

Before the
Pennsylvania Public Utility Commission

COPPERSTONE – HARRISBURG #1 & #2 138/69 kV LINE

EXHIBITS AND APPENDICES IN SUPPORT OF THE LETTER OF NOTIFICATION

Application Docket No. _____

Submitted by: PPL Electric Utilities Corp.

SUMMARY

This filing is submitted by PPL Electric Utilities Corporation (PPL Electric), pursuant to the Pennsylvania Public Utility Commission's (PUC or the Commission) regulations at 52 Pa. Code §§ 57.71 through 57.77, for Commission approval to reinforce the 230 kV and 69 kV systems in central Dauphin County. As part of this reinforcement, PPL Electric proposes to construct the Copperstone 230-69 kV Substation ("Copperstone Substation"). This Project involves the construction of three separate transmission lines. Each transmission line will be connected to the Copperstone Substation. Each transmission line will be the subject of a separate filing.

Here, PPL Electric seeks the Commission's approval of Part 1 of the Project, the construction of the new Copperstone – Harrisburg #1 & #2 138/69 kV Transmission Line, which will be approximately 1.33 miles. This Project is located in South Hanover and Lower Paxton Townships, Dauphin County. Studies conducted for PPL Electric's transmission system, in conjunction with the PJM Regional Transmission Expansion Process ("RTEP"), revealed several transmission line thermal overload violations pertaining to the Bulk Electric System ("BES," generally defined as 100 kV and above), as well as PPL Electric's underlying 69 kV transmission system and substation equipment in the summer of 2012.

The estimated cost to site, design, and construct the transmission facilities for Part 1 of the Project is $2,356,000. Construction is scheduled to begin in March 2011, to support the project's in-service date of May 2012.

This document, which describes the need for the project and discusses the engineering and siting analysis for the proposed construction, consists of the following exhibits and appendices:

Exhibit "A"-Necessity Statement

Exhibit "B"-Engineering Description

Exhibit "C"-Environmental Assessment

Appendix A-PPL Design Criteria and Safety Practices

Appendix B-Magnetic Field Management at PPL Electric

Appendix C- List of property owners within the proposed Right-of-Way

Appendix D -List of Involved Governmental Agencies, Municipalities, and Other Public Entities

PPL ELECTRIC UTILITIES SERVICE TERRITORY

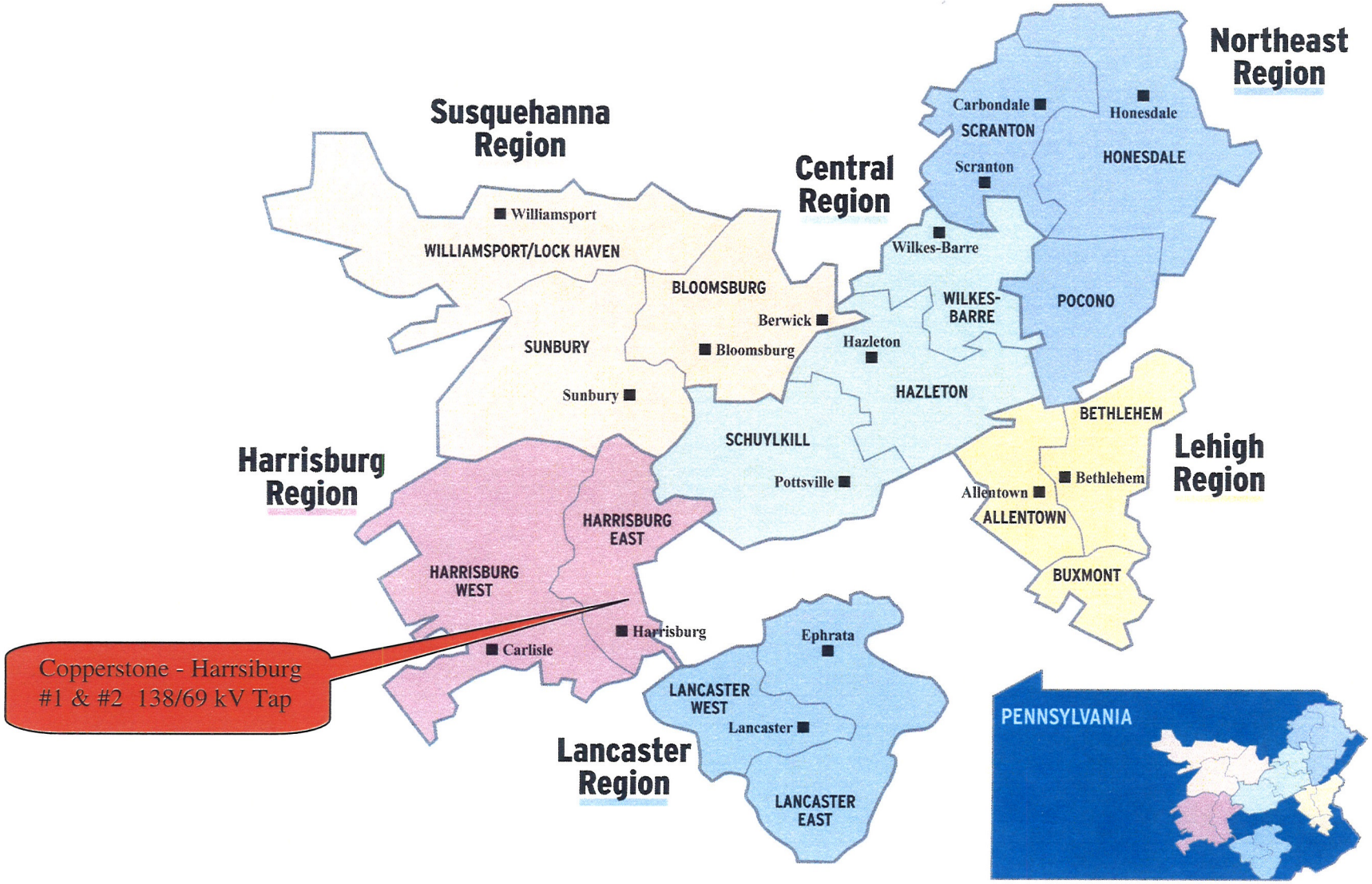


Exhibit
A

EXHIBIT "A"

COPPERSTONE – HARRISBURG #1 & #2 138/69 kV LINE

NECESSITY STATEMENT

TABLE OF CONTENTS

SECTION	TOPIC	PAGE
A.	INTRODUCTION.....	1
B.	EXISTING SYSTEM.....	2
C.	DEFINITION OF THE PROBLEM.....	2
D.	PROPOSED SOLUTION.....	4
E.	FUNCTIONAL ALTERNATIVES.....	5

LIST OF FIGURES

FIGURE 1 EXISTING ONE-LINE DIAGRAM

FIGURE 2 FUTURE ONE-LINE DIAGRAM

MAP

MAP 1 PPL ELECTRIC SYSTEM MAP — Exhibit "A" Map Pocket

EXHIBIT "A"

COPPERSTONE – HARRISBURG #1 & #2 138/69 kV LINE

NECESSITY STATEMENT

A. INTRODUCTION

PPL Electric proposes to construct the Copperstone 230-69 kV Substation ("Copperstone Substation") to reinforce the 230 kV and 69 kV systems in central Dauphin County. This Project involves the construction of three separate transmission lines that will connect to the Copperstone Substation. Each transmission line will be the subject of a separate filing with the Commission.

In Part 1 of the Project, which is the subject of this filing, PPL Electric requests Commission approval to construct the proposed 1.33 mile Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Lines. This line will be designed for 138 kV operation, although it initially will be operated at 69 kV. Conversion to 138 kV operation will occur when increasing demand for electricity approaches the limit of operation at 69 kV. The proposed Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Lines will tie into the existing Hummelstown–Harrisburg #3 & #4 69 kV Transmission Lines, west of the existing Paxton 69-12 kV Substation, and connect with the proposed Copperstone Substation. This portion of the existing Hummelstown-Harrisburg #3 & #4 69 kV Transmission Lines will be renamed the Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Lines.

In Part 2 of the Project, a different portion of the existing Hummelstown-Harrisburg #3 & #4 69 kV Transmission Lines will be connected with the proposed Copperstone 230-69 kV Substation by constructing approximately 0.53 miles of new double circuit 138/69 kV line, initially operated at 69 kV. This will create the new Dauphin–Copperstone #1 & #2 138/69 kV Transmission Lines, which will be the subject of a subsequent filing with the Commission.

Finally, in Part 3 of the Project, PPL Electric proposes to construct two new 230 kV taps to connect with the proposed Copperstone 230-69 kV Substation. One tap will be the proposed

Middletown Junction–Copperstone 230 kV Tap, and the second tap will be the proposed Copperstone–North Lebanon 230 kV Tap. These 230 kV taps will connect the proposed Copperstone Substation to the existing Metropolitan Edison Middletown Junction- North Lebanon 230 kV Line by splitting this line in the area of the proposed Copperstone Substation . These 230 kV taps will be the subject of a subsequent filing with the Commission.

The estimated costs to site, design, and construct the transmission facilities for Part 1 of the Project are approximately $2,356,000. Part 1 has a scheduled construction start date of March 2011, to meet a required in-service date of May 2012. The required in-service date is defined as the date that the proposed facility must be placed in service to prevent overloads or unacceptable voltage levels that could potentially damage equipment and result in service interruptions to customers.

A PPL system map showing existing transmission facilities with a design voltage of 35 kV or greater is included in the Exhibit "A" map pocket. This filing addresses only the existing and proposed transmission system in central Dauphin County.

B. EXISTING SYSTEM

Presently, central Dauphin County receives the bulk of its electric power from two sources, the Hummelstown 230-69 kV Substation and the Dauphin 230-69 kV Substation. The existing 69 kV transmission lines that exit these substations deliver electric power to various 69-12 kV substations throughout central Dauphin County. The existing transmission arrangement is shown in Figure 1.

C. DEFINITION OF THE PROBLEM

Studies conducted for PPL Electric's transmission system, in conjunction with the PJM RTEP (Regional Transmission Expansion Process), revealed several transmission line thermal overload violations pertaining to the Bulk Electric System (BES, generally defined as 100 kV and above)

in central Dauphin County, as well as the PPL Electric underlying 69 kV transmission system and substation equipment in the summer of 2012.

The studies indicated that NERC and PJM violations are likely to occur on PPL Electric's 230 kV electric system in central Dauphin County under N-1-1 conditions. An N-1-1 condition is defined as one 230 kV line outage, followed by a subsequent second 230 kV line outage. The studies conducted for PPL Electric's summer peak transmission system for the year 2012 indicated the following N-1-1 conditions are likely to cause overloads on the BES system in central Dauphin County:

- By the summer of 2012, under forecasted summer peak load conditions, a forced outage of the Dauphin–Juniata 230 kV Transmission Line and a subsequent outage of the Hummelstown–Middletown Junction #1 230 kV Transmission Line would overload the Hummelstown-Middletown Junction #2 - Steel Tap 230 kV Transmission Line.

- By the summer of 2012, under forecasted summer peak load conditions, a forced outage of the Dauphin–Juniata 230 kV Transmission Line and subsequent outage of Hummelstown–Middletown Junction #2 - Steel Tap 230 kV Transmission Line would overload Hummelstown-Middletown Junction #1 230 kV Transmission Line.

The studies also indicated that, in violation of PPL Electric Reliability Principles and Practices (RP&P), the following overloads will occur on PPL Electric's 69 kV system in central Dauphin County for single contingency operations:

- The Dauphin 230-69 kV Substation is designed with two 230-69 kV transformers. By the summer of 2012, under forecasted summer peak load conditions, a forced outage of either transformer at the Dauphin 230-69 kV Substation would overload the remaining transformer.

- The Hummelstown 230/69kV Substation is designed with three 230-69 kV transformers. By the summer of 2012, under forecasted summer peak load conditions, a forced outage of one transformer at the Hummelstown 230-69 kV Substation would overload the remaining 230-69 kV transformers.

- By the summer of 2012, under forecasted summer peak load conditions, a forced outage of the Hummelstown–Harrisburg #1 and #2 69 kV Transmission Line would cause overloads on the Hummelstown–Harrisburg #3 and #4 69 kV Transmission Line .

- By the summer of 2012, under forecasted summer peak load conditions, a forced outage of the Hummelstown–Harrisburg #4 69 kV Transmission Line or the Harrisburg Substation 69 kV bus section #3, would cause overloads on the Hummelstown–Harrisburg #3 69 kV Transmission Line.

