B&B Engineers & Geologists
of new york, p.c.
an affiliate of Gradient

Electric and Magnetic Field (EMF) Modeling Analysis for the Syosset to Oakwood 138 kV Transmission Line Project

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July 9, 2025

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Abbreviations

A	Ampere
AC	Alternating Current
B&B	B&B Engineers & Geologists of New York, P.C.
B_{Max}	$B_{Maximum}$
BPA	Bonneville Power Administration
DC	Direct Current
EF	Electric Field
EMF	Electric and Magnetic Field
EPRI	Electric Power Research Institute
FEM	Finite Element Method
G	Gauss
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
kcmil	Kilocircular Mil
kV/m	Kilovolt Per Meter
MF	Magnetic Field
mG	Milligauss
NYSPSC	New York State Public Service Commission
RMS	Root Mean Square
ROW	Right-of-Way
T	Tesla
US	United States
V	Volt
µT	Microtesla

1 Introduction and Summary

PSEG Long Island, as agent of and acting on behalf of Long Island Lighting Company d/b/a LIPA, proposes to construct a new approximately 2.8-mile 138 kilovolt (kV) underground transmission line primarily within a roadway right-of-way (ROW) between the Woodbury Tap in the Town of Woodbury, Nassau County, New York, and the Oakwood Substation in Huntington Station, Suffolk County, New York (the Syosset to Oakwood 138 kV Transmission Line Project [the "Project"]). The Project will also involve the installation of new riser and overhead transmission poles at the Woodbury Tap.

Burns & McDonnell requested that B&B Engineers & Geologists of New York, P.C. (B&B), an affiliate of Gradient, perform an independent assessment of the electric and magnetic field (EMF) impacts associated with the Syosset to Oakwood 138 kV Transmission Line Project. For this EMF assessment, magnetic field (MF) impacts were modeled 1 meter above the ground surface for three underground line cross sections representative of typical underground line installation cases with differing conductor configurations for the proposed Project 138 kV phase conductors. Underground lines produce no aboveground electric fields, so these new underground 138 kV conductors will not produce any aboveground electric fields and no electric field (EF) modeling was performed. B&B also modeled both MF and EF impacts at a height of 1 meter above the ground surface for one existing (*i.e.*, pre-Project) and two proposed (*i.e.*, post-Project) overhead line cross sections for the Circuit 138-676 underground to overhead transition at the Woodbury Tap. Per New York State Public Service Commission (NYSPSC) Article VII requirements, all MF modeling was performed for winter normal conductor ratings, and EF modeling was performed for the rated line voltage.

As described in this report and summarized in Tables 1.1 and 1.2 below, our EMF modeling calculations demonstrate that modeled post-Project MF levels at designated ROW edges for each representative underground and overhead transmission line cross section will comply with the NYSPSC edge-of-ROW MF interim standard of 200 milligauss (mG). In addition, as summarized in Table 1.3, our calculations demonstrate that modeled post-Project EF levels at designated ROW edges for the two representative overhead cross sections will comply with the NYSPSC edge-of-ROW EF interim standard of 1.6 kilovolts per meter (kV/m). Moreover, even the highest modeled MF levels directly above the underground conductor centerlines, and directly beneath the overhead lines, are well below the health-based guideline issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for allowable public exposure to MFs (2,000 mG; ICNIRP, 2010). All modeled EF levels, including directly beneath the overhead lines, are also well below the health-based guideline issued by ICNIRP for allowable public exposure to EFs (4.2 kV/m; ICNIRP, 2010).

Table 1.1 Summary of Modeled Magnetic Fields (MFs) 1 Meter Above Ground Surface for the Representative Project Underground Transmission Line Cross Sections

Cross Section	Max. MF (mG), Directly Above Centerline	ROW Edge MF (mG), -25 ft from Centerline	ROW Edge MF (mG), +25 ft from Centerline
Typical Underground Line Sections: Typical Direct Buried Conduits in Trefoil Configuration (two conductors per phase)	124.9	11.5	11.5
Jumper Sections: Typical Direct Buried Conduits in Trefoil Configuration (one conductor per phase)	61.2	5.3	5.3
Trenchless Excavation Line Sections: Conduits in Bore Configuration (two conductors per phase)	74.0	20.1	20.1

Notes:
ft = Feet; mG = Milligauss; ROW = Right-of-Way.

Table 1.2 Summary of Modeled Magnetic Fields 1 Meter Above Ground Surface for the Representative Project Overhead Transmission Line Cross Sections

Cross Section	Magnetic Field (mG)			
	Southern Edge-of-ROW		Northern Edge-of-ROW	
	Pre-Project	Post-Project	Pre-Project	Post-Project
CS1[a]	58.0	109.1	72.1	84.5
CS2[b]	--	15.6	--	42.2

Notes:
CS = Cross Section; mG = Milligauss; ROW = Right-of-Way.
(a) Pre-Project and post-Project CS1 are both for the line segment starting at the Existing Steel Pole #20 and ending at the Existing Riser 20S Poles. For post-Project CS1, the Proposed Steel Pole #20N is to be constructed between the Existing Steel Pole #20 and the Existing Riser 20S Poles.
(b) Post-Project CS2 is for the proposed line segment from the Proposed Riser Pole on the 133 Woodbury Road property to the Proposed Steel Pole #21.

Table 1.3 Summary of Modeled Electric Fields 1 Meter Above Ground Surface for the Representative Project Overhead Transmission Line Cross Sections

Cross Section	Electric Field (kV/m)			
	Southern Edge-of-ROW		Northern Edge-of-ROW	
	Pre-Project	Post-Project	Pre-Project	Post-Project
CS1[a]	0.33	0.99	0.04	0.06
CS2[b]	--	0.02	--	0.07

Notes:
CS = Cross Section; kV/m = Kilovolts per Meter; ROW = Right-of-Way.
(a) Pre-Project and post-Project CS1 are both for the line segment starting at the Existing Steel Pole #20 and ending at the Existing Riser 20S Poles. For post-Project CS1, the Proposed Steel Pole #20N is to be constructed between the Existing Steel Pole #20 and the Existing Riser 20S Poles.
(b) Post-Project CS2 is for the proposed line segment from the Proposed Riser Pole on the 133 Woodbury Road property to the Proposed Steel Pole #21.

Section 2 of this report describes the nature of EMFs, provides values for EMF levels from common sources, and provides background on the NYSPSC edge-of-ROW MF and EF interim standards. Section 3 outlines the modeling procedures and provides MF modeling results for the modeled representative underground line cross sections. Section 4 outlines the modeling procedures and provides both MF and EF modeling results for the modeled representative overhead line cross sections. Section 5 summarizes the conclusions, and the Reference list provides the sources cited in this report.

2 Nature of Electric and Magnetic Fields

All matter contains electrically charged particles. Most objects are electrically neutral because positive and negative charges are present in equal numbers. When the balance of electric charges is altered, we experience electrical effects. Common examples are the static electricity attraction between a comb and our hair, or a static electricity spark after walking on a synthetic rug in the wintertime. Electrical effects occur both in nature and through our society's use of electric power (generation, transmission, and consumption).

2.1 Units for EMFs are kilovolts per meter (kV/m) and milligauss (mG).

The electrical tension on utility power lines is expressed in volts (V) or kV (1 kV = 1,000 V). Voltage is the "pressure" of the electricity and can be envisioned as analogous to the pressure of water in a plumbing system. The existence of a voltage difference between overhead power lines and ground results in an "electric field," usually expressed in units of kV/m. The size of the electric field depends on the line voltage, the separation between lines and the ground surface, and other factors.

Power lines also carry an electric current that creates a "magnetic field." The units for electric current are amperes (A), which is a measure of the "flow" of electricity. Electric current is analogous to the flow of water in a plumbing system. The MF produced by an electric current is usually expressed in units of gauss (G) or mG (1 G = 1,000 mG).[1] The size of the MF depends on the electric current in the line conductors, the distance to the current-carrying conductor, and other factors.

2.2 There are many natural and man-made sources of EMFs.

Everyone experiences a variety of natural and man-made EMFs. EMF levels can be steady or slowly varying (often called direct current [DC] fields), or EMF levels can vary in time (often called alternating current [AC] fields). When the time variation corresponds to that of standard North American power line currents (*i.e.*, 60 cycles per second), the fields are called 60-hertz (Hz) AC, or power-frequency EMF. Man-made MFs are common in everyday life. For example, many childhood toys contain magnets. Such permanent magnets generate strong, steady (DC) MFs. Toy magnets (*e.g.*, "refrigerator door" magnets) can have DC magnetic fields in the range of 10,000-100,000 mG (National High Magnetic Field Laboratory, 2022a,b). On a larger scale, Earth's core also creates a steady DC MF that can be easily demonstrated with a compass needle. The size of Earth's MF in New York City is about 510 mG.

2.3 Power-frequency EMFs are found near electric lines and appliances.

In North America, electric power transmission lines, distribution lines, and electric wiring in buildings carry AC currents and voltages that change size and direction at a frequency of 60 Hz. These 60-Hz currents and voltages create 60-Hz AC EMFs nearby. The size of the MF is proportional to the line current, while the size of the electric field is proportional to the line voltage. The EMFs associated with electrical wires and

[1] Another unit for MF levels is the microtesla (μT) (1 μT = 10 mG, and 1 tesla (T) = 10,000 G).

electrical equipment decrease rapidly with increasing distance away from the electrical wires and/or equipment. Specifically, EMFs from a set of three, 120-degree-phased, balanced current conductors decrease in proportion to the square of the distance from the conductors (Institute of Electrical and Electronics Engineers [IEEE] 1127 [IEEE, 2014]).

When EMF derives from different wires or conductors that are in close proximity, or adjacent to one another, the level of the net EMF produced will be somewhere in the range between the sum of EMF from the individual sources and the difference of the EMF from the individual sources. EMF may partially add or partially cancel, but generally, because adjacent phase conductors often carry current in opposite directions for typical three-phase lines, the EMFs produced tend to cancel.

EMFs in the home arise from electric appliances, indoor wiring, grounding currents on pipes and ground wires, and outdoor distribution line or transmission line circuits. Inside residences, typical baseline 60-Hz MF levels (away from appliances) range from 0.5-5.0 mG.

Higher 60-Hz MF levels are found near operating electrical appliances. For example, can openers, mixers, blenders, refrigerators, fluorescent lamps, electric ranges, clothes washers, toasters, portable heaters, vacuum cleaners, electric tools, and many other appliances generate MF levels in the range of 40-300 mG at distances of 1 foot (NIEHS, 2002). MF levels from personal care appliances typically held within half a foot (*e.g.*, shavers, hair dryers, massagers) can produce average fields of 600-700 mG. At school and in the workplace, lights, motors, copy machines, vending machines, video-display terminals, pencil sharpeners, electric tools, electric heaters, and building wiring are all sources of 60-Hz MFs.

2.4 New York State Public Service Commission (NYSPSC) Magnetic Field (MF) and Electric Field (EF) Interim Standards for Right-of-Way (ROW) Edges

The NYSPSC has an edge-of-ROW MF interim standard of 200 mG and an edge-of-ROW EF interim standard of 1.6 kV/m (NYSPSC, 1990, 1978). As defined in NYSPSC's "Statement of Interim Policy on Magnetic Fields of Major Electric Transmission Facilities," which was issued on September 11, 1990 (NYSPSC, 1990), this interim MF standard is to be applied to MFs at 1 m (3.28 ft) above the ground surface for line loading conditions corresponding to winter normal conductor ratings. This MF interim standard is not health-based and is 10 times lower than the health-based guideline issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for allowable public exposure to MFs (2,000 mG; ICNIRP, 2010). It is based on modeled average edge-of-ROW MFs for a large sample of 345 kV transmission lines in New York State for assumed line loading conditions at the winter normal conductor ratings (NYSPSC, 1990). Opinion 78-13 issued by NYSPSC on June 19, 1978 (NYSPSC, 1978), introduced the edge-of-ROW EF interim standard of 1.6 kV/m, and stated that it is applicable to a height of 1 m (3.28 ft) above ground level and with the line at the rated voltage. Similar to the MF interim standard, this EF interim standard is not health-based and is about 2.6 times lower than the health-based guideline issued by the ICNIRP for allowable public exposure to EFs (4.2 kV/m; ICNIRP, 2010).

3 MF Modeling for Representative Underground Line Cross Sections

3.1 Software Program Used for Modeling MFs

The "EMF and Corona Effects Analysis" calculation program, designed by the Bonneville Power Administration (BPA) of the United States (US) Department of Energy, was used to calculate aboveground MFs from the proposed underground transmission line.[2] This program operates using Maxwell's equations, which accurately apply the laws of physics as related to electricity and magnetism (EPRI, 1982, 1993). Modeled fields using this program are both precise and accurate for the input data used. The results of the model have been checked against results from other software (*e.g.*, Southern California Edison's FIELDS program), confirming that the implementation of the laws of physics in this program is consistent. The BPA calculation program reports the root mean square (RMS) values of the real "maximum" rotating magnetic fields, *i.e.*, the RMS values of the semi-major axis magnitudes of the field ellipse that are known as $B_{Maximum}$ or B_{Max}. These results are thus consistent with the NYSPSC guidelines that specifically refer to the calculation of the "maximum rms flux density" magnetic fields (NYSPSC, 1990). Underground lines produce no aboveground electric fields, so these new underground 138 kV conductors will not produce any aboveground electric fields and no electric field modeling was performed.

3.2 Conductor Rating Information

Per Article VII requirements, all MF modeling was conducted for winter normal conductor ratings. Table 3.1 summarizes the voltage and winter normal conductor ratings for the new underground 138-676 Project line.

[2] Note that the MF modeling calculations for the overhead transmission line cross sections are discussed in Section 4.

Table 3.1 Voltage and Winter Normal Conductor Ratings for the Project 138-676 Underground Transmission Line

Line Section	Voltage (kV)	Winter Normal Conductor Rating (A per Conductor)
Typical Underground Line Sections: Typical Direct Buried Conduits in Trefoil Configuration (two conductors per phase)	138	757.5
Jumper Sections: Typical Direct Buried Conduits in Trefoil Configuration (one conductor per phase)	138	706.0
Trenchless Excavation Line Sections: Conduits in Bore Configuration (two conductors per phase)	138	757.5

Notes:
A = Ampere; kV = Kilovolt.

