Electric and Magnetic Fields Report

Geronimo Wind Energy
Prairie Rose Wind Farm Transmission Interconnection

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The technical material and data contained in this report for Geronimo Wind Energy was prepared by or under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

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1.0 ABSTRACT

HDR has estimated the potential electric and magnetic fields from the proposed Geronimo Prairie Rose Interconnection 115 kV Single Circuit Transmission Line to complete the Minnesota Public Utilities Commission Route Application Permit. The Transmission Line will serve as an interconnection between the proposed Prairie Rose Wind Farm in Rock County, Minnesota, and Xcel Energy's Split Rock Substation located near Brandon, South Dakota.

The 115 kV Single Circuit Delta Configuration Transmission Line at the edge of right-of-way (ROW) has a maximum electric field of 0.93 kV/m on the left side (road side) and 0.78 kV/m on the right side (private easement side). The maximum magnetic field at the edge of right-of-way is 92.38 mG on the left side and 92.70 mG on the right side. For the delta configuration it is assumed that the line will be centered in a 75-foot ROW corridor cross country, or will be located 2.5 feet out of road ROW when paralleling a public road using a 40-foot private ROW corridor. The edge of ROW going cross-county will be at 37.5 feet left and 37.5 feet right of centerline, or 40.0 feet from road ROW on private when paralleling a road. The maximum calculated field values and location in the corridor are as follows: at 15.0 feet right of centerline the electric field is 1.98 kV/m and the magnetic field is 254.54 mG at the centerline of the line.

The 115 kV Single Circuit Vertical Configuration Transmission Line at the edge of ROW has a maximum electric field of 0.40 kV/m on the left side (road side) and 0.35 kV/m on the right side (private easement side). The maximum magnetic field at the edge of right-of-way is 102.01 mG on the left side and 102.21 mG on the right side. For the vertical configuration it is assumed that the line's lowest phase will be centered in a 60-foot ROW corridor cross country with the structures being offset 8 feet right, or the structures would be offset 8 feet from the centerline and located 2.5 feet out of road ROW when paralleling a public road using a 24.5-foot private ROW corridor. The edge of ROW cross county will be at 30 feet left and 30 feet right of centerline (lowest phase), or 24.5 feet from road ROW when paralleling a road (centerline of the line being 5.5 feet in road ROW). The maximum calculated field values located at the centerline of the corridor are as follows: electric field is 2.27 kV/m and the magnetic field is 211.34 mG.

2.0 INTRODUCTION

The term EMF refers to electric and magnetic fields that arise from the electrical potential (voltage) and the movement of an electrical charge (current) associated with the transmission and use of electricity. Electric and magnetic fields are invisible just like radio, television, and cellular phone signals, all of which are part of the electromagnetic spectrum. The frequency of transmission line EMF in the United States is 60 hertz and falls in the extremely low frequency (ELF) range of the electromagnetic spectrum (any frequency below 300 hertz). For the lower frequencies associated with power lines, the electric and magnetic fields are typically evaluated separately. The intensity of the electric field is related to the voltage of the line, while the intensity of the magnetic field is related to the current flow along the conductors.

Concerns about health effects of EMF from power lines were first raised in the late 1970s. Since then, considerable research has been conducted to determine if exposure to magnetic fields, such as those from high-voltage power lines, causes biological responses and health effects. Initial epidemiological studies done in the late 1970s showed a weak correlation between surrogate indicators of magnetic field exposure (such as wiring codes or distance from roads) and increased rates of childhood leukemia. (Wertheimer et. al, 1979). More recent studies that used direct measurements of magnetic field exposure show either a very weak, or no statistical correlation with adverse health affects (Savitz, et. al. 1988) and toxicological and laboratory studies have not identified a biological mechanism between ELF-EMF and cancer or other adverse health effects.

While there are numerous internet sites devoted to EMF dangers (whether from power lines, cell phones, or radio frequency signals), the vast majority of experts believe that EMF from power lines does not cause leukemia or any other health problem. In part, these experts argue the physical impossibility of any health effect due to such low-frequency, low-energy magnetic fields.

Natural and human-made electromagnetic fields are, in fact, present everywhere in the environment. Natural electric fields in the atmosphere range from background static levels of 10 to 120 volts per meter (V/m) to well over several kilovolts per meter (kV/m) produced by the build-up of electric charges in thunderstorms. The earth itself has a magnetic field that ranges from approximately 300 to 700 milligauss (mG). In addition to the presence of the earth's steady state electric field, an average home experiences additional magnetic fields of 0.5 mG to 4 mG, which arise from the general wiring and appliances located in a typical home (National Cancer Institute, 2009).

Electric Fields

Electric fields are created by voltage or the difference in the electric charge between two points, and are measured in V/m or kV/m; higher voltage produces stronger electric fields. The intensity of an electric field decreases significantly with increasing distance from the source and is easily shielded or weakened by objects such as trees, buildings, clothing, and skin.

The available data for exposure to static electric fields suggest that the only negative human health effects are the direct perception of body hair movement and small shocks, similar to the shock received by the induced friction from walking on a carpet and then touching a doorknob. On the whole, scientific evidence indicates that chronic exposure to electric fields at or below levels traditionally established for safety does not cause adverse health effects. Safety concerns related to electric fields are sufficiently addressed by adherence to the National Electric Safety Code (NESC).

There are currently no federal guidelines on the strength of electrical fields beneath high voltage transmission lines. However, a few states and agencies have established regulations or guidelines with regard to transmission line electric fields.

Table 1. Electric Field Exposure Guidelines

Organization	Electric Field Exposure Guidelines (kV/m)	
	General Public	Occupational
ICNIRP (2009)	4.2	8.3
IEEE (2002)	5.0	20.0
ACGIH (2009)	_	25.0

ICNIRP – International Commission on Non-Ionizing Radiation Protection

IEEE – Institute of Electrical Engineers and Electronic Engineers

ACGIH – American Conference of Governmental Industrial Hygienists

The Minnesota Public Utilities Commission (Commission) has established an 8 kV/m guideline designed to prevent injury from shocks when touching large objects such as a bus or agricultural equipment parked under high-voltage transmission lines of 345 kV or greater. A route permit for a high-voltage transmission line typically states the line shall be designed, constructed, and operated in such a manner that the electric field measured one meter above ground level immediately below the transmission line shall not exceed 8.0 kV/m.

Electric fields around transmission lines are produced by electrical charges, measured as voltage, on the energized conductor. Electric field strength is directly proportional to the line's voltage; that is, increased voltage produces a stronger electric field. The electric field is inversely proportional to the distance a sensor is from the conductors, so that the electric field strength declines as the distance from the conductor increases. For the proposed Prairie Rose Interconnection 115 kV Single Circuit Transmission Line, the voltage and electric field would alternate at a frequency of 60 Hz. The strength of the electric field is measured in units of kilovolts per meter (kV/m). The voltage, and therefore the electric field, around a transmission line remains practically steady and is not affected by the common daily and seasonal fluctuations in electricity usage by customers.

Magnetic Fields

Magnetic fields are created by electric current or flow (measured in amperes); higher currents produce stronger magnetic fields. However, unlike electric fields, magnetic fields are not easily shielded and pass through most structures or objects. Consequently health concerns regarding EMF have focused more closely on magnetic fields than electric fields.

People encounter magnetic fields from everyday things such as radar and microwave towers, television and computer screens, motors, fluorescent lights, microwave ovens, cell phones, electric blankets, house wiring, and hundreds of other common electrical devices. As with electric fields, magnetic fields decrease in strength with increased distance from the source. The strength of both the electric and magnetic fields from transmission lines is inversely proportional to the square of the distance from the source conductors. Magnetic fields also vary in intensity depending on the type of structure and the amount of current flowing through the transmission line in a given area.

There are currently no state or federal guidelines for magnetic fields generated by high-voltage transmission lines. However, several agencies have established exposure guidelines for general public and occupational magnetic field exposure.

