Before the
Pennsylvania Public Utility Commission

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION

ATTACHMENTS IN SUPPORT OF THE

Letter of Notification

Application Docket No.___________

Submitted by: PPL Electric Utilities Corporation

ppl ™

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 PUC approval to construct and relocate transmission line connections associated with the proposed Breinigsville 500-138-69 kV Substation (Breinigsville Project). This Project will involve: (1) the construction of the Breinigsville 500-138-69 kV Substation; (2) re-routing approximately 3,300 feet of the existing AT&T #1 and #2 138/69 kV Tap Line (AT&T Tap Line) around the proposed Breinigsville Substation; (3) re-terminating approximately 1,525 feet of the existing Alburtis-Wescosville 500 kV Transmission Line into the Breinigsville Substation; and (4) constructing the new double-circuit Breinigsville-Wescosville #1 & #2 138/69 kV Transmission Line, which will extend approximately 325 feet between the Breinigsville 500-138-69 kV Substation and the existing AT&T Tap Line. The proposed Project is located entirely within the PPL Electric-owned site for the Breinigsville 500-138-69 kV Substation in Upper Macungie Township, Lehigh County, Pennsylvania.

The proposed line connections and the new Breinigsville 500-138-69 kV Substation are required to relieve increasing load growth in the Western Lehigh Region and improve reliability of service to the area. The estimated cost to construct and relocate these proposed transmission lines is $2,900,000. Subject to Commission approval, construction will be completed in three parts beginning in October 2012 to support the Project's overall in-service date of May 2015.

The Attachments to the Letter of Notification describe the need, engineering, and environmental analysis for the proposed Breinigsville Project and provide additional information, including the following:

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Attachment 2	Engineering Description
Attachment 3	Environmental Assessment
Attachment 4	PPL Design Criteria and Safety Practices
Attachment 5	PPL Electric Magnetic Field Management Program

PPL ELECTRIC UTILITIES SERVICE TERRITORY

Attachment 1

ATTACHMENT 1

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES

AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION

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BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION

NECESSITY STATEMENT

A. INTRODUCTION

PPL Electric is requesting Pennsylvania Public Utility Commission (PUC or the Commission) approval to relocate and re-terminate transmission lines in preparation for the construction of the proposed Breinigsville 500-138-69 kV Substation (Breinigsville Project). The Breinigsville Substation will be located in Upper Macungie Township, Lehigh County at the northeast corner of the intersection of Long Lane and Tillage Road. As explained below, the Breinigsville Project is required to resolve identified transmission reliability criteria violations, to meet increasing load growth, and to maintain reliable electric service to customers in portions of the Upper Macungie, Lower Macungie, and Upper Milford Townships of Lehigh County.

PJM Interconnection, L.L.C. ("PJM") is a Federal Energy Regulatory Commission ("FERC") approved Regional Transmission Organization charged with ensuring the reliability of the electric transmission system under its functional control and coordinating the movement of electricity in all or parts of thirteen states and the District of Columbia, including most of Pennsylvania. PPL Electric, as an owner of transmission facilities in Pennsylvania, is a member of PJM and actively participates in the PJM transmission planning process. As explained in the sections that follow, the Breinigsville Project is required to resolve violations of PJM's Reliability Planning Criteria as defined in "Manual 14B: PJM Region Transmission Planning Process" (PJM Manual 14B) and PPL Electric's Reliability Principles and Practices (RP&P). After identifying these violations, through a coordinated effort, PPL Electric explored various solutions to address these violations. After extensive analysis, PPL Electric proposed the Breinigsville Project, which will be completed in three parts.

Part one of the Breinigsville Project involves the relocation of the existing AT&T #1 & #2 138/69 kV Tap Line (AT&T Tap Line) to create the required space for the construction of the proposed Breinigsville 500-138-69 kV Substation. This part of the Project is scheduled to begin in October 2012 and to be completed by March 2013 to accommodate the scheduled construction of the new Breinigsville 500-138-69 kV Substation. The estimated cost of this part of the Project is $1.45 million.

Part two of the Project involves splitting the existing Wescosville-Alburtis 500 kV Transmission Line and re-terminating the Line into the 500 kV yard at the proposed Breinigsville 500-138-69 kV Substation. Construction of part two of the Project is scheduled to begin by November 2012 to meet a required in-service date of March 2015. The construction of part two has been carefully coordinated with planned outages of the Susquehanna-Wescosville-Alburtis 500 kV line and the Unit 2 outage at the Susquehanna Steam Electric Station nuclear plant in 2013 and 2015. The estimated cost of this part of the Project is $1.1 million.

In part three of the Project, new double circuit Breinigsville-Wescosville #1 & #2 138/69 kV Transmission Line (Breinigsville-Wescosville Transmission Line) will be constructed to connect the relocated portion of the AT&T Tap Lines to the 69 kV yard at the proposed Breinigsville Substation. Construction of the Breinigsville-Wescosville Transmission Line will be coordinated with construction of the Breinigsville Substation and be completed by May 2015. The estimated cost of this part of the Project is $350,000.

The relocated portion of the existing AT&T Tap Lines and the new Breinigsville-Wescosville Transmission Line will be designed for 138 kV operation, but initially will operate at 69 kV until load growth in the area makes it appropriate to increase the operating voltage. As further explained below, this Project is required to reduce loading on the existing Wescosville 500-230-138-69 kV Substation and the associated Wescosville-Trexlertown #1 & #2 138/69 kV Transmission Line.

Construction is scheduled to begin by October 2012 to meet a required in-service date of March 2013 for the AT&T Tap Line and March 2015 for the Wescosville-Alburtis 500 kV Transmission Line. The required in-service date is defined as the date that the identified facilities must be in place in order to accommodate the scheduled line outages for the construction of the new Breinigsville 500-138-69 kV Substation.

A PPL Electric system map showing existing transmission facilities with a design voltage of 35 kV or greater is included in the Attachment "1" map pocket. This filing addresses only the existing and proposed transmission system in this portion of Lehigh County.

B. SYSTEM PLANNING PROCESS AND GUIDELINES

1. Transmission Reliability Standards

The nation's interconnected transmission grid serves as the backbone for the safe and reliable delivery of large amounts of electricity from generating stations over substantial distances to customers served by transmission and local distribution systems. It is critically important that this interconnected transmission system (transmission grid) be planned and designed to be highly reliable so that reliable electric service can be provided under peak and all loading conditions and when certain elements of the system are out of service (system contingencies) due to planned or forced outages.

On February 3, 2006, FERC certified the North American Electric Reliability Corporation ("NERC") as the organization required to establish and enforce reliability standards for the bulk electric system. Thereafter, NERC develops and enforces reliability standards, which define the reliability requirements for planning and operating transmission systems in North America. The NERC Reliability Standards apply to all users, owners, and operators of the nation's interconnected transmission grid, including PPL Electric. The NERC Reliability Standards are monitored and enforced by NERC and the regional reliability organizations that function under its auspices. NERC achieves compliance through monitoring, audits and investigations, the imposition of financial penalties, and other enforcement actions for non-compliance. These FERC-approved NERC Reliability Standards for are mandatory and failure to comply can result in penalties of up to $1 million per day per violation.

2. System Planning

System Planning is the process which assures that the transmission system can supply electricity to all customer loads reliably and economically. The System Planning process assures that the transmission systems:

- Are able to accommodate the forecasted system flows during the summer peak load conditions
- Are constructed to adequately serve customers' needs with regard to capacity, voltage, and reliability for all load levels throughout the daily load cycle;
- Can sustain probable contingencies and disturbances with no consequential loss of load; and
- Conform to the applicable transmission planning reliability principles, practices, and standards of PPL Electric, PJM, and NERC for all normal and emergency operating conditions.

3. PJM Planning Process

PJM is the FERC-approved Regional Transmission Organization ("RTO") charged with ensuring the reliability of the electric transmission systems under its functional control (100 kV and above), and coordinating the movement of wholesale electricity in all or parts of thirteen states and the District of Columbia, including most of Pennsylvania. In order to ensure reliable transmission service, PJM prepares an annual Regional Transmission Expansion Plan ("RTEP") to identify system reinforcements that are required to, among other things, meet the NERC Reliability Standards. The RTEP is a FERC-approved transmission planning process that undertakes a comprehensive analysis to identify existing and forecasted violations of the NERC Reliability Standards on the transmission systems within PJM's service territory.[1]

PJM's RTEP is an annual process that encompasses a comprehensive series of detailed analyses to ensure power continues to flow reliably to customers under stringent reliability criteria set by NERC. The NERC reliability standards, transmission owner criteria, and PJM reliability planning criteria are used by PJM to analyze the system and to determine the specific transmission upgrade projects, as part of the overall reliability solution, that are needed to ensure long-term reliable electric service to customers and competitive power markets. Based upon this analysis, PJM determines the transmission upgrades that are needed to meet NERC reliability standards.