D. PROPOSED SOLUTION (SEE FIGURE 2)

To resolve the issues discussed above, PPL Electric, with the Commission's approval, proposes the following:

Construct the new Copperstone 230-69kV Substation. The Copperstone Substation would be constructed with a 230 kV four breaker ring bus and will be supplied power via two short 230 kV single circuit taps from the existing Middletown Junction-North Lebanon 230 kV Transmission Line. The single circuit 230 kV taps will supply two 230-69 kV 150 MVA transformers that will provide power supply to the 69 kV system. From the 69 kV system, four short 138/69 kV overhead transmission lines (two double circuit lines) will be constructed and sectionalized into the existing Hummelstown – Harrisburg #3 and #4 69 kV Lines: one double circuit line approximately 1.3 miles and one double circuit line approximately half a mile long.

This reinforcement alternative resolves all the overloads explained in section C above, and provides additional capacity for future electric system load growth.

This alternative will have the least amount of impact because it requires the construction of relatively short overhead transmission lines utilizing mostly existing rights-of-way and a small amount of recently acquired rights-of-way. Further, this project will not require extensive outages of the existing facilities, which would maintain reliable electric service to the customers in the area during construction. Hence, this option is considered the preferred option.

The estimated cost of this Alternative is $28 million, which includes the total estimated cost to site, design, and construct all overhead transmission facilities and the 230-69 kV substation.

E. FUNCTIONAL ALTERNATIVES

Alternative 2 – Upgrade the following substations and 69kV transmission lines:

- Add a 3rd 230-69 kV transformer at the Dauphin 230-69 kV Substation.
- Add a 3rd 230-69 kV transformer at the West Shore 230-69 kV Substation.
- Rebuild the West Shore–Harrisburg #1 and #2 69 kV Transmission Lines.
- Build a new double circuit 69 kV line from the Hummelstown 230-69 kV Substation to the Duke 69kV tap.
- Build a new 230 kV line from the Hummelstown 230-69 kV Substation to the Middletown Junction 230 kV Substation.

The total estimated cost of the Alternative 2 projects would be approximately $43.0 million.

This reinforcement alternative also resolves the contingency overloads explained in section C above and provides long term capacity upgrades for future growth. However, Alternative 2 has several deficiencies when compared to the preferred option. Specifically, Alternative 2 was not selected as the preferred option due to the following:

- More expensive.
- Requires extensive new rights-of-way for 230 kV and 69 kV transmission lines.
- Requires extensive outages at several substations and on the 69 kV transmission systems, thus reducing reliability to customers supplied from these transmission lines.

Alternative 3

Construct a new 230-69 kV substation at the PPL Electric's existing Steelton 230 - 69 kV Substation. Construct four new 138/69 kV lines from the new 230-69 kV substation and sectionalize them into the existing West Shore–Harrisburg #1 and #2 69 kV Transmission Lines. In addition, Alternative 3 would require the following upgrades:

- Install a 3rd 230-69 kV transformer at the Dauphin 230-69 kV Substation.
- Rebuild 2 miles of the West Shore–Harrisburg #1 and #2 69 kV Transmission Lines from the Harrisburg 69 kV Substation to the Steelton–Harrisburg 69 kV Transmission Line tap point.
- Rebuild the Steel 230 kV Tap from the Hummelstown-Middletown Junction #2 230 kV Transmission Line to Steelton Substation with higher capacity conductors.
- Build a new 230 kV line between the Hummelstown 230-69 kV Substation and the Middletown Junction 230kV Substation.

The total estimated cost of the Alternative 3 projects would be approximately $58.85 million.

This reinforcement alternative also resolves the contingency overloads explained in section C above and provides long term capacity upgrades for future growth. However, Alternative 3 has several deficiencies when compared to the preferred option. Specifically, Alternative 3 was not selected as the preferred option due to the following:

- More expensive.
- Requires new rights-of-way for 230 kV and 69 kV transmission lines.
- Requires extensive outages at several substations and on the 69 kV transmission system reducing reliability to customers supplied from these transmission lines.

FIGURE 1
EXISTING 69 KV SYSTEM

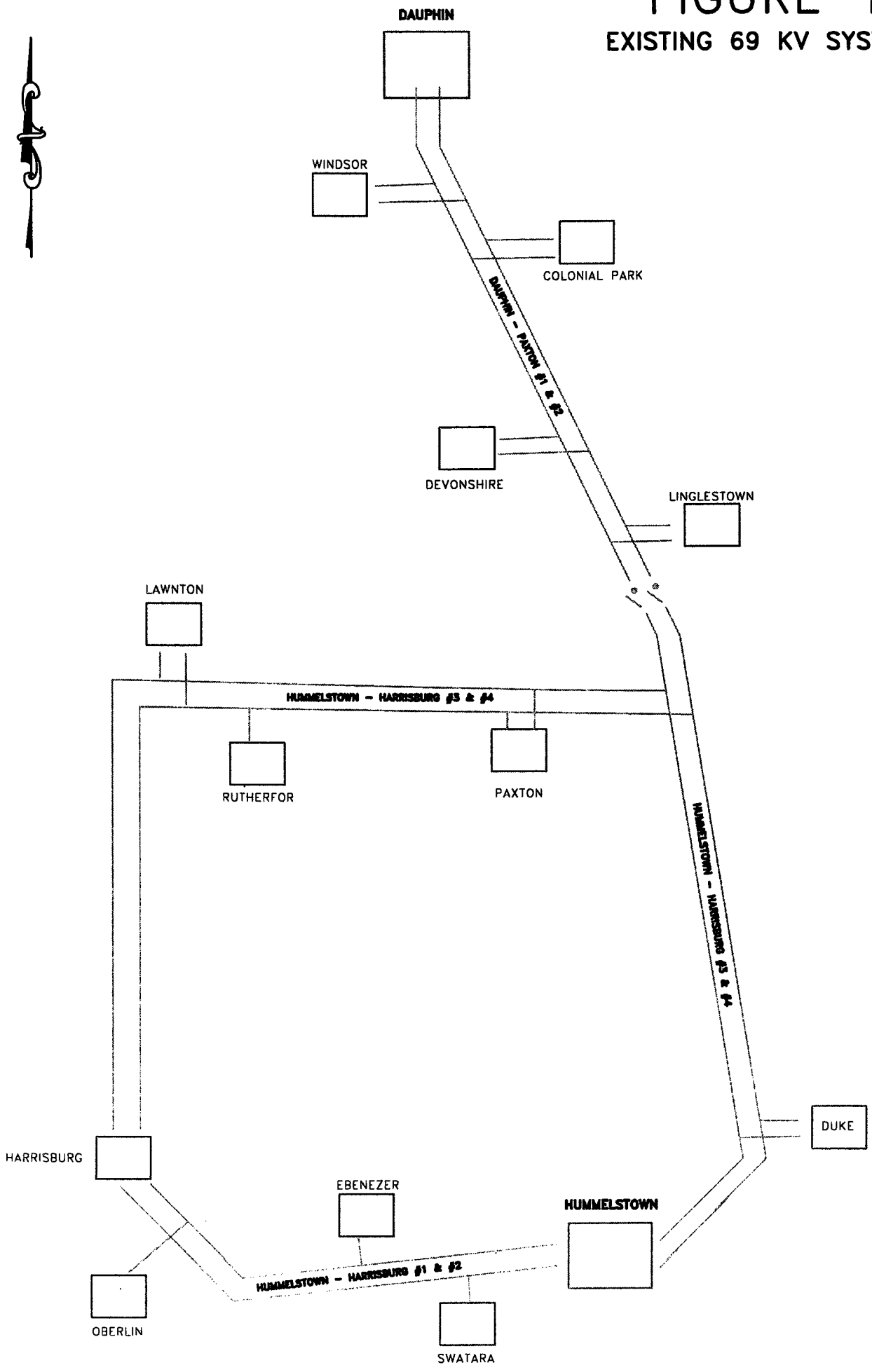
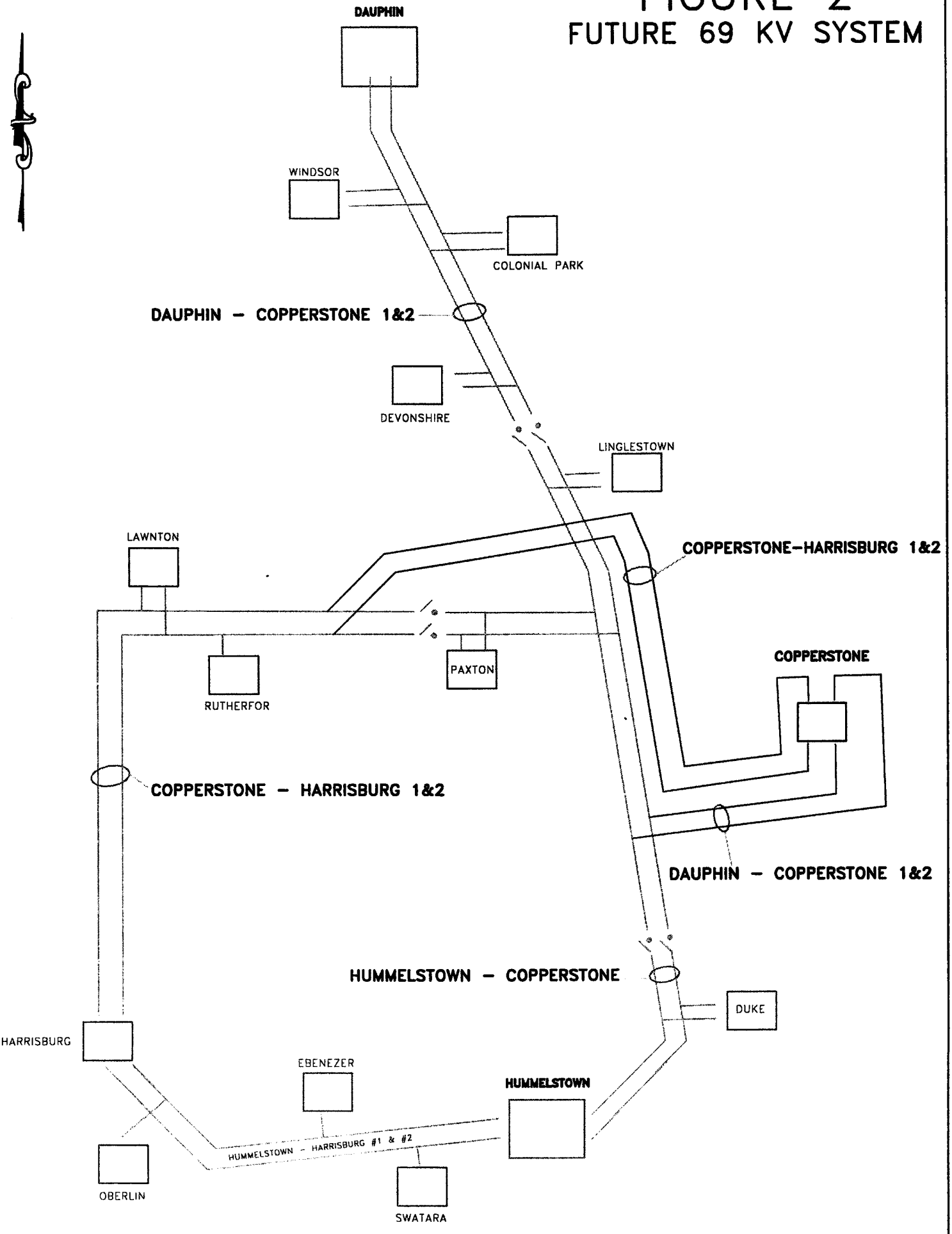


FIGURE 2
FUTURE 69 KV SYSTEM



THIS DRAWING IS THE PROPERTY OF PPL ELECTRIC UTILITIES AND CONTAINS PROPRIETARY AND CONFIDENTIAL INFORMATION THAT IS NOT TO BE DUPLICATED, USED OR DISCLOSED WITHOUT WRITTEN AUTHORIZATION FROM PPL ELECTRIC UTILITIES.