Table 2. Magnetic Field Exposure Guidelines

Organization	Magnetic Field Exposure Guidelines (mG)	
	General Public	Occupational
ICNIRP (2009)	833	4,200
IEEE (2002)	9040	27,100
ACGIH (2009)	_	10,000

ICNIRP – International Commission on Non-Ionizing Radiation Protection

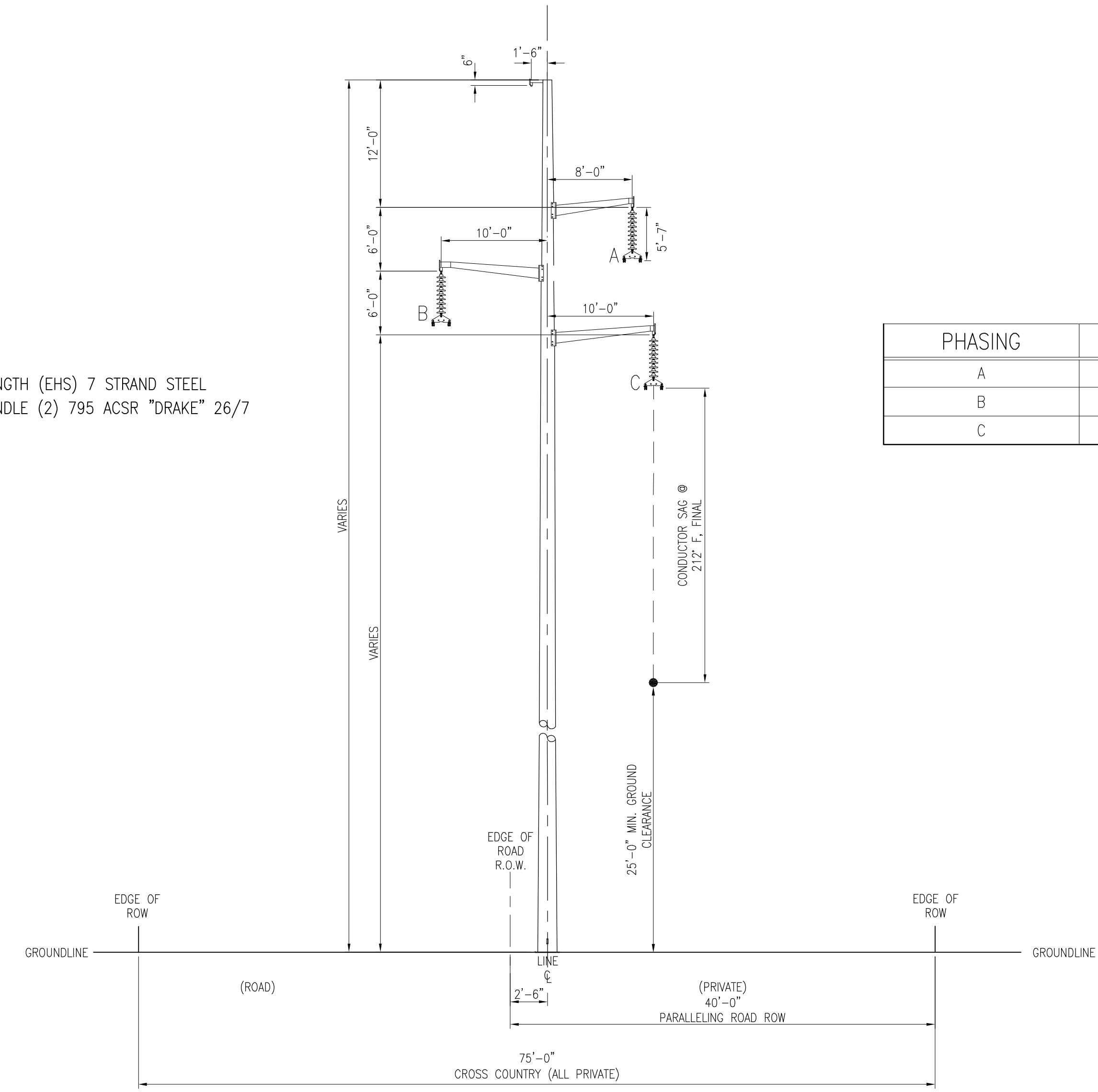
IEEE – Institute of Electrical Engineers and Electronic Engineers

ACGIH – American Conference of Governmental Industrial Hygienists

Geronimo Wind Energy has retained HDR Engineering, Inc., (HDR) to study the electric and magnetic fields of the proposed Prairie Rose Transmission Line Interconnection Facilities. It is important that any discussion of EMF include the assumptions (see 3.0) used to calculate these fields and to remember that EMF in the vicinity of the power lines varies with regard to line configuration/design, line loading, distance from the line, as well as other factors.

The proposed line would be constructed using a typical single-circuit, 115 kV steel monopole structure with davit arms in either a delta or vertical configuration. The typical tangent delta configuration will center the poles on a 75-foot ROW corridor and the typical tangent vertical configuration will center top/bottom phases on a 60-foot ROW corridor (see Figure 1 for typical single circuit delta configuration structure and corridor, and Figure 2 for typical single circuit vertical configuration structure and corridor).

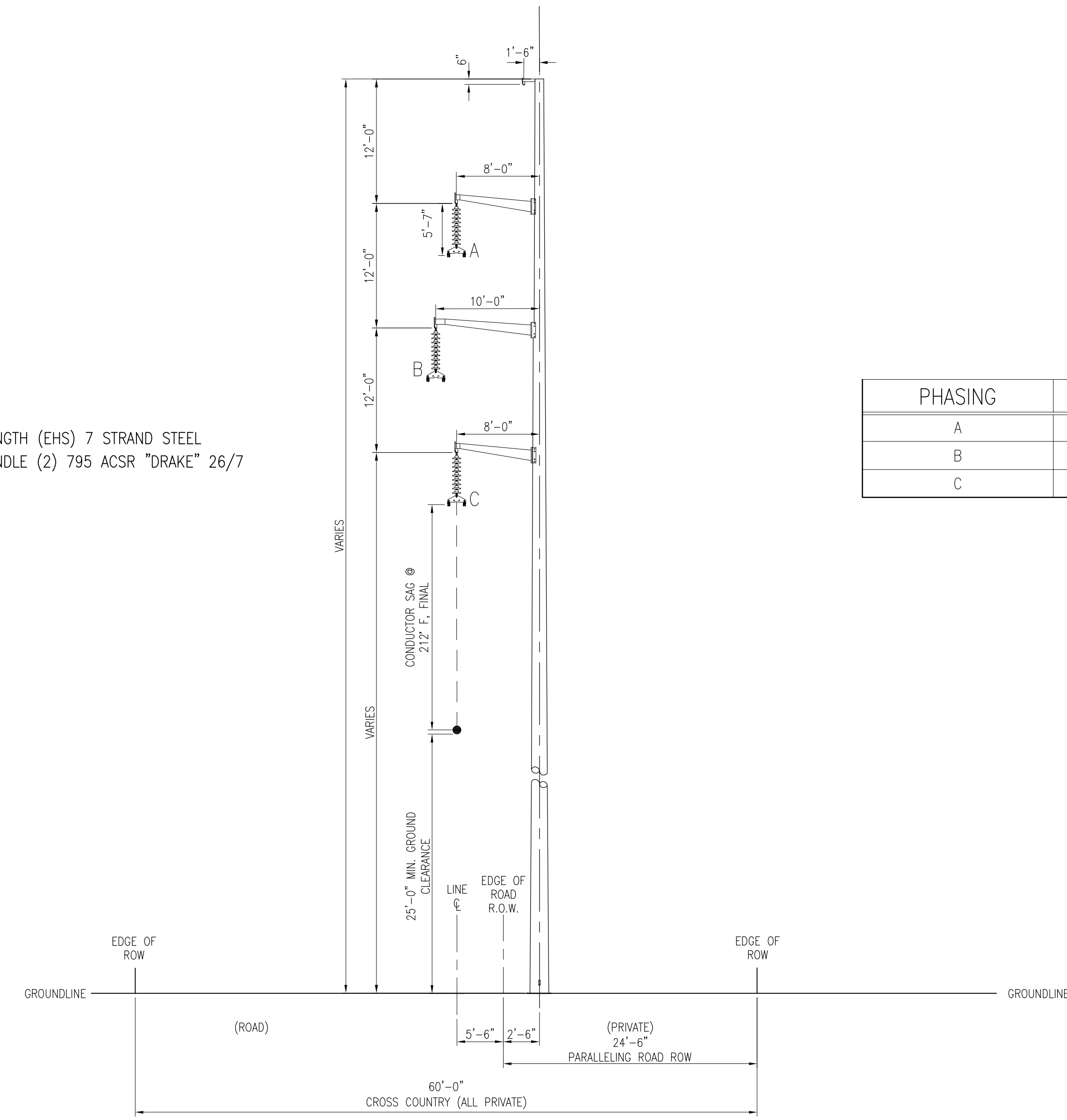
SHIELDWIRE: 3/8" EXTRA HIGH STRENGTH (EHS) 7 STRAND STEEL
CONDUCTOR: 18" HORIZONTAL DOUBLE BUNDLE (2) 795 ACSR "DRAKE" 26/7



PHASING	DEGREE
A	0°
B	120°
C	240°

Figure 1 – Proposed Delta Configuration Structure and Right-of-Way Corridor

SHIELDWIRE: 3/8" EXTRA HIGH STRENGTH (EHS) 7 STRAND STEEL
CONDUCTOR: 18" HORIZONTAL DOUBLE BUNDLE (2) 795 ACSR "DRAKE" 26/7



PHASING	DEGREE
A	0°
B	120°
C	240°

Figure 2 – Proposed Vertical Configuration Structure and Right-of-Way Corridor

HDR was requested to estimate the values of electric and magnetic fields at the edge of the ROW as a result of the operation of these transmission facilities in the proposed configuration. The calculations were done at maximum voltage (electric fields are in kilovolts per meter - kV/m) and at both maximum and average loading/current (magnetic fields are in milligauss - mG).

