Exhibit AA

Electromagnetic Frequencies from Transmission Lines

Wheatridge Renewable Energy Facility East
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Prepared for
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Acronyms and Abbreviations

EMF	electromagnetic field
AC	Alternating current
Hz	Hertz
ELF	Extremely low frequency
kV	Kilovolt
mG	Milligauss
FCC	Federal Communications Commission
EMR	Electromagnetic radiation
kHz	Kilohertz
GHz	Gigahertz
MHz	Megahertz
dB	Decibel
µV/m	Microvolt per meter

1.0 Introduction

The Wheatridge Renewable Energy Facility East (Facility) is an approved, but not yet constructed, wind energy generation facility consisting of up to 66 turbines and related or supporting facilities with a peak generating capacity of up to 200 megawatts (MW), to be located in an Approved Site Boundary of approximately 4,582 acres on over 42,000 acres of leased land in Morrow and Umatilla counties, Oregon. As part of Request for Amendment (RFA) 1 to the Facility Site Certificate, Wheatridge East Wind, LLC (Certificate Holder) is proposing to expand wind power generation at the Facility to provide the opportunity for increased power capacity and availability. This includes expanding the Site Boundary and micrositing corridors, increasing the peak generating capacity by adding more and newer turbines, changing the intraconnection routes, and extending the construction date. See the RFA 1's Division 27 document (*Request for Amendment #1 for the Wheatridge Renewable Energy Facility East*) for a more detailed summary of the proposed changes.

This Exhibit AA was prepared to meet the submittal requirements in Oregon Administrative Rules (OAR) 345-021-0010(1)(aa). Analysis in this exhibit incorporates and/or relies on reference information, analysis, and findings found in the Application for Site Certificate, previous RFAs, and Oregon Department of Energy Final Orders to demonstrate that the Facility, as modified by RFA 1, continues to comply with applicable Site Certificate conditions and the standard in OAR 345-021-0010(1)(aa). OAR 345 Division 22 does not provide an approval standard specific to Exhibit AA. This exhibit also includes the submittal requirements outlined in the Specific Standards for Transmission Lines under OAR 345-024-0090:

> *(1) Can design, construct and operate the proposed transmission line so that alternating current electric fields do not exceed 9 kV per meter at one meter above the ground surface in areas accessible to the public;*
>
> *(2) Can design, construct and operate the proposed transmission line so that induced currents resulting from the transmission line and related or supporting facilities will be as low as reasonably achievable.*

1.1 EMF Background Information

Electromagnetic fields (EMFs) occur both naturally and as a result of the generation, transmission, and use of electric power. The earth itself generates steady-state magnetic and electric fields. Electromagnetic fields are present around any conductors or devices that transmit or use electrical energy; as a result, exposure to EMF is common from an array of electrical appliances and equipment, building wiring, and electric distribution and transmission lines. The electrical power system in the United States is an alternating current (AC) system operating at a frequency of 60 hertz (Hz)[1], resulting in "power frequency" or "extremely low frequency (ELF)" EMF.[2] While electric and magnetic fields are often referred to and thought of collectively, each arises through a different mechanism and can have differing effects.

Electric fields around transmission lines are produced by the presence of an electric charge, 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 strength of the electric field is inversely proportional to the square of distance from the conductors; the electric field strength declines as the distance from the conductor increases. The strength of the electric field is measured in units of kilovolts (kV) per meter (kV/m). Electric fields are readily weakened or blocked by conductive objects such as trees or buildings. The direction of force within the electric field alternates at a frequency of 60 Hz, in direct relation to the charge on each conductor. However, the overall transmission line voltage, and therefore the overall strength and reach of the electric field, remains practically steady and is not affected by the common daily and seasonal fluctuations in usage of electricity by customers.

Magnetic fields around transmission lines are produced by the movement of electrical charge, measured in terms of amperage, through the conductors. Like the electric field, the magnetic field alternates at a frequency of 60 Hz. Magnetic field strength is expressed in units of milligauss (mG).[3] The magnetic field strength is directly proportional to the amperage; that is, increased current flow resulting from increased power flow through the line produces a stronger magnetic field. As with electric fields, the magnetic field is inversely proportional to the square of the distance from the conductors, declining in strength as the distance from the conductor increases. Magnetic fields are not blocked or shielded by most materials. Unlike voltage, the amperage and the resulting magnetic field around a transmission line fluctuate daily and seasonally as the usage of electricity varies and the resulting amount of current flow varies.

Each AC three-phase circuit carries power over three conductors. One phase of the circuit is carried by each of the three conductors. The AC voltage and current in each phase conductor is out of sync with the other two phases by 120 degrees, or one-third of the 360-degree cycle. The fields from each of these conductors tend to cancel each other out because of this phase difference. However, since the conductors are separated from each other, when a person stands under a transmission line, one conductor is somewhat closer than the others and will contribute a net uncanceled field at the person's location.

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[1] Hertz is a measure of cycles per second. In a 60-Hz transmission system, the charge and direction of current flow on each conductor will cycle from positive to negative and back to positive 60 times per second. The direction of force in the electric and magnetic fields will also cycle in direct relation to the charge and direction of flow on the conductor.

[2] The electric transmission system in the U.S. operates at 60 Hz, while in Europe and other parts of the world, the systems operate at 50 Hz; both produce fields that are referred to as power frequency or ELF EMF.

[3] Magnetic field strength may also be measured in terms of the Tesla, an International System unit of measurement. 1 Gauss = 0.0001 Tesla, or 1 Tesla = 10,000 Gauss; 1 Gauss = 1,000 mG.

1.2 EMF Standards

No federal regulations or guidelines apply directly to the EMF levels for transmission lines. The National Institute of Environmental Health Sciences performed an extensive review of field-related issues in the 1990s that resulted in the decision that regulatory actions are unwarranted (NIEHS 1999).

Although there are no federal regulations on power-frequency EMF in the United States, international recommendations and guidelines exist. Table AA-1 lists power-frequency EMF guidelines recommended by the European Union, the International Committee on Electromagnetic Safety, and the International Commission on Non-Ionizing Radiation Protection, which is an affiliate of the World Health Organization (EU 1999, ICES 2002, ICNIRP 2010).