PJM conducts RTEP studies in conjunction with its transmission owners and applies NERC, regional, and transmission owner reliability criteria to specific conditions on the transmission system. When the studies show an inability of the transmission system to meet a specific reliability standard under these conditions, solutions such as construction of one or more new transmission lines or one or more upgrades to existing transmission facilities may be necessary.

[1] PJM's RTEP process is currently set forth in Schedule 6 of PJM's Amended and Restated Operating Agreement ("Schedule 6"). Schedule 6 governs the process by which PJM's members rely on PJM to prepare an annual regional plan for the enhancement and expansion of the transmission facilities to ensure long-term, reliable electric service consistent with established reliability criteria. In addition, Schedule 6 addresses the procedures used to develop the RTEP, the review and approval process for the RTEP, the obligation of transmission owners to build transmission upgrades included in the RTEP, and the process by which interregional transmission upgrades will be developed.

NERC reliability standards require PJM to identify the "critical system conditions" against which the system must be evaluated to ensure that it meets the performance criteria specified in the standards. Specifically, the NERC reliability standards require PJM to test events which fall into the following categories:

- NERC Category A criteria require that, for all facilities in service, equipment thermal ratings and system voltage levels are within applicable limits and that the system is stable, referred to as "N minus zero" or N-0.

- NERC Category B criteria impose similar requirements with one facility removed from service. This is referred to as the "n minus 1" or "N-1" criteria. These criteria ensure that the system continues to remain within applicable limits and stable upon the outage of a transmission element.

- NERC Category C criteria require the system to be stable and within applicable equipment thermal ratings and system voltage limits for less probable contingency events. Such events include multiple facility outages such as bus, tower line, or circuit breaker failures. Also included are second contingencies involving the loss of one system element followed by manual system readjustments, and then the loss of a second system element. These second contingencies are referred to as the "N minus 1 minus 1" or "N-1-1" criteria.

PJM has developed the PJM Reliability Planning Criteria as set forth in the PJM Manual 14B. The PJM Reliability Planning Criteria consist of multiple standards and applicable planning principles that include PJM planning procedures, NERC Planning Standards, NERC Regional Council planning criteria, Reliability First Corporation (RFC) Standards, and Transmission Owner-defined reliability criteria (in this case, the PPL Electric RP&P). PJM applies all applicable planning criteria when identifying reliability problems and determining the need for transmission system upgrades the PJM service territory. As a transmission owner in the PJM service territory, PPL Electric is required to follow the PJM Reliability Planning Criteria.

When a potential reliability violation is identified, PJM and the affected transmission owner develop specific solutions to resolve the identified violation. PJM presents the results of the analyses to its Transmission Expansion Advisory Committee ("TEAC") to solicit comments on the violations and recommendations to resolve the identified reliability violations. The TEAC is open to participation by: (i) all transmission customers; (ii) all PJM members; (iii) state commissions and consumer advocates; (iv) any other entity proposing to build Merchant transmission facilities to be integrated into the PJM region; and (v) any other interested entities or persons. The TEAC reviews potential solutions to the identified reliability violations, including transmission line solutions. Where the solution requires construction of new or upgraded transmission facilities, PJM will direct the relevant transmission owner to undertake the required project.

3. <u>The PPL Electric System Planning Process</u>

The reliable and economical operation of PPL Electric's transmission system requires upholding PPL Electric's planning guidelines for system expansion. The principles upon which these planning guidelines are based recognize that:

- The system expansion should be coordinated to achieve the most economical balance of construction and operating expenditures.
- It should maintain a proper balance between the degree of risk, amount and type of load interrupted, and the cost of providing the needed expansion.
- System reliability should be maintained to prevent large scale, long term, or frequent service interruptions to avoid adverse effects and hazards to the public.

These principles are incorporated in PPL Electric's RP&P document.

PPL Electric undertakes an independent analysis of both its bulk electric system (BES) transmission facilities, which include transmission facilities operated at voltages of 100 kV or higher and are under the functional control of PJM, and its non-bulk electric transmission system facilities. The PPL Electric planning guidelines are outlined the RP&P, which was developed to ensure adequate and appropriate levels of electric service to its customers consistent with good utility practice. The PPL Electric RP&P for the bulk electric system is consistent with NERC Reliability Standards and PJM Reliability Planning Criteria.

In accordance with the RP&P guidelines, PPL Electric's transmission system is planned so that it can be operated at all projected load levels and during normal schedule outages to withstand specific unscheduled contingencies without exceeding the equipment capability, causing system instability or cascade tripping, or exceeding voltage tolerances. The transmission system is required to have adequate capability so that it can be operated normally and can withstand the following unscheduled contingencies and other system conditions:

- For the normal system operations, the system should remain stable, and both thermal and voltage limits should remain within the applicable ratings in order to prevent equipment damage, N-0 category.

- For the loss of any single element (single or double circuit transmission line, transformer, or generator, N-1 category), following the contingency, the system should remain stable and both thermal and voltage limits should stay within the applicable ratings in order to prevent equipment damage and cascading outages.

- For the loss of a bus, double circuit transmission line, or the combination of a single line or three phase fault with stuck breaker, or a single line to ground fault with a failure of protection system (N-2 category), following the contingency, the system should remain stable and both thermal and voltage limits should stay within the applicable ratings in order to prevent equipment damage and cascading transmission outages.

- For the loss of a single element and subsequent loss of a second single element (N-1-1, a special category of N-2), after the initial loss, appropriate switching and/or starting of available generation, and load shedding procedures can be initiated to prevent damage to equipment and cascading outages.

- Load loss resulting from the loss of the non-bulk electrical transmission facilities should remain within the RP&P guidelines.

The planning process begins with development of a computer model of the future system. A specific study year is chosen and the future system model is developed using the existing system plus any planned modifications to the transmission system scheduled to be in service prior to the study year. The load forecast is based on recent PJM summer peak loads and on temperature and humidity indices.

Once the system model is complete, comprehensive power flow simulations are performed to determine the ability of the system to comply with the PPL Electric Reliability Criteria. This is accomplished by simulating an outage of each non-BES and bulk power facility. All conditions where the system is not in conformance with the PPL Electric Reliability Criteria are identified and system reinforcements are added to bring the system into conformance. After that, system reinforcement projects are compiled, their cost and lead times for completion are estimated, and computer simulations of the system with the identified reinforcement alternatives are completed to identify the best overall reinforcement that will meet the needs of the region in a reliable and economic manner.

