVcable route, as depicted on the Volume 9 maps.
4. Refers to vernal pool habitat number assigned during field surveys.

Shading = Denotes wetland that provides vernal pool / amphibian breeding habitat.

Groundwater in the vicinity of Mansfield Underground Variation is classified as "GA". The route variation does not traverse any SCELs or watercourses with associated FEMA-designated 100-year floodplains.

15.2.4.4 Biological Resources

Vegetative Communities

Of the estimated 11.6 acres that the Mansfield Underground Variation would disturb, approximately 9.1 acres are presently forested (upland and wetland), whereas 2.5 consist of scrub-shrub vegetation. Approximately 96% of the 0.7-mile cable route would traverse scrub-shrub communities within the managed portions of CL&P's existing ROW.

The cable system would extend across only approximately 200 feet of upland deciduous forest and 50 feet of forested wetlands. However, both of the line transition station sites, each encompassing up to 4 acres, would be located in upland deciduous forested areas.

The acreage, by vegetative community type, within the cable system footprint was calculated based on the following assumptions:

- As illustrated on the cross-section (XS-UG-2) in Appendix 15B, the duct bank generally would be centered 15 feet from the outside conductor of the existing overhead transmission line (i.e., the 330 Line). The construction workspace and permanent cable system ROW (all of which would be located within CL&P's existing 300-foot-wide ROW) would be 40 feet wide. All vegetation within this area would be affected by construction.

- An additional 40-foot by 130-foot area, adjacent to the 40-foot wide area would be required for the three vaults at each splice-vault location.

- Each of the two line transition stations would require an approximately 4-acre site.

Fish and Wildlife Resources

Based on consultations with the CT DEEP, the two perennial watercourses traversed by the underground variation are likely to contain warmwater fish species. Wildlife species in the vicinity of the variation are likely to be those most commonly associated with forested upland and wetland areas, as well as scrub-shrub habitats (refer to Volume 1, Section 5 for a discussion of such species).

As summarized in Table 15-3, two of the wetlands (W20-41 and W20-43) along the underground variation contain vernal pool habitat. Based on the vernal pool / amphibian breeding habitat field surveys conducted along CL&P's ROWs during the spring of 2008 and 2011, one isolated area in W20-41 and six isolated areas in W20-43 were identified to be functioning as vernal pool habitat.

Table 15-3 identifies the locations of these habitats in relation to the underground variation. As this table indicates, three vernal pools (MA-2-VP, MA-5-VP, and MA-6-VP) would be directly affected by the cable system.

Listed Species

Although there is no known habitat for any federally-listed species near the underground variation, the CT NDDB indicated that one State-Listed Special Concern butterfly, Horace's duskywing (*Erynnis horatius*), may be present. This butterfly inhabits barrens, scrub, and open woodlands and uses scrub oak (*Quercus ilicifolia*) and other oaks as host plants.

However, Lepidoptera (butterfly and moth) field surveys conducted along the Project ROWs in 2008 – 2010 did not result in the identification of any Horace's duskywing species, or host plants, along the ROW in the vicinity of the Mansfield Underground Variation. As a result, the species is not likely to occur along the ROW segment. (Refer to Volume 4 for additional information concerning the Lepidoptera surveys.)

15.2.4.5 Land Uses

Forest lands, interspersed with residential development, dominate land use patterns in the vicinity of the Mansfield Underground Variation. Forest land is also the dominant use along and adjacent to the CL&P

transmission line ROW and at the potential 345-kV line transition station sites. Within CL&P's existing transmission line easement, the potential underground cable system would traverse primarily areas managed in scrub-shrub vegetation along and in the vicinity of the existing 330 Line.

Single-family residential homes are located near CL&P's ROW along Highland Road, which the ROW crosses, and Stone Ridge Lane, which connects to Highland Road and extends south of the ROW. Homes also are located along Woodmont Drive, which ends in a cul-de-sac approximately 250 feet north of the CL&P ROW.

No day-care facilities, schools, or playgrounds are located along the Mansfield Underground Variation. However, six homes are located within 300 feet of the variation along Highland Road, Woodmont Drive, and Stone Ridge Road.

Approximately 0.1 mile of the underground variation would extend across a parcel of CL&P -owned land, located east of Highland Road. In addition, approximately 0.2 mile of the ROW traverses town-designated open space in the vicinity of Highland Road. This open space extends across the ROW. The remainder of the 0.7-mile underground variation crosses privately-owned property on which CL&P has easement rights for overhead, but not underground, lines.

The two 345-kV line transition stations, which would be required at each end of the underground cable route, would be located on privately-owned property presently devoted to forest uses. Portions of both line transition stations would be located outside of the existing CL&P ROW.

The western line transition station site is characterized by forested upland; nearby land uses include residential areas along Woodmont Drive, the existing CL&P ROW, mixed forest, and agricultural areas. The Highland Ridge Driving Range is located approximately 1,500 feet southwest of the transition station site. The eastern line transition station site also consists of upland forest land; Conantville Brook is located to the north and west of the site. Land uses surrounding this site include the existing CL&P ROW, forested wetlands, and mixed forest tracts.

As illustrated on the Volume 9 maps, lands in the vicinity of most of the Mansfield Underground Variation are zoned primarily for Rural Agricultural Residential (RAR-40) uses. However, the areas near the western portion of the variation are within a Planned Business 5 Zone (PB-5).

15.2.4.6 Transportation, Access, and Utility Crossings

Highland Road, a town roadway, is the only transportation route crossed along the underground variation. Highland Road provides primary access to Stone Ridge Lane, and also interconnects to Stearns Road (to the north) and provides access to State Route 32 (Stafford Road) to the southwest.

15.2.4.7 Cultural (Archaeological and Historic) Resources

Because the Mansfield Underground Variation would be aligned within CL&P's ROW, the *Cultural Resources Assessment* conducted for the Proposed Route applies to the 0.7-mile variation (refer to Volume 1, Sections 5 and 6, and Volume 3). A review of background data for the *Assessment* revealed that while there are no significant historic resources within 500 feet of the variation, two reported archaeological sites are located within 1 mile of the variation (but both are at least 2,000 feet from the ROW).

Using the assessment procedures designed to identify the sensitivity of proposed project areas for undiscovered archaeological sites, initial cultural resource analyses (research) determined that approximately 74% of the 0.7-mile Mansfield Underground Variation was considered sensitive for possible Native American archaeological sites. Subsequently, as part of field surveys along the Proposed Route for the proposed 345-kV overhead line, cultural resource field investigations (subsurface reconnaissance) were performed along the 0.7-mile ROW segment. These field studies focused on areas of cultural resource sensitivity that would be affected by the development of the proposed 345-kV line in an overhead configuration (e.g., crane pads, structure sites, access road, and forest vegetation removal).

Along the 0.7-mile ROW segment, the field investigations located one Native American site potentially eligible for the NRHP/SRHP, confirming the archaeological sensitivity of the area. Additional field investigations (subsurface testing) would be required along the construction footprint of the underground cable route and 345-kV line transition station sites in order to fully evaluate the resources along the underground variation.

15.2.5 Potential Environmental Effects and Mitigation Measures

The construction and operation of the underground cable system along the Mansfield Underground Variation would directly affect topography, soils, water resources (including wetlands and vernal pools), land uses, visual resources, cultural resources, and transportation. Most of these effects would occur during construction, but some would extend throughout the operation of the cable system. For example, the installation of the cable system through wetlands, including vernal pools, would involve fill, resulting in a net loss of wetland habitat.

All land within the underground cable system construction workspace would be directly affected as a result of the vegetation clearing, grading, and filling required to create a level workspace for the installation of the duct banks and splice vaults. Similarly, all vegetation on the line transition station sites (within the footprint of the line transition stations and access areas) would have to be cleared, and the sites would have to be leveled to accommodate the construction activities at each site.

Duct-bank and splice-vault excavations also would directly affect soil resources and possibly groundwater, and would require unavoidable construction activities directly in wetlands and watercourses. Construction activities also would create nuisance type effects on local residents in terms of noise and dust from cable system installation activities, as well as from the movement of construction equipment and vehicles along Highland Drive to access the cable construction workspaces along the ROW.

The operation of the cable system would require the maintenance of a permanent access road along the length of the cable route. In addition, the two 345-kV line transition stations would represent permanent changes to the local visual environment.

Appendix 15A describes the typical environmental effects caused by the construction and operation of an underground cable system, and identifies the mitigation measures that CL&P would typically use to minimize adverse effects to the extent possible. Appendix 15B presents a typical cross-section of the underground cable system within the ROW, as well as a typical layout for the underground cable system at splice vault locations.

Table 15-4 summarizes the specific environmental effects that would occur as a result of the development of the 345-kV cable system along the Mansfield Underground Variation.

Table 15-4: Summary of Primary Effects and Potential Mitigation for the Mansfield Underground Variation

Environmental Feature	Environmental / Social Effects: Construction	Environmental / Social Effects: Operation / Maintenance	Potential Mitigation
Topography, Geology, and Soils	Effects on topography and soils due to • Grading / filling along 0.7-mile construction ROW to create a level workspace and access road for use during construction. • Grading / filling at line transition station sites • Excavations for duct bank trench and splice vaults Potential for erosion and sedimentation into watercourses and wetlands	Permanent changes in topography along ROW as a result of grading and creation of permanent access road, and site development at line transition station sites.	Install temporary and permanent erosion and sediment controls. Segregate topsoil layer during construction. To the extent practical and safe, restore contours and replace topsoil along ROW as part of restoration.
Water Resources	Direct disturbance to two perennial streams and six wetlands as a result of clearing, grading, excavating for trench / splice vaults, and access road development. Approximately 0.4 acres of PFO wetlands would be directly affected. Installation of flowable thermal backfill in duct bank will constitute permanent fill in wetlands, as will the development of permanent access roads through wetlands. Potential sedimentation associated with dewatering if groundwater is encountered in excavations.	An estimated net loss of approximately 0.4 acres of wetlands due to duct bank fill and access roads	Use temporary erosion and sediment controls to minimize off-ROW water resource impacts. Dewater to upland areas. Revegetate or otherwise stabilize disturbed soil areas to limit the potential for sedimentation into water resources. Coordinate with USACE and CT DEEP regarding off-site compensation for permanent loss of wetlands.
Biological Resources	Clearing activities along ROW and at line transition station sites will affect a total of approximately 11.6 acres of vegetative communities. Removal of 9.1 acres of forest lands (including 8.8 acres of upland forest and 0.3 acre of forested wetland) Direct effects to three vernal pools.	Permanent conversion of forested upland and wetland areas along cable route to scrub-shrub vegetative communities; net loss of wetland habitat, including impacts to vernal pools, as detailed above due to access roads and cable trench. Net loss of vegetative habitat at line transition station sites, which will be converted to utility use.	Coordinate with CT DEEP regarding measures to mitigate effects on amphibian breeding areas. Allow ROW to revegetate with species compatible with underground cable use.

Environmental Feature	Environmental / Social Effects		Potential Mitigation
	Construction	Operation / Maintenance	
Land Use, including Statutory Facilities and Designated Recreational Areas	Modifications to land uses along the ROW, including conversion of approximately 1.1 acres of forested vegetation to scrub-shrub vegetation or access road use, and conversion of up to 8 acres of forest land to utility use for the line transition stations. No recreational resources, day cares, group homes, or schools would be affected	Permanent change in land use at line transition station sites, which would not be consistent with other nearby land uses.	
Visual Resources	Temporary visual changes due to construction activities along the ROW. Removal of forest vegetation from line transition station sites will change views of these areas.	Change to visual environment associated with the development of the transition stations on previously undeveloped forested sites. Line transition stations may be visible from some nearby residential areas. Permanent access road along 0.7-mile ROW may be visible from Highland Drive and nearby homes.	Vegetation screening
Transportation	Potential traffic along Highland Drive and other roads leading to the ROW; potential land closure and delays during trenching across Highland Drive	Permanent access required off Highland Drive for access to line transition stations and cable system ROW	Implement traffic management plan during construction; coordinate with Town of Mansfield
Cultural Resources	Any archaeological sites within the construction footprint would be adversely and permanently affected as a result of earth-disturbing activities such as grading, excavation, and access road development	Permanent adverse effects would occur to archaeological sites during construction	Conduct field investigations to identify archaeological sites and, if significant sites are found, to develop appropriate mitigation measures (e.g., data recovery), based on consultations with the SHPO, Native Americans, ACHP

15.2.6 Electric and Magnetic Fields

Electric and magnetic fields were calculated for the 0.7-mile Mansfield Underground Variation assuming that the underground cable system would be aligned within CL&P's 300-foot-wide ROW and would be offset 41 feet north of the centerline of the existing 330 Line. The relatively short length of the variation would not significantly change the new circuit's impedance and therefore the same circuit currents were used for these calculations as were used for the proposed overhead line configuration. Volume 1, Section 7 of the Application includes details on the system assumptions made in the power-flow modeling used to determine these circuit currents.

Magnetic fields across the ROW produced by both the existing and proposed lines along this section of the ROW at AAL were calculated, and are graphed as illustrated on Figure 15-3. The location of the underground cable system in relation to the existing 330 Line is shown in red on the sketch beneath the graph. The calculated levels of magnetic and electric fields at the ROW edges before and after the completion of the Project with the Mansfield Underground Variation at average annual loading (AAL) are summarized in Table 15-5.[12]

As is evident on Figure 15-3, magnetic fields are elevated directly above and near the underground cables. Magnetic fields at the edges of the ROW are 2 to 4 mG lower in 2020 than the pre-Project levels in 2015 under the conservatively projected AAL conditions in each year (refer to Table 15-5). Near cable-splice vaults, the magnetic field contribution by the underground cables would increase because of increased spacing between the cables.

[12] For all magnetic field calculations included for the underground variations presented in Section 15, currents were assumed to flow in the outermost six of the nine cables whenever a 345-kV underground cable system was modeled. Under normal operating conditions, six-cable operation would be expected, and this specific selection yields higher magnetic fields from the cable system.

Figure 15-3: Magnetic Field Profiles under Pre-Interstate (2015) and Post-NEEWS (2020) Conditions at AAL for the Mansfield Underground Variation

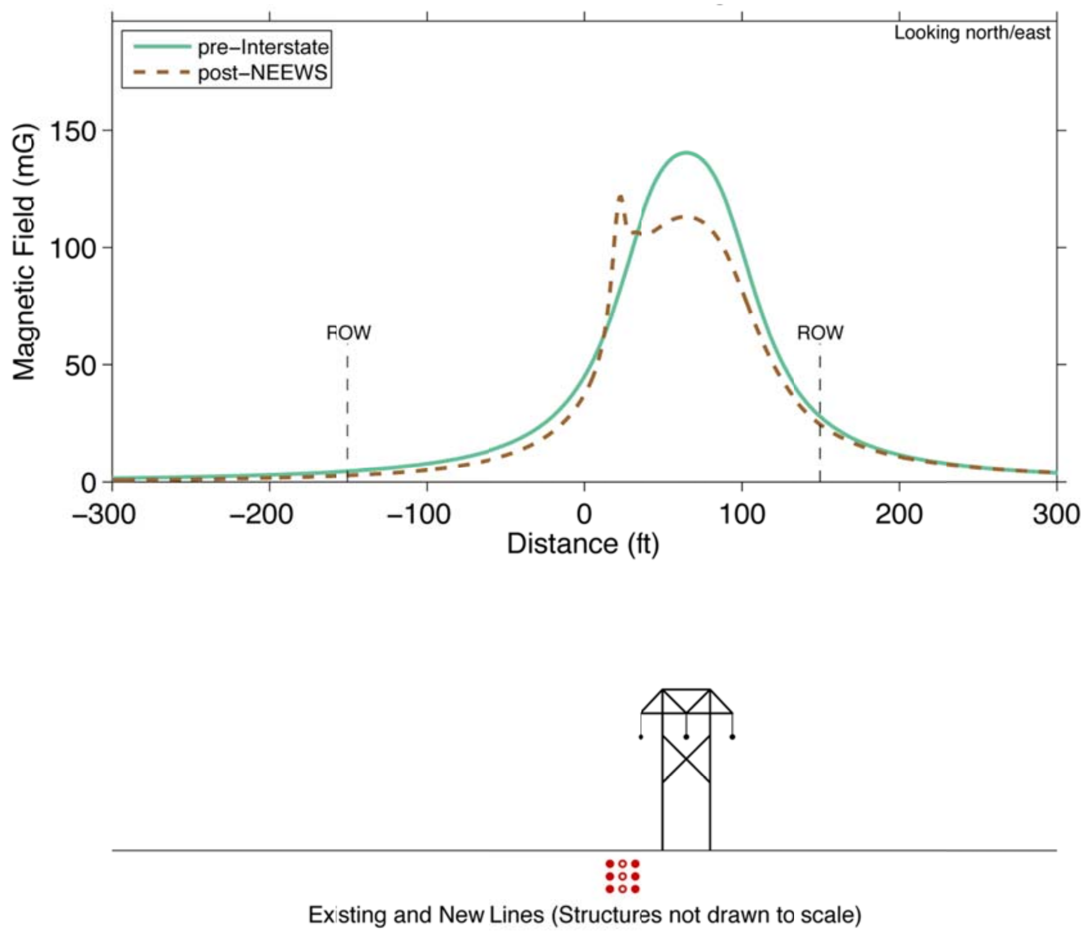


Table 15-5: Summary of Pre-Interstate (2015) and Post-NEEWS (2020) EMF Levels at the Edge of the ROW at AAL for the Mansfield Underground Variation

	Magnetic Field (mG)		Electric Field (kV/m)	
Cross-Section	**North ROW**	**South ROW**	**North ROW**	**South ROW**
XS-UG-2 – Pre	4.6	28.0	0.09	1.20
XS-UG-2 – Post	2.8	24.6	0.09	1.20

The operation of the new 345-kV transmission line with the incorporation of the Mansfield Underground Variation would not result in a large change in magnetic field levels along this segment of the line route, compared to the levels existing before the Project. If the new 345-kV line were built overhead as proposed, magnetic fields would be higher than pre-Project levels along the north edge of the ROW, but would be lower than the existing levels on the south ROW edge. The proposed overhead line configuration would employ a best phasing with the existing 330 Line, enhancing field cancellation and resulting in a magnetic field reduction at the south ROW edge nearest to the existing line. The magnetic fields at the north ROW edge could be reduced by the use of a different overhead line design, such as the proposed delta conductor configuration. (Refer to Volume 1, Section 7, Appendix 7B for details concerning magnetic field levels and alternative overhead line designs in "Focus Area A".)

Compared to the proposed overhead delta line configuration, the use of the Mansfield Underground Variation would actually result in higher magnetic field levels along the south ROW edge nearest to the existing 330 Line. This is due to the fact that the effect of mutual magnetic field cancelation between the two lines is lost if the new 345-kV line is constructed underground. Table 15-6 compares magnetic field levels at AAL at each ROW edge under both pre- and post-Project conditions for the base line design (overhead, horizontally-configured conductors supported by H-frame structures), the Mansfield Underground Variation, and the proposed Focus Area A delta configuration.

Table 15-6: Comparison of Magnetic Field Levels at AAL for Overhead Lines and the Mansfield Underground Variation

	Magnetic Fields for Annual Average Load Case (mG)			
	Pre-Interstate	**Post-NEEWS**		
ROW Edge	**Existing Configuration**	**Base Line Design***	**Underground Variation**	**Focus Area A Delta Configuration**
North	4.6	7.2	2.8	5.2
South	28.0	18.4	24.6	20.6

* Base line design consists of horizontally configured conductors supported by H-frame structures. The overhead delta line configuration proposed for this segment of the ROW (as depicted in XS-2 BMP) represents an EMF BMP as described in Volume 1, Section 7, Appendix 7B.

Underground transmission cable systems do not produce electric fields above ground. Therefore, the electric field profile across the ROW with the incorporation of the Mansfield Underground Variation would be the same as the existing electric field profile. Thus, in Table 15-5, there is no difference between the ROW edge levels before and after the construction of the Mansfield Underground Variation. Table 15-7 compares the electric fields at ROW edges with this variation to those with the base horizontal overhead line design and the proposed delta overhead line design. EMF tables are included in Appendix 15C.

Table 15-7: Comparison of Electric Field Levels for Overhead Lines and the Mansfield Underground Variation at AAL

	Electric Field (kV/m)			
	Pre-Interstate	Post-NEEWS		
ROW Edge	Existing Configuration	Base Line Design	Underground Variation	Focus Area A Delta Configuration
North	0.09	0.39	0.09	0.29
South	1.20	1.19	1.20	1.21

15.2.7 Comparison of the Mansfield Underground Variation to the Segment of the Proposed Route Replaced

As summarized in Table 15-8, compared to the use of the proposed overhead delta line configuration along the Proposed Route as shown in XS-2 BMP, the incorporation of the 0.7-mile Mansfield Underground Variation into the Project would cause greater long-term impacts to environmental resources, pose transmission line design and construction complexities, and substantially increase Project costs. Moreover, use of the underground variation would not result in significant advantages with respect to magnetic fields. Magnetic field levels would be reduced along both existing ROW edges relative to pre-Project levels. However, Post-Project fields would be lower along the north or west ROW edge, but would remain higher along the south or east ROW edge, when compared to the proposed delta line design.

Table 15-8: Comparison of the Mansfield Underground Variation to the Proposed Overhead Delta Transmission Line Configuration

Route Characteristic	Proposed Overhead Delta Transmission Line Configuration	Mansfield Underground Variation
Location, Design, and Appearance		
Route Location (ROW, Town)	Existing CL&P ROW (Mansfield)	Existing CL&P ROW, except for transition station sites (Mansfield)
Route Length (miles)	0.7 mile	0.7 mile
Overhead Structures (type, est. number)	7 Delta Steel Monopoles (refer to XS2-BMP)	N/A
Splice Vaults (est. number)	N/A	Two locations (6 vaults)
New ROW Easements or Land Acquisition Required (est. acres)	0	8 acres
Biological Resources		
Upland Forest Clearing (est. acres)	4.3 acres	8.8 acres
Forested Wetland Clearing (est. acres)	2.3 acres	0.3 acres
Scrub-Shrub Clearing (est. acres)	Less than 0.1 acre	2.6 acres
Watercourse Crossings (no.)	2 (span)	2 (direct effects, trenching)
Wetlands, Permanent Effects (Fill) (est. acres)	0 structures 0.1 acre (access roads)	0.4 acre (Fill for duct bank and access road)
Wetlands, Temporary Effects (est. acres)	Less than 0.1 acre (access road)	0 (Assumes all access roads are permanent)
Listed Species (no. species)	1	1
Land Uses		
Designated Town Open Space along ROW (length)	0.2 mile	0.3 mile
CL&P-Owned Land Traversed	0.1 mile	0.1 mile
Total Construction ROW / Work Space, Temporary Land Disturbance (est. acres)	8.1 acres	11.6 acres
Cost of Transmission Line Segment ($ Million, $ 2010)		
Capital Cost	$4.7	$58.2
Cost to Connecticut Consumers[1]	$2.2	$55.7
Life-cycle Cost	$7.9	$82.6

1. Assumes localization of all costs above the base line cost spent on underground cables and EMF BMP designs.

The cost of the underground cable-system segment is a significant consideration. While the comparable 0.7-mile segment of the proposed overhead delta transmission line would cost $4.7 million, the capital cost of the underground variation is estimated at $58.2 million and thus would add a net $53.5 million to the total cost of the Project. As described in Section 14.3.1.3, these increased costs would not likely qualify for inclusion in New England regional transmission rates. As a result, in addition to paying 27% of the cost of building the base-case overhead line, Connecticut consumers would likely be responsible for paying 100% of any costs that exceed the cost of building the base-case overhead line, including extra costs for constructing underground cables and EMF BMP line designs.[13]

The Mansfield Underground Variation would cost approximately 12 times more than the comparable segment of the proposed overhead delta transmission line configuration. Consequently, the cost to Connecticut consumers for the 0.7-mile underground segment (based on the cost allocation described above) would be approximately $55.7 million, or 25 times more than that of the overhead delta line. This is calculated as follows:

Connecticut consumer cost for section of overhead line to be replaced:

Estimated cost of proposed overhead delta transmission line:	$4.7 million
Estimated cost of overhead H-frame transmission line:	$3.4 million
Incremental cost of delta configuration:	$1.3 million
Connecticut consumer cost for overhead section to be replaced = (H-frame line cost x 27%) + (Incremental increase over H-frame x 100%)	$2.2 million

[13] Note: With respect to inclusion in New England regional rates, ISO-NE, by precedent, would also not allow the difference in the costs to construct the delta steel-pole line that CL&P proposes per XS-2 BMP along this segment of ROW, in comparison to the cost of the base case H-frame line construction.

Connecticut consumer cost for underground variation:

Estimated cost of the underground variation:	$58.2 million
Incremental cost of underground variation over an overhead H-frame transmission line:	$54.8 million
Connecticut consumer cost for underground variation = (Incremental cost for underground x 100%) + (H-frame line cost x 27%):	$55.7 million

Finally, dividing the Connecticut consumer cost for the underground variation by the Connecticut consumer cost for the overhead line section to be replaced yields: ($55.7 million / $2.2 million) = 25.

To develop the 345-kV cable segment along the Mansfield Underground Variation, CL&P would have to obtain easement rights for an underground line from private landowners. Although the variation would be located within CL&P's existing 300-foot-wide ROW, the existing easement rights pertain only to overhead utilities.

In addition, CL&P would have to purchase up to 8 acres of privately-owned land (in fee) for the line transition station sites. This land would be converted to utility use for the life of the new line, and would involve the removal of up to 8 acres of existing upland forest for the development of the line transition stations. In comparison, no additional ROW would be required to install the new 345-kV transmission line overhead along the portion of the Proposed Route that the variation would replace.

Because the development of the underground cable system would involve continuous trenching for the duct banks, excavations for the splice vaults, and the creation of a permanent access road along the length of the cable route for operation and maintenance purposes, all of the environmental resources within the cable system ROW, water resources including vernal pools, would be directly impacted. In comparison, the construction and operation of the overhead 345-kV line would only require direct disturbance to soils at structure installation sites or along temporary and permanent access roads. Although existing forest vegetation in the vicinity of the new overhead line would have to be cleared, soils along the majority of the route segment would not be affected and scrub-shrub vegetation would be expected to quickly colonize the formerly wooded areas.

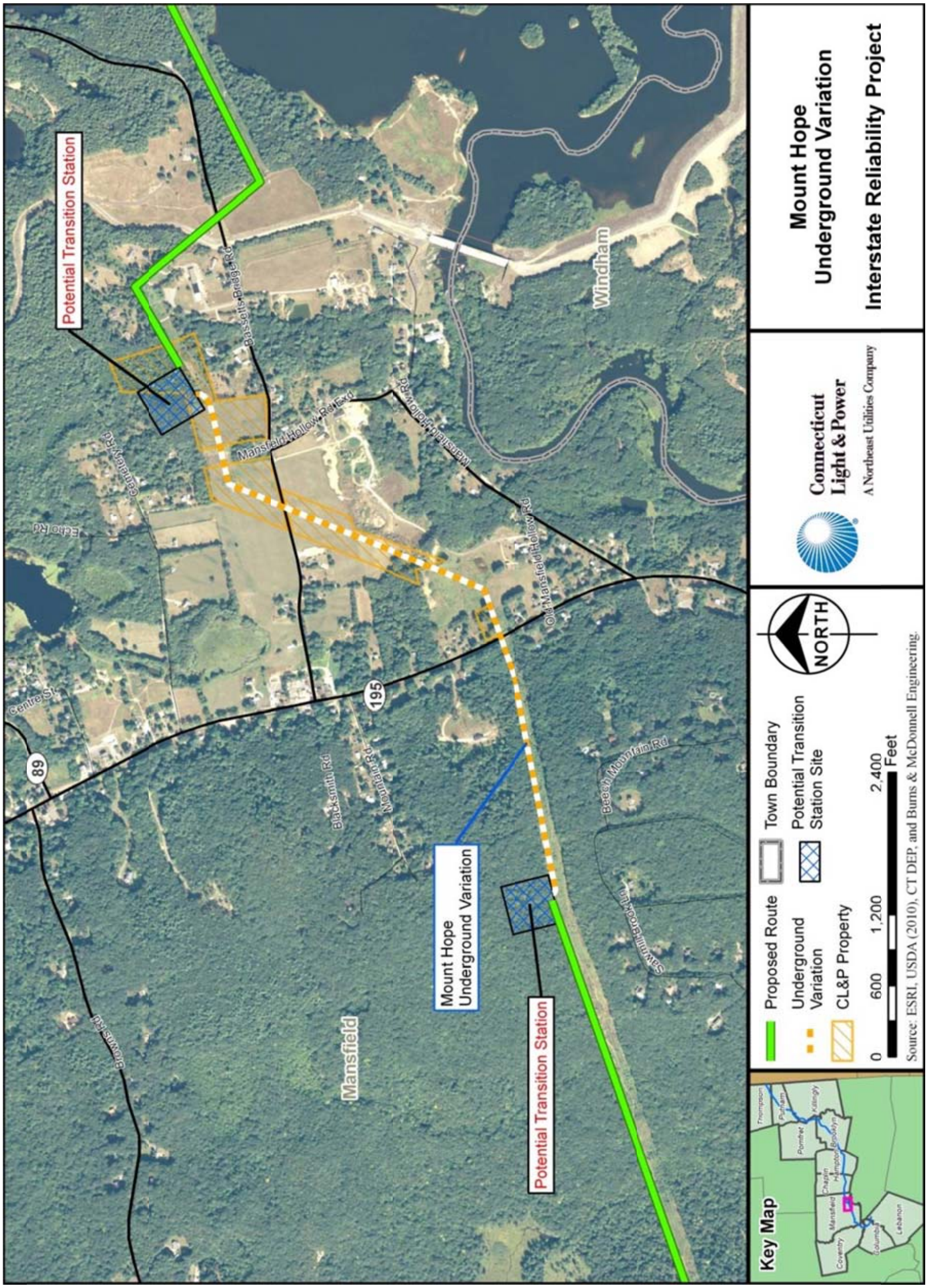
Overall, the proposed Project's overhead line design is preferred over the Mansfield Underground Variation. Compared to the proposed overhead delta line design, the use of the variation would be significantly more costly, would result in greater long-term environmental effects (particularly to water resources and vernal pools), and would require the permanent conversion of up to 8 acres of additional land to transition station use. Moreover, the Mansfield Underground Variation would not result in a significant overall reduction in magnetic fields along the ROW.

15.3 MOUNT HOPE UNDERGROUND VARIATION

15.3.1 Purpose and Location of the Variation

The 1.1-mile Mount Hope Underground Variation would be located within CL&P's existing ROW in the southeastern portion of the Town of Mansfield, west of Mansfield Hollow State Park (refer to Figure 15-4 and to the Volume 9 maps). The variation was identified as a potential alternative to the alignment of the proposed overhead 345-kV transmission line within CL&P's existing ROW near the Mount Hope Montessori School and the Green Dragon Day Care, both of which are located adjacent to Bassetts Bridge Road, as well as near the Come Play with Me Day Care, which is located adjacent to Storrs Road (State Route 195).

Figure 15-4: Mount Hope Underground Variation



The Mount Hope Montessori School property is located on the south side of Bassetts Bridge Road, west of CL&P's existing ROW. In this area, the 300-foot-wide transmission line ROW extends across CL&P - owned property. Because CL&P's existing overhead 345-kV transmission line (i.e., the 330 Line) is aligned along the eastern side of this ROW, the closest line conductors are presently located approximately 325 feet from the nearest actively used portion of the school property (a playground).

The proposed new overhead 345-kV H-frame transmission line configuration would be situated within the ROW to the west of the 330 Line, closer to the school. If the proposed overhead 345-kV line were developed in a horizontal H-frame configuration and centered 85 feet from (and west of) the center of the 330 Line, the nearest conductors would be approximately 85 feet closer to the playground (i.e., 240 feet away). The proposed overhead line design and location within the ROW are depicted on XS-2 (refer to Volume 1, Section 3 [Appendix 3A], Volume 9, and Volume 10).

The Come Play with Me Day Care is located adjacent to Storrs Road, approximately 80 feet south of CL&P's ROW, while the Green Dragon Day Care is located adjacent to Bassetts Bridge Road, between two parcels of CL&P-owned property. The Green Dragon Day Care is located approximately 245 feet east and 195 feet south of CL&P's ROW.

Except for the line transition station sites that would be required at each end of the cable system, the Mount Hope Underground Variation would be located within CL&P's existing overhead line ROW. Commencing from a new line transition station, which would be located approximately 1,600 feet west of Storrs Road, the variation would extend generally east along the CL&P ROW. After crossing Storrs Road, the variation would follow the CL&P ROW to the north, traversing Bassetts Bridge Road and then turning east before ending at a second new line transition station, which would be located 800 feet north of Bassetts Bridge Road on a site consisting partially of CL&P-owned property along the transmission line ROW and partially on privately-owned land that would have to be acquired.

15.3.2 Technical Description (Design, Appearance, Land Requirements, Cost)

The underground variation would be located within CL&P's 255- to 300-foot wide ROW, and would replace a 1.1-mile segment of the proposed overhead 345-kV transmission line. Within the 1.1-mile segment of CL&P ROW, the underground cable system would be aligned north or west of the existing 330 Line. The centerline of the cable duct bank would be offset 15 feet from the outside conductor of the existing 330 Line, between existing 330 Line structure Nos. 9068 and 9078 (refer to Figure 15-6 and the maps of the underground variation in Volume 9).

The underground cable system would consist of nine XLPE cables in a common duct bank (refer to cross-section [XS]-UG-2 in Appendix 15B). At each splice location, three separate splice vaults (one for each set of three XLPE cables) would be required.

Although the Mount Hope Underground Variation would be aligned within CL&P's existing overhead transmission line ROW, CL&P would have to obtain additional easement rights from private landowners for the installation of the underground cable system. In addition, CL&P would have to purchase up to 6 acres of land for the line transition stations that would be required on either end of the cable segment.[14]

The capital cost of the Mount Hope Underground Variation is estimated at $65 million. In comparison, the capital cost for the proposed overhead 345-kV transmission line along this 1.1-mile segment is estimated at $5.4 million.

15.3.3 Construction and Operation/Maintenance Considerations

Along the Mount Hope Underground Variation, the construction of the cable system (duct banks, splice vaults, cable installation) and associated line transition stations would be performed using the methods described in Section 14.3.2. Cable-system installation requires continuous trenching and, as a result,

[14] While CL&P would have to purchase the line transition station site on the western end of the cable system (4 acres), approximately half of the line transition station site on the eastern end would occupy CL&P fee-owned property. As a result, only approximately 2 acres of this site would have to be acquired for the 345-kV line transition station.

lands along the entire length of the variation would be disturbed. Land also would have to be cleared and leveled for the development of the line transition stations at each end of the cable route.

The construction of the Mount Hope Underground Variation would disturb up to 13.7 acres of land for the installation of the cable duct bank, splice vaults at three locations, access road, and line transition stations (the same assumptions described for the construction of the Mansfield Underground Variation in Section 15.2.3 would apply to the Mount Hope Underground Variation). The installation of the duct bank would involve the use of a 40-foot-wide work area along the 1.1-mile underground cable segment, affecting approximately 5.3 acres. An additional 0.4 acre would be required for the three splice-vault locations. Within this construction footprint, land would have to be cleared of vegetation and graded as necessary to create a level construction work space and to accommodate a 20-foot-wide access road along the cable route. To reach the on-ROW access road, equipment and vehicles would use Storrs Road and Bassetts Bridge Road.

Based on a typical average construction progress for cable-system installation of 50 to 100 feet per day, the construction of the 1.1-mile underground cable system along the Mount Hope Underground Variation could require two to four months. The construction of each of the 345-kV line transition stations can be expected to require approximately 12 to 18 months. As a result, the completion of the cable system, including the line transition stations, along the Mount Hope Variation could require up to 18 months.

As described for the Mansfield Underground Variation in Section 15.2.3, the operation of the underground cable system along the 1.1-mile Mount Hope Underground Variation would require that a permanent access road be maintained along the entire length of the route. Encompassing approximately 2.5 acres, this road would be located within CL&P’s existing ROW and would provide access to both the cable system (i.e., duct banks and splice vaults), as well as to the line transition stations. Access to the on-ROW road would be via Storrs Road and Bassetts Bridge Road.

Each of the line transition stations would consist of an above-ground 345-kV line terminal structure, a control building, and related equipment to connect the underground cable system to the overhead portion of the 345-kV transmission line. The developed portion of each line transition station would be graded, surfaced with crushed stone, and fenced.

15.3.4 Existing Environmental Features

15.3.4.1 Topography, Geology, and Soils

The Mount Hope Underground Variation is characterized by diverse topography, which ranges from approximately 490 feet NGVD at the western end of the route to 220 feet NGVD just west of Storrs Road. East of Storrs Road, the topography is generally flat. The variation also would traverse a variety of soil types, as summarized in Table 15-9. As this table indicates, the variation traverses some areas of Prime Farmland Soils and Farmland Soils of Statewide Importance.

15.3.4.2 Water Resources

The Mount Hope Underground Variation is located within the Thames River drainage basin and the Natchaug River regional drainage basin. The variation would be aligned within a segment of CL&P's ROW, along which wetlands and watercourses were field delineated in 2008 as part of studies of the proposed overhead transmission line route.

The variation would traverse two un-named, intermittent watercourses: stream S20-18 (a CT DEEP-listed coldwater stream that has a water quality classification of A) and S20-19A, which is not classified (refer to the Volume 9 maps). In addition, east of Storrs Road, three man-made ponds are located within CL&P's ROW, near the existing 330 Line. One of these ponds would be located adjacent to the 40-foot-wide construction workspace required for the cable system. The variation would not traverse any SCELs or FEMA-designated 100-year floodplains.

Table 15-9: Soils and Soil Characteristics along the Mount Hope Underground Variation

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factors[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
3 Ridgebury, Leicester, Whitman	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss	Yes	0.15	--	0.0-1.5
13* Walpole sandy loam	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	Yes	--	--	0.0-1.0
15 Scarboro muck	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	Yes	--	--	0.0-1.0
32A** Haven and Enfield soils, 0 to 3% slopes	Coarse-loamy and coarse-silty eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.32	--	--
34B** Merrimac sandy loam, 3 to 8% slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.24	--	--
38C* Hinckley gravelly sandy loam, 3 to 15% slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--
38E Hinckley gravelly sandy loam, 15 to 45% slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--
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	0.15	--	1.5-2.5
62D Canton and Charlton, 15 to 35% slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	1.5-2.5
85C Paxton and Montauk fine sandy loam, 8 to 15% slopes, very stony	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	0.20	--	1.5-2.5

Source: USDA Natural Resources Conservation Service, Online Soil Surveys and Geographic Data of Windham County, 2009.
* Soils classified as Farmland Soils of Statewide Importance
** Soils classified as Prime Farmland Soils
[1] Erosion Factor (K (dimensionless)): Indicates the erodability of the whole soil, the higher the value, the more susceptible the soil to erosion.
-- No Data Available. No bedrock or water encountered to survey depth.

The 2008 and 2011 wetland delineation surveys identified seven wetlands within or adjacent to the segment of CL&P's existing ROW along which the underground variation would be located. Of these, only three wetlands would be located along the Mount Hope Underground Variation; the remaining four wetlands are located on portions of CL&P's ROW outside of the underground variation route. Table 15-10 summarizes the characteristics of these wetlands (refer to Volume 2 for additional information regarding each wetland).

Table 15-10: Delineated Wetlands along the Mount Hope Underground Variation

Vol. 9 Mapsheet Numbers	Wetland Series Number[1]	Wetland Classification[2]	Relationship to Proposed Underground Route (Feet traversed)[3]	Vernal Pool / Amphibian Breeding Habitat		
				Vernal Pool / Habitat Number[4]	Location along ROWs	Species Observed
1 of 1	W20-60	PSS	55 feet			
1 of 1	W20-61	PFO / PSS	115 feet			
1 of 1	W20-62	PEM	15 feet			
1 of 1	W20-62A	POW	Adjacent			
1 of 1	W20-62B	POW	Adjacent			
1 of 1	W20-62C	POW	Adjacent	MA-1-ABH	South of existing Structure No. 9074. Beneath existing 345-kV transmission line.	Pickerel frog
2 of 2	W20-64	PFO / PSS	Adjacent	MA-17-VP MA-18-VP MA-19-VP	East of existing Structure No. 9079. East of eastern potential line transition station site.	Spotted salamander; spring peeper

NOTES:

1. Series No. refers to wetland number designated in the field report (Volume 2) and illustrated on the aerial photographs in Volume 9. The CL&P ROW along which the underground variation would be located is illustrated in Volume 11, Mapsheets 27 through 31 of 134 Vernal pools along this ROW segment also are illustrated on the Volume 11 maps.
2. Wetlands classification according to Cowardin et al 1979; PEM = Palustrine Emergent Wetland; PFO = Palustrine Forested Wetland; PSS = Palustrine Scrub-Shrub Wetland; POW = Palustrine Open Water; PUB = Palustrine Unconsolidated Bottom.
3. "Feet traversed" refers to linear distance crossed by center of 345-kVcable route, as depicted on the Volume 9 and 11 maps.
4. Refers to vernal pool habitat number assigned during field surveys.

Shading = Denotes wetland that provides vernal pool / amphibian habitat.

The wetlands along the variation are characterized by emergent marsh, scrub-shrub, and forest communities. Overall, less than 0.1 acre of palustrine forested wetland, approximately 0.1 acre of scrub-shrub wetland, and less than 0.1 acre of emergent marsh wetland are located within the portion of the CL&P ROW that would be affected by the Mount Hope Underground Variation. All of these wetlands would be along the comparable section of the proposed overhead 345-kV transmission line.

Groundwater in the vicinity of the Mount Hope Underground Variation is classified as “GA/GAAs” and “GA/GAA may not meet current standards”. No public wells, aquifer protection public supply wells, or Connecticut Aquifer Protection Areas are crossed by or within the vicinity of the variation. However, in the vicinity of the underground variation, drinking water is obtained primarily from private groundwater wells.

15.3.4.3 Biological Resources

Vegetative Communities

The vegetative communities along and in the vicinity of the underground variation consist of scrub-shrub habitat along the managed portions of the overhead transmission line ROW, as well as tracts of upland deciduous forest and agricultural/open fields along the western and eastern portions of the route, respectively. Scattered ornamental vegetation and lawn areas are associated with the residential developments along Storrs Road. Forest is the primary vegetative community type in the general vicinity of the variation. Both of the line transition station sites also are characterized primarily by upland (mature mixed) deciduous forest.

Overall, as summarized in Section 15.3.3, the underground route variation would encompass approximately 13.7 acres, which includes 8 acres associated with the two line transition station locations. Of the approximately 13.7 total acres that could be affected by the cable system, approximately 8.1 acres are presently forested (upland and wetland).

Fish and Wildlife Resources

The two intermittent watercourses traversed by the variation are unlikely to contain self-supporting fish populations. However, one of the streams (S20-18) is listed by the CT DEEP as potentially providing habitat for coldwater fish species. The Natchaug River is located approximately 1,600 feet south of the variation. The CT DEEP typically stocks hatchery-raised adult-sized trout (adult brook, brown, and rainbow trout) for put-and-take purposes in publicly-accessible portions of this river.

Wildlife species in the vicinity of the variation are likely to be those most commonly associated with mature mixed forested upland and wetland areas, as well as scrub-shrub and open field habitats (refer to Volume 1, Section 5 for a discussion of such species). As summarized in Table 15-10, two of the wetlands (W20-62C and W20-64) along or near the underground variation contain vernal pool habitat or amphibian breeding habitat. Based on the vernal pool / amphibian breeding habitat field surveys conducted along CL&P's ROWs during the spring of 2008 and 2011, one area in W20-62C was identified to be functioning as amphibian breeding habitat, and three areas within W20-64 were identified to be functioning as vernal pool habitat. Table 15-10 identifies the locations of these habitats in relation to the underground variation. (The Volume 11 maps for the Proposed Route [mapsheets 29 and 31] also illustrate these habitats.)

Listed Species

Based on data provided by the USFWS, the variation does not encompass areas of known habitat for any federally-listed species. Correspondence with the CT NDDB indicated that one state-listed species of special concern, the frosted elfin butterfly (*Callophryus irus*), may be present in the vicinity of the Mount Hope Underground Variation. This butterfly, which is considered to be declining across much of its range, feeds exclusively on wild lupine (*Lupinus perennis*) and wild indigo (*Baptisia tinctoria*). Transmission line ROWs in eastern Connecticut are considered important habitat for this species. The butterfly and moth field surveys conducted in 2008 – 2010 resulted in the identification of this species along the ROW in the vicinity of the Mount Hope Underground Variation. (Refer to Volume 4 for additional information concerning the butterfly and moth surveys.)

15.3.4.4 Land Uses

Along the underground variation route, land uses consist predominantly of forest land and open areas, with residential development concentrated along Storrs Road and Bassetts Bridge Road. The Mount Hope Montessori School, Green Dragon Day Care, and the Come Play with Me Day Care also abut these roads and would be located less than 300 feet from the centerline of the underground cable system.

However, the Green Dragon Day Care and Come Play with Me Day Care are both located south of CL&P's existing ROW, and thus are closer to the existing 330 Line. Both the underground variation and the proposed overhead 345-kV line would be aligned north (or west) of the 330 Line, and thus farther from these two day cares. The Mount Hope Montessori School is located to the west of CL&P's ROW along Bassetts Bridge Road and thus would be closer to the underground variation (and to the proposed overhead 345-kV line).

The variation would not traverse any designated parks, open space, or recreational areas. However, several designated recreational use or open space parcels are located in the vicinity. The Connecticut Forest and Park Association's (CFPA's) Nipmuck Trail (West Branch) is located just west of Sawmill Brook, approximately 0.5 mile west of the western 345-kV line transition station site. An undeveloped parcel of town open space land abuts the CL&P ROW to the west along Bassetts Bridge Road, whereas several parcels owned by Joshua's Tract Conservation and Historic Trust, Inc. are located approximately 0.2 mile north of the eastern end of the variation (north of Cemetery Road; refer to the Volume 9 maps of the route variation). In addition, Mansfield Hollow State Park is located approximately 0.2 mile east of the eastern end of the variation.

