May 24, 2004

Ms. Pamela B. Katz
Chairman
Connecticut Siting Council
10 Franklin Square
New Britain, CT 06051

Re: Docket No. 272 - Middletown-Norwalk 345kV Transmission Line

Dear Ms. Katz:

This letter provides the response to requests for the information listed below.

While it is not possible to provide all the information requested at this time, the Company is attaching the information which has been completed.

Response to TOWNS-06 Interrogatories dated 04/02/2004
TOWNS - 066 SP-01

Very truly yours,

Anne B. Bartosewicz
Project Director - Transmission Business

ABB/yv
cc: Service List

Status: **File Pending**

CL&P/UI
Docket No. 272

Data Request TOWNS-06
Dated: 04/02/2004
Q- TOWNS-066-SP01

Witness: **Roger C. Zaklukiewicz; James M. Hogan**
Request from: **TOWNS**

Question:
Reference Addendum #2 to the Supplemental Filing, at pages 2 and 3.

Please provide the analyses, reports, workpapers and source documents for the investigation of whether the 387 line transmission structures could support conductors with a capacity larger than 2-954 ACSR and if so, how that would affect the thermal load flow results.

Response:
Attached please find the "Feasibility Study of Reconductoring the Middletown to East Shore 387 Line and the Southington to Frost Bridge 329 Line as a Potential Alternative to the Middletown Norwalk 345-kV Project".

Final Report Lines 387 & 329 5-21-2004.pdf

FEASIBILITY STUDY OF RECONDUCTORING THE MIDDLETOWN – EAST SHORE 387 LINE AND THE SOUTHINGTON TO FROST BRIDGE 329 LINE AS A POTENTIAL ALTERNATIVE TO THE MIDDLETOWN – NORWALK 345-KV PROJECT

For

The Connecticut Light and Power Company and United Illuminating Company

2004

Project No. 35813

Northeast Utilities System

Burns & McDonnell
SINCE 1898

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INTRODUCTION

INTRODUCTION TO THE PROJECT

The Connecticut Light and Power Company (CL&P) and United Illuminating (UI) are proposing an upgrade of the electric transmission system in Southwest Connecticut. A 345-kV line is currently before the Connecticut Siting Council from Scovill Rock Switching Station in Middletown to Norwalk Substation in Norwalk. This new line will improve system reliability by enhancing interconnections between Southwest Connecticut and the remainder of New England, eliminating generation restrictions, short circuit problems at substations, and transmission line restrictions (to prevent thermal overload under system contingency conditions).

A municipal official suggested a possible alternative to the proposed Middletown–Norwalk 345-kV transmission line would be to reconductor the existing 345-kV line (387 Line) between CL&P's Scovill Rock Switchyard and UI's East Shore Substation near New Haven Harbor. This report assesses the feasibility of this alternative. System analysis of this alternative determined that reconductoring the 387 Line would impact the existing 345-kV line (329 Line) between Southington and Frost Bridge Substations, so similar reconductoring would be necessary on the 329 Line. In addition, there are further transmission lines which experience overloads that would need to be addressed. This study does not look at each of these lines, but they are identified in addendum 3 of the supplemental filing. These lines are listed below:

- 318/362 Line between Southington S/S and Meriden S/S (345-kV; 3.9 miles)
- 1342 Line between Bokum S/S and Green Hill S/S (115-kV; 11.3 miles)
- 1610 Line between Glen Lake Junction and Southington S/S (115-kV; 18.3 miles)
- 1610 Line between Mix Avenue S/S and Glen Lake Junction (115-kV; 2.9 miles)
- 1990 Line between Frost Bridge S/S and Baldwin Junction (115-kV; 7.0 miles)
- 1990 Line Between Stevenson S/S and Baldwin Junction (115-kV; 10.4 miles)
- 91001 Line between CRRA and Ash Creek S/S (115-kV; 1.2 miles)

Both the 387 and the 329 lines consist of ACSR (Aluminum Conductor, Steel-Reinforced) conductors supported along several sections of right-of-way by a variety of wood H-frame, steel pole and steel lattice structures that were constructed in the 1960's and 1970's. A table summarizing the physical characteristics of these structures is provided in Appendix A.