SUBSTATION LISTING

1	WEST WILLIAMSPORT	151	CRACKERSPORT	301	CENTER CITY
2	FAIRFIELD	152	SCHNECKSVILLE	302	NEW KINGSTOWN
3	MONTGOMERY	153	HEMLOCK	303	REAMSTOWN
4	WARDEN	154	MT. ALLEN	304	DUPONT
5	HONESDALE	155	PRINCE	305	HUMBOLDT
6	JERSEY SHORE	156	WAKEFIELD	306	CEDAR AVE.
7	LOGANTON	157	COOPERSBURG	307	INDIAN ORCHARD
8	VALMONT	158	WERTZVILLE	308	NOTTINGHAM
9	RIVER	159	WEST CARLISLE	309	NORTH COOLBAUGH
10	LIMESTONE	160	BENVENUE	310	LETORT
11	NORTHUMBERLAND	161	HEGINS	311	EAST MOUNTAIN
12	REED	162	LEOLA	312	JERMYN
13	WRIGHT	163	YATESVILLE	313	BLOOMSBURG
14	ST.JOHNS	164	CENTRAL ALLENTOWN	314	MIFFLINTOWN
15	FREELAND	165	OBERLIN	315	RIDGE ROAD
16	*	166	STRASBURG	316	SUSQUEHANNA
17	GILBERT	167	ATGLEN		T-10 SW. YD.
18	*	168	BROOKSIDE	317	KIMBLES
19	CHERRY HILL	169	WILLIAMSTOWN	318	CHRISTMANS
20	SUSQUEHANNA 230KV	170	E. PETERSBURG	319	OTTER CREEK
21	TAMANEND	171	WERNERSVILLE	320	STEEL CITY
22	WHITE HILL	172	N. BETHLEHEM	321	MCGOVERNVILLE
23	PALMERTON	173	W. ALLENTOWN	322	ROBESONIA
24	HAMILTON	174	FLEMINGTON	323	S.FOGELSVILLE
25	HUNTER	175	MECKESVILLE	324	ELROY
26	FAIRVIEW	176	DONERVILLE	325	BUSHKILL
27	*	177	MILLERSVILLE	326	WALLENPAUPACK
28	*	178	SHILLINGTON	327	ELK MOUNTAIN
29	MONTOUR PUMP	179	DUKE	328	JACK FROST
30	MT. CARMEL	180	MCALLISTERVILLE	329	HARWOOD 230/69KV
31	KELLY	181	NEWFOUNDLAND	330	HARWOOD CTG
32	SPORTING HILL	182	MARLIN	331	HARWOOD 69/12KV
33	MAHANOY CITY	183	WEST BERWICK	332	NAZARETH
34	GREENWOOD	184	KEYSER AVENUE	333	ALBURTIS
35	MOWRY	185	MICKLEYS	334	FRACKVILLE
36	ALTAMONT	186	EAST ALLENTOWN	335	*
37	HAMLIN	187	PINE RIDGE	336	ELIMSPORT
38	ASHFIELD	188	DALMATIA	337	ALLENWOOD
39	SOUTH SLATINGTON	189	PENNSBORO	338	*
40	SOUTH MIDDLEBURG	190	NORTH COLUMBIA	339	GRATZ
41	WALKER	191	HUGHESVILLE	340	HOCKERSVILLE
42	FRAILEY	192	SOUTH ALLENTOWN	341	BLOOMING GROVE
43	MORGANTOWN	193	WEISSPORT	342	MONROE
44	EGYPT	194	HONEYBROOK	343	LACKAWANNA ##
45	CRESSONA	195	MOSCOW	344	STANTON
46	SOUTH WHITEHALL	196	*	345	JACKSON
47	EAST TOMHICKEN	197	ROSSMOYNE	346	EAST PALMERTON
48	BEAR GAP	198	NORTHAMPTON	347	SIEGFRIED
49	SALISBURY	199	WOOLRICH	348	HOSENSACK 230/69KV
50	SOUTH MILTON	200	FAXON	349	HOSENSACK 500KV
51	HEIDELBERG	201	ELIZABETHTOWN	350	CONESTOGA
52	LYKENS	202	ENOLA	351	MANOR
53	UPPER HANOVER	203	TERRE HILL	352	CLINTON
54	RICHLAND	204	BUCK	353	EXCHANGE
55	MACADA	205	MT. BETHEL	354	MILTON
56	ROCKVILLE	206	RICHFIELD	355	DAUPHIN
57	THOMPSONTOWN	207	SCRANTON	356	QUARRY SUB.
58	PAXTON	208	TWIN LAKES	357	STEELTON
59	COLALICO	209	HARLEIGH	358	JUNIATA 500/230KV
60	EAST ELIZABETHTOWN	210	TAFTON	359	JUNIATA 230/69KV
61	WARWICK	211	BEAR CREEK	360	CUMBERLAND
62	EARL	212	ORWIGSBURG	361	DONEGAL
63	HEMPFIELD	213	EAST TEXAS	362	JENKINS 230/69KV
64	EAST LANCASTER	214	CANDENSIS	363	JENKINS CTG
65	KINZER	215	LINDEN	364	WILKES-BARRE
66	MT. NEBO	216	MT. JOY	365	BUXMONT
67	MT. POCONO	217	WEST BLOOMSBURG	366	SOUTH AKRON 230/138/69KV
68	PENNS	218	MINSI TRAIL	367	SOUTH AKRON 69/12KV
69	GOULDSBORO	219	LAKE NAOMI	368	SOUTH MANHEIM 69/12KV
70	DILLERVILLE	220	LANARK	369	SOUTH MANHEIM 230/69KV
71	GIRARD MANOR	221	*	370	ENGLESIDE
72	KENMAR	222	MONTOURSVILLE	371	COLUMBIA
73	GOWEN CITY	223	PORT CARBON	372	DANVILLE
74	*	224	BLYTHEBURN	373	SUNBURY
75	ELLIOT HEIGHTS	225	MILFORD	374	HUMMELS WHARF
76	ROHRERSTOWN	226	TREICHLERS	375	LYCOMING
77	MACUNGIE	227	ROSEVILLE	376	LOCK HAVEN CTG
78	EAST HAZLETON	228	RUTHERFORD	377	LOCK HAVEN 69/12KV
79	WAGNERS	229	HARTLAND	378	HUMMELSTOWN
80	EAST CARBONDALE	230	PARRISH	379	WEST SHORE
81	LYNDON	231	WEST NEW HOLLAND	380	MONTAGUE
82	MINOOKA	232	POINT	381	SOUTH FARMERSVILLE
83	OLD FORGE	233	LINCOLN	382	WESCOSVILLE
84	FOUNTAIN SPRINGS	234	MIDDLETON	383	FISHBACH
85	SULLIVAN TRAIL	235	STATE HILL	384	BERKS
86	*	236	MILLVILLE	385	MONTOUR
87	SWATARA	237	TINKER	386	SUBURBAN YARD
88	*	238	LAKEVILLE	387	*
89	HEPBURN	239	NORTH MANHEIM	388	*
90	*	240	HATFIELD	389	MACK
91	*	241	HERSHEY	390	WILLIAMSPORT
92	FRANCONIA	242	S. HERSHEY	391	HARRISBURG
93	EMMAUS	243	S. WILLIAMSPORT	392	ELDRED
94	MORGAN	244	FOGELSVILLE	393	*
95	THROOP	245	WINDSOR	394	MILLWOOD
96	*	246	W. WILLOW	395	TELFORD
97	*	247	WESTGATE	396	TWIN VALLEY
98	CHAPMAN	248	EDELA	397	DEVONSHIRE
99	SUBURBAN	249	SUMMERDALE	397	JESSUP
100	*	250	DORNEYVILLE	398	BELTZVILLE
101	*	251	BOHEMIA	399	SCHOENECK
102	*	252	WHITE HAVEN	400	HAWLEY
103	PROVIDENCE	253	LAURELTON	401	EFFORT MOUNTAIN
104	*	254	LINGLESTOWN	402	COPPERSTONE
105	AVOCA	255	PIOCONO FARMS		
106	*	256	HICKORY RUN		
107	CASS	257	BLOOMING GLEN		
108	CATASAQUA	258	SHERMANSDALE		
109	*	259	*		
110	SUSQUEHANNA 500KV	260	LARRYS CREEK		
111	SEIDERSVILLE	261	SPANGLER MILLS		
112	ROSEMONT	262	E. DANVILLE		
113	QUARRYVILLE	263	DELAND		
114	LAWNTON	264	CARBON		
115	LITITZ	265	SELLERSVILLE		
116	RENOVO	266	MECHANICSBURG		
117	WALNUT	267	CARLISLE		
118	WATSON	268	CEDAR		
119	TREXLERTOWN	269	ARROWHEAD		
120	LAVINO	270	NEWPORT		
121	SPRING	271	HALIFAX		
122	COLONIAL PARK	272	MILLERSUBRG		
123	WEST LANCASTER	273	MUNCY		
124	MADISONVILLE	274	HAUTO		
125	NEFFSVILLE	275	BERWICK		
126	BEAVERTOWN	276	SHENANDOAH		
127	BELMONT	277	PINE GROVE		
128	LAKE HARMONY	278	STROUDSBURG		
129	GEORGETOWN	279	FREEMANSBURG		
130	SCOTT	280	ALLENTOWN		
131	N. HARRISBURG	281	BINGEN		
132	MOUNT ROCK	282	RHEEMS		
133	GREENLAND	283	CLEVELAND		
134	LANDISVILLE	284	LITTLE GAP		
135	GREEN PARK	285	ORVILLA		
136	SELINSGROVE	286	TUSCARORA		
137	SUMNER	287	BARTONSVILLE		
138	AUBURN	288	ALTON PARK		
139	ROHRSBURG	289	SALEM		
140	BERRY	290	NORTH BRIDGEPORT		
141	EAST GREENVILLE	291	HAMPDEN		
142	WEST DAMASCUS	292	CAMELBACK		
143	NEW COLUMBIA	293	SILVER SPRING		
144	FARMERSVILLE	294	BRECKNOCK		
145	GREENFIELD	295	BENTON		
146	NORTH STROUDSBURG	296	MCMICHAELS		
147	TANNERSVILLE	297	HUGHESTOWN		
148	ELIZABETHVILLE	298	NEWVILLE		
149	WYOMISSING	299	POINTE NORTH		
150	EXETER	300	MARIETTA		