3.0 ASSUMPTIONS

Geronimo Wind Energy provided HDR with the anticipated peak and average electric loads for the line to be used as a worst case and average scenario in the estimates. The industry standard maximum voltage of 5 percent over nominal kilovolt line rating was assumed. See Table 3 for the electric loads and voltages used in this analysis.

Table 3. Electric Loads and Voltages

Line	MVA*	Nominal Voltage Phase to Phase (kV)	Nominal Voltage Phase to Ground (kV)	Maximum Voltage Phase to Ground (kV)	Current at Nominal kV (Amps)
Single Circuit 115kV (Maximum)	300	115	66.4	69.7	1506
Single Circuit 115kV (Average)	132	115	66.4	69.7	663

*MVA – Apparent Power (mega volt amp)

The conductor for the 115 kV lines will be an 18-inch horizontal bundle of two 795 kcmil (thousand circular mils) “Drake” Aluminum Conductor Steel Reinforced (ACSR) 26/7 conductors with an outside diameter of 1.108 inches. Above the transmission circuit, one shield wire of 3/8 inch Extra High Strength (EHS) seven-strand (0.375 inch diameter) will be employed. These conductor and shield wire sizes were used in the calculations to estimate the electric fields. HDR assumed that the proposed transmission lines will be stand-alone and have no under-build distribution or communications.

4.0 METHODS AND PROCEDURES

HDR used previously developed spreadsheets to estimate electric fields and magnetic fields at the locations desired using the general procedures outlined in the Institute of Electrical Engineers and Electronic Engineers (IEEE) technical paper 1127, 1998. Using the locations of each conductor inside a typical tangent configuration and at the highest voltages, the electric fields were calculated at 3.28 feet above ground level (1 meter) and were estimated and plotted over a projected 100-foot corridor. Similarly, the magnetic field levels were estimated at 3.28 feet above ground level using the maximum current flow at peak loads and the assumed average current flow; both were also plotted against a 100-foot corridor.

5.0 RESULTS

Full analysis results with supporting data can be found in Appendix A – Electric, and Appendix B – Magnetic. The plots of the electric and magnetic field(s) were estimated against the ROW corridor for both the delta and vertical configurations. They were prepared and analyzed to determine the magnitudes in the desired locations. Results from that analysis are summarized in Table 4 and Table 6 for the delta configuration and Table 5 and Table 7 for the vertical configuration. The edge of ROW values are shown in Table 4 and Table 5 and the results of the easement centerline are shown in Table 6 and Table 7

Both the electric and magnetic fields are close to being symmetrical at the edge of ROW for both configurations. The effects of having two phases on the right side of the delta structure cause the electric fields to create the maximum field value (1.98 kV/m) on that side under the two phases. The delta structure maximum magnetic field is on that side as well (254.54 mG), but closer to the centerline of the ROW due to the effects of the single phase on the left side. Both the electric field and magnetic field maximum values are at the center of the corridor for the vertical configuration.

Table 4. Electric and Magnetic Field Results at Edge of ROW 115 kV Single Circuit Delta Configuration

Location in Corridor	Electric Field kV/m	Maximum Magnetic Field mG	Average Magnetic Field mG
Edge of ROW – 37.5’ LT	0.93	92.38	38.83
Edge of ROW – 37.5’ RT	0.78	92.70	38.96

Table 5. Electric and Magnetic Field Results at Edge of ROW 115 kV Single Circuit Vertical Configuration

Location in Corridor	Electric Field kV/m	Maximum Magnetic Field mG	Average Magnetic Field mG
Edge of ROW – 30.0’ LT	0.40	102.01	42.88
Edge of ROW – 30.0’ RT	0.35	102.21	42.96

Table 6. ROW Centerline Electric and Magnetic Field Results
115 kV Single Circuit Delta Configuration

Location in Corridor	Electric Field kV/m	Maximum Magnetic Field mG	Average Magnetic Field mG
25' Left of ROW Centerline	1.34	143.32	60.24
20' Left of ROW Centerline	1.43	169.30	71.16
15' Left of ROW Centerline	1.41	196.53	82.61
10' Left of ROW Centerline	1.25	222.14	93.37
5' Left of ROW Centerline	1.07	242.65	101.99
Centerline of ROW	1.21	254.54*	106.99*
5' Right of ROW Centerline	1.64	254.50	106.97
10' Right of ROW Centerline	1.95	240.63	101.14
15' Right of ROW Centerline	1.98*	214.85	90.31
20' Right of ROW Centerline	1.77	183.12	76.97
25' Right of ROW Centerline	1.45	151.76	63.79

* Maximum field strength in corridor

Table 7. ROW Centerline Electric and Magnetic Field Results
115 kV Single Circuit Vertical Configuration

Location in Corridor	Electric Field kV/m	Maximum Magnetic Field mG	Average Magnetic Field mG
25' Left of ROW Centerline	0.63	119.97	50.43
20' Left of ROW Centerline	0.95	140.88	59.22
15' Left of ROW Centerline	1.35	163.94	68.91
10' Left of ROW Centerline	1.79	186.69	78.47
5' Left of ROW Centerline	2.14	204.39	85.91
Centerline of ROW	2.27*	211.34*	88.83*
5' Right of ROW Centerline	2.11	204.72	86.05
10' Right of ROW Centerline	1.73	187.19	78.68
15' Right of ROW Centerline	1.29	164.45	69.12
20' Right of ROW Centerline	0.89	141.29	59.39
25' Right of ROW Centerline	0.58	120.26	50.55