The feasibility of reconductoring the existing transmission structures involves the assessment of the capability of each structure type along each section of right-of-way to support larger conductor sizes. The primary objective of reconductoring would be to maximize the line ampacity while minimizing the amount of structure replacement. For this study an acceptable structure replacement range was less than 50% for any section of right-of-way. Replacement of more than 50% of the structures would not be considered good utility practice, as replacement of more than 50% would necessitate the re-evaluation of all the structures using the heavier Extreme Wind loading case of the latest NESC Edition.

SCOPE OF WORK

The scope of work for the study consisted of the following tasks:

Data Collection: The following information for both the 387 and 329 Lines was obtained from CL&P and UI:

a.) Plan and profile drawings of the existing 387 and 329 Lines

b.) Design Charts for allowable spans/loads for existing structures

c.) Structure erection drawings for the existing 387 and 329 Lines

d.) Design criteria to be used for structure loads and conductor sags.

Code Review: The 2002 Edition of the National Electrical Safety Code (NESC) was reviewed to determine the applicable Edition of the Code that would apply to reconductoring of these lines.

Conductor Selection: Conductors that would allow for the largest ampacity while meeting code ground clearances were evaluated to determine the least impact on the existing structures.

Line Availability: The time required to reconductor the 387 and 329 Lines was evaluated.

Constructability: A review of the construction methods required to complete the reconductoring was evaluated.

NESC REQUIREMENTS

Before starting the analysis of the existing structures, the National Electrical Safety Code (NESC) requirements applicable to reconductoring an existing transmission line were reviewed. The Connecticut Department of Public Utility Control adopts the latest NESC as their standard for transmission line construction. The latest edition of the NESC (2002) sets forth the following rules for existing installations (The Code is scheduled to be revised in late 2006):

Rule 013B. Existing Installations

1. Where an existing installation meets, or is altered to meet, these rules, such installation is considered to be in compliance with this edition and is not required to comply with any previous editions.

2. Existing installations, including maintenance replacements that currently comply with prior editions of the Code need not be modified to comply with these rules except as may be required for safety reasons by the administrative authority.
1. Where conductors or equipment are added, altered, or replaced on an existing structure the structure or the facilities on the structure need not be modified or replaced if the resulting installation will be in compliance with either (a) the rules that were in effect at the time of the original installation, or (b) the rules in effect in a subsequent edition to which the installation has been previously brought into compliance, or (c) the rules of this edition in accordance with Rule 013B1.

Based on these requirements, existing structures can be reconductored using the loading and strength requirements of the NESC edition used at the time of the original design. If existing structures need to be replaced, the new structures must be designed in accordance with the current edition of the NESC (2002).

The Scovill Rock-Black Pond segment of the 387 Line and the Southington-Frost Bridge 329 Line were designed using the 1961 edition of the NESC. The Black Pond-East Shore segment of the 387 Line was designed using the 1977 edition. The following is a summary of the design requirements of these editions, as well as the 2002 edition:

NESC (1961)

Loading Conditions:

- NESC district loading – Heavy. 0°F, 0.5 inches of radial ice, 4 psf wind, constant 0.31
- Extreme wind. In this edition of the NESC there is no extreme wind requirement, however, CL&P used a 16 psf wind

Overload Capacity Factors for steel structures, grade B construction:

- Vertical – 1.27
- Transverse – 2.54
- Longitudinal – 1.65

Overload Capacity Factors for wood structures, grade B construction:

- Vertical – 4.0
- Transverse – 4.0 (NESC Heavy); 2.0 (Extreme Wind)
- Longitudinal – 2.0

NESC (1977)

Loading Conditions:

- NESC district loading – Heavy. 0°F, 0.5 inches of radial ice, 4 psf wind, constant 0.30
- Extreme wind – 60°F, 0 inches of radial ice, 16 psf wind

Overload Capacity Factors for steel structures, grade B construction:

- Vertical – 1.5
- Transverse – 2.5
- Longitudinal – 1.65

Overload Capacity Factors for wood structures, grade B construction:

- Vertical – 4.0
- Transverse – 4.0 (NESC Heavy); 2.0 (Extreme Wind)
- Longitudinal – 2.0

NESC (2002)

Loading Conditions:

- NESC district loading – Heavy. 0°F, 0.5 inches of radial ice, 4 psf wind, constant 0.30
- Extreme wind - 60°F, 0 inches of radial ice, 32.11psf

Overload Capacity Factors for steel structures, grade B construction:

- Vertical – 1.5
- Transverse – 2.5
- Longitudinal – 1.65

Overload Capacity Factors for wood structures, grade B construction:

- Vertical – 2.20
- Transverse – 4.0 (NESC Heavy); 1.33(Extreme Wind)
- Longitudinal – 2.0

CONDUCTOR ANALYSIS AND SELECTION

The present 387 Line has a single 2156 kcmil ACSR “Bluebird” conductor on the Scovill Rock-Black Pond segment and a two-conductor bundle of 954 kcmil ACSR “Rail” conductor on the Black Pond-East Shore segment. The Southington-Frost Bridge 329 Line has a single 2156 kcmil ACSR “Bluebird” conductor. The initial step was to determine conductor types (using a two-conductor bundle) that had the potential to replace those existing conductors. The first criteria was to identify commercially available conductors which have sag/tension characteristics that, using existing structures, satisfy CL&P ground clearances.

To meet the anticipated circuit loading and strength requirements needed due to the existing structure span and height, it was determined that ACSS/TW (Aluminum Conductor, Steel Supported with Trapezoidal Wire aluminum strands, diameters equal to standard ACSR conductors) conductors would have the best performance for this application. The tensile strength of ACSS/TW conductor is supported entirely by the steel core and not the aluminum strands. The result is a conductor that operates at elevated temperatures without loss of aluminum strength (and additional steel strain and sag), which allows the conductor to carry higher ampacity as compared to similarly sized ACSR conductors. Other advantages of trapezoidal wire is its smaller cross-sectional area which minimizes the wind load on the supporting structures, and its excellent self-damping properties which reduces the dependency on dampers. The early stages of the feasibility analysis considered 954- and 1272-kcmil ACSR, but that was discontinued because of the disadvantages compared to ACSS/TW for reconductor projects.

The next phase of the analysis was to evaluate the sag/tension performance of the ACSS/TW conductors compared to the existing ACSR conductors. The design criteria used for the existing Rail and Bluebird conductors are as follows:

Segment(s)	Black Pond – East Shore	Scovill Rock – Black Pond Southington – Frost Bridge
Conductor Name	954 ACSR "Rail"	2156 ACSR "Bluebird"
Conductors per Phase	2	1
***Rated Ampacity (Amps per conductor) Long Term Emergency**	1600 (bundled pair delivers 3200)	2685
Design Tension (per conductor based on 800-ft. span)	8,000-lbs.	18,000-lbs.
Design Condition	NESC Heavy; "Final" Tension	NESC Heavy; "Final" Tension
Hot Curve Temperature	285^{o}F (140^{o}C)	285^{o}F (140^{o}C)
Design Ruling Span	700-ft.	700-ft.
“Final” Hot Curve Sag (ft.)	28.82	25.88

*Rated ampacity is the Long Term Emergency (LTE) rating with a conductor temperature of 140^{o}C (285^{o}F), ambient temperature of 37.8^{o}C (100^{o}F), and a 3 ft/sec wind. A summary of the LTE calculations is provided in Appendix B.

A 700-ft. design ruling span was used for this analysis, which is the approximate ruling span length for both lines. The design tension from an 800-ft. span was used because it results in slightly higher tensions, therefore giving more conservative analysis results.

To establish the sag/tension criteria for the new ACSS/TW conductors, the sag of the new conductor was matched to the sag of the existing conductors (within 0.5-ft.) for the design span under the hot curve temperature. This sag/tension analysis was completed using Alcoa’s Sag10 computerized program. Per

CL&P/UI requirements, the hot curve temperature for the new ACSS/TW conductor was set at 356°F (180°C). The sag limit for the ACSS/TW at 356°F was set to match the sag at 285°F for the ACSR "Rail" from Black Pond to East Shore; and 285°F for the ACSR "Bluebird" from Scovill Rock to Black Pond and Southington to Frost Bridge in order to meet clearance requirements.