Approximately 0.5 mile of the underground variation would extend across CL&P-owned land, all of which is located east of Storrs Road. The remainder of the 1.1-mile variation would cross privately-owned property on which CL&P has easement rights only for overhead lines.

The two 345-kV line transition stations at each end of the underground cable route would be located on undeveloped forested property. Portions of both line transition station sites would be located outside of the existing CL&P ROW, on privately-owned property that would have to be acquired for utility purposes. The western line transition station site is characterized by forested upland; nearby land uses include undeveloped forest land, as well as residential areas along Sawmill Brook Lane, Beech Mountain Road, and Mountain Road. The eastern line transition station site, which would be located partially on CL&P-owned property, is characterized by upland mature mixed forest land. Land uses in the vicinity of this site include the existing CL&P ROW, forested wetlands (W20-64), residences along Hawthorne Lane and Bassetts Bridge Road, and Mansfield Hollow State Park. As illustrated on the Volume 9 maps, lands in the vicinity of the Mount Hope Underground Variation are zoned for Rural Agricultural Residential (RAR-40 and RAR-90) uses.

15.3.4.5 Transportation, Access, and Utility Crossings

The Mount Hope Underground Variation would cross both Storrs Road (State Route 195) and Bassetts Bridge Road. Storrs Road is a major regional north-south route, whereas Bassetts Bridge Road is a local two-lane road. However, Bassetts Bridge provides primary access to recreational areas within Mansfield Hollow State Park and to Mansfield Hollow Lake.

ConnDOT would not allow the cable to be installed across Storrs Road using an open-cut method. As a result, a subsurface technique (such as HDD or jack and bore) would be required. Any subsurface method would require staging areas on either side of the road crossing to accommodate the drilling or jacking equipment, support vehicles, and support materials.

15.3.4.6 Cultural (Archaeological and Historic) Resources

Because the Mount Hope Underground Variation would be aligned within CL&P's ROW, the *Cultural Resources Assessment* conducted for the Proposed Route applies to the variation (refer to Volume 1, Sections 5 and 6, and Volume 3). The archaeological sensitivity of the Mount Hope Underground Variation is the same as for the comparable section of the overhead line along the Proposed Route. Nine Native American archaeological sites are reported within 1 mile of the variation; of these, two were recorded within 300 feet of the variation.

Applying the assessment procedures designed to identify the sensitivity of areas for undiscovered archaeological sites, approximately 69% of the Mount Hope Underground Variation was considered sensitive for possible Native American archaeological sites. Subsequent subsurface archaeological reconnaissance investigations confirmed the archaeological sensitivity of the ROW along the Mount Hope Underground Variation. As a result of these initial field investigations, two Native American sites were discovered. One of these sites is potentially eligible for the NRHP/SRHP and the other requires further field study to assess potential NRHP/SRHP eligibility. In addition, further archaeological reconnaissance would be required to investigate sensitive on-ROW and off-ROW locations (i.e., the line transition station sites) areas that would be affected by the cable system construction and that have not otherwise been tested. (Note that no archaeological investigations have been conducted on privately-owned potential line transition station sites).

Four Euro-American archaeological sites, none of which have been determined eligible for the NRHP, are reported within 1 mile of the variation. The boundary of the Mansfield Hollow Historic District is approximately 500 feet east of the Mount Hope Underground Variation, although the nearest historic structures within the district are approximately 1,000 feet from this variation.

15.3.5 Potential Environmental Effects and Mitigation Measures

The construction and operation of the underground cable system along the Mount Hope Underground Variation would cause direct temporary and permanent effects on topography, soils, water resources, land use and visual resources, cultural resources, and transportation. Construction activities also would create nuisance type effects on local residents in terms of noise and dust from on-ROW cable system installation activities, as well as from the movement of construction equipment and vehicles along Storrs Road and Bassetts Bridge Road to access the ROW. The same types of effects as described for the Mansfield Underground Variation also would occur as a result of the construction and operation of the Mount Hope Underground Variation.

All lands within the underground cable construction workspace would be directly affected as a result of the vegetation clearing, grading, and filling required to create level areas for the installation of the duct banks and splice vaults. In certain area, extra construction workspace also would be required, such as to stage the installation of the cable ducts beneath Storrs Road (State Route 195) or to safely install the cable system along steeper slopes.

Similarly, all vegetation on the line transition station sites (within the footprint of the stations and access areas) would have to be cleared, and the sites would have to be graded to create a level base for the line transition station facilities and to accommodate construction work and equipment / material staging. Duct-bank and splice-vault excavations also would directly affect soil resources and possibly groundwater, and would require unavoidable construction activities directly in wetlands and watercourses.

The operation of the cable system would require a permanent access road to be maintained along the entire length of the cable route. In addition, the two 345-kV line transition stations would represent permanent changes to the local visual environment.

Appendix 15A describes the typical environmental effects caused by the construction and operation of an underground cable system, and identifies the mitigation measures that CL&P would typically use to minimize adverse effects to the extent possible. Table 15-11 summarizes the potential environmental effects that would result from the development of an underground cable system along the Mount Hope Variation. Table 15-11 also lists potential mitigation measures that CL&P would typically consider to minimize adverse effects to the extent possible.

15.3.6 Electric and Magnetic Fields

Electric and magnetic fields were calculated for the 1.1-mile Mount Hope Underground Variation assuming that the underground cable system would be aligned within CL&P's 300-foot-wide ROW and offset 41 feet west/north from the centerline of the existing 330 Line. The relatively short length of the variation would not significantly change the new circuit's impedance and therefore the same circuit currents were used for these calculations as were used for the proposed overhead H-frame line configuration. Volume 1, Section 7 of the Application includes details on the system assumptions made in the power-flow modeling used to determine these circuit currents.

Magnetic fields across the ROW produced by the existing line and the underground variation along this section of the ROW were calculated at AAL and are graphed on Figure 15-5. The location of the underground cable system in relation to the existing 330 Line is shown in red on the sketch beneath the graph. Table 15-12 summarizes the calculated levels of magnetic and electric fields at the ROW edges before and after the completion of the Project with the Mount Hope Underground Variation at AAL.

As illustrated on Figure 15-5, magnetic fields are elevated directly above and near the cable system. Magnetic fields at the edges of the ROW are 2 to 4 mG lower in 2020 than the pre-Project levels in 2015 under the conservatively projected AAL conditions in each year (refer to Table 15-12). Near cable-splice vaults, the magnetic field contribution by the underground cables would increase because of increased spacing between the cables.

Table 15-11: Summary of Primary Effects and Potential Mitigation for the Mount Hope Underground Variation

Environmental Feature	Potential Environmental / Social Effects		Potential Mitigation
	Construction	Operation / Maintenance	
Topography and Soils	Effects on topography and soils due to: ▪ Grading / filling along 1.1-mile construction ROW ▪ Grading / filling at line transition station sites ▪ Excavations for duct-bank trench and splice vaults. Potential for erosion and sedimentation into watercourses and wetlands, particularly along ROW in hillier terrain west of Storrs Road.	Permanent changes in topography along ROW as a result of grading and creation of a permanent access road. Permanent change in topography and soils at line transition station sites	Install temporary erosion and sediment controls. Segregate topsoil layer during construction. To the extent practical and safe, restore contours and replace topsoil along ROW as part of restoration.
Water Resources	Direct disturbance to two intermittent streams and three wetlands as a result of clearing, grading, excavating for trench / splice vaults, and access road development. Approximately 0.1 acre of scrub-shrub wetland, less than 0.1 acre of forested wetland and 0.1 acre of emergent marsh wetland would be affected. Potential sedimentation associated with dewatering if groundwater is encountered in excavations. Installation of flowable thermal backfill in duct bank could constitute permanent fill in wetlands, as will the development of permanent access roads through wetlands.	An estimated net loss of less than approximately 0.1 acre of wetlands due to duct bank fill and access roads	Use temporary erosion and sediment controls to minimize off-ROW water resource impacts. Revegetate or otherwise stabilize disturbed soil areas to limit the potential for sedimentation into water resources. Coordinate with USACE and CT DEEP regarding off-site compensation for permanent loss of wetlands.
Biological Resources	Direct disturbance of approximately 13.7 acres of habitat as a result of construction, including removal of 8.1 acres of forest lands (including 8.1 acres of upland forest and less than 0.1 acre of forested wetland).	Permanent conversion of forested areas, including forested wetland to scrub-shrub vegetative communities; net loss of wetland habitat as detailed above due to access roads and cable trench. Permanent net loss of all habitat types as a result of the creation of access road along the length of the cable system. Net loss of vegetative habitat at line transition station sites, which would be converted to utility use.	Coordinate with CT DEEP regarding mitigation, if required, for the frosted elfin butterfly

Environmental Feature	**Potential Environmental / Social Effects**		**Potential Mitigation**
	Construction	**Operation / Maintenance**	
Land Use, including Statutory Facilities and Designated Recreational Areas	Cable system, including two transition stations, would affect approximately 3.2 acres of open field and shrubland; 0.1 acre of transportation ROWs; 8.1 acres of upland forest; 2.3 acres of agricultural land. Purchase of privately-owned line transition station sites and conversion to electric transmission uses. No direct effect on recreational areas.	Permanent change in land use at line transition station sites; creation of permanent access road along ROW.	
Visual Resources	Visual changes associated with the development of the line transition station sites, including the removal of existing forested vegetation. Construction activities along the ROW will cause temporary changes in the viewscape.	Change to visual environment associated with the development of the line transition stations on previously undeveloped forested sites; maintenance of permanent access road along 1.1-mile ROW. Line transition station sites will be potentially visible from nearby residential areas, as well as from public recreational use sites (e.g., Nipmuck Trail, Mansfield Hollow State Park)	Possible visual screening
Transportation	Increase in traffic along Storrs Road and Bassetts Bridge Road as a result of movement of construction equipment and vehicles to / from the ROW; lane closures and delays during trenching across Bassetts Bridge Road The installation of the cable system beneath Storrs Road (State Route 195) would require the use of a subsurface method such as HDD or jack and bore. Either of these methods would involve staging areas on either side of the road and would require considerable time to perform.	Permanent access required off Storrs Road and Bassetts Bridge Road for access to line transition stations and cable system ROW	Implement traffic management plan during construction; coordinate with Town of Mansfield
Cultural Resources	Any archaeological sites within the construction footprint would be adversely and permanently affected as a result of earth-disturbing activities such as grading, excavation, and access road development. Two Native American sites have been located along the Mount Hope Underground Variation ROW.	Permanent adverse effects could occur to archaeological sites during construction (i.e., potentially significant NRHP sites could not be avoided); detailed mitigation involving archaeological data recovery would be required	Conduct field investigations to further define archaeological site boundaries and to develop appropriate mitigation measures (e.g., data recovery), based on consultations with the SHPO, Native American Tribes, ACHP

Figure 15-5: Magnetic Field Profiles under Pre-Interstate (2015) and Post-NEEWS (2020) Conditions at AAL for the Mount Hope Underground Variation

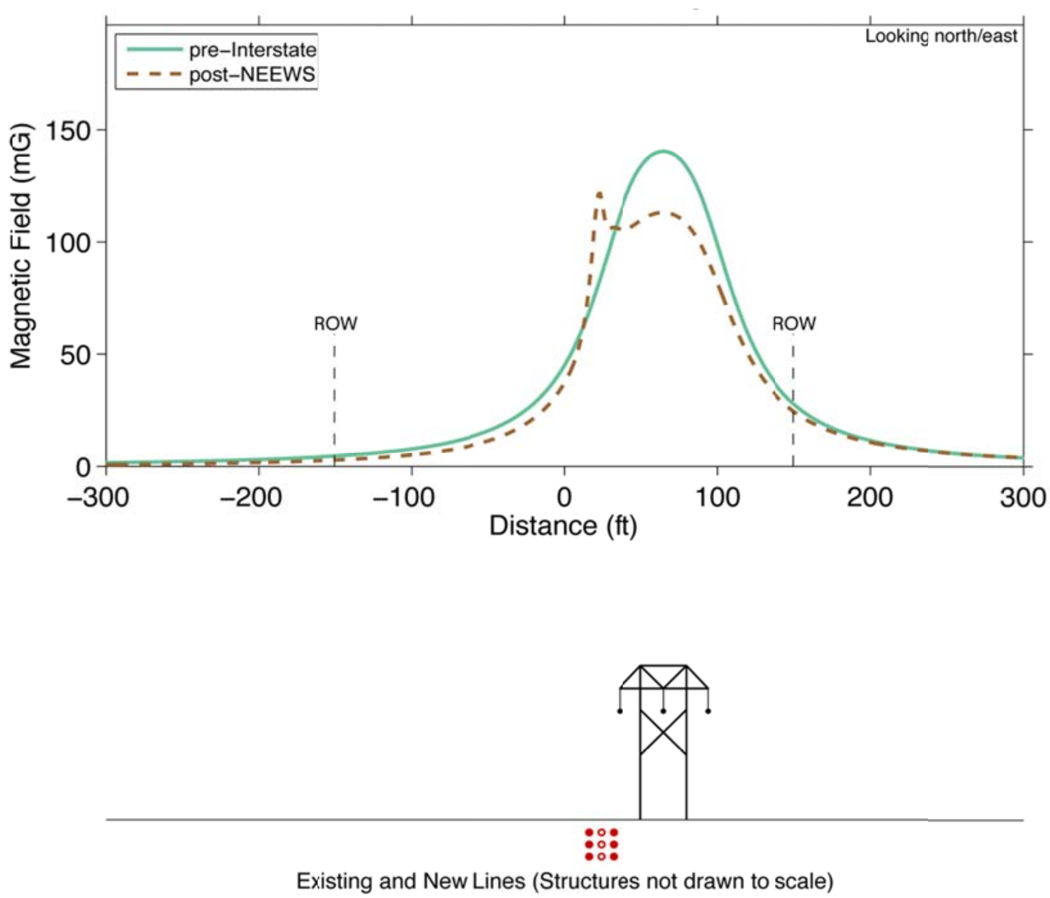


Table 15-12: Summary of Pre-Interstate (2015) and Post-NEEWS (2020) EMF Levels at the Edge of the ROW at AAL for the Mount Hope Underground Variation

	Magnetic Field (mG)		Electric Field (kV/m)	
Cross-Section	**West/North ROW**	**East/South ROW**	**West/North ROW**	**East/South ROW**
XS-UG-2 – Pre	4.6	28.0	0.09	1.20
XS-UG-2 – Post	2.8	24.6	0.09	1.20

The operation of the new Mount Hope Underground Variation transmission line would not result in a large change in magnetic field levels along this segment of the line route, compared to the levels existing before the development of the Project. If the proposed 345-kV overhead H-frame line was built, magnetic fields would be higher than pre-Project levels along the west/north edge of the ROW, but would be lower than the pre-Project levels on the east/south ROW edge.

Compared to the proposed H-frame overhead line design, the underground variation would actually result in higher magnetic field levels along the east/south ROW edge nearest to the existing 330 Line. The proposed overhead H-frame line configuration would employ best phasing with the existing 330 Line, enhancing field cancellation and resulting in a magnetic field reduction at the east/south ROW edge nearest to the existing line. This cancellation effect would be lost if the new line were to be constructed in an underground configuration along the Mount Hope Underground Variation.

Magnetic field levels at AAL at each ROW edge along the Mount Hope Underground Variation and at the nearest points of three nearby Statutory Facilities are compared for each case in Table 15-13 and Table 15-14, respectively.

Table 15-13: Comparison of Magnetic Field Levels at AAL for the Proposed Overhead H-Frame Line Configuration and the Mount Hope Underground Variation

ROW Edge	Magnetic Fields for Annual Average Load Case (mG)		
	Pre-Interstate	Post-NEEWS	
	Existing Configuration	Overhead H-Frame Line Configuration	Underground Variation
North	4.6	7.2	2.8
South	28.0	18.4	24.6

Table 15-14: Magnetic Field Levels at Statutory Facilities Near the Mount Hope Underground Variation Route

Facility	Distance to Nearest Edge of ROW (ft)	Magnetic Fields for Annual Average Load Case (mG)		
		Pre-Interstate	Post-NEEWS	
			Overhead H-Frame Line Configuration	Underground Variation
Mount Hope Montessori School	137	1.7	1.2	0.8
Green Dragon Day Care	196	2.7	0.9	2.9
Come Play with Me Day Care	76	8.2	4.0	7.8

As Table 15-14 shows, when using the proposed overhead, H-frame line design, post-Project (2020) projected magnetic fields are lower than pre-Interstate (2015) levels at all three Statutory Facilities near the Mount Hope Underground Variation. In two of the three cases, the underground variation would result in magnetic fields similar to the pre-Project levels and higher than those that would occur with the use of the proposed overhead, H-frame line configuration.

Underground transmission cable systems do not produce electric fields above ground. Therefore, the electric field profile across the ROW with the Mount Hope Underground Variation would be the same as the existing electric field profile. Thus, in Table 15-15, there is no difference between the ROW edge levels before and after the construction of the Mount Hope Underground Variation. Table 15-15 compares the electric fields at ROW edges with this variation to those with the overhead H-frame line design.

Table 15-15: Comparison of Electric Field Levels for Overhead H-Frame Line and the Mt. Hope Underground Variation

ROW Edge	Electric Field (kV/m)		
	Pre-Interstate	Post-NEEWS	
	Existing Configuration	Overhead H-Frame Line Configuration	Underground Variation
North	0.09	0.39	0.09
South	1.20	1.19	1.20

15.3.7 Comparison of the Mount Hope Underground Variation to the Segment of the Proposed Route Replaced

The Mount Hope Underground Variation provides a potential alternative to the proposed overhead H-frame line configuration near the Mount Hope Montessori School and two residential child day-care facilities. Table 15-16 summarizes the characteristics of the underground variation compared to the portion of the proposed overhead 345-kV H-frame line that the underground cable segment would replace. As discussed below, CL&P prefers the proposed overhead H-frame line configuration, aligned within the existing ROW, over the Mount Hope Underground Variation.

The variation would require the acquisition from private landowners of up to approximately 6 acres of land for the two 345-kV line transition stations and the acquisition of easement rights for underground lines along CL&P's existing ROW. In comparison, no new land or rights would be required for the development of the overhead 345-kV line, as proposed, within CL&P's existing ROW.

The cost of the underground cable system segment is a significant consideration. While the comparable 1.1-mile segment of the proposed overhead H-frame transmission line would cost $5.4 million, the capital cost of the underground variation is estimated at $65 million and thus would add a net $59.6 million to the total cost of the Project.

Table 15-16: Comparison of the Mount Hope Underground Variation to the Proposed Project Overhead H-Frame Line Segment

Route Characteristic	Proposed Overhead H-Frame Line Configuration	Mount Hope Underground Variation
Location, Design, and Appearance		
Route Location (ROW, Town)	Existing CL&P ROW (Mansfield)	Existing CL&P ROW, except for transition station sites (Mansfield)
Route Length (miles)	1.1 miles	1.1 miles
Overhead Structures (type, est. number)	H-frame 12	N/A
Splice Vaults (est. number)	N/A	3 locations (9 vaults)
New ROW Easements or Land Acquisition Required (est. acres)	0	8 acres
Biological Resources		
Upland Forest Clearing (est. acres)	5.8 acres	8.1 acres
Forested Wetland Clearing (est. acres)	0.2 acre	Less than 0.1 acre
Scrub-Shrub Clearing (est. acres)	Less than 0.1 acre	0.1 acre
Watercourse Crossings (no.)	2 (span)	2 (direct effects, trenching)
Wetlands, Permanent Effects (Fill) (est. acres)	0 structures 0 acres (access roads)	less than 0.1 acre
Wetlands, Temporary Effects (est. acres)	0 acres (access road)	0
Listed Species (no. species)	1	1
Land Uses		
Designated Recreational Open Space along ROW (length)	665 feet	665 feet
CL&P-Owned Land Traversed	0.5 mile	0.5 mile
Total Construction ROW / Work Space, Temporary Land Disturbance (est. acres)	14.7 acres	13.7 acres
Cost of Transmission Line Segment ($ Million, $ 2010)		
Capital Cost	$5.4	$65.0
Cost to Connecticut Consumers[1]	$1.5	$61.1
Life-cycle Cost	$9.5	$92.5

Assumes localization of extra costs for underground cables.

As described in Section 14.3.1.3, these increased costs would not likely qualify for inclusion in New England regional transmission rates. As a result, Connecticut consumers would bear 100% of these excess costs, in addition to the 27% share of the basic cost of the overhead line construction that the variation would replace.

The Mount Hope Underground Variation would cost significantly more than the comparable segment of proposed overhead transmission line (constructed pursuant to standard good utility practice). Consequently, the cost to Connecticut consumers for the 1.1-mile underground segment would be approximately $61 million, or 41 times more than that of the overhead line. This is calculated as follows:

Connecticut consumer cost for section of overhead line to be replaced:

Estimated cost of overhead H-frame transmission line:	$5.4 million
Connecticut consumer cost for overhead section to be replaced = (H-frame line cost x 27%)	$1.5 million

Connecticut consumer cost for underground variation:

Estimated cost of the underground variation:	$65 million
Incremental cost of underground variation over an overhead H-frame transmission line:	$59.6 million
Connecticut consumer cost for underground variation = (Incremental cost for underground x 100%) + (H-frame line cost x 27%):	$61.1 million

Finally, dividing the Connecticut consumer cost for the underground variation by the Connecticut consumer cost for the overhead line section to be replaced yields: ($61.1 million / $1.5 million) = 41.

If built as CL&P proposes (i.e., overhead on the existing ROW), the new 345-kV line would be "adjacent to" the Mount Hope Montessori School, but separated from the day-care facilities on the other side of the ROW by the existing 330 Line. Because the new 345-kV line would be optimally phased so that magnetic fields from the new and existing lines would partially cancel each other, construction of the line as proposed would cause relatively small changes to the pre-Project magnetic field levels along (outside of) the edges of the ROW.

In fact, magnetic field levels at the Mount Hope Montessori School and at the two child day-cares would be reduced, as compared to the field levels that would be produced by the existing line if no new line were built. Further reductions in some off-ROW areas closer to the ROW edges can be achieved by incorporating other overhead line designs. For details regarding the magnetic fields associated with the section of the proposed overhead line that this variation would replace, refer to the text, figures, and tables concerning "Focus Area B" in Volume 1, Section 7 (Appendix 7B).

Connecticut electricity consumers would have to pay significant additional costs for the development of the cable system along the Mount Hope Underground Variation as part of the Project. However, compared to pre-Project conditions, the use of the underground variation would not produce large reductions in magnetic field levels along the edge of the ROW or at adjacent Statutory Facilities. The significant expenditures for the variation, with little magnetic field reduction to show for it, would impose an unreasonable burden on the state's electric consumers.

Based on these unreasonable additional costs to consumers, the lack of magnetic field reduction, and the additional land acquisition that would be required to develop this variation, CL&P's proposed overhead 345-kV H-frame line design, located within CL&P's ROW, was selected over the Mount Hope Underground Variation.

15.4 BROOKLYN VARIATIONS

15.4.1 Introduction and Summary

15.4.1.1 Purpose of the Variations

In the Town of Brooklyn, CL&P proposes to align the new 345-kV transmission line in an overhead configuration within the existing ROW, which extends northeast across most of the town before turning north at Day Street Junction. In the vicinity of Day Street Junction in the northeastern corner of the Town of Brooklyn, CL&P's existing ROW (which is generally 300 to 360 feet wide) traverses near residential land uses located along Church Street, Darby Road, Hickory Lane, and Meadowbrook Lane (refer to the Volume 9 maps).

Along a 0.5-mile segment of this ROW beginning approximately 0.2 mile west of Church Street and continuing 0.3 mile east of Church Street, nine homes, one of which is a residential child day-care facility, are located within 100 feet of the edge of either the northern or western side of the ROW. A total of 24 homes (including the nine within 100 feet) are located within 300 feet of the northern or western edges of ROW along this 0.5-mile segment. A second residential day-care facility, located on Hickory Lane, is located approximately 500 feet from the existing ROW. Along the south side of this ROW segment, five homes (including two homes within 100 feet) are located within 300 feet of the edge of ROW.

The existing ROW along which the Proposed Route would be located in the Town of Brooklyn varies in width, and the number of transmission lines on the ROW changes at Day Street Junction. For example, east-northeast from the border with the Town of Hampton to Day Street Junction, only the 330 Line is located within the ROW. However, at Day Street Junction (east of Church Street), the CL&P ROW turns to the north and widens to approximately 360 feet. In addition to the 330 Line, two 115-kV transmission lines (the 1607 and 1505 Lines) occupy this ROW segment.

Within Brooklyn, CL&P proposes the following configuration for the new overhead 345-kV transmission line:

Horizontally-configured conductors supported by H-frame structures, generally aligned to the north of the existing 330 Line along a portion of the existing CL&P ROW that extends east-northeast from the Town of Hampton to existing 330 Line Structure No. 9209. (Refer to XS-6)

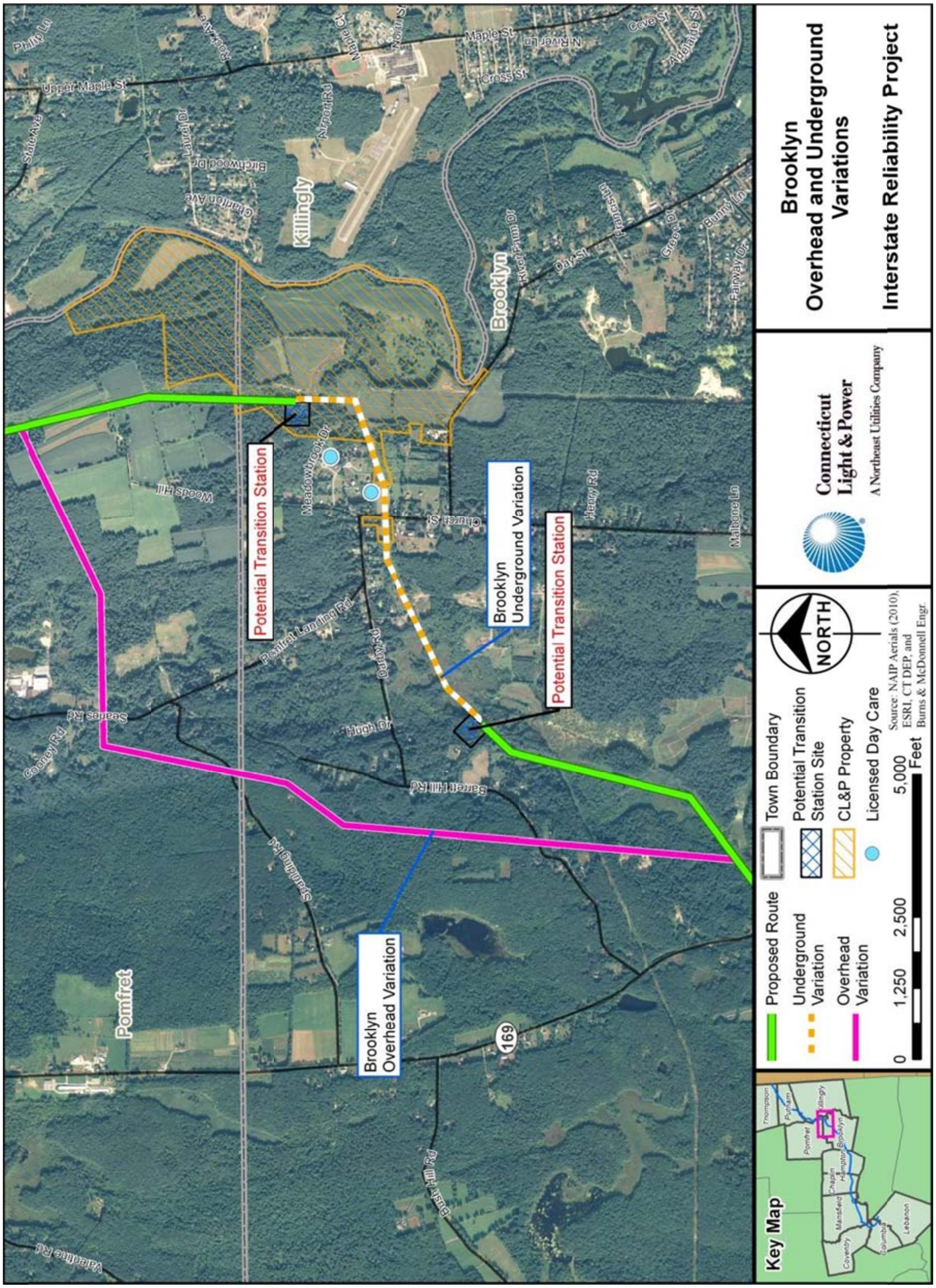
From existing 330 Line Structure No. 9210 to Day Street Junction (Structure No. 9219), the proposed overhead line would consist of delta-configured conductors supported by steel monopoles, which CL&P recommends to mitigate magnetic field levels in Focus Area D. (Refer to Volume 1, Section 7 [Appendix 7B] for additional information regarding Focus Area D and to XS-6 BMP in Volume 1, Section 3, Appendix 3A and Volume 9)

North of Structure No. 9219, the proposed overhead configuration for the new line returns to the base line configuration of horizontally-configured conductors supported on H-frame structures, aligned generally to the west of the 330 Line. Refer to cross-sections XS-6, XS-6 BMP and XS-7 in Volume 1, Section 3 (Appendix 3A), Volume 9, and Volume 10 for additional details.

Two variations – an overhead H-frame line configuration on a new greenfield ROW (the Brooklyn Overhead Variation) and an underground cable system located within the existing ROW (the Brooklyn Underground Variation) – were identified as potential alternatives to avoid developing the new 345-kV transmission line in an overhead configuration near the 0.5-mile ROW segment near homes and residential child day-care facilities along and in the vicinity of Church Street. These variations are depicted on Figure 15-6 and illustrated in detail on the Volume 9 maps.

The cross-sections in Appendix 15B illustrate the configuration of the Brooklyn variations, which are described in Section 15.4.2 (Brooklyn Overhead Variation) and 15.4.3 (Brooklyn Underground Variation). Section 15.4.1.2 provides a summary comparison of the Brooklyn Variations to the segments of the Proposed Route and 345-kV overhead line design that each would replace.

Figure 15-6: Brooklyn Overhead and Underground Variations



15.4.1.2 Summary Comparison of the Brooklyn Variations to the Segments of the Proposed Project that would be Replaced

As detailed in Sections 15.4.2 and 15.4.3, the proposed Project (i.e., the 345-kV overhead transmission line aligned along CL&P's existing ROWs) is preferable to either of the Brooklyn Variations. Both of the variations, but particularly the Brooklyn Underground Variation, would be substantially more costly than the proposed overhead line configuration located within the existing ROW. Table 15-17 summarizes and compares the principal differences between the Brooklyn Overhead and Underground Variations and the proposed overhead line configuration that each variation would replace.

Table 15-17: Comparison of Brooklyn Variations to Segments of the Proposed Project Each Would Replace

Characteristic	Brooklyn Overhead Variation		Brooklyn Underground Variation	
	Proposed Overhead Route Segment to be Replaced	Overhead Variation	Proposed Route Segment to be Replaced	Underground Variation
Town(s) Traversed	Brooklyn, Pomfret	Brooklyn, Pomfret	Brooklyn	Brooklyn
Route Length (miles)	3.4	3.3	1.4	1.4
Route Location	CL&P ROW	Greenfield Corridor	CL&P ROW	CL&P ROW
Overhead Line Structures (est. no.)	30	28	14	n/a
Splice Vaults (est. number)	n/a	n/a	n/a	3 Locations (9 vaults)
New ROW or Other Land Acquisition Required (est. acres)	0 acres	58.8 acres	0 acres	4 acres
Upland Forest Clearing (est. acres)	12.9 acres	47.6 acres [1]	3.9 acres	4.6 acres
Forested Wetland Clearing (est. acres)	3.2 acres	2.1 acres [1]	0.6 acre	< 0.1 acre
Scrub-Shrub Clearing (est. acres)	4.3 acres (upland) 1.9 acres (wetland)	1.5 acres (upland) 1.2 acres (wetland) [1]	2.9 acres (upland) 1.1 acres (wetland)	6.7 acres (upland) 0.7 acre (wetland)
Watercourse Crossings (number)	7	3	3	3
Wetlands, Temporary Effects (est. acres)	1.0	0.8[1]	0.2	0
Cost ($) million	$16.9	$27.4	$8.2	$82.0
Cost ($) million to CT consumers after localization of excess costs	$5.7	$16.2	$3.3	$77.2
Life-cycle Cost ($) million	$29.2	$43.8	$13.8	$116.8

Notes:
1. Based on aerial photo interpretation in conjunction with USFWS National Wetland Inventory and hydric soils data.
2. For the Brooklyn Overhead Variation the impacts would be temporary based on an assumption that temporary access roads would be removed and there would not be any poles located in wetlands.

As illustrated in Figure 15-6, the Brooklyn Overhead Variation would entail the development of the proposed 345-kV line on 3.3 miles of new ROW, located west and north of CL&P's existing ROW.

Compared to the segment of the proposed overhead line (located within CL&P's existing ROW) that would be replaced, this new ROW would result in greater environmental effects, and would be inconsistent with federal and state guidelines for maximizing the collocation of linear utilities.

Both variations (most significantly, the underground variation) would impose cost burdens on Connecticut electric consumers without achieving any notable off-ROW reduction in magnetic field levels. As Table 15-17 shows, compared to the proposed Project segment that it would replace, the Brooklyn Overhead Variation would cost an additional $10.5 million, all of which would be borne by Connecticut consumers. This cost would be in addition to their 27% (regionalized) share of the $15.3 million cost of the baseline H-frame overhead line segment that would be replaced plus the incremental cost of the delta-configured overhead transmission line for EMF Best Management Practices over the H-frame transmission line.

Developing the new 345-kV transmission line along the Brooklyn Overhead Variation would create a new linear ROW within the Quinebaug-Shetucket Rivers Valley National Heritage Corridor and would not be consistent with land use plans. In addition, the use of the variation would generate a new linear source of magnetic fields along the new ROW.

On the other hand, if built as proposed (i.e., overhead transmission line located adjacent to the 330 Line within CL&P's existing ROW), the new 345-kV line could be phased so that magnetic fields from the new and existing lines would partially cancel each other. Compared to pre-Project conditions, there would be little change in magnetic field levels outside the edges of the ROW. Indeed, under the projected 2020 annual average load conditions modeled, no increase in magnetic field levels would occur at one of the two residential day-care facilities near the ROW. Magnetic field levels at the other day-care facility could be reduced to pre-Project levels by using a field management alternative line design, at a fraction of the cost of the overhead variation (refer to Volume 1, Section 7 [Appendix 7B]). On the other hand, implementation of the Brooklyn Overhead Variation would introduce a new source of transmission line magnetic fields along a new utility corridor, while the fields along the existing ROW would remain broadly similar to the pre-Project levels (refer to Volume 1, Section 7).

Similarly, the Brooklyn Underground Variation is inferior to the segment of the proposed overhead line design that would be replaced. The 1.4-mile underground cable system would extend along CL&P's existing ROW, and would require two line transition stations.

The development of the underground cable system would increase total Project costs by $73.9 million. All of these excess costs would be borne by Connecticut consumers, in addition to a 27% share of the cost for the $6.6 million baseline H-frame overhead line configuration that would be replaced and 100% of the incremental cost between the delta-configured line and H-frame line.[15] While the use of this variation would cause a decrease in magnetic field levels near one residential child day-care facility, a reduction at less cost could be achieved by the use of a different overhead line design (refer to the discussion regarding "Focus Area D" in Volume 1, Section 7, Appendix 7B).

15.4.2 Brooklyn Overhead Variation

15.4.2.1 Location of the Route Variation

The 3.3-mile Brooklyn Overhead Variation, which would traverse portions of the Towns of Brooklyn and Pomfret, would replace 3.4 miles of the Proposed Route and would involve the development of the new overhead 345-kV line on a new "greenfield" corridor.[16] The route variation would diverge from the

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[15] Note: With respect to inclusion in New England regional rates, ISO-NE, by precedent, also would not allow the difference in the costs to construct the delta steel-pole line along this segment of ROW, in comparison to the cost of H-frame line construction.

[16] As illustrated on Figure 15-8 and USGS map 6 of 9 in Volume 9, in the vicinity of the Brooklyn Overhead Variation, an existing 23-kV distribution line ROW extends west-to-east, south of CL&P's Line 330 line ROW and interconnects to CL&P's existing 115-kV line ROW between Brooklyn Substation and Day Street Junction. CL&P investigated the use of these ROWs as an option for an overhead variation to avoid the residential areas along the Proposed Route near Church Street. However, this option was eliminated from detailed consideration because the ROWs would have to be expanded to 150 feet, requiring the placement of the new line close to other residences along Church Street. In addition, east of Church Street, a large wetland complex would be unavoidably affected.

existing CL&P ROW approximately 0.2 mile east of State Route 169 in Brooklyn (near existing 330 Line structure No. 9201), and would extend due north for approximately 2.1 miles, traversing predominantly forested areas before crossing into the Town of Pomfret. In Pomfret, the route variation would turn east, extending for 1.2 miles and crossing Spaulding and Searles roads before rejoining CL&P's existing ROW near 330 Line structure Nos. 9229 and 9230.

15.4.2.2 Technical Description (Design, Appearance, Land Requirements, Cost)

The Brooklyn Overhead Variation would require the acquisition and development of a new 150-foot-wide, 3.3-mile segment of ROW for the construction and operation of the new 345-kV H-frame transmission line configuration. The 330 Line would remain on CL&P's existing ROW. Based on a 150-foot-wide ROW, the 3.3-mile variation would require the acquisition of permanent easement rights on approximately 58.8 acres of land.

Along the route variation, the new overhead 345-kV transmission line would be supported on H-frame structures, ranging in height from 85 to 90 feet. These structures would be centered in the 150-foot-wide ROW as shown in XS-B-1 of Appendix 15B. Figure 15-6.depicts the location of the route variation.

The capital cost of the Brooklyn Overhead Variation is estimated at $27.4 million. In comparison, the capital cost for the proposed overhead 345-kV transmission line segment that would be replaced by the variation would be $10.5 million less (i.e., $16.9 million).

15.4.2.3 Construction and Operation/Maintenance Considerations

The construction of the overhead H-frame transmission line along the 3.3-mile Brooklyn Overhead Variation would involve the same general techniques as described for the proposed overhead 345-kV line (refer to Volume 1, Section 4). However, because the route variation would involve the use of a new (greenfield) ROW, additional work would be required to develop new access roads along the ROW, as well as to clear vegetation. Forest vegetation would be removed within the 150-foot-wide area along the length of the 150-foot-wide ROW.

After the installation of the overhead line along the variation, vegetation within the ROW would be managed in low-growth species, pursuant to CL&P policies and regulatory standards. In addition, because the overhead line variation would extend primarily through areas with few public road access points, some permanent on-ROW access roads could be required to allow equipment to reach structure sites for maintenance purposes.

15.4.2.4 Existing Environmental Features

15.4.2.4.1 Topography, Geology, and Soils

Elevations along the Brooklyn Overhead Variation range from approximately 250 feet NGVD to 500 feet NGVD. Bedrock geology in the area includes the Quinebaug and Tatnic Hill formations. Surficial geology along the variation consists primarily of sand and gravel, and sand and gravel overlying sand and fines. Like the existing transmission ROW, the variation would traverse some soils classified as Prime Farmland or Farmland Soils of Statewide Importance (refer to Table 15-18).

Table 15-18: Soils and Soil Characteristics along the Brooklyn Overhead Variation

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
3 Ridgebury, Leicester, Whitman	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss	Yes	0.15	--	0.0-1.5
18 Catden and Freetown soils	Woody organic material	Yes	--	--	0.0-1.0
38C* Hinckley gravelly sandy loam, 3 to 15 % slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--
45A** Woodbridge fine sandy loam, 0 to 3 % slopes	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss	No	0.17	--	1.5-2.5
45B** Woodbridge fine sandy loam, 3 to 8 % slopes	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss	No	0.17	--	1.5-2.5
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	0.15	--	1.5-2.5
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	0.10	--	1.5-2.5
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	0.15	--	1.5-2.5
60B** Canton and Charlton, 3 to 8 % slopes	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
60C* Canton and Charlton, 8 to 15 % slopes	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
61B Canton and Charlton, 3 to 8 % slopes, very stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
62C Canton and Charlton, 3 to 15 % slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
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	0.17	20-40	--
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	0.17	20-40	--
75E Hollis-Chatfield-rock outcrop complex, 15 to 45 % slopes	Loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.05	0-20	--
102** Pootatuck fine sandy loam	Coarse-loamy alluvium	No	0.24	--	1.5-2.5
103* Rippowam fine sandy loam	Coarse-loamy alluvium	Yes	0.15	--	0.0-1.5

Source: USDA Natural Resources Conservation Service, Online Soil Surveys and Geographic Data of Windham County 2009.
* Soils classified as Farmland Soils of Statewide Importance
** Soils classified as Prime Farmland Soils
1. Erosion Factor (K (dimensionless)): Indicates the erodability of the whole soil, the higher the value, the more susceptible the soil to erosion.
-- No Data Available. No bedrock or water encountered to survey depth.

15.4.2.4.2 Water Resources

The Brooklyn Overhead Variation is located within the Quinebaug River subregional drainage basin within the Thames River drainage basin. The route variation would be aligned approximately 1 mile west of the Quinebaug River and would traverse three perennial watercourses: one in the Town of Brooklyn (S24-1, White Brook, a Class A coldwater stream) and two in the Town of Pomfret (S24-3, Barrett Ledge Brook, a Class A coldwater stream, and S24-4, White Brook, a Class B/A coldwater stream). The route would cross 100-year FEMA floodplains associated with Barrett Ledge Brook and White Brook (refer to the Volume 9 maps).

Based on the review of published wetland (NWI) maps, soils maps, state GIS data, and aerial photography, the Brooklyn Overhead Variation would traverse five wetlands. Table 15-19 summarizes the characteristics of these wetlands.

Table 15-19: Wetlands along the Brooklyn Overhead Variation

Vol. 9 Mapsheet Nos.	Wetland Series No.[1]	Wetland Classification[2]	Relationship to Proposed Overhead Variation (Feet traversed / adjacent)[3]
Brooklyn			
2 of 5	W24-1	PFO	315 feet
2 of 5	W24-2	PFO	Adjacent, not within cleared ROW
Pomfret			
4 of 5	W24-3	PFO	85 feet
4 of 5	W24-4	PEM /PSS	500 feet
4 of 5	W24-5	PEM / PSS	150 feet
4 & 5 of 5	W24-6	PFO	225 feet

NOTES:

1. Series No. refers to wetland number illustrated on the maps in Volume 9.
2. Wetlands classification according to Cowardin et al 1979; PEM = Palustrine Emergent Wetland; PFO = Palustrine Forested Wetland; PSS = Palustrine Scrub-Shrub Wetland; POW = Palustrine Open Water; PUB = Palustrine Unconsolidated Bottom.
3. “Feet traversed” refers to linear distance crossed by center of 345-kV transmission line, as depicted on the Volume 9 maps.

No wetland delineations were conducted along the Brooklyn Overhead Variation due to lack of survey rights on private lands. However, a review of aerial photography and NWI mapping indicates that these wetlands consist of approximately 2.1 acres of palustrine-forested wetland, 1.2 acres of palustrine scrub-shrub wetland, and 1.1 acres of emergent marsh.

Groundwater in the vicinity of the Brooklyn Overhead Variation is classified as “GA”. No public wells, aquifer protection public supply wells, or Connecticut Aquifer Protection Areas are crossed by or within the vicinity of the route variation. Near the Brooklyn Overhead Variation, drinking water is obtained primarily from private groundwater wells.

15.4.2.4.3 Biological Resources

Vegetative Communities

The Brooklyn Overhead Variation would require a new ROW that would extend primarily through forested habitat, intermixed with isolated areas of rural residential development (lawn areas) and agricultural fields. Overall, the footprint of the Brooklyn Overhead Variation (based on a typical 150-foot-wide ROW) would encompass approximately 58.8 acres.

Of this 58.8 total acres, approximately 47.6 acres are mature mixed upland forest and 2.1 acres are forested wetland. Other vegetative communities within the overhead variation ROW include agricultural lands (3.1 acres), commercial/industrial (1.8 acres), open field / shrub lands upland (1.5 acres), road ROW (0.4 acre), scrub-shrub wetland (1.2 acres) and emergent wetland (1.1 acres).

Fish and Wildlife Resources

Based on consultations with the CT DEEP, the perennial watercourses traversed by the variation are likely to contain coldwater fish species. The CT DEEP stocks White Brook with hatchery-raised adult-sized trout (adult brook, brown, and rainbow trout) for put-and-take purposes within publicly-accessible portions of the river. Wildlife species in the vicinity of the route variation are likely to be those most commonly associated with forested upland and wetland areas, as well as scrub-shrub habitats (refer to Volume 1, Section 5 for a discussion of such species).

Amphibians

Due to the lack of survey rights on the privately-owned properties along the route, no field investigations to determine amphibian breeding habitat or potential areas of vernal pools were conducted along the Brooklyn Overhead Variation.

Listed Species

Based on a review of USFWS databases, there is no known habitat for any federally-listed species near the route variation. However, the eastern end of the route variation (in the Town of Pomfret near the intersection with the Proposed Route along CL&P's existing ROW) is in the vicinity of habitat for the wood turtle, a state-listed species of special concern.

15.4.2.4.4 Land Uses

The Brooklyn Overhead Variation would be aligned predominantly across forest lands, with the exception of several parcels of agricultural land located near the eastern terminus of the route in the Town of Pomfret. Approximately 1.7 miles of the variation would be located in the northeastern portion of the Town of Brooklyn, and 1.6 miles would extend across the southeastern portion of Pomfret. All of the route variation would be located on privately-owned property, across which CL&P would have to acquire utility easements.

As illustrated on the Volume 9 maps, lands along and in the vicinity of the Brooklyn Overhead Variation are zoned for Rural Agricultural (RA) uses in the Town of Brooklyn and for Rural Residential (RR) and Commercial/Business (CB) uses in the Town of Pomfret.

No schools, child day-care facilities, or group homes are located along the variation. However, low-density residential developments are located near the route variation in the vicinity of Barrett Hill Road in Brooklyn, and Searles, Cooney, and Spaulding roads in Pomfret. In these areas, five homes are located within 300 feet of the edge of the variation ROW.