Table AA-1. International Guidelines for Alternating Current Power-Frequency EMF Levels

Agency	Exposure	Electric Field (kV/m)	Magnetic Field (mG)
European Union	General public	4.2	833
International Committee on Electromagnetic Safety [1]	Occupational	20	27,100
	General public	5	9,040
	General public within right-of-way	10	NA
International Commission on Non-Ionizing Radiation Protection	Occupational	8.3	10,000
	General public	4.2	2,000

Magnetic fields are measured in gauss (G) and milligauss. 1 G = 1,000 mG

NA = Not Applicable (no requirements)

1. International Committee on Electromagnetic Safety recommendations have been adopted as standards by the Institute of Electrical and Electronics Engineers; see Standard C95.6 -2002 (R2007).

Transmission line projects in Oregon must comply with the electric field standard found in OAR 345-024-0090, which requires that the applicant design, construct, and operate the proposed transmission line so that AC electric fields do not exceed 9 kV/m at 1 meter above the ground surface in areas accessible to the public. There is no similar Oregon design standard for magnetic fields.

Six other states have adopted limits for electric field strength either at the edge or within the right-of-way of the transmission line corridor. Only Florida and New York currently limit magnetic fields levels from transmission lines. The magnetic field levels set in those two states only apply at the edge of the right-of-way and were developed to prevent magnetic fields from increasing beyond levels currently experienced by the public. Table AA-2 shows the AC electric field and magnetic field standards that have been adopted by states in the United States.

Table AA-2. Other State Alternating Current Power-Frequency EMF Standards

State		Location	Electric Field (kV/m)	Magnetic Field (mG)
Florida	230 to 500 kV lines	Within right-of-way	10	NA
		Edge of right-of-way	2	200 [1]
	230 kV or less	Within right-of-way	8	NA
		Edge of right-of-way	2	150
Minnesota		Within right-of-way	8	NA
Montana		Within right-of-way: road crossing	7	NA
		Edge of right-of-way	1 [2]	NA
New Jersey		Within right-of-way	NA	NA
		Edge of right-of-way	3	NA
New York		Within right-of-way: open	11.8	NA
		Within right-of-way: public road	7	NA
		Within right-of-way: private road	11	NA
		Edge of right-of-way	1.6	200
North Dakota		Within right-of-way	9	NA
		Edge of right-of-way	NA	NA
Oregon		Within right-of-way	9	NA
		Edge of right-of-way	NA	NA

NA = Not Applicable (no requirements)

1. Magnetic field strength is limited to 250 mG for new double-circuit 500-kV lines constructed on a previously existing right-of-way.
2. Can be waived by landowner.

In the fall of 2009, the Oregon Energy Facility Siting Council commissioned a review of existing information to prepare for the review of several transmission lines under discussion at that time. That review was conducted by Dr. Kara Warner and presented to the Council on November 20, 2009, during a regular Council meeting. The prevailing conclusions were that there is a need to continue to monitor the science on EMF; that low-cost, prudent avoidance measures of public EMF exposure are appropriate; and that health-based limits are not appropriate given the scientific data available (EFSC 2009).

2.0 Facility EMF – OAR 345-021-0010(1)(aa)(A)

OAR 345-021-0010(1)(aa) Exhibit AA. If the proposed energy facility is a transmission line or has, as a related or supporting facility, a transmission line of any size:

OAR 345-021-0010(1)(aa)(A) Information about the expected electric and magnetic fields, including:

The proposed amended Facility includes a 230-kV overhead Intraconnection Line that would be approximately 26 miles in length. This would connect the electrical collection system, the substations, and battery storage to the existing Blue Ridge Substation, which is northwest of the Facility. There are two options for the Intraconnection Line route options (see Figure 2 and Figures 2.1 through 2.11 in this RFA's Division 27 document for further details), but both use the same transmission line structure designs and carry similar currents (see Section 2.3).

Both of the Intraconnection Line route options have a specific right-of-way width defined. Both routes would occupy private land pursuant to leases or easements with landowners or road authority. The leases would authorize placement of the cables and restrict inconsistent or competing uses of the property, but will not contain any defined right-of-way with a fixed width. Therefore, no new right-of-way would be required, and no existing right-of-way would be widened.

2.1 Analysis Area – OAR 345-021-0010(1)(aa)(A)(i)(ii)(iii)

> *OAR 345-021-0010(1)(aa)(A)(i) The distance in feet from the proposed center line of each proposed transmission line to the edge of the right-of-way.*
>
> *OAR 345-021-0010(1)(aa)(A)(ii) The type of each occupied structure, including but not limited to residences, commercial establishments, industrial facilities, schools, daycare centers and hospitals, within 200 feet on each side of the proposed center line of each proposed transmission line.*
>
> *OAR 345-021-0010(1)(aa)(A)(iii) The approximate distance in feet from the proposed center line to each structure identified in (A).*

There are no known occupied buildings, residences, or other sensitive receptors within 200 feet of the Intraconnection Line route options. The nearest residence is located over 1,000 feet from one of the Intraconnection Line route options.

Table AA-3. Identified Structures

Structure ID	Location	Distance from Centerline[1, 2, 3]
1029	Easting 318829, Northing 5046049	1,002
1028	Easting 318851, Northing 5046078	1,072
1025	Easting 318874, Northing 5046093	1,136
1027	Easting 318936, Northing 5046079	1,346
1026	Easting 318945, Northing 5046038	1,374
1189	Easting 313867, Northing 5041100	2,781
1096	Easting 313901, Northing 5041098	2,818
1094	Easting 313881, Northing 5041168	3,030
1093	Easting 313960, Northing 5041192	3,147
1114	Easting 308032, Northing 5036983	4,224
1044	Easting 302689, Northing 5043006	4,433 (Option 1), 1,561 (Option 2)

Structure ID	Location	Distance from Centerline[1, 2, 3]
1048	Easting 302821, Northing 5043009	4,466 (Option 1), 1,582 (Option 2)
1047	Easting 302811, Northing 5043075	4,678 (Option 1), 1,802 (Option 2)
1. Distance to closet feature in feet. 2. Per definition in OAR 345-021-0010(1)(aa)(A), all structures listed are considered occupied. 3. The distance to transmission line does not depend on routing option selected for the Facility if no separate measurement is provided.		