To lessen the number of conductors evaluated, Sag10 analysis was completed only for ACSS/TW conductors with diameters equal to the ACSR "Rail" and larger. After completing the Sag10 analysis for the ACSS/TW conductors, additional conductors were eliminated due to the inability to meet NESC tension limits when matching hot curve sags on the ACSR conductor. The number of conductors was further reduced by grouping conductors with similar sag-tension performance and physical characteristics and selecting one conductor from the group. This process of elimination yielded four (4) ACSS/TW conductors, which were used in the analysis of the structures. Below is the summary of the physical, electrical and sag-tension characteristics of these conductors:

Conductor Size	1158.0	1455.3	1730.6	2153.8
Code Word	Genesee	Miramichi	James	Powder
Stranding (aluminum/steel)	45/7	45/7	54/19	84/19
Area (square inches)	0.9733	1.2222	1.5314	1.8290
Diameter (in.)	1.165	1.302	1.470	1.602
Weight (lbs./1000-ft.)	1308	1640	2221	2498
Rated Breaking Strength (lbs.)	20,500	25,600	46,400	42,100
***Rated Ampacity per conductor (Amps) Long Term Emergency**	2085	2410	2730	3055
****CASE 1 – Final Sag at 356°F (ft.)**	24.51	24.57	24.45	24.57
****CASE 1 – NESC "Heavy" Initial Tension (lbs.)**	9,050	11,044	14,500	16,350
****CASE 2 – Final Sag at 356°F (ft.)**	28.39	28.46	28.91	28.90
****CASE 2 – NESC "Heavy" Initial Tension (lbs.)**	7,700	9,245	11,275	12,900

*Rated ampacity is the Long Term Emergency (LTE) rating with a conductor temperature of 180°C (356°F), ambient temperature of 37.8°C (100°F), and a 3 ft/sec wind. A summary of the ampacity calculations prepared by CL&P is provided in Appendix B.

** The sag-tension characteristics noted as "Case 1" are those based on matching sags with the ACSR "Bluebird" at 285°F and "Case 2" matches the ACSR "Rail" at 285°F.

STRUCTURE ANALYSIS

The last step was to apply the mechanical loadings from these conductors to the existing structures to determine which conductors would not fail more than 50% of the structures on any right-of-way section. The 387 Line consists of 267 structures and the 329 Line has 106 structures, a mix of wood H-frame structures, guyed wood-pole angles, steel poles and lattice steel towers. These structures were originally designed in the 1960’s and 1970’s based on the NESC requirements at the time. A majority of the structures are wood H-frame structures with lattice steel crossarms. A listing of the structure types and quantities is provided in Appendix A.

The initial step in reviewing the structures was verifying the capacity of the structures under the existing loading conditions using the applicable NESC loading conditions. For the tangent structures, this was the determination of the allowable wind/weight spans; for angle structures the allowable wind/weight span and transverse loading from wire tensions; and for deadends, the longitudinal loading from conductor tensions.

On the Scovill Rock to Black Pond segment of the 387 Line and the Southington to Frost Bridge segment of the 329 Line, the allowable wind span for tangent structures (Type “A” tangent structures designed in 1965) was based on using the latest structural analysis program for transmission structures (PLS-Pole). PLS-Pole is a specialized computer program for the finite element analysis and design of concrete, steel or wood transmission structures in either linear or non-linear mode.

For the wood tangent structures on the Black Pond to East Shore segment of the 387 Line, the allowable spans for the existing conditions were established using a structure-spotting chart, which defines the allowable wind/weight spans versus structure height, provided by CL&P. The allowable wind span for this structure was also checked using PLS-Pole.

The Black Pond to East Shore segment also consists of steel pole tangent, angle, and dead-end structures designed for both single and double 345-kV circuits (none presently carrying more than one 345-kV circuit). The allowable loads for these structures were determined based on design load components (transverse, longitudinal and vertical loads) from the structure fabrication drawings provided by CL&P. Although CL&P reliability standards presently do not allow double circuit 345-kV structures, the existing design loads are based on this situation. Currently, these structures support one (1) 115-kV circuit with a single conductor per phase and one (1) 345-kV circuit with two (2) conductors per phase resulting in applied loads of approximately 75% of the design loads. Analysis of these structures using these reduced loads was not included in the scope of the study.