The route variation does not cross any parks, open space, recreation, or public trust lands. A Wolf Den Land Trust parcel is located along Darby Road to the east and south of the route variation (refer to the Volume 9 maps).

15.4.2.4.5 Transportation, Access, and Utility Crossings

The Brooklyn Overhead Variation would cross three local roads: Barrett Hill Road in the Town of Brooklyn, and Spaulding Road and Searles Road in the Town of Pomfret. The variation also crosses a 23-kV electric distribution line ROW in Brooklyn, just south of Barrett Hill Road.

15.4.2.4.6 Cultural (Archaeological and Historic) Resources

Based on the analysis of published cultural resource data, there are no reported archaeological sites within 1 mile of the Brooklyn Overhead Variation. Approximately 80% of the variation route appears sensitive for possible Native American archaeological resources. This variation route appears to have limited sensitivity for possible Euro-American archaeological resources (refer to the *Cultural Resources Assessment* in Volume 3). No significant above-ground historic sites or structures were identified within approximately 0.25 mile of the variation.

15.4.2.5 Potential Environmental Effects and Mitigation Measures

The construction and operation of a new 345-kV transmission line along the Brooklyn Overhead Variation would cause both temporary and long-term effects associated with the creation of a new utility corridor on presently undeveloped land. In addition, the development of the new 3.3-mile “greenfield” ROW segment would not be consistent with state and federal policies that advocate the collocation of utility corridors to the extent possible, and would generally be inconsistent with the land preservation policies advocated within the Quinebaug-Shetucket Rivers Valley National Heritage Corridor.

Appendix 15A describes the typical environmental effects that would be caused by the construction and operation of an overhead transmission line along a new corridor. The appendix also identifies the mitigation measures that CL&P would typically use to minimize adverse effects to the extent possible.

In general, as summarized in Table 15-20, the development of the 345-kV overhead H-frame line segment on the new 3.3-mile ROW would affect vegetation and wildlife resources, soils, water resources, land use and visual resources, cultural resources, and transportation. In addition, the acquisition from private landowners of 58.8 acres of easement for utility purposes would affect land-use patterns. Table 15-20 reviews these potential environmental effects, and lists the mitigation measures that CL&P would typically use to minimize, to the extent practical, adverse effects from transmission line construction and operation.

Table 15-20: Summary of Primary Effects and Potential Mitigation for the Brooklyn Overhead Variation

Environmental Feature	Potential Environmental / Social Effects		Potential Mitigation
	Construction	**Operation / Maintenance**	
Topography and Soils	Grading / filling along ROW to create access roads for use during construction; soil disturbance at structure installation / crane pad sites and other on-ROW staging areas	Permanent access roads along ROW and to structure sites may require permanent fill or topographic alteration	Use temporary soil erosion and sediment control measures to minimize erosion and sedimentation during construction; revegetate or otherwise stabilize disturbed areas of ROW after construction
Water Resources	Access road crossings of wetlands and watercourses (temporary and possibly permanent fill). Potential effects associated with dewatering if groundwater if encountered in structure foundation excavations. Wetland vegetation removal.	Potential net loss wetlands due to permanent access road; conversion of forested wetlands to scrub-shrub for the life of the Project	Use temporary erosion and sediment controls to minimize off-ROW water resource impacts. Revegetate or otherwise stabilize disturbed soil areas to limit the potential for sedimentation into water resources. Restore wetlands as final phase of construction. Coordinate with USACE and CT DEEP regarding off-site compensation for permanent loss of wetlands.
Biological Resources	Removal of approximately 49.7 acres of forest lands (including 47.6 acres of upland forest and 2.1 acres of forested wetland)	Permanent conversion of forested areas, including forested wetland to scrub-shrub vegetative communities; net loss of wetland habitat as detailed above due to access roads and cable trench. Creation of entirely new ROW through large tracts of forest land could promote forest fragmentation	Off-site compensation, in coordination with USACE and CT DEEP
Land Use, including Statutory Facilities and Designated Recreational Areas	The new ROW would encompass approximately 49.7 acres of forest, as well as 1.5 acres of old field shrub land, 0.4 acre of ROW, and 3.1 acres of agricultural land.	Permanent new utility easements across privately-owned properties along the length of the ROW segment. Limitations on land uses within the ROW, consistent with overhead transmission line use.	Easement acquisition process would compensate landowners for new ROW

Environmental Feature	Potential Environmental / Social Effects		Potential Mitigation
	Construction	Operation / Maintenance	
Visual Resources	Vegetation clearing will open up new views, as well as views of the ROW.	Long-term change in visual resources as a result of the development of the new ROW and overhead structures	Potential vegetation screening at road crossings (e.g., allow taller shrubs adjacent to public road crossings)
Transportation	Potential increase in traffic along roads leading to the ROW as a result of the movement of construction vehicles and equipment	Permanent access may be required along ROW	Implement traffic management plan during construction; coordinate with town officials
Cultural Resources	Archaeological sites within the construction footprint could be adversely and permanently affected as a result of earth-disturbing activities such as access road development or structure installation.	None	Conduct field investigations to identify archaeological sites and, if significant sites are found, to develop appropriate mitigation measures (e.g., data recovery), based on consultations with the SHPO

15.4.2.6 Electric and Magnetic Fields

Electric and magnetic fields were calculated for a new 345-kV transmission line along the 3.3-mile Brooklyn Overhead Variation. For these calculations, CL&P assumed that the overhead line would be constructed using H-frame structures centered on a 150-foot-wide, greenfield ROW (refer to the cross-sections in Appendix 15B). The relatively short length of the variation would not significantly change the new circuit's impedance, and therefore the same circuit currents were used for these calculations as were used for the proposed overhead line configuration and route. Volume 1, Section 7 of the Application includes details on the system assumptions made in the power-flow modeling to determine these circuit currents. Magnetic fields across the new ROW produced by the new 345-kV line at AAL were calculated and are graphed as illustrated on Figure 15-7. The calculated levels of magnetic and electric fields at the ROW edges of the Brooklyn Overhead Variation route after the completion of the Project at AAL are summarized in Table 15-21.

Figure 15-7: Magnetic Field Profiles Under Post-NEEWS (2020) Conditions at AAL for the Brooklyn Overhead Variation

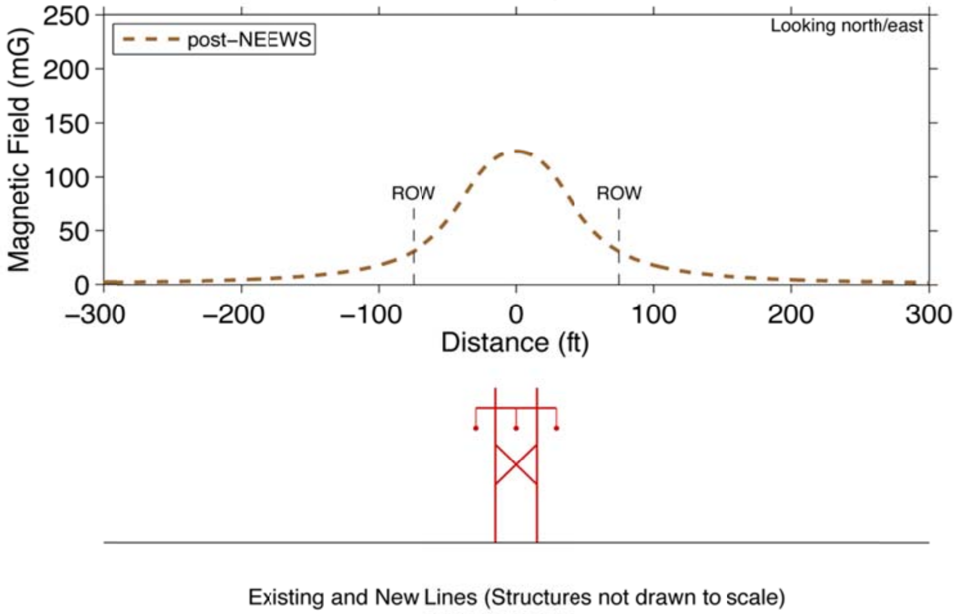


Table 15-21: Post-NEEWS (2020) EMF Levels at the Edge of the ROW at AAL for the Brooklyn Overhead Variation

Cross-Section	Magnetic Field (mG)		Electric Field (kV/m)	
	West/North ROW Edge	East/South ROW Edge	West/North ROW Edge	East/South ROW Edge
XS-B-1 Post-NEEWS	30.9	30.9	1.67	1.67

If the Brooklyn Overhead Variation (BOV) was incorporated into the route for the new 345-kV line, two separate ROWs, each occupied by 345-kV transmission lines, would extend through the eastern portion of the Town of Brooklyn. The existing transmission lines would remain on the existing CL&P ROW segments, but would carry different currents in 2020 than they would prior to the Project. The calculated levels of electric and magnetic fields in 2020 along the edges of the existing ROW segments (i.e., XS-6, XS-6 BMP and XS-7 in Brooklyn), compared to pre-Project levels in 2015, would be as shown in Table 15-22.

Table 15-22: Summary of Pre-Interstate (2015) and Post-NEEWS (2020) EMF Levels at the Edge of the Existing ROW at AAL for Existing ROW Segments With and Without Completion of the Brooklyn Overhead Variation (BOV)

Cross-Section	Magnetic Field (mG)		Electric Field (kV/m)	
	West/North ROW Edge	East/South ROW Edge	West/North ROW Edge	East/South ROW Edge
XS-6 Pre-Project	4.6	28.0	0.09	1.20
XS-6 Post-NEEWS With BOV	3.9	24.0	0.09	1.20
XS-6 Post-NEEWS Without BOV	7.2	18.4	0.39	1.19
XS-6 BMP Pre-Project	4.6	28.0	0.09	1.20
XS-6 BMP Post-NEEWS With BOV	3.9	24.0	0.09	1.20
XS-6 BMP Post-NEEWS Without BOV	5.2	20.6	0.28	1.21
XS-7 Pre-Project	6.4	16.6	0.18	0.68
XS 7 Post-NEEWS With BOV	5.3	17.4	0.18	0.68
XS 7 Post-NEEWS Without BOV	20.0	18.7	1,22	0.67

Magnetic field levels in 2020 along both edges of the existing XS-6 ROW and one edge of the existing XS-7 ROW would be slightly reduced from the 2015 pre-Project levels by constructing the new 3.3-mile overhead 345-kV H-frame line section on a different ROW (BOV). On the east/south edge of the avoided XS-7 ROW segment, the 2020 magnetic field level would slightly increase. These changes would result from changes in circuit currents after the new line is added to the system.

However, the Brooklyn Overhead Variation would result in magnetic fields along two separate ROWs, and the opportunity for reducing magnetic fields along the existing ROW by cancellation through best circuit phasings with a new line would be lost. To show this effect, Table 15-22 also includes data for the post-Project projections with the new transmission line constructed as proposed along the existing route (i.e. "XS-6 – Post Without BOV", "XS-6 BMP – Post Without BOV", and "XS-7 – Post Without BOV").

15.4.2.7 Comparison of the Brooklyn Overhead Variation to the Segment of the Proposed Route Replaced

As summarized in Table 15-23, compared to the development of a new 345-kV overhead transmission line within CL&P's existing ROW, the use of the Brooklyn Overhead Variation would cause greater overall impacts to environmental resources (particularly forested habitat), land uses, visual resources, and privately-owned properties, and would increase Project costs. In addition, the use of this variation would result in the creation of two ROWs, each supporting one 345-kV line without the benefit of magnetic field cancellation. As a result, for the primary reasons summarized below, the proposed Project (i.e., the 345-kV overhead transmission line, located within CL&P's existing ROW) is preferred.

While the development of the comparable 3.4-mile segment of the proposed 345-kV overhead transmission line within CL&P's ROW would cost $16.9 million, the capital cost of the overhead H-frame Brooklyn Overhead Variation is estimated at $27.4 million. This cost includes an estimate for the acquisition of the new ROW. Therefore, the use of the Brooklyn Overhead Variation would add a net $10.5 million to the total cost of the Project. As described in Section 14.3.1.3, these increased costs would not likely qualify for inclusion in New England regional transmission rates. As a result, in addition to paying 27% of the cost of building the base-case overhead line, Connecticut consumers would likely be responsible for paying100% of any costs that exceed the cost of building the base-case overhead line, including extra costs for construction of the overhead route variation and EMF BMP line designs.

Table 15-23: Comparison of the Brooklyn Overhead Variation to the Proposed Overhead Line to be Replaced

Route Characteristic	Proposed Overhead Transmission Line Along Existing ROW to be Replaced	Brooklyn Overhead Variation
Location, Design, and Appearance		
Route Location (ROW, Town)	Existing CL&P ROW (Brooklyn, Pomfret)	New ROW (Brooklyn, Pomfret)
Route Length (miles)	3.4 miles	3.3 miles
Structures (type, est. number)	H-frame (19) Delta (11)	H-frame (28)
New ROW Easements or Land Acquisition Required (est. acres)	0	58.8 acres
Biological Resources		
Upland Forest Clearing (est. acres)	12.9 acres	47.7 acres
Forested Wetland Clearing (est. acres)	3.2 acres	2.1 acres
Scrub-Shrub Clearing (est. acres)	4.3 acres (upland) 1.9 acres (wetland)	1.5 acres (upland) 1.2 acres (wetland)
Watercourse Crossings (no.)	7 (span)	3 (span)
Wetlands, Permanent Effects (Fill) (est. acres)	0 structures Less than 0.1 acre (access roads)	0 structures[1] 0.6 acre (access roads)
Listed Species (no. species)	1	1
Land Uses		
Designated Recreational or Open Space along ROW (length)	0.2 mile (Wolf Den Land Trust)	0
CL&P-Owned Land Traversed	0.7 mile	0
Total Construction ROW / Work Space, Temporary Land Disturbance (est. acres)	39.1 acres	58.8 acres
Total Permanent ROW (acres)	33.5 acres	58.8 acres
Cost of Transmission Line Segment ($ Million, $ 2010)		
Capital Cost	$16.9	$27.4
Cost to Connecticut Consumers[1]	$5.7	$16.2
Life-cycle Cost	$29.2	$43.8

1. Assumes localization of extra costs for EMF BMP line design.

The Brooklyn Overhead Variation would cost approximately 1.6 times more than the comparable segment of the proposed overhead transmission line. Consequently, the cost to Connecticut consumers for this overhead line variation (based on the cost allocation described above) would be approximately $16.2 million, or approximately three times more than that of the overhead delta line constructed within the existing ROW. This is calculated as follows:

Connecticut consumer cost for section of overhead line to be replaced:

Estimated cost of proposed overhead transmission line (including delta structures for EMF Focus Area D):	$16.9 million
Estimated cost of overhead H-frame transmission line:	$15.3 million
Incremental cost of delta configuration:	$1.6 million
Connecticut consumer cost for overhead section to be replaced = (H-frame line cost x 27%) + (Incremental increase over H-frame x 100%)	$5.7 million

<u>Connecticut consumer cost for overhead variation:</u>

Estimated cost of the overhead variation:	$27.4 million
Incremental cost of overhead variation over an overhead H-frame transmission line within the existing ROW:	$12.1 million
Connecticut consumer cost for overhead variation = (Incremental cost for overhead variation x 100%) + (H-frame line cost x 27%):	$16.2 million

Finally, dividing the Connecticut consumer cost for the overhead variation by the Connecticut consumer cost for the overhead line section to be replaced yields: ($16.2 million / $5.7 million) = 3.

To develop the overhead 345-kV transmission line segment along the Brooklyn Overhead Variation, CL&P would have to obtain easements from private landowners for the 150-foot-wide, 3.3-mile ROW. Overall, approximately 58.8 acres of easements would have to be acquired.

Pursuant to CL&P standards, on lands under easement for utility purposes, landowners would be precluded from uses that would be inconsistent with the safe and reliable operation and maintenance of the line. In comparison, no additional ROW would be required to install the proposed 345-kV overhead transmission line along the portion of the existing transmission ROW that the Brooklyn Overhead Variation would replace, and the lands along the existing ROW are already subject to restrictions regarding activities that are inconsistent with utility line use.

In summary, CL&P prefers the proposed overhead transmission line within the existing ROW and not the Brooklyn Overhead Variation. Compared to the proposed transmission line, the Brooklyn Overhead Variation would increase costs, result in greater long-term environmental effects (particularly to forest lands), and would require the permanent conversion to utility purposes of 58.8 acres of privately-owned land.

Selection of this greenfield ROW over use of the existing ROW would be inconsistent with the FERC environmental guidelines to which new transmission line projects are required to conform.[17] Moreover, the development of the transmission line along the route variation would introduce a new source of transmission line magnetic fields along a new corridor, while not achieving a significant overall reduction in magnetic fields in the vicinity of the existing CL&P ROW where certain residences are located nearby.

15.4.3 Brooklyn Underground Variation

15.4.3.1 Location of the Underground Variation

The 1.4-mile Brooklyn Underground Variation (refer to Figure 15-8) would be located entirely in the Town of Brooklyn and would replace 1.4 miles of the proposed 345-kV overhead transmission line route. The variation would involve the development of a 345-kV cable system, starting at a point northeast of

[17] The Council is required to find that the overhead portions of any new transmission line will be consistent with the FERC's "Guidelines for the Protection of Natural Historic Scenic and Recreational Values in the Design and Location of Rights-of-Way and Transmission Facilities, " Conn. Gen. Stats. ¶16-50p(a)(3)(D)(iii). In order to minimize conflicts between electric transmission rights-of-way and other land uses, these guidelines specify that "existing rights-of-way should be given priority as locations for additions to existing transmission facilities." *Id.*,1

the proposed 345-kV transmission line structure No. 208 on CL&P's existing 300-foot-wide ROW and ending near the proposed 345-kV transmission line structure No. 222 north of Day Street Junction on CL&P's existing 360-foot-wide ROW.

The underground line variation would extend northeast from a new 345-kV line transition station to be located approximately 0.8 mile west of Church Street to a new 345-kV line transition station located on CL&P-owned property approximately 0.2 mile north of Day Street Junction. Except for the western line transition station, which would be located on private property adjacent to the ROW, the underground cable system would be aligned within CL&P's ROW or on CL&P-owned property.

15.4.3.2 Technical Description (Design, Appearance, Land Requirements, Cost)

The Brooklyn Underground Variation would replace 1.4 miles of the proposed 345-kV overhead transmission line.[18] Cross-sections in Appendix 15B (XS-UG-2 and -3) illustrate the location of the underground cable system within the CL&P ROW west of Day Street Junction and north of Day Street Junction, respectively. As these cross-sections illustrate, the centerline of the underground cable system would be offset 15 feet from the outside conductors of the existing 330 Line.

The underground cable system would be developed principally within CL&P's existing ROWs or on CL&P-owned property. However, up to 4 acres of privately-owned property would have to be acquired for development of the line transition station at the western end of the underground cable segment. In addition, CL&P would have to obtain easement rights to install the underground cable system within the overhead line ROW.

[18] Along the portion of CL&P's 300-foot-wide (typical width) ROW that extends east-northeast through the Town of Brooklyn to Day Street Junction, the new overhead transmission line is proposed for location north of and adjacent to the 330 Line. At Day Street Junction, the CL&P ROW turns to the north and encompasses 360 feet; in this area, the proposed overhead 345-kV transmission line would be located within the ROW to the west of the Line 330. Two existing 115-kV transmission lines (i.e., the 1607 and 1505 Lines) also occupy the ROW in this area. (For information concerning the configuration of the proposed overhead line route in this area, refer to XS-6, XS-6-BMP, and XS-7 in Volume 1, Section 3 (Appendix 3A), Volume 9, and Volume 10).

The capital cost of the Brooklyn Underground Variation is estimated at $82 million. In comparison, the capital cost for the proposed 345-kV overhead transmission line along this 1.4-mile segment is estimated at $8.2 million or $73.8 million less than the cost of the underground variation.

15.4.3.3 Construction and Operation/Maintenance Considerations

Along the Brooklyn Underground Variation, the construction of the cable system (duct banks, splice vaults, cable installation) and associated line transition stations would be performed using the methods described in Section 14.3.2. Cable-system installation requires continuous trenching and, as a result, land along the entire length of the variation would be disturbed. Up to 8 acres of land also would have to be cleared and leveled for the development of the line transition stations at each end of the cable route.

The construction of the Brooklyn Underground Variation would disturb up to 15 acres of land for the installation of the cable duct banks, four sets of splice vaults, access road, and line transition stations. The installation of the duct bank would involve the use of a 40-foot-wide construction work area along the 1.4-mile underground cable segment, affecting 6.7 acres. At the splice-vault locations, an additional 0.4 acre would be required outside of this 40-foot-wide construction work area. Within this construction footprint, land would have to be cleared of vegetation and graded and filled as necessary to create a level construction work space and to accommodate a 20-foot-wide access road along the length of the cable route. Each of the splice vaults (spaced at intervals of approximately 1,600 feet) along the underground cable route would require approximately 0.25 acre (80 feet x 130 feet); half of this work room would be within the 40-foot-wide construction area along the duct bank. To reach the on-ROW access road required for the cable-system installation, equipment and vehicles would most likely use Church Street.

Up to an additional 4 acres of land would have to be acquired (in fee ownership) and subsequently cleared and leveled for the development of the line transition station at the western end of the cable route. Although the line transition station at the eastern terminus of the underground variation would be located within a large parcel of CL&P-owned property, the site would have to be cleared of forested vegetation, graded, and otherwise prepared for site development.

Compared to overhead transmission line installation, underground cable-system construction is more time consuming. Underground cable-system construction timeframes can vary significantly, depending on site-specific conditions, such as the amount of grading required along the ROW and the type of subsurface conditions encountered during excavations for the duct bank and splice vaults. On average, after clearing and grading are completed along the ROW, trenching could be expected to progress at between 50 and 100 feet per day. Construction of each of the line transition stations can be expected to require between 12 and 18 months. As a result, the construction of the cable system along the Brooklyn Underground Variation, including the line transition stations, could require approximately 18 months to complete.

The operation of the underground cable system would require the maintenance of a permanent access road along the length of the route variation. This road would provide access to both the cable system (i.e., duct banks and splice vaults) and the line transition stations. Access to the on-ROW road would be via Church Street. In addition, each of the line transition stations would consist of an above-ground line-terminal structure, a control building, and related equipment to interconnect the underground cable system to the overhead portion of the 345-kV transmission line. The developed portion of each station would be graded, surfaced with crushed stone, and fenced.

15.4.3.4 Existing Environmental Features

15.4.3.4.1 Topography, Geology, and Soils

Elevations along the Brooklyn Underground Variation range from approximately 200 feet NGVD to 330 feet NGVD. Bedrock geology in the area includes the Quinebaug and Tatnic Hill formations. Surficial geology along the variation consists primarily of sand and gravel, and sand and gravel overlying sand and fines. As is the case for this segment of the proposed route, the variation traverses some soils classified as Prime Farmland or Farmland Soils of Statewide Importance (refer to Table 15-24).

Table 15-24: Soils and Soil Characteristics along the Brooklyn Underground Variation

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
13* Walpole sandy loam	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	Yes	--	--	0.0-1.0
15 Scarboro muck	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	Yes	--	--	0.0-1.0
17 Timakwa and Natchaug	Woody organic material over sandy and gravelly glaciofluvial deposits, and woody organic material over loamy alluvium and/or loamy glaciofluvial deposits and/or loamy till	Yes	--	--	0.0-1.0
23A** Sudbury sandy loam, 0 to 5% slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss, and coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.43	--	1.5-3.0
38C* Hinckley gravelly sandy loam, 3 to 15 % slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--
50A** Sutton fine sandy loam, 0 to 3 % slopes	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.15	--	1.5-2.5
50B** Sutton fine sandy loam, 3 to 8 % slopes	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.15	--	1.5-2.5
61B Canton and Charlton, 3 to 8 % slopes, very stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
62C Canton and Charlton, 3 to 15 % slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
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	0.17	20-40	--
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	0.17	20-40	--
108 Saco silt loam	Coarse-silty alluvium	Yes	0.2	--	0.0-0.5

Source: USDA Natural Resources Conservation Service, Online Soil Surveys and Geographic Data of Windham County 2009.
* Soils classified as Farmland Soils of Statewide Importance
** Soils classified as Prime Farmland Soils
1. Erosion Factor (K (dimensionless)): Indicates the erodability of the whole soil, the higher the value, the more susceptible the soil to erosion. -- No Data Available. No bedrock or water encountered to survey depth.

15.4.3.4.2 Water Resources

The Brooklyn Underground Variation is located within the Quinebaug River drainage basin. Because the underground variation would be aligned within a 1.4-mile segment of CL&P's ROW, the wetlands and watercourses along the variation were delineated in 2008 and verified in 2011 as part of field investigations of the proposed overhead transmission line route.

The underground variation would cross three perennial, Class A streams: White Brook, Creamery Brook, and an un-named watercourse. The route of the cables would cross the 100-year FEMA floodplains associated with White Brook and Creamery Brook. In addition, a fourth watercourse (an un-named Class A stream), abuts the western boundary of the western line transition station site. The underground variation does not traverse any SCELs.

Based on the 2008 and 2011 wetland delineation surveys, six wetlands are located along the Brooklyn Underground Variation. Table 15-25 summarizes the characteristics of these wetlands, including those that provide vernal pool / amphibian habitat (refer to Volume 2 for additional information regarding each wetland).

As illustrated on the Volume 9 maps and summarized in Table 15-25, the underground variation would extend through several large wetland complexes, including a 1,615-foot crossing of wetland W20-157. Overall, less than approximately 0.1 acre of palustrine-forested wetland, approximately 0.7 acres of scrub-shrub wetland, and approximately 1.2 acres of palustrine-emergent marsh wetland would be located along the portion of the CL&P ROW that would be affected by the Brooklyn Underground Variation. All of these wetlands would be traversed (generally, spanned) by the comparable section of the proposed overhead 345-kV transmission line route.

Table 15-25: Delineated Wetlands / Vernal Pools and Wetland Supporting Amphibian Habitat: Brooklyn Underground Variation

Vol. 9 Mapsheet Nos.	Wetland Series No.[1]	Wetland Classification[2]	Relationship to Proposed Underground Variation (Feet traversed / adjacent)[3]	Vernal Pool / Amphibian Breeding Habitat		
				Vernal Pool / Habitat No.[4]	Location along ROWs	Species Observed
1 of 2	W20-157	PEM / PSS / PFO	1,615 feet	BR-18-VP	South of access road, beneath existing 345-kV line	Spotted salamande
1 of 2	W20-158	PSS / PUB / PFO	325 feet	BR-19-VP	Beneath and north of existing 345-kV line	Spotted salamande amphibious snails, caddisfly larvae
1 of 2	W20-159	PFO / PSS	South of existing 345-kV 330 Line and access road			
2 of 2	W20-159A	PEM / PFO	Adjacent			
2 of 2	W20-160	PSS / PFO	260 feet	BR-6-ABH	Off ROW	Spotted salamander, green frog, aquatic beetle
2 of 2	W20-160A	PSS	Off-ROW access road (30 feet)			

NOTES:

1. Series No. refers to wetland number designated in the field report (Volume 2) and illustrated on the aerial photographs in Volume 9. The CL&P ROW segment along which the Brooklyn Underground Variation would be located also is depicted on the Volume 11 maps (mapsheets 84 through 89).
2. Wetlands classification according to Cowardin et al 1979; PEM = Palustrine Emergent Wetland; PFO = Palustrine Forested Wetland; PSS = Palustrine Scrub-Shrub Wetland; POW = Palustrine Open Water; PUB = Palustrine Unconsolidated Bottom.
3. "Feet traversed" refers to linear distance crossed by center of 345-kV cable route, as depicted on the Volume 9 maps.
4. Refers to vernal pool habitat number assigned during field surveys

Shading = Denotes wetland that provides vernal pool / amphibian habitat.

Groundwater in the vicinity of the Brooklyn Underground Variation is classified as "GA". No public wells, aquifer protection public supply wells, or Connecticut Aquifer Protection Areas are crossed by or within the vicinity of the underground variation. Near the route, drinking water is obtained primarily from private groundwater wells.

15.4.3.4.3 Biological Resources

Vegetative Communities

The vegetative community types along the Brooklyn Underground Variation consist of the scrub-shrub habitat maintained on the existing CL&P ROWs, as well as scattered areas of old field, forests, wetlands, and maintained lawn / ornamental vegetation. Overall, the footprint of the Brooklyn Underground Variation (based on a typical 40-foot-wide construction work area and the development of 8 acres for the two line transition stations) would encompass approximately 15 acres. Of this 15 total acres, approximately 4.6 acres are presently forested (upland and wetland). Of the 4.6 acres of forest, less than 0.1 acre is forested wetland. The ROW would encompass a total of 2.0 acres of wetlands, comprised of 1.2 acres of emergent wetland, 0.7 acre of scrub-shrub wetland and less than 0.1 acre of forest wetland.

Fish and Wildlife Resources

Based on consultations with the CT DEEP, two of the perennial watercourses traversed by the underground variation (White Brook and Creamery Brook) could contain coldwater fish species. No fisheries data was available for watercourse S20-53. The CT DEEP stocks White Brook with hatchery-raised adult-sized trout (adult brook, brown, and rainbow trout) for put-and-take purposes within publicly-accessible portions the brook. Wildlife species in the vicinity of the underground variation are likely to be those most commonly associated with forested upland and wetland areas, as well as scrub-shrub habitats (refer to Volume 1, Section 5 for a discussion of such species).

Amphibians

As summarized in Table 15-26, based on the 2008 and 2011 field surveys of the CL&P ROWs, two vernal pools (in wetlands W20-157 and W20-158) were confirmed within the portion of the CL&P ROW along which the underground variation would be located. In addition, an amphibian-breeding habitat was confirmed in wetland W20-160.

Listed Species

Based on consultations with the USFWS and the CT NDDB, the Brooklyn Underground Variation does not encompass any areas of known habitat for either federally- or state-listed species.

15.4.3.4.4 Land Uses

The Brooklyn Underground Variation would be aligned predominantly within CL&P's existing ROWs or on CL&P-owned lands, where land is presently dedicated to utility use. The underground cables would extend primarily across portions of the CL&P ROWs that are either presently managed in scrub-shrub vegetation (consistent with CL&P's overhead transmission line operation and maintenance procedures) or consist of forested vegetation. Along the underground variation, land uses consist of open field / shrub lands upland (6.7 acres), forest (4.6 acres), agricultural (1.8 acres), emergent wetland (1.2 acres), scrub-shrub wetland (0.7 acre) and road ROW (less than 0.1 acre).

Approximately 0.5 miles (38%) of the underground cable-system route would extend across CL&P-owned land, which is located adjacent to Church Street and in the vicinity of Day Street Junction. The remainder of the cable-system route would traverse privately-owned property on which CL&P has only overhead line easement rights. Although the eastern line transition station would be sited on CL&P-owned property, CL&P would have to purchase up to 4 acres of land for the western line transition station site.

As illustrated on the Volume 9 maps, lands along and in the vicinity of the Brooklyn Underground Variation are zoned for Rural Agricultural (RA) and Residence 30 (R-30) uses. Two residential day-care facilities are located in the vicinity of the underground variation near Church Street. Single-family residential homes are located near CL&P's ROW along Darby Road, Church Street, Meadowbrook Drive, and Hickory Lane.

The Brooklyn Underground Variation would traverse approximately 1,100 feet of land designated within the Wolf Den Land Trust's White Brook property (refer to Volume 9 mapsheet 1 of 2 along the Brooklyn Underground Variation). Other than this location, the underground variation would not cross any parks, open space, recreation, or public trust lands.

15.4.3.4.5 Transportation, Access, and Utility Crossings

The Brooklyn Underground Variation crosses Church Street, a local road.

15.4.3.4.6 Cultural (Archaeological and Historic) Resources

Because the Brooklyn Underground Variation would be aligned within CL&P's ROW, the cultural resource studies conducted for the Proposed Route apply to the 1.4-mile underground variation (refer to Volume 1, Sections 5 and 6, and the *Cultural Resources Assessment* in Volume 3). A review of historical records revealed that there are no reported archaeological sites located within 1 mile of the variation, and no significant historic resources within approximately 500 feet of the variation.

Using the assessment procedures designed to identify the sensitivity of Proposed Route areas for undiscovered archaeological sites, approximately 77% of the Brooklyn Underground Variation was identified as sensitive for possible Native American archaeological sites. Subsequently, cultural resource field studies, consisting of subsurface reconnaissance investigations, were completed for approximately 90% of the areas along the Proposed Route segment where overhead line construction activities could disturb soils (e.g., proposed structure sites, construction pads, access roads, forest vegetation clearing locations).

These investigations confirmed the archaeological sensitivity of the ROW segment associated with the Brooklyn Underground Variation, locating five Native American sites potentially eligible for the NRHP/SRHP. Additional cultural resource reconnaissance studies would be required to determine the potential for cultural resource sites (and potential site significance if sites are discovered) in areas along the underground variation that were not part of the field investigations for the Proposed Route; such areas would include the line transition station sites and all areas of potential disturbance along the cable-system route, including splice-vault locations.

15.4.3.5 Potential Environmental Effects and Mitigation Measures

The construction and operation of the 345-kV cable segment along the Brooklyn Underground Variation would cause direct temporary and permanent effects on topography, soils, water resources (including vernal pools), vegetation and wildlife, land uses and visual resources, cultural resources, and transportation. Construction activities also would create nuisance type effects on local residents in terms of noise and dust from on-ROW cable-system installation activities, as well as from the movement of construction equipment and vehicles along Church Street to access the ROW.

Appendix 15A describes the typical environmental effects caused by the construction and operation of an underground cable system, and identifies the mitigation measures that CL&P would typically use to minimize adverse effects to the extent possible. Table 15-26 summarizes these potential environmental effects, along with the mitigation measures that CL&P would typically use to minimize adverse effects to the extent possible.

Table 15-26: Summary of Primary Effects and Potential Mitigation for the Brooklyn Underground Variation

Environmental Feature	Potential Environmental / Social Effects		Potential Mitigation
	Construction	Operation / Maintenance	
Topography and Soils	Effects on topography and soils due to: • Grading / filling along 1.4-mile construction ROW • Grading / filling at line transition station sites • Excavations for duct bank trench and splice vaults. Potential for erosion and sedimentation into watercourses and wetlands.	Permanent changes in topography along ROW as a result of grading and creation of a permanent access road. Permanent change in topography and soils at line transition station sites	Install temporary erosion and sediment controls. Segregate topsoil layer during construction. To the extent practical and safe, restore contours and replace topsoil along ROW as part of restoration.
Water Resources	Direct disturbance to three perennial streams and four wetlands (including one large wetland complex) as a result of clearing, grading, excavating for trench / splice vaults, and access road development. Less than approximately 0.1 acre of forested wetland, approximately 0.7 acre of scrub-shrub wetland and approximately 1.2 acres of emergent marsh wetland would be affected. Potential sedimentation associated with dewatering if groundwater is encountered in excavations. Installation of flowable thermal backfill in duct bank will constitute permanent fill in wetlands, as will the development of permanent access roads through wetlands.	An estimated net loss of approximately 1 acre of wetlands due to duct bank fill and access roads	Use temporary erosion and sediment controls to minimize off-ROW water resource impacts. Revegetate or otherwise stabilize disturbed soil areas to limit the potential for sedimentation into water resources. Coordinate with USACE and CT DEEP regarding off-site compensation for permanent loss of wetlands.
Biological Resources	Direct disturbance of approximately 15.1 acres of habitat as a result of construction, including removal of 4.6 acres of forest lands (including 4.6 acres of upland forest and less than 0.1 acre of forested wetland).	Permanent conversion of forested areas, including forested wetland to scrub-shrub vegetative communities; net loss of wetland habitat as detailed above due to access roads and cable trench. Permanent net loss of all habitat types as a result of the creation of access road along the length of the cable system. Net loss of vegetative habitat at transition station sites, which will be converted to utility use.	Coordinate with CT DEEP regarding mitigation, if required, for the frosted elfin butterfly

Environmental Feature	Potential Environmental / Social Effects		Potential Mitigation
	Construction	**Operation / Maintenance**	
Land Use, including Statutory Facilities and Designated Recreational Areas	Cable system would affect approximately acres of open field and shrub land; acre of transportation ROWs; acres of upland forest; acres of agricultural land. The western line transition station would be developed adjacent to the Wolf Den Land Trust's White Brook property, and would be visible from this designated open space area. The cable system also would require the creation of a construction access road, which would remain permanently, through this land trust parcel.	Permanent change in land use at line transition station sites.	Coordinate with Wolf Den Land Trust to evaluate mitigation options for the access road through the land trust property
Visual Resources	Visual changes associated with the development of the line transition station sites, including the removal of existing forested vegetation. Construction activities along the ROW will cause temporary changes in the viewscape.	Change to visual environment associated with the development of the line transition stations on previously undeveloped forested sites; maintenance of permanent access road along 1.4-mile ROW. Line transition station sites will be potentially visible from nearby residential areas and from the Wolf Den Land Trust White Brook parcel (western line transition station).	Visual screening
Transportation	Increase in traffic along Storrs Road and Bassetts Bridge Road as a result of movement of construction equipment and vehicles to / from the ROW; lane closures and delays during trenching across Church Street.	Permanent on-ROW road required to access line transition stations and for access along cable system ROW. Public ingress / egress to this access road would be via Church Street.	Implement traffic management plan during construction; coordinate with Town of Brooklyn
Cultural Resources	Any archaeological sites within the construction footprint would be adversely and permanently affected as a result of earth-disturbing activities such as grading, excavation, and access road development	Permanent adverse effects would occur to archaeological sites during construction	Conduct field investigations to identify archaeological sites and, if significant sites are found, to develop appropriate mitigation measures (e.g., data recovery), based on consultations with the SHPO

15.4.3.6 Electric and Magnetic Fields

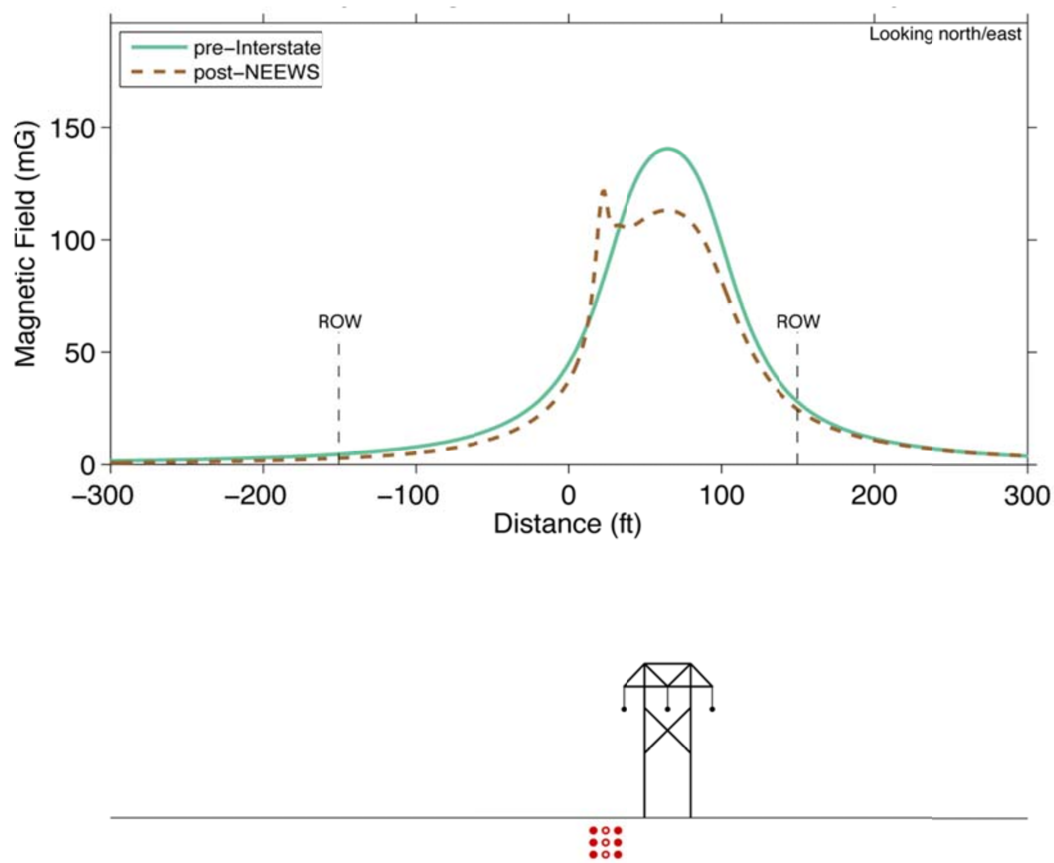
Electric and magnetic fields were calculated for the 1.4-mile Brooklyn Underground Variation. The electric and magnetic field calculations are based on the alignment of the underground cable system offset 41 feet west/north from the centerline of the existing 330 Line within CL&P's 300- to 360-foot-wide ROW. These configurations are represented in Cross-Sections XS-UG-2 and XS-UG-3 (refer to Appendix 15B), which correspond to proposed overhead line routes illustrated in XS-6 and XS-7, respectively (refer to Volume 1, Section 3, Appendix 3A).

The relatively short length of the variation would not significantly change the new circuit's impedance, and therefore the same circuit currents were used for these calculations as were used for the proposed overhead line configuration. Volume 1, Section 7 of the Application includes details on the system assumptions made in the power-flow modeling used to determine these circuit currents.

Magnetic fields across the ROW produced by both the existing overhead transmission line and the Brooklyn Underground Variation along this section of the ROW at AAL were calculated and graphed as illustrated on Figure 15-8 and Figure 15-9 for segments XS-UG-2 (west of Day Street Junction) and XS-UG-3 (north of Day Street Junction) respectively. The underground cable system location in relation to the existing overhead H-frame transmission line is shown in red on the sketch beneath each graph. The calculated levels of magnetic and electric fields at the ROW edges before and after the completion of the Project with the Brooklyn Underground Variation at AAL are summarized in Table 15-27.

As Figure 15-8 and Figure 15-9 illustrate, magnetic fields are elevated directly above and near the underground cable system. Magnetic fields at both edges of the ROW for XS-UG-2 are 2 to 4 mG lower in 2020 than the pre-Project levels in 2015 under the conservatively projected AAL conditions in each year (refer to Table 15-27). However, post-NEEWS (2020) XS-UG-3 magnetic fields are only reduced at west/north ROW edge of the ROW, and increase at the east/south ROW edge when compared to pre-Project (2015) levels. Near cable-splice vaults, the magnetic field contribution by the underground cables would increase because of increased spacing between the cables.

Figure 15-8: Magnetic Fields Under Pre-Interstate (2015) and Post-NEEWS (2020) Conditions at AAL for the Brooklyn Underground Variation in XS-UG-2



Existing and New Lines (Structures not drawn to scale)

Figure 15-9: Magnetic Fields Under Pre-Interstate (2015) and Post-NEEWS (2020) Conditions at AAL for the Brooklyn Underground Variation in XS-UG-3

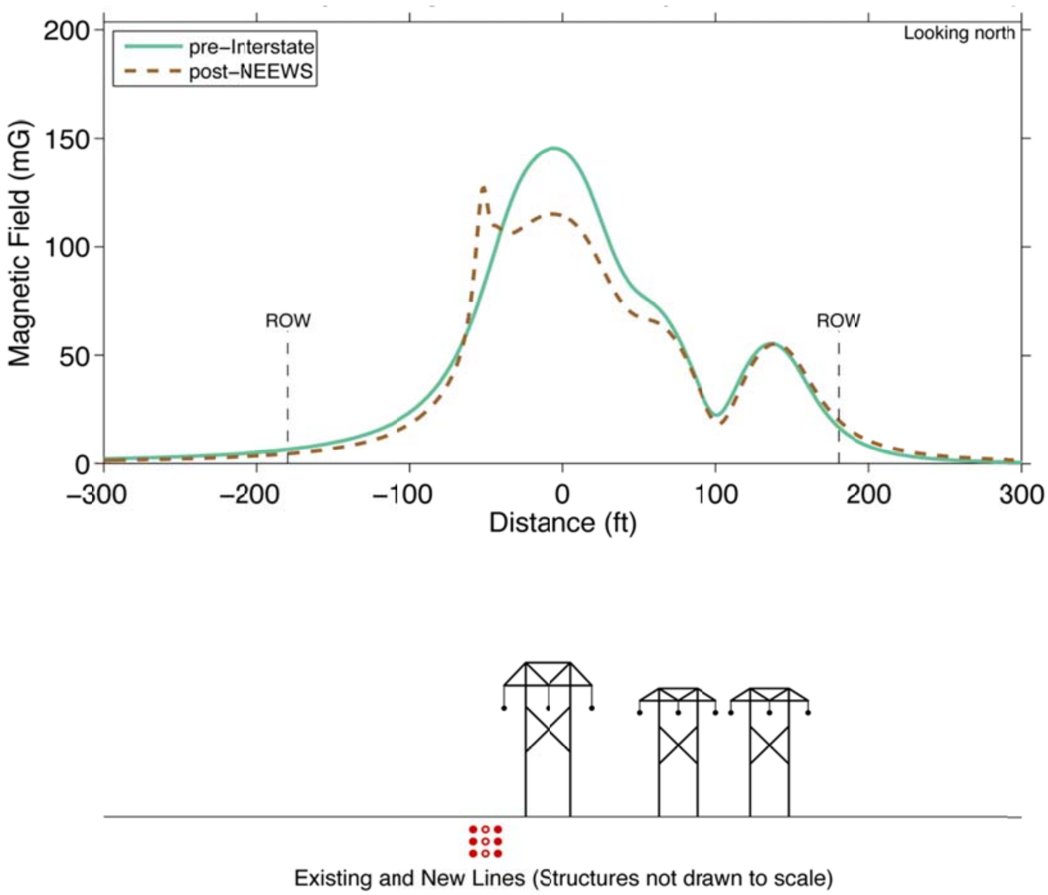


Table 15-27: Summary of Pre-Interstate (2015) and Post-NEEWS (2020) EMF Levels at the Edge of the ROW at AAL for the Brooklyn Underground Variation

Cross-Section	Magnetic Field (mG)		Electric Field (kV/m)	
	West/North ROW Edge	East/South ROW Edge	West/North ROW Edge	East/South ROW Edge
XS-UG-2 Pre-Interstate	4.6	28.0	0.09	1.20
XS-UG-2 Post-NEEWS	2.8	24.6	0.09	1.20
XS-UG-3 Pre-Interstate	6.4	16.6	0.18	0.72
XS-UG-3 Post-NEEWS	4.5	19.8	0.18	0.72

The operation of the new 345-kV transmission line with the incorporation of the Brooklyn Underground Variation would result in lower magnetic field levels along the west/north edge of the ROW in this segment of the line route, compared to those existing before the Project. If the new 345-kV line was built overhead as proposed, magnetic fields would be higher than pre-Interstate levels along the west/north edge of the ROW in XS-6 BMP and along both ROW edges in XS-7, but would be lower than the levels on the east/south ROW edge in XS-6 BMP.