3.3 Modeled Representative Underground Line Cross Sections

MF modeling was conducted for three underground line cross sections representative of typical underground line installation cases with differing configurations for the Project 138 kV phase conductors:

1. Typical direct buried conduits in trefoil configuration, with two conductors per phase, as shown in Figure 3.1. This is to be the default conductor configuration for the typical underground line sections.
2. Typical direct buried conduits in trefoil configuration for jumper sections, with one conductor per phase, as shown in Figure 3.2.
3. Typical trenchless crossing bore, as shown in Figure 3.3

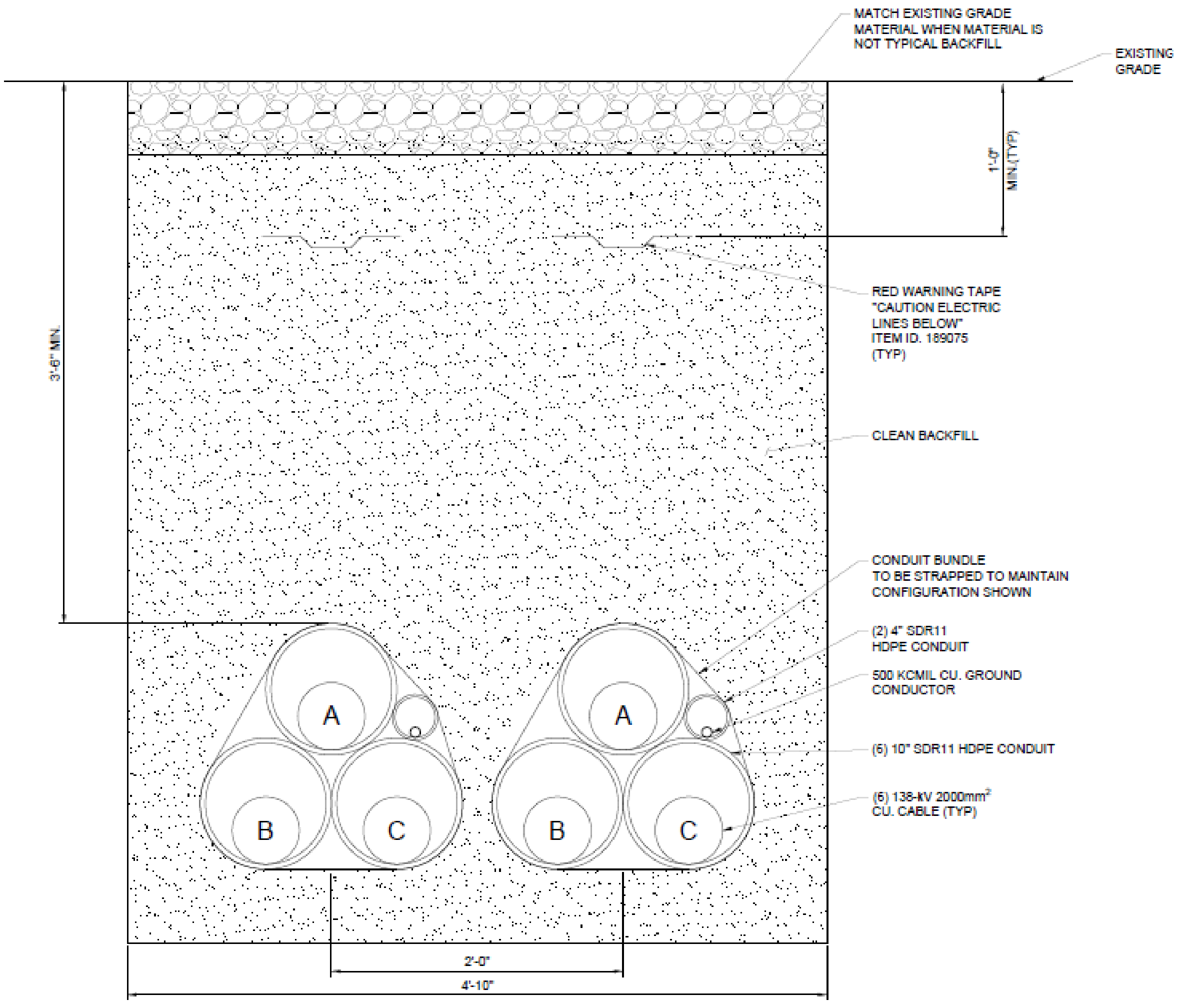

Figure 3.1 Representative Cross Sectional View for Typical Underground Line Sections with Typical Direct Buried Conduits in Trefoil Configuration (Two Conductors per Phase). As provided by Burns & McDonnell. Assumed conductor phasing is indicated. Each phase conductor is installed in the bottom of a 10-inch SDR11 high-density polyethylene (HDPE) conduit.

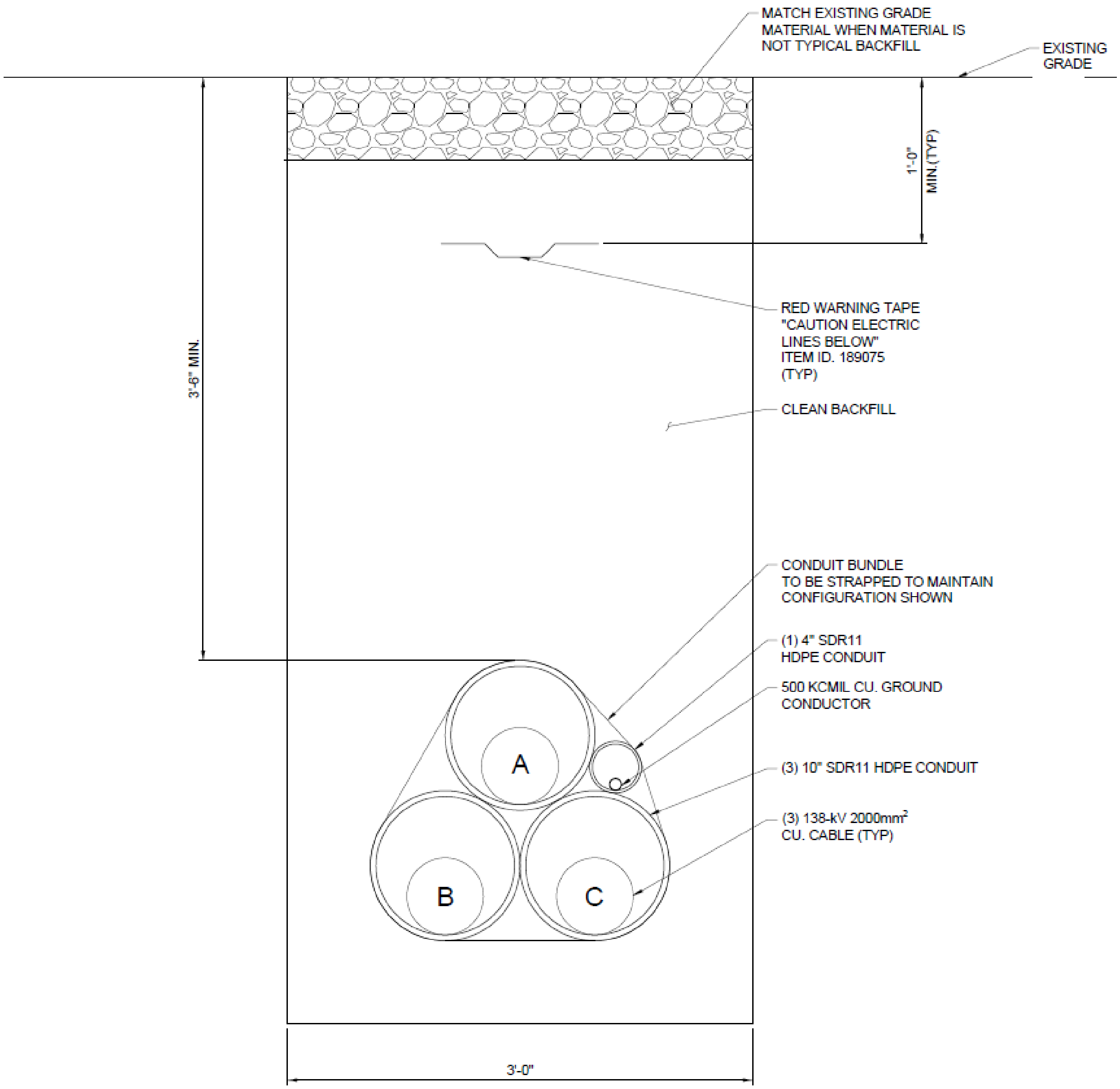

Figure 3.2 Representative Cross Sectional View for Underground Line Jumper Sections with Typical Direct Buried Conduits in Trefoil Configuration (One Conductor per Phase). As provided by Burns & McDonnell. Assumed conductor phasing is indicated. Each phase conductor is installed in the bottom of a 10-inch SDR11 HDPE conduit.

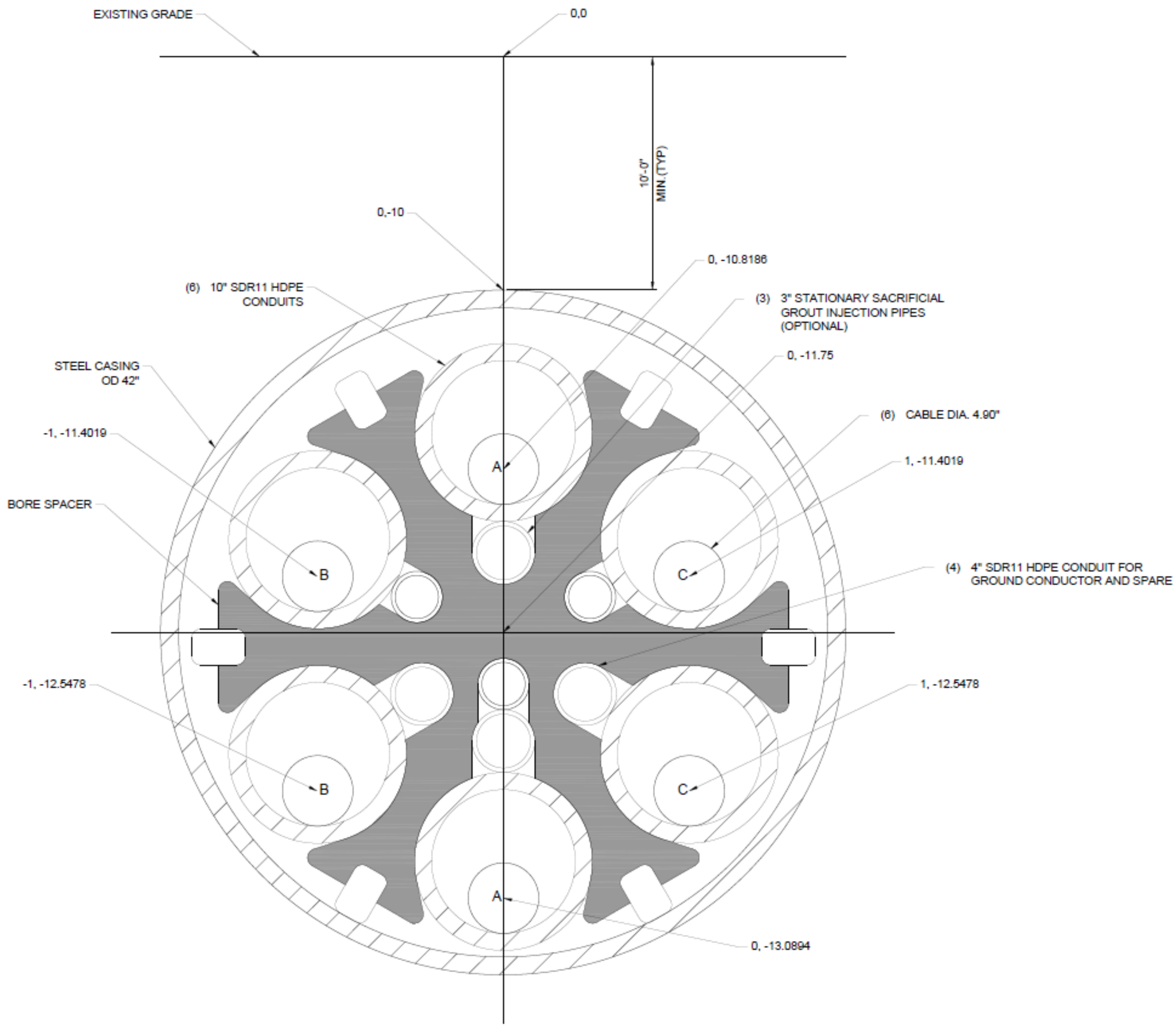

Figure 3.3 Representative Cross Sectional View for Underground Line Trenchless Crossing Sections with Conduits in Bore Configuration (Two Conductors per Phase). As provided by Burns & McDonnell. Assumed conductor phasing is indicated. Each phase conductor is installed in the bottom of a 10-inch SDR11 HDPE conduit.

For each of the representative underground line cross sections, aboveground MFs were modeled as a function of horizontal distance, perpendicular to the direction of current flow. MF levels were calculated out to 100 feet on either side of the conductor centerline, with MF levels at ±25 feet selected to represent edge-of-ROW MF levels. Per standard industry practices (IEEE Power Engineering Society, 1995a,b), MF levels were modeled at a height of 1 meter above the ground surface. For both the typical underground line sections and jumper sections with the typical direct buried conduits in trefoil configuration, each phase conductor was assumed to lie in the bottom of the 10-inch SDR11 HDPE conduits, and horizontal and vertical conductor coordinates were calculated based on the minimum cover depth, the dimensions shown in Figures 3.1 and 3.2, and conductor specifications (see Appendix A). Burns & McDonnell provided horizontal and vertical conductor coordinates for the representative trenchless crossing bore cross section (Figure 3.3). Based on minimum cover depths, burial depths to the centers of the uppermost phase conductors ranged from approximately 4.1 feet (for the typical underground line sections and jumper sections with the typical direct buried conduits in trefoil configurations) to 10.8 feet (for the trenchless crossing bore).