* - SUBSTATIONS THAT HAVE BEEN RETIRED.
- SITE OF THE EXISTING 230KV SUBSTATION AND PROPOSED 500KV SUBSTATION

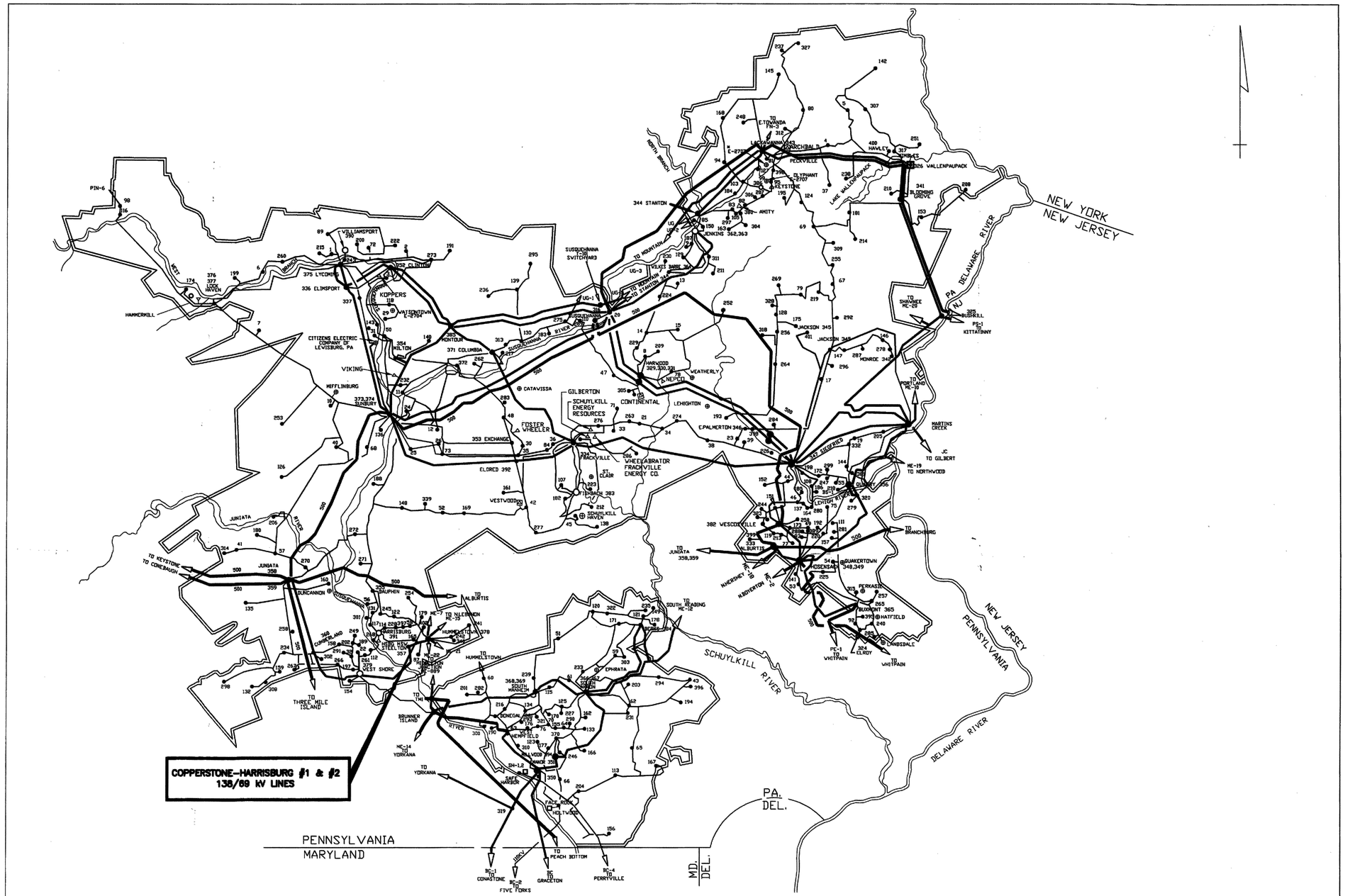

COPPERSTONE–HARRISBURG #1 & #2
138/69 kV LINES
NEW YORK
NEW JERSEY
PA DELAWARE RIVER
NEW JERSEY
PENNSYLVANIA
SCHUYLKILL RIVER
DELAWARE RIVER
PENNSYLVANIA
MARYLAND
PA. DEL.
MD. DEL.
SUSQUEHANNA SUBSTATION
WILLIAMSPORT
LYCOMING
ELIMSPORT
KOPPERS
MONTOUR
COLUMBIA
MILTON
EXCHANGE
DANVILLE
SUNBURY
HUMMELS WHARF
MIFFLINBURG
VIKING
CATAWISSA
GILBERTON
SCHUYLKILL ENERGY RESOURCES
CONTINENTAL
LEHIGHTON
WEATHERLY
JACKSON
MONROE
EAST PALMERTON
SIEGFRIED
FOSTER WHEELER
FRACKVILLE
WHEELABRATOR FRACKVILLE ENERGY CO.
ELDRED
WESTWOOD
JUNIATA
DUNCANNON
HARRISBURG
HERR NEW STEELTON
WEST SHORE
HUMMELSTOWN
SOUTH AKRON
SOUTH MANHEIM
EPHRATA
DONEGAL
HENRYFIELD
HOLTWOOD
SAFE HARBOR
FACE ROCK
PEACH BOTTOM
CONASTONE
FIVE FORKS
GRACETON
PERRYVILLE
YORKANA
THREE MILE ISLAND
BRUNNER ISLAND
ALBURTIS
STANTON
AMITY
JENKINS 362,363
SUSQUEHANNA SWITCHYARD
TO MOUNTAIN
TO HOSENSACK
TO STANTON
TO ALBURTIS
TO NEWTOWN
TO HUMMELSTOWN
TO SOUTH READING
TO SHAWNEE
TO PORTLAND
TO BRANCHBURG
TO JUNIATA
TO KEYSTONE
TO CONEMAUGH
TO WHITPAIN
TO PEACH BOTTOM
TO YORKANA
TO CONASTONE
TO GRACETON
TO PERRYVILLE
TO FIVE FORKS
TO ELDRED
TO MONTOUR

Exhibit
B

EXHIBIT "B"

COPPERSTONE – HARRISBURG #1 & #2 138/69 kV LINE

ENGINEERING DESCRIPTION

TABLE OF CONTENTS

SECTION	TOPIC	PAGE
A.	DESCRIPTION OF PROPOSED PROJECT	1
B.	MAGNETIC FIELD MANAGEMENT	3
C.	RIGHT-OF-WAY STATUS	3
TABLE 1	DESIGN MINIMUM CONDUCTOR CLEARANCES LACKAWANNA-EAST CARBONDALE & LACKAWANNA-EDELLA LINES	2
TABLE 2	CONDUCTOR THERMAL RATINGS	3
MAP 1	AERIAL SHOWING THE OVERALL PROJECT	EXHIBIT "B" MAP POCKET

EXHIBIT "B"

COPPERSTONE – HARRISBURG #1 & #2 138/69 kV LINE

ENGINEERING DESCRIPTION

A. DESCRIPTION OF THE PROPOSED LINE

PPL Electric proposes to construct a portion of the new Copperstone-Harrisburg #1 & #2 138/69 kV Transmission Line. The proposed line will exit the new Copperstone 230-69 kV Substation and will extend approximately 1.33 miles to connect with the existing Hummelstown–Harrisburg #3 and #4 69 kV Transmission Line just west of the existing Paxton 69-12 kV Substation. The proposed line is being constructed for double circuit 138 kV, but will be operated at 69 kV until future load growth in the area requires upgrade to 138 kV.

The new line will consist of single and multi-pole fabricated weathering steel structures. These structures will be equipped with upswept weathering steel arms, polymer 138 kV insulator assemblies, (6) 795.0 kcmil, 30/19 stranding, ACSR conductors, and one 3/8 inch high-strength steel overhead ground wire. All new poles for the proposed Copperstone-Harrisburg #1 & #2 138/69 kV Transmission Line will be either direct embedded or installed on concrete foundations with an approximate above-ground height of 85 to 100 feet. Line angles and tap structures could be guyed. This work will be completed under existing and newly acquired PPL Electric right-of-way agreements.

This project is located in South Hanover and Lower Paxton Townships, Dauphin County. An aerial plot plan for the proposed transmission line project is provided in the Exhibit "B" map pocket.

The proposed line facilities will be designed to, and generally exceed, National Electrical Safety Code (NESC) standards. Design specifications and safety rules practiced by PPL Electric are included in Appendix A. The minimum conductor to ground clearance will be 30 feet on all new line facilities. Those clearances occur at a maximum thermal conductor temperature of 125 degrees Celsius.

The designed minimum conductor clearances and conductor thermal ratings for the line are as follow:

TABLE 1

DESIGN MINIMUM CONDUCTOR CLEARANCES
FOR 795 KCMIL, 30/19 STRANDING ACSR*

COPPERSTONE – HARRISBURG #1 & #2 138/69 kV LINE

Condition	Double-Circuit Design Clearance-to-Ground
Normal load; average weather (16°C ambient temperature)	33.0 feet
Predicted extreme thermal load (125°C conductor temperature)	30.0 feet
Predicted NESC Extreme wind load (100 mph, 16°C)	31.7 feet
Predicted extreme weather conditions (1inch ice, 4 lbs. wind, -18°C)	32.1 feet

*Clearances based on a maximum tension of 10,000 pounds, at 1 inch ice, 0° F, 4 lb wind, and a ruling span of 335 feet.

TABLE 2

CONDUCTOR THERMAL RATING
795 KCMIL 30/19 STRANDING ACSR
(257°F) 125°C MAXIMUM CONDUCTOR TEMPERATURE

Condition	Ambient Temperature °C	Wind Speed Knots	Ampacity Amps
Summer Normal	35	0	1056
Winter Normal	10	0	1217
Summer Emergency	35	1 1/2	1347
Winter Emergency	10	1 1/2	1517

B. MAGNETIC FIELD MANAGEMENT

PPL Electric's Magnetic Field Management Program, summarized in Appendix B, is applied to new and reconstructed transmission line projects. To reduce magnetic field exposures, the program generally prescribes the use of a line design that provides five feet higher ground clearance and reverses phasing of new double circuit lines where it is feasible to do so at low or no cost. The implementation of additional modifications should be considered, provided those modifications can be made at low or no cost.

Increased ground clearance and reverse phasing are included in the design of the new double circuit Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Line.

C. RIGHT-OF-WAY STATUS

Most of the work for the new Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Line will be completed on PPL Electric fee-owned property and under existing PPL Electric right-of-way agreements with defined right-of-way widths. Although some

additional rights-of-way were required to construct the Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Line, PPL Electric has successfully negotiated with the relevant property owners and secured right-of-way agreements necessary to construct this overhead line section. A list of property owners within the existing right-of-way is presented in Appendix C.



LEGEND

- EXISTING TRANSMISSION LINE
- PROPOSED TRANSMISSION LINE
- EXISTING RIGHT-OF-WAY
- EXISTING PROPERTY LINE
- NEW PPL PROPERTY LINE
- TOWNSHIP LINE

Property Number	Property Owner
1	LOYAL E. AND PATRICIA A. MORRIS
2	JOHN AND SANDRA MILLS
3	ROBERT E. SMITH
4	DAVID AND MARILYN WAGNER
5	GREGORY AND BARBARA HARRIS
6	MICHAEL AND CAROL CARRICATO
7	FRANCIS AND NORMA PURCELL
8	JOHN AND SUZANNE SEITZ
9	GERALD AND ELSIE KAPP
10	GLENN L. CASSEL AND BARBARA R. CASSEL
11	PPL ELECTRIC UTILITIES 32.7 & 11.4 ACRES

EXHIBIT B

AERIAL EXHIBIT
SHEET 1

COPPERSTONE-HARRISBURG
#1 AND #2
138/69KV LINES
SOUTH HANOVER & LOWER PAXTON TOWNSHIP
DAUPHIN COUNTY, PA.

SCALE: 1" = 200'
200' 0 100' 200' 400'

PREPARED BY:
PPL ELECTRIC UTILITIES CORP.
PPL ELECTRIC UTILITIES

REFERENCE TITLE	NUMBER	REFERENCE TITLE	NUMBER	NO.	DATE	ACCT.	REVISION	BY	REVIEWED	APPROVED
										C
							LOCATION CODES			SORTS

ACCT- 169983
SCALE- 1"=200'
BY- RRC
REVIEWED

COPPERSTONE-HARRISBURG #1 & #2
138/69KV LINES

SOUTH HANOVER & LOWER PAXTON TOWNSHIP — DAUPHIN COUNTY, PA.

APPROVED: DOUGLAS L. KAUFF — DATE: 9/5/09 — PPL ELECTRIC UTILITIES

PPL DRAWING NO.: EXHIBIT "B" — SHEET NO.: 1 — REV.: 0

EXHIBIT B_5001.DWG/TIF

FRACTIONAL 0 1 2 — DECIMAL 2 1 0

PPL EU FORM 4877 (7/03)

PC CAD

Exhibit C

EXHIBIT "C"

COPPERSTONE – HARRISBURG #1 & #2 138/69 kV LINE

ENVIRONMENTAL ASSESSMENT

TABLE OF CONTENTS

SECTION	TOPIC	PAGE
A.	INTRODUCTION.....	1
B.	LAND USE.....	1
C.	CULTURAL RESOURCES.....	2
D.	NATURAL FEATURES.....	3
E.	THREATENED AND ENDANGERED SPECIES.....	3

EXHIBIT "C"

COPPERSTONE – HARRISBURG #1 & #2 138/69 kV LINE

ENVIRONMENTAL ASSESSMENT

A. INTRODUCTION

PPL Electric proposes to reinforce the 230 kV and 69 kV electric delivery system in central Dauphin County. To accomplish this, PPL Electric requests Commission approval to construct approximately 1.33 miles of the new Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Line, which will be initially operated at 69 kV. This new double circuit 138/69 kV line will tie into the existing Hummelstown–Harrisburg #3 & #4 69 kV Transmission Line, west of the existing Paxton 69-12 kV Substation. A portion of the existing Hummelstown-Harrisburg #3 & #4 69 kV Transmission Line will be renamed the Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Line. Although there are other parts to the project, PPL Electric only seeks Commission approval for the proposed 1.33 mile Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Line at this time.

This proposed project was reviewed with South Hanover and Lower Paxton Townships and Dauphin County. Neither the Townships or County Officials have any objection to the project. A list of involved governmental agencies, municipalities, and other public entities is presented in Appendix D.

B. LAND USE

The Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Line will create minimal new land use impacts. The line will be reconstructed entirely within and newly acquired PPL Electric rights-of-way or on PPL Electric fee-owned property and will parallel an existing PPL Electric tower line for a portion of its route.

The proposed Copperstone–Harrisburg #1 & #2 138/69 kV Transmission Line is generally located in woodland, farmland, and residential areas. There are 10 properties that will be traversed by the proposed project. No nearby railroads, communication towers, pipelines or other utilities will be affected by the proposed project. Existing field access roads will be used, although new roads may be needed in some cases for construction in residential areas. All disturbed areas will be returned to there original condition after construction.