2.2 Modeling Results – OAR 345-021-0010(1)(aa)(iv)

OAR 345-021-0010(1)(aa)(A)(iv) At representative locations along each proposed transmission line, a graph of the predicted electric and magnetic fields levels from the proposed center line to 200 feet on each side of the proposed center line.

Table AA-4 shows calculated electric field values for the 230-kV Intraconnection Line. Table AA-5 shows calculated magnetic field values for the 230-kV Intraconnection Line.

Table AA-4. Calculated Electric Field Values

Line Description	Figure	Electric Field (kV/m)		
		200 feet Left	Peak Value	200 feet Right
230-kV Intraconnection Line	AA-1 AA-3	0.036	4.751 (16 feet left of centerline)	0.067
Note: The 230-kV Intraconnection Line is located within the Amended Wind Micrositing Corridors.				

Table AA-5. Calculated Magnetic Field Values

Line Description	Figure	Magnetic Field (mG)		
		200 feet Left	Peak Value	200 feet Right
230-kV Intraconnection Line	AA-2 AA-3	5.62	301.26 (on centerline)	5.74
Note: The 230-kV Intraconnection Line is located within the Amended Wind Micrositing Corridors.				

The analysis results of the Bonneville Power Administration Corona and Fields Effect Program, Version 3 (CAFE) model (BPA) presented in Table AA-4 demonstrate that the proposed 230-kV Intraconnecton Line can be constructed and operated such that the AC electric field would not exceed 9 kV/m at 1 meter above the ground surface, as required by OAR 345-024-0090(1). See Figure AA-1 for the electric field graph for the 230-kV Intraconnecton Line, and Figure AA-2 for the magnetic field graphs for the 230-kV Intraconnecton Line. The analysis results for the 230-kV Intraconnecton Line are provided in Attachment AA-1. The modeling assumptions related to the Facility are intentionally conservative, producing worst-case EMF results. EMF levels under normal operating conditions would be lower than indicated by this analysis.