* Maximum field strength in corridor

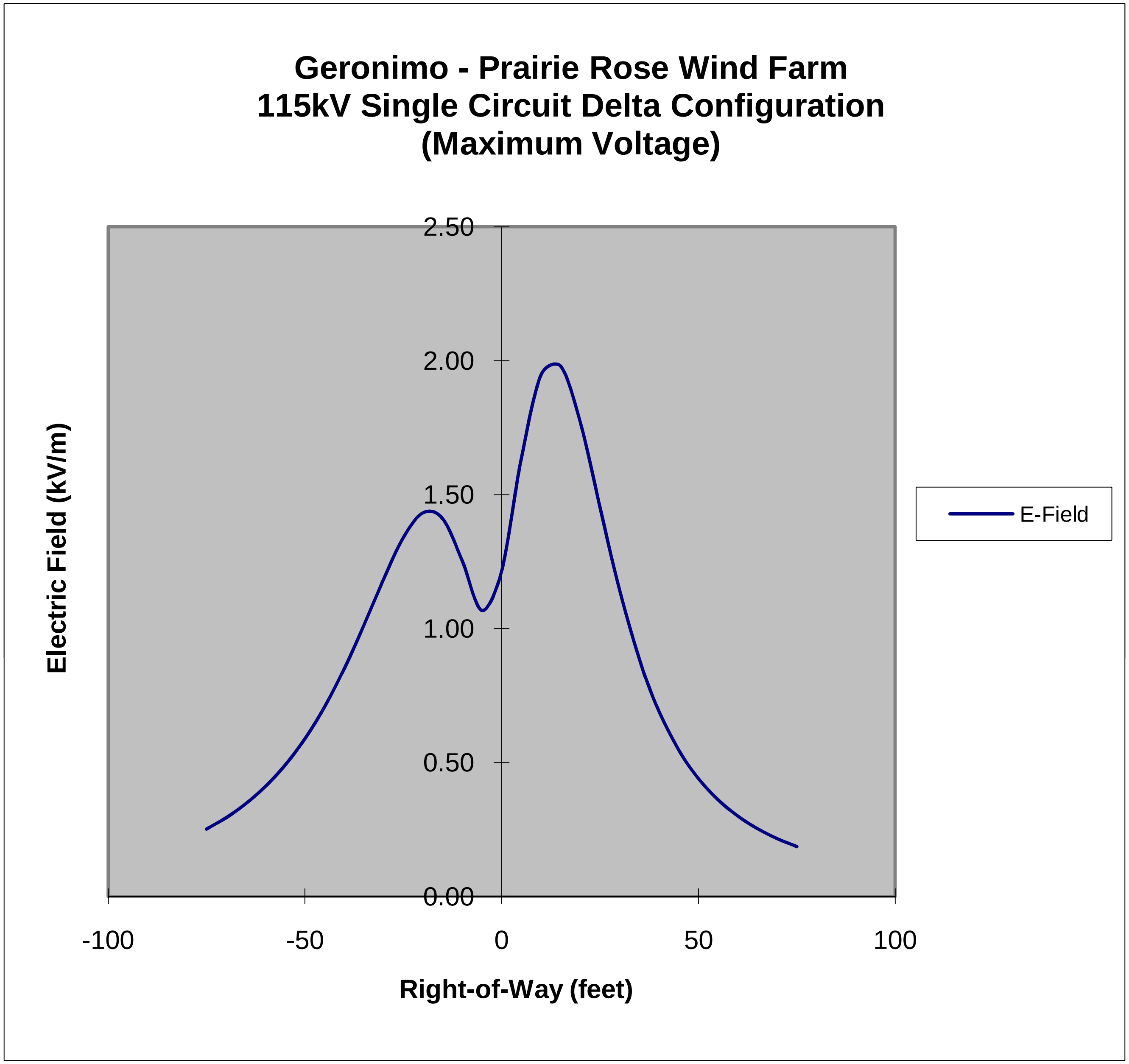
6.0 CONCLUSIONS

The 115 kV Single Circuit Delta Configuration Transmission Line potential electric fields were estimated at the left and right edge of ROW to be 0.93 kV/m and 0.78 kV/m, respectively. The potential magnetic fields were 92.38 mG on the left and 92.70 mG on the right for the delta configuration. The maximum field values of 1.98 kV/m and 254.54 mG were all on the right side, but close to the center of the 75-foot corridor.

Potential electric fields for the 115 kV Single Circuit Vertical Configuration Transmission Line were estimated at the left and right edge of ROW to be 0.40 kV/m and 0.35 kV/m, respectively. Potential magnetic fields were 102.01 mG on the left and 102.21 mG on the right for the vertical configuration. The maximum field values of 2.27 kV/m and 211.34 mG were all on the centerline of the 60-foot corridor.

Overall, field strengths diminish rapidly outside of the edge of ROW for both configurations; approximately the inverse square of the distance from the power line. The delta configuration has an overall higher electric and magnetic field distribution throughout the corridor, but a lower maximum value than the vertical. The vertical configuration has a higher field in the center of the corridor, but it diminishes more quickly than the delta configuration. In both configurations there are some effects in the calculations due to the locations of the phases and their influence on each other from being above and below. Increasing line height is the most effective line design change to reduce the maximum field at ground under the line.

Appendix A – Electric Field

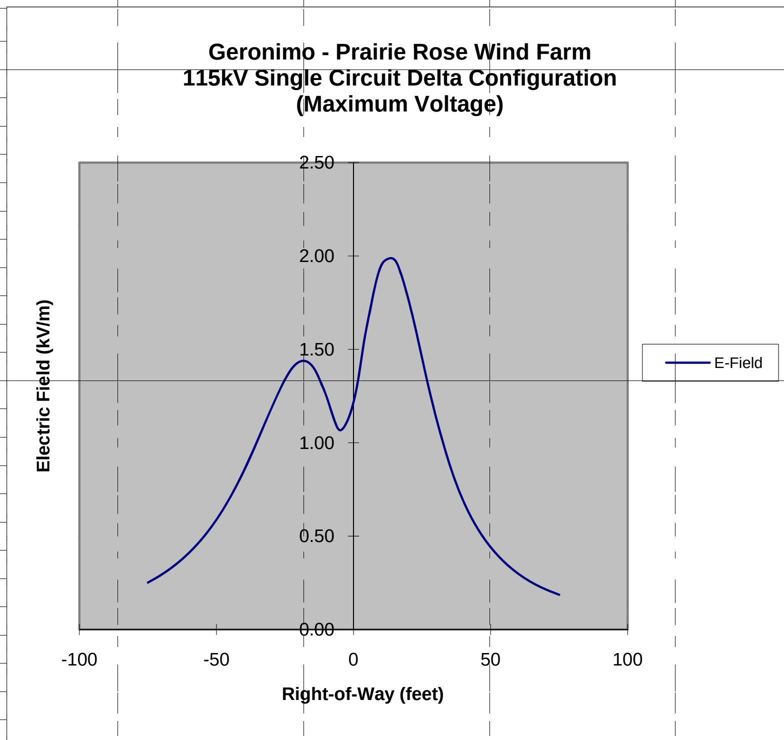

Geronimo - Prairie Rose Wind Farm
115kV Single Circuit Delta Configuration
(Maximum Voltage)
Electric Field (kV/m)
2.50
2.00
1.50
1.00
0.50
0.00
-100
-50
0
50
100
Right-of-Way (feet)
E-Field

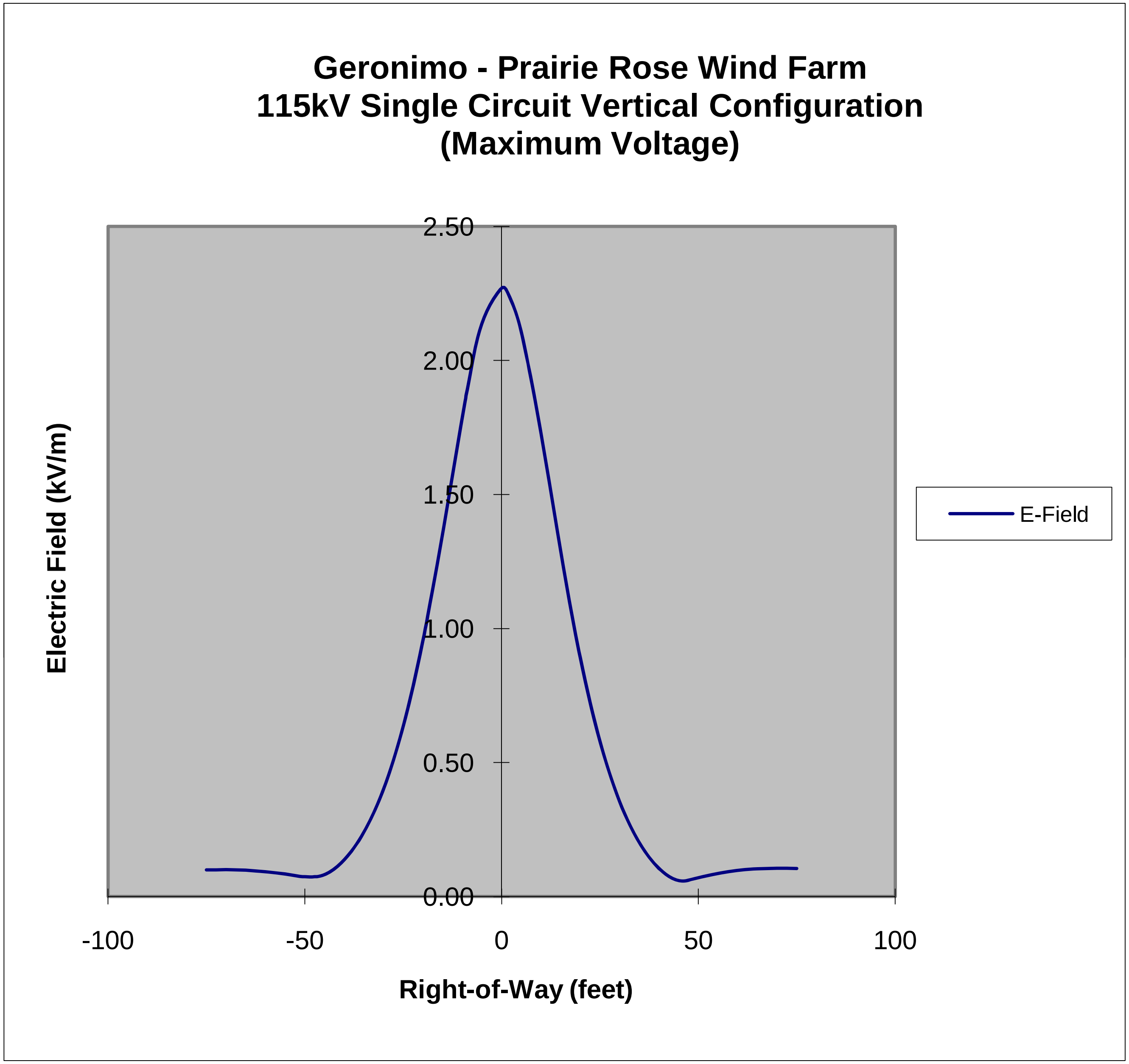
Geronimo - Praire Rose Wind Farm

Electric Field

Bundle	x-feet	y-feet	n cond	cond dia	spacing	l-n Kilovolts	phase
1	-1.50	57.00	1	0.375	0	0	0.00
2	8.00	37.00	2	1.108	18	69.7	0.00
3	-10.00	31.00	2	1.108	18	69.7	120.00
4	10.00	25.00	2	1.108	18	69.7	240.00
5							
6							
7							
8							
NPH=	4.00						
(Inverse	794.299	Dummy Ouput)					