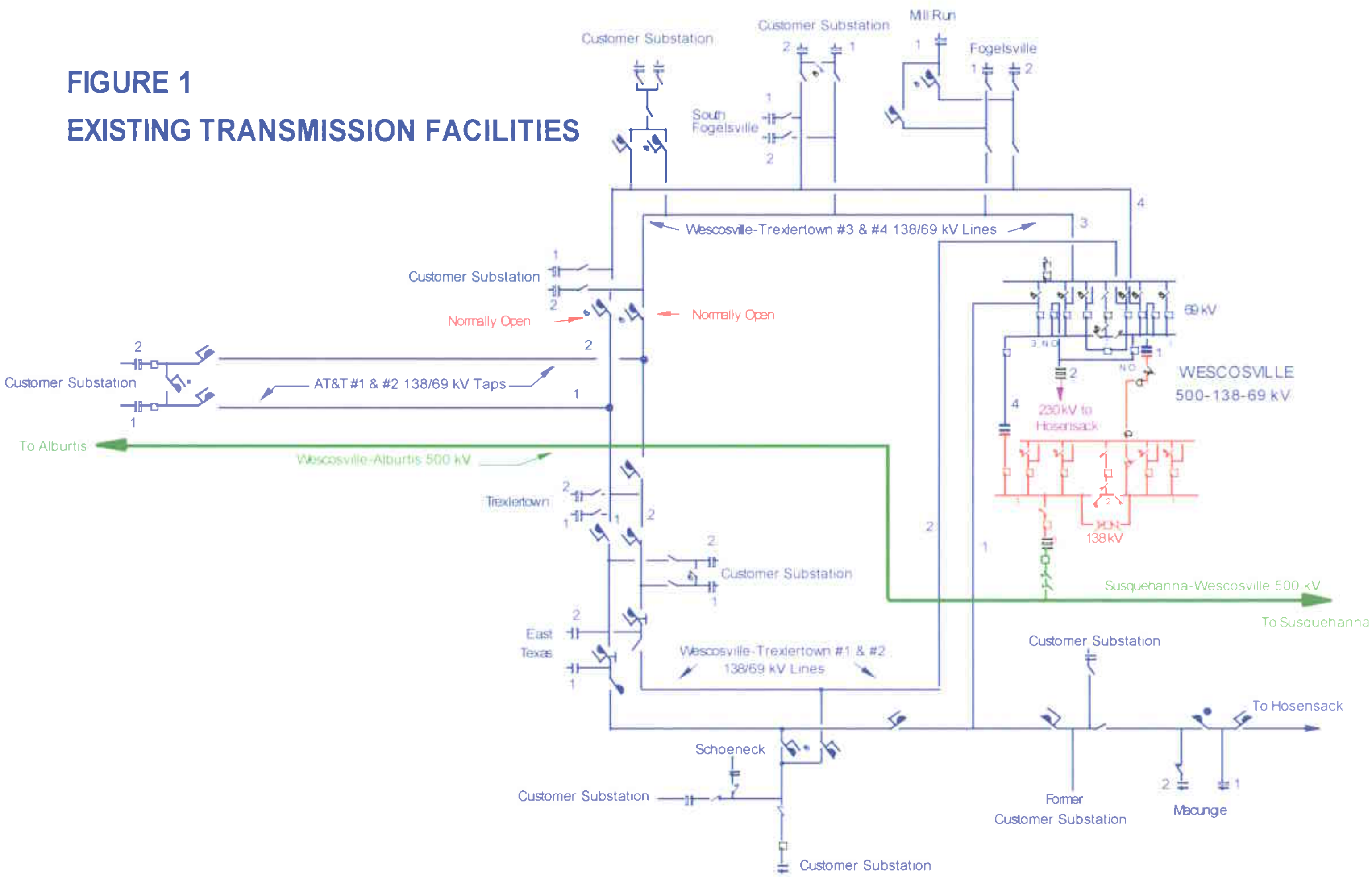
C. EXISTING SYSTEM

Approximately 27,000 customers (approximately 300 MVA of load) in western Lehigh County are presently served from the 69 kV yard at the Wescosville 500-230-138-69 kV Substation. The 500 kV yard at the Wescosville 500-230-138-69 kV Substation is supplied by the Susquehanna-Wescosville-Alburtis 500 kV Line. The 138 kV yard at the Wescosville 500-230-138-69 kV Substation is supplied by a 500-138 kV transformer, the T3 transformer. The 138 kV yard feeds four 138 kV lines and two 138-69 kV transformers, the T1 and T4 transformers. The two 138-69 kV transformers, in turn, feed the 69 kV yard. The 69 kV yard feeds six 69 kV lines. There also is a 230-69 kV transformer at the Wescosville 500-230-138-69 kV Substation, the T2 transformer, which can supply the 69 kV yard. However, due to the criticality of the 69 kV bus at the Wescosville 500-230-138-69 kV Substation, the T2 230-69 kV transformer does not normally carry load and serves as an emergency backup source for a contingency loss of one of the T1 or T4 138-69 kV transformers.[2]

Four of the 69 kV lines terminating at the 69 kV yard at the Wescosville 500-230-138-69 kV Substation are identified as the Wescosville-Trexlertown #1, #2, #3, and #4 138/69 kV Transmission Lines. The AT&T Tap Line is connected to and supplied by the Wescosville-Trexlertown #1 & #2 138/69 kV Transmission Line. Figure 1 below depicts the present system configuration in the area of the proposed new Breinigsville Substation.

[2] Presently, there are a total of four transformers at the Wescosville 500-230-138-69 kV Substation: the T1 138-69 kV transformer, the T2 230-69 kV transformer, the T3 500-138 kV transformer, and the T4 138-69 kV transformer.

FIGURE 1
EXISTING TRANSMISSION FACILITIES



D. DEFINITION OF THE PROBLEM

Applying the RTEP process as outlined above, the 2010 RTEP identified violations of the PJM Reliability Planning Criteria and PPL Electric RP&P. Specifically, the 2010 RTEP identified a load loss violation and a thermal overload for an N-1 event. The major violations identified in the 2010 RTEP are summarized below.

Customers in the western portion of Lehigh County primarily are served by the Wescosville 500-230-138-69 kV Substation. Load growth in the western Lehigh County area has been increasing beyond normal load growth projections with new industrial, commercial, and residential loads. Approximately 27,000 customers are served from the 69 kV yard at the heavily loaded Wescosville 500-230-138-69 kV Substation.

By the summer of 2015, the peak load on the 69 kV yard at the Wescosville 500-230-138-69 kV Substation will be approximately 300 MVA. A failure to relieve the loading on the Wescosville 500-230-138-69 kV Substation could result in thermal damage to either the T1 or T4 138-69 kV transformers, if either transformer were lost, an N-1 event. This could put approximately 300 MVA of load, approximately 27,000 customers, at risk of being interrupted. This load loss would violate the PJM Reliability Planning Criteria identified in Manual 14B, which limits load loss to 300 MW for all criteria tests.

Although the T2 230-69 kV transformer T2 could be placed into network operation via SCADA control from the Transmission System Operator, it could only able to restore approximately 230 MVA of load. Further, due to the limited transfer capability of the system, only approximately 40 MVA could be supplied from alternate sources. Consequently, if either the T1 or T4 transformers were lost, about 30 MVA of load would experience an extended interruption until a mobile transformer could be installed on an emergency basis.

Further, a contingency loss of either the T1 or T4 138-69 kV transformer, an N-1 event, will load the remaining transformer to 112% of its summer 2-hour emergency rating[3] of 269 MVA, which would be a violation of both the PPL Electric RP&P guidelines and PJM Planning Criteria.[4] As a stop gap measure, the T2 230-69 kV transformer at the Wescosville 500-230-138-69 kV Substation would be placed into network operation via SCADA control. However, due to the functional configuration, the operation of the T2 230-69 kV Transformer would only slightly reduce the loading on the remaining 138-69 kV transformer. As such, even with the support of the T2 230-69 kV transformer, the load on the remaining 138-69 kV transformer would be approximately 100% of its one month thermal rating[5] of 231 MVA.

Additionally, a contingency loss of the T3 500-138 kV transformer, an N-1 event, at the Wescosville 500-230-138-69 kV Substation would result in an 8% voltage drop on the networked 138 kV lines between the Wescosville 500-230-138-69 kV Substation and the Siegfried 230-138-69 kV Substation. This voltage drop would violate the maximum allowable voltage drop of 5% permitted after a contingency as set forth in both the PPL Electric RP&P guidelines and PJM Planning Criteria.

Another reliability criteria violation occurs for the contingency loss of the Wescosville-Trexlertown #1 & #2 138/69 kV Transmission Lines. A double-circuit outage of the Wescosville-Trexlertown #1 & #2 138/69 kV Transmission

[3] The 2 hour emergency rating is used for the initial loss of one transformer. The remaining transformers must be below the 2 hour emergency rating after the loss of the first transformer.

[4] If the T1 138-69 kV transformer were lost, the load on the T4 138-69 kV transformer would be 112% of its summer 2-hour emergency rating, and vice versa.

[5] The one month thermal rating is used after another transformer is put in service via SCADA to relieve the loading on the remaining transformer. It takes approximately one month to install a replacement transformer.

Lines would initially interrupt approximately 150 MW of load. The load interrupted by this contingency would exceed the RP&P guideline for maximum allowable load drop due to a double-circuit outage, which only allows a maximum of 120 MW of load to be interrupted for up to 2 hours until manual switching can be completed. The Wescosville-Trexlertown #1 & #2 138/69 kV Transmission Lines have normally open ties to the Wescosville-Trexlertown #3 & #4 138/69 kV Transmission Lines. Transferring load from the Wescosville-Trexlertown #1 & #2 138/69 kV Transmission Lines to the Wescosville-Trexlertown #3 & #4 138/69 kV Transmission Lines to reduce loading below the 120 MW guideline, however, is not a viable option because these Lines are also heavily loaded.

In addition, a single-circuit outage of either circuit on the Wescosville-Trexlertown #1 or #2 138/69 kV Transmission Line would initially interrupt approximately 75 MW of load. The load interrupted by this contingency would exceed the RP&P guideline for maximum allowable load drop due to a single-circuit outage, which only allows a maximum of 60 MW of load to be interrupted for up to 2 hours until manual switching can be completed. Again, transferring load from the Wescosville-Trexlertown #1 & #2 138/69 kV Transmission Lines to the Wescosville-Trexlertown #3 & #4 138/69 kV Transmission Lines to reduce loading on each line below the 60 MW guideline is not a viable option as these lines are also heavily loaded.