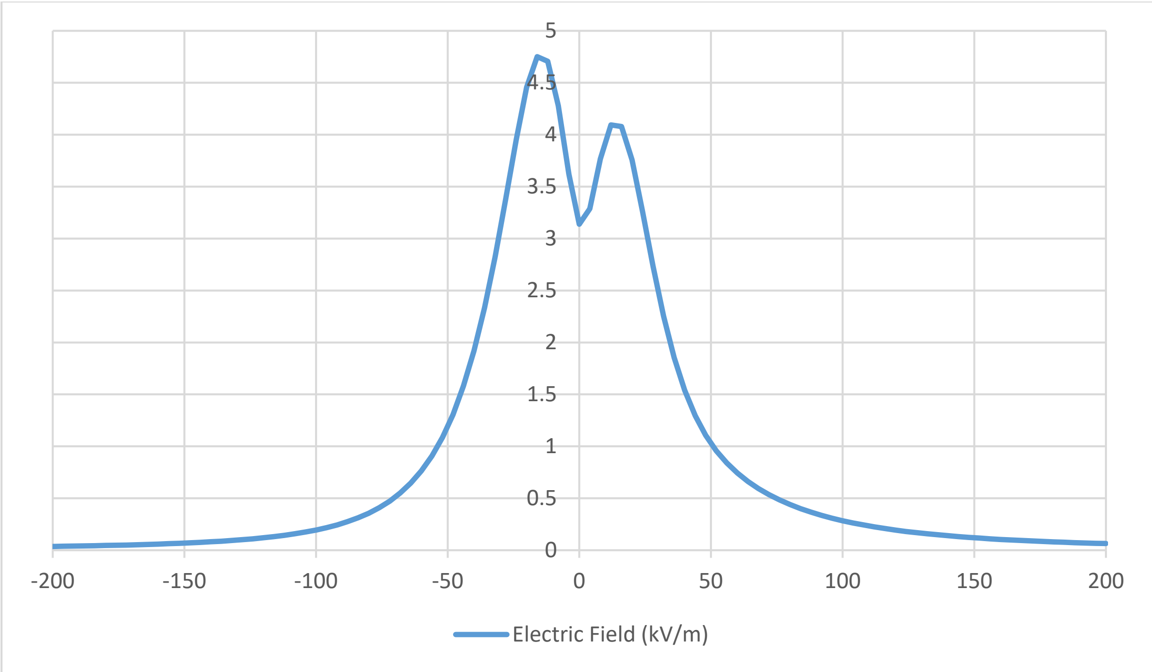


Figure AA-1. Electric Field, 230-kV Intraconnection Line

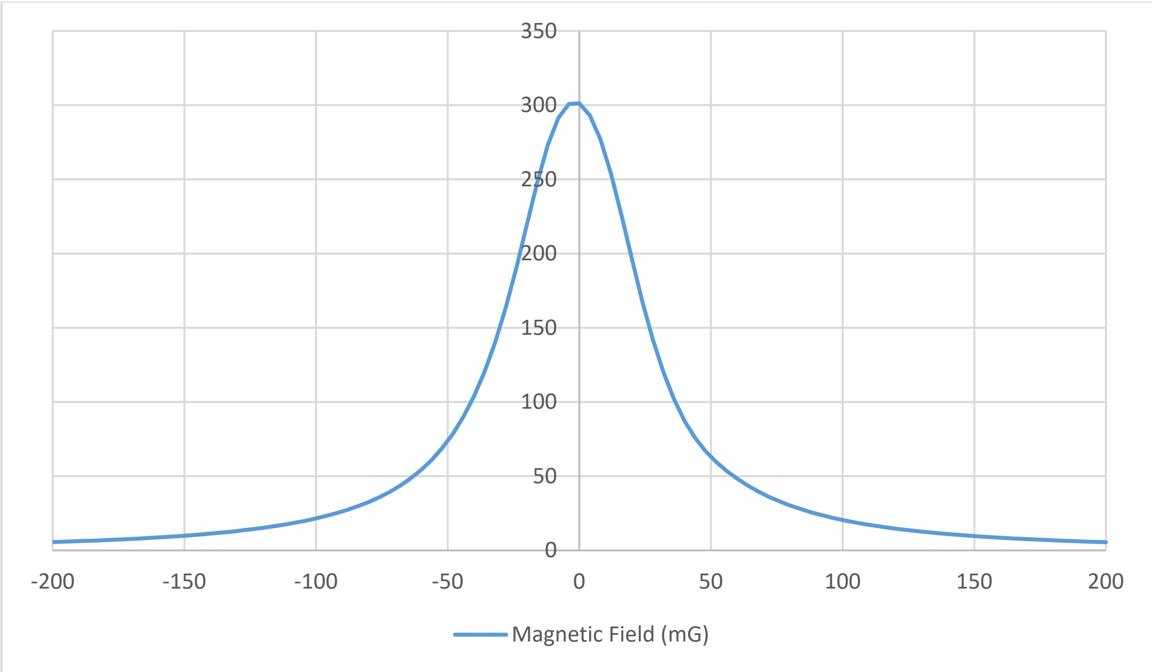


Figure AA-2. Magnetic Field, 230-kV Intraconnection Line

2.3 EMF Calculation Methods – OAR 345-021-0010(1)(aa)(vi)

OAR 345-021-0010(1)(aa)(A)(vi) The assumptions and methods used in the electric and magnetic field analysis, including the current in amperes on each proposed transmission line.

The following assumptions are used for the calculation of the electric and magnetic field analysis of the 230-kV Intraconnection Line. The planned 230-kV Intraconnection Line configuration is shown in Figure AA-3. Assumptions for modeling are as follows:

- Environmental parameters – 1 inch of precipitation per hour, 2.0 miles per hour wind speed (for modeling wet-weather conditions)
- Height for both electrical and magnetic field measurements – 1 meter, or 3.28 feet above ground.
- 230-kV Intraconnection Line information:
    - Line amperage – 1,395 amps
    - Line voltage – 230-kV phase/phase or 132.9-kV phase/ground
    - Conductor type – Bundle of two 1272 KCMIL ACSR “Bittern” conductors, 1.345” in diameter, separated by 18” from center to center as shown in Figure AA-3.
    - Ground wire – two OPGW SFPOC/SFSJ-J-4388R2 ground wire, 0.530” in diameter, as shown in Figure AA-3. Height from ground is 59 feet.
    - Minimum height of conductor from ground – 25 feet.
    - A phase is located on the upper arm of the transmission structure at 43 feet, B and C phases are located on the lower arms of the transmission structure at 25 feet. Phasing is shown on Figure AA-3.

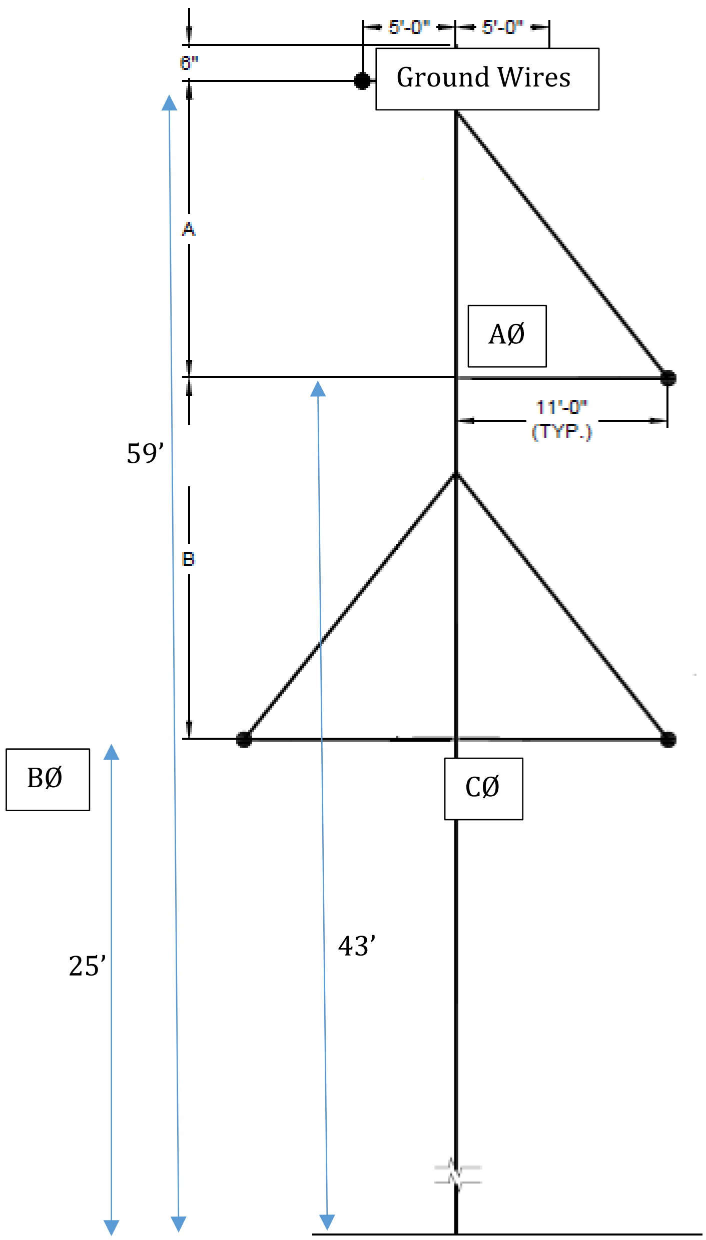


Figure AA-3. Typical Overhead Transmission Line

3.0 EMF Mitigation Measures – OAR 345-021-0010(1)(aa)(A)(v)

OAR 345-021-0010(1)(aa)(A)(v) Any measures the applicant proposes to reduce electric or magnetic field levels.