The underground variation would actually result in higher magnetic field levels along the east/south ROW edge nearest to the existing line when compared to the proposed overhead line design. The proposed overhead line configuration would employ a best phasing with the existing line, enhancing field cancellation and resulting in a magnetic field reduction at the south ROW edge nearest to the existing line. This effect would be lost if the new line was constructed underground.

As stated above, magnetic field levels would be somewhat higher along the north ROW edge if the proposed line was built overhead within the existing ROW than they would be if the underground variation was adopted. However, the magnetic fields for an overhead line configuration could be reduced by the use of a different overhead line design, such as a delta conductor configuration. (Refer to Appendix 7B for details concerning magnetic field levels and alternative overhead line designs in “Focus Area D”.) Magnetic field levels at AAL at each ROW edge along the Brooklyn Underground Variation are compared for each case in Table 15-28.

Table 15-28: Comparison of Magnetic Field Levels at AAL for Overhead Lines and Underground Variation

ROW Edge	Magnetic Field (mG)			
	Pre-Interstate	Post-NEEWS		
	Existing Configuration	Overhead H-Frame Configuration	Underground Variation	Focus Area D Delta Configuration
West/North, XS-6	4.6	7.2	2.8	5.2
East/South, XS-6	28.0	18.4	24.6	20.6
West, XS-7	6.4	20.0	4.5	N/A
East, XS-7	16.6	18.7	19.8	N/A

Underground transmission cable systems do not produce electric fields above ground. Therefore, the electric field profile across the ROW associated with the Brooklyn Underground Variation would be the same as the existing electric field profile. Thus, in Table 15-27, there is no difference between the ROW edge levels before and after the construction of the Brooklyn Underground Variation. Table 15-29 compares the electric fields at ROW edges with this variation to those with the base overhead line design and the delta overhead line design.

Table 15-29: Comparison of Electric Field Levels for Overhead Lines and the Brooklyn Underground Variation

ROW Edge	Electric Field (kV/m)			
	Pre-Interstate	Post-NEEWS		
	Existing Configuration	Overhead H-Frame Configuration	Underground Variation	Focus Area D Delta Configuration
XS-6 North	0.09	0.39	0.09	0.28
XS-6 South	1.20	1.19	1.20	1.21
XS-7 West	0.18	1.22	0.09	N/A
XS-7 East	0.68	0.67	1.20	N/A

Two Statutory Facilities have been identified in the area near the Brooklyn Underground Variation. Magnetic fields at AAL at the closest points of these two facilities from a ROW edge are shown in Table

15-30 for the 2015 pre-Project condition and for the 2020 post-NEEWS condition with the two alternate line designs. The incorporation of the underground variation would reduce magnetic field levels by about 2 mG (to 2.5 mG) at the Jacqueline Ben Day Care facility. The proposed overhead delta line design using a BMP configuration in this area would produce minimal changes in magnetic field levels at either of the Statutory Facilities near the Brooklyn Underground Variation when compared to 2015 pre-Project levels.

Table 15-30: Magnetic Field Levels at Statutory Facilities Near the Brooklyn Underground Variation Route

Facility	Distance to Nearest Edge of ROW (ft)	Magnetic Fields for Annual Average Load Case (mG)		
		2015	2020 Post-NEEWS	
		Pre-Interstate (mG)	Overhead Delta Configuration*	Underground Variation
Jacqueline Ben Day Care	11	4.2	4.5	2.5
Susan Kirkconnell Day Care	497	0.4	0.3	0.3

* The proposed overhead line design in the specific area nearest these statutory facilities is a delta configuration (See Cross-Section XS-6 BMP). See Appendix 7B for details concerning magnetic field levels and alternative overhead line designs in "Focus Area D".

15.4.3.7 Comparison of the Brooklyn Underground Variation to the Segment of the Proposed Route Replaced

As summarized in Table 15-31, compared to the development of the new 345-kV overhead transmission line within CL&P's existing ROW, the use of the Brooklyn Underground Variation would substantially increase Project costs. In addition, the development of the underground cable system and associated line transition stations would cause direct impacts to environmental resources (e.g., wetlands, including a large wetland complex, vernal pools; amphibian habitat); visual resources; and privately-owned properties. As a result, for the primary reasons summarized below, the proposed Project (i.e., the 345-kV overhead transmission line located within CL&P's existing ROW) is preferred.

The cost of the underground cable system segment is a significant consideration. While the comparable 1.4-mile segment of the proposed overhead transmission line would cost $8.2 million, the capital cost of the underground variation is estimated at $82 million and thus would add a net $73.8 million to the total cost of the Project. As described in Section 14.3.1.3, it is unlikely that these increased costs would qualify for inclusion in New England regional transmission rates. As a result, in addition to paying 27% of the cost of building the base-case overhead line, Connecticut consumers would likely be responsible to pay 100% of any costs that exceed the cost of building the base-case overhead line, including extra costs for constructing underground cables and EMF BMP line designs. Since the Brooklyn Underground Variation would cost 10 times more than the comparable segment of proposed overhead transmission line, the cost to Connecticut consumers for the 1.4-mile underground segment would be approximately 23 times more than that of the overhead line, calculated as follows:[19]

CT consumer cost for section of overhead line to be replaced:

Estimated cost of proposed overhead transmission line(including delta structures for EMF Focus Area D) :	$8.2 million
Estimated cost of overhead H-frame transmission line:	$6.6 million
Incremental increase of delta configuration:	$1.6 million
Connecticut consumer cost of overhead section to be replaced = (H-frame line cost x 27%) + (Incremental increase over H-frame x 100%)	$3.3 million

Connecticut consumer cost for underground variation:

Estimated cost of the underground variation:	$82.0 million
Incremental increase of underground variation over an overhead H-frame transmission line:	$75.4 million
Connecticut consumer cost for underground variation = (Incremental increase for underground x 100%) + (H-frame line cost x 27%):	$77.2 million

Finally, dividing the Connecticut consumer cost for the underground variation by the Connecticut consumer cost for the overhead line section to be replaced yields: ($77.2 million / $3.3 million) = 23.

19 Note: With respect to inclusion in New England regional rates, ISO-NE, by precedent, would also may not allow the difference in the costs to construct the delta steel-pole line along this segment of ROW (as CL&P proposes in XS-6 BMP), in comparison to the cost of H-frame line construction.

To develop the 345-kV cable segment along the Brooklyn Underground Variation, CL&P would have to obtain underground easement rights from private landowners along a majority of the route. Although the variation would be located within CL&P's ROWs, the existing easement rights pertain only to overhead lines.

In addition, CL&P would have to purchase up to 4 acres of privately-owned land (in fee) for the western line transition station site. This land would be converted to utility use for the life of the line, and would involve the removal of approximately 4.6 acres of existing upland forest. In comparison, no additional ROW would be required to install the new 345-kV transmission line overhead along the portion of the route that the variation would replace.

Because the development of the underground cable system would involve continuous trenching for the duct banks, excavations for the splice vaults, and the creation of a permanent access road along the length of the cable route for operation and maintenance purposes, all of the environmental resources within the cable-system ROW would be directly impacted. In comparison, the construction and operation of the overhead 345-kV line would only require direct disturbance to soils in certain areas, such as at structure installation sites or along temporary and permanent access roads. Although existing forest vegetation in the vicinity of the new overhead line would have to be cleared, soils along the majority of the route segment would not be affected and scrub-shrub vegetation would be expected to quickly colonize the formerly wooded areas.

While the cable system would be buried and thus not visible once installed, the 345-kV line transition station sites would represent a long-term change in land use and visual character. At both line transition station sites, existing forested areas would be converted to utility use for the life of the Project. Although forested buffer areas would remain, the above-ground facilities at the line transition stations could be visible from nearby residential areas along Darby Road and Hickory Lane.

Overall, the proposed Project's overhead transmission line design within the existing ROW is preferred over the Brooklyn Underground Variation. Compared to the proposed overhead line design, the use of the variation would be significantly more costly, would result in greater long-term environmental effects (particularly to water resources), and would require the permanent conversion of up to 8 acres of land to line transition station use. Moreover, the Brooklyn Underground Variation would not result in a significant overall reduction in magnetic fields along the ROW.

Table 15-31: Comparison of the Brooklyn Underground Variation to the Proposed Project Segment (Overhead Line) Replaced

Route Characteristic	Proposed Route Segment to be Replaced	Brooklyn Underground Variation
Location, Design, and Appearance		
Route Location (ROW, Town)	Existing CL&P ROW (Brooklyn)	Existing CL&P ROW (Brooklyn)
Route Length (miles)	1.4 miles	1.4 miles
Overhead Structures (type, est. number)	11 delta steel poles 3 H-frame	N/A
Splice Vaults (est. number)	N/A	4 locations (12 vaults)
New ROW Easements or Land Acquisition Required (est. acres)	0	4 acres Underground easement rights along existing ROW may have to be acquired
Biological Resources		
Upland Forest Clearing (est. acres)	3.9 acres	4.6 acres
Forested Wetland Clearing (est. acres)	0.6 acre	Less than 0.1 acre
Scrub-Shrub Clearing (est. acres)	2.9 acres (upland) 1.1 acres (wetland)	6.7 acres (upland) 0.7 acre (wetland)
Watercourse Crossings (no.)	3 (span)	3 (direct effects, trenching)
Wetlands, Permanent Effects (Fill) (est. acres)	0 structures 0 acre (access roads)	1.0 acre
Wetlands, Temporary Effects (est. acres)	0.2 acre (access road)	0
Listed Species (no. species)	0	0
Land Uses		
Designated Open Space or Recreational Uses along ROW (length)	0.2 acre	0.2 acre
CL&P-Owned Land Traversed	0.7 mile	0.7 mile
Total Construction ROW / Work Space, Temporary Land Disturbance (est. acres)	14.5 acres	15.1 acres
Total Permanent ROW (acres)		
Cost of Transmission Line Segment ($ Million, $ 2010)		
Capital Cost	$8.2	$82.0
Cost to Connecticut Consumers[1]	$3.3	$77.2
Life-cycle Cost	$13.8	$116.8

1. Assumes localization of extra costs for EMF BMP line design and for underground cables..

15.5 WILLIMANTIC SOUTH VARIATIONS

15.5.1 Introduction and Summary

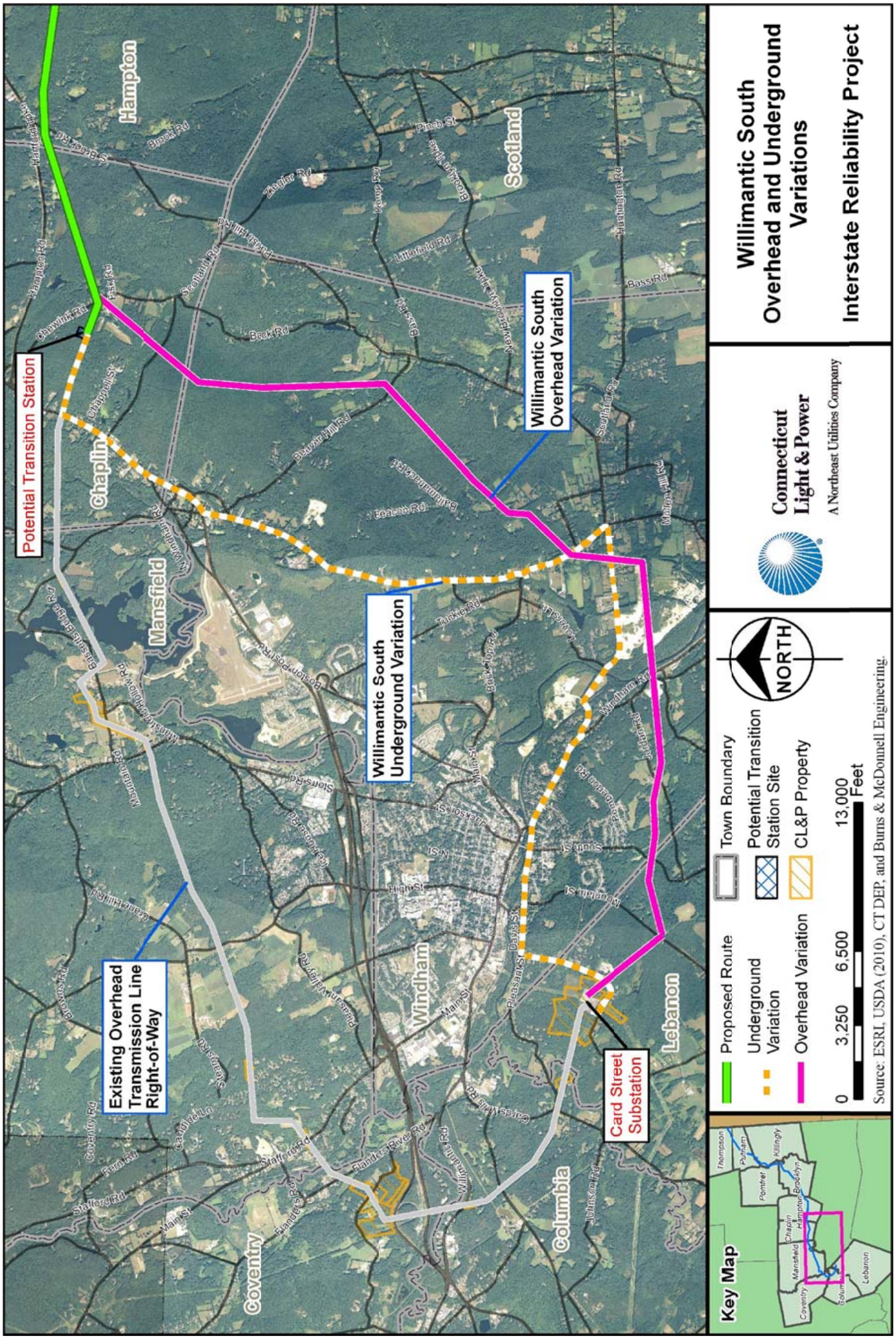
15.5.1.1 Purpose of the Variations

The Willimantic South Overhead and Underground Variations provide potential routing and transmission line configuration alternatives to the western 11.6 to 11.9 miles of the proposed Project (i.e., the 345-kV overhead transmission line located adjacent to CL&P's existing 330 Line through portions of the towns of Lebanon, Columbia, Coventry, Mansfield, and Chaplin). The two route variations were identified as alternatives for consideration to avoid aligning the new 345-kV transmission line across the approximately 1.4 miles of federally-owned properties through Mansfield Hollow State Park (including Mansfield Hollow Lake) and the Mansfield Hollow WMA in the towns of Mansfield and Chaplin. As described in Volume 1, to develop the Project as proposed along these ROW segments, CL&P plans to obtain additional easements (totaling approximately 11 acres) from the federal government. The additional easements would allow CL&P to expand the existing 150-foot-wide ROW to construct and operate the new 345-kV line adjacent to the 330 Line in a matching configuration. In addition to this proposed configuration, CL&P has identified two other configuration options for aligning the new 345-kV line through the Mansfield Hollow federal lands, using either no ROW expansion or a minimum ROW expansion (refer to Section 10, Volume 1 for further discussion of these configuration options). The Willimantic South Variations would not traverse these federally-owned properties.

Figure 15-10 illustrates the locations of the Willimantic South Variations in relation to the Proposed Route[20]. As Figure 15-10 shows, both of the Willimantic South Variations would extend east from CL&P's Card Street Substation in the Town of Lebanon, passing south of the City of Willimantic before turning north-northeast to interconnect to CL&P's existing 345-kV transmission line ROW, east of U.S. Route 6, in the Town of Chaplin.

[20] Note that the Proposed Route is illustrated on Figure 15-10 as a gray line.

Figure 15-10: Willimantic South Variations



The Willimantic South Overhead Variation would replace approximately 11.9 miles of the proposed Project, whereas the Willimantic South Underground Variation would replace approximately 11.6 miles of the proposed Project. The portions of the proposed 345-kV overhead line route that would be replaced are depicted on XS-1 to XS-6, including XS-2 BMP (these cross-sections are included in Volume 1, Section 3 [Appendix 3A], Volume 9, and Volume 10).

15.5.1.2 Summary Comparison of the Willimantic South Variations to the Segments of the Proposed Project that would be Replaced

The Project on the route proposed in Volume 1 (i.e., the 345-kV overhead transmission line aligned along CL&P's existing ROWs) is preferred over either of the Willimantic South Variations. As summarized below and in Table 15-32, and as discussed in detail in Sections 15.5.2 and 15.5.3, compared to the portions of the proposed overhead 345-kV transmission line route that would be replaced, the development of the new 345-kV line along either of the Willimantic South Variations would result in greater impacts to environmental resources or would be more costly. These adverse effects would significantly outweigh any benefits that would be achieved by avoiding the alignment of the new 345-kV transmission line through the approximately 1.4 miles of the federally-owned Mansfield Hollow properties.

Willimantic South Overhead Variation

Except for a 1-mile segment directly southeast of Card Street Substation, the 9.6-mile Willimantic South Overhead Variation would require a new "greenfield" utility corridor for the western portion of the proposed overhead 345-kV line. The development of the 345-kV line along this variation would add an estimated $17 million to the cost of the Project, including new ROW acquisition costs.

Table 15-32: Comparison of Willimantic South Variations to the Portions of the Proposed Route that Each Would Replace

Characteristic	Willimantic South – Overhead		Willimantic South – Underground	
	Proposed Route Segment to be Replaced	Overhead Variation	Proposed Route Segment to be Replaced	Underground Variation
Town(s) Traversed	Lebanon, Columbia, Coventry, Mansfield, Chaplin	Lebanon, Windham, Chaplin	Lebanon, Columbia, Coventry, Mansfield, Chaplin	Lebanon, Windham, Chaplin
Route Length (miles)	11.9	9.6	11.6	10.7
Route Location	CL&P ROW except for proposed ROW expansion in Mansfield, Chaplin	0.3 mile of CL&P Card Street Substation property, 0.7 mile of CL&P ROW; greenfield corridor for 8.6 miles	CL&P ROW except for proposed ROW expansion in Mansfield, Chaplin	10.1 miles along road ROWs; 0.6 mile along CL&P ROW
Overhead Line Structures (est. no.)	111	80	108	-
Splice Vaults (est. no.)	-	-	-	35 location (105 vaults)
New ROW or Other Land Acquisition (approximate acres)	11 acres (ROW expansion: Mansfield Hollow State Park and WMA)	156 acres (15-foot ROW expansion along 0.7-mile segment; all new ROW for 8.6 miles)	11 acres (ROW expansion: Mansfield Hollow State Park and WMA)	8.2 acres (Line transition station and off-ROW Splice Vaults)
Upland Forest Clearing (est. acres)	60.0 acres	111.6 acres	61.4 acres	6.7 acres
Forested Wetland Clearing (est. acres)	10.5 acres	16.1 acres	10.2 acres	0.2 acre
Scrub-Shrub Clearing (est. acres)	9.6 acres (upland) 0.7 acre (wetland)	19.1 acres (upland) 5.5 acres (wetland)	8.8 acres (upland) 0.5 acre (wetland)	2.7 acres (upland) 0.9 acre(wetland)
Watercourse Crossings (number)*	27	15	25	3
Wetlands, Permanent Effects (fill, est. acres)	0.4 acre (access roads)	0 [2] (access roads)	0.4 acre (access roads)	1.1 acres (duct bank/access roads)
Wetlands, Temporary Effects (est. acres)	1.1 acres (access roads)	3.2 acres [1] (access roads)	1.1 acres (access roads)	0.1 acres (access roads)
Cost ($) million[2]	$62.3	$79.3	$60.8	$325.9
Cost ($) million to CT Consumers, assuming localization of excess UG Cost	$18.8	$35.8	$18.4	$283.6
Life-cycle Cost ($) million	$106.3	$126.4	$103.7	$467.8

* Streams and wetlands were field-delineated only along the Proposed Route. For the route variations, streams and wetlands were identified based on the review of aerial photography, published water resource maps, and GIS data.

1. For the overhead route variation, specific structure locations have not been defined. However, for this impact evaluation, it is assumed that all structures could be located outside of wetlands and that all access roads across wetlands and streams would be temporary (removed after construction).

2. Cost comparisons assume that the Proposed Route and overhead line configurations would be as proposed by CL&P and that the Mansfield Underground Variation and the Mount Hope Underground Variation would not be used. Estimates for the Proposed Route segment similarly assume that the new 345-kV line through the Mansfield Hollow federally-owned lands would be built as proposed by CL&P and not according to one of the configuration options.

To develop the new 345-kV line along the Willimantic South Overhead Variation, CL&P would have to acquire 156 acres of new ROW (including a 15-foot expansion of the existing 0.7-mile ROW and a 150-foot-wide "greenfield" corridor along 8.6 miles of the route). Approximately 4 acres of forest land also would have to be removed on CL&P's Card Street Substation property to connect the new 345-kV line into the substation.

Compared to the portion of the Proposed Route replaced, the route variation would require 145 more acres of new ROW, approximately 52 more acres of forest clearing, and new on-ROW access roads, and would create a new 8.6-mile linear utility corridor across wetlands and streams. In addition, the region traversed by the new corridor is considered highly sensitive for the location of as-yet unrecorded archaeological sites and, as a result, extensive cultural resource field investigations would be required to assess potential effects on such resources.

Whereas the route variation would avoid the Mansfield Hollow area, it would create a new corridor across Pomeroy State Park in the Town of Lebanon, the Shetucket River in Windham, and the Airline State Park Trail in Chaplin. The new ROW would also abut portions of Beaver Brook State Park in the towns of Windham and Chaplin. Furthermore, the new overhead transmission line ROW would create a new linear corridor through the Quinebaug – Shetucket Rivers Valley National Heritage Corridor and would not be consistent with the general goals for resource protection in the towns encompassed by the Heritage Corridor.

Overall, the Willimantic South Overhead Variation was determined to be decisively inferior to the proposed overhead 345-kV line aligned along CL&P's existing ROW. The variation would not be consistent with federal and state policies for the collocation of linear corridors and would require a new "greenfield" ROW for which CL&P would have to acquire new utility easements across privately and publicly owned properties. The use of the variation would result in comparatively significant long-term environmental impacts associated with the creation of a new ROW (e.g., forest clearing, wetland and stream crossings).

In addition, the use of the Willimantic South Overhead Variation would result in magnetic fields along two separate ROWs, and the opportunity for reducing magnetic fields along at least one edge of the existing ROW by cancellation through best circuit phasings with a new 345-kV line adjacent to the existing 330 circuit within the existing CL&P ROW would be lost. Further, compared to the proposed Project segment that would be replaced, the variation would not present a clear magnetic field reduction advantage and would be significantly more costly. (Refer to Volume 1, Section 7 for a discussion of MF along the Proposed Route.)

Willimantic South Underground Variation

The 10.7-mile Willimantic South Underground Variation would be aligned predominantly along road ROWs, with a short (0.6-mile) segment of underground cable aligned within the existing CL&P transmission ROW in the Town of Chaplin. Like the Willimantic South Overhead Variation, this underground variation also would avoid the federally-owned lands in the Mansfield Hollow area. If the “along road” portions of the underground variation could be installed primarily within paved road ROWs (which is not certain), potential environmental effects associated with vegetation clearing would be minimized.

On the other hand, the variation would involve continuous trenching and excavation for the cable system’s duct bank and splice vaults. This would result in extensive soil disturbance and potential direct effects to water resources, including small streams and wetlands. The installation of the cable system beneath larger watercourses (the Shetucket River) and railroads would require the use of special construction techniques (e.g., jack and bore or HDD). In addition, the construction and operation of a new 345-kV line transition station on the eastern end of the cable system would require the acquisition and conversion to utility use of up to 4 acres of property. On the western end of the underground cable system, the line transition facilities could be accommodated within the fenced area at CL&P's Card Street Substation.

Like the Willimantic South Overhead Variation, the Willimantic South Underground Variation also would be more costly, requiring estimated capital expenditures of $265.1 million more than those of an overhead line configuration along the Proposed Route. As described in Section 14.3.1.3, these increased costs would not likely qualify for inclusion in New England regional transmission rates. As a result, in addition to paying 27% of the cost of building the base-case overhead line, Connecticut consumers would likely be responsible to pay 100% of any costs that exceed the cost of building the base-case overhead line, including extra costs for constructing underground cables and EMF BMP line designs.[21] Because this variation would be constructed for 10.1 miles along or adjacent to road ROWs, it would provide an additional linear source of magnetic fields for this length, and would pass by several Statutory Facilities. However, while magnetic fields would be elevated directly over and near to the cables and splice vaults, they would drop off quickly to background levels laterally.

Along the 0.6-mile segment in Chaplin where the cable system would be aligned within CL&P's existing ROW, implementing this variation would result in lower magnetic field levels along the northern edge of the existing ROW, but higher magnetic field levels on the southern edge of the ROW, compared to the situation where the new proposed overhead transmission line was built within the ROW. The magnetic fields on the northern edge of the ROW could be reduced by the use of a different overhead line design. (For information concerning projected magnetic fields along sections of the ROW that would be replaced

[21] Connecticut consumers would likely bear all of these extra costs, in addition to the 27% share of the cost of the base-case overhead line construction that the variation would replace. Since the Willimantic South Underground Variation would cost approximately six times more than the comparable segment of proposed overhead transmission line (constructed pursuant to standard good utility practice), the cost to Connecticut consumers for the 10.7-mile underground segment would be approximately 15 times more than that of the overhead line, as further detailed in Section 15.5.3.7.

by the Willimantic South Variations, refer to the information concerning "Focus Areas" A, B, and C in Volume 1, Section 7, Appendix 7B.)

Based on the substantial additional costs of constructing the Willimantic South Underground Variation and its lack of any significant advantage in reducing magnetic field levels or exposures, the proposed overhead 345-kV line configuration, aligned along the Proposed Route, was selected over the variation.

15.5.2 Willimantic South Overhead Variation

15.5.2.1 Location of the Route Variation

The approximately 9.6-mile Willimantic South Overhead Variation would replace the western-most 11.9 miles of the Proposed Route, along which the new 345-kV line would be developed in an overhead configuration adjacent to the 330 Line within CL&P's existing ROWs. The variation would involve the development of the new overhead 345-kV transmission line for approximately 0.3 mile on CL&P's Card Street Substation property, 0.7-mile along CL&P's existing 115-kV line ROW (with a small expansion) near Card Street Substation, and then for approximately 8.6 miles along a new "greenfield" corridor (refer to Figure 15-10).

From Card Street Substation, the route variation would traverse generally southeast through the Town of Lebanon and then east – northeast through portions of the towns of Windham and Chaplin, before re-connecting to CL&P's existing 330 Line ROW near U.S. Route 6. Table 15-33 identifies the towns that would be traversed along the variation, compared to the Proposed Route. To develop a 345-kV overhead transmission line along this variation, CL&P would have to acquire new utility easements from private landowners, as well as from the state (for the crossing of Pomeroy State Park, the Airline State Park Trail, and possibly Beaver Brook State Park).

Table 15-33: Towns Traversed along the Willimantic South Overhead Variation vs. the Proposed Route

Municipality	Proposed Overhead Transmission Line Segment on Existing CL&P ROW to be Replaced (Miles)	Willimantic South Overhead Variation (Miles)
Lebanon	0.6	1.7
Columbia	1.7	-
Coventry	1.2	-
Mansfield	6.4	-
Chaplin	2.0	1.0
Windham	-	6.9
Total Miles	**11.9**	**9.6**

15.5.2.2 Technical Description (Design, Appearance, Land Requirements, Cost)

The Willimantic South Overhead Variation would extend for approximately 9.6 miles through the towns of Lebanon, Windham, and Chaplin. Along 8.6 miles of the variation, CL&P would have to acquire easements, predominantly from private landowners, to develop a new 150-foot-wide ROW for the overhead 345-kV line. Along approximately 1 mile of the variation (extending south-southeast from Card Street Substation), the variation would be aligned along an existing 125-foot-wide CL&P ROW that would need widening. This ROW is presently occupied by two existing 115-kV transmission lines (the 1080/1490 circuits), supported on H-frame structures. A 23-kV distribution line shares the ROW from the substation to Card Street.

Along the 0.7-mile segment of existing CL&P ROW in Lebanon, the line route variation would be constructed with a vertical configuration of the conductors on steel-monopole structures (refer to Appendix 15B). Along the 8.6-mile "greenfields" portion of the variation, the base design of the new overhead transmission line would be H-frame structures with a typical height of 85 to 90 feet (refer to Appendix 15B).

To accommodate the new 345-kV overhead line along the 0.7-mile segment, the existing ROW would have to be expanded by 15 feet along the eastern side of the ROW. Because residences are located along Card Street near the existing 1080/1490 Line ROW, options for widening the ROW to accommodate a new 345-kV overhead line are limited; specifically, the new line could not be developed on H-frame structures (which require more widening of the ROW) without affecting the residences. In order to accommodate the new 345-kV overhead transmission line along this existing ROW segment while minimizing the amount of new ROW and without purchasing and removing the residences in the vicinity of Card Street, the existing double-circuit 115-kV line would have to be re-built using vertical conductor configurations on double-circuit steel-monopole structures, and the new 345-kV line would also be constructed with a vertical conductor configuration on single-circuit steel-monopole structures. The existing distribution line would be relocated to one edge of the ROW (refer to Appendix 15B).

The Willimantic South Overhead Variation would be approximately 2.3 miles shorter than the portion of the Proposed Route that it would replace. However, in order to construct and operate the new 345-kV overhead transmission line along this route variation, CL&P would have to acquire permanent easement rights, over approximately 156 acres of land, principally from private landowners.

In the Town of Lebanon, the overhead line-route variation would extend east-southeast from Card Street Substation for a distance of approximately 1.5 miles, 0.3 mile of which would be adjacent to Card Street Substation, 0.7 mile of which would be along CL&P's existing 115-kV transmission line ROW, and 0.5 mile of which would be new ROW. The route variation would traverse a mix of woodlands and scrub-shrub lands, passing near residential areas along Card Street and would then cross approximately 0.5 mile of Pomeroy State Park, 0.3 mile of which would be along CL&P's existing 115-kV transmission line ROW. Along this 0.3-mile segment, the existing CL&P ROW would have to be expanded by 15 feet to accommodate the new 345-kV line. Along the remaining 0.2-mile route through the park, CL&P would have to acquire a new 150-foot wide ROW.

In the Town of Windham, the line-route variation would extend east for approximately 2.4 miles before turning north-northeast and traversing approximately 4.5 miles, crossing into the Town of Chaplin near

Beaver Brook State Park. CL&P would have to acquire a new 150-foot wide ROW over the entire 6.9 miles. The overhead line-route variation would create a new utility crossing of the Shetucket River and would traverse combinations of mature mixed and wetland forested areas. The overhead variation would pass near residential areas in the vicinity of Plains Road and North Road.

In the Town of Chaplin, CL&P would have to acquire a 1.0 mile long new 150-foot wide ROW. The overhead variation route would traverse approximately 0.3 mile adjacent to the Beaver Brook State Park and would cross the Airline State Park Trail (North Section). The line route then continues across the Fin, Fur & Feather Club, Inc. property before joining the Proposed Route along CL&P's existing 345-kV transmission line ROW near Chewink Road, approximately 1 mile east of U.S. Route 6. Lands along the line-route variation in Chaplin consist primarily of mature mixed forest with some open fields and residential areas near Chewink Road.

The estimated cost of this overhead line-route variation is $79.3 million. This cost is $17 million higher than the cost for the replaced overhead 345-kV line segment along the Proposed Route built as proposed by CL&P.

15.5.2.3 Construction and Operation/Maintenance Considerations

The construction of an overhead 345-kV transmission line along the Willimantic South Overhead Variation would involve the same general techniques as described for the overhead 345-kV line on the Proposed Route (refer to Volume 1, Section 4). However, because the line-route variation would involve the use of a new (greenfield) ROW, additional work would be required to clear vegetation within the corridor and to develop new access roads along the ROW. In addition, to accommodate the new 345-kV line along the 0.7 miles of existing ROW in Lebanon, the existing 115-kV line structures along this segment would have to be removed and rebuilt, and an existing distribution line would have to be relocated to the edge of the ROW.

After the installation of an overhead line along the route variation, the entire 150-foot ROW width would have to be managed in low-growth vegetation, pursuant to CL&P policies and regulatory standards. In addition, permanent on-ROW roads would likely be required to access structure sites for operation and maintenance purposes.

15.5.2.4 Existing Environmental Features

15.5.2.4.1 Topography, Geology, and Soils

Elevations along the Willimantic South Overhead Variation range from approximately 200 feet NGVD to 590 feet NGVD. Bedrock geology in the area includes the Quinebaug and Tatnic Hill formations, whereas surficial geology consists primarily of floodplain alluvium (sand, gravel, silt and some organic matter of variable thickness), overlying sand and fines. Like the Proposed Route, the variation traverses some soils classified as Prime Farmland or Farmland Soils of Statewide Importance (refer to Table 15-34).

15.5.2.4.2 Water Resources

The Willimantic South Overhead Variation is located within the Thames River drainage basin, and would extend through regional drainage basins associated with the Natchaug, Shetucket, and Willimantic rivers. As summarized in Table 15-35, the route variation would traverse 15 watercourses (as identified based on aerial photographs and GIS data), the largest of which are Jordan Brook and the Shetucket River. All of these surface waters have water quality classifications of AA, A, or B. The route variation traverses FEMA-designated 100-year floodplains associated with Jordan Brook and the Shetucket River. The variation does not traverse any SCELs (the designated SCEL along the Shetucket River ends at Plains Road, north of the line route variation).

Table 15-34: Soils and Soil Characteristics along the Willimantic South Overhead Variation

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
3 Ridgebury, Leicester, Whitman	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss	Yes	0.15	--	0.0-1.5
13* Walpole sandy loam	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	Yes	--	--	0.0-1.0
17 Timakwa and Natchaug	Woody organic material over sandy and gravelly glaciofluvial deposits, and woody organic material over loamy alluvium and/or loamy glaciofluvial deposits and/or loamy till	Yes	--	--	0.0-1.0
21A** Ninigret and Tisbury, 0 to 5 % slopes	Coarse-loamy aeolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.43	--	1.5-2.5
23A** Sudbury sandy loam, 0 to 5 % slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss, and coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	--	--	1.5-3.0
29A** Agawam fine sandy loam, 0 to 3 % slopes	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.28	--	--
29B** Agawam fine sandy loam, 3 to 8 % slopes	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.29	--	--
34A** Merrimac sandy loam, 0 to 3 % slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.24	--	--
34B** Merrimac sandy loam, 3 to 8 % slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.24	--	--
36B* Windsor loamy sand, 3 to 8 % slopes	Eolian sands over sandy glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	--	--	--
38C* Hinckley gravelly sandy loam, 3 to 15 % slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--
38E Hinckley gravelly sandy loam, 15 to 45 % slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--
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	0.15	--	1.5-2.5
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	0.10	--	1.5-2.5
50B** Sutton fine sandy loam, 3 to 8 % slopes	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.15	--	1.5-2.5
51B Sutton sandy loam, 2 to 8 % slopes, very stony	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.15	--	1.5-2.5

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
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	0.15	--	1.5-2.5
60B** Canton and Charlton, 3 to 8 % slopes	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
61B Canton and Charlton, 3 to 8 % slopes, very stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
61C Canton and Charlton, 8 to 15 % slopes, very stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
62C Canton and Charlton, 3 to 15 % slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
62D Canton and Charlton, 15 to 35 % slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
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	0.17	20-40	--
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	0.17	20-40	--
84B** Paxton and Montauk fine sandy loam, 3 to 8 % slopes	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	0.20	--	1.5-2.5
85B Paxton and Montauk fine sandy loam, 3 to 8 % slopes, very stony	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	0.20	--	1.5-2.5
86C Paxton and Montauk fine sandy loam, 3 to 15 % slopes, extremely stony	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	0.20	--	1.5-2.5
86D Paxton and Montauk fine sandy loam, 15 to 35 % slopes, extremely stony	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	0.20	--	1.5-2.5
102** Pootatuck fine sandy loam	Coarse-loamy alluvium	No	0.24	--	1.5-2.5
103* Rippowam fine sandy loam	Coarse-loamy alluvium	Yes	0.15	--	0.0-1.5

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
307 Urban land	This is a miscellaneous area ***				

Source: USDA Natural Resources Conservation Service, Online Soil Surveys and Geographic Data of New London, Tolland, and Windham counties, 2009.
* Soils classified as Farmland Soils of Statewide Importance
** Soils classified as Prime Farmland Soils
*** Miscellaneous areas are those instances where soils have been altered or obscured by urban works and structures (buildings, paved areas, industrial areas) or standing water.
1. Erosion Factor (K (dimensionless)): Indicates the erodability of the whole soil, the higher the value, the more susceptible the soil to erosion.
-- No Data Available. No bedrock or water encountered to survey depth.

Table 15-35: Watercourses Traversed by the Willimantic South Overhead Variation

Municipality	Watercourse Series Number[1] and Name (Where Applicable)	Water Quality[2] / Fisheries Classification[3] (where applicable)	Watercourse Frequency Type (P or I) [4]
Lebanon			
	S23-1/Jordan Brook	A/coldwater	P
Windham			
	S23-2/Intermittent Tributary to Jordan Brook	A/coldwater	I
	S23-3/Intermittent Tributary to Jordan Brook	A/coldwater	I
	S23-4/Intermittent Tributary to Jordan Brook	A	I
	S23-5/Intermittent Tributary to Jordan Brook	A/coldwater	I
	S23-6/Intermittent Tributary to Jordan Brook	A/coldwater	I
	S23-7/Shetucket River	B/coldwater	P
	S23-8/Intermittent Watercourse	A	I
	S23-9/Pottens Brook	A	I
	S23-10/Chestnut Hill Brook	A/coldwater	P
	S23-11/Ballymahack Brook	A/coldwater	P
	S23-12Intermittent Tributary to Beaver Brook	A	I
	S23-13/Intermittent Tributary to Beaver Brook Pond	A/coldwater	I
Chaplin			
	S23-14/Ames Brook	AA/coldwater	P
	S23-15/Intermittent Tributary to Ames Brook	A/coldwater	I

1. Series No. refers to waterbody numbers on the aerial photographs in Volume 9.
2. Table 5-2 in Volume 1 defines the water classifications as defined by the Connecticut Water Quality Standards:
3. Fishery Classification (where applicable) was obtained by personnel communication with Don Gonyea and Neal Hagstrom at CT DEEP.
4. P = Perennial; I = Intermittent.

Based on reviews of published wetland (NWI) maps, soils maps, state GIS data, and aerial photography, the Willimantic South Overhead Variation would traverse 22 wetlands. Table 15-36 summarizes the characteristics of these wetlands.

A review of aerial photography and NWI mapping indicates that a total of approximately 29 acres of wetlands would be located along the line route variation[22]. These wetlands consist of the following cover types: approximately 17 acres of palustrine forested (PFO), 6.2 acres of palustrine scrub-shrub (PSS), 3.2 acres of palustrine emergent (PEM), and 2.4 acres of open water (PUB) or riverine (R2).

Groundwater resources along the Willimantic South Overhead Variation are classified by CT DEEP as "GA" within the Town of Lebanon; "GA", "GB", "GC", or "GA/GAA" within the Town of Windham; and "GA/GAA/GAA" within the Town of Chaplin. No public wells, or Connecticut Aquifer Protection Areas are crossed by or within the vicinity of the variation. Potable water is obtained from a combination of private groundwater wells and from surface water drawn from the Willimantic Reservoir, which is located more than 2 miles northwest of the variation, near the Windham Airport.

[22] Acreage of wetlands was calculated using the area of the ROW across the wetland type.

Table 15-36: Wetlands along the Willimantic South Overhead Variation

Municipality Vol. 9 Mapsheet Nos.	Wetland Series Number[1]	Wetland Classification[2]
Lebanon		
1 of 11	W21-16	PFO
1 of 11	W21-14	PFO/PSS
1 of 11	W22-1	PFO/PSS
1 of 11	W23-1	PFO/POW/PSS/PFO
2 of 11	W23-2	PFO
Lebanon/Windham		
2 of 11	W23-3	PFO
Windham		
3 of 11	W23-5	PFO/POW/PSS
3 of 11	W23-6	PFO/PEM/PSS
4 of 11	W23-7	PFO
4 of 113	W23-8	PFO/POW/PEM
4 of 11	W23-9	PEM/PFO/POW/PSS
5 of 11	W22-5	PSS
5 of 113	W23-10	PFO
5-6 of 11	W23-11	PFO
6 of 11	W23-12	PSS
6 of 11	W23-13	PFO
7 of 11	W23-14	PSS
7 of 11	W23-15	PSS
7 of 11	W23-16	PFO
7 of 11	W23-17	PFO
7-8 of 11	W23-18	PSS/PFO
8 of 11	W23-19	PFO
9-10 of 11	W23-20	PFO
Chaplin		
11 of 113	W23-21	PFO

NOTES:

1. Series No. refers to wetland number illustrated on the maps for the route variation in Volume 9.
2. Wetlands classification according to Cowardin et al 1979; PEM = Palustrine Emergent Wetland; PFO = Palustrine Forested Wetland; PSS = Palustrine Scrub-Shrub Wetland; POW = Palustrine Open Water; PUB = Palustrine Unconsolidated Bottom.

15.5.2.4.3 Biological Resources

Vegetative Communities

Most of the Willimantic South Overhead Variation would traverse along a new ROW, along which vegetative communities are dominated by forest habitat, intermixed with areas of open fields, wooded floodplains along the Shetucket River, and wetlands. Based on a 150-foot-wide width for the new ROW and the expansion of the existing 115-kV ROW, the footprint of the Willimantic South Overhead Variation would encompass approximately 172.5 acres, of which approximately 127.7 acres are presently forested (upland and wetland). These acreages include the 0.3 miles of line that would be construction adjacent to Card Street Substation on a 150-foot wide ROW located on land owned by CL&P, 0.7 miles of line constructed on existing ROW to be slightly expanded (including impacts along the 140-foot-wide ROW) and 8.6 miles of new ROW.

Approximately 26.8 acres of wetlands would be located within the construction footprint of the route variation. These include approximately 3.2 acres of emergent marsh, 16.1 acres of forested wetlands, 2 acres of open water / riverine areas, and 5.5 acres of scrub-shrub wetlands.

Fish and Wildlife Resources

The wildlife resources associated with the habitat types found along the Willimantic South Overhead Variation can be expected to be similar to those identified for the same habitats for the Proposed Route (refer to Section 5.3, Volume 1).

Based on consultations with the CT DEEP, the perennial watercourses traversed by the Willimantic South Overhead Variation provide fishery habitat, principally for cold-water fish species. Each fall, the CT DEEP stocks the Shetucket River with large (2 to 15 pound) Atlantic salmon below the Scotland Dam, which is 3 miles south of the route variation. The Shetucket River is also a proposed Trophy Trout Water.

Amphibians

Due to the lack of survey rights to the privately-owned properties, no field surveys to determine amphibian breeding habitat or potential areas of vernal pools were conducted along the Willimantic South Overhead Variation.

Listed Species

CL&P consulted with both federal and state agencies regarding the known or potential occurrence of federally- or state-listed species in the vicinity of the route variation (copies of correspondence from these agencies are included in Volume 4). Although the variation does not encompass the known habitat of any federally-listed species, the New England cottontail (*Sylvilagus transitionalis*), which the USFWS lists as a candidate species for federal protection, is reported to occur in the Town of Lebanon.

Based on a review of CT NDDB, the route variation does not traverse any areas of known habitat for state-listed species, except near the intersection with the Proposed Route in the Town of Chaplin. In addition, the variation is located directly south of, but does not traverse, CT NDDB designated areas along the Shetucket River and near Lake Marie, both in the Town of Windham.

WMAs and Other Wildlife Management Areas

The Willimantic South Overhead Variation would not cross any state- or federally-designated WMAs. However, the route variation would traverse approximately 0.5 mile across Pomeroy State Park in the Town of Lebanon and would traverse approximately 0.3 mile adjacent to Beaver Brook State Park in the Towns of Windham and Chaplin. Although not designated as WMAs, both of these parks include areas where bow hunting is allowed.

Immediately to the north of Beaver Brook State Park, the overhead route variation would traverse approximately 0.6 mile of property owned by the Fin, Fur and Feather Club, Inc. in the Town of Chaplin.

The Fin, Fur, and Feather Club, Inc. property is a privately-owned sportsman's area that offers archery, black powder, hunting, fishing, rifle, pistol, and shotgun sports activities.

15.5.2.4.4 Land Uses

The Willimantic South Overhead Variation would traverse the northeastern portion of the Town of Lebanon, central and northern portions of the Town of Windham, and the southern portion of the Town of Chaplin. Land-use plans for these towns were reviewed, and land uses along and adjacent to this line route variation were characterized.

Land uses in the vicinity of the Overhead Variation consist primarily of forested lands, interspersed with residential and commercial development, scrub-shrub lands, and agricultural areas. As illustrated on the Volume 9 maps, extending south and then east from Card Street Substation to the Lebanon/Windham town border, the Willimantic South Overhead Variation would traverse primarily scrub-shrub and forested areas, including lands managed in low-growth vegetation along CL&P's existing ROW. In this area, the line-route variation would cross approximately 0.5 mile through Pomeroy State Park.

In the Town of Windham, the route variation would cross a mix of land uses, including forested, commercial, residential, and agricultural areas. Within the Town of Chaplin, the majority of the route variation would be aligned across forested areas, although some residential areas would be located near the ROW along Chewink Road. The line-route variation then crosses several recreational-use areas, including the Airline State Park Trail and the Fin. Fur, and Feather Club, Inc. property.