C. CULTURAL RESOURCES

This project was reviewed with the Pennsylvania Historical and Museum Commission (PHMC). PHMC has determined that, due to the absence of historical sites and the small project size, no further archaeological investigations are required so long as construction activities are located outside a 300-foot buffer of any watercourse.

The following lists were reviewed for the presence of historical districts and structures in the area:

- National Historic Landmarks in Pennsylvania
- National Register Historic Districts in Pennsylvania
- National Register Individual Properties and Historic Districts in Pennsylvania
- National Register/Listed and Eligible Properties in Pennsylvania

There are several structures of historical interest in the vicinity of this project. Impacts to these historical structures are not expected due to the distance between the structures and this project. The Reservoir Park Overlook is located approximately 5.5 miles west of the project area, and the Landis Mill Millers House located at the intersection of N.Railroad Street and Duke Street, Hummelstown is approximately 2.2 miles south of the project area.

D. NATURAL FEATURES

The proposed project will not affect any unique geological, scenic, or natural areas. No parks or recreational facilities are located near the project area. Tree clearing is required for the construction of this line segment through woodlands. However, PPL Electric will apply its "Specifications For Initial Clearing and Control of Vegetation on or Adjacent to Electric Line Right-of-Way Through Use of Herbicides, Mechanical and Hand Clearing Techniques, to Mitigate the Impacts of This Clearing Work".

The lines will cross Beaver Creek and some wetlands. All wetlands and waters have been delineated and added to the construction drawings. All are easily spanned and, therefore, no impacts are anticipated. All required permits will be obtained from the Pennsylvania Department of Environmental Protection and the United States Army Corps of Engineers prior to construction.

E. THREATENED AND ENDANGERED SPECIES

PPL Electric has coordinated with different state and federal agencies to obtain information regarding endangered and threatened species in the study area. A review of the Pennsylvania Natural Diversity Inventory (PNDI) records indicates that the Pennsylvania Department of Conservation and natural Resources (DCNR) has recorded one potential conflict in the project area. At the request of DCNR, PPL Electric hired Mr. Richard Mellon, Mellon Biological Services to perform a presence/absence survey for the *Triosteum angustifolium* (Tentatively Undetermined, Proposed PA Endanger), which did not detect the presence of any such species. Based on this study a final report from DCNR, dated January 7, 2008, indicated that no impact was likely. Because the report has since expired, it will be resubmitted to DNCR for review. Based on a recent PNDI review, PPL Electric anticipates no impacts. (Reference PNDI # 20071017113376 and 20090915209963).

Appendices

LIST OF APPENDICES

APPENDIX A - PPL Electric Design Criteria and Safety Practices

APPENDIX B - Magnetic Field Management at PPL Electric

APPENDIX C - List of property owners within the existing Right-of-Way

APPENDIX D - List of Involved Governmental Agencies, Municipalities, and Other Public Entities

APPENDIX "A"

PPL DESIGN CRITERIA AND SAFETY PRACTICES

The National Electrical Safety Code (NESC) is a set of rules to safeguard people during the installation, operation, and maintenance of electric power lines. The NESC contains the basic provisions considered necessary for the safety of employees and the public. Although it is not intended as a design specification, its provisions establish minimum design requirements. PPL Electric Utilities Corp. (PPL Electric) has developed design specifications and safety rules which meet or surpass all provisions specified by the NESC.

Engineering Design Criteria and Parameters

The NESC includes loading requirements and clearances for the design, construction, and operation of power lines. The "loads" on conductors and supporting structures are the mechanical forces that develop from the weight of the conductors, the weight of ice on the conductors, plus wind pressure on the conductors and supporting structures. Loading requirements are the loads on the conductors and structures that are anticipated assuming certain ice and wind conditions. Loading requirements always contain "safety factors" to allow for unknown or unanticipated contingencies. The clearances and loading requirements contained in the NESC were developed to ensure public safety and welfare.

PPL Electric transmission line design standards meet or surpass the NESC standards. For example, the relative order of grades of construction for conductors and supporting structures is B, C, and N; Grade B being the highest. According to the NESC standards, construction Grades B, C, or N may be used for transmission lines (except at crossings of railroad tracks and limited access highways where Grade B construction is specified). However, PPL Electric designs all of its transmission lines for Grade B construction. The use of Grade B design and construction specifies such things as larger-minimum cross-arm dimensions, larger-minimum conductor size, and increased safety factors.

Another example is the design parameters utilized to account for ice and wind loadings on the overhead ground wire (OHGW) and power conductors. The NESC standard ice and wind design magnitudes for the PPL Electric territory are 0.5 inch thickness of radial ice combined with four pounds per square foot horizontal wind pressure (equivalent to 40-mile per hour wind velocity). The conductor sags and tensions used in line designs are the result of various ice and wind combinations, depending on the elevation at the line location and line design voltage. The conductor sags and tensions used in the design of all PPL Electric transmission lines are at least 0.5-inch ice combined with eight pounds wind pressure (equivalent to 57 miles per hour wind velocity). This means that PPL Electric lines are designed to operate safely and reliably during inclement weather even more severe than assumed by the NESC. In addition, PPL Electric transmission lines are designed with more clearance to the ground than required by the NESC. The tables below compare PPL Electric and NESC ground clearances for lines of various voltages.

138 kV

Surface Underneath Conductors	Vertical Clearance to Ground	
	NESC Standard	PPL Electric Design
Roads, streets, alleys	21 Ft.	30 Ft.
Other land traversed by vehicles (such as cultivated field, forest, etc.)	21 Ft.	30 Ft.
Spaces accessible to pedestrians only	17 Ft.	30 Ft.
Railroad tracks	31 Ft.	35 Ft.

230 kV

Surface Underneath Conductors	Vertical Clearance to Ground	
	NESC Standard	PPL Electric Design
Roads, streets, alleys	23 Ft.	32 Ft.
Other land traversed by vehicles (such as cultivated field, forest, etc.)	23 Ft.	32 Ft.
Spaces accessible to pedestrians only	19 Ft.	32 Ft.
Railroad tracks	31 Ft.	36 Ft.

500 kV

Surface Underneath Conductors	Vertical Clearance to Ground NESC Standard	PPL Electric Design
Roads, streets, alleys	28 Ft.	53 Ft.
Other land traversed by vehicles (such as cultivated field, forest, etc.)	28 Ft.	53 Ft.
Spaces accessible to pedestrians only	24 Ft.	53 Ft.
Railroad tracks	38 Ft.	53 Ft.

A relay protection system is used to protect the public safety and welfare as well as equipment and the transmission system. Relay protection is installed for all transmission lines to automatically de-energize the line in the unlikely event that the line or supporting structure fails and the line contacts the ground.

Periodic Maintenance Program on All Transmission Lines

To ensure continued public safety and integrity of service, a periodic maintenance and inspection program is implemented for every transmission line. The program is administered through the use of helicopter patrols, with supplemental foot and structure climbing patrols. A number of helicopter patrols are performed on all lines annually. The two-man helicopter crew flies parallel, to the left, and above the line so that the observer can look for signs of line damage or deterioration and observe clearances between vegetation and conductors. The observations are included in a report that is forwarded to the appropriate department for corrective action.

Foot and structure climbing patrol programs for a transmission line begin approximately three to five years after the line is energized, unless a helicopter patrol reports a need for earlier action. The frequency of foot patrols varies from once every year to once every several years depending on line type and age.

An assigned foot patroller checks right-of-way conditions, including access roads, bridges, pole washouts, tower footers, vegetation height and clearance to conductors, pole and tower deterioration

and, with the use of binoculars, insulators, and condition of hardware. Identified problems are included in a report that is forwarded to the appropriate department for corrective action.

A scheduled line outage is required to perform an overhead patrol because of "hands-on" inspection of hardware. Overhead patrols are conducted on a schedule determined by line age, operating record, and observed general condition. The necessary repairs are also done during the inspection outage.

Personnel Safety Rules

The following are a few of the PPL Electric safety rules that demonstrate the Company's concern for employee safety:

- Work procedures have been developed to allow work to be performed on energized facilities in a safe manner. When lines or apparatus are removed from service to be worked on, the Energy Control Process system is applied. This system provides that a red tag must be physically placed on the control handle of the de-energized equipment. The red tag may be removed only after proper authorization to energize the equipment. Various other tags are used for limited operations and informational purposes. Employees will not apply or remove a tag or change the status of tagged equipment unless authorized.

- Temporary safety grounds are used on de-energized facilities for employee safety during maintenance, construction, or reconstruction work. Safety grounds are wires connecting the de-energized facility to an electrical ground. If the facility should be energized, the safety grounds will divert the current directly to ground and reduce the likelihood of personal injury. The conductor size and attachment clamps of temporary safety grounds must be capable of conducting anticipated fault currents. Rubber gloves, rubber sleeves, and additional rubber protective equipment are used as required when applying or removing temporary safety grounds to or from the lines or apparatus to be grounded. An approved nonconductive working stick of sufficient length to allow workers to maintain the following required minimum clearances is used to test that the line has been de-energized and to apply temporary safety grounds:

Voltage-kV	Minimum Clearance
138	3'-7"
230	5'-3"
500	11'-3"

Before applying grounds, a test is done to confirm that the line is de-energized. The voltage test device is checked before and after use to assure reliability. When ground pins are used to establish proper ground points, they are driven to a depth of not less than four feet as near vertical as possible.

- Poles or structures are inspected and examined for structural integrity before climbing. If there is any reason to believe that a pole is unsafe, it is stabilized before work is performed. Appropriate safety gear in the form of body belts, safety straps, hard hats, gloves, etc., is worn by linemen during line work activity.



MAGNETIC FIELD MANAGEMENT

PPL Electric Utilities Corporation

APPENDIX B

DECEMBER 2004

TABLE OF CONTENTS

INTRODUCTION 1

DEVELOPMENT OF PPL EU's MAGNETIC FIELD MANAGEMENT PROGRAM 6

VARIABLES THAT AFFECT MAGNETIC FIELDS 6

Effect of Phase Current on Magnetic Fields 6

Effect of Conductor Configuration on Magnetic Fields 7

Effect of Distance from the Magnetic Field Source 7

SUMMARY OF PPL EU's MAGNETIC FIELD MANAGEMENT PROGRAM 8

MAGNETIC FIELD MANAGEMENT PROGRAM GUIDELINES 9

Overhead Lines 9

New or Rebuilt Transmission Lines 9

Reconductoring or Adding Additional Circuits to Existing Transmission Lines 14

Distribution Lines 14

Underground Transmission Lines 15

CHARTS 16

INTRODUCTION

At PPL Electric Utilities Corp. (PPL EU), magnetic field management means investigating and implementing methods at low or no cost to reduce magnetic fields in new or rebuilt transmission and distribution lines. This document explains PPL EU's Magnetic Field Management Program, which is part of PPL EU's larger Electric and Magnetic Fields (EMF) policy.

PPL EU's View

Some people are worried that electric and magnetic fields are harming their health. Others think the scientific research does not show a problem at all, and still others believe there's just too much scientific uncertainty to draw any conclusions.

Here's what we do know now. Various panels of scientists that have reviewed the EMF research generally have drawn two main conclusions. First, the large body of evidence does not demonstrate that EMF are harmful. Second, additional research is recommended to explore questions raised in some studies.

Given these conclusions, PPL EU is taking a reasoned approach in responding to the EMF issue. PPL EU's approach to the EMF issue consists of five elements:

- Providing EMF information to customers and employees
- Providing magnetic field measurements
- Establishing and implementing a magnetic field management program to reduce magnetic fields in new or rebuilt facilities when it can be done at no, or low, cost
- Integrating EMF in the public involvement process that PPL EU undertakes in the siting of transmission lines
- Have supported additional research

EMF Are All Around Us

Electric and magnetic fields occur in nature and in all living things. The earth, for instance, has a magnetic field, which makes the needle on a compass point north.

Electric fields and magnetic fields of a different type also surround every wire that carries electricity. In everyday life, these EMF arise from several basic sources, including power lines, electrical appliances, home and building wiring, other utility lines and cables, and currents flowing on water pipes. Though they often occur together, EMF are made up of two separate components:

Electric Fields

Electric fields are produced by the voltage—or electrical pressure—on a wire. The higher the voltage, the higher the electric field. As long as a wire is energized—has voltage present—an electric field is present (see Figure 1). In other words, an appliance, or an electric power line, doesn't actually have to be turned on to create an electric field. It just has to be plugged in. Electric fields diminish with distance and can be blocked or partially shielded by objects such as trees and houses.