3.4 MF Modeling Results

Results of the MF modeling for the representative underground line cross sections are summarized in Table 3.2 and Figures 3.4 to 3.6. A tabular summary of modeled MF levels out to distances ±100 feet from the centerline of the conductors is presented in Appendix C. As shown in each of the figures, for assumed line loadings equal to winter normal conductor ratings, modeled MFs are below the NYSPSC edge-of-ROW MF interim standard of 200 mG at the assumed ROW edges ±25 feet from the centerline of the Project underground conductors, as well as directly above the conductor centerlines, for all modeled representative cross sections. Moreover, the maximum modeled MF values directly above the conductor centerline remain well below the health-based guideline issued by the ICNIRP for allowable public exposure to MFs (2,000 mG; ICNIRP, 2010). The figures demonstrate how modeled MFs drop off rapidly with increasing lateral distance away from the Project conductors.

Table 3.2 Summary of Modeled Magnetic Fields (MFs) 1 Meter Above Ground Surface for the Representative Project Underground Transmission Line Cross Sections

Cross Section	Max. MF (mG), Directly Above Centerline	ROW Edge MF (mG), -25 ft from Centerline	ROW Edge MF (mG), +25 ft from Centerline
Typical Underground Line Sections: Typical Direct Buried Conduits in Trefoil Configuration (two conductors per phase)	124.9	11.5	11.5
Jumper Sections: Typical Direct Buried Conduits in Trefoil Configuration (one conductor per phase)	61.2	5.3	5.3
Trenchless Excavation Line Sections: Conduits in Bore Configuration (two conductors per phase)	74.0	20.1	20.1

Notes:
ft = Feet; mG = Milligauss; ROW = Right-of-Way.

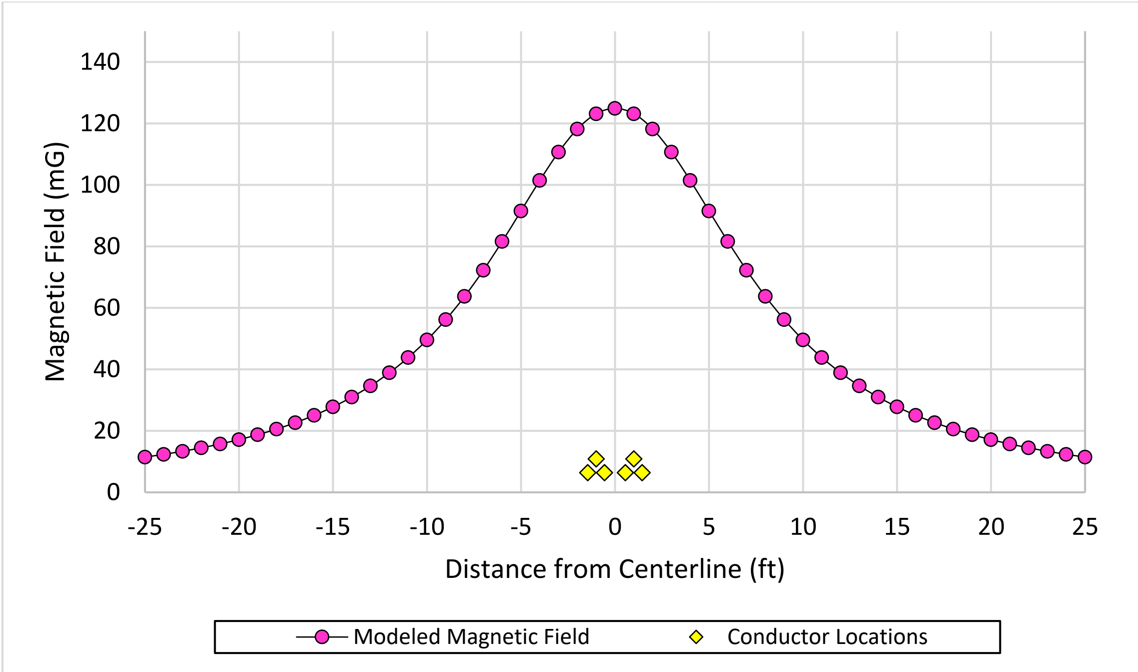

Figure 3.4 Magnetic Field Modeling Results for Typical Underground Line Sections with Typical Direct Buried Conduits in Trefoil Configuration (Two Conductors per Phase). ft = Foot; mG = Milligauss. Modeled MF levels are for winter normal conductor ratings and a height of 1 m (3.28 ft) above the ground surface.

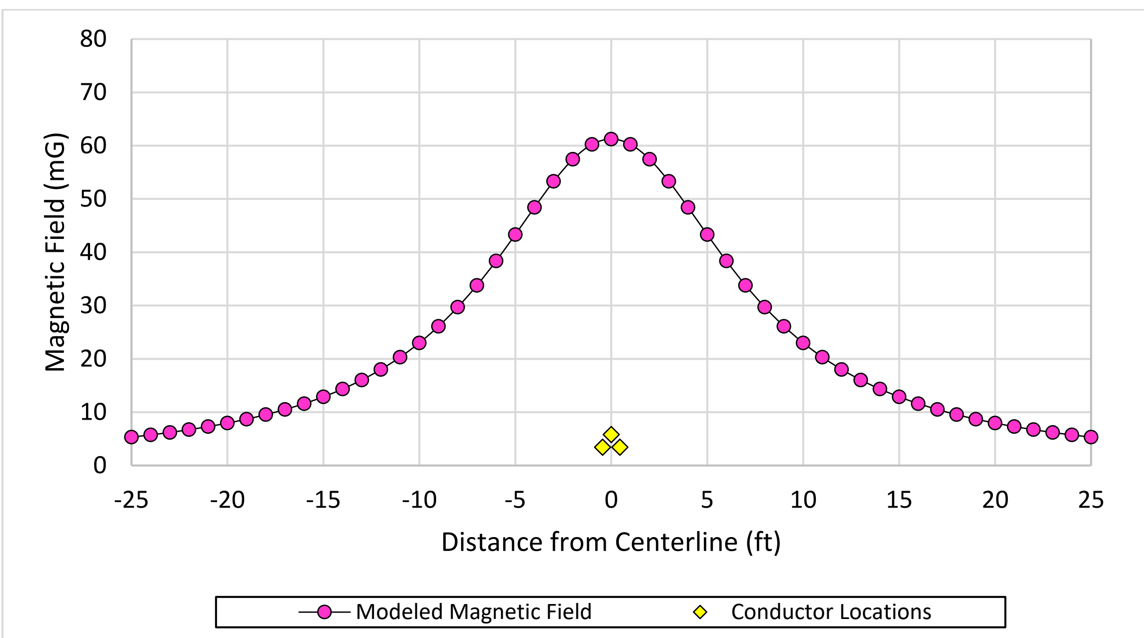

Figure 3.5 Magnetic Field Modeling Results for Underground Line Jumper Sections with Typical Direct Buried Conduits in Trefoil Configuration (One Conductor per Phase). ft = Foot; mG = Milligauss. Modeled MF levels are for winter normal conductor ratings and a height of 1 m (3.28 ft) above the ground surface.

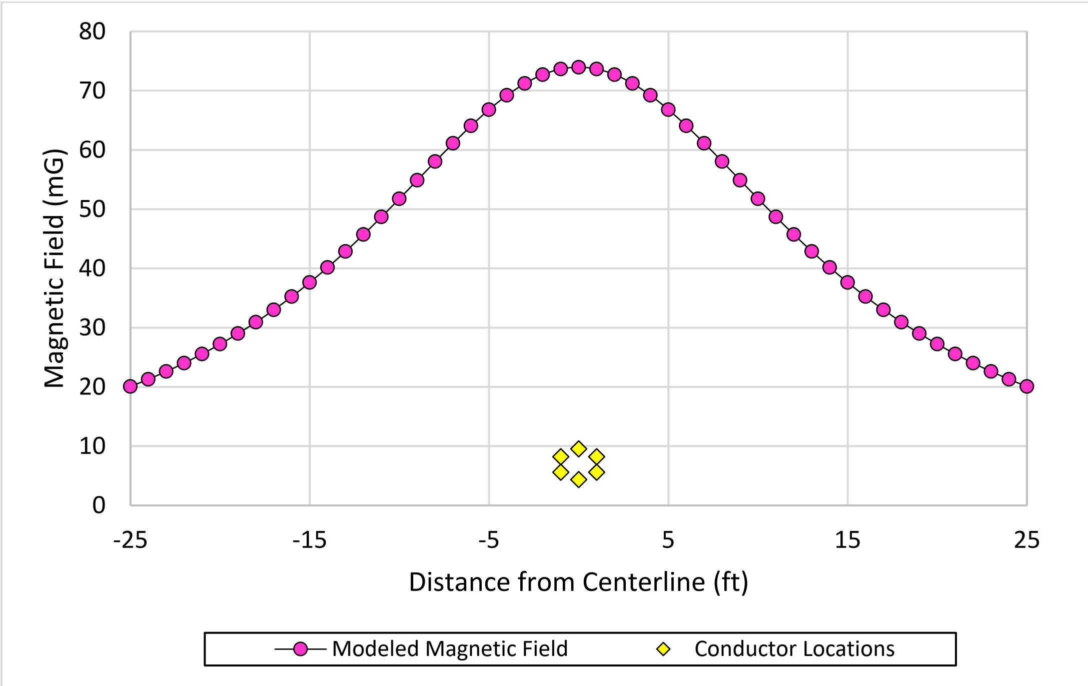

Figure 3.6 Magnetic Field Modeling Results for Underground Line Trenchless Crossing Sections with Conduits in Bore Configuration (Two Conductors per Phase). ft = Foot; mG = Milligauss. Modeled MF levels are for winter normal conductor ratings and a height of 1 m (3.28 ft) above the ground surface.

4 EMF Modeling for Representative Overhead Line Cross Sections

4.1 Software Program Used for Modeling EMFs

The commercial package COMSOL MultiPhysics Version 6.2, which is a finite element analysis, solver, and simulation software suite that includes the AC/DC Module for simulation of AC/DC electromagnetics in 2D and 3D, was used to calculate both electric and magnetic fields for the representative overhead transmission line cross sections. COMSOL was used rather than the BPA "EMF and Corona Effects Analysis" calculation program because COMSOL can account for the turns in the path of the overhead circuit, as well as the changes to the heights and vertical and horizontal spacing of the phase conductors. Similar to the BPA "EMF and Corona Effects Analysis" calculation program, COMSOL's AC/DC Module also operates using Maxwell's equations, which accurately apply the laws of physics as related to electricity and magnetism (EPRI, 1982, 1993), and modeled fields using this program are both precise and accurate for the input data used. COMSOL allows the user to define the geometry of the transmission lines and sources of voltage and current, assign material properties, and apply boundary conditions. The software uses the finite element method (FEM) to discretize the domain and compute the distribution of electric and magnetic fields, with capabilities for both time and frequency domain studies.

4.2 Conductor Rating Information

Per Article VII requirements, MF modeling was conducted for winter normal conductor ratings, and EF modeling for the voltage ratings. Table 4.1 summarizes the voltage and winter normal conductor ratings for the Project 138 kV overhead transmission line (Circuit 138-676). Both the existing and proposed conductors are 2,300 kilocircular mil (kcmil) (61 wire) all-aluminum conductor (AAC) "Pigweed" conductors.

Table 4.1 Voltage and Winter Normal Conductor Ratings for the Project 138-676 Overhead Transmission Line

Voltage (kV)	Winter Normal Conductor Rating (A)
138	2371

Notes:
A = Ampere; kV = Kilovolt.

4.3 Modeled Representative Overhead Line Cross Sections

Burns & McDonnell provided B&B with one existing overhead transmission line cross section diagram and two proposed overhead transmission line cross section diagrams, as well as a plan view diagram, detailing the existing and proposed line geometries and conductor configurations of the Circuit 138-676 underground to overhead transition at the Woodbury Tap (Appendix A). For the pre-Project cross section for the existing overhead line segment from Existing Steel Pole #20 to the Existing Riser 20S Poles (Appendix A Figure

A.1), B&B modeled pre-Project EMFs expected to exist 1 m (3.28 ft) above the ground surface both on and off the utility property, including at the property lines to the south of existing Steel Pole #20 and to the north of the Existing Riser 20S Poles that are designated as ROW edges in the existing cross section. The post-Project model included the proposed overhead line segments from the Proposed Riser on the newly purchased property at 133 Woodbury Road to the Proposed Steel Pole #21, from the Proposed Steel Pole #21 to the Existing Steel Pole #20, and from the Existing Steel Pole #20 to the Proposed Steel Pole #20N to the Existing Riser 20S Poles (Appendix A Figure A.1 through A.3). B&B modeled post-Project EMFs expected to exist 1 m (3.28 ft) above the ground surface both on and off the utility properties, including at the property lines designated as ROW edges in the two post-Project cross sections. As shown in Appendix A Figure A.1, for the first post-Project cross section from Existing Steel Pole #20 to the Proposed Steel Pole #20N to the Existing Riser 20S Poles, ROW edges were designated at the property lines to the south of existing Steel Pole #20 and to the north of the Existing Riser 20S Poles, similar to the pre-Project cross section. For the second post Project cross section from the Proposed Riser on the newly purchased property at 133 Woodbury Road to the Proposed Steel Pole #21, ROW edges were designated at the property lines south of the Proposed Riser on 133 Woodbury Road and north of Proposed Steel Pole #21 and the railroad tracks (Appendix A Figure A.2). Per Article VII requirements, all EMF modeling was conducted for the rated line voltages and winter normal conductor ratings. EMF levels were modeled at a height of 1 m (3.28 ft) above the ground surface per standard industry practices (IEEE Power Engineering Society, 1995a,b).