E. <u>PROPOSED SOLUTION</u>

To resolve the reliability problems explained above, PPL Electric proposes to construct the new Breinigsville 500-138-69 kV Substation and connecting lines. The new Breinigsville 500-138-69 kV Substation will provide load relief for the T1 and T4 138-69 kV transformers at the Wescosville 500-230-138-69 kV Substation, as well as load relief for the Wescosville-Trexlertown #1 & #2 138/69 kV Transmission Lines. The Breinigsville 500-138-69 kV Substation also will provide a backup source for transferring load away from the Wescosville 500-

230-138-69 kV Substation for emergency outages or planned line or transformer maintenance outages.[6]

The new Breinigsville 500-138-69 kV Substation development plan is to build a 500 kV yard with the ability to accommodate a maximum of three 500 kV lines. There will be one 500-138 kV transformer initially serving a 138-69 kV transformer supplying a temporary 69 kV yard with two line terminations.[7] It is proposed that the existing AT&T Tap Line will be terminated into this 69 kV yard. For reliability purposes, the AT&T Tap Line will operate in network between the 69 kV yards of the Wescosville 500-230-138-69 kV Substation and the proposed Breinigsville 500-138-69 kV Substation. The Breinigsville Substation will ultimately have the flexibility to accommodate four 138 kV line bays (refer to Figure 2).

The new Breinigsville 500-138-69 kV Substation will enable approximately 120 MVA of load to be transferred from the heavily loaded Wescosville 500-230-138-69 kV Substation. Upon completion of the Breinigsville 500-138-69 kV Substation, the load on each of the T1 and T4 138-69 transformers at the Wescosville 500-230-138-69 kV Substation will be reduced from approximately 150 MVA to 85 MVA during the summer of 2015. Further, the loading on each of the Wescosville-Trexlertown #1 & #2 138/69 kV Transmission Lines will be reduced from approximately 80 MVA to approximately 20 MVA during the summer of 2015. The new Breinigsville 500-138-69 kV Substation and connecting lines will resolve the identified violations of the PJM Planning Criteria and PPL Electric RP&P.

Further, the addition of the Breinigsville 500-138-69 kV Substation will allow for the implementation of the future plan convert the area to 138 kV operation. Load

[6] This maintenance outage concern is a secondary deficiency that currently exists at Wescosville 500-230-138-69 kV Substation.

[7] The 69 kV yard will only be temporary because conversion to 138 kV is expected within 10 years from the installation of the Substation.

from Wescosville 500-230-138-69 kV Substation will be transferred to Breinigsville 500-138-69 kV Substation while the 138 kV yard at the Wescosville 500-230-138-69 kV Substation is expanded to accommodate additional 138 kV bays.

Although a temporary 69 kV yard will temporarily be installed at the Breinigsville 500-138-69 kV Substation, the Substation will be designed to accommodate the future 500 – 138 kV arrangement. Conversion to 138 kV is expected within 10 years from the installation of the Substation.

In order to provide sufficient safety clearance to build the new Breinigsville Substation, the existing AT&T Tap Line will need to be relocated as shown in Figure 3. In order to energize the new Breinigsville 500-138-69 kV Substation to provide service to the customers in Upper Macungie, Lower Macungie, and Upper Milford Townships of Lehigh County, PPL Electric will need to split and re-terminate the existing Wescosville-Alburtis 500 kV Transmission Line into the 500 kV yard at the Breinigsville 500-138-69 kV Substation. PPL Electric also will need to construct a new 138/69 kV double-circuit tap to connect the relocated AT&T Tap Line into the 69 kV yard at the Breinigsville 500-138-69 kV Substation as indicated in Figure 3. Without this work, the new Breinigsville 500-138-69 kV Substation cannot be placed into service.

F. FUNCTIONAL ALTERNATIVE

PPL Electric considered converting the existing Wescosville-Trexlertown #1, #2, #3 and #4 69 kV Transmission Lines to 138 kV operation and expanding the existing Wescosville 500-230-138-69 kV Substation to accommodate additional 138 kV bays as an alternative to the proposed Breinigsville 500-138-69 kV Substation Project. Converting the 69 kV lines to 138 kV operation would require converting seven PPL Electric distribution substations and expanding or rebuilding both the 500 kV and 138 kV yards at Wescosville 500-230-138-69 kV Substation. The 500 kV yard at the Wescosville 500-230-138-69 kV Substation would need to be modified to accommodate the installation of a new 500-138 kV transformer for thermal and voltage support on the 138 kV lines. The 138 kV yard at the Wescosville 500-230-138-69 kV Substation would need to be expanded to accommodate the number of additional 138 kV lines that would be required. In addition to this work, approximately eight existing 69 kV customers would be required to convert their substations to 138 kV operation. The cost to convert the 69 kV lines to 138 kV operation is comparable to the cost to construct the new Breinigsville 500-138-69 kV Substation. However, the work to expand the Wescosville 500-230-138-69 kV Substation and convert the transmission lines and associated area supply substations would be very difficult because there is no alternate source to transfer the load during the construction phase.

PPL Electric also considered the installation of a new Breinigsville 500 – 138 kV Substation without the 69 kV option. However, the estimated cost of this alternative exceeded the preferred alternative. This option would involve both construction of a new substation, conversion of the 69 kV lines to 138 kV operation, and conversion of seven area supply substations to 138 kV. This alternative would still require the relocation of the AT&T Tap Line, the construction of a new 138/69 kV double-circuit tap to connect the relocated AT&T Tap Line into the 69 kV yard at the Breinigsville Substation, and the re-termination of the Wescosville-Alburtis 500 kV Line into the Breinigsville Substation.

For the reasons stated above, construction of the new Breinigsville 500-138-69 kV Substation and associated line connections is the preferred and most economically feasible solution to resolve all the transmission reliability violations.

Attachment
2

ATTACHMENT 2

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES

AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION

ENGINEERING DESCRIPTION

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ATTACHMENT 2

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES

AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION

ENGINEERING DESCRIPTION

A. DESCRIPTION OF THE PROPOSED LINE

PPL Electric Utilities Corporation seeks approval of the Pennsylvania Public Utility Commissoin (PUC or Commission) to construct and relocate transmission lines in preparation for the construction of the Breinigsville 500-138-69 kV Substation (Breinigsville Project). The proposed Project is located entirely within property owned by PPL Electric in Upper Macungie Township, Lehigh County, Pennsylvania. The Breinigsville Project is required to resolve identified transmission reliability criteria violations, to meet increasing load growth, and to maintain reliable electric service to customers in portions of the Upper Macungie, Lower Macungie, and Upper Milford Townships of Lehigh County.

The Breinigsville Project is being carefully planned to coordinate with and take advantage of a planned outage of the Susquehanna-Wescosville-Alburtis 500 kV Transmission Line that will ultimately be re-terminated and connected to the proposed Breinigsville 500-138-69 kV Substation. Pending approval by the Commission, the transmission line work for this Project will be completed in three parts: (1) re-routing approximately 3,300 feet of the AT&T #1 and #2 138/69 kV Tap Line (AT&T Tap Line) to create the required space for construction of the proposed Breinigsville 500-138-69 kV Substation; (2) re-terminating approximately 1,525 feet of the existing Albertis-Wescosville 500 kV Transmission Line into the Breinigsville Substation; and (3) constructing approximately 325 feet of new double circuit Breinigsville-Wescosville #1 & #2 138/69 kV Transmission Line (Breinigsville-Wescosville Transmission Line) to connect the relocated portion of the AT&T Tap Line to the 69 kV yard at the proposed Breinigsville Substation. These three parts of the Project are further explained below.

1. Relocation of the AT&T Tap Line.

Part one of the Breinigsville Project involves re-routing approximately 3,300 feet of the AT&T Tap Line to create the required space for construction of the proposed Breinigsville 500-138-69 kV Substation. The relocation of the AT&T Tap Line requires the installation of 4 double-circuit poles and 2 single-circuit tap poles that will be located approximately 2200 feet from the existing location of the AT&T Tap Line. The poles will have a height of 105 feet. The existing Tap Line consists of monopoles with 6 arms. Six power conductors and one overhead groundwire will be installed. The power conductors will be 556.5 kcmil[8] 24/7 stranding ACSR.[9] The overhead ground wire will be either 3/8-inch or 1/2-inch diameter high strength steel and will provide lightning protection for the relocated section of AT&T Tap Line.

The relocated AT&T Tap Line will be designed to, and generally exceed, National Electrical Safety Code minimum standards. Design specifications and safety rules practiced by PPL Electric are included in Attachment 4. The minimum conductor to ground clearance for the proposed line will be 30 feet, which occurs at a maximum conductor temperature of 125°C. The designed minimum conductor clearances and conductor thermal ratings are set forth in Tables 1 and 2 at the end of this Attachment.