Magnetic Fields

Magnetic fields are created by the current or flow of electricity through a wire. Generally speaking, the higher the current, the higher the magnetic field. Because they only occur when current is flowing, magnetic fields are present only when the power is turned on (see Figure 1). Magnetic fields also diminish with distance, but—unlike electric fields—are not blocked by common objects. In recent years, public and scientific interest has turned toward the magnetic field component of EMF because of some scientific studies regarding these fields.

Figure 1

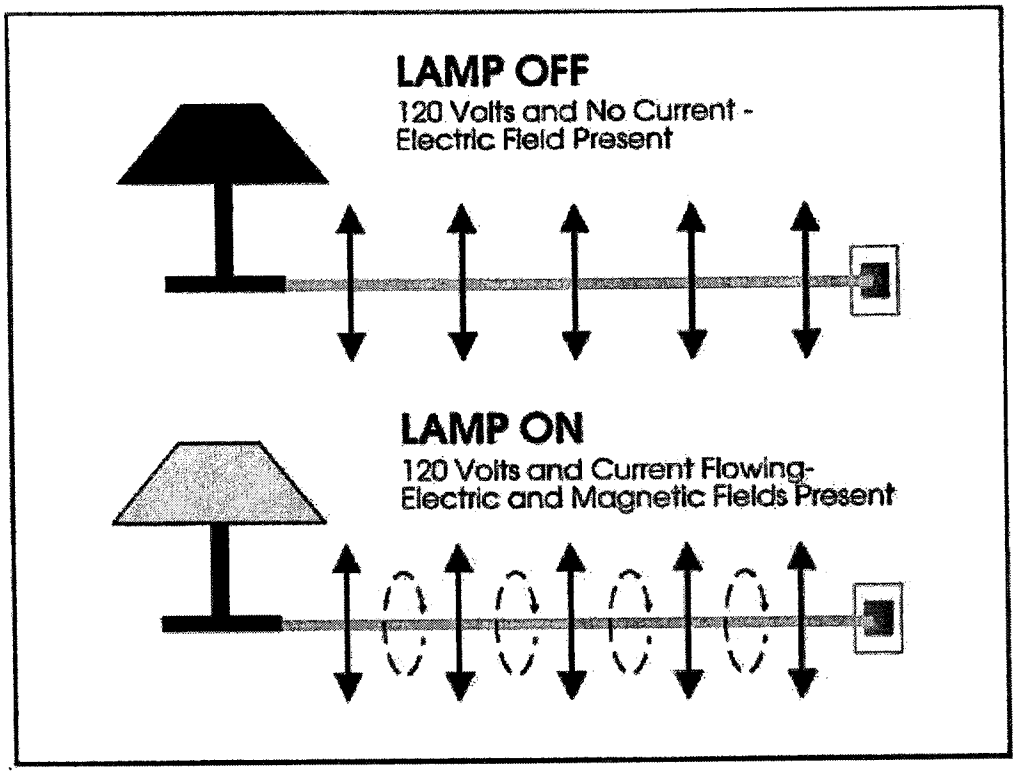

LAMP OFF
120 Volts and No Current -
Electric Field Present
LAMP ON
120 Volts and Current Flowing-
Electric and Magnetic Fields Present

Figure 2

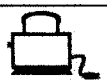
Magnetic field strengths decrease with distance Magnetic fields are measured in milligauss	Source: "EMF In Your Environment", U.S. Environmental Protection Agency 1992 At 6 inches	At 1 foot	At 2 feet
Clothes dryer 	2 to 10	* to 3	*
Microwave oven 	100 to 300	1 to 200	1 to 30
Toaster 	5 to 20	* to 7	*
Power drill 	100 to 200	20 to 40	3 to 6
Can opener 	500 to 1500	40 to 300	3 to 30
Mixer 	30 to 600	5 to 100	* to 10
Hair dryer 	1 to 700	* to 70	* to 10
Color television 	Data not available	* to 20	* to 8

FIGURE 2 * The magnetic field measurement at this distance from the operating appliance could not be distinguished from background measurements taken before the appliance had been turned on.

Measuring Magnetic Fields

Magnetic fields usually are measured in a unit called a milligauss. Magnetic field levels found in the living areas of homes typically range from less than 1 milligauss to about 4 milligauss according to the U.S. Environmental Protection Agency. They can be higher in some cases. The levels next to appliances can exceed 1,000 milligauss (1 gauss). Figures 2 and 3 show how the strength of the field falls off as you move away from the source, just as the heat of a campfire grows weaker as you walk away from it. For overhead power lines, the strength of the magnetic fields is dependent upon a number of factors that will be explained later. Those factors produce a magnetic field that drops off rapidly as you move away from the power line.

Figure 3

Sample Magnetic Field Levels in Milligauss				
Type of Overhead Power Line	**Distance from the line**			
	Under the line	**50 ft.**	**100 ft.**	**200 ft.**
220 kV and 500 kV	5-400	5-250	1-75	0.5-20
69 kV and 138 kV	3-80	0.5-2.5	0.1-10	0.1-3
12 kV and below	0.4-20	0.1-1	-	-

The magnetic field values provided in this table represent a general range of values associated with the types of overhead power lines listed and are provided for illustration. There will be circumstances in which there will be magnetic field levels above or below the range of values provided due to variations in such factors as height of the wires, current flow and so on.

DEVELOPMENT OF PPL EU's MAGNETIC FIELD MANAGEMENT PROGRAM

One element of our response to EMF concerns expressed by some of our customers is PPL EU's Magnetic Field Management Program. The program was initiated in March 1991 because PPL EU believes it makes good sense, as a matter of policy, to respond to the concerns expressed by some of our customers and to reduce magnetic fields in new and rebuilt facilities where it can be done with either no-cost or low-cost design changes.

This document updates the original program which has been revised several times since 1991. These guidelines were developed by PPL EU's EMF Working Group.

VARIABLES THAT AFFECT MAGNETIC FIELDS

Magnetic fields from transmission and distribution lines are a function of a number of design variables. The following parameters affect the magnetic field levels produced by transmission and distribution lines:

- Current
- Height of conductors above ground
- Configuration of conductors
- Distance from the line

EFFECT OF PHASE CURRENT ON MAGNETIC FIELDS

At power frequencies (i.e., 60 hertz), the magnetic field level is a function of the current or flow of electricity through a wire. Keeping all other parameters the same, the magnetic field is proportional to the current. Hence, if the current increases by 25 percent, the resulting magnetic field level will increase by 25 percent.

The overall load current on any line varies with the demand for power. It's usually highest during daytime hours and lowest at night. There also are weekly, monthly, seasonal and yearly variations.

The difference in the currents between each phase in a multiphase line also can affect the magnetic field. This difference is called phase unbalance. For a constant load, a statistical analysis of this phase unbalance can be made to determine its effect on the magnetic field. Close to the line, there is very little effect. However, the phase unbalance slows the rate at which the magnetic field decreases with distance from the line.

Effect of Conductor Configuration on Magnetic Fields

In the transmission and distribution of power, utilities like PPL EU presently use both three-phase and single-phase lines. Each phase on a three-phase power line has either a single conductor or a bundle of two or more conductors. In a three-phase system, the ground-level magnetic field is a result of the fields produced by the currents in each of the phases. Placing the three phases as close together as possible (compaction) creates some field cancellation, and the ground-level magnetic field is reduced. However, appropriate phase separation is required for the reliable operation of the line. In addition, the arrangement of the phases can create some; field cancellation and reduction of the ground-level magnetic field.

Effect of Distance From the Magnetic Field Source

Magnetic field strength diminishes with the vertical and lateral distances from the magnetic field source. Increasing the height of the conductors above ground is useful for magnetic field reduction at ground level, but may result in increased structure costs and increased aesthetic impact of the structures. Another possible method of increasing the distance to the magnetic field source is to increase the right-of-way requirements. By keeping buildings off increased rights of way, thereby requiring the public to live and work further away from lines, exposure to magnetic fields produced by the lines can be reduced. Increases in right of way are not always practical and may increase costs significantly, however.

SUMMARY OF PPL EU's
MAGNETIC FIELD MANAGEMENT PROGRAM

Under its Magnetic Field Management Program, PPL EU has changed the way it builds and rebuilds some of its transmission and distribution lines. These design changes reduce magnetic field levels (assuming balanced circuit loadings and phase currents) by up to 69 percent in most of the company's new transmission lines. These guidelines now are being applied to new and reconstructed transmission facilities, based on this program.

The distribution component of the program focuses on 12 kV lines, the company's standard distribution voltage. It concentrates on the three-phase, primary 12 kV lines, since these are the most heavily loaded facilities and often are located in densely populated areas. The guidelines in this program are being applied to these three-phase, primary 12 kV lines.

A maximum 3-5 percent change in estimated cost was used as the limit for the guidelines since this value is consistent with low cost, is within estimating accuracy and is likely to have little impact on overall line costs.

The magnetic field calculations used in this document for the design of PPL EU's overall magnetic field management plan assume balanced load conditions among the phases and a fixed level of current, not necessarily representative of specific transmission or distribution lines. These levels were calculated using the Electric Power Research Institute's ENVIRO computer program. Under actual operating conditions, the magnetic field levels that result may vary due to such things as actual load per circuit, overall current on each phase conductor and the electrical configuration and operation of each line.

MAGNETIC FIELD MANAGEMENT PROGRAM GUIDELINES

The guidelines for magnetic field management are noted below, with discussion points for each.

OVERHEAD LINES

NEW OR REBUILT TRANSMISSION LINES

1. **Balance transmission circuit loads and phase currents as much as possible.**
   - PPL EU should continue to make every effort to balance loadings between the two circuits of a double circuit line when planning new or rebuilt facilities to maximize the effects of reverse phasing.
   - PPL EU should continue the practice of balancing single-phase loads across the three phases of the distribution system. (Unbalanced phase currents on the distribution system are reflected through to the transmission system.)
     - Unbalanced phase currents result in higher magnetic fields that do not drop off as quickly with distance as do the fields resulting from balanced phase currents.
     - For a 5 percent phase current unbalance, the magnetic field 50 feet from the centerline of a single circuit 138 kV line could be more than twice the value than if the same line had balanced phase circuits.
   - Balanced phase currents on each three-phase distribution circuit also reduce magnetic fields from the distribution circuits themselves. In addition, they reduce magnetic fields on the transmission system from which the distribution system circuits are supplied and connected through substations.
   - Apart from magnetic field considerations, balanced phase currents on each three-phase distribution circuit also reduce line losses and improve the system voltage.

2. **Continue with the present practice of using long-span construction as the PPL EU 138/69 kV standard**

- Structure designs for short-span and long-span construction are illustrated on Charts I and II, respectively.
  - Short-span design does not significantly reduce magnetic fields when compared to long-span design even though it is more compact than long-span design. Comparison of the magnetic field values from Chart III indicates essentially the same values. Therefore, short-span design should not be used solely to reduce magnetic fields.
  - PPL EU will continue to use long-span construction for 138/69 kV double-circuit lines and for single-circuit/future-double-circuit lines.
  - For single-circuit/future-double-circuit lines, PPL EU will continue to install two conductors on the top positions and one in the middle position as shown in Chart IV.
    - This arrangement minimizes magnetic fields as shown in Chart V by placing the three initial conductors higher on the structure, which increases the ground clearances, and by placing the conductors in a triangular configuration.

3. **Compact design structures are not a low-cost alternative and should be used for magnetic field reduction only in special applications.**

Chart VI illustrates the compact design structure.

- The compact design increases the initial installation costs by 79 percent when compared to the long-span design but reduces the magnetic field from 9 mG to 3 mG (about 67 percent) at the edge of the 100-foot-wide right of way as shown on Chart III.

4. **Reverse phase new or rebuilt double-circuit transmission lines for all voltage levels.**

- Reverse phasing was adopted by PPL EU in March 1991 for double-circuit 138/69 kV transmission lines and in April 1992 for all other double circuit transmission lines. Reverse phasing is shown in Chart VII. Reverse phasing will reduce the magnetic fields when the current flow on both circuits is in the same

direction. Calculated values contained here are based on balanced and equal phase currents on both circuits.

- Reverse phasing reduces the magnetic field of a double circuit 138 kV single pole transmission line from 29 mG to 9 mG (about 69 percent) at the edge of the 100-foot-wide right of way as shown on Chart III.
- Reverse phasing reduces the magnetic field of a double circuit 230 kV single pole transmission line from 49 mG to 16 mG (about 67 percent) at the edge of the 150-foot-wide right of way as shown on Chart VIII.
- Reverse phasing reduces the magnetic field of a double-circuit 500 kV single pole transmission line from 37 mG to 21 mG (about 43 percent) at the edge of the 200-foot-wide right of way as shown on Chart IX.