Overall, the overhead line-route variation would encompass approximately 26.8 acres of wetlands, 19.2 acres of open field / shrubland uses, 2.1 acres of ROWs, 111.6 acres of mature mixed forest, 3.3 acres of agricultural lands, 2.2 acres of house/yard uses, and 7.5 acres of commercial / industrial uses. Except for the state-owned parklands, the route variation would be located on privately-owned property, across which CL&P would have to acquire new easements for the 345-kV overhead transmission line; along the

0.7-mile segment of ROW near Card Street Substation, CL&P would have to acquire additional rights for an easement expansion.

As illustrated on the Volume 9 and 11 maps, lands along and in the vicinity of the Willimantic South Overhead Variation are zoned primarily for residential use. Zoning classifications include Residential Agricultural (RA) uses in the Town of Lebanon; Residential (R-1, R-2, R-3, R-4) and industrial (M-1, M-2) uses in the Town of Windham; and Rural Agriculture Residence District (RAR) and Light Industry (L) uses in the Town of Chaplin.

No Statutory Facilities are located along the Willimantic South Overhead Variation. However, low-density rural residential developments are located near the route variation in the vicinity of Plains Road, North Road, and Ballamahack Road in the Town of Windham, and Chewink Road in the Town of Chaplin. In these areas, 22 homes would be located within 300 feet of the edge of the line-route variation ROW.

The three towns traversed by the Willimantic South Overhead Variation are all located within the designated Quinebaug-Shetucket Rivers Valley National Heritage Corridor. The variation also would traverse Pomeroy State Park a 286-acre state-designated area of preserved open space. The park is undeveloped and contains no public facilities, but is open to bow hunting. Along the Shetucket River in Windham, the variation would cross land designated for Shetucket River Water Access. In Windham and Chaplin, the variation abuts Beaver Brook State Park, which is an undeveloped park of approximately 400 acres (303 acres are open to bow hunting). Bordering Beaver Brook State Park to the north, the variation crosses the Airline State Park Trail (Northern Section), and then extends across land owned by the Fin, Fur, and Feather Club, Inc. before joining the Proposed Route along CL&P's existing transmission ROW.

The Windham *Plan of Conservation and Development* was last updated in 2007 and includes community goals of improving community image, maintaining existing town character, expanding, improving, and diversifying the town's economic base, enhancing and developing quality of life, providing balanced growth, protecting natural and man-made resources, and promoting energy efficiency. Other applicable local land-use plans include those for the towns of Lebanon and Chaplin, which are discussed for the proposed Project in Volume 1, Section 5.4.

Applicable regional, state, and federal plans include those prepared by the Windham Region Council of Governments (WINCOG) and the NECCOG, and the Conservation and Development Plan for the State of Connecticut. These plans also are described in Volume 1, Section 5.4.

15.5.2.4.5 Transportation, Access, and Utility Crossings

The Willimantic South Overhead Variation would cross 14 roads (refer to Table 15-37). Of these, the primary highways are State Routes 289, 32, and 14/203. Portions of State Routes 14 and 203 are state-designated scenic highways. The Windham Airport is located approximately 2 miles west of the route variation, adjacent to the Willimantic Reservoir.

Table 15-37: Road Crossings along the Willimantic South Overhead Variation

Municipality	Road Name	Road Type
Lebanon	Card Street	Local Road
Lebanon	Beaumont Highway (Route 289)	Highway
Lebanon	Unnamed	Thoroughfare
Windham	South Street	Local Road
Windham	Jordan Road	Local Road
Windham	South Windham Road	Local Road
Windham	Windham Road (Route 32)	Highway
Windham	Plains Road	Local Road
Windham	North Road (Route 14/203)	Highway
Windham	Ballamahack Road	Local Road
Windham	Beaver Hill Road	Local Road
Chaplin	Lynch Road	Local Road
Chaplin	Unnamed	Thoroughfare
Chaplin	Chewink Road	Local Road

Source: US Dept of Commerce, US Census Bureau, and UCONN Center for Geographic Information and Analysis. Connecticut Street Network State Plane/TIGER Line 2000, 2002.

The route variation also would cross two active rail lines. The New England Central Railroad operates an active freight line on the west side of the Shetucket River adjacent to Windham Road. The Providence & Worcester Railroad provides freight service on a line east of the Shetucket River.

15.5.2.4.6 Cultural (Archaeological and Historic) Resources

Based on an analysis of published cultural resource data, four reported Native American archaeological sites are located within 1 mile of the Willimantic South Overhead Variation. However, none of the sites are adjacent to or within the route variation ROW. Approximately 72% of this route variation appears to be sensitive for possible Native American sites.

Similar to the Proposed Route (refer to Volume 1, Section 5 and to the *Cultural Resources Assessment* in Volume 3), this variation generally appears to have limited sensitivity for significant below-ground Euro-American archaeological sites. Three previously reported Euro-American sites were identified within 1 mile of this route variation. Of these three sites, two are 400 to 5,100 feet from the route variation, while one is traversed by the variation corridor. This NRHP archaeological site is the Fourth Camp of Rochambeau's Army, a 16-acre Revolutionary War encampment. The location of this archaeological site is restricted from public documents to protect its integrity.

The route variation extends across one former New York & New England Railroad track bed in the Town of Chaplin. No cultural resource studies have been conducted of this crossing.

Four significant historic resources (including 29 individual structures or sites) have been identified within approximately 0.25 mile of the Willimantic South Overhead Variation. These include the Dr. Chester Hunt Office and the Windham Center Historic District in Windham, and the Chewink and Old cemeteries in Chaplin. The Windham Center Historic District, which is located along Plains and North Roads (State Routes 14 and 203), was designated on the NRHP in 1979.

Additional information about these cultural resources is presented in the *Cultural Resources Assessment* (Volume 3). A number of other above-ground properties located within 0.25 mile of the Willimantic South Overhead Variation have been inventoried in surveys, but no determinations of NRHP eligibility have been made to date.

15.5.2.5 Potential Environmental Effects and Mitigation Measures

The construction and operation of the new 345-kV transmission line along the Willimantic South Overhead Variation would cause both temporary and long-term effects associated with the expansion of CL&P's existing ROW for 0.7 mile and the creation of a new, 8.6-mile utility corridor on presently undeveloped land. In addition, the connection of the 345-kV line to the Card Street Substation would require approximately 0.3 mile of ROW on CL&P's property. The development of the new "greenfield" ROW segment would not be consistent with state and federal policies that advocate the collocation of utility corridors to the extent possible.

Appendix 15A describes the typical environmental effects caused by the construction and operation of an overhead transmission line along a new corridor, and identifies the mitigation measures that CL&P would typically use to minimize adverse effects to the extent possible. Appendix 15B includes representative cross-sections of the ROW along the Willimantic South Overhead Variation.

In general, the development of the 345-kV line along the Willimantic South Overhead Variation would affect soils, water resources, biological resources, land use and visual resources, cultural resources, and transportation. In addition, the acquisition of 156 acres of new easement for utility purposes would affect land-use patterns. Table 15-38 reviews these potential environmental effects, and summarizes the mitigation measures that CL&P would typically use to minimize, to the extent practical, adverse effects from transmission line construction and operation.

Table 15-38: Summary of Primary Effects and Potential Mitigation for the Willimantic South Overhead Variation

Environmental Feature	Potential Environmental / Social Effects		Potential Mitigation
	Construction	Operation / Maintenance	
Topography and Soils	Grading / filling along ROW to create access roads for use during construction; soil disturbance at structure installation / crane pad sites and other on-ROW staging areas Soil disturbance associated with removal and reconstruction of existing 115-kV line structures and distribution line along 0.7-mile segment of existing ROW in Lebanon	Permanent access roads as needed	Use temporary soil erosion and sediment control measures during construction. Stabilize disturbed sites after construction. Allow ROW to permanently revegetate in scrub-shrub species.
Water Resources	Development of new ROW across 15 watercourses, with temporary access roads likely required across smaller streams. New ROW across Shetucket River, which is part of the federally-designated Quinebaug – Shetucket Rivers Valley National Heritage Corridor. Potential direct or indirect effects to approximately 26.8 acres of wetlands located along the line route variation. Access road crossings of wetlands and watercourses (temporary fill). Potential effects associated with dewatering if groundwater is encountered in structure foundation excavations. Wetland vegetation clearing.	Permanent, culverted access roads likely required along the new 150-foot-wide ROW at some stream crossings. Also, permanent access across some wetlands, if required, would result in a potential net loss wetland habitat. Conversion of forested wetlands to scrub-shrub for the life of the Project will result in indirect wetland effects. *(Note: For purposes of this analysis, it is assumed that all access roads across wetlands would be removed after transmission line construction, and that no structures would be located in wetlands. However, specific effects cannot be determined without more detail engineering design regarding structure locations.)*	Use temporary erosion and sediment controls to minimize off-ROW water resource impacts. Revegetate or otherwise stabilize disturbed soil areas to limit the potential for sedimentation into water resources. Restore wetlands as final phase of construction. Coordinate with USACE and CT DEEP regarding off-site compensation for permanent loss of wetlands.
Biological Resources	Removal of approximately 127.7 acres of forest lands (including 111.6 acres of mature mixed forest and 16.1 acres of forested wetland)	Permanent conversion of forested areas, including forested wetland to scrub-shrub vegetative communities ; net loss of wetland habitat as detailed above due to access roads and cable trench The 8.6 miles of new ROW through previously undisturbed forest lands could potentially "segment" forested tracts, affecting habitat use by wildlife.	Off-site compensation, in coordination with USACE and CT DEEP
Land Use, including Statutory Facilities and Designated Recreational Areas	Acquisition and long-term dedication to utility use of 156 acres of new electric transmission line easements. New ROW across Pomeroy State Park and Airline State Park Trail, as well as near Beaver Brook State Park	New ROW would not conform to policies regarding the collocation of linear corridors to the extent practical. Along the new corridor, the 345-kV transmission line would be within 300 feet of 22 homes.	

Environmental Feature	Potential Environmental / Social Effects		Potential Mitigation
	Construction	Operation / Maintenance	
Visual Resources	The construction of the new 345-kV line will alter the visual character of the 8.6 miles of the line route variation where no ROW currently exists. The New 345-kV H-frame line structures (the shortest of the transmission line structure options) could nonetheless be visible from designated recreational areas, historic sites, and residences. The visual character of the 0.7-mile segment along CL&P's existing ROW will be modified by the removal of the existing 115-kV H-frame line structures and their replacement with taller structures to support vertically-configured conductors.	Long-term change in visual resources as a result of views of the new, vegetatively managed ROW and overhead structures	The use of H-frame structures minimizes the potential for views of the transmission line above the tree line. CL&P would work with affected landowners and towns to manage vegetation along the ROW to minimize visual intrusion to the extent practical.
Transportation	Potential increase in traffic along roads leading to the ROW as a result of the movement of construction vehicles and equipment	Permanent access likely to be required along the new ROW	Implement traffic management plan during construction; coordinate with town officials
Cultural Resources	Area is sensitive for the location of archaeological sites, and one site is known to occur within the new ROW. For new structures located near the Windham Center Historic District, visual simulations could be required to evaluate potential indirect aesthetic effects.	Permanent adverse effects would occur to archaeological sites during construction and possible long-term indirect visual effects could occur to structures within the Windham Center Historic District as a result of possible views of the new 345-kV line structures	Conduct field investigations to identify archaeological sites and, if significant sites are found, to develop appropriate mitigation measures (e.g., data recovery), based on consultations with the SHPO. Conduct visual simulations of overhead line near historic structures and districts.

15.5.2.6 Electric and Magnetic Fields

The 9.6-mile Willimantic South Overhead Variation would entail the development of approximately 8.6 miles of new overhead 345-kV transmission line, along a new 150-foot-wide ROW, 0.7 mile within an existing and slightly expanded ROW, and 0.3 mile on CL&P's Card Street Substation property. Within the new ROW, the new 345-kV line would be centered within the ROW and would be supported on steel- or wood-pole H-frame structures (refer to Appendix 15B). Along the 0.7 mile of ROW that would be expanded by 15 feet, an existing double-circuit 115-kV line would be rebuilt on steel-monopole structures, and the new 345-kV line would be supported on steel-monopole structures.

Electric and magnetic fields were calculated for a base design (H-frame) configuration of the 345-kV transmission line along the Willimantic South Overhead Variation. Because the Willimantic South Variation would be generally comparable in length to the portion of the proposed overhead transmission line that it would replace (9.6 miles vs. 11.9 miles, respectively), the incorporation of the variation as part of the new Card Street substation to Lake Road 345-kV line would not significantly change the new circuit's impedance, and therefore the same circuit currents were used for these calculations as were used for the proposed overhead line configuration and route. Volume 1, Section 7 of the Application includes details on the system assumptions made in the power-flow modeling to determine these circuit currents.

Magnetic fields produced by the overhead variation line along the segments of the variation ROW at AAL were calculated and graphed as shown on Figures 15-11, 15-12 and 15-13. Following each figure, the calculated levels of magnetic and electric fields at the ROW edges of the Willimantic South Overhead Variation route after the completion of the Project at AAL are summarized in Table 15-39, Table 15-40, and Table 15-41.

Figure 15-11: Magnetic Field Profiles Under Pre Interstate (2015) and Post-NEEWS (2020) Conditions at AAL for the Willimantic South Overhead Variation: Card Street Substation to Existing Structure 7814 – XS-WS-OH-1

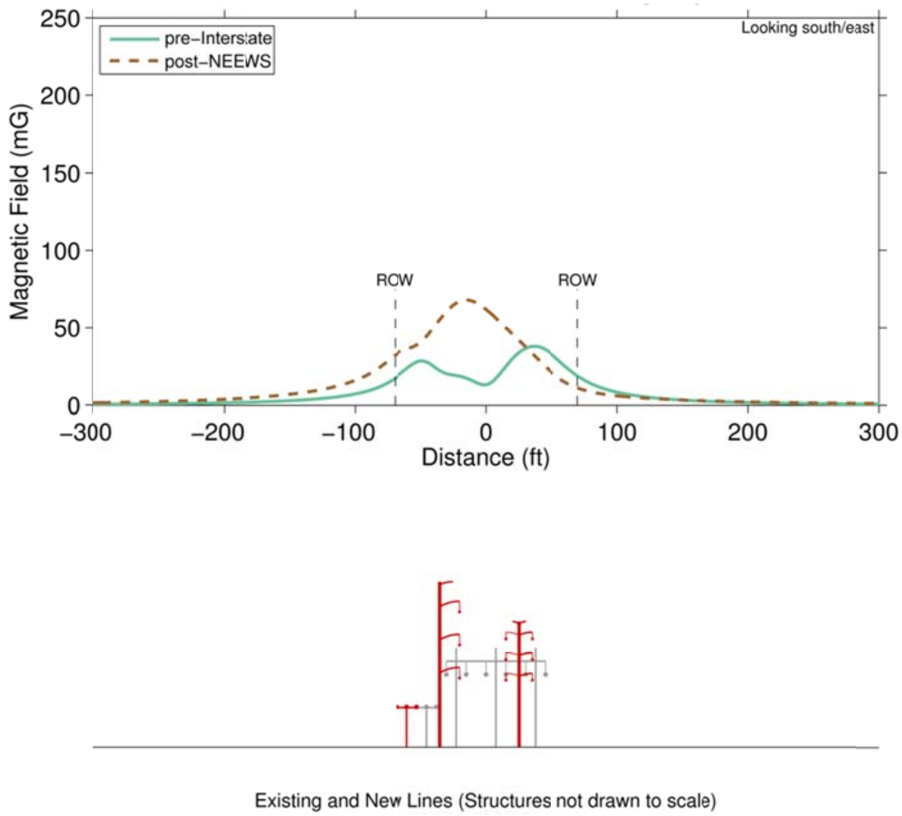
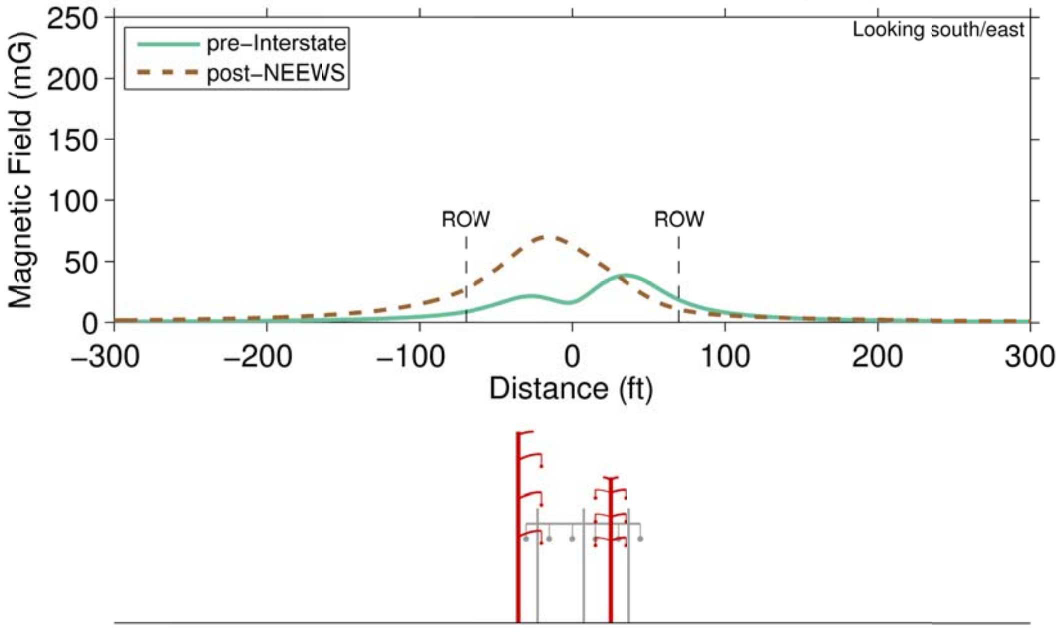


Table 15-39: Summary of Pre-Interstate(2015) and Post-NEEWS (2020) EMF Levels at the Edge of the ROW at AAL for the Willimantic South Overhead Variation: Card Street Substation to Existing Structure 7814 at Card Street – XS-WS-OH-1

	Magnetic Field (mG)		Electric Field (kV/m)	
Cross-Section	**West/North ROW Edge**	**East/South ROW Edge**	**West/North ROW Edge**	**East/South ROW Edge**
XS-OH-WS-1 – Pre-Interstate	17.4	19.1	0.33	0.86
XS-OH-WS-1 – Post-NEEWS	32.3	11.3	0.21	0.25

Figure 15-12: Magnetic Field Profiles Under Pre Interstate (2015) and Post-NEEWS (2020) Conditions at AAL for the Willimantic South Overhead Variation: Existing Structure 7814 at Card Street to Structure 7809 at Route 289 – XS-WS-OH-2



Existing and New Lines (Structures not drawn to scale)

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Table 15-40: Summary of Pre-Interstate(2015) and Post-NEEWS (2020) EMF Levels at the Edge of the ROW at AAL for the Willimantic South Overhead Variation: Existing Structure 7814 at Card Street to Structure 7809 at Route 289 – XS-WS-OH-2

Cross-Section	Magnetic Field (mG)		Electric Field (kV/m)	
	West/North ROW Edge	East/South ROW Edge	West/North ROW Edge	East/South ROW Edge
XS-OH-WS-2 – Pre-Interstate	8.8	18.6	0.49	0.85
XS-OH-WS-2 – Post-NEEWS	27.5	10.8	0.54	0.25

Figure 15-13: Magnetic Field Profiles Post-NEEWS (2020) Conditions at AAL for the Willimantic South Overhead Variation: Route 289 in Lebanon to Chewink Road in Chaplin– XS-WS-OH-3

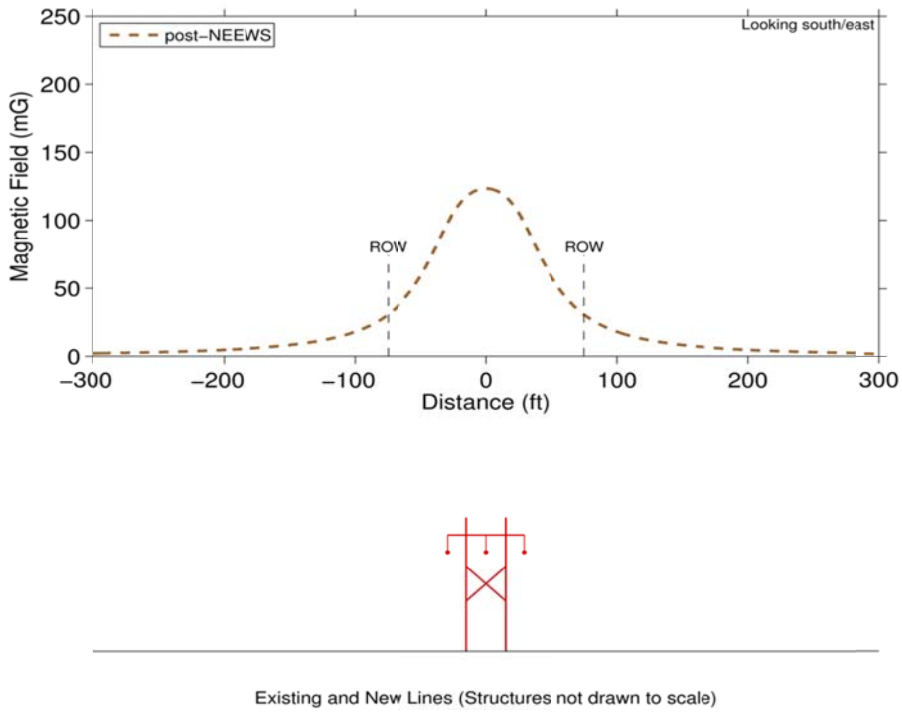


Table 15-41: Summary of Post-NEEWS (2020) EMF Levels at the Edge of the ROW at AAL for the Willimantic South Overhead Variation: Route 289 in Lebanon to Chewink Road in Chaplin – XS-WS-OH-3

Cross-Section	Magnetic Field (mG)		Electric Field (kV/m)	
	West/North ROW Edge	East/South ROW Edge	West/North ROW Edge	East/South ROW Edge
XS-WS-OH-3 – Post-NEEWS	30.9	30.9	1.67	1.67

If the Willimantic South Overhead Variation were incorporated into the new 345-kV line, the existing 330 Line would remain on the avoided segments of ROW, but would carry different currents. The calculated levels of electric and magnetic fields in 2020 along such existing ROW segments, compared to pre-Project levels in 2015, would be as shown in Table 15-42.

Table 15-42: Comparison of Pre-Interstate (2015) and Post-NEEWS (2020) EMF Levels at the Edges of the Existing CL&P Transmission ROW at AAL, With and Without Use of the Willimantic South Overhead Variation (WSOV)

Cross Section(s)	Magnetic Fields for Annual Average Load Case			
	South/West ROW Edge Level (mG)	North/East ROW Edge Level (mG)	North/West ROW Edge Level (mG)	South/East ROW Edge Level (mG)
XS-1 Pre-Interstate (2015)	7.6	28.2		
XS-1 Post-NEEWS (2020) With WSOV	7.2	24.2		
XS-1 Post-NEEWS (2020) Without WSOV	5.8	18.7		
XS-2, XS-4, & XS-6 Pre-Interstate (2015)			4.6	28.0
XS-2, XS-4, & XS-6 Post-NEEWS (2020) With WSOV			3.9	24.0
XS-2, XS-4, & XS-6 Post-NEEWS (2020) Without WSOV			7.2	18.4
XS-2 BMP Pre-Interstate (2015)			4.6	28.0
XS-2 BMP Post-NEEWS (2020) With WSOV			3.9	24.0
XS-2 BMP Post-NEEWS (2020) Without WSOV			5.2	20.6
XS-3 Pre-Interstate (2015)			8.8	24.7
XS-3 Post-NEEWS (2020) With WSOV			7.5	21.2
XS-3 Post-NEEWS (2020) Without WSOV			24.1	22.3
XS-5 Pre-Interstate (2015)			8.3	35.2
XS-5 Post-NEEWS (2020) With WSOV			7.1	30.1
XS-5 Post-NEEWS (2020) Without WSOV			25.1	24.1

Magnetic field levels in 2020 along both edges of the avoided 330 Line ROW segment included in Table 15-41 would be slightly reduced from the 2015 pre-Project levels by constructing the new overhead line section on a different ROW (see rows in table labeled as "With WSOV"). These reductions would result from changes in circuit currents after the new 345-kV line is constructed and placed in service on the Willimantic South Overhead Variation ROW. However, the use of the Willimantic South Overhead Variation would result in magnetic fields along two separate ROWs, and the opportunity for reducing magnetic fields along at least one edge of the existing ROW by cancellation through best circuit phasings with a new 345-kV line adjacent to the existing 330 circuit within the existing CL&P ROW would be lost.

To show this effect, Table 15-42 also includes data representing the post-Project projections for magnetic field levels with the proposed line constructed using the proposed new transmission line configurations along the existing CL&P transmission ROW (see rows in table labeled "Without WSOV"). As this data shows, for most cross-sections, the proposed overhead transmission line designs would produce the lowest magnetic field levels along the south or east ROW edges, but would do so at the expense of higher magnetic field levels along the north or west ROW edge (not including XS-1) when compared to pre-Interstate levels or to the post-NEEWS levels with the Willimantic South Overhead Variation 345-kV line in service. However, the projected magnetic field levels in 2020 on the CL&P ROW following the construction of the proposed overhead transmission line in Cross-Sections 1 through 6 are all lower than the levels at the south or east ROW edge under pre-Interstate conditions.

15.5.2.7 Comparison of the Willimantic South Overhead Variation to the Segments of the Proposed Route that Would be Replaced

As summarized in Table 15-43, compared to the development of the new proposed 345-kV overhead transmission line along the Proposed Route within CL&P's existing ROWs, the use of the Willimantic South Overhead Variation would cause greater overall impacts to environmental resources, visual resources, and privately-owned properties, and would increase Project costs.

The route variation would avoid recreational use areas in the Towns of Mansfield and Chaplin (i.e., Mansfield Hollow State Park and WMA). In addition, the variation would avoid aligning the new

345-kV overhead transmission line, adjacent to the existing 330 Line within CL&P's ROWs near certain groups of homes (which may or may not qualify as Statutory Facilities), two residential child day cares, and the Mount Hope Montessori School in the Town of Mansfield.

However, the Willimantic South Overhead Variation would expand or create a new utility corridor across other recreational areas (i.e., Pomeroy State Park and the Airline State Park Trail) and near the Windham Center NRHP Historic District and Beaver Brook State Park. As a result, for the primary reasons summarized below, the proposed Project (i.e., the 345-kV overhead transmission line configuration located within CL&P's existing ROW) is preferred.

The development of the overhead transmission line along the Willimantic South Overhead Variation would increase Project costs by approximately $17 million. Specifically, the capital cost of the overhead line-route variation is estimated at $79.3 million. In comparison, the capital cost for the 11.9-mile segment of the proposed overhead transmission line within the existing CL&P ROW is $62.3 million. As described in Section 14.3.1.3, these increased costs would not likely qualify for inclusion in New England regional transmission rates. As a result, in addition to paying 27% of the cost of building the base-case overhead line, Connecticut consumers would likely be responsible to pay 100% of any costs that exceed the cost of building the base-case overhead line, including extra costs for construction of this overhead line-route variation and EMF BMP line designs.

The Willimantic South overhead variation would cost approximately 1.3 times more than the comparable segment of the proposed overhead transmission line constructed pursuant to standard good utility practice. Consequently, the cost to Connecticut consumers for this overhead line variation (based on the cost allocation described above) would be approximately $35.8 million, or approximately two times more than the cost of the overhead line proposed within the existing ROW. This is calculated as follows:

Connecticut consumer cost for section of overhead line to be replaced:

Estimated cost of the proposed overhead transmission line (including delta structures for EMF Focus Area A and delta structures through Mansfield Hollow State Park):	$62.3 million
Estimated cost of overhead base transmission line (i.e., H-frame structures through Focus Area A and delta structures through Mansfield Hollow State Park):	$59.6 million
Incremental cost of line with delta structures through EMF Focus Area A:	$2.7 million
Connecticut consumer cost for overhead section to be replaced = (base-line cost x 27%) + (Incremental increase over base-line cost for delta structures in EMF Focus Area A x 100%)	$18.8 million

Connecticut consumer cost for overhead variation:

Estimated cost of the overhead variation:	$79.3 million
Incremental cost of the overhead variation over an overhead base-line design (i.e., H-frames in EMF Focus Area A and delta structures in Mansfield Hollow State Park):	$19.7 million
Connecticut consumer cost for overhead variation = (Incremental cost for overhead variation x 100%) + (Base-line cost x 27%):	$35.8 million

Finally, dividing the Connecticut consumer cost for the overhead variation by the Connecticut consumer cost for the overhead line section to be replaced yields: ($35.8 million / $18.8 million) = 2.

To develop an overhead 345-kV transmission line along the Willimantic South Overhead Variation, CL&P would have to obtain approximately 156 acres of new utility easements. Pursuant to CL&P standards, lands under easement for utility purposes would be precluded from land uses that would be inconsistent with the safe operation and maintenance of the overhead transmission line. In comparison, except for the approximately 11 acres of proposed easement expansion across the federally-owned properties in the Mansfield Hollow area[23], no additional ROW would be required to install the new 345-kV transmission line overhead along the portion of the Proposed Route that the variation would replace. Selection of this line-route variation over use of the existing ROW would be inconsistent with the FERC environmental guidelines to which approved transmission line projects are required to conform.[24]

In sum, CL&P prefers the proposed overhead transmission line within the existing CL&P ROW over the Willimantic South Overhead Variation. Compared to the 11.9-mile proposed Project segment that would be replaced, the use of the overhead variation would increase costs, result in greater long-term environmental effects (particularly to forest lands), and would require the permanent conversion of 156 acres of primarily forested lands to utility use. Moreover, the development of the transmission line along the route variation would introduce a new source of transmission line magnetic fields along a new corridor, while not achieving a significant overall reduction in magnetic fields in the vicinity of the existing CL&P ROW where certain residences and statutory facilities are located.

[23] The 11-acre ROW expansion in the Mansfield Hollow area assumes the use of the proposed Project design, rather than either of the two alternative configurations described in Volume 1, Section 10. The adoption of either of these configurations would either minimize or avoid ROW expansion through Mansfield Hollow State Park and WMA.

[24] The Council is required to find that the overhead portions of any new transmission line will be consistent with the FERC's "Guidelines for the Protection of Natural Historic Scenic and Recreational Values in the Design and Location of Rights-of-Way and Transmission Facilities, " Conn. Gen. Stats. ¶16-50p(a)(3)(D)(iii). In order to minimize conflicts between electric transmission rights-of-way and other land uses, these guidelines specify that "existing rights-of-way should be given priority as locations for additions to existing transmission facilities." *Id.,* ¶1

Table 15-43: Comparison of the Willimantic South Overhead Variation to the Proposed Transmission Line Segment (Overhead Line) on Existing CL&P ROW to be Replaced

Route Characteristic	Proposed Overhead Transmission Line Segment on Existing CL&P ROW to be Replaced	Willimantic South Overhead Variation
Location, Design, and Appearance		
Route Location (ROW, Town)	Existing CL&P ROW (Lebanon, Columbia, Coventry, Mansfield, Chaplin)	0.7 mile ROW expansion (Lebanon) 8.6 miles new ROW (Lebanon, Windham, Chaplin)
Route Length (miles)	11.9 miles	9.6 miles
Structures (type)	H-frames Delta steel poles	H-frames Delta steel pole
New ROW Easements or Land Acquisition Required (approximate acres)	11 acres (USACE property, Mansfield Hollow)	156 acres
Biological Resources		
Upland Forest Clearing (est. acres)	60.0 acres	111.6 acres
Forested Wetland Clearing (est. acres)	10.5 acres	16.1 acres
Scrub-Shrub Clearing (est. acres)	9.6 acres (upland) 0.7 acre (wetland)	17.2 acres (upland) 5.5 acres (wetland)
Watercourse Crossings (no.)	2 (span)	15
Wetlands, Permanent Effects (Fill) (est. acres)	0 structures 0.4 acre (access roads)	0 structures [2] 0 (access roads) [2]
Wetlands, Temporary Effects (est. acres)	1.1 acres (access roads)	3.1 acres (access roads) [2]
Listed Species (no. species)	0	0
Land Uses		
Designated Recreational or Open Space along ROW (length, miles)	3.0 miles	1.4 miles
CL&P-Owned Land Traversed (miles)	1.8 miles	0
Total Construction ROW / Work Space, Temporary Land Disturbance (est. acres)	137.1 acres	172.5 acres
Cost of Transmission Line Segment ($ Million, $ 2010)		
Capital Cost	$62.3	$79.3
Cost to Connecticut Consumers[1]	$18.8	$35.8
Life-cycle Cost	$106.3	$126.4

1. Assumes localization of extra costs for EMF BMP line designs and for underground cables.
2. For the overhead route variation, specific structure locations have not been defined. However, for this impact evaluation, CL&P assumed that all structures could be located outside of wetlands and that all access roads across wetlands and streams would be temporary (removed after construction).

15.5.3 Willimantic South Underground Variation

15.5.3.1 Location of the Route Variation

The Willimantic South Underground Variation would replace the westernmost 11.6 miles of the proposed overhead 345-kV transmission line route. The underground route variation would entail the development of a 10.7-mile underground cable system, extending through portions of the towns of Lebanon, Windham, and Chaplin, as well as 345-kV line transition facilities at either end of the cable system (refer to Table 15-44, Appendix 15B, and the Volume 9 maps). With the exception of a 0.6-mile segment within CL&P's existing ROW in Chaplin, the underground cable system would be aligned primarily beneath or adjacent to paved road ROWs.

Table 15-44: Towns Traversed along the Willimantic South Underground Variation vs. the Proposed Route Within Existing CL&P ROW

Municipality	Proposed Overhead Transmission Line Segment on Existing CL&P ROW to be Replaced (Miles)	Willimantic South Underground Variation (Miles)
Lebanon	0.7	0.8
Columbia	1.7	-
Coventry	1.2	-
Mansfield	6.4	-
Chaplin	1.6	1.8
Windham	-	8.1
Total Miles	**11.6**	**10.7**

The cable system would commence at the Card Street Substation where 345-kV line transition facilities would be installed. From the substation, the underground cable system would extend north along Card Street to Pleasant Street, and then would follow Pleasant Street east to Plains Road. The underground route variation would continue along Plains Road, crossing the Shetucket River, to the intersection of State Routes 14 and 203 in Windham Center. The cable-system route would then turn north and follow State Route 203 to U.S. Route 6 (Boston Post Road / Willimantic Road). Following U.S. Route 6, the route would extend north into the Town of Chaplin.

At the intersection of U.S. Route 6 and CL&P's existing transmission line ROW (i.e., the 330 Line ROW, the proposed route for the preferred overhead 345-kV transmission line), the cable system would turn east to follow the CL&P ROW for approximately 0.6 mile. Between proposed 345-kV overhead line structure Nos. 107 and 108 (refer to the Volume 9 maps), a new 345-kV line transition station would have to be developed. This new 345-kV line transition station would be located approximately 100 feet east of Park Road in the Town of Chaplin.

15.5.3.2 Technical Description (Design, Appearance, Land Requirements, Cost)

The Willimantic South Underground Variation would involve the construction and operation of a 10.7-mile, 345-kV cable system (cables, splice vaults, line transition facilities). Appendix 15B illustrates the typical location of the underground cable system along public road ROWs, whereas Appendix 15B depicts the location of the underground cable system for approximately 0.6 mile within the CL&P ROW east of U.S. Route 6. As Appendix 15B illustrates, within CL&P's ROW, the center of the cable system would be aligned north of the existing 330 Line, approximately 15 feet from the outside conductors.

Along the approximately 10.1 miles of the route variation that would be aligned along roads, easements would not be required from private landowners if the cable system can be accommodated within the public highway ROWs. However, as described in Section 14.3, due to constraints posed by utilities buried beneath road travel lanes or conflicts with public highway use policies, splice vaults and portions of the cable duct bank would likely have to be located on private properties adjacent to the road ROWs. The number and acreages of easements that would be required from private landowners could not be defined until the final stages of cable-system design.

Similarly, to align the 0.6-mile segment of the cable system within CL&P's existing transmission line ROW in the Town of Chaplin, underground easement rights would have to be obtained from private landowners. In addition, up to 4 acres of land would have to be acquired from private landowners for the development of the 345-kV line transition station on the eastern end of the underground cable segment.

On the western end of the cable system, 345-kV line transition facilities would be developed on CL&P's Card Street Substation site. Shunt reactors would likely be needed at one or both of these transition facilities and could then increase the development area.

The estimated capital cost of the Willimantic South Underground Variation is $325.9 million, or $265.1 million more than the portion of the proposed overhead 345-kV transmission line that would be replaced.

15.5.3.3 Construction and Operation/Maintenance Considerations

Construction of the 10.7-mile cable system (duct banks, splice vaults, cable installation) and associated 345-kV line transition facilities would be performed using the methods described generally in Section 14.3.2. Because cable-system installation requires continuous trenching, as well as trenching for splice vaults, lands along the entire length of the route variation would be disturbed. Lands along the cable-system route would encompass paved roads, road shoulders, areas adjacent to the road ROWs, and areas along CL&P's ROW.

Along the majority of the route variation (i.e., 10.1 miles), the cable system would follow public road ROWs. Although the cable system would optimally be located within the paved portions of these ROWs, the actual alignment would depend on a variety of factors, such as the presence of buried utilities, highway use policies, site-specific land-use conditions, and the need to use special sub-surface installation techniques (such as HDD or jack and bore) to install the cable system beneath watercourses, wetlands, railroads or highly traveled state highways. As a result, it is likely that the approximately 40-foot-wide work area typically required for cable-system construction along road ROWs would encompass areas adjacent to the paved road travel lanes. Final cable-system design would be required to enable an estimate of the amount of land affected outside of the paved road ROWs. However, assuming the use of a 40-foot-wide construction work area, the installation of the cable system would affect approximately 60 acres, including approximately 4.2 acres for splice-vault installation (in excess of the 40-foot-wide construction work area) and 4 acres at the line transition station site on the eastern end of the cable system.

Along the 0.6-mile segment within CL&P's ROW, assuming the use of a 40-foot-wide construction work area, approximately 3.6 acres of land would have to be cleared of all vegetation, and then graded and filled to create a level construction work space and to accommodate a 20-foot-wide construction / permanent access road along the length of the cable route. The 3.6 acres includes approximately 0.2 acre for installation of splice vaults adjacent to the 40-foot wide construction work area for the duct bank. To reach the access road along the cable-system route, equipment and vehicles would most likely utilize Willimantic Road (U.S. Route 6) or Park Drive.

Up to an additional 4 acres of land would have to be acquired (in fee ownership) and subsequently cleared and leveled for the development of a 345-kV line transition station at the eastern end of the cable route. A potential line transition station site (refer to the Volume 9 maps) is located on private property near the Natchaug State Forest and lands owned by the Fin, Fur, and Feather Club, Inc. The site would have to be cleared of forest vegetation, graded, and otherwise prepared for site development.

The new 345-kV line transition station at the eastern terminus of the underground cable system would consist of an above-ground line-terminal structure, a control building, and related equipment to interconnect the underground cable system to the overhead portion of the 345-kV transmission line. The developed portion of the station would be graded, surfaced with crushed stone, and fenced. On the western end of the cable system, 345-kV line transition facilities would be constructed within CL&P's property at Card Street Substation (for the purposes of this analysis, it is assumed that these facilities could be accommodated within the existing station fence line).

The construction of the underground cable system along the Willimantic South Underground Variation would require approximately two to three years to complete. This schedule assumes that duct-bank trenching would progress at approximately 50 to100 feet per day. The development of the 345-kV line transition facilities can be expected to require approximately 12 to 18 months to complete; this work would be accomplished concurrent with the underground cable work and would not extend the time required to complete the construction of the entire underground variation project.

15.5.3.4 Existing Environmental Features

15.5.3.4.1 Topography, Geology, and Soils

The topography along the Willimantic South Underground Variation is less variable than along the portion of the Proposed Route that it would replace, as roadways tend to be in relatively level areas with gradual changes in topography. Bedrock geology in the vicinity of the variation consists of the Canterbury Gneiss, Tantic Hill, Waterford Group, Hebron Gneiss, and Scotland Gneiss formations. Surficial geology along the route variation consists of sand and gravel, sand and gravel overlying sand, till, alluvium overlying sand, gravel, and sand and gravel overlying sand overlying fines. The variation would traverse some areas classified as Farmland of Statewide Significance soils. Soils along the variation are identified in Table 15-45.

15.5.3.4.2 Water Resources

Like the Willimantic South Overhead Variation, the Willimantic South Underground Variation is located within the Thames River drainage basin. Regional drainage basins traversed by the route variation include Natchaug River, Shetucket River, and Willimantic River.

Along the portion of the underground route variation that would be aligned within or adjacent to road ROWs, wetlands and watercourses were identified using published wetland and soils maps and aerial photographs, as well as on observations from the public roads. Along the 0.6-mile segment of the route that is located within CL&P's ROW, wetlands and watercourses were field delineated as part of the analyses of the Proposed Route.

Table 15-45: Soils and Soil Characteristics along the Willimantic South Underground Variation

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
3 Ridgebury, Leicester, Whitman	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss	Yes	0.15	--	0.0-1.5
13* Walpole sandy loam	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	Yes	--	--	0.0-1.0
15 Scarboro muck	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	Yes	--	--	0.0-1.0
17 Timakwa and Natchaug	Woody organic material over sandy and gravelly glaciofluvial deposits, and woody organic material over loamy alluvium and/or loamy glaciofluvial deposits and/or loamy till	Yes	--	--	0.0-1.0
18 Catden and Freetown soils	Woody organic material	Yes	--	--	0.0-1.0
21A** Ninigret and Tisbury, 0 to 5 percent slopes	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.43	--	1.5-2.5
23A** Sudbury sandy loam, 0 to 5 percent slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss, and coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	--	--	1.5-3.0
29A** Agawam fine sandy loam, 0 to 3 percent slopes	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.28	--	--
29B** Agawam fine sandy loam, 3 to 8 percent slopes	Coarse-loamy eolian deposits over sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.29	--	--
34A** Merrimac sandy loam, 0 to 3 percent slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.24	--	--
34B** Merrimac sandy loam, 3 to 8 percent slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.24	--	--
36B* Windsor loamy sand, 3 to 8 percent slopes	Eolian sands over sandy glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	--	--	--
38A* Hinckley gravelly sandy loam, 0 to 3 percent slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
38C* Hinckley gravelly sandy loam, 3 to 15 percent slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--
38E Hinckley gravelly sandy loam, 15 to 45 percent slopes	Sandy and gravelly glaciofluvial deposits derived from granite and/or schist and/or gneiss	No	0.15	--	--
47C Woodbridge fine sandy loam, 2 to 15 percent slopes, extremely stony	Coarse-loamy lodgment till derived from granite and/or schist and/or gneiss	No	0.10	--	1.5-2.5
50B** Sutton fine sandy loam, 3 to 8 percent slopes	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.15	--	1.5-2.5
51B Sutton sandy loam, 2 to 8 percent slopes, very stony	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.15	--	1.5-2.5
52C Sutton fine sandy loam, 2 to 15 percent slopes, extremely stony	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.15	--	1.5-2.5
58B Gloucester gravelly sandy loam, 3 to 8 percent, very stony	Sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
60B** Canton and Charlton, 3 to 8 percent slopes	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
61B Canton and Charlton, 3 to 8 percent slopes, very stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
62D Canton and Charlton, 15 to 35 percent slopes, extremely stony	Coarse-loamy over sandy and gravelly melt-out till derived from granite and/or schist and/or gneiss	No	0.17	--	--
73C Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky	Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss	No	0.17	20-40	--
84B** Paxton and Montauk fine sandy loam, 3 to 8 percent slopes	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	0.20	--	1.5-2.5

Soil Map Unit Name and Symbol	Parent Material	Hydric Soil	Erosion Factor[1]	Depth to Bedrock (inches)	Depth to Water Table (feet)
84C* Paxton and Montauk fine sandy loam, 8 to 15 percent slopes	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	.020	--	1.5-2.5
85B Paxton and Montauk fine sandy loam, 3 to 8 percent slopes, very stony	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	0.20	--	1.5-2.5
306 Udorthents-Urban land complex	Drift	No	0.28	--	4.5->6.0
307 Urban land	This is a miscellaneous area***				

Source: USDA Natural Resources Conservation Service, Online Soil Surveys and Geographic Data of New London, Tolland, and Windham Counties, 2009
* Soils classified as Farmland Soils of Statewide Importance
** Soils classified as Prime Farmland Soils
*** Miscellaneous areas are those instances where soils have been altered or obscured by urban works and structures (buildings, paved areas, industrial areas) or standing water.
1. Erosion Factor (K (dimensionless)): Indicates the erodability of the whole soil, the higher the value, the more susceptible the soil to erosion.
-- No Data Available. No bedrock or water encountered to survey depth

Based on this information, the Willimantic South Underground Variation would cross 17 watercourses, the largest of which are the Shetucket River and Potash Brook (refer to Table 15-46). The route variation would traverse FEMA-designated 100-year flood boundaries along both of these larger watercourses (refer to the aerial segment maps in Volume 9 for the locations of these FEMA boundaries). In the Town of Windham, the underground route variation would extend along Pleasant Street, south of the Willimantic River and its associated SCEL, and along Plains Road, across and adjacent to the SCEL associated with the Shetucket River.