Subject to the Commission's approval, this part of the Project is scheduled to begin in October 2012 and be completed by May 2013 to accommodate the scheduled construction of the new Breinigsville 500-138-69 kV Substation. The estimated cost of this part of the Project is $1.45 million.

[8] Kcmil stands for thousand circular mills. Kcmil wire size is the equivalent cross sectional area in thousands of circular mils. A circular mil is the area of a circle with a diameter of one thousandth (.001) of an inch.

[9] ACSR stands for aluminum conductor steel reinforced

2. Re-Terminating the Albertis-Wescosville 500 kV Transmission Line

Part two of the Project involves splitting the existing Wescosville-Alburtis 500 kV Transmission Line and re-terminating the Line into the 500 kV yard at the proposed Breinigsville 500-138-69 kV Substation. The split and re-termination of the Wescosville- Alburtis 500 kV Transmission Line requires the removal of one existing transmission line steel pole structure. The proposed modification will be designed to accommodate a single-circuit 500kV line.

The split and re-termination of the Wescosville-Alburtis 500 kV Transmission Line requires the installation of approximately 4 structures. The structures will be H-frame steel poles equipped with one steel cross arm, with an average height of 100 feet and an average span length of 626 feet. All poles will be installed on concrete foundations. Six power conductors and two overhead ground wires will be installed. The power conductors will be twin bundled, 2493 kcmil 54/37 stranding Aluminum Conductor Aluminum Alloy Reinforced (ACAR). The overhead ground wire will be 19 #9 alumoweld and will provide lightning protection for the re-terminated Lines.

The re-terminated Wescosville-Alburtis 500 kV Transmission Line will be designed to, and generally exceed, National Electrical Safety Code minimum standards. Design specifications and safety rules practiced by PPL Electric Utilities are included in Attachment 4. The minimum conductor-to-ground clearance will be 54 feet for the modified transmission line. The minimum clearance occurs at maximum sag, which occurs at the maximum thermal conductor temperature of 100°C or a maximum ice loading. Table 3 shows the designed minimum conductor clearances and Table 4 shows the conductor thermal rating of the modified transmission line.

Subject to the Commission's approval, construction of part two of the Project is scheduled to begin by October 2012 to meet a required in-service date of March

2015. The construction of part two has been carefully coordinated with planned outages of the Susquehanna-Wescosville-Alburtis 500 kV Transmission Line and the Unit 2 outage at the Susquehanna Steam Electric Station nuclear plant in 2013 and 2015. The estimated cost of this part of the Project is $1.1 million.

3. Construction of the Breinigsville-Wescosville Transmission Line

In part three of the Project, the new double circuit Breinigsville-Wescosville Transmission Line will be constructed to connect the relocated portion of the AT&T Tap Lines to the 69 kV yard at the proposed Breinigsville 500-138-69 kV Substation. The construction of the new Breiningsville Wescosville Transmission Lines will consist of the installation of 2 single-circuit poles with an average height of 75 feet. Three power conductors and one overhead ground wire will be installed for each Line. The power conductors will be 556.5 kcmil 24/7 stranding ACSR. The overhead ground wire will 3/8-inch diameter high strength steel and will provide lightning protection for the new Transmission Lines.

The proposed new Breiningsville-Wescosville Transmission Line will be designed to, and generally exceed, National Electrical Safety Code minimum standards. Design specifications and safety rules practiced by PPL Electric are included in Attachment 4. The minimum conductor to ground clearance for the proposed line will be 30 feet which occurs at a maximum conductor temperature of 125°C. The designed minimum conductor clearances and conductor thermal ratings are set forth in Tables 1 and 2 at the end of this Attachment.

Subject to the Commission's approval, construction of the Breinigsville-Wescosville Transmission Line will be coordinated with the construction of the Breinigsville 500-138-69 kV Substation and be completed by May 2015. The estimated cost of this part of the Project is $350,000.

B. MAGNETIC FIELD MANAGEMENT

PPL Electric's Magnetic Field Management Program is included in Attachment 5 and applied to reconstruction and new line projects. In order to lower magnetic field exposures, the program generally prescribes the use of line design that provides 20 feet higher ground clearances for 500 kV and 5 feet higher ground clearances for 138/69 kV than those required under the NESC and reverse phasing new double-circuit lines where it is feasible to do so at low or no cost. The implementation of additional modifications will be considered, provided those modifications can be made at low or no cost and will not interfere with the operation of the line.

The relocated AT&T Tap Line is a double circuit and will be reversed phased to reduce magnetic fields. Similarly, the new Breinigsville-Wescosville Transmission Line is a double circuit and will be reverse phased. The re-terminated Wescosville- Alburtis 500 kV Transmission Line is a single-circuit line and cannot be reverse phased. However, pursuant to PPL Electric's Magnetic Field Management Program, some reduction in magnetic field levels will be attained through the use of structures that are higher than the existing lattice towers.

C. RIGHT-OF-WAY STATUS

No additional rights-of-way are required for this Project. The relocated AT&T Tap Line, re-terminated Wescosville-Alburtis 500 kV Transmission Line, and new Breiningsville-Wescosville Transmission Line will all be constructed entirely within existing substation site for the Breinigsville 500-138-69 kV Substation owned by PPL Electric. The Aerial Exhibit at the end of Attachment 2 shows existing property lines and current ownership near the substation site. A list of all owners of property within the right-of-way is included as Attachment 6.

TABLE 1
DESIGN MINIMUM CONDUCTOR CLEARANCES
FOR 556.5 KCMIL 24/7 STRANDING ACSR*
AT&T #1 and #2 138/69 kV Tap Lines and
the Breiningsville – Wescosville #1 & #2 138/69 kV Tap Line

Condition	Double-Circuit Design Clearance to Ground
Normal load, average weather (16°C ambient temperature)	33.00 feet
Predicted extreme thermal load (125°C conductor temperature)	30.00 feet
Predicted NESC extreme wind load (16°C ambient temperature)	32.11 feet
Predicted extreme weather conditions (1-inch ice, 4 lbs. wind, -10°C)	32.21 feet

Clearances based on a maximum tension of 3540 lbs. at 1 inch ice, 4 lbs. wind, -10°C and a ruling span of 290 feet. (NESC Rule 250D)

TABLE 2
CONDUCTOR THERMAL RATING
556.5 KCMIL 24/7 STRANDING ACSR
125°C MAXIMUM CONDUCTOR TEMPERATURE
AT&T #1 and #2 138/69 kV Tap Lines and
the Breiningsville – Wescosville #1 & #2 138/69 kV Tap Line

Ambient Temperature Condition	Wind Speed °C	Ampacity Knots	Amps
Summer Normal	35	0	815
Winter Normal	10	0	926
Summer Emergency	35	1.5	1041
Winter Emergency	10	1.5	1163

TABLE 3
DESIGN MINIMUM CONDUCTOR CLEARANCES
FOR BUNDLED 2493 KCMIL 54/37 ACAR STRANDING ACAR*
Wescosville – Alburtis 500 kV Transmission Line

Condition	Double-Circuit Design Clearance to Ground
Normal load, average weather (16°C ambient temperature)	58.00 feet
Predicted extreme thermal load (100°C conductor temperature)	54.00 feet
Predicted extreme weather conditions (1-inch ice, 4 lbs. wind, -18°C)	59.00 feet

Clearances based on a maximum tension of 35,678 lbs. and an average ruling span of 626 feet.

TABLE 4
CONDUCTOR THERMAL RATING
TWIN BUNDLED 2493 KCMIL 54/37 ACAR
125°C MAXIMUM CONDUCTOR TEMPERATURE
Wescosville – Alburtis 500 kV Transmission Line

Ambient Temperature Condition	Wind Speed °C	Ampacity Knots	Amps
Summer Normal	35	0	3470
Winter Normal	10	0	3900
Summer Emergency	35	1.5	4360
Winter Emergency	10	1.5	4610

Attachment
3

ATTACHMENT 3

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION ENVIRONMENTAL ASSESSMENT

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ATTACHMENT 3
BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION ENVIRONMENTAL ASSESSMENT

A. INTRODUCTION

PPL Electric Utilities Corporation ("PPL Electric") seeks approval of the Pennsylvania Public Utility Commission (PUC or Commission) to construct and relocate transmission lines in preparation for the proposed construction of the Breinigsville 500-138-69 kV Substation (Breinigsville Project). This work would involve (1) re-routing approximately 3,300 feet of the AT&T #1 and #2 138/69 kV Tap Line (AT&T Tap Line) around the proposed Breinigsville Substation; (2) re-terminating approximately 1,525 feet of the existing Albertis-Wescosville 500 kV Transmission Line into the Breinigsville 500-138-69 kV Substation; and (3) constructing approximately 325 feet of the new double-circuit Breinigsville-Wescosville #1 & #2 138/69 kV Transmission Line to connect the relocated AT&T Tap Line to the proposed Breinigsville 500-138-69 kV Substation. The Breinigsville Project is required to resolve identified transmission reliability criteria violations, to meet increasing load, growth and to maintain reliable electric service to customers in portions of the Upper Macungie, Lower Macungie, and Upper Milford Townships of Lehigh County.