The Certificate Holder will comply with the following Site Certificate conditions to limit EMF impacts.[4]

- *PRE-TL-01: Prior to construction, the certificate holder shall schedule a time to brief the OPUC Safety, Reliability, and Security Division (Safety) Staff as to how it will comply with OAR Chapter 860, Division 024 during design, construction, operations, and maintenance of the facilities.*
- *CON-TL-01: During construction, the certificate holder shall take reasonable steps to reduce or manage human exposure to electromagnetic fields, including:*
    - *a. Constructing all aboveground collector and transmission lines at least 200 feet from any residence or other occupied structure, measured from the centerline of the transmission line.*
    - *b. Constructing all aboveground 34.5-kV transmission lines with a minimum clearance of 25 feet from the ground.*
    - *c. Constructing all aboveground 230-kV transmission lines with a minimum clearance of 30 feet from the ground.*
    - *d. Developing and implementing a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, irrigation systems, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line (OAR 345-027-0023(4)).*
    - *e. Providing to landowners a map of underground and overhead transmission lines on their property and advising landowners of possible health and safety risks from induced currents caused by electric and magnetic fields.*
    - *f. Designing and maintaining all transmission lines so that alternating current electric fields do not exceed 9 kV per meter at one meter above the ground surface in areas accessible to the public.*
    - *g. Increasing the intraconnection transmission line height, shielding the electric field, or installing access barriers, if needed, to prevent induced current and nuisance shock of mobile vehicles.*

[4] Site Certificate for the Wheatridge Renewable Energy Facility II, First Amended Site Certificate (November 2020)

h. *Designing and maintaining all transmission lines so that induced voltages during operation are as low as reasonably achievable.*

i. *Designing, constructing and operating the transmission line in accordance with the requirements of the 2012 Edition of the National Electrical Safety Code approved on June 3, 2011 by the American National Standards Institute (OAR 345-027-0023(4)).*

j. *Implement a safety protocol to ensure adherence to NESC grounding requirements.*

- *OPR-TL-01: During operation, the certificate holder shall:*

1) *Update the OPUC Safety Staff as to how the operator will comply with OAR Chapter 860, Division 024 on an ongoing basis considering future operations, maintenance, emergency response, and alterations until facility retirement.*

2) *File the following required information with the Commission:*

   a) *758.013 Operator of electric power line to provide Public Utility Commission with safety information; availability of information to public utilities. (1) Each person who is subject to the Public Utility Commission's authority under ORS 757.035 and who engages in the operation of an electric power line as described in ORS 757.035 must provide the commission with the following information before January 2 of each even-numbered year:*

      i) *The name and contact information of the person that is responsible for the operation and maintenance of the electric power line, and for ensuring that the electric power line is safe, on an ongoing basis; and*

      ii) *The name and contact information of the person who is responsible for responding to conditions that present an imminent threat to the safety of employees, customers and the public.*

      iii) *In the event that the contact information described in subsection (1) of this section changes or that ownership of the electric power line changes, the person who engages in the operation of the electric power line must notify the commission of the change as soon as practicable, but no later than within 90 days.*

      iv) *If the person described in subsection (1) of this section is not the public utility, as defined in ORS 757.005, in whose service territory the electric power line is located, the commission shall make the information provided to the commission under subsection (1) of this section available to the public utility in whose service territory the electric power line is located. [2013 c.235 §3]*

3) *Provide OPUC Safety Staff with:*

   a) *Maps and Drawings of routes and installation of electrical supply lines showing:*

      (1) *Transmission lines and structures (over 50,000 Volts)*

      (2) *Distribution lines and structures - differentiating underground and overhead lines (over 600 Volts to 50,000 Volts)*

(3) Substations, roads and highways

(4) Plan and profile drawings of the transmission lines (and name and contact information of responsible professional engineer).

4.0 EMF Monitoring Program – OAR 345-021-0010(1)(aa)(A)(vii)

OAR 345-021-0010(1)(aa)(A)(vii) The applicant's proposed monitoring program, if any, for actual electric and magnetic field levels.

No program for monitoring actual EMF levels before or after construction is proposed at this time.

5.0 Radio and TV Interference – OAR 345-021-0010(1)(aa)(B)

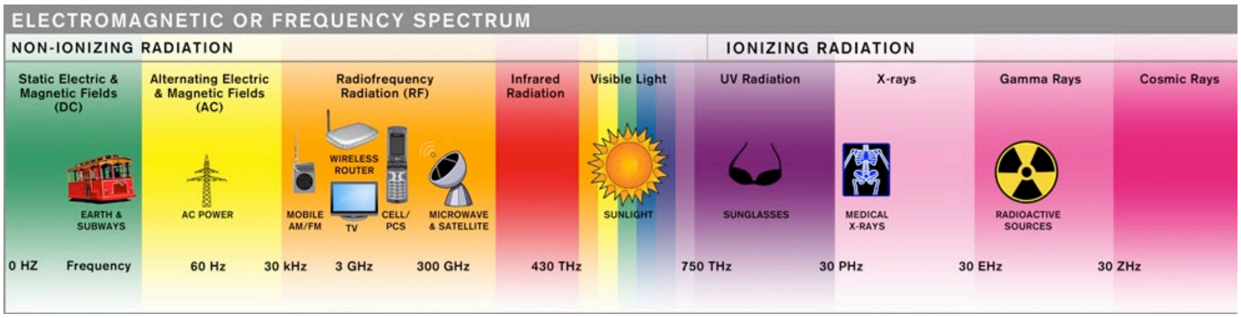
OAR 345-021-0010(1)(aa)(B) An evaluation of alternate methods and costs of reducing radio interference likely to be caused by the transmission line in the primary reception area near interstate, U.S. and state highways.

5.1 Background

5.1.1 Electromagnetic Interference

Electromagnetic interference from power transmission systems in the U.S. is governed by the Federal Communications Commission (FCC) Rules and Regulations (FCC 1988). A power transmission line is categorized by the FCC as an "incidental radiation device." It is defined as "a device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy." Such a device "shall be operated so that the radio frequency energy that is emitted does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interference." In this case, "harmful interference" is defined as "any emission, radiation or induction which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with this chapter" (FCC 1988). Oregon does not have regulatory standards for either radio or TV interference.

Modern communications systems all rely on electromagnetic radiation (EMR) to transmit information. AM and FM radio, TV, shortwave radio, cellular telephones, radar, GPS devices and satellite communications, cordless telephones, Bluetooth, and wireless computer networks such as Wi-Fi or wireless local area network all utilize a region of the electromagnetic spectrum known as "radio frequency" EMR, which extends from the very low-frequency end at about 30 kilohertz (kHz) up into the high-frequency microwave range at about 300 gigahertz (GHz). Each type of technology uses a specific segment of the electromagnetic frequency spectrum; older technology such as AM radio is at the low-frequency end, while newer technologies such as GPS and Wi-Fi utilize high-frequency signals. Figure AA-9 provides a visual representation of typical communications frequencies.