Table 15-46: Watercourses along the Willimantic South Underground Variation

Municipality	Watercourse Series Number[1] and Name (Where Applicable)	Water Quality[2] / Fisheries Classification[3] (where applicable)	Watercourse Frequency Type (P or I)[4]
Lebanon			
	S22-1/Intermittent Tributary to Willimantic River	A/coldwater	I
Windham			
	S22-2/Intermittent Tributary to Shetucket River	A/coldwater	I
	S22-3/Intermittent Tributary to Shetucket River	A/coldwater	I
	S22-4/Shetucket River	B/coldwater	P
	S22-5/Intermittent Tributary to Potash Pond	A	I
	S22-6/Intermittent Tributary to Potash Pond	A	I
	S22-7/Intermittent Tributary to Potash Brook	A	I
	S22-8/Intermittent Tributary to Potash Brook	A	I
	Potash Brook		
	S22-9/Intermittent Watercourse	A	I
	S22-10/Intermittent Tributary to Hams Pond	AA	I
	S22-11Intermittent Tributary to Hams Pond	AA	I
	S22-12/Intermittent Tributary to Natchaug River	AA	I
Chaplin			
	S22-13/Tributary to Natchaug River	AA	P
	S20-25/Tributary to Natchaug River	A	P
	S20-26/Tributary to Natchaug River	A	P
	S20-27/Tributary to Natchaug River	A	I

1. Series No. refers to waterbody numbers designated in the CL&P field reports (Volume 2) and illustrated on the aerial photographs in Volume 9.
2. Table 5-2 (Volume 1) defines the water classifications as defined by the Connecticut Water Quality Standards:
3. Fishery Classification (where applicable) was obtained by personnel communication with Don Gonyea and Neal Hagstrom at CT DEEP.
4. P = Perennial; I = Intermittent.

As listed in Table 15-47, 34 wetlands are located along the Willimantic South Underground Variation. Of these, one wetland would be crossed on CL&P's Card Street Substation property and five (wetland Nos. W20-80 through -84) are located along the portion of the variation that would extend along CL&P's existing ROW. The five wetlands located within the CL&P ROW were identified during the 2008 and 2011 field delineations (refer to Volume 2 for additional information concerning the characteristics of each of these wetlands).

The remaining 28 wetlands along the underground route variation were identified based on the review of aerial photographs, NWI maps, and soil maps, as well as observations from the road ROWs along the cable system route. These 28 wetlands either are directly traversed by the road ROWs along which the underground route variation would be located or are situated along the road ROWs (these latter wetlands are identified in Table 15-39 as "adjacent" to the underground cable system route).

As identified by the CT DEEP, groundwater near the Willimantic South Underground Variation is classified as "GA" within the Town of Lebanon; "GA", "GB", "GC", or "GA/GAA" within the Town of Windham; and "GA/GAA/GAA" within the Town of Chaplin. No public wells, aquifer protection public supply wells, or Connecticut Aquifer Protection Areas are crossed by or within the vicinity of the route variation. Drinking water is obtained from a combination of private groundwater wells, and surface water drawn from the Willimantic Reservoir, which is located approximately 1.5 miles west of the route variation.

Table 15-47: Wetlands: Willimantic South Underground Variation

Route Variation Mapsheet Nos. (Volume 9)	Wetland Series No.[1]	Wetland Classification[2]	Relationship to Underground Route (Feet traversed / adjacent) [3]
Lebanon			
1 of 13	W21-15	PFO	50 feet
1 of 13	W22-1	PFO, PSS	Adjacent
1 of 13	W22-2	PFO, PEM	Adjacent
Windham			
5 of 13	W22-3	PEM	375 feet
5 of 13	W22-4	PSS / PFO	Adjacent
5 of 13	W22-5	PEM / PSS	100 feet
6 of 13	W22-8	PFO / PSS	Adjacent
7 of 13	W22-9	PFO / PEM	Adjacent
7 of 13	W22-10	PSS	Adjacent
7 of 13	W22-11	PEM	Adjacent
7 of 13	W22-12	PEM	Adjacent
Chaplin			
8 of 13	W22-13	PFO	Adjacent
9 of 13	W22-14	PFO	Adjacent
9 of 13	W22-16	PFO	400 feet
9 of 13	W22-18	PFO	200 feet
10 of 13	W22-19	PFO / PSS	100 feet
10 of 13	W22-20	PFO / PEM	50 feet
10 of 13	W22-21	PFO	150 feet
11 of 13	W22-22	PFO / PEM	Adjacent
11 of 13	W22-23	PEM	300 feet
11 of 13	W22-24	PFO	Adjacent
11 of 13	W22-25	PEM / PFO	100 feet
11 of 13	W22-26	PFO	Adjacent
12 of 13	W22-27	PSS	100 feet
12 of 13	W22-28	PSS	Adjacent
12 of 13	W22-29	PEM / PFO	Adjacent
12 of 13	W22-30	PFO	50 feet
13 of 13	W22-31	PFO	200 feet
13 of 13	W22-32	PFO	100 feet
13 of 13	W20-80	PFO / PSS	60 feet
13 of 13	W20-81	PFO / PSS	550 feet
13 of 13	W20-82	PSS	50 feet
13 of 13	W20-83	PSS / PFO	50 feet
13 of 13	W20-84	PSS / PFO	250 feet

NOTES:

1. Series No. refers to wetland number illustrated on the aerial photographs in Volume 9.
2. Wetlands classification according to Cowardin et al 1979; PEM = Palustrine Emergent Wetland; PFO = Palustrine Forested Wetland; PSS = Palustrine Scrub-Shrub Wetland; POW = Palustrine Open Water; PUB = Palustrine Unconsolidated Bottom.
3. "Feet traversed" refers to linear distance crossed by center of 345-kVcable route, as depicted on the Volume 9 and 11 maps.

Shading = Denotes wetland that provides vernal pool / amphibian habitat along CL&P ROW. Amphibian habitat studies were not performed of wetlands adjacent to road ROWs.

15.5.3.4.3 Biological Resources

Vegetative Communities

The vegetative communities adjacent to the roads along which the underground variation would be located consist of riparian wooded floodplains, maintained lawn/road shoulder areas, agricultural areas, scrub-shrub areas, scattered wetlands, and forest land. Along the portion of the variation that would be located within the existing CL&P ROW, vegetation is dominated by scrub-shrub and forested (upland and wetland) communities.

Based on a typical construction work area width of 40 feet along the road ROWs and along the CL&P ROW and the alignment of the underground cable route as generally depicted in Appendix 15B, the footprint of the Willimantic South Underground Variation would disturb approximately 60 acres.[25] Of this 60 total acres, approximately 6.9 acres are presently forested (upland and wetland). Of the 6.9 acres of forest, 0.2 acre is forested wetland. The cable system construction work area would encompass a total of 1.3 acres of wetlands overall (i.e., forested and other types).

Fish and Wildlife Resources

Wildlife species in the vicinity of the underground route variation are likely to be those most commonly associated with forested upland and wetland areas; scrub-shrub habitats; or the transition areas (edge) between these habitats (refer to Volume 1, Section 5 for a discussion of such species). Based on consultations with the CT DEEP, the Shetucket River and its tributaries support cold-water fish species.

As described in Section 15.5.2, the CT DEEP stocks the Shetucket River with Atlantic salmon below the Scotland Dam, which is located 3 miles south of the route variation. The CT DEEP also has proposed the Shetucket River as a Trophy Trout Water.

[25] The calculation of underground disturbance consists of a 40-foot construction corridor along the length of the cable with additional 40-foot by 130-foot splice vault areas located approximately every 1,600 feet along the line.

Amphibians

Along the portion of the route variation located within or adjacent to road ROWs, no field surveys to determine amphibian breeding habitat or potential areas of vernal pools were conducted (due to lack of survey rights on private lands). However, seven vernal pools and one amphibian breeding habitat were identified along the portion of the route that would be collocated within CL&P's ROW in the Town of Chaplin. These vernal pools (which are depicted for the segment of the CL&P ROW along which the variation would be located on Volume 11 mapsheets 41 and 42) are designated as follows:

- CH-3-ABH, CH-6-VP, CH-7-VP, and CH-8 VP (in wetland W20-81). CH-3-ABH, CH-7-VP, and CH-8-VP are located beneath the existing 330 Line on the managed portion of CL&P's ROW. CH-8-VP is located adjacent to and north of the existing 330 Line and will be traversed by the underground variation. These vernal pools/amphibian breeding areas provide habitat for both wood frogs, spotted salamanders, American toad, and caddisfly.

- CH-9-VP (in wetland W20-83). This vernal pool is located beneath the existing 330 Line on the managed portion of the ROW. This vernal pool provides habitat for wood frogs.

- CH-10-VP, CH-11-VP and CH-12-VP (in wetland W20-84). These vernal pools are located beneath and south of the existing 330 Line, on the southern edge of the existing CL&P ROW. Amphibians observed include wood frog, spotted salamander, green frog, and red-back salamander.

Listed Species

Based on consultations with the USFWS, the Willimantic South Underground Variation does not encompass the known habitat for any federally-listed species. However, the New England cottontail (*Sylvilagus transitionalis*), which is listed as a candidate species for federal protection, occurs in the Town of Lebanon.

The western-most portion of the Willimantic South Underground Variation does not traverse any state-designated threatened, endangered, or special concern habitats, as identified by the CT NDDB. However, in the vicinity of the Shetucket River (Windham), U.S. Route 6 (Windham / Chaplin), and the CL&P ROW (Chaplin), the underground route variation is within the known habitat of various state-listed species. Consultations with the CT NDDB revealed that the following six state-listed species of invertebrates (dragonflies, butterflies, moths) may occur in proximity to the Willimantic South Underground Variation:

- One endangered species, the banded bog skimmer dragonfly (*Williamsonia lintneri*);
- Three threatened species, the frosted elfin (*Callophryus irus*), Harris' checkerspot (*Chlosyne harrisii*), and the moustached clubtail (*Gomphus adelphus*); and
- Two species of special concern, Horace's duskywing (*Erynnis horatius*) and the bog copper butterfly (*Lycaena epixanthe*).

With the exception of the banded bog skimmer dragonfly and the bog copper butterfly, these state-listed species have also been identified along the Proposed Route (refer to Volume 1, Section 5.3.6 and the Insect Survey Report in Volume 4 for details regarding these species, including preferred habitat types). The banded bog skimmer dragonfly is associated with bog/fen habitat, whereas the bog copper butterfly is associated with sphagnum bogs in Connecticut. Both of the species have been identified as inhabiting areas near the Shetucket River.

15.5.3.4.4 Land Uses

The Willimantic South Underground Variation would traverse the northeastern portion of the Town of Lebanon, central and northern portions of the Town of Windham, and the southern portion of the Town of Chaplin. Land-use plans for these towns were reviewed, and land uses along and adjacent to the road ROWs within which the underground cables would be aligned, were characterized.

As illustrated on the Volume 9 maps, extending east – northeast and then east from Card Street Substation into Windham, the route variation would be aligned along Card Street, State Route 32 (Pleasant Street), Plains Road, and State Route 203. These road ROWs are bordered by a mix of land uses, consisting of residential, civic, and commercial developments, agricultural areas, and forests. In northern Windham and extending into Chaplin, the route variation would be aligned along U.S. Route 6, adjacent to which are forest lands, open fields, commercial / industrial developments and residential areas. In Chaplin, the underground route variation also would extend along CL&P's existing overhead transmission line ROW, which traverses mostly forested areas near Natchaug State Forest and lands owned by the Fin, Fur, and Feather Club, Inc. The local zoning classifications along the route variation reflect the variety of land uses traversed, and range from rural residential and open space zones to business, commercial, and industrial zones (refer to the Volume 9 maps for specific zoning classifications).

Overall, the underground variation would traverse approximately 45.8 acres of road ROWs, 2.7 acres of open field / shrub land upland, 6.7 acres of upland forest, 0.2 acre of forested wetland, 0.1 acre of agricultural land, 3.1 acres of house / yard / other areas, 0.1 acre of emergent wetland, 0.9 acre of scrub-shrub wetland, and 0.4 acre of commercial / industrial uses.

The Willimantic South Underground Variation would be located within 300 feet of six Statutory Facilities. These facilities, which are identified on the Volume 9 maps, include:

- **Town of Windham**: a residential child day-care adjacent to Plains Road (mapsheet 5 of 13), the Windham Center School and playground, and North Windham Elementary School and playground (mapsheet 10 of 13). Another residential child day-care is located approximately 350 feet from the underground route variation, adjacent to Jordan Lane (mapsheet 10 of 13).

- **Town of Chaplin**: Carelot Children's Center, located adjacent to U.S. Route 6 (Willimantic Road) and Old Willimantic Road (mapsheets 11-12 of 13).

Following the road ROWs, the route variation also would traverse adjacent to various residential developments, ranging from low-density rural residential areas to subdivisions. The most densely developed residential areas are located along Pleasant Street and Plains Road in Windham and U.S. Route 6 in Windham and Chaplin. These areas consist primarily of single-family residences interspersed with some multi-family apartments. Less-densely developed areas of single-family residences are located along Card Street in Lebanon and North Road and North Windham Road in Windham.

The Willimantic South Underground Variation would not traverse any designated open space or recreational areas in the Town of Lebanon. However, in Windham, the route variation would be aligned near several recreational land uses, including, as shown on the Volume 9 maps, the American Legion athletic fields and the Willimantic Camp Meeting Association property (a Methodist Church retreat) along State Route 32 (mapsheet 3 of 13), town open space and ball fields (mapsheet 4 of 13), the Windham Center School Playground (mapsheet 5 of 13), and the Windham Elementary School Playground (mapsheet 10 of 13). Along State Route 203 (North Windham Road), the route variation would traverse the Airline State Park Trail, Northern Section (mapsheet 10 of 13).

Along U.S. Route 6 in Windham and Chaplin, the route variation would extend south of and adjacent to the Mansfield Hollow State Park and WMA. Within CL&P's existing ROW, the underground route variation would traverse approximately 300 feet south of the Natchaug State Forest. Along this segment of the route variation, parcels of land owned by the Fin, Fur, and Feather Club, Inc. abut portions of CL&P's ROW to both the north and south. The proposed line transition station at the eastern end of the route variation would be located within a wooded area, adjacent to the CL&P ROW and Fin, Fur, and Feather Club, Inc. property off Park Drive.

15.5.3.4.5 Transportation, Access, and Utility Crossings

For 10.1 miles of the 10.7-mile route, the Willimantic South Underground Variation would be aligned within or adjacent to public roads and would traverse beneath various cross streets. Along the 0.6-mile portion of the variation that would be located within CL&P's ROW, the route would cross one road.

The road ROWs within which the variation could be located are all two-lane roads (one lane in each direction), except for turning lanes located at intersections. Table 15-48 lists the roads along which the variation would be located, as well as the road, railroad, and major utility crossings.

Table 15-48: Roads and Major Utility Crossings along the Willimantic South Underground Variation

Municipality	Road / Railroad / Utility Name	Relationship to Route Variation	
		Variation aligned within or adjacent to road (miles)	**Crosses**
Lebanon			
	Card Street	0.7 miles	
	CL&P 310 Line		Overhead transmission line
	Pipeline		Buried pipeline crossing
Windham			
	Card Street	0.3 miles	
	Pleasant Street. Windham Road	2.0 miles	
	Mountain Street		Road crossing
	Jackson Street		Road crossing
	Plains Road	1.9 miles	
	New England Central Railroad		Railroad crossing
	North Road	0.8 miles	
	North Windham Road	2.8 miles	
	Airline State Park Trail		Former railroad crossing (now state park trail)
	U.S. Route 6 (Boston Post Road)	0.4 miles	
Chaplin			
	U.S. Route 6 (Willimantic Road)	1.0 miles	
	Park Road		Crosses along CL&P ROW

The Windham Airport is located approximately 1 mile west of the route variation, adjacent to the Willimantic Reservoir. The Willimantic South Underground Variation crosses one active rail line, the New England Central Railroad (which provides freight service on a line west of the Shetucket River).

15.5.3.4.6 Cultural (Archaeological and Historic) Resources

A total of 16 reported Native American archaeological sites are located within 1 mile of the Willimantic South Underground Variation. None of the sites are adjacent to or within the construction work area for the underground route variation. Due to previous in-road construction disturbance, underground line construction within existing paved roadways is assumed to have no archaeological sensitivity. However, along these roads, approximately 71% of adjacent unpaved areas appear sensitive, and undocumented disturbance may have occurred within some of these areas.

Reviews of historical maps and available secondary sources indicate that the Willimantic South Underground Variation would be located primarily in or adjacent to road ROWs built on previously undeveloped land. Most of the roads traversed by the underground route variation were established between the late 17th and late 19th centuries. Episodes of road and utility construction have probably removed or severely damaged remains of original unpaved roads, as well as much of the underlying soils.

There are 16 previously reported Euro-American archaeological sites within approximately 1 mile of the Willimantic South Underground Variation. Two of these sites are Rochambeau Army Revolutionary War encampments in the Town of Windham; both sites are listed on the NRHP. The Fourth Camp of Rochambeau's Army is a 16-acre site delineated approximately 850 feet from the underground route variation. The 47th Camp of Rochambeau's Army is a 16-acre site delineated approximately 2,300 feet from the variation. The specific locations of these sites are restricted to protect the integrity of the archaeological sites.

The former New York & New England Railroad once crossed this route variation near the Windham Airport, but recent maps and aerial photographs suggest that this crossing has been completely removed.

Seven significant above-ground historic properties (including 32 individual sites or structures) are located within 500 feet of the underground route variation (refer to the Volume 9 maps). These sites are all located in the Town of Windham and include: Willimantic Armory, Willimantic Elks Club, Willimantic Footbridge, Windham Road Bridge (No. 01850), Dr. Chester Hunt Office, Windham Center Historic District, and North Windham Cemetery. Additional information about these resources is presented in the *Cultural Resources Assessment* in Volume 3.

15.5.3.5 Potential Environmental Effects and Mitigation Measures

The construction of the Willimantic South Underground Variation would predominantly impact soils, water resources, and transportation patterns. Along the roads that the underground route variation would follow, lane closures, detours, and traffic delays would commonly occur throughout the construction process. Construction activities also would create nuisance effects by limiting access to businesses and residences in the vicinity of duct-bank and splice vault construction work, and by creating construction-generated noise and dust.

Along the portion of the route variation that would be constructed within CL&P's ROW, the cable system would directly impact water resources as a result of excavations for the duct bank and splice vaults and the creation of a permanent access road adjacent to the duct bank. The 345-kV line transition station that would be located on the eastern end of the underground route variation (near the Natchaug State Forest and the Fin, Fur, and Feather Club property) also would represent a permanent land-use change and modification to the visual environment.

In addition, along the underground route, CL&P would have to acquire easement rights from private landowners for the installation of splice vaults (where ConnDOT or local highway policies preclude the location of the splice vaults within road ROWs). CL&P also would have to acquire new easements from private landowners for an underground cable system within the existing overhead transmission line ROW.

Appendix 15A reviews the typical environmental effects associated with underground cable construction and the principal measures that could be applied to mitigate such effects. Table 15-49 summarizes these potential environmental effects, along with the mitigation measures that CL&P would typically use to minimize adverse effects to the extent possible.

Table 15-49: Summary of Primary Effects and Potential Mitigation for the Willimantic South Underground Variation

Environmental Feature	Environmental / Social Effects		Potential Mitigation
	Construction	**Operation / Maintenance**	
Topography and Soils	Effects on topography and soils due to: • Grading / filling along 0.6-mile construction ROW within CL&P easement • Grading / filling at transition station sites • Excavations for duct-bank trench and splice vaults. Saw cutting pavement and excavation of soils beneath roads could disturb potentially contaminated soils. Potential for erosion and sedimentation into watercourses and wetlands.	Permanent change in grade along 0.6-mile segment of ROW along CL&P easement; permanent access road; permanent change in topography and soils at the line transition station site.	Install temporary erosion and sediment controls. Segregate topsoil layer during construction. To the extent practical and safe, restore contours and replace topsoil along ROW as part of restoration. Develop material handling plan
Water Resources	Direct disturbance to streams and wetlands as a result of clearing, grading, excavating for trench / splice vaults, and access road development. Approximately 0.2 acre of forested wetland, 0.9 acre of scrub-shrub wetland, and 0.1 acre of emergent marsh wetland would be affected. Vernal pools would also be affected. Potential effects associated with dewatering if groundwater is encountered in excavations Installation of flowable thermal backfill in duct-bank trench would constitute permanent fill in wetlands, as will the development of permanent access roads through wetlands.	An estimated net loss of 1.1 acres of wetlands due to duct-bank fill, splice vaults and access roads.	Use temporary erosion and sediment controls to minimize off-ROW water resource impacts. Revegetate or otherwise stabilize disturbed soil areas to limit the potential for sedimentation into water resources. Coordinate with USACE and CT DEEP regarding off-site compensation for permanent loss of wetlands.
Biological Resources	Direct disturbance to an estimated 13.8 acres of vegetation, including removal of 6.9 acres of forest lands (including 6.7 acres of upland forest and 0.2 acre of forested wetland)	Permanent conversion of forested areas, including forested wetland to scrub-shrub vegetative communities ; net loss of wetland habitat as detailed above due to access roads and cable trench	

Environmental Feature	Environmental / Social Effects		Potential Mitigation
	Construction	Operation / Maintenance	
Land Use, including Statutory Facilities and Designated Recreational Areas	Development of cable system along road ROWs would cause temporary potential disruption to adjacent land uses, as well as nuisance effects. Cable system would affect approximately 2.7 acres of open field and shrubland; 45.8 acres of transportation ROWs; 6.7 acres of upland forest; 0.1 acre of agricultural land.		
Visual Resources	Visual changes associated with the development of the line transition station, including the removal of existing forested vegetation. Construction activities along the ROW will cause temporary changes in the viewscape.	Change to visual environment associated with the development of the line transition station on previously undeveloped forested sites; maintenance of permanent access road along the 0.6-mile segment of route along CL&P's ROW	
Transportation	Increase in traffic as a result of movement of construction equipment and vehicles to / from the ROW and work sites; lane closures and delays during trenching and splice-vault installation along roads.	Permanent access required for access to the line transition station and along cable system ROW	Implement traffic management plan during construction; coordinate with affected towns
Cultural Resources	Any archaeological sites within the construction footprint would be adversely and permanently affected as a result of earth-disturbing activities such as grading, excavation, and access road development	Permanent adverse effects would occur to archaeological sites during construction	Conduct field investigations to identify archaeological sites and, if significant sites are found, to develop appropriate mitigation measures (e.g., data recovery), based on consultations with the SHPO

In general, the use of the underground variation would likely require a trenchless crossing of the Shetucket River (e.g., using jack and bore or HDD), which would involve extensive staging areas on either side of the river. The installation of the cable system beneath the active railroad line also would have to be performed using trenchless technology. Overall, the construction footprint for the route variation would encompass approximately 1.2 acres of wetlands (based on data from the CT DEEP); all of these wetlands would be directly affected by the duct-bank installation. Seven significant above-ground historic resources, encompassing 32 individual structures, would be located within approximately 500 feet of the route variation.

15.5.3.6 Electric and Magnetic Fields

Electric and magnetic fields were calculated for the 10.7-mile Willimantic South Underground Variation, which would be aligned principally along public road ROWs. A short section of the variation route would be located within CL&P's existing ROW in the Town of Chaplin between existing 330 Line structures Nos. 9101 and 9107. Along this in-ROW segment, the electric and magnetic field calculations assume an alignment of the underground cable system within CL&P's 300-foot-wide ROW offset 41 feet north from the centerline of the existing 330 Line. Along the portion of the variation that would follow road ROWs, the calculations assumed for simplicity that no other sources of electric and magnetic fields, such as electric distribution lines, are present.[26] Refer to Figure 15-14 for a graph of the magnetic field calculation results at AAL along the road route and to Figure 15-15 for a graph of the AAL results along the short ROW section.

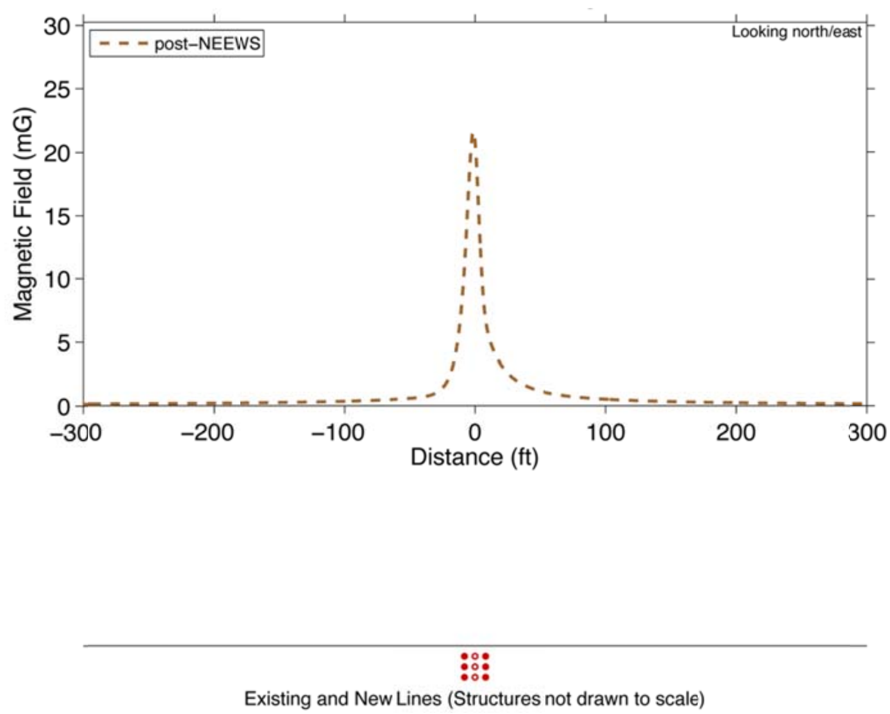
The relatively long length (10.7 miles) of the Willimantic South Underground Variation would significantly change the new circuit's impedance. Therefore, the system power-flow modeling to determine circuit currents for magnetic field calculations was repeated with an appropriate circuit-

[26] That there are such existing sources is evident in measurement results presented subsequently in Figure 15-16.

impedance change. Volume 1, Section 7 of the Application includes details on the system assumptions made in the power-flow modeling used to determine these circuit currents.

As Figure 15-14 shows, magnetic fields would be elevated directly above and near the underground cable system, but would decrease with distance to background levels. The calculated levels of magnetic fields at 25 feet to either side of the center of the cables after the completion of the Project with the Willimantic South Underground Variation at AAL are listed in Table 15-50. There are no defined ROW boundaries for underground cable systems installed within public roads, and the 25-foot distances were arbitrarily selected to show that magnetic fields from the cables would drop off to background levels over short distances. Near cable-splice vaults, many of which would need to be located outside of the road ROWs on private property, the magnetic fields produced by the underground cables would increase because of increased spacing between the cables.

Figure 15-14: Magnetic Field Profiles under Post-NEEWS (2020) Conditions at AAL for the Willimantic South Underground Variation Route from Card Street Substation to Existing Structure 9101 – XS-UG-1



Underground transmission cable systems do not produce electric fields above ground. Therefore, electric field values at the ROW edge are shown as N/A in Table 15-51 for this portion of the Willimantic South Underground Variation.

Table 15-50: Summary of Post-Project (2020) EMF Levels at ±25 Feet from the ROW Centerline at AAL for the Willimantic South Underground Variation Route from Card Street Substation to Existing Structure 9101 – XS-UG-1

Cross-Section	Magnetic Field (mG)		Electric Field (kV/m)	
	-25 ft from center	+25 ft from center	-25 ft from center	+25 ft from center
XS-UG-1 Post-NEEWS	1.4	2.5	N/A	N/A

Between existing structure Nos. 9101 and 9106, a 0.7-mile portion of the Willimantic South Underground Variation would be located within CL&P's overhead transmission line ROW. Along this segment, the underground cable system would be aligned approximately 41 feet north of the existing 345-kV transmission line (refer to Appendix 15B). Magnetic fields produced by both the existing and proposed lines along the short ROW section of the route in Chaplin at AAL were calculated and graphed on Figure 15-15. Figure 15-15 depicts the pre-Project (2015) and post-NEEWS (2020) magnetic field profiles at AAL for the ROW cross-section where the underground cable system would be installed.

The cable system location is shown in red on the sketch beneath the graph. The calculated levels of magnetic and electric fields at the ROW edges of this short segment before and after the completion of the Project with the Willimantic South Underground Variation at AAL are summarized in Table 15-51.

Figure 15-15: Magnetic Field Profiles under Pre-Interstate (2015) and Post-NEEWS (2020) Conditions at AAL for the Willimantic South Underground Variation Route between Existing Structures 9101 and 9106 – XS-UG-2

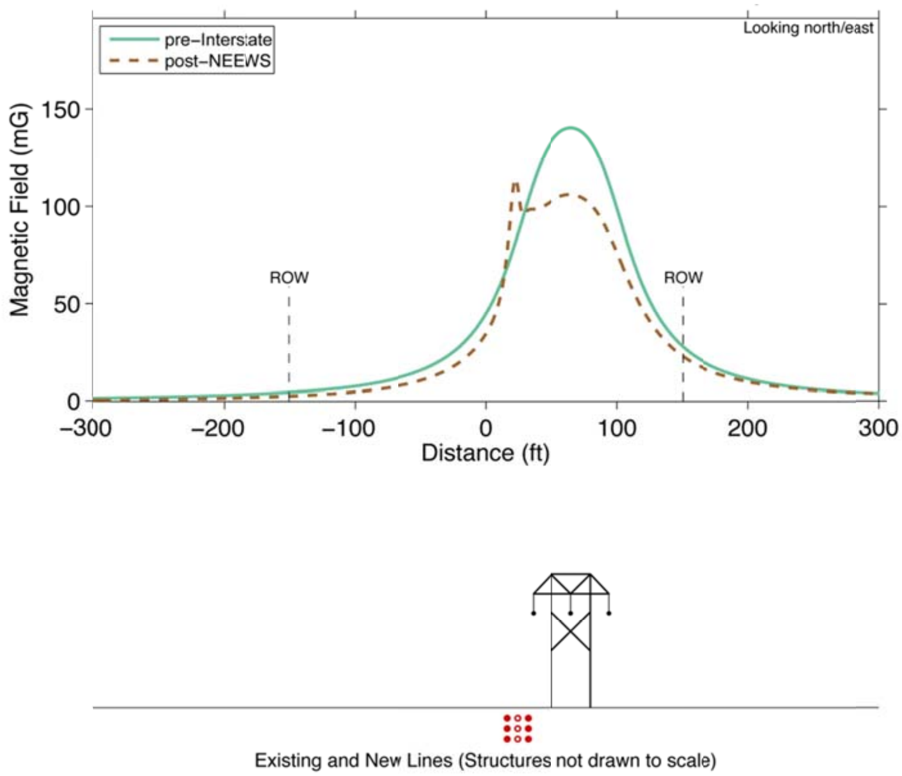


Table 15-51: Summary of Post-Project (2020) EMF Levels at the Edge of the ROW at AAL for the Willimantic South Underground Variation Route between Existing Structures 9101 and 9106 – XS-UG-2

Cross-Section	Magnetic Field (mG)		Electric Field (kV/m)	
	West/North ROW Edge	East/South ROW Edge	West/North ROW Edge	East/South ROW Edge
XS-UG-2 Pre-Interstate	4.6	28.0	0.09	1.20
XS-UG-2 Post-NEEWS	2.7	23.0	0.09	1.20

Underground transmission cable systems do not produce electric fields above ground. Therefore, the electric field profile across the road route and across the short ROW section in Chaplin with the Willimantic South Underground Variation would be the same as the existing electric field profile. Thus, in Table 15-52 for the short ROW section in Chaplin, there is no difference between the ROW edge levels before and after the construction of the Willimantic South Underground Variation.

Table 15-52 compares the electric fields at ROW edges with the Willimantic South Underground Variation to those with the proposed overhead transmission line within the existing CL&P ROW.

Table 15-52: Comparison of Electric Field Levels at the Edge of the Existing 345-kV ROW With the Proposed Overhead Transmission Line and the Underground Variation Within the CL&P ROW

ROW Edge	Electric Field (kV/m)		
	Pre-Interstate	Post-NEEWS	
	Existing Configuration	Proposed Overhead Transmission Line Within Existing CL&P ROW	Underground Variation
North	0.09	0.39	0.09
South	1.20	1.19	1.20

If the Willimantic South Underground Variation were incorporated into the new 345-kV line, the existing 330 Line would remain on the avoided segments of ROW, but would carry different currents. The calculated levels of magnetic fields in 2020 along such existing ROW segments, compared to pre-Interstate levels in 2015, would be as shown in Table 15-53.

Table 15-53: Comparison of Pre-Interstate (2015) and Post-NEEWS (2020) EMF Levels at the Edge of the ROW at AAL for Existing ROW, With and Without Use of the Willimantic South Underground Variation (WSUV)

Cross Section(s)	Magnetic Fields for Annual Average Load Case			
	South/West ROW Edge Level (mG)	North/East ROW Edge Level (mG)	North/West ROW Edge Level (mG)	South/East ROW Edge Level (mG)
XS-1 Pre-Interstate (2015)	7.6	28.2		
XS-1 Post-NEEWS (2020) With WSUV	7.1	22.6		
XS-1 Post-NEEWS (2020) Without WSUV	5.8	18.7		
XS-2, XS-4, & XS-6 Pre-Interstate (2015)			4.6	28.0
XS-2, XS-4, & XS-6 Post-NEEWS (2020) With WSUV			3.7	22.4
XS-2, XS-4, & XS-6 Post-NEEWS (2020) Without WSUV			7.2	18.4
XS-2 BMP Pre-Interstate (2015)			4.6	28.0
XS-2 BMP Post-NEEWS (2020) With WSUV			3.7	22.4
XS-2 BMP Post-NEEWS (2020) Without WSUV			5.2	20.6
XS-3 Pre-Interstate (2015)			8.8	24.7
XS-3 Post-NEEWS (2020) With WSUV			7.0	19.8
XS-3 Post-NEEWS (2020) Without WSUV			24.1	22.3
XS-5 Pre-Interstate (2015)			8.3	35.2
XS-5 Post-NEEWS (2020) With WSUV			6.6	28.1
XS-5 Post-NEEWS (2020) Without WSUV			25.1	24.1

Six Statutory Facilities would be within 300 feet of the Willimantic South Underground Variation, including: Carelot Children's Center, one residential child day-care, the Windham Center School and playground, and the North Windham Elementary School and playground. A summary of magnetic and electric field measurements taken along the route of the Willimantic South Underground Variation in the vicinity of these locations is shown in Table 15-54. Field measurements were taken on November 17, 2008, between the hours of 9 a.m. and 3 p.m. Further measurements were taken along the entire route of XS-UG-1, which are graphed on Figure 15-16. These measurements were taken on the same day between the hours of 3 p.m. and 5 p.m.

Figure 15-16: Measured Magnetic Fields Along Willimantic South Underground Variation Route From Card Street Substation to Near Existing Structure 9101

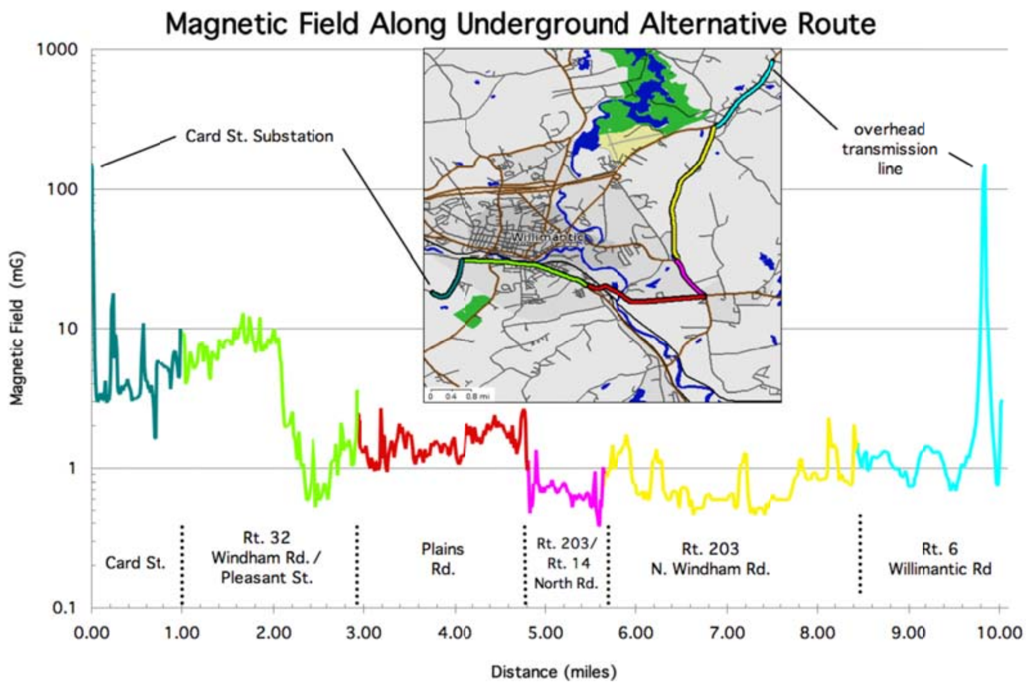


Table 15-54: Measured Electric and Magnetic Fields for the Willimantic South Underground Variation in the Vicinity of Child Day-Care Facilities, Playgrounds, and Schools: Cross Section XS-UG1 (Road ROWs)

Location Name/Address	Town	Volume 9 Route Variation Mapsheet No. (of 13)	Magnetic Field (mG)	Electric Field (kV/m)	Distance From New 345-kV Undergound Transmission Cables (ft)
Little Lights Christian Learning Center 90 South Park St	Windham	18	0.7-1.0**	0.140	590
Windham Center School 45 North Rd	Windham	19 of 21	0.3 – 0.5**	0.022	50
Windham Center School Playground 45 North Rd	Windham	19 of 21	0.2	--	100
North Windham Elementary School 112 Jordan Lane	Windham	21 of 21	0.3 – 0.4**	--	40
North Windham Elementary Playground 112 Jordan Lane	Windham	21 of 21	0.1	--	240
Residential Child Day-Care 90 Jordan Lane	Windham	21 of 21	0.1 – 0.3**	0.011	230

-- Shielding by vegetation prevented the collection of measurable electric field levels at this location from existing sources, e.g., distribution lines.

** Range of measurements made at several different sites near this location. Measurements generally made on the side of the street closest to address.

15.5.3.7 Comparison of the Willimantic South Underground Variation to the Segment of the Proposed Route Replaced

Like the Willimantic South Overhead Variation, the Willimantic South Underground Variation would avoid the federally-owned properties in the Mansfield Hollow area and would avoid aligning the new proposed 345-kV overhead transmission line within CL&P's ROW near existing and potential Statutory Facilities in the Town of Mansfield. However, as summarized in Table 15-55, compared to the development of the new proposed 345-kV overhead transmission line within the CL&P ROW, the use of the Willimantic South Underground Variation would substantially increase Project costs. In addition, the development of the underground cable system and an associated 345-kV line transition station on the eastern end of the cable segment would cause direct impacts to environmental resources, visual resources, and privately-owned properties. As a result, for the primary reasons summarized below, CL&P prefers the proposed 345-kV overhead transmission line located within CL&P's existing ROW.

The cost of the underground cable-system segment is a significant consideration. While the comparable 11.6-mile segment of the proposed overhead transmission line would cost $60.8 million, the capital cost of the 10.7-mile underground route variation is estimated at $325.9 million. Therefore, the underground route variation would add $265.1 million to the total cost of the Project.[27]

As described in Section 14.3.1.3, these increased costs would not likely qualify for inclusion in New England regional transmission rates. As a result, in addition to paying 27% of the cost of building the base-case overhead line, Connecticut consumers would likely be responsible to pay 100% of any costs that exceed the cost of building the base-case overhead line, including extra costs for constructing underground cables and EMF BMP line designs. Since the Willimantic South Underground Variation would cost approximately five times more than the comparable segment of proposed overhead transmission line (constructed pursuant to standard good utility practice), the cost to Connecticut

[27] For this length of underground cables, it is likely that shunt reactors would be needed at one or both ends of the underground cables. No costs for shunt reactors are included in the cost estimate.

consumers for the 10.7-mile underground segment would be approximately 15 times more than that of the overhead line. This is calculated as follows:

Connecticut consumer cost for section of overhead line to be replaced:

Estimated cost of the proposed overhead transmission line (including delta structures for EMF Focus Area A and delta structures through Mansfield Hollow State Park):	$60.8 million
Estimated cost of overhead base transmission line (i.e., H-frame structures through Focus Area A and delta structures through Mansfield Hollow State Park):	$58.1 million
Incremental cost of overhead line with delta structures through EMF Focus Area A:	$2.7 million
Connecticut consumer cost for overhead section to be replaced = (base-line cost x 27%) + (Incremental increase over base-line cost for delta structures in EMF Focus Area A x 100%)	$18.4 million

Connecticut consumer cost for underground variation:

Estimated cost of the underground variation:	$325.9 million
Incremental increase of underground variation over an overhead H-frame transmission line (but including delta structures in Mansfield Hollow State Park):	$267.8 million
Connecticut consumer cost for underground variation = (Incremental cost for underground x 100%) + (H-frame line cost x 27%):	$283.6 million

Finally, dividing the Connecticut consumer cost for the underground variation by the Connecticut consumer cost for the overhead line section to be replaced yields: ($283.6 million / $18.4 million) = 15.

In addition, CL&P would have to purchase up to 4 acres of privately-owned land (in fee) for the eastern line transition station site. This land would be converted to utility use for the life of the Project, and would involve the removal of up to approximately 4 acres of existing upland forest, representing a permanent change in the nearby viewscape.

The development of the underground cable system would cause transportation management issues as a result of construction work (i.e., continuous trenching for the duct banks as well as excavations for the splice vaults) within or adjacent to road ROWs.

Overall, CL&P prefers the proposed Project design over the Willimantic South Underground Variation. Compared to the proposed overhead line, the variation would be significantly more costly, would result in greater long-term environmental effects (particularly to water resources), and would require the permanent conversion of up to 8 acres of land to transition station use.

Table 15-55: Comparison of the Willimantic South Underground Variation to the Proposed Project Segment (Overhead Line) to be Replaced

Route Characteristic	Proposed Route Segment to be Replaced	Willimantic South Underground Variation
Location, Design, and Appearance		
Route Location (ROW, Town[s])	Existing CL&P ROW (Lebanon, Columbia, Coventry, Mansfield, Chaplin)	Within or adjacent to road ROWs, CL&P ROW (Lebanon, Windham, Chaplin)
Route Length (miles)	11.6 miles	10.7 miles
Splice Vaults (est. number)	N/A	35 sets (106 separate splice vaults)
New ROW Easements or Land Acquisition Required (est. acres)	11 acres (ROW expansion: Mansfield Hollow State Park and WMA)	8.2 acres (Line transition station and splice vaults) Underground easement rights along existing ROW and adjacent to road ROWs as needed
Biological Resources		
Upland Forest Clearing (est. acres)	61.4 acres	6.7 acres
Forested Wetland Clearing (est. acres)	10.2 acres	0.2 acre
Scrub-Shrub Clearing (est. acres)	8.8 acres (upland) 0.5 acre (wetland)	2.7 acres (upland) 0.9 acre (wetland)
Watercourse Crossings (no.)	25 (span)	3 (direct effects, trenching)
Wetlands, Permanent Effects (Fill) (est. acres)	1 structure 104 0.4 acre (access roads, structure)	Approximately 1.1 acres
Wetlands, Temporary Effects (est. acres)	1.1 acres (access road)	0.1 acre
Land Uses		
Designated Open Space or Recreational Uses along ROW (length)	0	0
CL&P-Owned Land Traversed	1.8 miles	Less than 0.1 miles
Total Construction ROW / Work Space, Temporary Land Disturbance (est. acres)	136 acres	60 acres
Cost of Transmission Line Segment ($ Million, $ 2010)		
Capital Cost	$60.8	$325.9
Cost to Connecticut Consumers[1]	$18.4	$283.6
Life-cycle Cost	$103.7	$467.8

1. Assumes localization of extra costs for EMF BMP line designs and for underground cables.

Appendix 15A – General Description of Potential Environmental Effects Associated with the Development of the Overhead and Underground Route Variations

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15A. GENERAL DESCRIPTION OF POTENTIAL ENVIRONMENTAL EFFECTS ASSOCIATED WITH THE DEVELOPMENT OF THE OVERHEAD AND UNDERGROUND ROUTE VARIATIONS

This appendix describes the environmental effects that would commonly occur as a result of the construction and operation of segments of the new 345-kV transmission line along:

- The overhead line-route variations (i.e., Brooklyn Overhead Variation and Willimantic South Variation), both of which would entail the creation of "greenfield" corridors for the new 345-kV transmission line; or
- The underground line-route variations, which would involve the development of a 345-kV cable system either along portions of CL&P's existing transmission line ROWs (i.e., the Mansfield Underground Variation, Mount Hope Underground Variation, Brooklyn Underground Variation) or along a combination of highway ROWs and CL&P's ROW (i.e., the Willimantic South Underground Variation).

The potential environmental effects discussed in this appendix are typical to the types of construction and maintenance activities that would be associated with each type of variation. The appendix supplements the specific impact analyses included for each of the variations in Sections 15.2 through 15.5.

15A.1 OVERHEAD VARIATIONS TO THE PROPOSED ROUTE

The development of the new 345-kV transmission line along either of the two overhead line-route variations (Brooklyn Overhead Variation and Willimantic South Overhead Variation) would require the creation of a new 150-foot-wide utility corridor across mostly privately-owned properties currently used for other purposes. This section discusses the potential environmental effects and mitigation measures that would apply to the development of the new 345-kV line along these route variations, focusing on the areas that would differ from the development of the overhead line along the Proposed Route.

15A.1.2 Topography, Geology, and Soils

Whereas along the Proposed Route the new 345-kV transmission lines would be located predominantly within CL&P's existing long-established ROWs, the overhead line-route variations would create new corridors through the landscape. The construction of a new transmission line along the overhead variations also would alter topography where grading or filling is necessary to improve or create new access roads, or to prepare work areas around structure sites.

Based on a review of soil types found along the route variations, in general, depth to bedrock along the overhead line-route variations is greater than 6 feet. As a result, extensive areas of rock would not likely be encountered during drilling for transmission line structure foundations. Erosion and sedimentation control measures would be deployed and maintained where soils are disturbed during construction.

However, the two variations traverse agricultural lands where special soil preservation methods may be required during construction. Typically, construction activities in agricultural lands would be performed to minimize crop damage and the mixing of topsoil and subsoil layers. As part of ROW restoration, de-compaction may be performed in agricultural areas to assist in restoring pre-construction soil texture.