On both the 387 Line and the 329 Line, the load capacity of the wood angle structures was based on allowable wind and weight spans provided by CL&P for the original design criteria. For Scovill Rock to Black Pond and Southington to Frost Bridge, the limits were a 1500-ft. wind span and a 2000-ft. weight span; and for Black Pond to East Shore both the wind and weight spans were 1550-ft. Using these values and the tension for the ACSR conductors on an 800-ft. ruling span, component loads were calculated for 15^{o}, 25^{o} and 45^{o} angle structures.

The remaining wood deadend structures did not have any available loading criteria. Since the capacity of the deadend structures will, in most cases, be controlled by the longitudinal loads from the conductor tension, the strength limitation was established based on the tension of the existing conductor under NESC Heavy conditions.

After estimating the loading capacity of the structures from the installed ACSR conductors, the loading from the four (4) selected ACSS/TW conductors was determined. Since loading from the allowable wind spans under extreme wind conditions controlled the wood tangent structures, the loading from the new conductor was established based on a ratio of the diameters of the conductor sizes. For example, the existing ACSR "Rail" conductor has a diameter of 1.165-in. and an ACSS/TW "Genesee" conductor has a diameter of 1.165-in. Since the diameters are identical, tangent structures currently supporting the "Rail" can carry the same span lengths of "Genesee". If a larger ACSS/TW "James" with a diameter of 1.470-in. is used, the tangent structure span capacity is 79% (1.165-in./1.470-in. = 0.79) of the existing span capacity. This ratio was calculated for each new conductor and then multiplied by the allowable wind span for wood tangent structures to determine the allowable wind span for the new ACSS/TW conductor. If the tangent wind span exceeded the new allowable wind span, the structure was identified as a failure.

The evaluation of the tangent structures also included a check of the allowable weight spans. Using the attachment elevations on the existing plan/profile drawings, the weight spans were determined for each of the proposed conductors. If the new weight span exceeded the equivalent allowable weight span, the structure was identified as a failure.

For the wood angle structures, the allowable spans for the ACSS/TW conductors were determined using the conductor loading components using tensions for an 800-ft. span (from the Sag10 analysis described previously) and wind loading on the estimated wind span for each individual structure under NESC "Heavy" conditions for the ACSS/TW conductors. The component loadings were then calculated using these values with the exact line angles for each structure. If the component loads from the ACSS/TW conductor exceeded the component loads for the standard loads using the ACSR conductors, the structure was identified as a failure.

The capacity of the existing deadend structures were based on NESC “Heavy” tensions. Since the deadend capacity is determined primarily by components from the conductor tensions, the determination of structure failure was based on the tension of the ACSS/TW conductor. If the tension on the ACSS/TW conductor exceeded that of the ACSR conductors, the structure was identified as a failure.

As noted above, the loading capacity of the steel tangent, angle and dead-end structures on the Black Pond to East Shore segment was determined from load components on the structure design drawings provided by CL&P. For each of the steel structures, the load on the new ACSS/TW conductors under the controlling load case (extreme wind on tangents and NESC “Heavy” on angles and deadends) for the actual spans were compared to the design loads. If the loads on the actual spans with the ACSS/TW conductors exceeded the design loads, the structure was identified as a failure.

Using these methods, all 267 structures on the Scovill Rock to East Shore segment of the 387 Line and 106 structures on the Southington to Frost Bridge segment of the 329 Line were analyzed. The failure rates for the structures were 24% under loads from the “Genesee” and 50% with the “Miramichi”. Conductors larger than the “Miramichi” were not analyzed, because they would obviously exceed the 50% replacement rate. A summary of the failures is shown below and a detailed listing by structure type can be found in Appendix C.

Line Section	Length of Line (Miles)	Bundled Rail ACSR	Bundled Genesee ACSS/TW	Bundled Miramichi ACSS/TW
Conductor Diameter (in)		1.165	1.165	1.302
		% Failure	% Failure	% Failure
387 Line - Scovill Rock to Black Pond	**10.1**	**35**	**39**	**69**
387 Line - Black Pond to East Shore (Steel)	**9.9**	**N/A**	**13**	**30**
387 Line - Black Pond to East Shore (Wood)	**11.8**	**N/A**	**5**	**33**
329 Line - Southington to Frost Bridge	**12.7**	**30**	**42**	**67**
TOTALS	**44.5**	**16**	**24**	**50**

CONSTRUCTABILTY AND LINE AVAILABILITY

The time and cost of reconductoring the 387 and 329 Lines will be affected by several factors including the number of structure replacements, construction access, outages on adjacent transmission lines, and environmental constraints.