Source: EMF & Radio Frequency Solutions. Available online at: http://www.emfrf.com/index.php/emf-rf/emf-overview/electromagnetic-spectrum-or-frequency-spectrum.html.

Figure AA-4. Communications Frequency Spectrum

The level of interference can be partially determined by how similar or different the signal frequency is compared to the noise frequency. In general, there is little interaction between signals of differing frequency; radio signals, TV signals, cellular phone signals, and GPS signals can all coexist in the same space and time without interfering with each other. For interference to occur, frequencies must be similar.

EMR and resulting interference can be an indirect product of electric transmission lines. EMR arises not from the lines themselves, but from the interaction of the strong electric field at the surface of the conductors and other energized components with the surrounding air. Two types of interactions may occur that create electromagnetic interference: corona discharge and gap discharge.

5.1.1.1 Corona Discharge

High-voltage power transmission lines generate a strong electric field at the surface of the conductor, which can be strong enough to split the surrounding air molecules, resulting in the emission of electromagnetic energy in the form of ultraviolet and near-ultraviolet light and broad-band radio frequency EMR (corona discharge also produces audible sound, which is addressed in Exhibit Y; audible sound is not discussed further in this exhibit). The former can sometimes be seen by humans under the right conditions or with specialized equipment, while the latter can sometimes be heard as electronic "noise," or interference with radio signal reception. Broadband corona EMR discharge typically occurs in the frequency spectrum from below 100 kHz to approximately 1,000 megahertz (MHz), which overlaps with the frequencies used for AM and FM radio and some TV signals. With sufficient corona activity, low-frequency radio and TV interference can be noticeable within a few hundred feet of the transmission line. These effects are most pronounced directly underneath the line conductors and decrease with distance from the transmission line.

Corona on a transmission line conductor depends on several factors such as operating voltage, conductor diameter, overall line geometry, weather conditions, and altitude. Conductor size, line voltage and line geometry are taken into consideration when designing a transmission line so that the electric fields at the conductor surface are minimized. However, for a high-voltage line, any incidental irregularities on the conductor surface (for example, water droplets, dust, debris, and nicks or scratches in the conductor) act as points where the electric field may be intensified sufficiently to produce corona. Thus, the level of corona activity is elevated during foul weather when raindrops on the conductor surface act as points producing corona.

5.1.1.2 Gap Discharge

A gap discharge occurs when current arcs across a gap between two conductive objects. Gap discharges can produce radio noise in the lower frequencies (AM radio frequencies) and well into the microwave range (analog TV frequencies). These discharges can be produced by loose connections, a problem that more commonly occurs on low-voltage distribution lines but rarely occurs on high-voltage transmission lines (Trinh 2012). Unlike corona discharge, which may occur anywhere along a high-voltage transmission line conductor, gap discharge occurs at mechanical connectors and components that are used to hold the conductors in place. Gap discharge is controlled through proper construction and maintenance practices to ensure all mechanical connectors and components are properly assembled. Because gap discharge is an intermittent, temporary, and readily resolved problem, and results only in localized electrical interference issues, the potential for interference with TV signals or higher-frequency communications is not considered a significant problem.

5.1.2 Radio Interference Effects

The corona-induced broadband EMR from transmission lines can produce interference to AM signals, such as a commercial AM radio audio signal (i.e., radio noise) or the video portion of an older analog broadcast TV station (i.e., TV noise). Technologies that use frequency modulation, such as FM radio stations and the audio portion of older analog broadcast TV signals, are generally not affected by noise from a transmission line. As digital signal processing has been integrated into these communication systems, the potential interference impact of corona-generated radio noise has decreased.

The level of interference caused by radio noise from a transmission line to the reception of a radio signal depends on the location of the radio transmitter, the radio receiver, and the transmission line. A transmission line that is directly between a radio transmitter and a listener's receiver may be more likely to interfere with that listener's reception, whereas a transmission line behind or beside the listener in relation to the transmitter will not necessarily cause interference, depending on the radio receiver's antennae. The radio noise generated by a transmission line is very low in power and decreases rapidly as distance from the line increases. It is experienced only when in close proximity to the transmission line.

In general, complaints related to corona-generated interference are infrequent. Moreover, the advent of cable and satellite TV service, and the federally-mandated conversion to digital TV broadcast in June 2009 have greatly reduced the occurrence of corona-generated interference. Low-frequency corona-induced EMR does not interact with the higher-frequency satellite signals or with wired communication systems, while digital TV receivers are equipped with systems to filter out interference. Many radio stations also broadcast in digital, reducing the likelihood of corona-induced EMR interference. Electric power companies are able to operate very effectively under the present FCC rule because harmful interference can generally be eliminated or effectively mitigated.

Radio noise is measured in units of decibels (dB) based on its field strength referenced to a signal level of 1 microvolt per meter (IEEE 1986). Corona-induced radio noise during fair weather is calculated to be approximately 40 dB (dB-1 microvolt per meter [1 μV/m]) at the edge of the right-of-way. This is considered an acceptable level (IEEE 1971). When the transmission line is in proximity to roadways (for example, interstates or federal and state highways), such as when it passes over these roadways, radio interference may be experienced for short distances while in proximity to the line. Interference may be more noticeable near the line particularly during foul weather, when corona activity is elevated.

5.1.3 Interference with Other Electronic Communications

Wireless computer network systems, cell phones, GPS units, and satellite receivers operate at high frequencies in the tens to hundreds of MHz or even GHz. These systems also often use FM or digital coding of the signals so they are relatively immune to electromagnetic interference from transmission line corona. GPS units are used in a wide range of activities, including several important agricultural activities such as monitoring pivot irrigation, tracking wheeled and tracked equipment movements during farming operation, and checking the orientation of aerial spraying aircraft. GPS units operate in the frequency range of 1.2 to 1.6 GHz. Satellite receivers operate at frequencies of 3.4 GHz to 7 GHz and have shown no effect from transmission lines unless the receiver was trying to view the satellite through the transmission tower or conductor bundle of the transmission line (Chartier et al. 1986). Repositioning the receiver by a few feet was sufficient to eliminate the obstruction and reduced signal. Mobile phones operate in the radiofrequency range of about 800 MHz to 1,900 MHz or higher. As a result of the high frequencies used by these devices, modulation and processing techniques, and the typically lower-frequency corona-induced EMR, effects from interference are unlikely.