15A.1.2 Water Resources

Wetlands and watercourses along the new ROWs associated with the overhead variations would be spanned to the extent possible. However, some structures and associated foundations, and guy-wire anchors may have to be located in wetlands due to design and safety codes.

As a result of vegetation clearing and subsequent vegetation management, the creation of new ROWs would affect previously undisturbed wetland systems. Clearing of vegetation for construction along these variations would convert primarily forested wetland communities to primarily scrub-shrub and/or emergent cover types. In addition, construction along a new ROW could increase the potential for erosion and sedimentation because activities such as tree clearing, removal of vegetation, and grading for access roads could expose large previously, undisturbed areas of soil to erosional forces and would remove existing wetland buffers and riparian vegetation along watercourses.

Line safety and reliability requirements would determine the extent of vegetative buffers retained along stream and riverbanks. New access roads along the ROWs would be required, likely resulting in some permanent wetland loss due to fill. Mitigation or compensation for these permanent effects would be required by state and federal permitting agencies.

15A.1.3 Biological Resources

Wildlife and Vegetation

Along the two overhead variations, vegetation would have to be cleared to allow for construction of the new 345-kV transmission line and to establish and maintain appropriate clearances between forest vegetation and the conductors of the new line. In general, the use of the overhead variations would require comparatively more vegetation removal than the alignment of a new 345-kV line overhead along the Proposed Route, along which portions of the on-ROW vegetation is presently managed in conjunction with the operation of the existing transmission lines. In areas along the route variations where forest lands presently exist, a conversion to shrubland would represent a long-term localized effect on habitat.

The effects of this habitat change on wildlife would be similar to those described for the Proposed Route in Volume 1, Section 6. However, whereas the Proposed Route would be aligned along an existing, vegetatively managed ROW where scrub-shrub habitat already exists, the route variations would create a new linear corridor through tracts of forestland.

Like the Proposed Route, the two overhead variations would be designed to avoid the placement of transmission line structures in watercourses; the conductors would span rivers, streams, and ponds. However, access roads would likely be required across smaller streams, and the construction and use of such roads would disturb stream banks and riparian vegetation.

Measures would be taken to minimize the potential for sedimentation into watercourses resulting from construction activities in nearby upland areas. In particular, 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 re-vegetated or otherwise stabilized.

Fisheries

Both of the overhead line-route variations traverse watercourses that support fisheries. The potential for localized, adverse effects on water quality, fisheries, or other aquatic organisms could occur as a result of new access road construction and equipment crossings of these watercourses.

In general, riparian vegetation along the variation ROWs would be maintained, to the extent possible, to provide shade. Vegetation along stream banks would be cut only if required to maintain safe clearances from the transmission facilities or to allow the development of access roads. Riparian vegetation removal could have effects on streamside shading and could locally disturb fish habitat.

Riparian forests minimize disruption of aquatic communities by maintaining stream flow during droughts and reducing stream bank erosion during flood events. Streamside forest areas serve as biological buffers to absorb excessive levels of sediment, nutrients, and other pollutants; and also serve to minimize erosion and/or sedimentation into the stream.

CL&P would minimize the potential for indirect effects (e.g., sedimentation into watercourses) by installing temporary soil erosion and sedimentation controls around areas of disturbed soils at work sites located near streams. These temporary erosion and sedimentation controls would remain in place until the disturbed areas are re-stabilized.

15A.1.4 Land Use, Land-Use Plans and Recreational/Scenic Resources

The development of a new 345-kV transmission line along the overhead route variations would create new utility corridors and would not be consistent with federal and state policies for collocating linear utility corridors where practical. For example, both of the overhead variations would require the creation of a new utility corridor through presently undeveloped lands within the Quinebaug-Shetucket Rivers Valley National Heritage Corridor. The use of the variations would also require the conversion of various existing land uses to utility line development. CL&P would have to acquire easement rights from the affected property owners. In such areas, future land uses along the ROW would be restricted to those compatible with utility use.

Construction of the overhead line-route variations may temporarily affect recreational and scenic resources, particularly those crossed by the transmission facilities. Construction of new utility ROWs and transmission line structures would also have a permanent effect on view-sheds within the Project area.

The Willimantic South Overhead Variation would traverse or be located adjacent to certain recreational, open space, or otherwise protected land uses (Pomeroy State Park, Airline State Park Trail, and Beaver Brook State Park). While similar resources also would be traversed by, or would be adjacent to, the Proposed Route, construction of the Willimantic South Overhead Variation would represent a new utility line crossing of these facilities. In addition, the Willimantic South Overhead Variation would extend across the Windham Center Historic District and State Route 14/203, a state-designated scenic road. The creation of a new utility crossing through these areas could affect views to / from scenic or historic sites.

Although the Brooklyn Overhead Variation would not extend across any state or federally designated scenic areas, the new transmission line structures and ROW would parallel and also cross Barretts Hill Road in Brooklyn. This road offers panoramic views of the valley to the southeast, which could be affected by the transmission line structures.

15A.1.5 Transportation, Access, and Utility Crossings

The construction of an overhead 345-kV transmission line along the overhead route variations would typically cause only temporary and highly localized adverse effects on transportation patterns. These effects would stem primarily from the movement of construction vehicles and equipment to and from the new ROWs via public roads. These vehicular movements could cause localized traffic congestion. In addition, the movement of heavy construction equipment over local roads may cause road damage.

The construction and maintenance of an overhead 345-kV line along the overhead route variations would require the creation of new on-ROW access roads (both temporary and – in some cases - permanent). Along the overhead variations, the overhead 345-kV transmission lines would span all public roads, railroad, and pipelines. As a result, the operation of the overhead transmission lines would not affect transportation.

15A.1.6 Cultural Resources

Because the overhead variations generally traverse undeveloped areas, where soils may not previously have been disturbed, the potential for locating intact buried archaeological sites can be expected to be higher than along the Proposed Route. Further field assessments of the archaeological sensitivity along the route variations would be required to evaluate the need for and extent of cultural resources testing. Field investigations also would be required, in coordination with Native American Tribal representatives, to determine areas of potential interest for Tribal purposes.

15A.2 UNDERGROUND VARIATIONS

The development of 345-kV transmission cable systems along any of the four underground variations, either within or adjacent to road ROWs or along sections of the existing CL&P ROWs, would have direct effects on all environmental resources within the construction footprint. These effects would occur as a result of grading (if necessary) and excavations for a cable-duct bank and splice vaults, as well as for construction access. In addition, all of the underground variations would require one or two 345-kV line transition stations, the development of which would represent long-term land-use conversions and cause localized adverse effects on the visual environment.

Within paved road ROWs, the operation of the underground transmission cable system typically would not result in adverse environmental effects, except to the extent that maintenance activities may require re-excavation of portions of the cable system or work within the existing splice vaults. This could cause traffic congestion due to lane closures or detours. In contrast, cable systems within the existing CL&P ROWs would require long-term land use conversions because of the need to maintain a permanent road allowing access along the entire length of any cable route.

The following sections first describe the potential effects of underground cable-system construction and maintenance on environmental resources in general (Sections 15A.2.1 through 15A.2.6), and then discuss the potential effects of the 345-kV line transition stations.

15A.2.1 Topography, Geology, and Soils

Underground cable-system construction, either within or adjacent to road ROWs or along the transmission line ROW, would result in effects to topography, geology, and soils as a result of grading, excavation (possibly requiring blasting or other rock removal activities), and soil disturbance. Unlike the development of an overhead transmission line along which such activities are only required along access roads or at structure locations, the installation of an underground cable system requires continuous and linear grading, excavation (of a trench for the cable ducts and splice vaults), and soil disturbance along the entire length of the underground cable route.

Additionally, subsurface conditions along the underground cable routes would have to be characterized prior to construction to develop a subsurface profile (to assess locations where bedrock and groundwater would be encountered) and also to test the quality of soils and groundwater. Based on the results of these analyses, a *Material Handling Guideline* would be prepared defining how soils and groundwater encountered during the trenching / excavation process would have to be managed.

The installation of the underground cables and splice vaults along road ROWs (i.e., the Willimantic South Underground Variation) would not require extensive grading and thus would have minimal adverse effects on topography and geology in most areas. In general, a construction width of approximately 40 feet would be needed to install the cable system along roads. However, in areas where the cables or splice vaults must be located off-road, including at watercourse crossings, clearing and grading would be necessary to cut stream banks, excavate the trench through the stream bed, and otherwise level the terrain so the cable system or vaults could be installed safely and at an appropriate elevation below grade. Extra work space would also be required in such areas to stage the equipment and materials required for the installation of the cable system beneath the watercourses. Additionally, extra work space for other staging areas (e.g., at jack and bore or HDD sites, or areas where construction equipment and materials would have to be temporarily stored) may involve localized earth-disturbing activities such as clearing and grading.

In contrast, the installation of a cable system along CL&P's transmission line ROWs (e.g., the Mansfield, Mount Hope, and Brooklyn Underground Variations) would involve vegetation clearing and grading along the entire length of the underground segment. For example, grading would be required to create permanent access roads[1], provide a level work space for construction equipment, and achieve appropriate subsurface elevations for the installation of the entire cable system (cables and splice vaults).

A minimum construction workspace width of approximately 40 feet would be required to install the cable system duct bank within the existing transmission line ROWs. Within CL&P's existing ROWs, the center of the cable duct bank would be offset 15 feet from the outside conductor of the existing 345-kV line. Additional space would be required at splice vault locations. This construction workspace would be needed to accommodate an access road (approximately 20 feet wide), as well as the trench/splice-vaults.

[1] Access roads would be developed and used during construction, but would have to remain in place permanently because access to the entire underground cable systems is required for maintenance purposes.

Within this construction area, all vegetation would be removed and the area would be graded or filled to create a level work space.

Whether along a road ROW or within the transmission line ROWs, cross-linked polyethylene (XLPE) cable installation would involve the excavation of a continuous trench (approximately 7 to 10 feet deep and 5 feet wide at the bottom, and typically with a 10-foot-wide opening at the surface), as well as excavations for concrete splice vaults (each requiring an excavation area approximately 13 feet wide by 13 feet high and 35 feet long). The splice vaults would typically be required at approximately 1,600-foot intervals along the cable system route (note, however, that this interval between vaults may vary depending on site-specific factors). The required excavations may be deeper or wider, depending on soil conditions and, when trenching along roads in particular, depending on whether the cable system must be installed below other buried utilities (e.g., water lines, sanitary sewers, storm sewers). Trench boxes and other types of shoring would be required to support the trenches during duct-bank installation. Shoring also is typically required at splice-vault installations.

To excavate the trench and splice-vault locations for the underground cables through areas of rock, special rock removal methods would be required. The preferred techniques for removing rock are mechanical methods (e.g., mechanical excavators and pneumatic hammers) or mechanical methods supplemented by controlled blasting. Such rock removal activities result in dust and vibration/noise in the immediate vicinity of the excavation work. Controlled blasting would only be used if other methods of rock removal are not practical.

Because underground cable installation is time-consuming, the lengths of time soils or excavations are exposed in any one location (and therefore subject to the potential for erosion or sedimentation into water resources) can be significant. The amount of construction time required at any one location depends on subsurface conditions, particularly whether bedrock or groundwater are encountered in the excavations.

During cable system excavations, temporary erosion and sediment controls would have to be deployed to contain spoil piles and to avoid erosion and sedimentation into watercourses or wetlands, either from erosion of disturbed soils or from sedimentation caused by excavation dewatering. Temporary erosion and sedimentation control measures would have to be consistent with CL&P's established plans and with the 2002 *Connecticut Guidelines for Soil Erosion and Sedimentation Control*.

For work within and adjacent to road ROWs, typical erosion and sedimentation control measures may include catch-basin protection, the use of fractionization tanks, or the use of dewatering structures or filter bags. Such temporary controls are typically maintained until the restoration of disturbed work sites is deemed successful.

After the completion of conduit and splice-vault installation, the excavated trench and splice-vault areas would be backfilled with special "flowable fill", a concrete mix designed to better dissipate heat from the cables. For the most part, the material originally excavated from the trench would not be used as backfill. Instead, soils would be trucked off-site and disposed of at approved sites, in accordance with applicable regulations.

After the completion of cable-system installation, disturbed ROW areas would be restored to grade to the extent practical. Along the Willimantic South Underground Variation, disturbed pavement would be resurfaced and affected road shoulders/curbing/sidewalks repaired. Along the in-ROW underground variations, the ROW would be reseeded and allowed to re-vegetate, except for the 20-foot-wide permanent access road, which would be maintained for operation and maintenance purposes.

15A.2.2 Water Resources

The construction and operation of the underground variations would cause both direct and, potentially, indirect effects to water resources. All of the underground variation routes traverse both wetlands and watercourses. While the Willimantic South Underground Variation may be constructed within road

ROWs above or below certain of these water resources, avoidance of effects to all water resources is unlikely because in some areas along the route, it would likely be infeasible to install the cable system on bridges or culverts. As a result, some in-water construction would be required.

Furthermore, while subsurface techniques, such as jack and bore or HDD may be considered for some larger watercourse crossings, even these techniques, which are both costly and time-consuming, would involve effects to water resources. For example, jack and bores near watercourses typically encounter groundwater, which must be pumped continuously from the excavated pits and typically is ultimately discharged to a surface water. HDDs require withdrawal of water for the drilling fluid mix, and also may result in inadvertent returns of the drilling fluid/drill cutting mix to surface or ground waters.

The in-ROW underground variations would involve direct effects to all water resources within the construction footprint. In order to install the duct bank, excavations would be required through both streams and wetlands. In addition, a permanent access road would likely be required across these water resources.

Potential effects to water resources associated with underground cable-system construction include sedimentation and turbidity (potentially caused by clearing and grading of stream banks), excavation in wetlands and streams, trench/vault dewatering, and backfilling. Additionally, the soils disturbed along the cleared ROW could erode, resulting in effects to water quality. In general, along the in-ROW underground variation routes, the clearing and grading of the ROW exposes large areas of soil to erosional forces and increases the potential for sedimentation into water resources. Riparian vegetation also must be removed along the ROW at watercourse crossings.

The use of flowable fill, rather than native backfill in the trench and splice vaults, could also have long-term localized adverse effects on water resources. It is possible that the flowable fill could disrupt natural subsurface water flows or could affect infiltration rates. This could be a potential concern along the in-

ROW underground variations, rather than for the construction of the Willimantic South Underground Variation, which would be aligned mostly within paved road ROWs.

Neither the construction nor the operation of the underground variations would result in significant adverse effects to groundwater resources or public water supplies. However, groundwater is likely to be encountered along all of the underground variations and would require careful management throughout the excavation phases of construction. Trench dewatering, whether along roads or along CL&P's transmission line ROW, has the potential to cause the discharge of turbid or sediment-laden water to streams and wetlands.

In general, if groundwater is encountered during trench or splice-vault construction, the water would be pumped from the excavated areas and discharged in accordance with the requirements of applicable regulations. Depending on regulatory authorizations and on the alignment of the underground variation, the water may be pumped into municipal storm water catch basins, to the sanitary sewer system, into temporary settling basins and sediment filter bags, or watercourses (if the water is sufficiently free of sediment). Alternatively, water may be pumped into a tank truck for off-site disposal.

Furthermore, along the Willimantic South Underground Variation and where the in-ROW variations traverse roads, the cable system would require careful alignment to avoid effects to other buried utilities, such as municipal water lines, as well as storm and sanitary sewers. Excavations for trenches or splice vaults would have to be performed carefully to avoid conflicts with these existing utilities.

15A.2.3 Biological Resources

The effects of underground cable-system installation and maintenance on biological resources would differ substantially, depending upon whether the underground cables are aligned within or adjacent to existing road ROWs or within the CL&P transmission line ROWs.

Wildlife and Vegetation

The construction and operation of an underground transmission cable system within or adjacent to road ROWs (e.g., the majority of the Willimantic South Underground Variation) would result in minimal effects on vegetation and wildlife resources. Where an underground cable can be aligned within paved portions of road ROWs, vegetation removal would not typically be required, except for vegetation within or near road shoulders or tree branches that overhang the road and that may interfere with construction. In addition, vegetation (including riparian areas and wetlands) could potentially be affected where the cable system must be aligned across water resources outside of the road ROWs.

If splice vaults must be located outside of road ROWs (as required pursuant to ConnDOT policies along state roads), existing lawns, trees, and ornamental vegetation would be affected. The amount and type of vegetation affected would depend on the actual splice-vault locations. In such areas, after the completion of the cable-system installation, lawn and ornamental vegetation could be restored in locations where it would not affect future access for cable system inspections and repairs.

In contrast, the construction and operation of an underground cable system along the route variations within CL&P's ROWs would result in both temporary and permanent effects on vegetation. Along the entire underground cable routes, all vegetation would have to be cleared, stumps removed, and the ROWs graded. After the completion of the cable-system installation, temporary work areas would be reseeded and then allowed to re-vegetate naturally, except the areas over the cable trench and splice vaults, which would be maintained in low-growth vegetation. However, along the permanent graveled access road that would have to be created and maintained along the entire underground cable system, vegetation would be precluded for the life of the Project.

Wildlife habitat would be altered both temporarily and permanently due to the vegetation changes described above. Construction activities would have direct effects on wildlife within the ROWs in terms of displacement, disturbance, and (for less mobile species), mortality. Vegetation clearing also would reduce cover, nesting, and foraging habitats for some wildlife. In forested areas, the principal effect of the vegetation removal and the long-term ROW maintenance, in low-growth vegetation, would be a change in the species using areas from those favoring wooded habitats to those preferring edge habitats or scrub-shrub or open habitats. The conversion of forested habitat to scrub-shrub would be advantageous to some species.

Fisheries

All of the underground route variations traverse watercourses, some of which support fisheries. Where the installation of the underground cable system may be accomplished without disturbing stream banks or stream beds (e.g., potentially along portions of the Willimantic South Underground Variation where the cable system could be installed above or below streams), no adverse effects would occur to water quality, fisheries, or other aquatic organisms. CL&P would minimize the potential for indirect effects (e.g., sedimentation into watercourses) by installing temporary soil erosion and sedimentation controls around areas of disturbed soils at work sites located near streams. These temporary erosion controls would remain in place until the disturbed areas are re-stabilized.

Along the underground variations within CL&P's existing ROWs, the cable system would have to be trenched across watercourses, causing direct effects to water quality and fishery resources. These direct effects would be unavoidable, because subsurface methods such as HDD or jack and bore would not be practical for all of the small watercourse crossings along the ROWs. To mitigate effects to fishery resources, CL&P would consult with CT DEEP to identify appropriate timing windows for in-water construction to avoid fish spawning periods. Additionally, construction methods such as dam and pump or dam and flume could be used to minimize adverse effects to water quality, and thus to fish habitat.

Amphibians

The cable-system construction along the underground variations would directly affect wetland resources and could potentially affect amphibian habitat or amphibians. Construction best management practices would be employed to contain the construction sites and control soil erosion and the discharge of sediment-laden water to wetlands and watercourses located along the existing roadways.

15A.2.4 Land Uses

In general, the development of an underground cable system along the route variations, either within CL&P's existing transmission line ROWs and/or within or adjacent to road ROWs, would not conflict with local, regional, state, or federal land-use plans. However, the 345-kV line transition stations required at each end of the underground segments represent utility uses that would not be consistent with local land uses or zoning.

Cable-system construction activities would cause land disturbance within construction work areas and would create temporary, highly localized nuisance effects (e.g., noise, dust, and traffic congestion). These effects would occur throughout the period of active construction, and would depend on the type of construction work at each location, as well as the schedule for such activities. Construction work could be designed and scheduled to avoid or limit the potential for interference with recreational activities. However, underground trenching, duct-bank installation, and backfilling work, as well as the excavations for and installation of splice vaults can require substantial time at any one location, depending on the subsurface conditions encountered (e.g., presence of rock, groundwater). As a result, construction work could extend over multiple months.

The development of the 345-kV facilities along any of the underground variations would change the visual environment. During construction, these effects would be associated with the removal of vegetation within the construction work spaces and views of work sites, etc. After the cable system is installed, the construction work areas would be restored (i.e., re-paved or re-vegetated). However, along the in-ROW underground variations, both the creation of the permanent access road along the cable system route and the management of the lands along the cable system route in non-forested vegetation would represent a long-term change in the visual environment. In addition, the above-ground 345-kV line transition stations would cause a long-term change in the character of the visual environment in the vicinity of each site.

15A.2.5 Transportation, Access, and Utility Crossings

The potential effects of underground cable-system construction and operation on transportation would depend on the location of the cable route.

In general, the construction of an underground cable system along CL&P's ROWs would have minor or highly localized effects on transportation and access. During construction, construction vehicles and equipment would have to access the ROW via local roads, which could cause traffic delays. In addition, the movement of heavy equipment over local roads may cause road damage. Along each of the in-ROW underground variations, local or state roads would have to be crossed, requiring temporary lane closures or detours during the construction period. The maintenance of the underground cables along the CL&P ROWs would not affect transportation patterns, except that permanent access would have to be maintained to the 345-kV line transition stations.

By comparison, the development of the Willimantic South Underground Variation would have temporary, but potentially significant effects on local traffic patterns. The variation also would have to be carefully designed to avoid conflicts with utilities buried within the roads. Because a majority of the underground variation would be aligned along road ROWs, construction activities would require temporary lane closures and would result in traffic disruption, delays, detours, and/or congestion. Construction workers traveling to work sites, as well as the movement of construction equipment, also could temporarily cause localized increases in traffic volumes, further aggravating traffic congestion. To mitigate the potential effects of the cable-system construction, CL&P would coordinate closely with ConnDOT and local highway authorities, and would typically develop a *Traffic Control Plan* and construction schedule (to avoid lane closures during peak travel periods).

The operation of the cable systems would not affect transportation patterns, except when maintenance or repair is required, involving access to the splice vaults or other portions of the buried cable, is necessary.

15A.2.6 Cultural (Archaeological and Historic) Resources

In general, the trenching and splice-vault excavation required for underground cable system construction would disturb soils and could potentially directly affect archaeological sites. As a prerequisite of regulatory approvals, all construction work spaces associated with an underground cable system would have to be investigated for the presence of buried cultural resources and, based on the results of such field investigations, if potentially significant cultural sites are discovered, mitigation strategies would have to be developed and implemented as appropriate. The *Cultural Resources Assessment Report* (refer to Volume 3) identifies the cultural resources potentially affected by the underground variations, including the identification of known or potential archaeological resources in the vicinity of each route and the evaluation of the potential visual effects of the Project on historic properties listed or eligible for listing on the State and National registers of historic places.

15A.2.7 Air Quality

The development of a cable system along any of the underground variations would result in short-term, highly localized effects on air quality during construction, primarily from fugitive dust and vehicular emissions associated with cable trench and splice-vault excavations. For in-road cable system installation, saw cutting of pavement also would generate dust and silt-laden water. During dry periods, to minimize the amount of fugitive dust generated by construction activities, water would be used as needed to wet down excavated spoil piles and dirt/gravel access roads. No adverse effects on air quality would be associated with the operation of the facilities.

15A.2.8 Noise

During construction of the cable system along any of the underground variations, activities such as vegetation removal, grading, access road development, trench excavation (particularly involving rock drilling, jack-hammering or blasting), the installation of splice vaults, and the general operation of construction equipment would increase ambient sound levels. Along the Willimantic South Underground Variation, saw-cutting of pavement, pavement removal, and re-paving also would emit noise. The underground cable-system operation would not result in any noise effects.

Construction-related noise would be short-term and highly localized in the vicinity of work sites. However, there are noise sensitive sites (receptors) in the vicinity of the underground variations. These include residences, schools, and public recreational areas. Because of the slow pace of underground construction work, noise-emitting activities could be localized in the vicinity of these receptors for several days or more.

Additionally, it is possible that some underground cable-system construction along the Willimantic South Underground Variation would have to occur at night, to minimize the potential for traffic congestion associated with lane closures or detours. People are more sensitive to increases in ambient sound levels at night; as a result, such night construction work could result in greater perceived adverse noise effects, particularly on sensitive noise receptors.

15A.2.9 345-kV Line Transition Stations

The development of any of the underground variations would require the associated construction and operation of one or two 345-kV line transition stations, each of which would involve the permanent conversion of approximately 2 to 4 acres of land to utility uses for the life of the Project. Except for the line transition stations that could be located entirely on CL&P’s fee-owned property, lands for the sites would have to be acquired from private owners. Figure 15A-1, located at the end of this appendix, provides an illustration of a typical 345-kV line transition station for three underground cable sets connecting to one overhead line with no shunt reactors.

In general, the construction and operation of each line transition station would result in a range of effects on environmental resources. The site development activities would require the removal of all vegetation within the construction footprint, permanently displacing the existing wildlife habitat. Subsequently, each site would be grubbed and graded to create a level area for the line transition station facilities. Potential short-term effects to soil resources, associated with earth-moving activities and the increased potential for erosion, would occur during the construction of the station.

New line transition stations would typically be sited in upland areas. As a result, the development of the sites would not directly affect water resources (i.e., watercourses, wetlands, or floodplains). However, construction activities could increase the potential for off-site erosion and sedimentation into water resources. Similarly, construction activities involving refueling and the storage of fuels and lubricants, etc. could increase the potential for accidental spills that could reach ground or surface water resources.

Further, the location of line transition stations in generally rural or rural residential areas would not typically be consistent with existing land-use patterns and also would create permanent visual changes to the character of the surrounding areas. Although located adjacent to the existing CL&P overhead transmission line ROWs, the line transition station facilities would constitute a visual contrast with the other undeveloped lands or existing land uses in the vicinity. On the other hand, the collocation of a line transition station within or adjacent to an existing substation (such as would be the case at Card Street Substation for the western line transition station for the Willimantic South Underground Variation) would be consistent with the utility use of the property and typically would result in only incremental visual effects.

The construction and operation of the 345-kV line transition stations would generally result in the same types of effects on transportation/access, noise, and air quality as described for the cable systems. However, some noise may be associated with the operation of circuit breakers. In addition, the line transition stations would be equipped with lighting, which would be used for night work or inspections and possibly for security purposes.

Likewise, as described in the *Cultural Resources Assessment* (refer to Volume 3), each potential line transition station site would be located in an area sensitive for potential (as yet undocumented) Native American archaeological sites. As a result, detailed field studies would be required to determine whether any archaeological sites are present and, if so, the potential effects of the line transition station development on such resources. In contrast, none of the proposed line transition station sites areas would be sited within 0.25 mile of significant above-ground historic resources; consequently, none of the stations would cause any potential for adverse visual effects on such historic structures.

Figures 15A-2 and 15A-3 illustrate existing CL&P line transition stations where two sets of 345-kV underground cables transition to an overhead line.

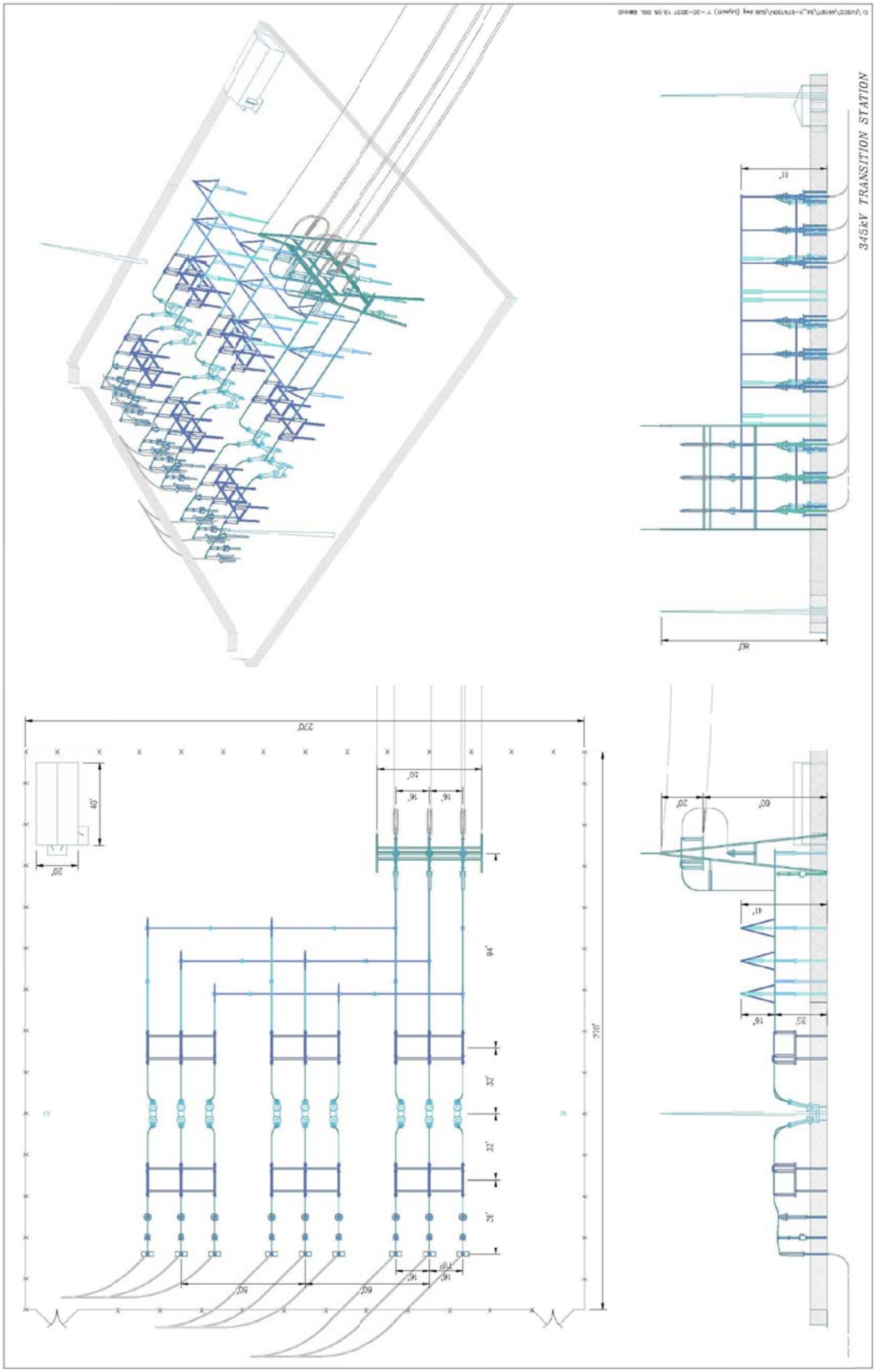
345kV TRANSITION STATION

Figure 15A-2: 345-kV Line Transition Station with Shunt Reactors

Figure 15A-3: 345-kV Line Transition Station with no Shunt Reactors

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Appendix 15B –Variations: Cross-Sections

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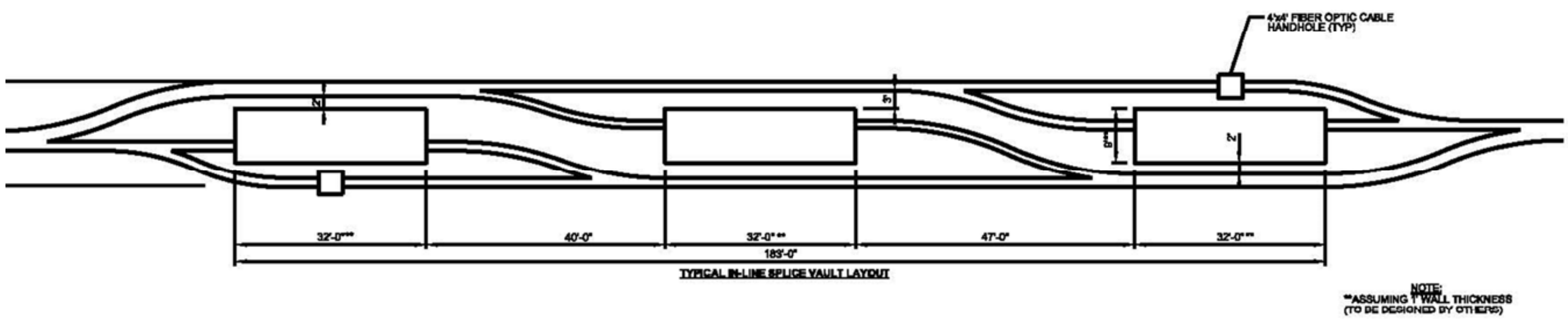
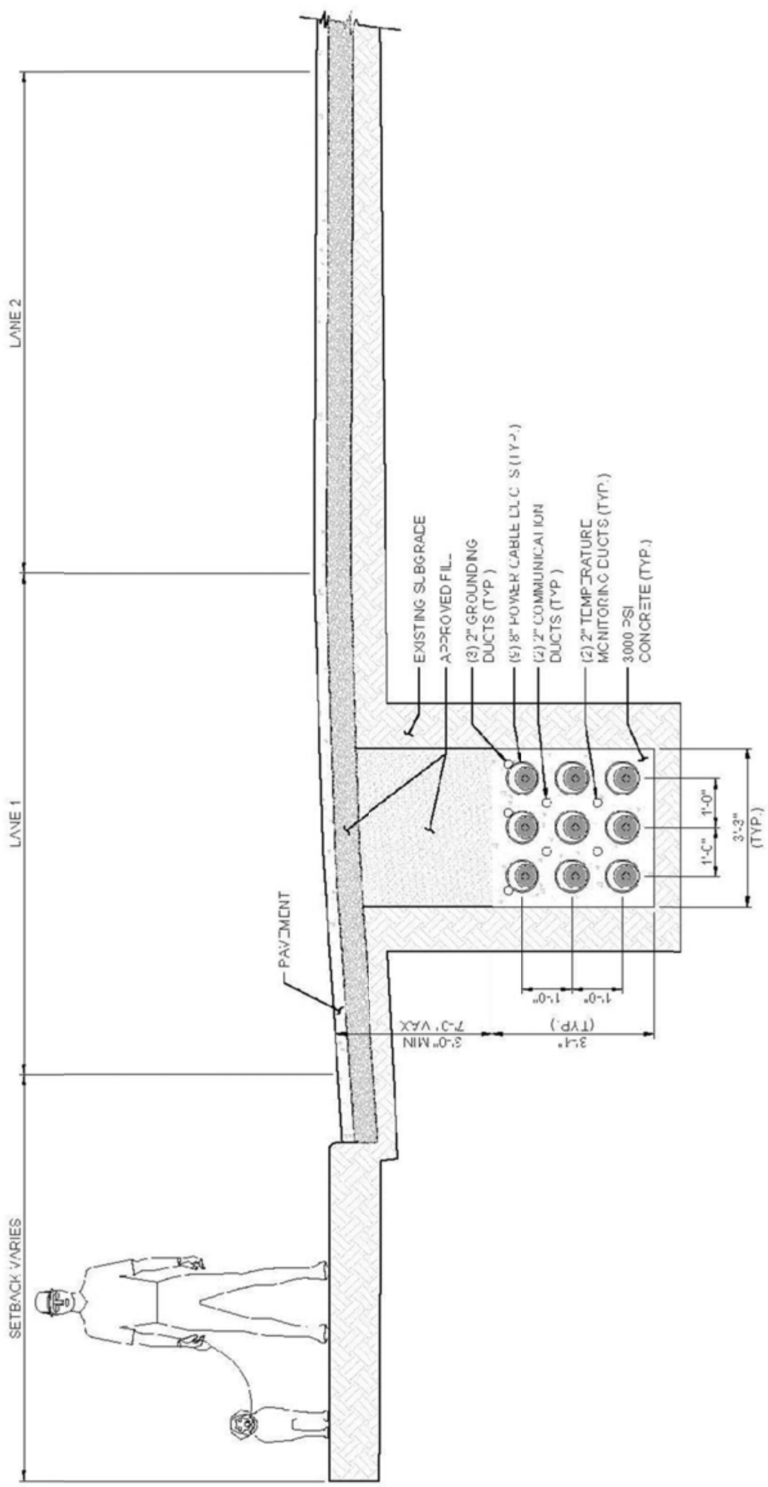
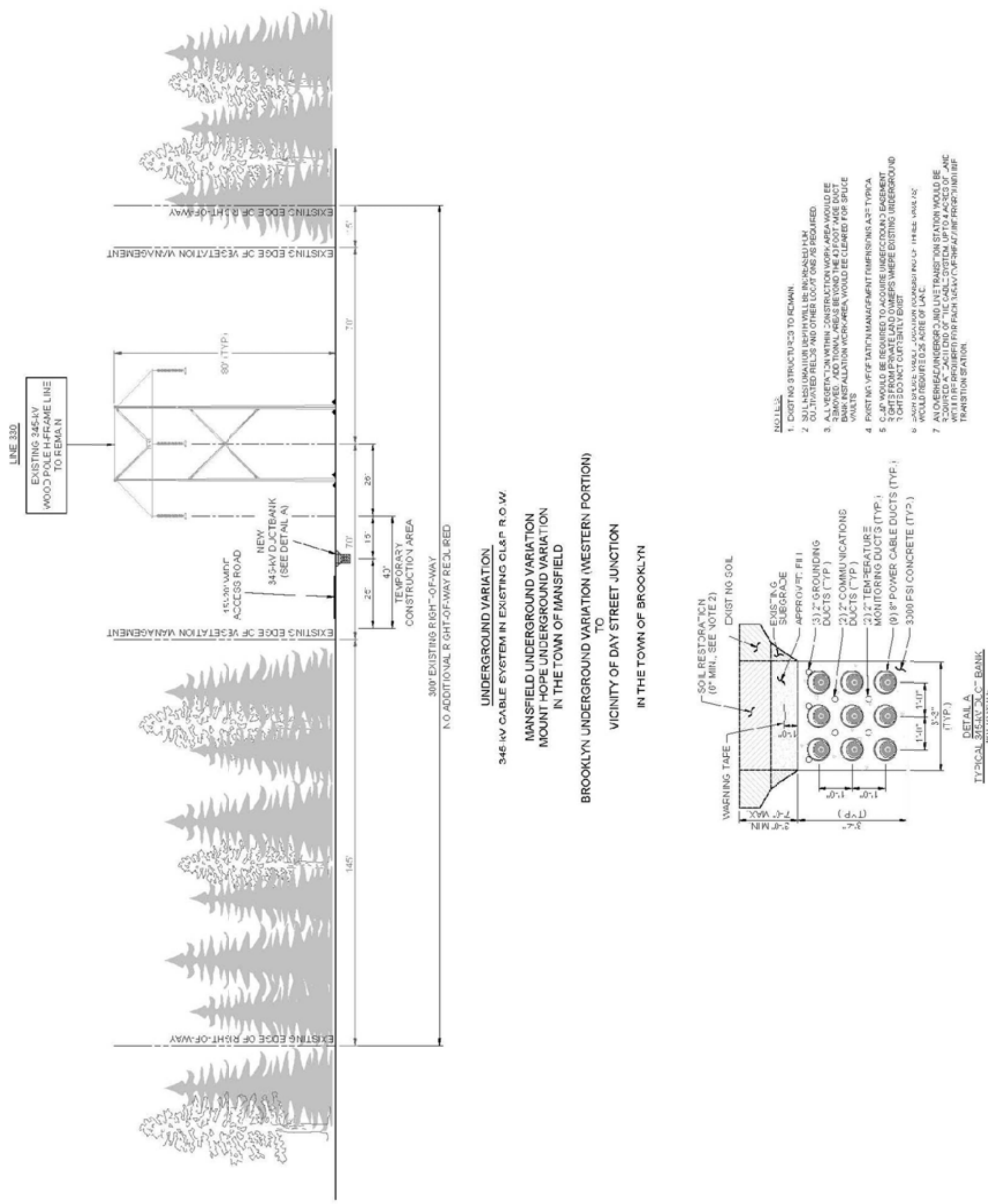
Typical Underground Cable System Layout at Splice Vault Locations



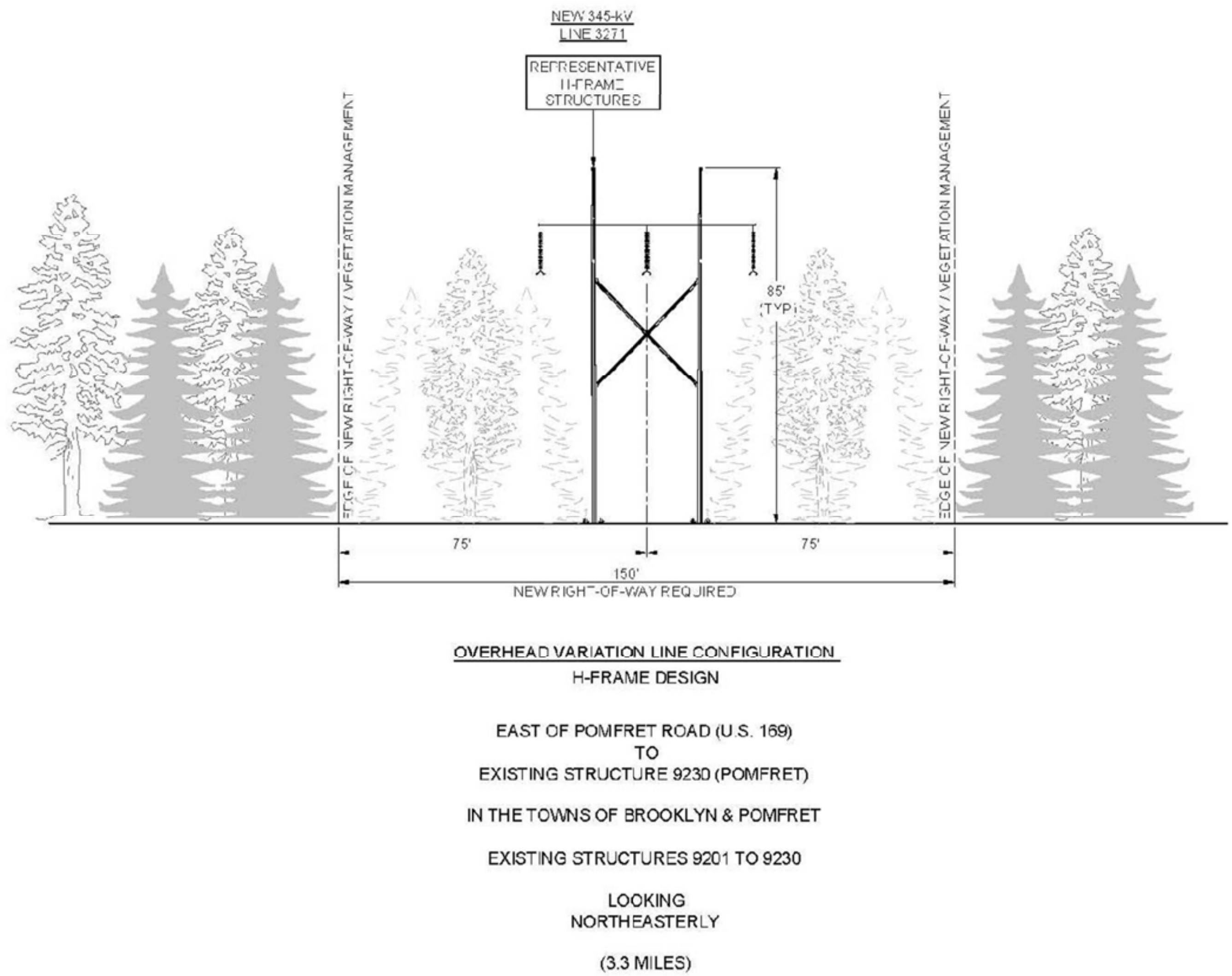
XS-UG-1: Underground Variation – 345-kV Cable System in Road



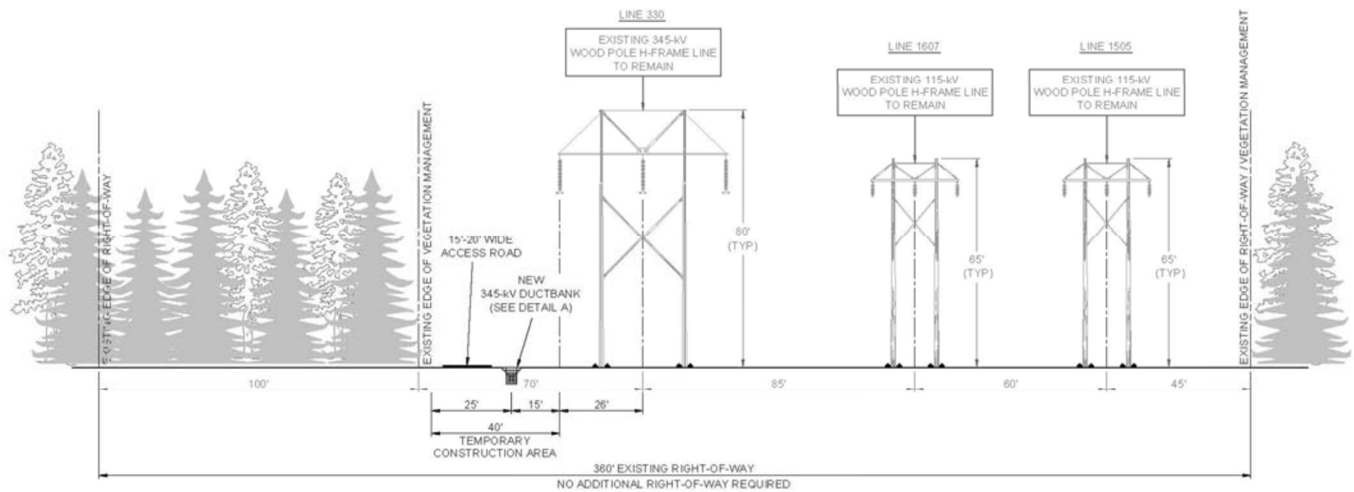
XS-UG-2: Underground Variation – 345-kV Cable System in Existing CL&P ROW



XS-B-1: Brooklyn Overhead Variation – Pomfret Road to Ten Spans North of Day Street Junction



XS-UG-3: Underground Variation – 345-kV Cable System in Existing CL&P ROW



BROOKLYN UNDERGROUND VARIATION
345-kV CABLE SYSTEM IN EXISTING CL&P R.O.W.