The proposed Project is located entirely within property owned by PPL Electric in Upper Macungie Township, Lehigh County, Pennsylvania. The proposed Project has been reviewed with representatives of Upper Macungie Township and Lehigh County, and neither the Township nor the County had any objection. A list of involved governmental agencies, municipalities, and other public entities is presented in Attachment 7.

B. LAND USE

The new Breinigsville Substation will be located adjacent to the existing Alburtis-Wescosville 500 kV and AT&T Tap Lines. The Substation and associated transmission line connections will traverse an agricultural area located at the northeast corner of Tillage Road and Long Lane in Upper Macungie Township. The transmission lines traverse limited forested areas. The closest residential community is located approximately 500 feet south of Long Lane. The proposed Substation and transmission line connections will be constructed entirely within the substation site which is owned by PPL Electric. Visual impacts to existing and future homes in the area associated with the transmission lines will be incremental because the existing Alburtis-Wescosville 500 kV and AT&T Tap Lines presently occupy a portion of the property.

No communication towers, pipelines, or other utilities will be affected by the proposed Project. The closest airport is the Allentown Municipal Airport, which is approximately 10 miles northeast of the Project. The proposed transmission line connections are not expected to impact airport operations. PPL Electric will file the appropriate documentation with both the Federal Aviation Administration and the PennDOT Bureau of Aviation to ensure that the proposed Project will not be a hazard to the airport's flight operations.

C. CULTURAL RESOURCES

PPL Electric consulted with the Pennsylvania Historical and Museum Commission (PHMC) regarding potential impacts from this Project. For the selected substation site, PHMC determined that there is a probability of significant archaeological sites in the area[10]. PHMC required a Phase I archaeological survey of the site to locate any significant archaeological resources. PPL Electric retained Dr. Frank Vento, Professor of Geology at

[10] File No. ER No. 08-0299-077-A

Clarion State University, to perform the Phase 1 survey. Dr. Vento recovered approximately 6,000 artifacts on the site, and submitted the appropriate documentation to PHMC. During this time, PPL Electric has continued to coordinate with the PHMC to determine appropriate mitigation measures, if required. PPL Electric will continue to consult with the PHMC and will comply with any further requests for investigations or surveys from the PHMC. PHMC has determined that no evaluation of historic structures will be necessary for this project.

D. NATURAL FEATURES

The project will not traverse or affect any other unique geological, scenic or natural areas. The Project will not affect any recreational areas or natural landmarks. No recreational areas are traversed by the Project. The closest recreational areas include Breinigsville Park located approximately 0.9 mile south of the Project and the Bob Rodale Cycling and Fitness Park located approximately 0.8 mile southeast of the Project. One Natural Area Inventory (NAI) site, the Jungle NAI, is located approximately 1 mile southeast of the Project.[11] No other NAI areas are located within 1 mile of the Project. This natural area is located within the floodplains of Spring Creek and Iron Run, partially within the Bob Rodale Fitness Park. The Jungle consists of thick vegetation and supports habitat for herons and other bird species. The site has historically supported up to six state-listed plant species; however, none were observed in recent surveys.[12] Based on the distance from the Project, no impacts to the Jungle NAI are anticipated.

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[11] The Nature Conservancy. (1999). A Natural Areas Inventory of Lehigh and Northampton Counties.

[12] The Jungle. (no date). The Nature Conservancy. Retrieved from: http://www.naturalheritage.state.pa.us /cnhi/cnhi/The%20Jungle.pdf

PPL Electric retained Woodland Design Associates, Inc. to conduct a wetland delineation of the Project area in October 2008. Three wetlands were observed within the Project area: two palustrine forested (PFO) wetlands (Wetlands A and B), and one palustrine emergent (PEM)/PFO wetland (Wetland C). Both PFO wetlands are considered to be vernal pools[13]. In addition, Breinig Run and a tributary to Breinig Run also traverse the Project area. Table 1 provides a summary of the wetland types and acreage delineated within the Project area.

TABLE 1. WETLAND FEATURES

Wetland Type	Acreage
PFO	0.4
PEM/PFO	2.8
Total	**3.2**

PPL Electric will avoid impacts to wetlands to the maximum extent practical. PPL Electric will acquire any required wetland permits, and will comply with any conditions placed on those permits.

Some minimal tree clearing may be required, and PPL Electric will apply its "Specification 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 any impacts. In addition, PPL Electric will acquire any required soil erosion and sedimentation control permits and comply with any conditions placed on those permits.

[13] According to the U.S. Environmental Protection Agency (USEPA), vernal pools are seasonal depressional wetlands that are covered by shallow water for variable periods between winter and spring. The unique environment of vernal pools provide habitat for numerous plants and animals, some of which may be rare.

E. THREATENED AND ENDANGERED SPECIES

PPL Electric has coordinated with the relevant state and federal agencies to obtain information regarding endangered and threatened species that could occur in the vicinity of the proposed Project. PPL Electric conducted an online Pennsylvania Natural Diversity Inventory (PNDI) review on July 29, 2008,[14] and again on October 7, 2011.[15] In both reviews, the Pennsylvania Game Commission (PGC), the Pennsylvania Department of Conservation and Natural Resources (DCNR), and the U.S. Fish and Wildlife (USFWS) indicated that no impacts on any species are anticipated. However, because the project is located within the range of the federally threatened bog turtle (*Clemmys muhlenbergii*), PPL Electric retained Mellon Biological Services, LLC to conduct bog turtle phase I and phase II survey activities for the wetlands identified within the project footprint. The phase II surveys were conducted on April 17, April 24, May 12 and May 19, 2009. No bog turtles were identified during the phase II survey. Therefore, the USFWS provided initial clearance in a letter dated February 3, 2010, and reconfirmed this clearance in a letter dated May 3, 2012.[16]

The Pennsylvania Fish and Boat Commission (PFBC) September 24, 2008[17] response letter indicated that the state endangered Eastern Spadefoot toad (*Scaphiopus holbrookii*) was known to exist in the vicinity of the Project. During the process of siting the Breinigsville Substation, PPL Electric retained Ecological Associates (EA) to conduct a survey for the Eastern Spadefoot toad. EA conducted a habitat assessment in May 2009, and determined that potentially suitable Eastern Spadefoot toad breeding and terrestrial habitats are located within the Project area. At the request of the PFBC, EA conducted presence/inferred absence studies for the Eastern Spadefoot toad. Studies were conducted between August and October 2009. During the study, four Eastern Spadefoot toads were

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[14] PNDI Review No. 20080729152671
[15] PNDI Review No. 20111007320192
[16] USFWS Project No. 2009-0538
[17] SIR Review No. 29421

observed east of the Substation footprint within Wetland B. Based on the results of the field study, PPL Electric coordinated with the PFBC to identify a 300-foot buffer area around the vernal pool and adjusted the substation footprint accordingly to minimize encroachment into the buffer area.

During subsequent discussions with PFBC, PPL Electric developed a construction minimization plan. This plan confirms the Substation location, indicates that PPL Electric will protect the two vernal pools and upland buffers through a deed restriction/land transfer, confirms that exclusion fencing will be used during construction, and describes measures to conduct Eastern Spadefoot toad monitoring for a minimum of 5 years following construction. Provided these avoidance and minimization measures are followed, PFBC indicated in a letter dated May 22, 2012, that no adverse impacts to the Eastern Spadefoot toad population are identified.

Attachment
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ATTACHMENT 4

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES

AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION

PPL ELECTRIC 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 requirements 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 enhancements such as larger-minimum crossarm 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

	Vertical Clearance to Ground	
Surface Underneath Conductors	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	Vertical Clearance to Ground: 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	Vertical Clearance to Ground: 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.