The availability of outages on the 387 and 329 Lines, and on any adjacent lines in the transmission corridor that would be required for construction, is a major concern. During replacement of tangent and angle structures, the lines on the same structures would have to be out of service for periods of up to several days. During reconductoring, the line would have to be out of service for multiple periods up to a week at a time. Typically, construction of this type takes a month per mile. Working from both ends to the middle could reduce that time, but either option would expose the system to a reliability risk for a significant length of time. Because the 387 Line is a major 345-kV line, any outage would likely result in substantial uplift charges.

For outages on adjacent lines, the line that would be impacted most would be the 115-kV line from East Meriden to Beseck and Totoket Junction to East Shore because it is supported on the same structures as the 387 Line. The preference would be to take this line out of service for extended periods during structure replacement and removal of line reclosing during reconductoring of the 387 Line. Structure replacement work could be completed with the 115-kV line energized but temporary line bypasses would be necessary.

Construction access along some sections will be a challenge where there exists some very rugged terrain, requiring additional work to re-establish construction access routes.

SUMMARY AND CONCLUSION

The existing 387 Line has three different configurations of conductor and structure types. This analysis considered each type of construction:

- Scovill Rock Switching Station to Black Pond Junction - Wood H-frames- 1-2156 kcmil ACSR "Bluebird" conductor
- Black Pond Junction to Beseck Junction - Steel Monopoles (Double circuit steel poles with a 345 kV and 115 kV circuit attached). The conductors on the 345-kV circuit are 2-954 kcmil ACSR "Rail". The conductor on the 115-kV line circuit is 1-1272 kcmil ACSR "Bittern"
- Beseck Junction to Totoket Junction - Wood H-frames - 2-954 kcmil ACSR "Rail" conductors
- Totoket Junction to East Shore Substation - Double Circuit Steel Poles. The conductors on the 345-kV circuits are 2-954 kcmil ACSR "Rail". The conductor on the 115-kV circuit is 1-1272 kcmil ACSR "Bittern".

One part of the analysis was to determine the feasibility of reconductoring the Bluebird section with 2-954 Rail conductors. The results of these analyses suggested that approximately 35% of the existing structures would have to be replaced between Scovill Rock Switching Station and Black Pond Junction.

The investigation was then extended to three larger conductor types and sizes. These conductors are listed below:

- 2-1158 kcmil ACSS/TW "Genesee"
- 2-1455.3 kcmil ACSS/TW "Miramichi"
- 2-1272 kcmil ACSR "Bittern"

The largest conductor size judged to be potentially feasible to install on the 387 Line is bundled Genesee ACSS/TW conductor. A bundled pair of Genesee ACSS/TW conductor has a summer normal rating of 1655 MVA and an emergency rating of 2490 MVA at 180 degrees centigrade. This requires the replacement of approximately 39% of the wood structures on the section of line between Scovill Rock and Black Pond, approximately 5% of the wood structures between Beseck and Totoket Junction and approximately 13% of the steel structures between Black Pond Junction to Beseck and Totoket Junction to East Shore Substation. There would be a total of approximately 47 structures being replaced.

The largest conductor size judged to be potentially feasible to install on the 329 line is bundled Genesee ACSS/TW conductor. A bundled pair of Genesee ACSS/TW conductor has a summer normal rating of 1655 MVA and an emergency rating of 2490 MVA at 180 degrees centigrade. This requires the replacement of approximately 42%, or approximately 44, of the structures on this line.