In total, four models were set up in COMSOL, including both pre-Project and post-Project EF models, and both pre-Project and post-Project MF models. Each model was based on either the pre-Project or post-Project line geometry and incorporated information on pole locations and conductor vertical and horizontal spacing obtained from the cross section diagrams. As a simplifying assumption, flat terrain was assumed in all models, where conductor heights were scaled off the minimum clearance heights at the location of maximum sag and structure heights provided by Burns & McDonnell. In addition to the phase conductors, a 7#6 Alumoweld 7-strand shield wire (diameter of 0.486 inches) was included in the post-Project EF model at the top of the proposed structures between the Proposed Riser on the newly purchased property at 133 Woodbury Road and the Proposed Steel Pole #21, between the Proposed Steel Pole #21 and the existing Steel Pole #20, and between the existing Steel Pole #20 and the Proposed Steel Pole #20N.

4.4 MF Modeling Results

Table 4.2 summarizes the MF modeling results for the pre-Project and post-Project cross sections, while Figures 4.1 and 4.2 show the full distributions of MF modeling results for the pre-Project and post-Project models, respectively. As indicated in Table 4.2, modeled post-Project MF levels at the property lines designated as ROW edges for the two representative overhead line cross sections will comply with the NYSPSC edge-of-ROW MF interim standard of 200 mG. Table 4.2 also shows post-Project MF levels at distances of 25 and 50 ft from the ROW edges, illustrating the rapid drop-off in MF levels moving away from the ROW edges. Figure 4.2 further illustrates the rapid drop-off in MF levels moving away from the post-Project ROW edges, and also shows that all modeled MF levels are well below the health-based guideline issued by the ICNIRP for allowable public exposure to MFs (2,000 mG; ICNIRP, 2010).

Table 4.2 Summary of Modeled Magnetic Fields 1 Meter Above Ground Surface for the Representative Overhead Transmission Line Cross Sections

Cross Section	Magnetic Field (mG)					
	Southern Edge-of-ROW			Northern Edge-of-ROW		
	ROW Edge	25 Feet from ROW Edge	50 Feet from ROW Edge	ROW Edge	25 Feet from ROW Edge	50 Feet from ROW Edge
Pre-Project CS1[a]	58.0	16.8	13.4	72.1	40.1	27.1
Post-Project CS1[b]	109.1	58.9	25.9	84.5	47.4	32.0
Post-Project CS2[c]	15.6	9.5	7.0	42.2	33.9	29.6

Notes:
CS = Cross Section; mG = Milligauss; ROW = Right-of-Way.
(a) Pre-Project CS1 is for the existing line segment from the Existing Steel Pole #20 to the Existing Riser 20S Poles.
(b) Post-Project CS1 is for the proposed line segment from the Existing Steel Pole #20 to the Proposed Steel Pole #20N to the Existing Riser 20S Poles.
(c) Post-Project CS2 is for the proposed line segment from the Proposed Riser Pole on the 133 Woodbury Road property to the Proposed Steel Pole #21.

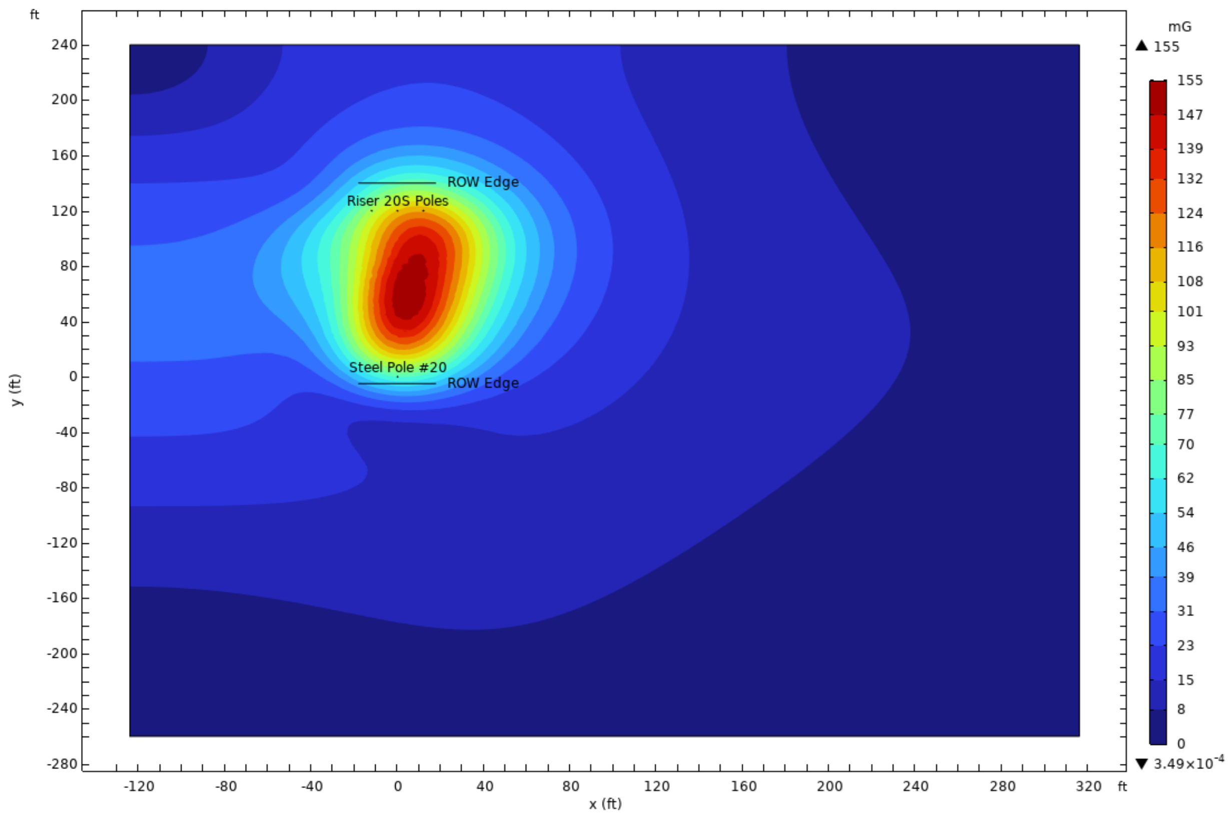

Figure 4.1 Distribution of Modeled Magnetic Fields 1 Meter Above Ground Surface: Existing 138-676 Circuit from Existing Steel Pole #20 to Existing Riser 20S Poles. ft = Foot; mG = Milligauss. Modeled MF levels are for winter normal conductor ratings and a height of 1 m (3.28 ft) above the ground surface.

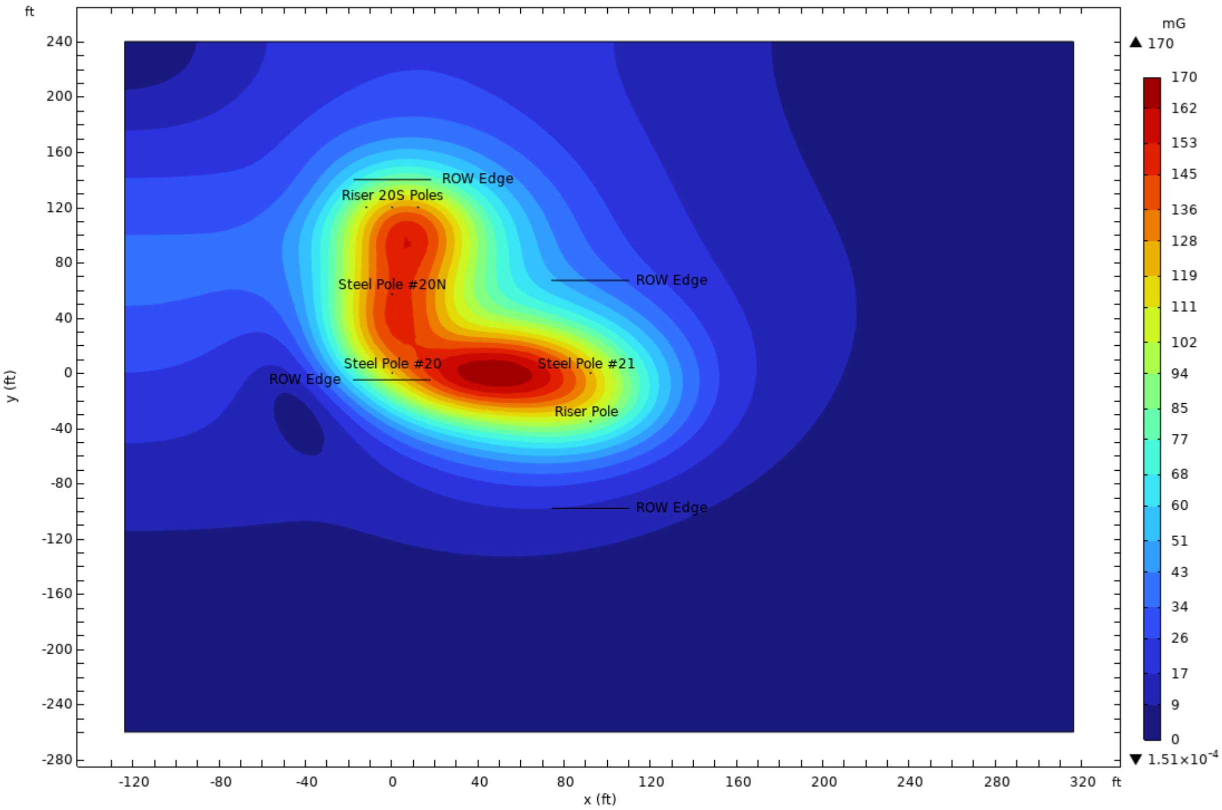

Figure 4.2 Distribution of Modeled Magnetic Fields 1 Meter Above Ground Surface: Proposed 138-676 Circuit from Proposed Riser Pole to Proposed Steel Pole #21 to Existing Steel Pole #20 to Proposed Steel Pole #20N to Existing Riser 20S Poles. ft = Foot; mG = Milligauss. Modeled MF levels are for winter normal conductor ratings and a height of 1 m (3.28 ft) above the ground surface.

4.5 EF Modeling Results

Table 4.3 summarizes the EF modeling results for the pre-Project and post-Project representative overhead line cross sections, while Figures 4.3 and 4.4 show the full distributions of EF modeling results for the pre-Project and post-Project models, respectively. As indicated in Table 4.3, modeled post-Project EF levels at the property lines designated as ROW edges will comply with the NYSPSC edge-of-ROW EF interim standard of 1.6 kV/m. Table 4.3 also shows post-Project EF levels at distances of 25 and 50 ft from the ROW edges, illustrating the rapid drop-off in EF levels moving away from the ROW edges. Figure 4.4 further illustrates the rapid drop-off in EF levels moving away from the post-Project ROW edges, and also shows that all modeled EF levels are well below the health-based guideline issued by the ICNIRP for allowable public exposure to EFs (4.2 kV/m; ICNIRP, 2010).

Table 4.3 Summary of Modeled Electric Fields 1 Meter Above Ground Surface for the Representative Overhead Transmission Line Cross Sections

Cross Section	Electric Field (kV/m)					
	Southern Edge-of-ROW			Northern Edge-of-ROW		
	ROW Edge	25 Feet from ROW Edge	50 Feet from ROW Edge	ROW Edge	25 Feet from ROW Edge	50 Feet from ROW Edge
Pre-Project CS1[a]	0.33	0.08	0.02	0.04	0.05	0.04
Post-Project CS1[b]	0.99	0.45	0.13	0.06	0.07	0.06
Post-Project CS2[c]	0.02	0.02	0.02	0.07	0.03	0.05

Notes:
CS = Cross Section; kV/m = Kilovolts per Meter; ROW = Right-of-Way.
(a) Pre-Project CS1 is for the existing line segment from the Existing Steel Pole #20 to the Existing Riser 20S Poles.
(b) Post-Project CS1 is for the proposed line segment from the Existing Steel Pole #20 to the Proposed Steel Pole #20N to the Existing Riser 20S Poles.
(c) Post-Project CS2 is for the proposed line segment from the Proposed Riser Pole on the 133 Woodbury Road property to the Proposed Steel Pole #21.

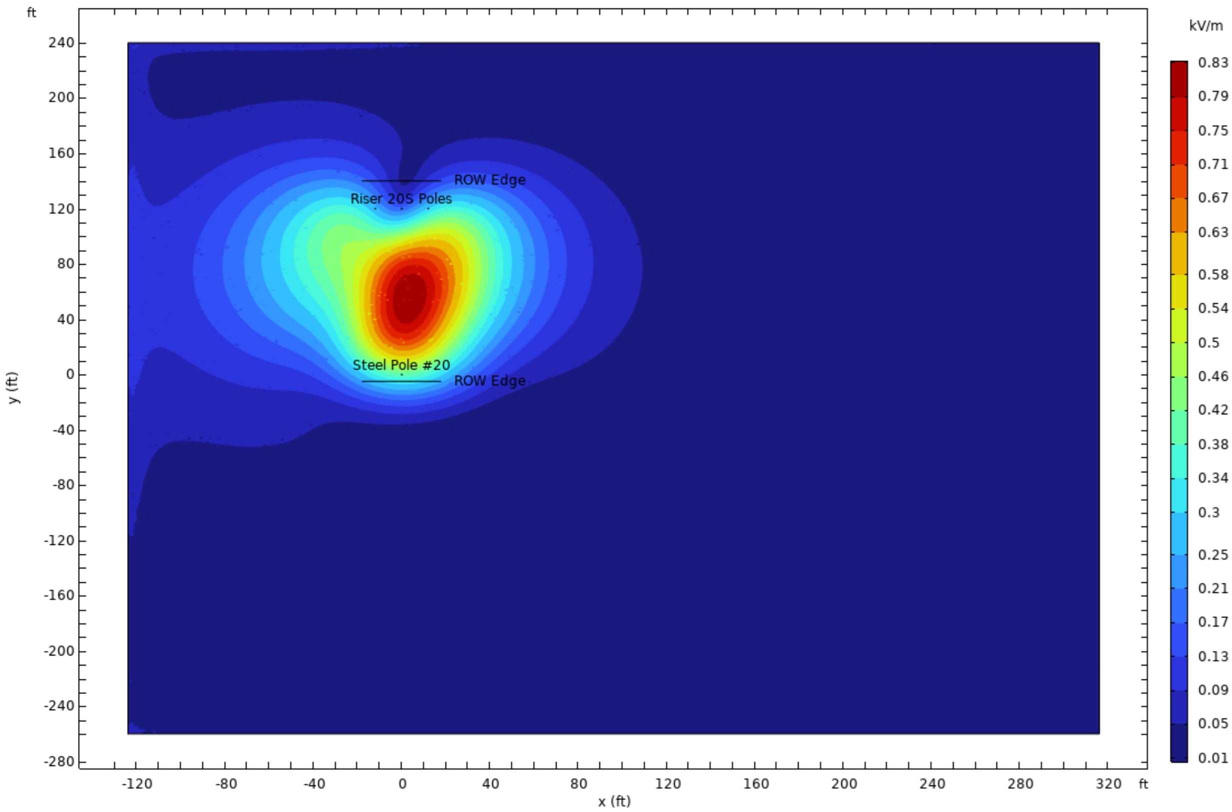

Figure 4.3 Distribution of Modeled Electric Fields 1 Meter Above Ground Surface: Existing 138-676 Circuit from Existing Steel Pole #20 to Existing Riser 20S Poles. ft = Foot; kV/m = Kilovolts per Meter. Modeled EF levels are for rated voltages and a height of 1 m (3.28 ft) above the ground surface.