Attachment
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ATTACHMENT 5

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION PPL ELECTRIC MAGNETIC FIELD MANAGEMENT PROGRAM

MAGNETIC FIELD MANAGEMENT

PPL Electric Utilities Corporation

DECEMBER 2004

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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

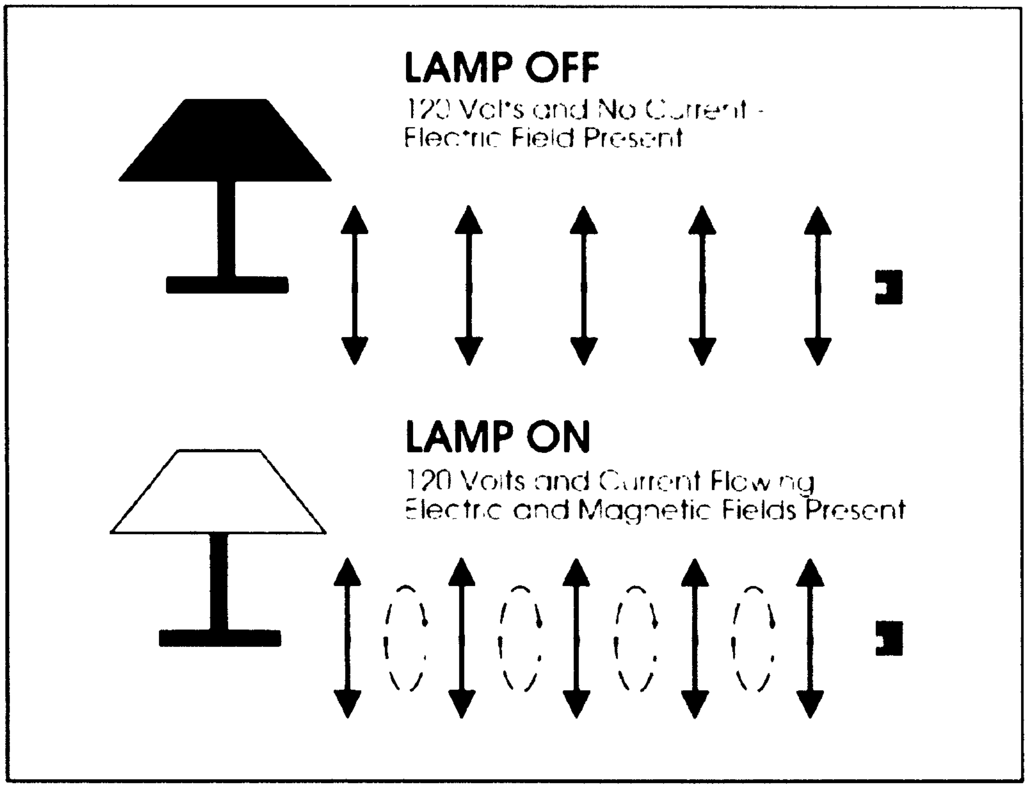

LAMP OFF
120 Volts and No Current -
Electric Field Present
LAMP ON
120 Volts and Current Flowing
Electric and Magnetic Fields Present

Figure 2

Magnetic field strengths decrease with distance Magnetic fields are measured in milligauss	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

Source. "EMF In Your Environment", U S Environmental Protection Agency 1992

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.

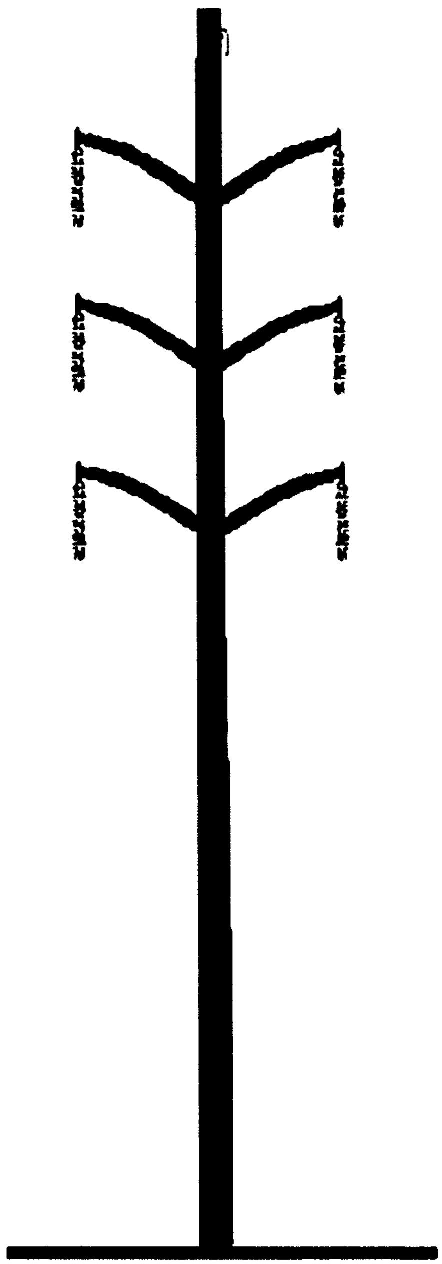
- Main lines are the most heavily loaded sections of a distribution line and therefore have the highest magnetic fields associated with them.
- Increasing the ground clearance by five feet reduces the magnetic field under the line from 14 mG to 11 mG using the standard eight-foot crossarm design. These 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.