Dist	Vert	kV/M
-100	3.28	0.13
-95	3.28	0.14
-90	3.28	0.16
-85	3.28	0.19
-80	3.28	0.22
-75	3.28	0.25
-70	3.28	0.29
-65	3.28	0.35
-60	3.28	0.41
-55	3.28	0.49
-50	3.28	0.59
-45	3.28	0.71
-40	3.28	0.85
-37.5	3.28	0.93
-35	3.28	1.01
-30	3.28	1.18
-25	3.28	1.34
-20	3.28	1.43
-15	3.28	1.41
-10	3.28	1.25
-5	3.28	1.07
0	3.28	1.21
5	3.28	1.64
10	3.28	1.95
15	3.28	1.98
20	3.28	1.77
25	3.28	1.45
30	3.28	1.14
35	3.28	0.88
37.5	3.28	0.78
40	3.28	0.69
45	3.28	0.55
50	3.28	0.44
55	3.28	0.36
60	3.28	0.30
65	3.28	0.25
70	3.28	0.22
75	3.28	0.19
80	3.28	0.16
85	3.28	0.14
90	3.28	0.12
95	3.28	0.11
100	3.28	0.10



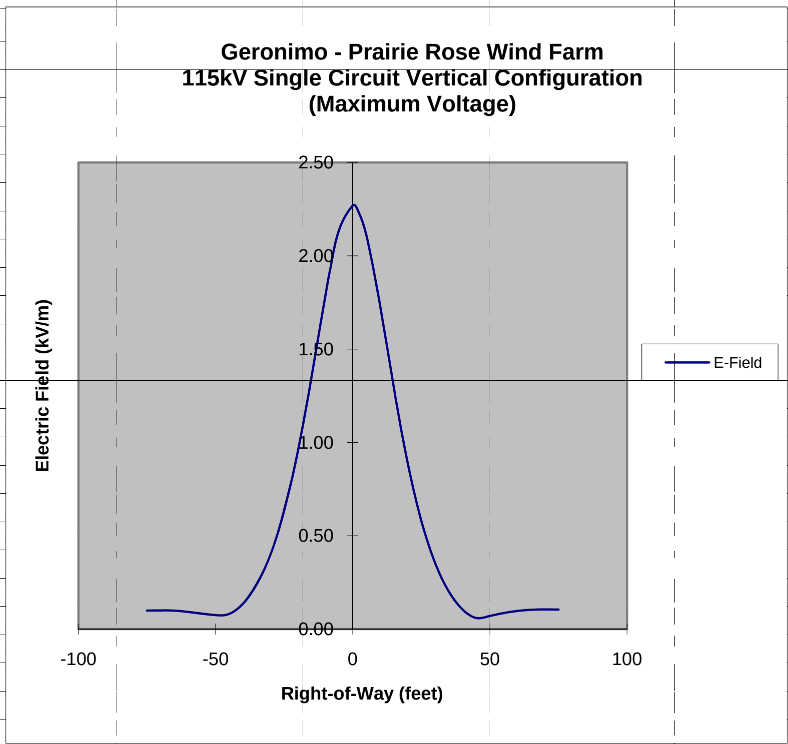

Geronimo - Prairie Rose Wind Farm
115kV Single Circuit Vertical Configuration
(Maximum Voltage)
Electric Field (kV/m)
2.50
2.00
1.50
1.00
0.50
0.00
-100
-50
0
50
100
Right-of-Way (feet)
E-Field

Geronimo - Praire Rose Wind Farm

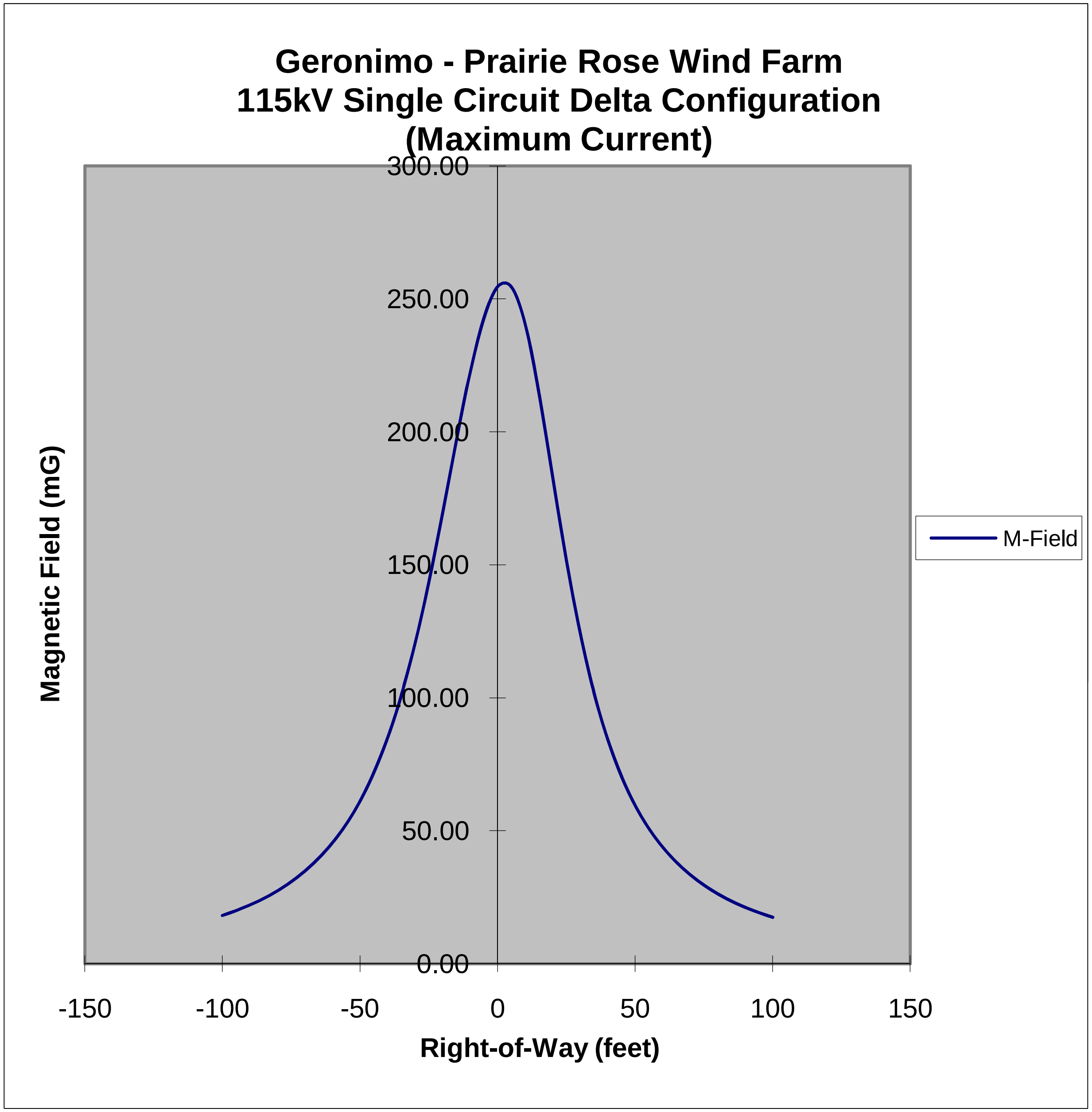
Electric Field

Bundle	x-feet	y-feet	n cond	cond dia	spacing	l-n Kilovolts	phase
1	-7.50	69.00	1	0.375	0	0	0.00
2	0.00	49.00	2	1.108	18	69.7	0.00
3	2.00	37.00	2	1.108	18	69.7	120.00
4	0.00	25.00	2	1.108	18	69.7	240.00
5							
6							
7							
8							
NPH=	4.00						
(Inverse	812.299	Dummy Ouput)					