• When new or rebuilt double-circuit lines require tapping existing double-circuit lines, PPL EU will review the existing lines to determine if reverse phasing can be provided at low cost.

• Computer modeling is required to develop the optimum phasing and overall conductor arrangements for lines added to, or rebuilt in, multiple-line corridors.

- Merely adding a reverse-phase double-circuit line to an existing transmission line corridor or reverse phasing a rebuilt line in the multiple-line corridor will not necessarily produce lower magnetic field levels at the edge of the corridor right of way.
- The corridor must be computer modeled with all the lines, existing phase conductor locations and currents. Then, magnetic field calculations must be made varying the phase arrangements of the new or reconstructed line to determine the appropriate phasing arrangement.
- Current flow direction on a line also must be considered. For example, a reverse-phased line should have the current flowing in the same direction on both circuits. If the current flow is in the opposite direction for one circuit, reverse phasing will not produce the lowest magnetic field and another phase arrangement that produces lower fields may need to be utilized.

5. **Increase the minimum ground clearance for all new transmission lines.**

138/69 kV Transmission Lines

- Increasing the minimum line design ground clearance from 25 feet to 30 feet may add up to about 5 percent to the installed cost of a new double-circuit single pole 138/69 kV line. For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. With long-span reverse-phase design, the, magnetic field is reduced from 9 mG to 7 mG (about 22 percent) at the edge of a 100-foot-wide right of way as shown in Chart X.
  - In the actual design of transmission lines to include higher minimum ground clearances, there may be limited segments (such as highway crossings, severe slopes and transmission line crossing locations) where National Electrical Safety Code (NESC) minimum ground clearances may need to be used. The NESC minimum ground clearances are less than the increased ground clearance discussed previously.

230 kV Transmission Lines

- Increasing the minimum line design ground clearances from 27 feet to 32 feet may add up to about 5 percent to the cost of a single-circuit single-pole line (current standard). For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. By increasing the clearances, the magnetic field is reduced from 30 mG to 28 mG (about 7 percent) at the edge of a 150-foot-wide right of way.
- Increasing clearances from 27 feet to 32 feet could theoretically add up to about 2.8 percent to the cost of a double-circuit single-pole line (current standard) and reduce the magnetic field of a reverse-phase line from 16 mG to 15 mG (about 6 percent) at the edge of a 150-foot-wide right of way. Chart XI is a summary of this data.
- Studies are required for each new 230 kV line to determine optimum structure types, ground clearances, configurations and designs to reduce field levels. Such

studies could include analysis of reduction measures such as additional minimum ground clearances, increasing conductor tensions, using reduced phase spacing (a "Delta" configuration on a single-circuit line), installing the second circuit initially, and/or adding a second set of conductors that are reverse phased and operated in parallel with the first set (bundled/split phase).

500 kV Transmission Lines

- Increasing ground clearances from 33 feet to 53 feet may add up to about 4.5 percent to the cost of a single-circuit "H-frame" line (current standard). For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. By increasing the clearances, the magnetic field is reduced from 42 mG to 35 mG (about 17 percent) at the edge of a 200-foot-wide right of way.
- Increasing ground clearances from 33 feet to 53 feet could theoretically add up to 2.8 percent to the cost of a double-circuit "H-frame" line (current standard) and reduces the magnetic field of a reverse-phase line from 21 mG to 16 mG (about 24 percent) at the edge of a 200-foot-wide right of way. Chart XII is a summary of this data.
- Studies are required for each new 500 kV line to determine optimum structure types, ground clearances, configurations and designs to reduce field levels. Such studies could include analysis of reduction measures such as additional minimum ground clearances, increasing conductor tensions, using reduced-phase spacing (a "Delta" configuration on a single circuit line), installing the second circuit initially, and/or adding a second set of conductors that are reverse phased and operated in parallel with the first set (bundled/split phase).

RECONDUCTORING OR ADDING ADDITIONAL CIRCUITS TO EXISTING TRANSMISSION LINES

When reconductoring or adding additional circuits to existing transmission lines, PPL EU will evaluate low-cost or no-cost options for magnetic field management on a case-by-case basis.

When reconductoring existing transmission lines or adding additional circuits, low-cost alternatives may not exist; however, the following steps will be taken:

- For a single-circuit line, the use of a Delta arrangement or other modifications on the existing structure, with reduced-phase spacing, will be evaluated.
- For double-circuit lines, application of reverse phasing may reduce the magnetic field under the line and within the right of way and will be evaluated.
- For single- and double-circuit lines, evaluate using higher conductor tensions that can increase the minimum line design ground clearance.

DISTRIBUTION LINES

At the 12 kV distribution level, new main three-phase lines will continue to be constructed with five feet of additional ground clearance.

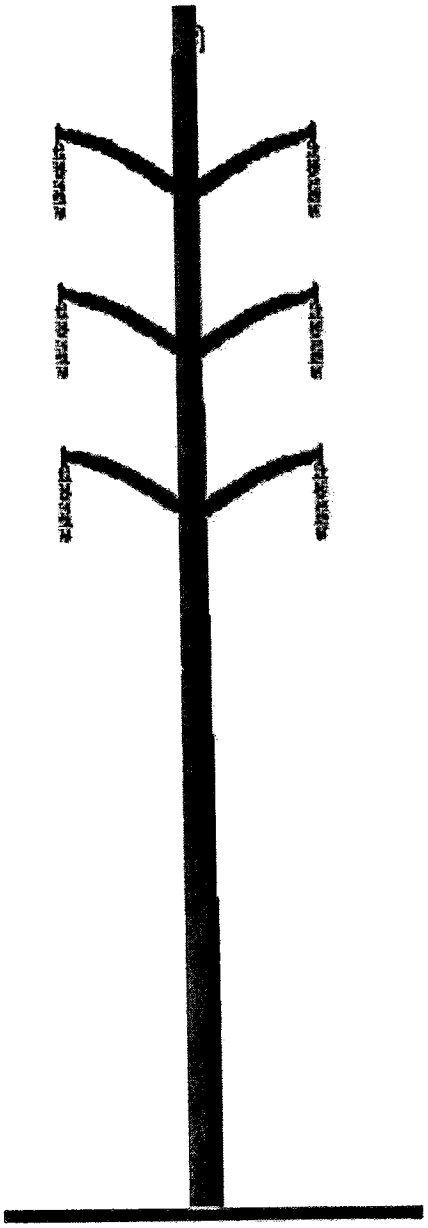
- Main lines are the most heavily loaded sections of a distribution line and therefore have the highest magnetic fields associated with them.
- Increasing the ground clearance by five feet reduces the magnetic field under the line from 14 mG to 11 mG using the standard eight-foot crossarm design. These values are based on increasing pole heights from 45 feet to 50 feet and a typical operating current of 300 amps per phase.
- Chart XIII is a summary of this data. Increasing ground clearance by five feet could theoretically add about 5 percent to the cost of a typical distribution line.

UNDERGROUND TRANSMISSION LINES

Underground transmission lines are required due to environmental or land use factors or restrictions on available clearances, PPL EU will evaluate options for magnetic field management techniques on a case-by-case basis.

- The phase arrangement that produces the lowest field will be determined.
- The depth of burial of the line will be determined considering the cost of excavation and the location of other buried utilities in the area.
- The use of steel pipe ferromagnetic shielding that reduces magnetic fields will be evaluated.

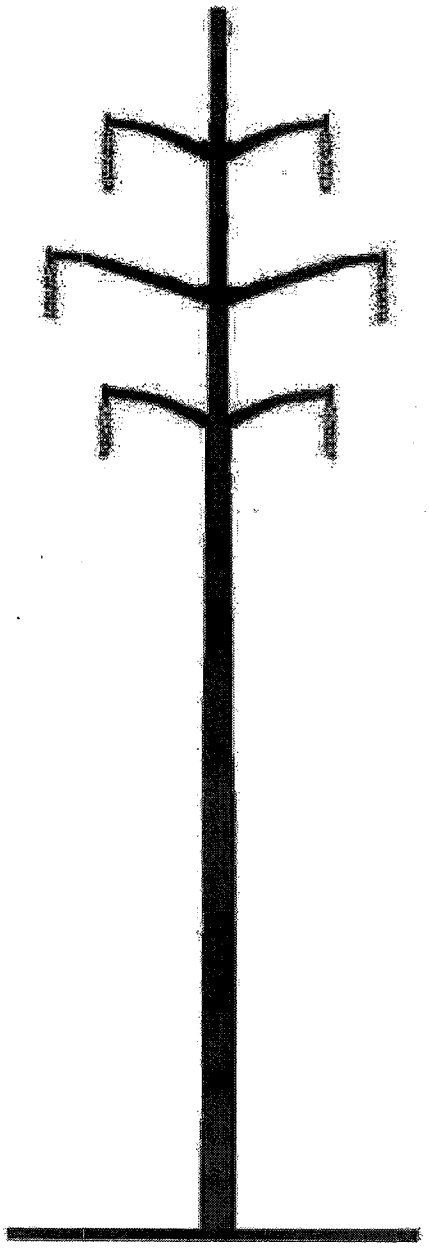
Short-Span Construction



- More compact design
- Should not be used solely to reduce magnetic fields
- Typical conductor data:

  1 3/8" HS steel overhead ground wire - 7.3 feet sag
  6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 10.0 feet sag
  Average span - 400 feet

Long-Span Construction Remains PPL EU 138 kV Standard



- **Lower cost alternative**
- **Reduces magnetic fields due to higher structures**
- **Typical conductor data:**

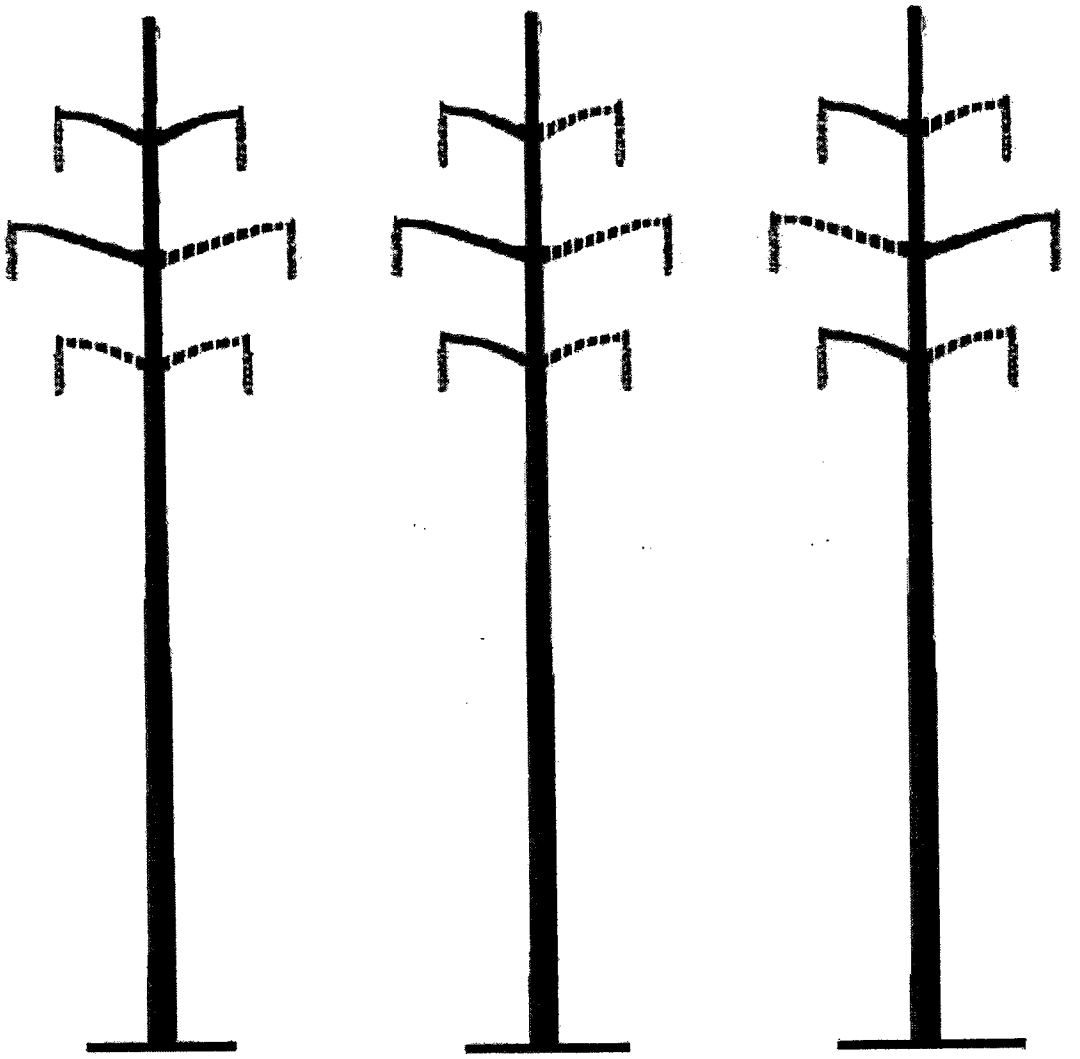
  1 3/8" HS steel overhead ground wire - 17.3 feet sag
  6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 23.0 feet sag
  Average span - 600 feet

138/69 kV REVERSE-PHASE TRANSMISSION LINES
CALCULATED MAGNETIC FIELDS AT 400 AMPERES

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SHORT SPAN (CHART I)	30
SHORT SPAN (REVERSE PHASE)	8
LONG SPAN (CHART II)	29
LONG SPAN (REVERSE PHASE)	9
COMPACT (CHART VI)	14
COMPACT (REVERSE PHASE)	3

The edge of right of way is 50 feet from the line centerline.
The 400 ampere phase current is balanced between phases.
Calculations are based on a minimum ground clearance of 25 feet.
LONG SPAN, SHORT SPAN and COMPACT are double-circuit lines.