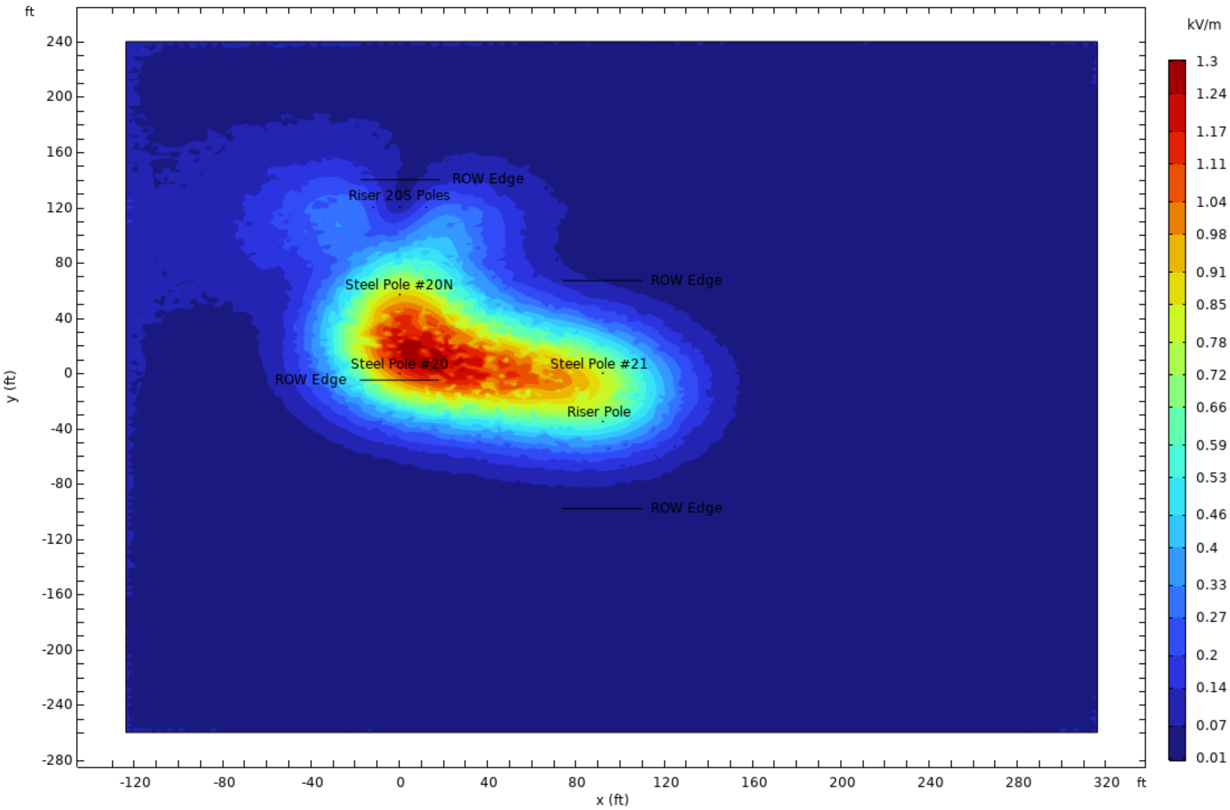

Figure 4.4 Distribution of Modeled Electric Fields 1 Meter Above Ground Surface: Proposed 138-676 Circuit from Proposed Riser Pole to Proposed Steel Pole #21 to Existing Steel Pole #20 to Proposed Steel Pole #20N to Existing Riser 20S Poles. ft = Foot; kV/m = Kilovolts per Meter. Modeled EF levels are for rated voltages and a height of 1 m (3.28 ft) above the ground surface.

5 Conclusions

B&B calculated MF levels at 1 meter above the ground surface for representative underground and overhead line cross sections, and EF levels at 1 meter above the ground surface for representative overhead line sections, for the Syosset to Oakwood 138 kV Transmission Line Project. We modeled MF levels for electric current loading levels at the winter normal conductor ratings, and EF levels for rated voltages. Our EMF modeling calculations demonstrate that modeled post-Project MF levels at designated ROW edges for each representative underground and overhead transmission line cross section will comply with the NYSPSC edge-of-ROW MF interim standard of 200 mG. In addition, our calculations demonstrate that modeled post-Project EF levels at designated ROW edges for the two representative overhead cross sections will comply with the NYSPSC edge-of-ROW EF interim standard of 1.6 kV/m.

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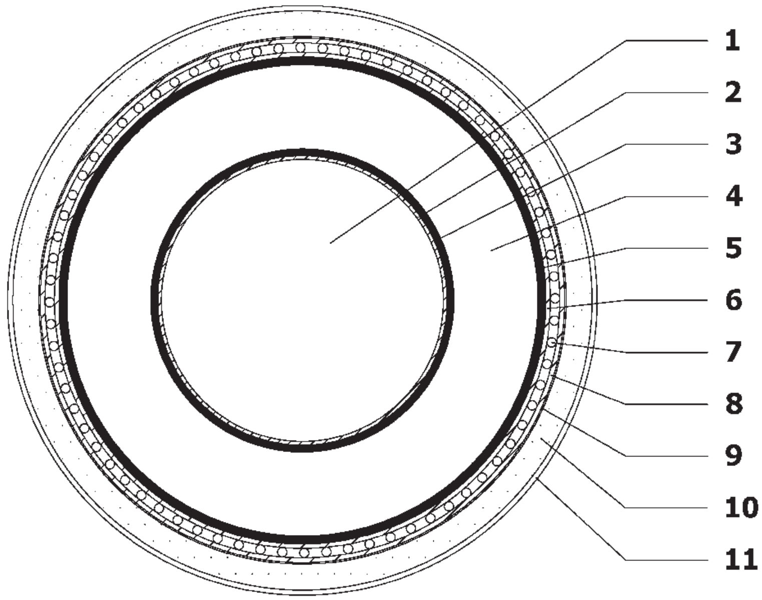
Appendix A

LS Cable Underground 138 kV Cable Specification

6. Characteristics & Cross-sectional drawing

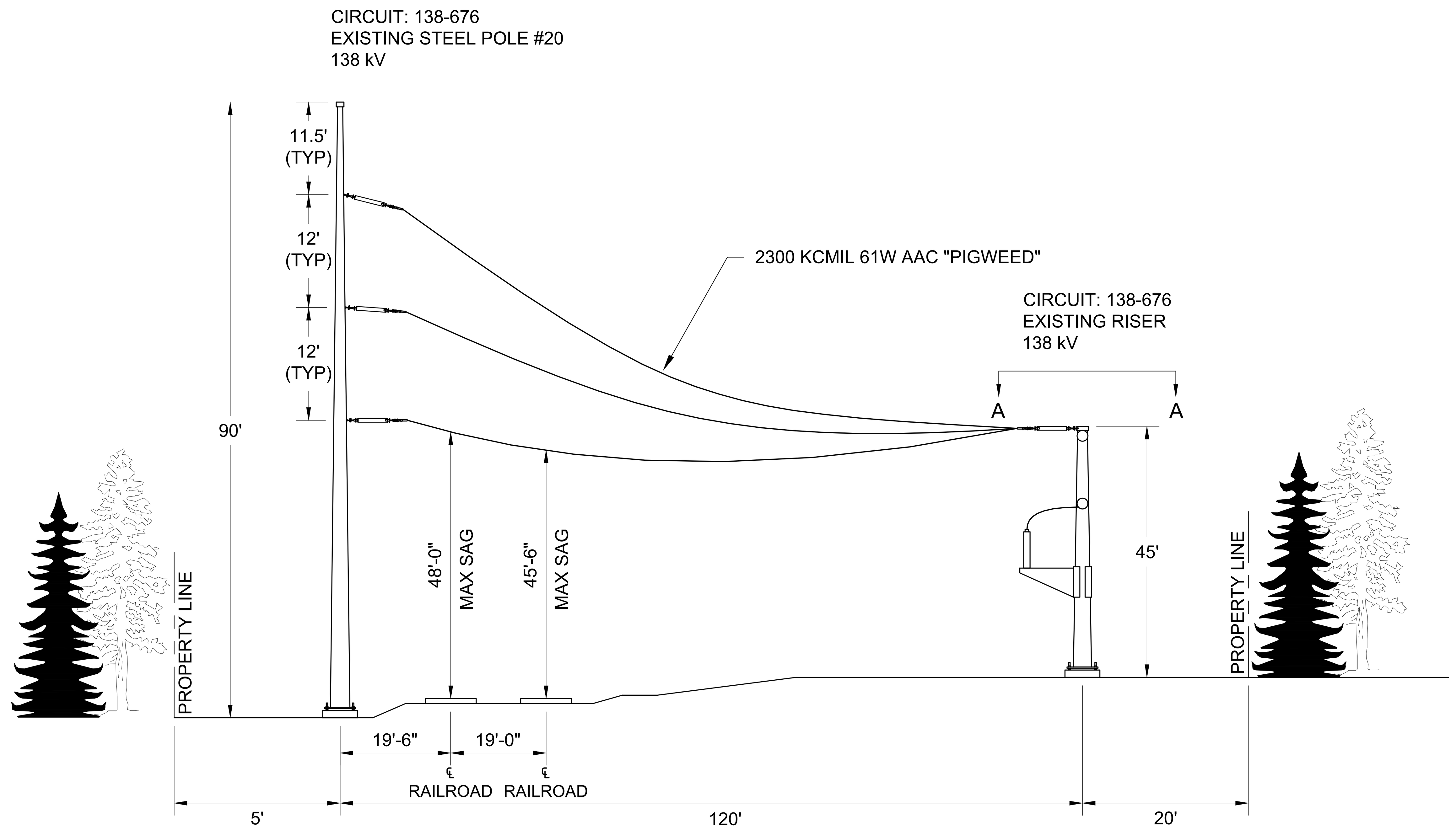
Scale : Not to scale



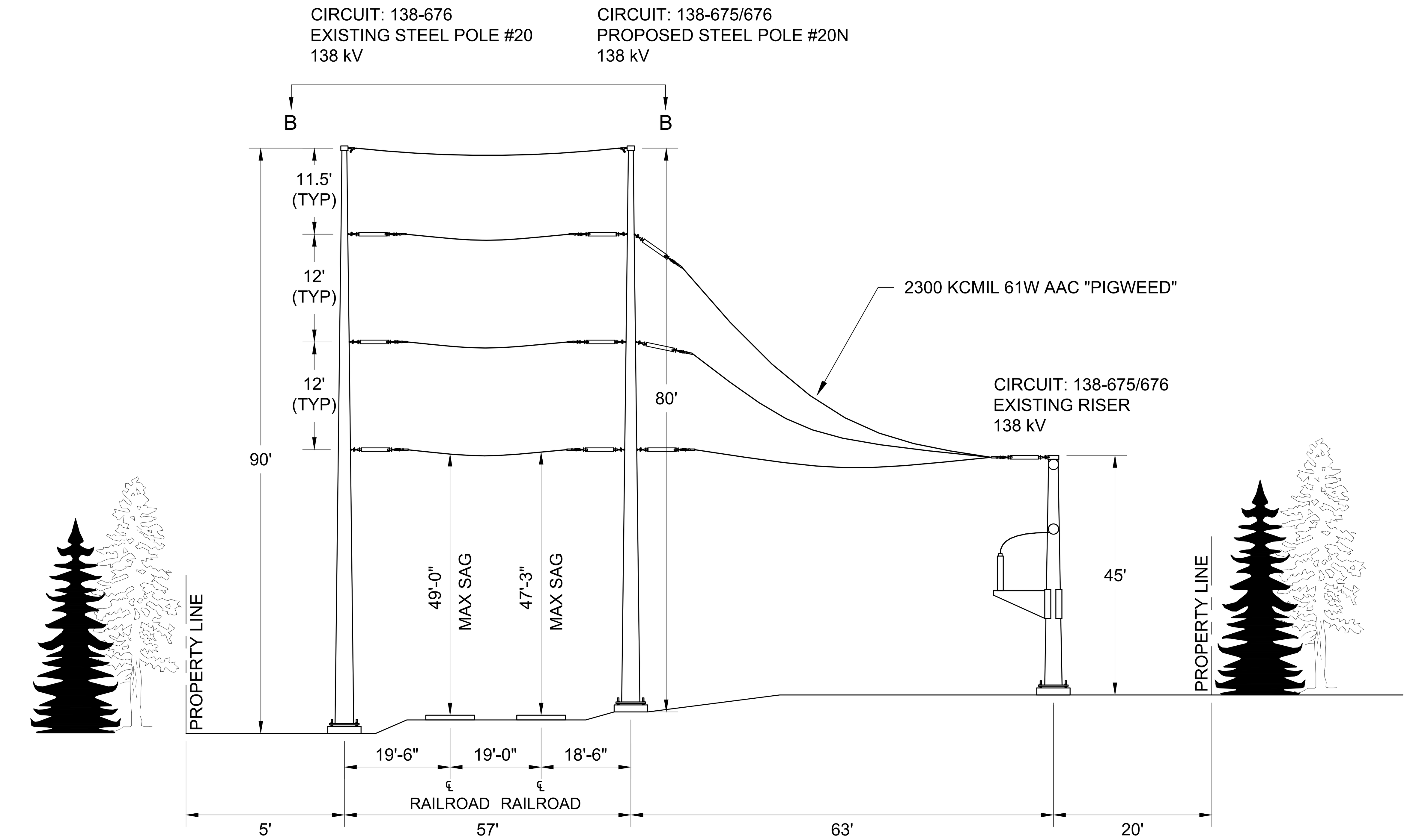
No.	Description	Unit	Particulars			
0	**Rated voltage**	kV	138			
1	**Conductor**		Plain annealed copper wires			
	- nominal cross-sectional area	mm²	1200	2000	2500	3000
	- shape		Segmental			
	- diameter (approx.)	inch(mm)	1.65(41.8)	2.14(54.3)	2.48(63.0)	2.72(69.0)
2	**Conductor binder**		Semi-conducting tape(s)			
3	**Conductor shield**		Semi-conducting thermosetting compound			
	- thickness (nom.)	mil(mm)	59(1.5)			
4	**Insulation**		Cross-linked polyethylene (XLPE)			
	- thickness (nom.)	mil(mm)	870(22.1)			
5	**Insulation shield**		Semi-conducting thermosetting compound			
	- thickness (nom.)	mil(mm)	59(1.5)			
6	**Water blocking layer**		Semi-conducting swellable tape(s)			
7	**Metallic shield**		Plain annealed copper wires			
	- diameter (nom.) x nos. of wires	mil(mm)xnos.	90.6(2.3) x 93			
8	**Water blocking layer**		Semi-conducting swellable tape(s)			
9	**Radial water impervious layer**		Laminated copper foil			
10	**Jacket**		Black LLDPE compound			
	- thickness (nom.)	mil(mm)	150(3.8)			
11	**Semi-conducting layer**		Black semi-conducting PE compound			
12	**Overall diameter** (approx.)	inch(mm)	4.41 (112.0)	4.90 (125)	5.24 (133)	5.48 (139)
13	**Weight of cable** (approx.)	lb/ft(kg/m)	14.7(21.9)	20.4(30.4)	24.3(36.2)	27.5(41.0)
14	**Conductor DC resistance** (20°C, max.)	Ω/kft(Ω/km)	0.00460 (0.0151)	0.00275 (0.0090)	0.00220 (0.0072)	0.00183 (0.0060)
15	**Capacitance** (nom.)	µF/kft(µF/km)	0.0627 (0.206)	0.0751 (0.246)	0.0836 (0.274)	0.0895 (0.294)