Dist	Vert	kV/M
-100	3.28	0.08
-95	3.28	0.09
-90	3.28	0.09
-85	3.28	0.09
-80	3.28	0.10
-75	3.28	0.10
-70	3.28	0.10
-65	3.28	0.10
-60	3.28	0.09
-55	3.28	0.08
-50	3.28	0.07
-45	3.28	0.08
-40	3.28	0.14
-35	3.28	0.24
-30	3.28	0.40
-25	3.28	0.63
-20	3.28	0.95
-15	3.28	1.35
-10	3.28	1.79
-8	3.28	1.95
-5	3.28	2.14
0	3.28	2.27
2	3.28	2.24
5	3.28	2.11
10	3.28	1.73
15	3.28	1.29
20	3.28	0.89
25	3.28	0.58
30	3.28	0.35
35	3.28	0.20
40	3.28	0.10
45	3.28	0.06
50	3.28	0.07
55	3.28	0.09
60	3.28	0.10
65	3.28	0.10
70	3.28	0.11
75	3.28	0.10
80	3.28	0.10
85	3.28	0.10
90	3.28	0.09
95	3.28	0.09
100	3.28	0.09



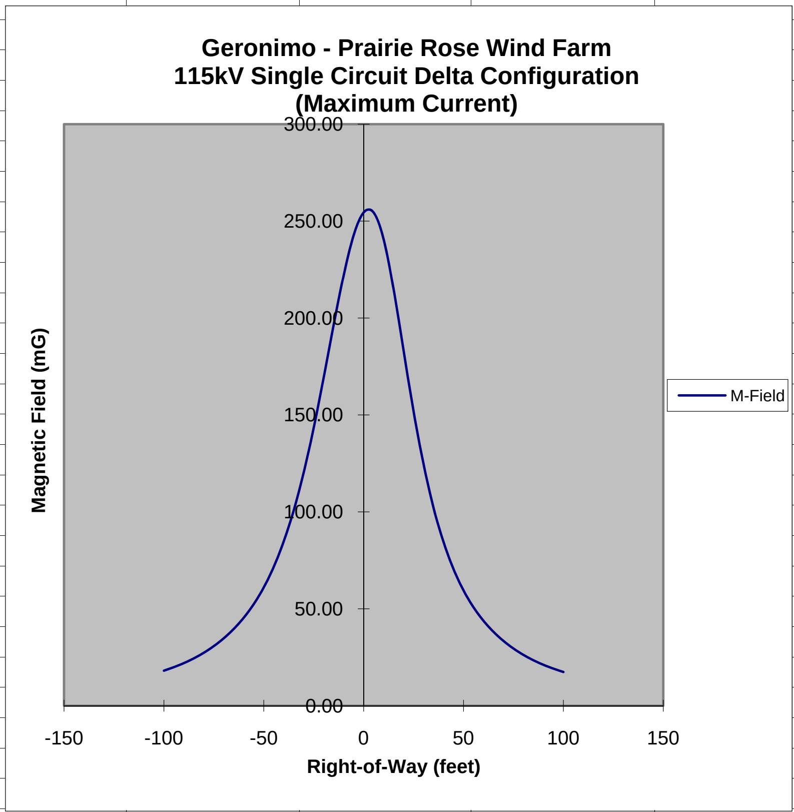
Appendix B – Magnetic Field

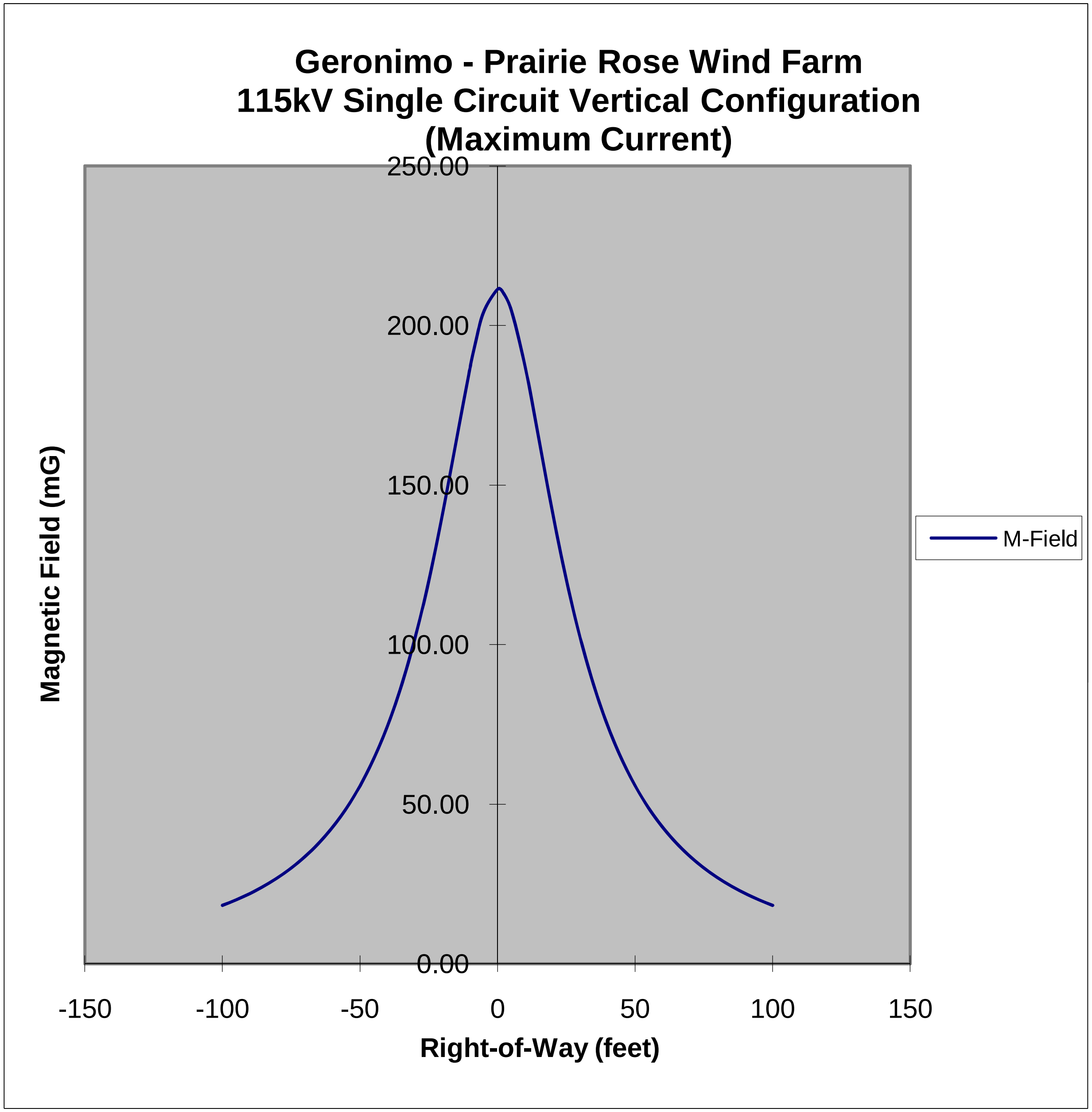

Geronimo - Prairie Rose Wind Farm
115kV Single Circuit Delta Configuration
(Maximum Current)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Magnetic Field (mG)
-150
-100
-50
0
50
100
150
Right-of-Way (feet)
M-Field

Geronimo - Prairie Rose Wind Farm

Magnetic Field

Bundle	x-feet	y-feet	amps	phase
1	-1.50	57.00	0.0	0.00
2	8.00	37.00	1506.0	0.00
3	-10.00	31.00	1506.0	120.00
4	10.00	25.00	1506.0	240.00
5				
6				
7				
8				
NPH=	4.00	**Calculated**		
Dist - ft	Vert	**Milligauss**		
-100	3.28	18.08		
-95	3.28	19.91		
-90	3.28	22.03		
-85	3.28	24.49		
-80	3.28	27.37		
-75	3.28	30.76		
-70	3.28	34.79		
-65	3.28	39.61		
-60	3.28	45.41		
-55	3.28	52.46		
-50	3.28	61.09		
-45	3.28	71.69		
-40	3.28	84.76		
-37.5	3.28	92.38		
-35	3.28	100.81		
-30	3.28	120.29		
-25	3.28	143.32		
-20	3.28	169.30		
-15	3.28	196.53		
-10	3.28	222.14		
-5	3.28	242.65		
0	3.28	254.54		
5	3.28	254.50		
10	3.28	240.63		
15	3.28	214.85		
20	3.28	183.12		
25	3.28	151.76		
30	3.28	124.41		
35	3.28	102.08		
37.5	3.28	92.70		
40	3.28	84.37		
45	3.28	70.46		
50	3.28	59.49		
55	3.28	50.77		
60	3.28	43.76		
65	3.28	38.07		
70	3.28	33.40		
75	3.28	29.52		
80	3.28	26.26		
85	3.28	23.51		
90	3.28	21.16		
95	3.28	19.14		
100	3.28	17.39		