Typical Single-Circuit Structure Designs

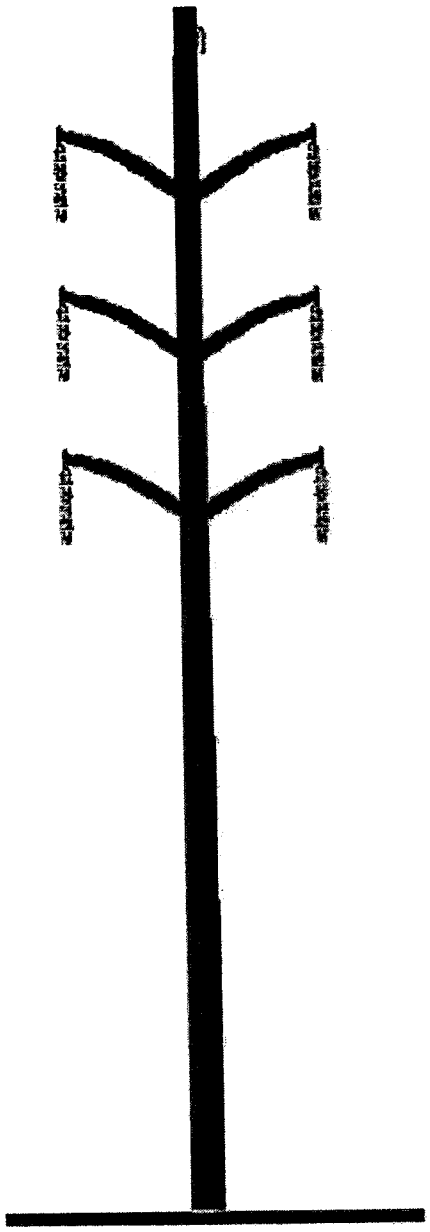


138/69 kV SINGLE CIRCUIT TRANSMISSION LINES
CALCULATED MAGNETIC FIELDS AT 400 AMPERES

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
TOP/MIDDLE/BOTTOM	20
VERTICAL	17
TOP/MIDDLE	12

The edge of right of way is 50 feet from the line centerline.
The 400 ampere phase current is balanced between phases.
Calculations are based on a minimum ground clearance of 25 feet.

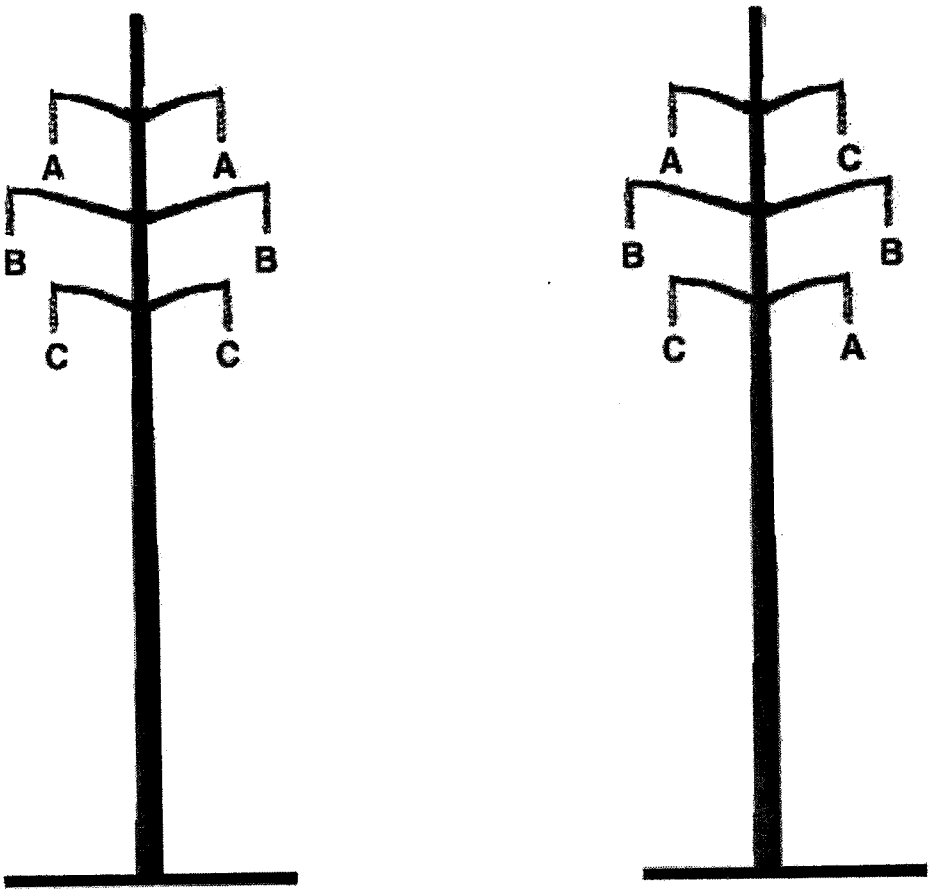
Compact Design Structure



- **Minimize magnetic fields due to compact design**
- **Not a low-cost alternative**
- **Typical conductor data:**

  1 3/8" HS steel overhead ground wire - 9.0 feet sag
  6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 9.0 feet sag
  Average span - 300 feet

Reverse Phasing of Double-Circuit Transmission Lines



From: → → → → To:

Reverse phasing also can be one of the following phase arrangements:

A	B		B	A		B	C		C	A		C	B
C	C	or	C	C	or	A	A	or	B	B	or	A	A
B	A		A	B		C	B		A	C		B	C

CHART VIII

230 kV REVERSE-PHASE TRANSMISSION LINES CALCULATED MAGNETIC FIELDS AT 800 AMPERES

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
DOUBLE CIRCUIT POLE	49
DOUBLE CIRCUIT POLE (REVERSE-PHASE)	16

The edge of right of way is 75 feet from the line centerline.
The 800 ampere phase current is balanced between phases.
Calculations are based on a minimum ground clearance of 27 feet.

CHART IX

500 kV REVERSE-PHASE TRANSMISSION LINES CALCULATED MAGNETIC FIELDS AT 1100 AMPERES

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
DOUBLE CIRCUIT POLE	37
DOUBLE CIRCUIT POLE (REVERSE PHASE)	21

The edge of right of way is 100 feet from the line centerline.
The 1,100 ampere phase current is balanced between phases.
Calculations are based on a minimum ground clearance of 33 feet.

CHART X

INCREASED 138/69 kV MINIMUM GROUND CLEARANCE CALCULATED MAGNETIC FIELDS AT 400 AMPERES

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT TOP/MIDDLE	25	12
SINGLE CIRCUIT TOP/MIDDLE	30	10
LONG SPAN	25	29
LONG SPAN	30	26
LONG SPAN (REVERSE PHASE)	25	9
LONG SPAN (REVERSE PHASE)	30	7

The edge of right of way is 50 feet from the line centerline.
The 400 ampere phase current is balanced between phases.

CHART XI

INCREASED 230 kV MINIMUM GROUND CLEARANCE CALCULATED MAGNETIC FIELDS AT 800 AMPERES

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT TOP/MIDDLE	27	30
SINGLE CIRCUIT TOP/MIDDLE	32	28
DOUBLE CIRCUIT POLE	27	49
DOUBLE CIRCUIT POLE	32	46
DOUBLE CIRCUIT POLE (REVERSE PHASE)	27	16
DOUBLE CIRCUIT POLE (REVERSE PHASE)	32	15

The edge of right of way is 75 feet from the line centerline.
The 800 ampere phase current is balanced between phases.

CHART XII

INCREASED 500 kV MINIMUM GROUND CLEARANCE CALCULATED MAGNETIC FIELDS AT 1,100 AMPERES

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT "H" STRUCTURE	33	42
SINGLE CIRCUIT "H" STRUCTURE	53	35
DOUBLE CIRCUIT POLE	33	37
DOUBLE CIRCUIT POLE	53	31
DOUBLE CIRCUIT POLE (REVERSE PHASE)	33	21
DOUBLE CIRCUIT POLE (REVERSE PHASE)	53	16

The edge of right of way is 100 feet from the line centerline.
The 1,100 ampere phase current is balanced between phases.

12 kV DISTRIBUTION LINES
CALCULATED MAGNETIC FIELDS AT 300 AMPERES

TYPE CONSTRUCTION	POLE HEIGHT FEET	MAGNETIC FIELD IN MILLIGAUSS*	
		AT CENTERLINE	AT 30 FEET FROM CENTERLINE
STANDARD CROSSARM	45	14	7
STANDARD CROSSARM	50	11	6

* Field level under the line at mid-span based on 300 amps, balanced loading, one meter above ground level.

APPENDIX "C"

LIST OF PROPERTY OWNERS WITHIN THE AFFECTED RIGHT-OF-WAY

Loyal E & Patricia A Morris
1616 Copperstone Road
Harrisburg, Pa 17111

Robert E. Smith
3161 Sunnyside Avenue
Harrisburg, Pa 17109

John H. & Sandra A. Mills
6500 Leonard Dr.
Harrisburg, PA 17111-4854

David K. & Marilyn S. Wagner
6510 Leonard Dr.
Harrisburg, PA 17111-4854

Gregory A. & Barbara A. Harris
6511 Leonard Dr.
Harrisburg, PA 17111-4855

Michael J. & Carol A. Carricato
6521 Leonard Dr.
Harrisburg, PA 17111-4855

Francis X. & Norma J. Purcell
6510 Leo Dr.
Harrisburg, PA 17111-4852

John L. & Suzanne E. Seitz
6520 Leo Dr.
Harrisburg, PA 17111-4852

Gerald W. Kapp, Jr. & Elsie J.
6521 Leo Dr
Harrisburg, PA 17111-4853

Glenn L. & Barbara R. Cassel
6611 Union Deposit Rd.
Harrisburg, PA 17111-4807

PPL Electric Utilities
2 N 9th Street
Allentown, PA 18101

APPENDIX "D"

LIST OF INVOLVED GOVERNMENTAL AGENCIES, MUNICIPALITIES AND OTHER PUBLIC ENTITIES

Pennsylvania Historical and Museum Commission
Bureau for Historic Preservation
Commonwealth Keystone Building, Second Floor
400 North Street
Harrisburg, Pennsylvania 17120-0053
Attn: Mr. Douglas C. McLearen, Chief

Pennsylvania Department of Transportation
Commonwealth Keystone Building
400 North Street, 8th Floor
Harrisburg, Pennsylvania 17120
Attn: The Honorable Allen D. Biehler, P.E., Secretary

Department of Environmental Protection
P.O. Box 2063
Market Street State Office Building
Harrisburg, Pennsylvania 17105-2063
Attn: Office of Field Operations

South Hanover Township Board of Supervisors
111 West Third Street
Hershey, Pa 17033-2498

South Hanover Township Planning Commission
c/o Penny Pollick, Township Manager
111 West Third Street
Hershey, Pa 17033-2498

Lower Paxton Township Board of Supervisors
425 Prince Street
Harrisburg, Pa 17109

Lower Paxton Township Planning Commission
425 Prince Street
Harrisburg, Pa 17109

Dauphin County Planning Commission
112 Market Street, 2nd Floor
Harrisburg, Pa 17101-2015

Dauphin County Commissioners
PO Box 1295
Harrisburg, Pa 17108