Appendix B

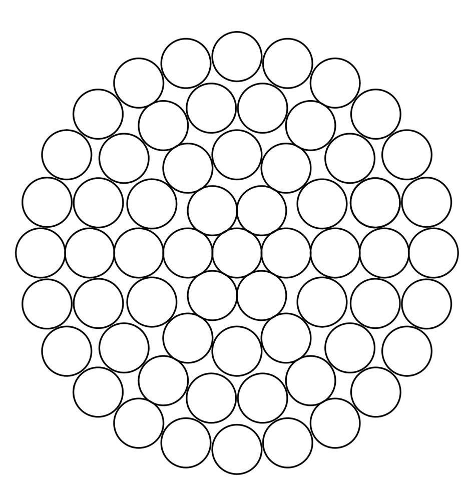
Woodbury Tap Representative Overhead Transmission Line Cross Sections and General Plan View



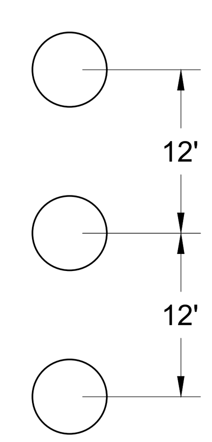
EXISTING CROSS SECTION



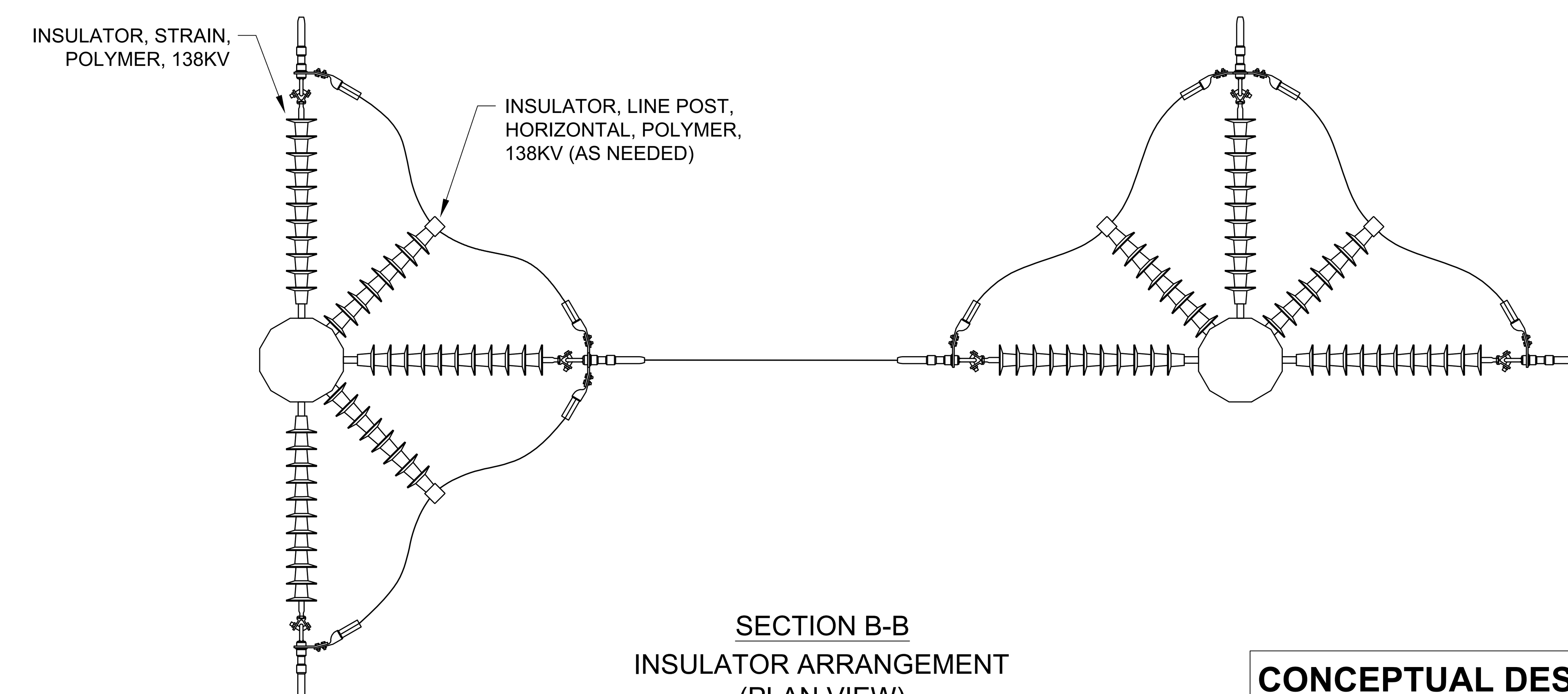
PROPOSED CROSS SECTION



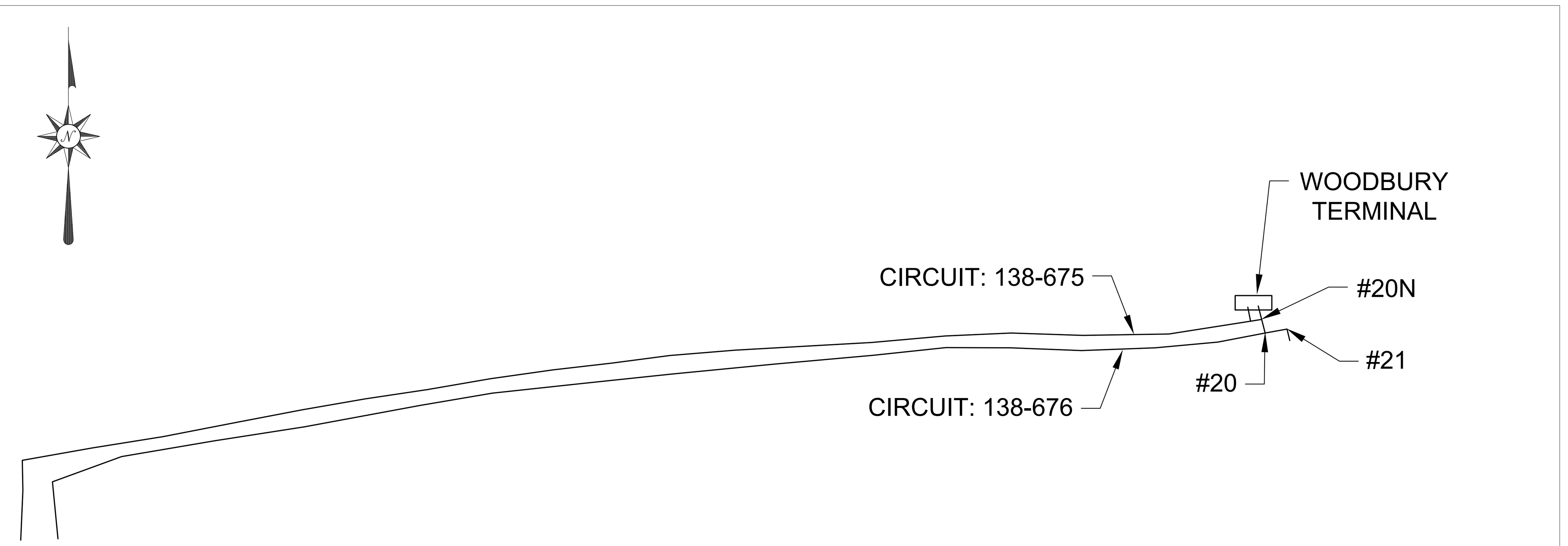
2300 KCMIL 61W AAC "PIGWEED" CROSS SECTION



SECTION A-A
EXISTING RISER PHASE SPACING



SECTION B-B
INSULATOR ARRANGEMENT
(PLAN VIEW)



CONCEPTUAL DESIGN SUBJECT TO CHANGE

NOTES:

1. ALL DIMENSIONS AND SPACING ARE PRELIMINARY AND SUBJECT TO CHANGE WITH FINAL SURVEY AND DESIGN.
2. CROSS SECTIONS ARE TYPICAL OF SEGMENT. VARIATIONS ALONG SEGMENT MAY OCCUR.
3. SECTION B-B REPRESENTS THE FULL POTENTIAL INSULATOR AND WIRE ARRANGEMENT. THIS ARRANGEMENT MAY BE REMOVED AND INSTALLED AT DIFFERENT TIMES PENDING OPERATIONAL NEEDS. FURTHER DETAILS ARE PROVIDED WITHIN THE ENVIRONMENTAL MANAGEMENT AND CONSTRUCTION PLAN.

REV	DATE	DESCRIPTION	DRAWN	REVIEW	APPR
A	3/7/2025	ARTICLE VII SUBMITTAL	JRO	JOC	MWK

BURNS McDONNELL
PROJ. NO. 178873

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NO.	DATE	W.O.	DESCRIPTION	DWN BY	CKD BY	REVIEWED	APPD
0	3/7/2025	L####	ORIGINAL ISSUE	JRO	JOC	M. KRUSE P.E.	S. MARZO P.E.

Long Island Power Authority
LONG ISLAND, NEW YORK

138KV TRANSMISSION LINE

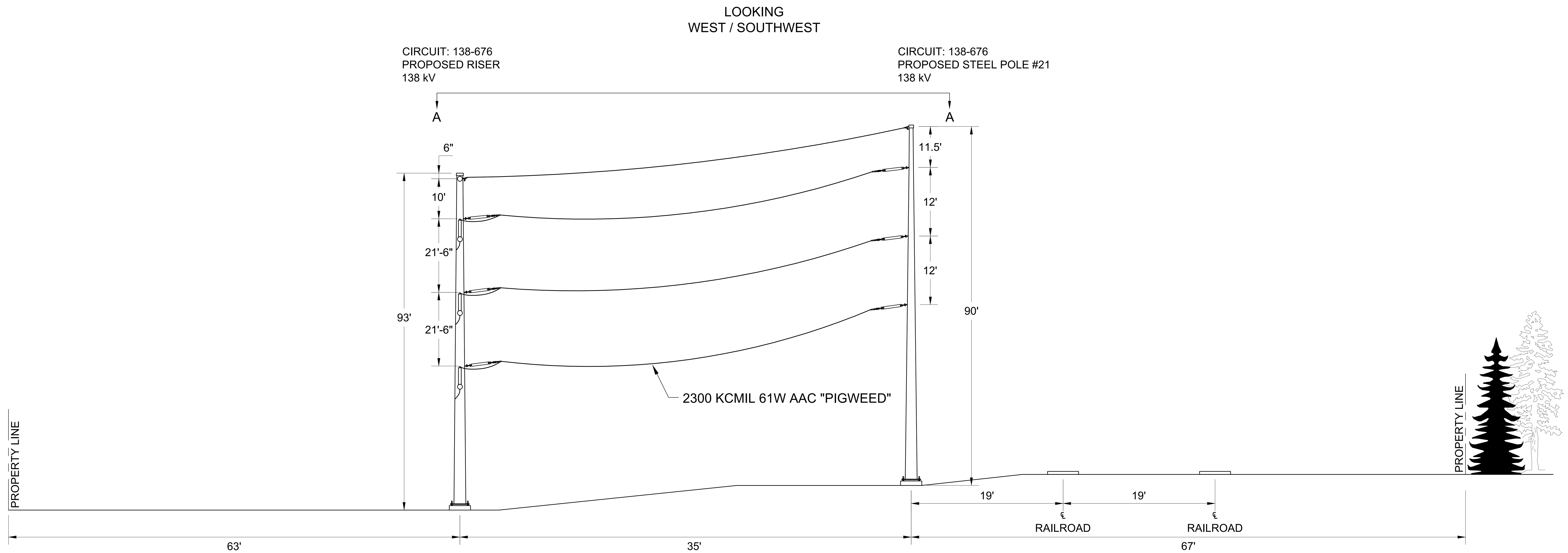
WOODBURY TERMINAL SOUTH
138KV OVERHEAD TRANSMISSION
GENERAL CROSS SECTION SHEET 1 OF 2