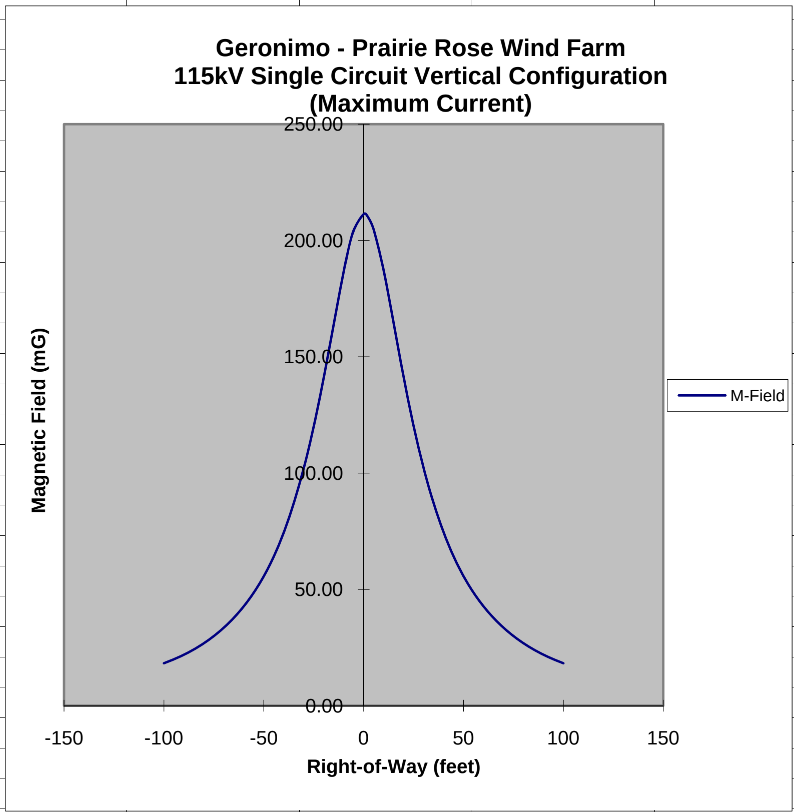


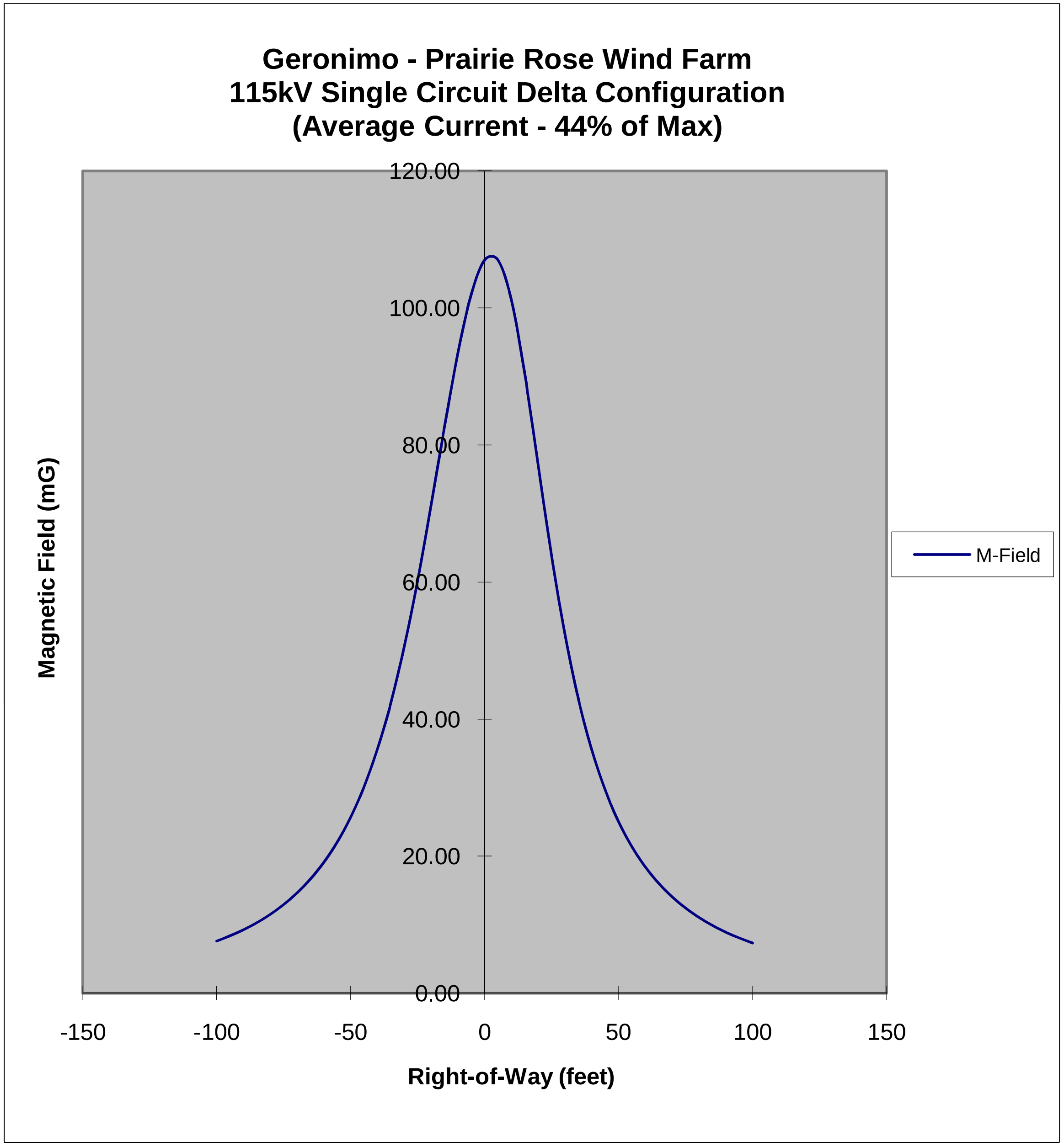

Geronimo - Prairie Rose Wind Farm
115kV Single Circuit Vertical Configuration
(Maximum Current)
250.00
200.00
150.00
100.00
50.00
0.00
Magnetic Field (mG)
-150
-100
-50
0
50
100
150
Right-of-Way (feet)
M-Field

Geronimo - Prairie Rose Wind Farm

Magnetic Field

Bundle	x-feet	y-feet	amps	phase
1	-7.50	69.00	0.0	0.00
2	0.00	49.00	1506.0	0.00
3	2.00	37.00	1506.0	120.00
4	0.00	25.00	1506.0	240.00
5				
6				
7				
8				
NPH=	4.00	**Calculated**		
Dist - ft	Vert	**Milligauss**		
-100	3.28	18.25		
-95	3.28	19.99		
-90	3.28	21.98		
-85	3.28	24.26		
-80	3.28	26.90		
-75	3.28	29.96		
-70	3.28	33.53		
-65	3.28	37.74		
-60	3.28	42.71		
-55	3.28	48.62		
-50	3.28	55.70		
-45	3.28	64.22		
-40	3.28	74.52		
-35	3.28	86.97		
-30	3.28	102.01		
-25	3.28	119.97		
-20	3.28	140.88		
-15	3.28	163.94		
-10	3.28	186.69		
-8	3.28	194.70		
-5	3.28	204.39		
0	3.28	211.34		
2	3.28	210.29		
5	3.28	204.72		
10	3.28	187.19		
15	3.28	164.45		
20	3.28	141.29		
25	3.28	120.26		
30	3.28	102.21		
35	3.28	87.10		
40	3.28	74.60		
45	3.28	64.27		
50	3.28	55.74		
55	3.28	48.64		
60	3.28	42.72		
65	3.28	37.75		
70	3.28	33.54		
75	3.28	29.96		
80	3.28	26.90		
85	3.28	24.26		
90	3.28	21.98		
95	3.28	19.99		
100	3.28	18.25		