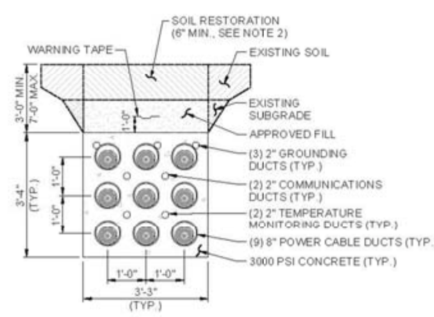
VICINITY OF DAY STREET JUNCTION NORTH TO LINE TRANSITION STATION

IN THE TOWN OF BROOKLYN

EXISTING STRUCTURES 9219-9221

LOOKING NORTH

(0.2 MILE)

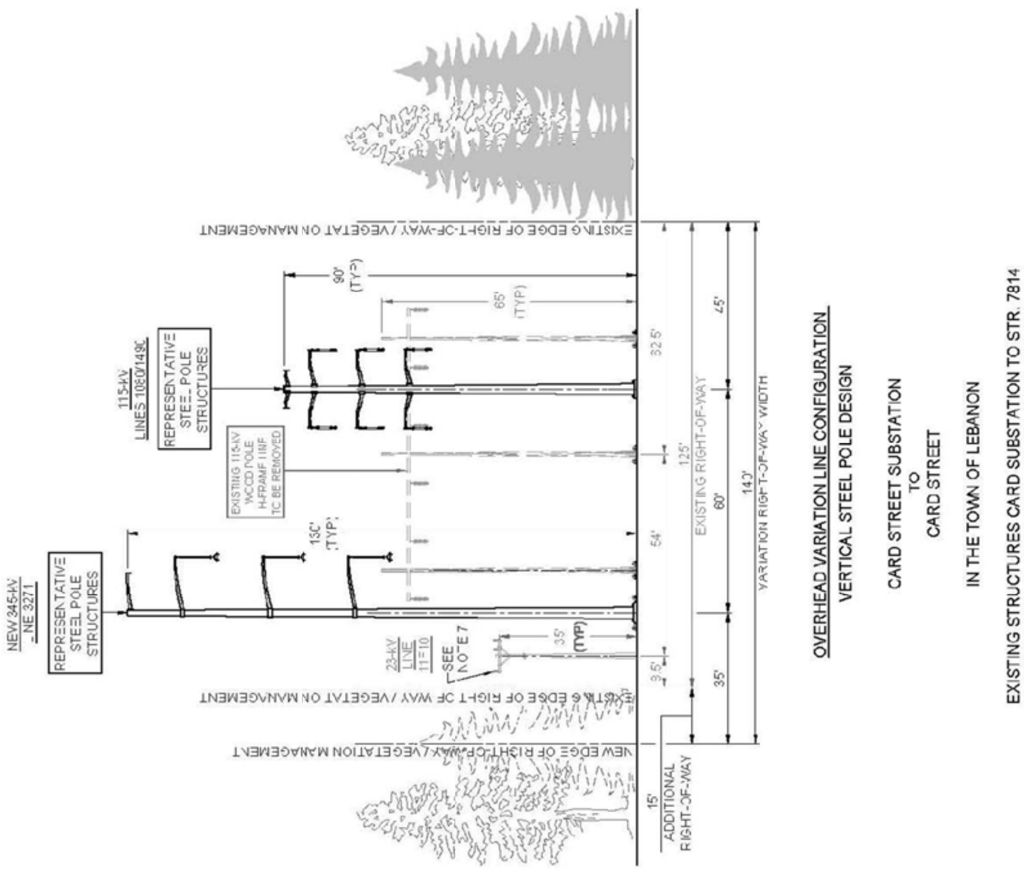


DETAIL A
TYPICAL 345-kV DUCT BANK
NOT TO SCALE

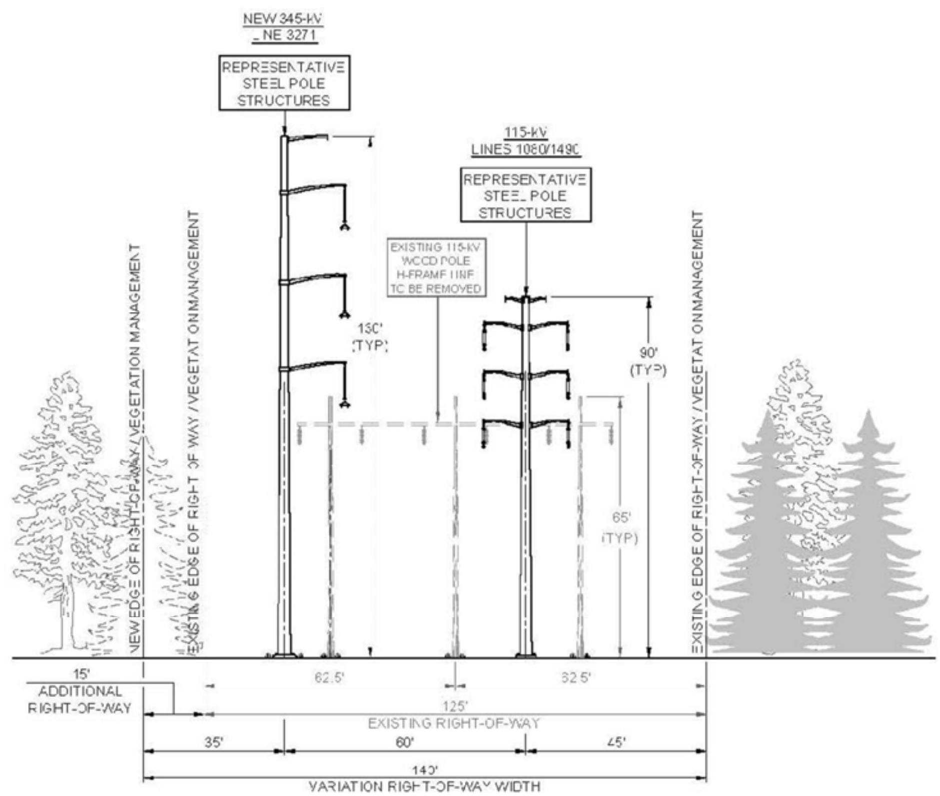
NOTES:

1. EXISTING STRUCTURES TO REMAIN.
2. SOIL RESTORATION DEPTH WILL BE INCREASED FOR CULTIVATED FIELDS AND OTHER LOCATIONS AS REQUIRED.
3. ALL VEGETATION WITHIN CONSTRUCTION WORK AREA WOULD BE REMOVED. ADDITIONAL AREAS BEYOND THE 40 FOOT WIDE DUCT BANK INSTALLATION WORK AREA, WOULD BE CLEARED FOR SPLICE VAULTS.
4. EXISTING VEGETATION MANAGEMENT DIMENSIONS ARE TYPICAL.
5. CL&P WOULD BE REQUIRED TO ACQUIRE UNDERGROUND EASEMENT RIGHTS FROM PRIVATE LAND OWNERS WHERE EXISTING UNDERGROUND RIGHTS DO NOT CURRENTLY EXIST.
6. EACH SPLICE VAULT LOCATION (CONSISTING OF THREE VAULTS) WOULD REQUIRE 0.25 ACRE OF LAND.
7. AN OVERHEAD/UNDERGROUND LINE TRANSITION STATION WOULD BE REQUIRED AT EACH END OF THE CABLE SYSTEM. UP TO 4 ACRES OF LAND WOULD BE REQUIRED FOR EACH 345-kV OVERHEAD/UNDERGROUND LINE TRANSITION STATION.

XS-WS-OH-1: Willimantic South Overhead Variation – Card Street Substation to Card Street



XS-WS-OH-2: Willimantic South Overhead Variation – Card Street to Beaumont Highway



OVERHEAD VARIATION LINE CONFIGURATION

VERTICAL STEEL POLE DESIGN

CARD STREET
TO
BEAUMONT HIGHWAY

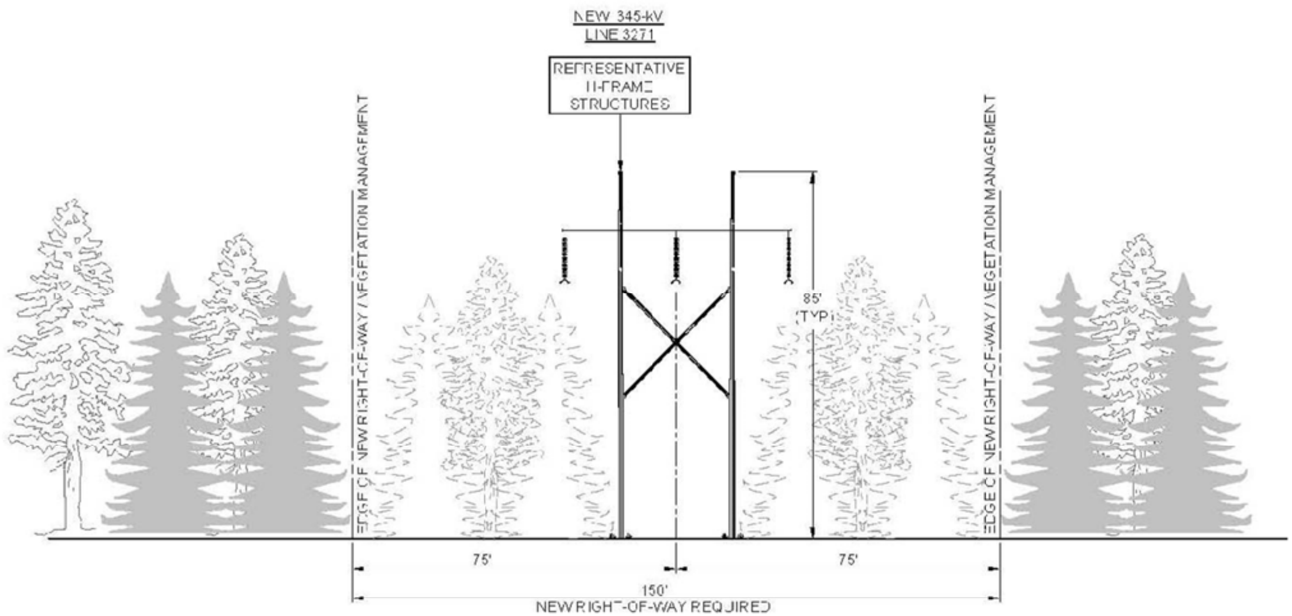
IN THE TOWN OF LEBANON

EXISTING STRUCTURES 7814 TO 7809

LOOKING
SOUTHEAST

(0.6 MILE)

XS-WS-OH-3: Willimantic South Overhead Variation – Beaumont Highway to Chewink Road



OVERHEAD VARIATION LINE CONFIGURATION
H-FRAME DESIGN

BEAUMONT HIGHWAY
TO
CHEWINK ROAD

IN THE TOWNS OF LEBANON, WINDHAM & CHAPLIN

EXISTING STRUCTURE 7809 (115-kV LINE 1080 & 1490 FROM CARD STREET SUBSTATION)
TO
EXISTING STRUCTURE 9110 (345-kV LINE 330)

LOOKING
NORTHEASTERLY

(8.6 MILES)

Appendix 15C – Tabular EMF Data for Variation Cross-Sections

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Table 1: Magnetic Field (mG) at Distances Relative to the ROW Centerline (ft) - Annual Average Load Condition (AAL)

Line Section	Configuration	-300	-275	-250	-225	-200	-175	-150	-125	-100	-75	-50	-25	0	25	50	75	100	125	150	175	200	225	250	275	300	- ROW Edge	+ ROW Edge
XS-UG-1: Mansfield Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	1.6	1.8	2.1	2.5	3.0	3.7	4.6	5.9	7.8	10.7	15.8	25.2	45.0	87.7	133.5	137.5	98.9	51.3	28.0	17.2	11.5	8.3	6.2	4.8	3.9	4.6	28.0
	post-NEEWS	0.8	0.9	1.1	1.4	1.7	2.2	2.8	3.7	5.1	7.4	11.3	19.0	37.3	114.8	109.5	111.0	81.7	43.8	24.6	15.5	10.7	7.9	6.1	4.8	4.0	2.8	24.6
XS-B-1: Brooklyn Overhead Variation - Pomfret Road to Ten Spans North of Day Street Junction	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	2.1	2.5	3.0	3.7	4.7	6.1	8.2	11.8	18.1	30.9	59.1	105.0	123.4	105.0	59.1	30.9	18.1	11.8	8.2	6.1	4.7	3.7	3.0	2.5	2.1	30.9	30.9
XS-UG-2: Brooklyn Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	1.6	1.8	2.1	2.5	3.0	3.7	4.6	5.9	7.8	10.7	15.8	25.2	45.0	87.7	133.5	137.5	98.9	51.3	28.0	17.2	11.5	8.3	6.2	4.8	3.9	4.6	28.0
	post-NEEWS	0.8	0.9	1.1	1.4	1.7	2.2	2.8	3.7	5.1	7.4	11.3	19.0	37.3	114.8	109.5	111.0	81.7	43.8	24.6	15.5	10.7	7.9	6.1	4.8	4.0	2.8	24.6
XS-UG-3: Brooklyn Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	2.1	2.5	3.1	3.9	5.1	6.8	9.6	14.4	23.6	43.3	86.6	135.3	144.4	112.2	78.2	58.1	22.3	50.1	47.7	20.2	7.9	3.5	1.7	0.9	0.5	6.4	16.6
	post-NEEWS	1.4	1.7	2.1	2.7	3.5	4.8	6.9	10.7	18.2	37.0	120.4	109.9	114.3	91.2	67.6	55.0	18.9	47.1	49.9	23.5	10.5	5.5	3.3	2.1	1.5	4.5	19.8
XS-WS-OH-1: Willimantic South Overhead Variation - Card St. Substation to Card St.	pre-Interstate	0.7	0.8	1.0	1.3	1.6	2.1	3.0	4.4	7.4	14.8	28.6	19.6	13.3	34.2	33.1	16.4	8.5	5.1	3.4	2.4	1.8	1.4	1.1	0.9	0.8	17.4	19.1
	post-NEEWS	1.7	2.0	2.4	3.0	3.9	5.1	7.1	10.3	16.2	29.0	40.4	64.5	61.9	41.9	21.3	9.9	6.1	4.4	3.4	2.7	2.2	1.8	1.5	1.3	1.1	32.3	11.3
XS-WS-OH-2: Willimantic South Overhead Variation - Card St. to Beaumont Hwy.	pre-Interstate	0.6	0.7	0.8	1.0	1.2	1.6	2.2	3.0	4.6	7.8	14.8	21.6	16.4	35.7	32.9	16.0	8.1	4.8	3.2	2.2	1.7	1.3	1.0	0.8	0.7	8.8	18.6
	post-NEEWS	1.7	2.0	2.4	3.0	3.9	5.1	6.9	10.0	15.2	24.7	42.9	67.3	63.2	42.0	20.8	9.4	5.8	4.3	3.3	2.7	2.2	1.8	1.5	1.3	1.1	27.5	10.8
XS-WS-OH-3: Willimantic South Overhead Variation - Beaumont Hwy. to Chewink Rd.	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	2.1	2.5	3.0	3.7	4.7	6.1	8.2	11.8	18.1	30.9	59.1	105.0	123.4	105.0	59.1	30.9	18.1	11.8	8.2	6.1	4.7	3.7	3.0	2.5	2.1	30.9	30.9
XS-UG-1: Willimantic South Underground Variation - 345-kV Cable System in Road*	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.6	1.4	20.9	2.5	1.1	0.7	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	1.4	2.5
XS-UG-2: Willimantic South Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	1.6	1.8	2.1	2.5	3.0	3.7	4.6	5.9	7.8	10.7	15.8	25.2	45.0	87.7	133.5	137.5	98.9	51.3	28.0	17.2	11.5	8.3	6.2	4.8	3.9	4.6	28.0
	post-NEEWS	0.7	0.9	1.1	1.3	1.6	2.1	2.7	3.5	4.8	6.9	10.6	17.8	34.7	104.6	102.7	103.8	76.3	40.9	23.0	14.5	10.0	7.3	5.7	4.5	3.7	2.7	23.0

Table 2: Magnetic Field (mG) at Distances Relative to the ROW Centerline (ft) - Annual Peak Load Condition (APL)

Line Section	Configuration	-300	-275	-250	-225	-200	-175	-150	-125	-100	-75	-50	-25	0	25	50	75	100	125	150	175	200	225	250	275	300	- ROW Edge	+ ROW Edge
XS-UG-1: Mansfield Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	3.3	3.8	4.5	5.3	6.3	7.7	9.5	12.2	16.1	22.3	32.7	52.2	93.4	181.8	276.8	285.0	205.0	106.4	58.0	35.6	23.9	17.1	12.8	10.0	8.0	9.5	58.0
	post-NEEWS	1.4	1.7	2.0	2.5	3.1	4.0	5.1	6.8	9.4	13.5	20.7	34.8	68.1	209.9	200.2	203.0	149.5	80.1	45.0	28.4	19.6	14.4	11.1	8.9	7.3	5.1	45.0
XS-B-1: Brooklyn Overhead Variation - Pomfret Road to Ten Spans North of Day Street Junction	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	3.8	4.5	5.5	6.7	8.5	11.1	15.1	21.5	33.1	56.4	108.0	192.0	225.6	192.0	108.0	56.4	33.1	21.5	15.1	11.1	8.5	6.7	5.5	4.5	3.8	56.4	56.4
XS-UG-2: Brooklyn Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	3.3	3.8	4.5	5.3	6.3	7.7	9.5	12.2	16.1	22.3	32.7	52.2	93.4	181.8	276.8	285.0	205.0	106.4	58.0	35.6	23.9	17.1	12.8	10.0	8.0	9.5	58.0
	post-NEEWS	1.4	1.7	2.0	2.5	3.1	4.0	5.1	6.8	9.4	13.5	20.7	34.8	68.1	209.9	200.2	203.0	149.5	80.1	45.0	28.4	19.6	14.4	11.1	8.9	7.3	5.1	45.0
XS-UG-3: Brooklyn Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	4.5	5.5	6.7	8.4	10.9	14.6	20.5	30.6	49.7	90.6	180.1	279.8	295.8	225.1	146.8	101.8	42.9	86.4	77.7	30.7	10.7	3.9	1.5	1.0	1.1	13.7	24.7
	post-NEEWS	2.6	3.1	3.9	5.0	6.5	8.9	12.8	19.8	33.6	68.1	223.0	200.6	206.1	161.6	113.2	86.9	30.8	76.2	78.1	35.7	15.5	7.8	4.5	2.8	1.9	8.4	29.9
XS-WS-OH-1: Willimantic South Overhead Variation - Card St. Substation to Card St.	pre-Interstate	0.3	0.3	0.4	0.5	0.7	1.0	1.5	2.4	4.8	12.6	36.3	27.9	16.0	15.9	12.6	5.8	2.9	1.7	1.1	0.8	0.6	0.5	0.4	0.3	0.2	15.9	6.8
	post-NEEWS	3.4	4.1	5.0	6.2	7.9	10.4	14.2	20.4	31.2	50.8	73.1	117.5	102.3	63.8	33.8	19.7	13.7	10.2	7.8	6.2	5.0	4.1	3.4	2.9	2.5	55.1	21.5
XS-WS-OH-2: Willimantic South Overhead Variation - Card St. to Beaumont Hwy.	pre-Interstate	0.1	0.2	0.2	0.2	0.3	0.4	0.6	0.8	1.3	2.5	5.9	12.6	18.1	18.6	12.5	5.3	2.5	1.4	0.9	0.6	0.4	0.3	0.3	0.2	0.2	3.0	6.4
	post-NEEWS	3.4	4.0	4.9	6.1	7.8	10.2	13.9	19.8	29.9	48.3	82.0	122.5	104.9	64.7	33.9	19.7	13.7	10.2	7.8	6.2	5.0	4.1	3.4	2.9	2.5	53.5	21.5
XS-WS-OH-3: Willimantic South Overhead Variation - Beaumont Hwy. to Chewink Rd.	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	3.8	4.5	5.5	6.7	8.5	11.1	15.1	21.5	33.1	56.4	108.0	192.0	225.6	192.0	108.0	56.4	33.1	21.5	15.1	11.1	8.5	6.7	5.5	4.5	3.8	56.4	56.4
XS-UG-1: Willimantic South Underground Variation - 345-kV Cable System in Road*	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.8	1.1	2.5	38.4	4.7	2.1	1.3	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	2.5	4.7
XS-UG-2: Willimantic South Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	3.3	3.8	4.5	5.3	6.3	7.7	9.5	12.2	16.1	22.3	32.7	52.2	93.4	181.8	276.8	285.0	205.0	106.4	58.0	35.6	23.9	17.1	12.8	10.0	8.0	9.5	58.0
	post-NEEWS	1.3	1.6	1.9	2.3	2.9	3.7	4.8	6.3	8.7	12.5	19.1	32.1	62.6	191.5	185.4	187.4	137.9	74.0	41.6	26.3	18.1	13.3	10.3	8.2	6.7	4.8	41.6

Table 3: Magnetic Field (mG) at Distances Relative to the ROW Centerline (ft) - Peak Daily Average Load Condition (PDAL)

Line Section	Configuration	-300	-275	-250	-225	-200	-175	-150	-125	-100	-75	-50	-25	0	25	50	75	100	125	150	175	200	225	250	275	300	- ROW Edge	+ ROW Edge
XS-UG-1: Mansfield Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	2.5	2.9	3.3	3.9	4.7	5.7	7.1	9.1	12.0	16.6	24.4	39.0	69.8	135.8	206.8	213.0	153.1	79.5	43.4	26.6	17.9	12.8	9.6	7.5	6.0	7.1	43.4
	post-NEEWS	1.0	1.2	1.4	1.8	2.2	2.8	3.7	4.9	6.7	9.6	14.8	24.8	48.6	149.7	142.7	144.7	106.5	57.1	32.1	20.3	14.0	10.3	7.9	6.3	5.2	3.7	32.1
XS-B-1: Brooklyn Overhead Variation - Pomfret Road to Ten Spans North of Day Street Junction	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	2.7	3.2	3.9	4.8	6.1	7.9	10.7	15.4	23.6	40.3	77.0	136.9	160.9	136.9	77.0	40.3	23.6	15.4	10.7	7.9	6.1	4.8	3.9	3.2	2.7	40.3	40.3
XS-UG-2: Brooklyn Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	2.5	2.9	3.3	3.9	4.7	5.7	7.1	9.1	12.0	16.6	24.4	39.0	69.8	135.8	206.8	213.0	153.1	79.5	43.4	26.6	17.9	12.8	9.6	7.5	6.0	7.1	43.4
	post-NEEWS	1.0	1.2	1.4	1.8	2.2	2.8	3.7	4.9	6.7	9.6	14.8	24.8	48.6	149.7	142.7	144.7	106.5	57.1	32.1	20.3	14.0	10.3	7.9	6.3	5.2	3.7	32.1
XS-UG-3: Brooklyn Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	3.3	4.0	4.9	6.2	8.0	10.8	15.1	22.6	36.8	67.4	134.4	209.2	222.3	170.9	115.0	82.7	32.8	70.8	65.8	27.0	10.0	4.1	1.8	0.9	0.7	10.1	22.0
	post-NEEWS	1.8	2.2	2.7	3.5	4.6	6.3	9.1	14.0	23.8	48.3	157.6	143.2	148.3	117.7	85.4	68.0	23.4	61.1	63.9	29.8	13.2	6.9	4.1	2.6	1.8	5.9	25.1
XS-WS-OH-1: Willimantic South Overhead Variation - Card St. Substation to Card St.	pre-Interstate	0.5	0.7	0.8	1.0	1.3	1.7	2.4	3.7	6.5	14.3	31.3	14.9	10.2	27.1	25.1	12.2	6.3	3.7	2.5	1.8	1.3	1.0	0.8	0.7	0.6	17.3	14.3
	post-NEEWS	2.3	2.8	3.4	4.2	5.4	7.1	9.8	14.1	22.0	37.9	52.6	83.6	76.0	48.8	24.7	13.0	8.8	6.6	5.1	4.0	3.3	2.7	2.3	1.9	1.7	41.7	14.4
XS-WS-OH-2: Willimantic South Overhead Variation - Card St. to Beaumont Hwy.	pre-Interstate	0.4	0.4	0.5	0.6	0.8	1.0	1.3	1.8	2.6	4.3	7.8	10.6	14.5	29.2	24.9	11.7	5.8	3.4	2.2	1.5	1.1	0.9	0.7	0.6	0.5	4.8	13.7
	post-NEEWS	2.3	2.8	3.4	4.2	5.4	7.0	9.6	13.7	20.7	33.5	57.4	87.5	77.9	49.2	24.3	12.7	8.7	6.5	5.0	4.0	3.3	2.7	2.3	1.9	1.6	37.2	14.0
XS-WS-OH-3: Willimantic South Overhead Variation - Beaumont Hwy. to Chewink Rd.	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	2.7	3.2	3.9	4.8	6.1	7.9	10.7	15.4	23.6	40.3	77.0	136.9	160.9	136.9	77.0	40.3	23.6	15.4	10.7	7.9	6.1	4.8	3.9	3.2	2.7	40.3	40.3
XS-UG-1: Willimantic South Underground Variation - 345-kV Cable System in Road*	pre-Interstate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	post-NEEWS	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.6	0.8	1.8	27.3	3.3	1.5	0.9	0.7	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	1.8	3.3
XS-UG-2: Willimantic South Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	2.5	2.9	3.3	3.9	4.7	5.7	7.1	9.1	12.0	16.6	24.4	39.0	69.8	135.8	206.8	213.0	153.1	79.5	43.4	26.6	17.9	12.8	9.6	7.5	6.0	7.1	43.4
	post-NEEWS	0.9	1.1	1.4	1.7	2.1	2.6	3.4	4.5	6.2	9.0	13.7	23.0	44.8	136.2	132.8	134.2	98.8	52.9	29.8	18.8	13.0	9.5	7.3	5.8	4.8	3.4	29.8

Table 4: Electric Field (kV/m) at Distances Relative to the ROW Centerline (ft)

Line Section	Configuration	-300	-275	-250	-225	-200	-175	-150	-125	-100	-75	-50	-25	0	25	50	75	100	125	150	175	200	225	250	275	300	- ROW Edge	+ ROW Edge
XS-UG-1: Mansfield Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	0.02	0.02	0.03	0.04	0.05	0.06	0.09	0.13	0.19	0.30	0.53	1.03	2.25	4.55	3.60	3.15	4.85	2.65	1.20	0.60	0.34	0.21	0.14	0.09	0.07	0.09	1.20
	post-NEEWS	0.02	0.02	0.03	0.04	0.05	0.06	0.09	0.13	0.19	0.30	0.53	1.03	2.25	4.55	3.60	3.15	4.85	2.65	1.20	0.60	0.34	0.21	0.14	0.09	0.07	0.09	1.20
XS-B-1: Brooklyn Overhead Variation - Pomfret Road to Ten Spans North of Day Street Junction	pre-Interstate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	post-NEEWS	0.04	0.04	0.06	0.08	0.11	0.16	0.26	0.43	0.80	1.67	3.69	4.80	2.97	4.80	3.69	1.67	0.80	0.43	0.26	0.16	0.11	0.08	0.06	0.04	0.04	1.67	1.67
XS-UG-2: Brooklyn Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	0.02	0.02	0.03	0.04	0.05	0.06	0.09	0.13	0.19	0.30	0.53	1.03	2.25	4.55	3.60	3.15	4.85	2.65	1.20	0.60	0.34	0.21	0.14	0.09	0.07	0.09	1.20
	post-NEEWS	0.02	0.02	0.03	0.04	0.05	0.06	0.09	0.13	0.19	0.30	0.53	1.03	2.25	4.55	3.60	3.15	4.85	2.65	1.20	0.60	0.34	0.21	0.14	0.09	0.07	0.09	1.20
XS-UG-3: Brooklyn Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	0.04	0.05	0.07	0.09	0.13	0.20	0.31	0.54	1.04	2.26	4.55	3.60	3.18	5.08	3.26	0.78	0.53	0.56	1.17	0.82	0.32	0.14	0.07	0.04	0.03	0.18	0.68
	post-NEEWS	0.04	0.05	0.07	0.09	0.13	0.20	0.31	0.54	1.04	2.26	4.55	3.60	3.18	5.08	3.26	0.78	0.53	0.56	1.17	0.82	0.32	0.14	0.07	0.04	0.03	0.18	0.68
XS-WS-OH-1: Willimantic South Overhead Variation - Card St. Substation to Card St.	pre-Interstate	0.00	0.01	0.01	0.01	0.02	0.02	0.04	0.07	0.13	0.28	0.49	0.73	0.28	0.35	1.34	0.71	0.29	0.14	0.08	0.05	0.03	0.02	0.02	0.01	0.01	0.33	0.86
	post-NEEWS	0.07	0.08	0.10	0.12	0.15	0.18	0.21	0.25	0.24	0.19	1.66	4.94	3.90	2.24	0.97	0.17	0.13	0.14	0.13	0.11	0.10	0.08	0.07	0.06	0.05	0.21	0.25
XS-WS-OH-2: Willimantic South Overhead Variation - Card St. to Beaumont Hwy.	pre-Interstate	0.01	0.01	0.01	0.02	0.02	0.03	0.05	0.09	0.18	0.41	1.01	1.08	0.24	0.35	1.33	0.71	0.29	0.14	0.07	0.04	0.03	0.02	0.01	0.01	0.01	0.49	0.85
	post-NEEWS	0.07	0.08	0.10	0.11	0.14	0.16	0.19	0.20	0.12	0.35	1.98	5.02	3.92	2.24	0.97	0.17	0.13	0.14	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.54	0.25
XS-WS-OH-3: Willimantic South Overhead Variation - Beaumont Hwy. to Chewink Rd.	pre-Interstate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	post-NEEWS	0.04	0.04	0.06	0.08	0.11	0.16	0.26	0.43	0.80	1.67	3.69	4.80	2.97	4.80	3.69	1.67	0.80	0.43	0.26	0.16	0.11	0.08	0.06	0.04	0.04	1.67	1.67
XS-UG-1: Willimantic South Underground Variation - 345-kV Cable System in Road*	pre-Interstate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	post-NEEWS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XS-UG-2: Willimantic South Underground Variation - 345-kV Cable System in Existing CL&P ROW	pre-Interstate	0.02	0.02	0.03	0.04	0.05	0.06	0.09	0.13	0.19	0.30	0.53	1.03	2.25	4.55	3.60	3.15	4.85	2.65	1.20	0.60	0.34	0.21	0.14	0.09	0.07	0.09	1.20
	post-NEEWS	0.02	0.02	0.03	0.04	0.05	0.06	0.09	0.13	0.19	0.30	0.53	1.03	2.25	4.55	3.60	3.15	4.85	2.65	1.20	0.60	0.34	0.21	0.14	0.09	0.07	0.09	1.20

SECTION 16

PROPOSED SUBSTATION AND SWITCHING STATION MODIFICATIONS: ALTERNATIVES REVIEW

16. PROPOSED SUBSTATION AND SWITCHING STATION MODIFICATIONS: ALTERNATIVES REVIEW

The proposed Project would involve modifications to CL&P's existing Card Street Substation, Lake Road Switching Station, and Killingly Substation in order to accommodate the new 345-kV transmission lines. All of these proposed station modifications, as described for the Project in Volume 1, are relatively minor and would not require the development of any facilities outside of the existing stations' fence lines.[1]

Since the proposed modifications would occur on property designated for utility use, and within already developed portions of the CL&P stations, there are no alternative, geographically distinct sites that could be developed to meet Project objectives more cost-effectively, efficiently, and with fewer adverse environmental effects. Only minor and highly localized environmental effects would occur as a result of the development of the station modifications as proposed (refer to Section 6.2). Further, no engineering design alternatives would be as cost-effective as the proposed station improvements.

The proposed modifications reflect the optimal approach for connecting the new 345-kV transmission lines to Card Street Substation and Lake Road Switching Station, and for providing two new support structures for the transmission line as it extends through Killingly Substation. As a result, no alternative siting studies were performed for the proposed station modifications.

[1] As described in Section 15.5, the development of the 345-kV line along either the Willimantic South Overhead Variation or the Willimantic South Underground Variation would require more extensive modifications to Card Street Substation. These modifications are discussed in Section 15.5. CL&P does not prefer either of the Willimantic South Variations.

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SECTION 17

APPLICATION DIRECTORY

17.APPLICATION DIRECTORY

The following Table 17-1 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.

Table 17-1: Cross-Reference between the Council's 2010 *Application Guide* and CL&P's Application

Council's Application Guide **(Section No. and Summary Description)**	**CL&P 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.)
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

Council's Application Guide (Section No. and Summary Description)	CL&P Application (Section Reference)
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*l*(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: A. An executive summary	Volume 1, 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
D. A justification for overhead portions, including life cycle cost studies comparing overhead alternatives with underground alternatives.	Volume 1, Section 3; Volume 1A, Sections 14 and 15
E. A program of dates showing the proposed program of ROW or property acquisition, construction, completion and operation.	Volume 1, Section 8
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.	Volumes 1, 9, 10, and 11
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 9, Exhibit 1
H. A narrative description of the proposed transmission line and transmission line alternatives, including the following:	Volume 1, Sections 3, 5, and 10; Volume 1A, Sections 14, 15, and 16; Volumes 9 and 11
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: i. Floral associations;	Volume 1, Section 5 (5.1.3 and 5.2); Volume 1A, Section 15; Volume 2; Volumes 9 and 11 Volume 1, Section 5 (5.1.3 and 5.2); Volume 1A, Section 15; Volume 2; Volumes 9 and 11
ii. Inventory of wildlife habitat with observed and expected wildlife users;	Volume 1, Section 5 (5.1.3, 5.2); Volume 1A, Section 15; Volume 4; Volumes 9 and 11

Council's Application Guide (Section No. and Summary Description)	**CL&P Application (Section Reference)**
iii. Species of Special Concern and rare or endangered species, including their habitats;	Volume 1, Sections 5 and 6; Volume 1A, Section 15; Volume 4; Volumes 9 and 11
iv. Inventory of breeding birds and their habitats;	Volume 1, Section 5 (5.1.3, 5.2); Volume 1A, Section 15; Volume 4
v. Riparian environments and buffer vegetation; and	Volume 1, Section 5 (5.1.2, 5.2); Volume 1A, Section 15; Volumes 2, 9 and 11
vi. Fishery habitat and cold water fisheries.	Volume 1, Section 5 (5.1.3, 5.2); Volume 1A, Section 15
b) Existing infrastructure (where applicable):	Volume 1, Section 3; Volume 1A, Section 15; Volumes 9, 10 and 11
i. Existing ROW boundaries;	Volume 1, Section 3; Volumes 9, 10, and 11
ii. Components of existing transmission line; and	Volume 1, Section 3; Volume 1A, Section 15; Volume 8 (Photographs); Volumes 9, 10, and 11
iii. Other improvements within existing and proposed rights-of-way.	Volume 1, Section 3; Volume 1A, Section 15; Volumes 9, 10, and 11
2. <u>Proposed Conditions</u>	Volume 1, Sections 3, 4, and 6; Volumes 7, 9, 10, and 11
a. Areas of disturbance (temporary and permanent)	Volume 1, Sections 3, 4, 6, and 10; Volumes 7, 9, 10, and 11
b. Proposed construction staging areas, conductor pulling sites, material marshaling yards, and construction field offices	Volume 1, Sections 3 and 4; Volumes 9 and 11
c. Proposed access roads and opportunities for alternative access	Volume 1, Section 4.1.5; Volumes 9 and 11
d. Proposed structure location envelopes	Volume 11
e. Proposed blasting, grading, and changes to drainage	Volume 1, Section 4

Council's Application Guide (Section No. and Summary Description)	**CL&P Application (Section Reference)**
I. Proposed route plans, at a scale no smaller than 1" = 100', 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 11 Volumes 9 and 11
b. Location of any existing transmission line structures and accessways;	Volumes 9 and 11
c. Contour mapping at 2' intervals;	Volume 11
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;	Volume 11 (some features also shown on Volume 9 maps)
e. Coastal Management Zone boundaries;	N/A for Project
f. 100-year flood plain boundaries as identified by the Federal Emergency Management Agency;	Volumes 9 and 11
g. Locations of protected and special concern species;	Volume 1, Section 5.1.3.3 and Volume 1A, Section 15 for narrative description. Locations of protected and special concern species not included on Volume 9 and 11 maps to protect species; only general NDDB locations are shown
h. Areas susceptible to soil erosion;	Volume 11 (topographic contours)
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. Volume 1, Section 5.1.3; Volume 1A, Section 15; Volumes 9 and 11
j. Fishery habitat and cold water fisheries.	Fishery habitat described in Volume 1 (Section 5.1.3); Volume 1A (Section 15); streams illustrated on the Volume 9 and 11maps
2. <u>Changes to existing conditions for the proposed transmission line</u>: a. Additional ROW width required, if any;	Volume 1, Section 3; Volumes 10 and 11 (see also Volume 9 maps for cross-sections)
b. Anticipated transmission line structure location envelopes;	Volume 11
c. Anticipated areas of disturbance (temporary and permanent);	Volumes 9, 10, and 11

Council's Application Guide (Section No. and Summary Description)	**CL&P Application (Section Reference)**
d. Anticipated area of disturbance to an inland wetland buffer boundary or to an inland wetland;	Volume 11
e. Anticipated area of disturbance for material staging and conductor pulling sites;	Discussed in Volume 1, Section 4 (areas not yet specifically identified)
f. Anticipated access roads and opportunities for alternative access;	Volumes 9 and 11
g. Substation connections; and	Volumes 7, 9, and 11
h. Other sensitive areas requiring special attention.	Volumes 9 and 11. Refer also to discussion of Mansfield Hollow area in Section 10, Volume 1 and accompanying cross-sections
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 and 3; Volume 1A; Volume 9 and 11 maps
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, 7[1]
1. Public health and safety	Volume 1, Section 7
2. Local, state, and federal land use plans including energy security;	Volume 1, Sections 5.1.5 and Section 6.1.4 *Note: energy security information is part of CEII data filed in a separate Appendix to Volume 5*
3. Existing and future development;	Volume 1, Section 5.1.5 and Section 6.1.4
4. Road and waterway crossings;	Volume 1, Sections 4 and 6
5. Wetland crossings;	Volume 1, Sections 4 and 6
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; Volumes 9, 10, and 11 (vegetation types and clearing limits)
7. Water supply areas;	Volume 1, Section 6 (6.1.2.3)

[1] Note: Section 15, Volume 1A, discusses the effects that the variations would have on the environment, ecology, recreational resources, visual resources, cultural resources, and public health. However, CL&P does not propose any of the variations discussed in Section 15.

Council's Application Guide (Section No. and Summary Description)	CL&P Application (Section Reference)
8. Archaeological and historic resources, with documentation by the SHPO; and	Volume 1, Section 6 (6.1.6, 6.2.6); Volume 3
9. Other environmental concerns identified by the applicant, the Council, or any public agency:	Volume 1, Sections 4, 6, and 10; Volume 8 (visual resources)
Coastal Consistency Analysis	N/A: Project is not within the coastal zone
Connecticut Heritage Areas	Volume 1, Section 6.1.4; Volume 8
Ridgeline Protection Zones	Volume 1, Section 6.1.1
Aquifer Protection Zones	Volume 1, Sections 5.1.2 and 6.1.2
DOT Scenic Lands	Volume 1, Sections 5.1.4 and 6.1.4; Volume 8
State Parks and Forests	Volume 1, Sections 5.1.3, 5.1.4., 6.1.3, 6.1.4; Volumes 9 and 11
Agricultural Lands	Volume 1, Sections 5.1.3, 5.1.4., 6.1.3, 6.1.4; Volumes 9 and 11
Wild and Scenic Rivers	N/A for Project
Protected Rivers	N/A for Project
Endangered, Threatened, and Special Concern Species	Volume 1, Sections 5.1.3, 6.1.3; Volume 4
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
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 10; Volumes 9 and 11
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 (4.1.8.3, 4.4)
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 4.4.1

Council's Application Guide (Section No. and Summary Description)	**CL&P Application (Section Reference)**
7. Methods for preservation of vegetation for wildlife habitat and screening;	Volume 1, Sections 4, 6.1.3
M. Safety and reliability information, including: 1. Provisions for emergency operations and shutdowns; and 2. Fire suppression technology.	Volume 1, Section 4.4.3
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.	CEII Appendix to Volume 1
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; Volume 4 (Agency Correspondence)
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 5.1.4, 6.1.4; Volume 1A, Section 15; Volumes 9 and 11 (zoning classifications) Bulk filing submitted separately
R. Such information any department or agency of the state exercising environmental controls may, by regulation, require.	Volume 1, Sections 5 and 6; Volumes 9 and 11

Council's Application Guide (Section No. and Summary Description)	CL&P Application (Section Reference)
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.	To be submitted, as applicable
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)	CL&P 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 2008 MCF and 2011 Supplemental MCF public outreach 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 e 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.

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SECTION 18

GLOSSARY OF TERMS

18.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 which 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 business.
ACSR: Aluminum Conductor, Steel Reinforced, a common type of overhead conductor.
ACSS: Aluminum Conductor with Steel Support, a common type of overhead conductor.
AFUDC: Allowance for Funds Used During Construction
AIS: Air-insulated Substation
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.
ANSI: American National Standards Institute
APL: Annual peak load
Arrester: 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
Bundle (circuit): Two or more parallel 3-conductor circuits joined together to operate as one single circuit.
Bundle (conductor): Two or more phase conductors or cables joined together to operate as a single phase of a circuit.
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.
CCB: Center for Conservation and Biodiversity (UConn)
CCRP: Central Connecticut Reliability Project (part of NEEWS)
CCVT: Capacitor coupling voltage transformers
CEII: Confidential Energy Infrastructure Information
CELT: ISO-NE, Forecast Report of Capacity, Energy, Loads and Transmission
CEAB: Connecticut Energy Advisory Board
Certificate: Certificate of Environmental Compatibility and Public Need (from the Connecticut Siting Council)
CFPA: Connecticut Forests and Parks 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
CLL: Critical Load Level
CMEEC: Connecticut Municipal Electrical Cooperative

ConnDOT: Connecticut Department of Transportation

Conductor: A metallic wire, busbar, rod, tube or cable which 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. As of July 1, 2011, the former CTDEP was consolidated with the former DPUC into the Connecticut Department of Energy and Environmental Protection. In this document, references to CTDEP pertain to publications and Project-related consultations conducted prior to July 1, 2011. References to CT DEEP pertain to ongoing agency programs or anticipated Project consultations.

CTDEP: Connecticut Department of Environmental Protection (see CT DEEP)

CWA: Clean Water Act (federal)

CWIP: Construction Work in Progress

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: is 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.

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.

DPUC: Connecticut Department of Public Utility Control (former); now part of CT DEEP Public Utility Regulatory Authority

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.

EFSB: Massachusetts Energy Facilities Siting Board or Rhode Island Energy Facility Siting Board

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.

ENE: Eastern New England

EPA: United States Environmental Protection Agency

EPAct: Electric Policy Act of 2005

ERCOT: Electric Reliability Council of Texas

ERO: Electric Reliability Organization

ESRI: Environmental Systems Research Institute, Inc. (database of environmental information)

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.

GIL: Gas-Insulated Transmission Line using sulfur hexafluoride gas (SF_6).

GIS: Gas-Insulated Substation, or when used to describe mapping or environmental features = 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.

HPGF Pipe Cable System: High-pressure gas-filled, a type of underground transmission line.

HVDC: High voltage direct current

Hz: Hertz, a measure of alternating current frequency; one cycle/second.

IEEE: Institute of Electrical and Electronics Engineers

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

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.

Lightning Shield Wire: Electric cable located to prevent lightning from striking transmission circuit conductors.

Line: A series of overhead transmission structures which 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.
LPFF: Low-pressure fluid-filled; a type of self-contained fluid filled (SCFF) underground transmission line.
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 (Connecticut Siting Council)
MF: Magnetic field
MHG: Material Handling Guidelines
mG: milligauss (see Magnetic Field)
MMP: Manchester to Meekville Junction Project
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)) Megawatt equals 1 million watts, measure of the work electricity can do.
MWh: per megawatt hour
NAAQS: National Ambient Air Quality Standards
National Grid: National Grid, USA, parent company of Narragansett Electric Company and the New England Power Company
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
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 (NUSCO and CL&P are wholly owned subsidiaries of NU)
NUSCO: Northeast Utilities Service Company
NWI: National Wetlands Inventory
NYISO: New York Independent System Operator
OH (Overhead): Electrical facilities installed above the surface of the earth.
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.
Pothead: See Terminator
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
PUB: Palustrine unconsolidated bottom (wetlands)
PURA: Public Utilities Regulatory Authority (part of CT DEEP, formerly DPUC)
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 Reliability Project (part of NEEWS)
RI-SEMA: Rhode Island Southeastern Massachusetts (interface)
ROW: Right-of-Way
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
SCEL: Stream Channel Encroachment Line (CTDEP designation)
SCFF Cable System: Self-contained fluid-filled hollow-core cable; a type of underground transmission line used primarily for submarine installations.
Series Reactor: A device used for introducing impedance into an electrical circuit, the principal element of which is inductive reactance.
SEMA/RI: Southeastern Massachusetts and Rhode Island area
SF_6: Sulfur hexafluoride, an insulating gas used in GIS substations and circuit breakers.
Shield Wire: See Lightning Shield Wire
SHPO: State Historic Preservation Office
Shunt Reactor: An electrical reactive power device primarily used to compensate for reactive power demands by high voltage underground transmission cables.
SNE: Southern New England
SNETR: Southern New England Transmission Reliability
SPCC: Spill Prevention, Containment, and Control (plan)

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.
Step-down Transformer: See Transformer
Step-up Transformer: See Transformer
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
Supplemental MCF: Supplemental Municipal Consultation Filing (Connecticut Siting Council process), issued for the Connecticut Portion of the Interstate Reliability Project in July 2011
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)
TLGV: The Last Green Valley, Inc., non-profit group that manages planning within the Quinebaug – Shetuckut Rivers Valley National Heritage Corridor (also known as The Last Green Valley)
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.
THPO: Tribal Historic Preservation Office
UCONN: University of Connecticut (Center for Conservation ad Biodiversity)
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.
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.
Watercourse: Rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs, and all other bodies of water, natural or artificial, public or private.
Wetland: is an area of land consisting of soil that is saturated with moisture, such as a swamp, marsh, or bog
WINCOG: Windham Regional Council of Governments
WMA: Wildlife Management Area (CTDEEP)
XLPE: Cross-linked polyethylene (solid dielectric) insulation for transmission