The voltages and currents associated with the Intraconnection Line have the potential to induce voltage and current in nearby conductors (e.g., ungrounded metal fences and ungrounded metal irrigation systems). This effect is more likely where ungrounded fences or irrigation systems are parallel and long (1 mile or more). These induced voltages could result in a "nuisance" shock to anyone who touches such a fence or irrigation system. These shocks are known as nuisance or "startle" shocks as they will not physically harm someone but may be noticed by some people and provoke a startle reaction. An example of an ungrounded metal irrigation system would be a center pivot system on rubber tires. By contrast, the Vermeer-type metal irrigation system is grounded through its metal wheels and therefore presents less of a shock hazard.

A GPS unit in farming equipment should work properly within the vicinity of a transmission line. GPS devices continually pull signals from a number of satellites, not just one and may also utilize a fixed base station. A signal may be blocked temporarily if the transmission structure is between the receiver and a weak signal, but it will return as the farm equipment moves past the structure. It is also common for GPS receivers to drop and pick up signals even in the absence of transmission lines and structures. If the base station signal is weak or blocked, additional or alternate locations may improve the signal and performance.

Signal interference occurs when other signals at the same frequency as the satellite signal are present. Multipath occurs when objects such as buildings, structures, or tractor parts reflect a GPS satellite signal, causing the satellite signal to arrive at the receiver later than it would have if it followed a straight line from the satellite. A study commissioned by EPRI found that signal interference is "unlikely" based on the design of GPS receivers and their ability to separate the GPS signal from background noise (Silva and Olsen 2002). Another study compared the accuracy of real-time kinematic GPS receivers at different locations to transmission lines and towers (Gibbings et al. 2001). This study concluded that multipath from transmission towers could result in GPS initialization errors (e.g., the system reports the wrong starting location) 1.1 percent to 2.3 percent of the time. This study also reported that GPS software was able to identify and correct these initialization errors within the normal startup time. This study reported initialization errors caused by electromagnetic interference from energized overhead transmission lines when the GPS receiver was located outside the vehicle, but concluded that "most, if not all of this effect can be eliminated by shielding the receiver and cables." Placing the receiver inside the vehicle significantly reduced initialization errors.

5.2 Evaluation of Alternate Methods and Costs to Reduce Interference

Design options for reducing the radio noise from the Intraconnection Line include use of larger diameter conductors, or use of more conductors within the conductor bundles. Increasing the distance between phases of the lines (conductor bundles) may also result in a decrease in the radio noise. These line design options have been employed to minimize the generation of radio noise to acceptable levels.

6.0 Conclusion

Exhibit AA demonstrates that the Facility will ensure public health and safety with respect to EMFs. Also, this exhibit demonstrates that the Facility's AC electric fields and induced currents will comply with the Specific Standards for Transmission Lines provided under OAR 345-024-0090.

7.0 References

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Attachment AA-1. CAFE EMF Output

ÛßßßÛ
Û C O R O N A A N D F I E L D Û
Û E F F E C T S P R O G R A M V E R. 3 Û
Û Source: Bonneville Power Administration Û
ÛÜÜÜÛ

INPUT DATA LIST

1/ 3/2023 08:44:12
WHEATRIDGE EAST EMF 2022

1,0, 3, 5,0.0, 2.00, 1.00, .00

(ENGLISH UNITS OPTION)

(GRADIENTS ARE COMPUTED BY PROGRAM)

PHYSICAL SYSTEM CONSISTS OF 5 CONDUCTORS, OF WHICH 3 ARE ENERGIZED PHASES

OPTIONS: EF,MF,AN
4.921, 6.562, 9.842, 1.000, 75.000, 7.000, 3.280, 6.700, 3.280
'230A ','A', 11.00, 43.00, 2, 1.345, 18.000, 132.900, .000, 1.395, .000
'230B ','A', -11.00, 25.00, 2, 1.345, 18.000, 132.900, 120.000, 1.395, .000
'230C ','A', 11.00, 25.00, 2, 1.345, 18.000, 132.900, 240.000, 1.395, .000
'G1 ','A', 5.00, 59.00, 1, .530, .000, .000, .000, .000, .000
'G2 ','A', -5.00, 59.00, 1, .530, .000, .000, .000, .000, .000
100 -200.0 4.0
1AUDIBLE NOISE CALCULATION - RAIN

DIST FROM REFERENCE (FEET)	TOTALS L5 (DBA)	L50 (DBA)	230A	230B	230C
-200.0	21.5	18.0	12.3	11.9	14.8
-196.0	21.6	18.1	12.4	12.1	14.9
-192.0	21.7	18.2	12.5	12.2	15.0
-188.0	21.8	18.3	12.6	12.3	15.1
-184.0	21.9	18.4	12.6	12.4	15.2
-180.0	22.0	18.5	12.7	12.5	15.3
-176.0	22.1	18.6	12.8	12.6	15.4
-172.0	22.2	18.7	13.0	12.7	15.5
-168.0	22.3	18.8	13.1	12.9	15.6
-164.0	22.4	18.9	13.2	13.0	15.8
-160.0	22.5	19.0	13.3	13.1	15.9
-156.0	22.7	19.2	13.4	13.2	16.0
-152.0	22.8	19.3	13.5	13.4	16.1
-148.0	22.9	19.4	13.6	13.5	16.2
-144.0	23.0	19.5	13.7	13.7	16.3
-140.0	23.2	19.7	13.9	13.8	16.5