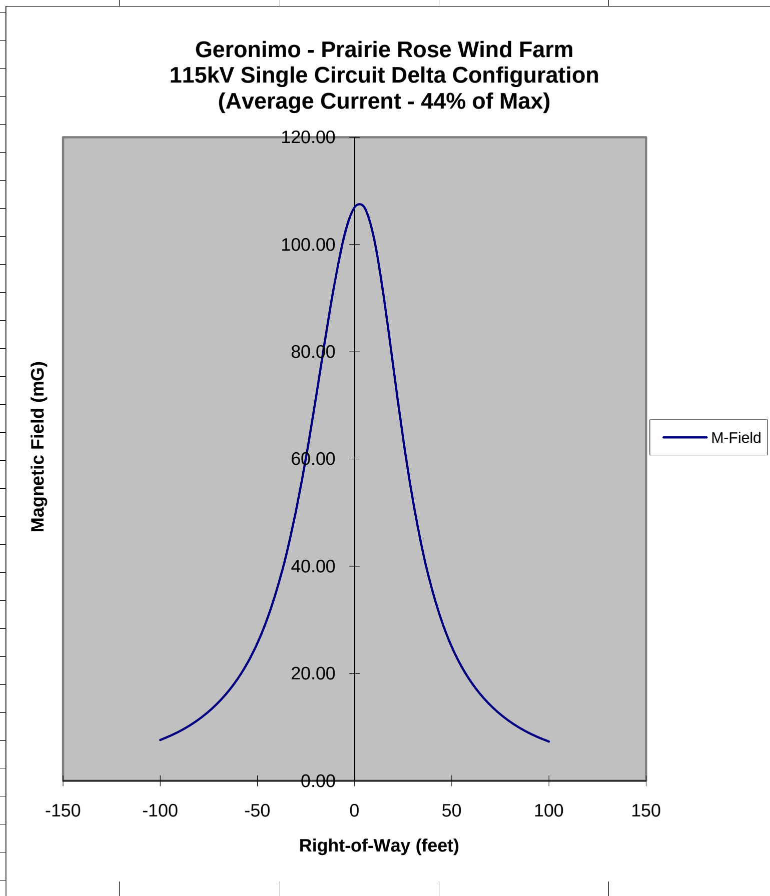

Geronimo - Prairie Rose Wind Farm
115kV Single Circuit Delta Configuration
(Average Current - 44% of Max)
Magnetic Field (mG)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
-150
-100
-50
0
50
100
150
Right-of-Way (feet)
M-Field

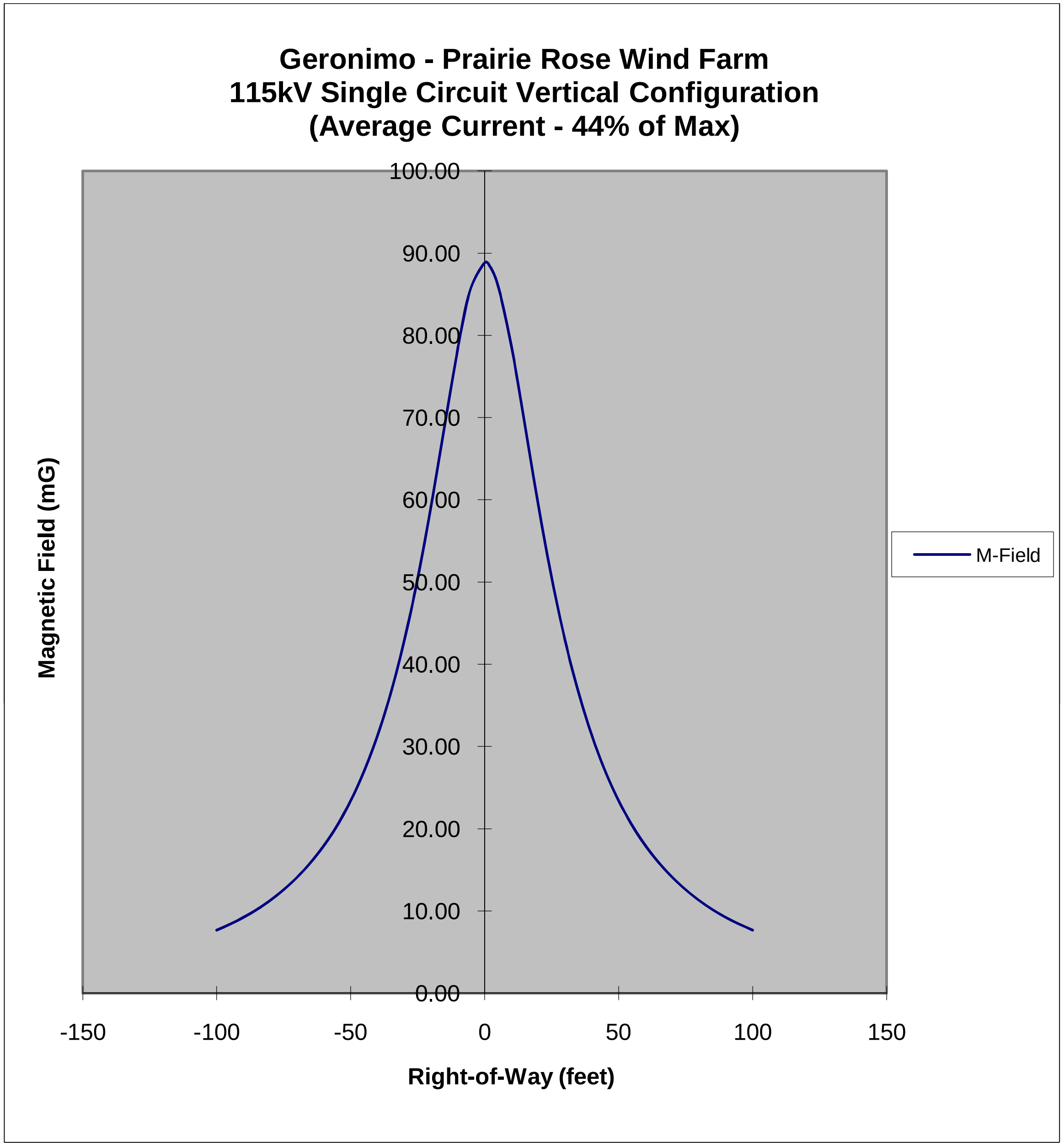
Geronimo - Prairie Rose Wind Farm

Magnetic Field

Bundle	x-feet	y-feet	amps	phase
1	-1.50	57.00	0.0	0.00
2	8.00	37.00	633.0	0.00
3	-10.00	31.00	633.0	120.00
4	10.00	25.00	633.0	240.00
5				
6				
7				
8				

NPH=	4.00	**Calculated**
Dist - ft	Vert	**Milligauss**
-100	3.28	7.60
-95	3.28	8.37
-90	3.28	9.26
-85	3.28	10.29
-80	3.28	11.50
-75	3.28	12.93
-70	3.28	14.62
-65	3.28	16.65
-60	3.28	19.09
-55	3.28	22.05
-50	3.28	25.68
-45	3.28	30.13
-40	3.28	35.63
-37.5	3.28	38.83
-35	3.28	42.37
-30	3.28	50.56
-25	3.28	60.24
-20	3.28	71.16
-15	3.28	82.61
-10	3.28	93.37
-5	3.28	101.99
0	3.28	106.99
5	3.28	106.97
10	3.28	101.14
15	3.28	90.31
20	3.28	76.97
25	3.28	63.79
30	3.28	52.29
35	3.28	42.91
37.5	3.28	38.96
40	3.28	35.46
45	3.28	29.61
50	3.28	25.00
55	3.28	21.34
60	3.28	18.39
65	3.28	16.00
70	3.28	14.04
75	3.28	12.41
80	3.28	11.04
85	3.28	9.88
90	3.28	8.89
95	3.28	8.04
100	3.28	7.31




Geronimo - Prairie Rose Wind Farm
115kV Single Circuit Vertical Configuration
(Average Current - 44% of Max)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-150
-100
-50
0
50
100
150
Magnetic Field (mG)
Right-of-Way (feet)
M-Field

Geronimo - Prairie Rose Wind Farm

Magnetic Field

Bundle	x-feet	y-feet	amps	phase
1	-7.50	69.00	0.0	0.00
2	0.00	49.00	633.0	0.00
3	2.00	37.00	633.0	120.00
4	0.00	25.00	633.0	240.00
5				
6				
7				
8				
NPH=	4.00	**Calculated**		
Dist - ft	Vert	**Milligauss**		
-100	3.28	7.67		
-95	3.28	8.40		
-90	3.28	9.24		
-85	3.28	10.20		
-80	3.28	11.30		
-75	3.28	12.59		
-70	3.28	14.09		
-65	3.28	15.86		
-60	3.28	17.95		
-55	3.28	20.44		
-50	3.28	23.41		
-45	3.28	26.99		
-40	3.28	31.32		
-35	3.28	36.56		
-30	3.28	42.88		
-25	3.28	50.43		
-20	3.28	59.22		
-15	3.28	68.91		
-10	3.28	78.47		
-8	3.28	81.84		
-5	3.28	85.91		
0	3.28	88.83		
2	3.28	88.39		
5	3.28	86.05		
10	3.28	78.68		
15	3.28	69.12		
20	3.28	59.39		
25	3.28	50.55		
30	3.28	42.96		
35	3.28	36.61		
40	3.28	31.35		
45	3.28	27.02		
50	3.28	23.43		
55	3.28	20.45		
60	3.28	17.96		
65	3.28	15.87		
70	3.28	14.10		
75	3.28	12.59		
80	3.28	11.31		
85	3.28	10.20		
90	3.28	9.24		
95	3.28	8.40		
100	3.28	7.67