PSEG LONG ISLAND
175 East Old Country Road
Hicksville, New York

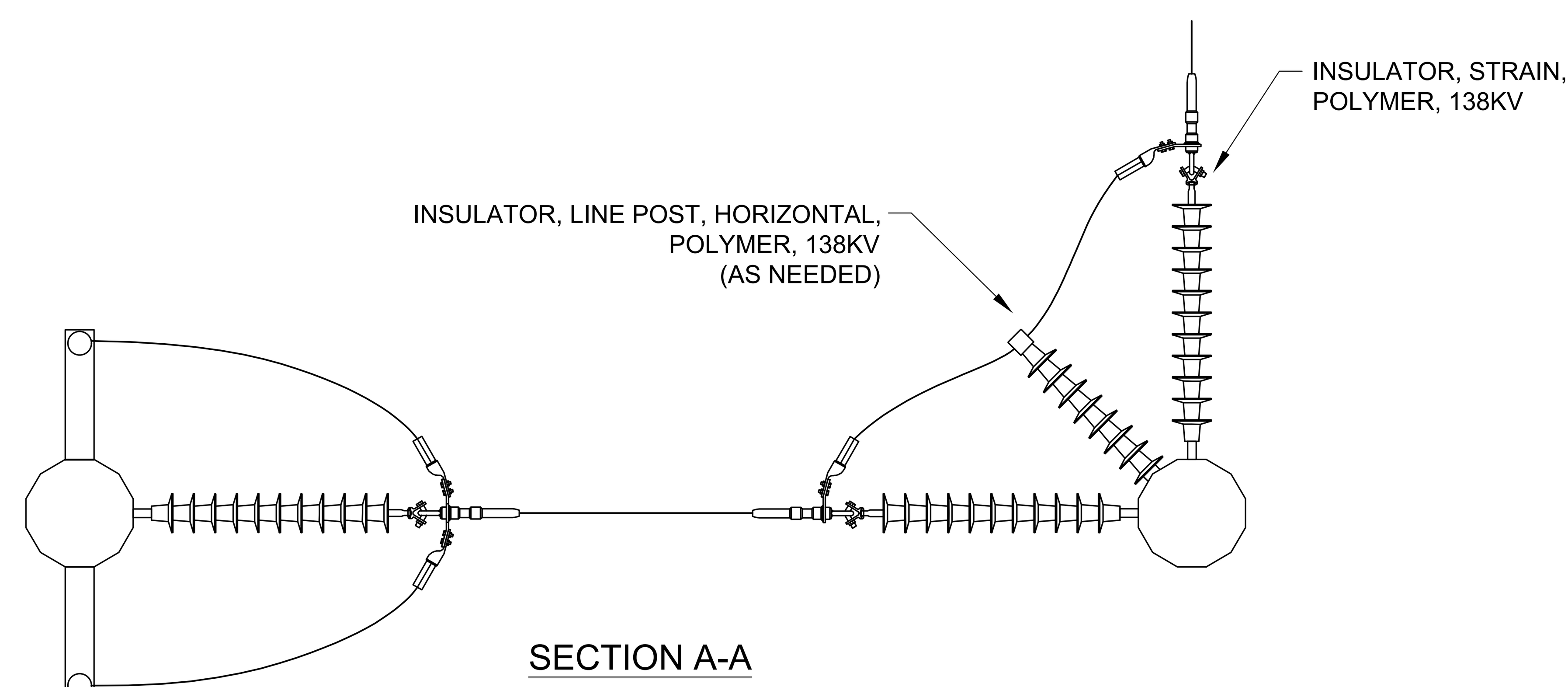
SCALE NONE | VENDOR DWG. NO.

DRAWING NO. Fxxxxxx | SMART NO. BWAxx-FU-xxxxxxx | REVISION 000

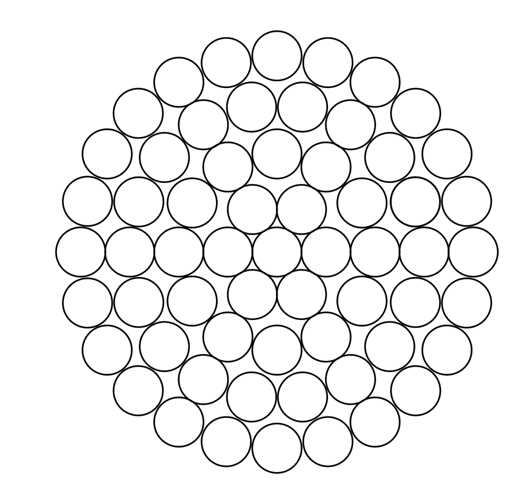
SYSTEM GRID NUMBER | CABINET NO. | FOLDER NO.



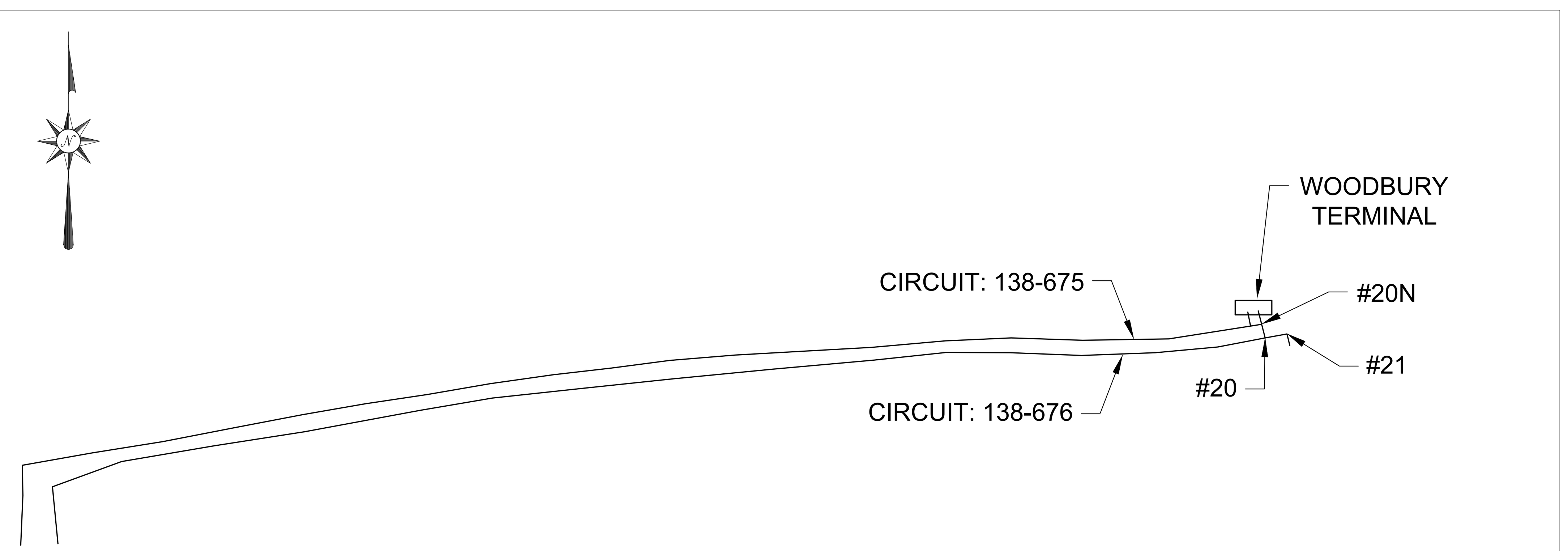
PROPOSED CROSS SECTION



SECTION A-A
INSULATOR ARRANGEMENT
(PLAN VIEW)



2300 KCMIL 61W AAC "PIGWEED" CROSS SECTION



**CONCEPTUAL DESIGN
SUBJECT TO CHANGE**

NOTES:

1. ALL DIMENSIONS AND SPACING ARE PRELIMINARY AND SUBJECT TO CHANGE WITH FINAL SURVEY AND DESIGN.
2. CROSS SECTIONS ARE TYPICAL OF SEGMENT. VARIATIONS ALONG SEGMENT MAY OCCUR.

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BURNS McDONNELL
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NO.	DATE	W.O.	DESCRIPTION	DWN BY	CKD BY	REVIEWED	APPD
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Long Island Power Authority
LONG ISLAND, NEW YORK

138KV TRANSMISSION LINE

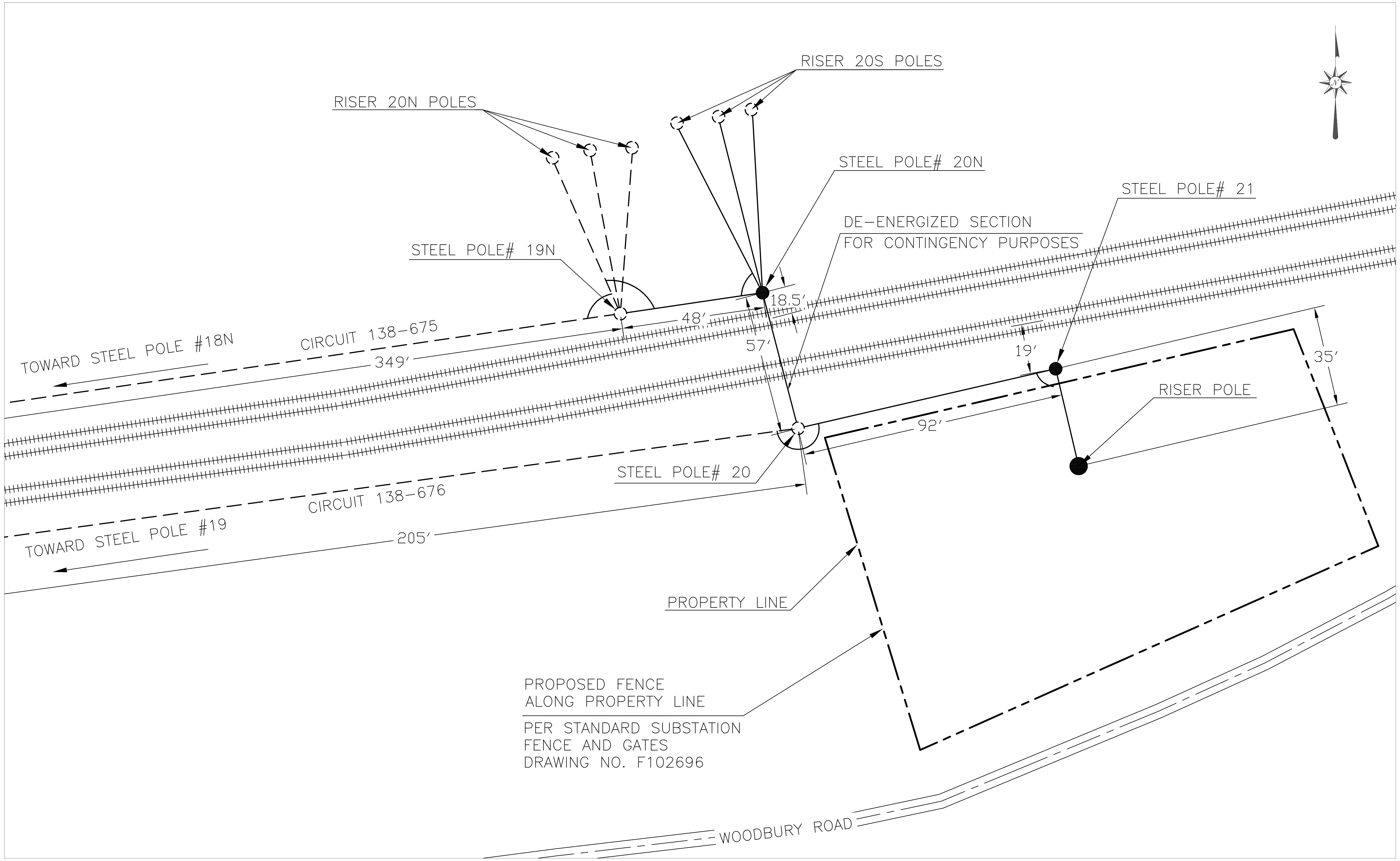
WOODBURY TERMINAL SOUTH
138KV OVERHEAD TRANSMISSION
GENERAL CROSS SECTION SHEET 2 OF 2

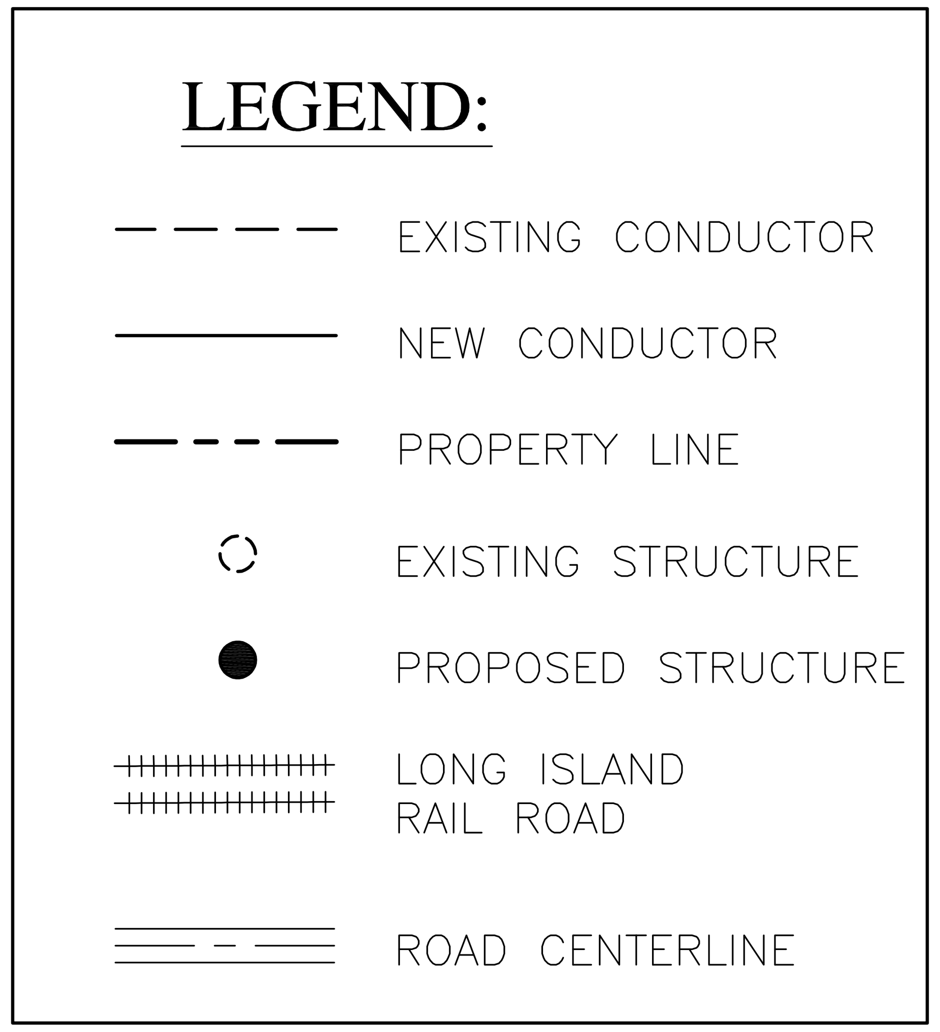
PSEG LONG ISLAND
175 East Old Country Road
Hicksville, New York

SCALE NONE
VENDOR DWG. NO.
DRAWING NO. Fxxxxxx
SMART NO. BWAxx-FU-xxxxxxx
REVISION 000
SYSTEM GRID NUMBER
CABINET NO.
FOLDER NO.