APPENDIX A

Appendix A

CL&P / United Illuminating
35813
387 and 329 Line Feasibility Study

Existing Transmission Line Characteristics

			Wood Structures						Steel Structures (pole and lattice)							Totals
			Tangents	Angles			Deadends		Tangents	Angles			Deadend			
	Conductor	Length (mi)	Type A/A2	Type C	Type D	Type E	Type F	Type H	Type A/B	Type C	Type D	Type E	Type F	Type G	Tower	
387 Line Scovill Rock - Black Pond	1-2156 ACSR 84/19 "Bluebird"	10.1	58	2	7	6	5	3							3	84
387 Line Black Pond - East Shore	2-954 ACSR 45/7 "Rail"	21.7	93	6	5	6	8	5	44	2	1	2	4	3	4	183
329 Line Southington - Frost Bridge	1-2156 ACSR 84/19 "Bluebird"	12.7	84	9	2	1	4	6								106
Totals		44.5	235	17	14	13	17	14	44	2	1	2	4	3	7	373

APPENDIX B

SUMMARY OF CONDUCTOR THERMAL RATINGS

Conductor Type	Summer Normal Rating (amps)	Summer Long Term Emergency Rating (amps)
Bluebird† 2156 kcmil ACSR	**2075**	**2685***
2-Rail‡ 954 kcmil ACSR	**2490**	**3200***
2-Genesee‡ 1158 kcmil ACSS/TW	**2770**	**4170****
2-Miramichi‡ 1455.3 kcmil ACSS/TW	**3190**	**4820****
2-Bittern‡ 1272 kcmil ACSR	**2980**	**3840***

† Single Conductor
‡ Bundled Pair of Conductors
* Based on 140°C Max Operating Temperature
** Based on 180°C Max Operating Temperature

APPENDIX C

Analysis summary of existing 345-kV structures.

The conductors shown are presented for the following reasons:
Genesee - Fails approximately 25% of the structures
Miramichi - Fails approximately 50% of the structures

Allowable Wind Span	Rail [t]	Bluebird*
Wood Tan	720	782

[t] Allowable wind span based on CL&P spotting chart
* Allowable wind span based on PLS-Pole analysis

		Conductor	Rail		Genesee		Miramichi	
		Structure	954 kcmil ACSR		1158 kcmil ACSS/TW		1455.3 kcmil ACSS/TW	
		Total	Failures	%	Failures	%	Failures	%
387 Line Scovill Rock - Black Pond								
Wood Structures								
Tangents	Type A/A2	58	21	36%	33	57%	44	76%
Angles	Type C	2	0	0%	0	0%	0	0%
	Type D	7	0	0%	0	0%	2	29%
	Type E	6	3	50%	0	0%	1	17%
Deadends	Type F	5	5	100%	0	0%	5	100%
	Type H	3	0	0%	0	0%	3	100%
	Tower	3	0	0%	0	0%	3	100%
Total		84	29	35%	33	39%	58	69%
387 Line Black Pond - East Shore								
Steel Structures								
Tangents	Type A/B	44	N/A	N/A	8	18%	10	23%
Angles	Type C	2	N/A	N/A	0	0%	1	50%
	Type D	1	N/A	N/A	0	0%	1	100%
	Type E	2	N/A	N/A	0	0%	1	50%
Deadends	Type F	4	N/A	N/A	0	0%	0	0%
	Type G	3	N/A	N/A	0	0%	1	33%
	Tower	4	N/A	N/A	0	0%	4	100%
Subtotal		60	N/A	N/A	8	13%	18	30%
Wood Structures								
Tangents	Type A/A2	93	N/A	N/A	6	6%	26	28%
Angles	Type C	6	N/A	N/A	0	0%	0	0%
	Type D	5	N/A	N/A	0	0%	0	0%
	Type E	6	N/A	N/A	0	0%	1	17%
Deadends	Type F	8	N/A	N/A	0	0%	8	100%
	Type H	5	N/A	N/A	0	0%	5	100%
Subtotal		123	N/A	N/A	6	5%	40	33%
Total		183	N/A	N/A	14	8%	58	32%
329 Line Southington - Frost Bridge								
Wood Structures								
Tangents	Type A/A2	84	24	29%	43	51%	54	64%
Angles	Type C	9	5	56%	1	11%	5	56%
	Type D	2	0	0%	0	0%	1	50%
	Type E	1	1	100%	0	0%	1	100%
Deadends	Type F	4	1	25%	0	0%	4	100%
	Type H	6	1	17%	0	0%	6	100%
Total		106	32	30%	44	42%	71	67%
Grand Total		373	61	16%	91	24%	187	50%