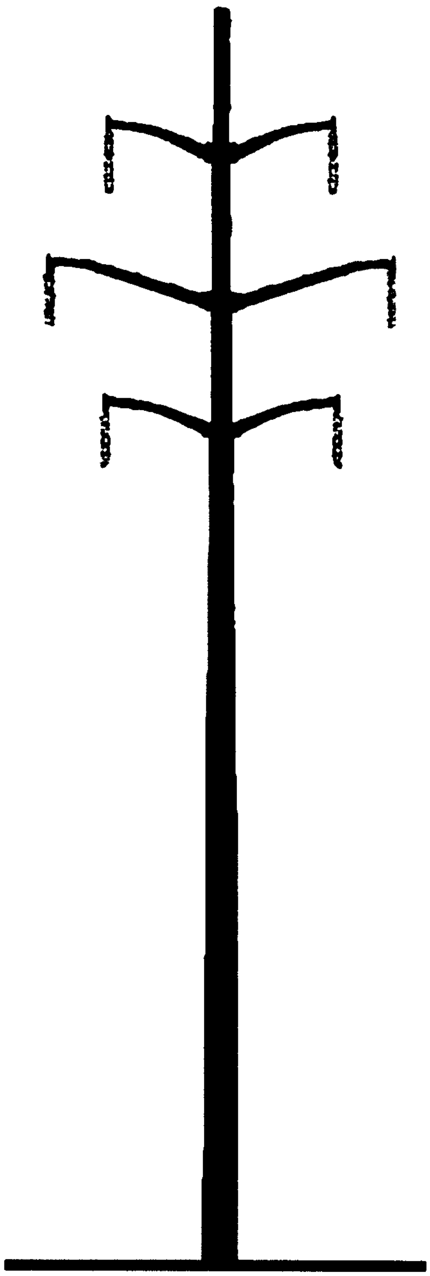
Short-Span Construction



- **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:**

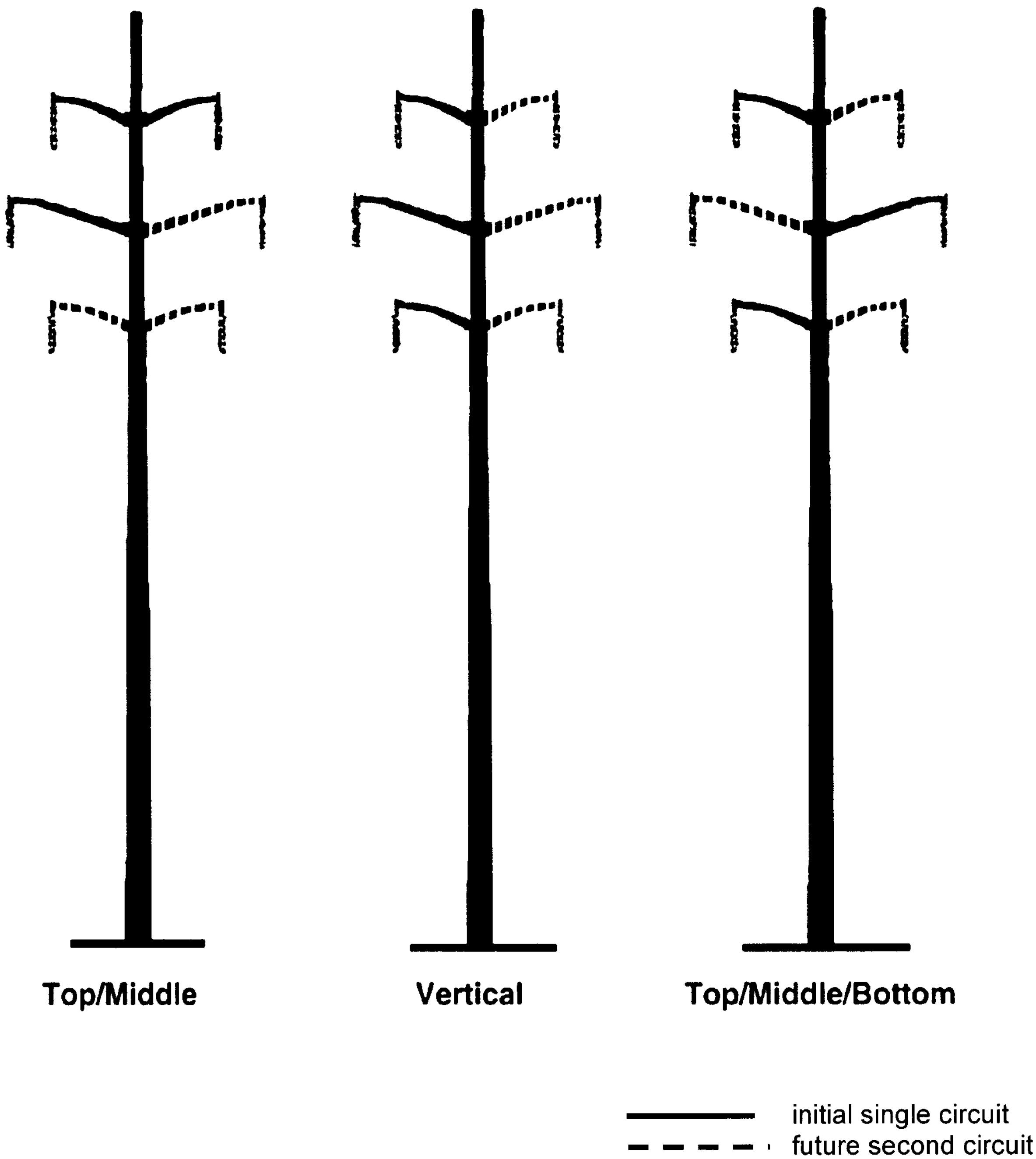
1 3/8" HS steel overhead ground wire - 17.3 feet sag
6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 23.0 feet sag
Average span - 600 feet

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

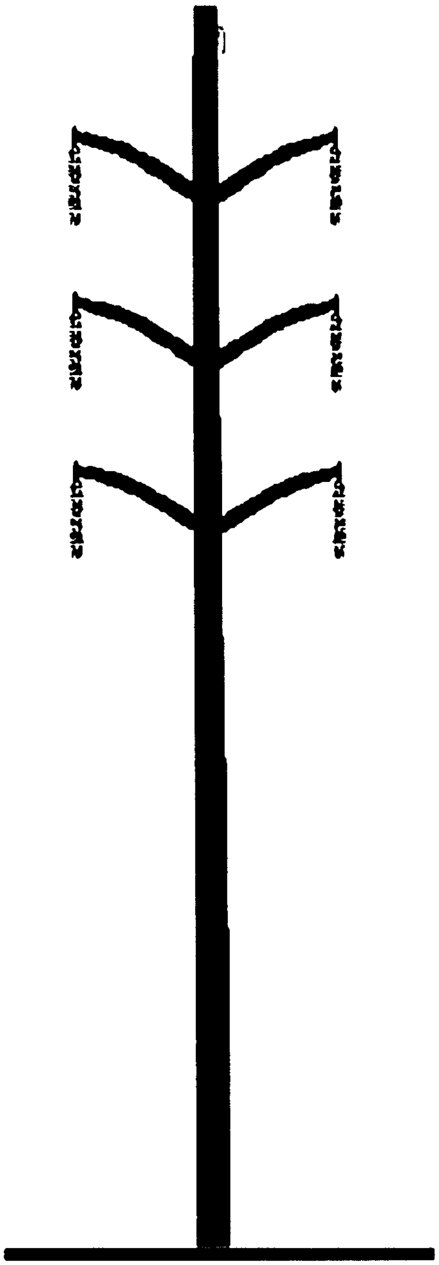


138/69 kV SINGLE CIRCUIT TRANSMISSION LINES
CALCULATED MAGNETIC FIELDS AT 400 AMPERES

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.

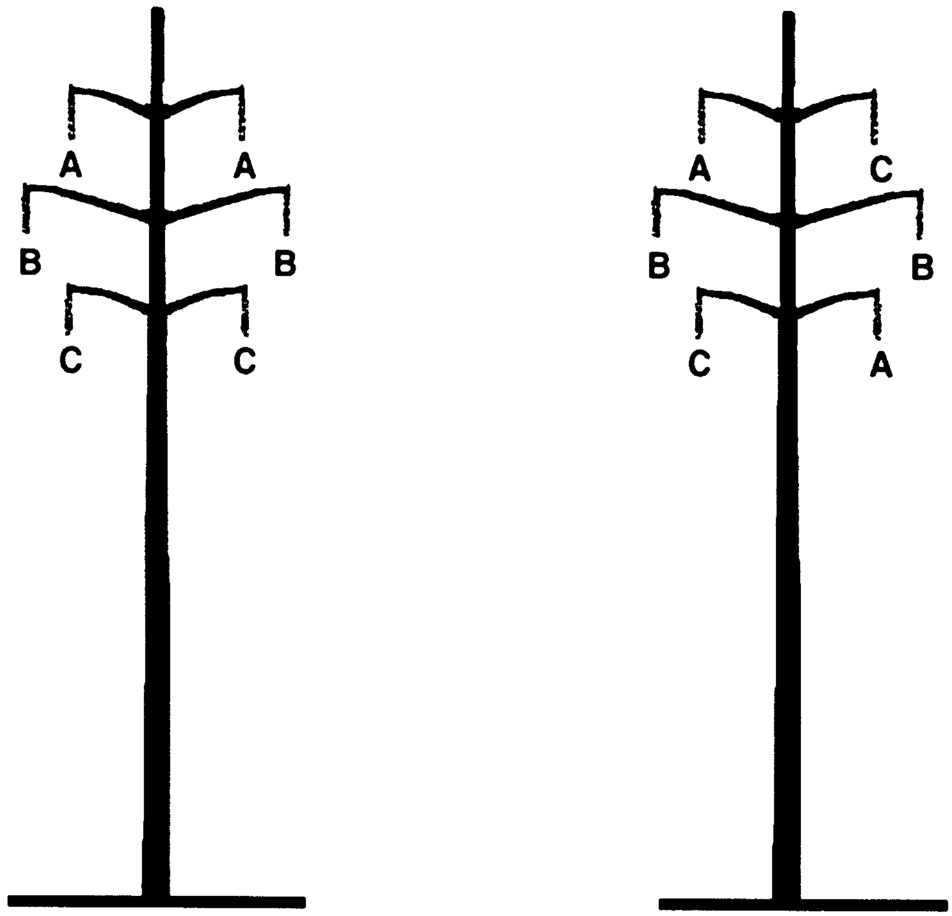
Compact Design Structure



- **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.

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.

Sitıng/Magnetıc Field Management doc/mlt

Attachment
6

ATTACHMENT 6

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES

AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION

PROPERTY OWNER

Property Owner/Address	Parcel Number
PPL Electric Utilities Two North Ninth Street Allentown, PA 18101	1

Attachment
7

ATTACHMENT 7

BREINIGSVILLE 500 KV AND 138/69 KV CONNECTING LINES AND AT&T #1 & #2 138/69 KV TAP LINE RELOCATION

LIST OF INVOLVED GOVERNMENTAL AGENCIES, MUNICIPALITIES AND OTHER PUBLIC ENTITIES RECEIVING APPLICATIONS

1. 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

2. Pennsylvania Department of Transportation
   Honorable Barry Schoch, P.E., Secretary
   c/o Office of Chief Counsel
   Commonwealth Keystone Building
   400 North Street, 9^{th} Floor
   Harrisburg, PA 17120
   Attn: Andrew Gordon

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

4. Lehigh Valley Planning Commission
   961 Marcon Boulevard - Suite 310
   Allentown, Pennsylvania 18109
   Attn: Mr. Michael Kaiser, AICP

5. Lehigh County Board of Commissioners
   17 South Seventh Street
   Allentown, PA. 18101-2400
   Attn: Mr. Brad Osborne, Chairman

6. Upper Macungie Township Planning Commission
   8330 Schantz Road
   Breinigsville, Pennsylvania 18031
   Attn: Mr. David Etowski, Chairman

7. Upper Macungie Township
   8330 Schantz Road
   Breinigsville, Pennsylvania 18031
   Attn: Ms. Kathy Rader, Secretary