138KV OVERHEAD/UNDERGROUND TRANSITION

PLAN VIEW





REV	DATE	DESCRIPTION	DRAWN	REVIEW	APPR
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BURNS McDONNELL
PROJ. NO. 178873

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NO.	DATE	W.O.	DESCRIPTION	DWN BY	CKD BY	REVIEWED	APPD
	3/7/2025	L####	ORIGINAL ISSUE	JRO	JOC	M. KRUSE P.E.	S. MARZO P.E.

Long Island Power Authority
LONG ISLAND, NEW YORK
138KV TRANSMISSION LINE

WOODBURY TERMINAL SOUTH
138KV OVERHEAD TRANSMISSION
GENERAL PLAN VIEW

PSEG LONG ISLAND
175 East Old Country Road
Hicksville, New York

SCALE: NONE
VENDOR DWG. NO.
DRAWING NO. Fxxxxxx
SMART NO. BWAxx-FU-xxxxxxx
REVISION 000
SYSTEM GRID NUMBER
CABINET NO.
FOLDER NO.

Appendix C

Tabular Summaries of Modeled Magnetic Field Results 1 Meter Above Ground Surface for the Representative Underground Transmission Line Cross Sections

Table C.1 Summary of Modeled Magnetic Fields for Typical Underground Line Sections (Typical Direct Buried Conduits in Trefoil Configuration, with Two Conductors per Phase)

Distance from Centerline (ft)	Magnetic Field (mG)
-100	0.77
-99	0.79
-98	0.80
-97	0.82
-96	0.84
-95	0.85
-94	0.87
-93	0.89
-92	0.91
-91	0.93
-90	0.95
-89	0.97
-88	0.99
-87	1.02
-86	1.04
-85	1.06
-84	1.09
-83	1.12
-82	1.14
-81	1.17
-80	1.20
-79	1.23
-78	1.26
-77	1.30
-76	1.33
-75	1.37
-74	1.40
-73	1.44
-72	1.48
-71	1.52
-70	1.57
-69	1.61
-68	1.66
-67	1.71
-66	1.76
-65	1.81
-64	1.87
-63	1.93
-62	1.99
-61	2.06
-60	2.12
-59	2.20
-58	2.27
-57	2.35
-56	2.43
-55	2.52

Table C.2 Summary of Modeled Magnetic Fields for Jumper Sections (Typical Direct Buried Conduits in Trefoil Configuration, with One Conductor per Phase)

Distance from Centerline (ft)	Magnetic Field (mG)
-100	0.36
-99	0.37
-98	0.37
-97	0.38
-96	0.39
-95	0.40
-94	0.41
-93	0.41
-92	0.42
-91	0.43
-90	0.44
-89	0.45
-88	0.46
-87	0.47
-86	0.48
-85	0.50
-84	0.51
-83	0.52
-82	0.53
-81	0.55
-80	0.56
-79	0.57
-78	0.59
-77	0.60
-76	0.62
-75	0.64
-74	0.65
-73	0.67
-72	0.69
-71	0.71
-70	0.73
-69	0.75
-68	0.77
-67	0.80
-66	0.82
-65	0.84
-64	0.87
-63	0.90
-62	0.93
-61	0.96
-60	0.99
-59	1.02
-58	1.06
-57	1.09
-56	1.13
-55	1.17

Table C.3 Summary of Modeled Magnetic Fields for Trenchless Excavation Sections (Bore Configuration, with Two Conductors per Phase)

Distance from Centerline (ft)	Magnetic Field (mG)
-100	1.68
-99	1.72
-98	1.75
-97	1.79
-96	1.82
-95	1.86
-94	1.90
-93	1.94
-92	1.98
-91	2.02
-90	2.07
-89	2.11
-88	2.16
-87	2.21
-86	2.26
-85	2.31
-84	2.36
-83	2.42
-82	2.47
-81	2.53
-80	2.60
-79	2.66
-78	2.73
-77	2.79
-76	2.87
-75	2.94
-74	3.02
-73	3.10
-72	3.18
-71	3.26
-70	3.35
-69	3.45
-68	3.54
-67	3.65
-66	3.75
-65	3.86
-64	3.98
-63	4.10
-62	4.22
-61	4.35
-60	4.49
-59	4.64
-58	4.79
-57	4.94
-56	5.11
-55	5.29

Distance from Centerline (ft)	Magnetic Field (mG)
-54	2.62
-53	2.71
-52	2.82
-51	2.93
-50	3.04
-49	3.17
-48	3.30
-47	3.44
-46	3.58
-45	3.74
-44	3.91
-43	4.09
-42	4.28
-41	4.48
-40	4.70
-39	4.94
-38	5.20
-37	5.47
-36	5.77
-35	6.09
-34	6.44
-33	6.81
-32	7.23
-31	7.67
-30	8.17
-29	8.71
-28	9.30
-27	9.95
-26	10.68
-25	11.48
-24	12.37
-23	13.37
-22	14.48
-21	15.74
-20	17.15
-19	18.76
-18	20.58
-17	22.67
-16	25.05
-15	27.80
-14	30.97
-13	34.65
-12	38.90
-11	43.85
-10	49.58
-9	56.19
-8	63.75
-7	72.27
-6	81.62
-5	91.53
-4	101.47

Distance from Centerline (ft)	Magnetic Field (mG)
-54	1.22
-53	1.26
-52	1.31
-51	1.36
-50	1.42
-49	1.47
-48	1.53
-47	1.60
-46	1.67
-45	1.74
-44	1.82
-43	1.90
-42	1.99
-41	2.09
-40	2.19
-39	2.30
-38	2.42
-37	2.54
-36	2.68
-35	2.83
-34	2.99
-33	3.17
-32	3.36
-31	3.57
-30	3.80
-29	4.05
-28	4.32
-27	4.62
-26	4.96
-25	5.33
-24	5.74
-23	6.20
-22	6.72
-21	7.30
-20	7.96
-19	8.70
-18	9.54
-17	10.50
-16	11.61
-15	12.88
-14	14.34
-13	16.05
-12	18.02
-11	20.32
-10	23.00
-9	26.11
-8	29.70
-7	33.79
-6	38.37
-5	43.32
-4	48.43

Distance from Centerline (ft)	Magnetic Field (mG)
-54	5.47
-53	5.66
-52	5.86
-51	6.08
-50	6.30
-49	6.54
-48	6.79
-47	7.05
-46	7.33
-45	7.63
-44	7.94
-43	8.27
-42	8.62
-41	9.00
-40	9.40
-39	9.82
-38	10.27
-37	10.75
-36	11.26
-35	11.81
-34	12.40
-33	13.03
-32	13.70
-31	14.43
-30	15.20
-29	16.04
-28	16.94
-27	17.91
-26	18.95
-25	20.08
-24	21.30
-23	22.61
-22	24.03
-21	25.57
-20	27.22
-19	29.01
-18	30.94
-17	33.02
-16	35.25
-15	37.64
-14	40.18
-13	42.88
-12	45.73
-11	48.70
-10	51.77
-9	54.90
-8	58.04
-7	61.13
-6	64.08
-5	66.81
-4	69.22

Distance from Centerline (ft)	Magnetic Field (mG)
-3	110.67
-2	118.20
-1	123.16
0	124.90
1	123.16
2	118.20
3	110.67
4	101.47
5	91.53
6	81.62
7	72.27
8	63.75
9	56.19
10	49.58
11	43.85
12	38.90
13	34.65
14	30.97
15	27.80
16	25.05
17	22.67
18	20.58
19	18.76
20	17.15
21	15.74
22	14.48
23	13.37
24	12.37
25	11.48
26	10.68
27	9.95
28	9.30
29	8.71
30	8.17
31	7.67
32	7.23
33	6.81
34	6.44
35	6.09
36	5.77
37	5.47
38	5.20
39	4.94
40	4.70
41	4.48
42	4.28
43	4.09
44	3.91
45	3.74
46	3.58
47	3.44

Distance from Centerline (ft)	Magnetic Field (mG)
-3	53.31
-2	57.44
-1	60.24
0	61.24
1	60.24
2	57.44
3	53.31
4	48.43
5	43.32
6	38.37
7	33.79
8	29.70
9	26.11
10	23.00
11	20.32
12	18.02
13	16.05
14	14.34
15	12.88
16	11.61
17	10.50
18	9.54
19	8.70
20	7.96
21	7.30
22	6.72
23	6.20
24	5.74
25	5.33
26	4.96
27	4.62
28	4.32
29	4.05
30	3.80
31	3.57
32	3.36
33	3.17
34	2.99
35	2.83
36	2.68
37	2.54
38	2.42
39	2.30
40	2.19
41	2.09
42	1.99
43	1.90
44	1.82
45	1.74
46	1.67
47	1.60

Distance from Centerline (ft)	Magnetic Field (mG)
-3	71.22
-2	72.72
-1	73.65
0	73.96
1	73.65
2	72.72
3	71.22
4	69.22
5	66.81
6	64.08
7	61.13
8	58.04
9	54.90
10	51.77
11	48.70
12	45.73
13	42.88
14	40.18
15	37.64
16	35.25
17	33.02
18	30.94
19	29.01
20	27.22
21	25.57
22	24.03
23	22.61
24	21.30
25	20.08
26	18.95
27	17.91
28	16.94
29	16.04
30	15.20
31	14.43
32	13.70
33	13.03
34	12.40
35	11.81
36	11.26
37	10.75
38	10.27
39	9.82
40	9.40
41	9.00
42	8.62
43	8.27
44	7.94
45	7.63
46	7.33
47	7.05

Distance from Centerline (ft)	Magnetic Field (mG)
48	3.30
49	3.17
50	3.04
51	2.93
52	2.82
53	2.71
54	2.62
55	2.52
56	2.43
57	2.35
58	2.27
59	2.20
60	2.12
61	2.06
62	1.99
63	1.93
64	1.87
65	1.81
66	1.76
67	1.71
68	1.66
69	1.61
70	1.57
71	1.52
72	1.48
73	1.44
74	1.40
75	1.37
76	1.33
77	1.30
78	1.26
79	1.23
80	1.20
81	1.17
82	1.14
83	1.12
84	1.09
85	1.06
86	1.04
87	1.02
88	0.99
89	0.97
90	0.95
91	0.93
92	0.91
93	0.89
94	0.87
95	0.85
96	0.84
97	0.82
98	0.80

Distance from Centerline (ft)	Magnetic Field (mG)
48	1.53
49	1.47
50	1.42
51	1.36
52	1.31
53	1.26
54	1.22
55	1.17
56	1.13
57	1.09
58	1.06
59	1.02
60	0.99
61	0.96
62	0.93
63	0.90
64	0.87
65	0.84
66	0.82
67	0.80
68	0.77
69	0.75
70	0.73
71	0.71
72	0.69
73	0.67
74	0.65
75	0.64
76	0.62
77	0.60
78	0.59
79	0.57
80	0.56
81	0.55
82	0.53
83	0.52
84	0.51
85	0.50
86	0.48
87	0.47
88	0.46
89	0.45
90	0.44
91	0.43
92	0.42
93	0.41
94	0.41
95	0.40
96	0.39
97	0.38
98	0.37

Distance from Centerline (ft)	Magnetic Field (mG)
48	6.79
49	6.54
50	6.30
51	6.08
52	5.86
53	5.66
54	5.47
55	5.29
56	5.11
57	4.94
58	4.79
59	4.64
60	4.49
61	4.35
62	4.22
63	4.10
64	3.98
65	3.86
66	3.75
67	3.65
68	3.54
69	3.45
70	3.35
71	3.26
72	3.18
73	3.10
74	3.02
75	2.94
76	2.87
77	2.79
78	2.73
79	2.66
80	2.60
81	2.53
82	2.47
83	2.42
84	2.36
85	2.31
86	2.26
87	2.21
88	2.16
89	2.11
90	2.07
91	2.02
92	1.98
93	1.94
94	1.90
95	1.86
96	1.82
97	1.79
98	1.75

Distance from Centerline (ft)	Magnetic Field (mG)
99	0.79
100	0.77

Distance from Centerline (ft)	Magnetic Field (mG)
99	0.37
100	0.36

Distance from Centerline (ft)	Magnetic Field (mG)
99	1.72
100	1.68