-136.0	23.3	19.8	14.0	14.0	16.6
-132.0	23.4	19.9	14.1	14.1	16.7
-128.0	23.6	20.1	14.2	14.3	16.9
-124.0	23.7	20.2	14.4	14.4	17.0
-120.0	23.9	20.4	14.5	14.6	17.2
-116.0	24.0	20.5	14.7	14.8	17.3
-112.0	24.2	20.7	14.8	15.0	17.5
-108.0	24.4	20.9	14.9	15.2	17.6
-104.0	24.5	21.0	15.1	15.4	17.8
-100.0	24.7	21.2	15.3	15.6	18.0
-96.0	24.9	21.4	15.4	15.8	18.1
-92.0	25.1	21.6	15.6	16.0	18.3
-88.0	25.3	21.8	15.8	16.3	18.5
-84.0	25.5	22.0	15.9	16.5	18.7
-80.0	25.7	22.2	16.1	16.8	18.9
-76.0	25.9	22.4	16.3	17.0	19.1
-72.0	26.2	22.7	16.5	17.3	19.3
-68.0	26.4	22.9	16.7	17.6	19.6
-64.0	26.7	23.2	16.9	17.9	19.8
-60.0	26.9	23.4	17.1	18.3	20.1
-56.0	27.2	23.7	17.3	18.6	20.3
-52.0	27.5	24.0	17.6	19.0	20.6
-48.0	27.8	24.3	17.8	19.4	20.9
-44.0	28.2	24.7	18.0	19.8	21.2
-40.0	28.5	25.0	18.3	20.3	21.5
-36.0	28.9	25.4	18.5	20.8	21.9
-32.0	29.3	25.8	18.8	21.2	22.2
-28.0	29.7	26.2	19.1	21.7	22.6
-24.0	30.1	26.6	19.3	22.2	23.1
-20.0	30.5	27.0	19.6	22.6	23.5
-16.0	30.8	27.3	19.8	22.9	23.9
-12.0	31.1	27.6	20.1	23.1	24.4
-8.0	31.4	27.9	20.3	23.0	24.9
-4.0	31.6	28.1	20.5	22.8	25.4
.0	31.8	28.3	20.6	22.4	25.9
4.0	31.9	28.4	20.7	22.0	26.2
8.0	32.0	28.5	20.8	21.5	26.5
12.0	31.9	28.4	20.8	21.0	26.5
16.0	31.7	28.2	20.8	20.5	26.4
20.0	31.4	27.9	20.7	20.1	26.1
24.0	31.1	27.6	20.6	19.6	25.6
28.0	30.7	27.2	20.4	19.2	25.2
32.0	30.3	26.8	20.2	18.8	24.7
36.0	29.8	26.3	19.9	18.4	24.2
40.0	29.4	25.9	19.7	18.1	23.7
44.0	29.1	25.6	19.4	17.8	23.3
48.0	28.7	25.2	19.2	17.5	22.8
52.0	28.4	24.9	18.9	17.2	22.4
56.0	28.0	24.5	18.7	16.9	22.1
60.0	27.7	24.2	18.4	16.6	21.7
64.0	27.4	23.9	18.2	16.4	21.4
68.0	27.1	23.6	17.9	16.1	21.1
72.0	26.9	23.4	17.7	15.9	20.7
76.0	26.6	23.1	17.5	15.7	20.5

80.0	26.3	22.8	17.2	15.5	20.2
84.0	26.1	22.6	17.0	15.3	19.9
88.0	25.9	22.4	16.8	15.1	19.7
92.0	25.7	22.2	16.6	14.9	19.5
96.0	25.5	22.0	16.4	14.7	19.2
100.0	25.3	21.8	16.2	14.5	19.0
104.0	25.1	21.6	16.0	14.4	18.8
108.0	24.9	21.4	15.8	14.2	18.6
112.0	24.7	21.2	15.7	14.0	18.4
116.0	24.5	21.0	15.5	13.9	18.2
120.0	24.3	20.8	15.3	13.7	18.0
124.0	24.2	20.7	15.2	13.6	17.9
128.0	24.0	20.5	15.0	13.4	17.7
132.0	23.9	20.4	14.9	13.3	17.5
136.0	23.7	20.2	14.7	13.2	17.4
140.0	23.6	20.1	14.6	13.0	17.2
144.0	23.4	19.9	14.4	12.9	17.1
148.0	23.3	19.8	14.3	12.8	16.9
152.0	23.2	19.7	14.2	12.7	16.8
156.0	23.0	19.5	14.0	12.6	16.7
160.0	22.9	19.4	13.9	12.4	16.5
164.0	22.8	19.3	13.8	12.3	16.4
168.0	22.7	19.2	13.7	12.2	16.3
172.0	22.5	19.0	13.6	12.1	16.2
176.0	22.4	18.9	13.4	12.0	16.0
180.0	22.3	18.8	13.3	11.9	15.9
184.0	22.2	18.7	13.2	11.8	15.8
188.0	22.1	18.6	13.1	11.7	15.7
192.0	22.0	18.5	13.0	11.6	15.6
196.0	21.9	18.4	12.9	11.5	15.5

1AUDIBLE NOISE CALCULATION - FAIR

DIST FROM REFERENCE (FEET)	TOTALS L5 (DBA)	L50 (DBA)	230A	230B	230C
-200.0	-3.5	-7.0	-12.7	-13.1	-10.2
-196.0	-3.4	-6.9	-12.6	-12.9	-10.1
-192.0	-3.3	-6.8	-12.5	-12.8	-10.0
-188.0	-3.2	-6.7	-12.4	-12.7	-9.9
-184.0	-3.1	-6.6	-12.4	-12.6	-9.8
-180.0	-3.0	-6.5	-12.3	-12.5	-9.7
-176.0	-2.9	-6.4	-12.2	-12.4	-9.6
-172.0	-2.8	-6.3	-12.0	-12.3	-9.5
-168.0	-2.7	-6.2	-11.9	-12.1	-9.4
-164.0	-2.6	-6.1	-11.8	-12.0	-9.2
-160.0	-2.5	-6.0	-11.7	-11.9	-9.1
-156.0	-2.3	-5.8	-11.6	-11.8	-9.0
-152.0	-2.2	-5.7	-11.5	-11.6	-8.9
-148.0	-2.1	-5.6	-11.4	-11.5	-8.8
-144.0	-2.0	-5.5	-11.3	-11.3	-8.7
-140.0	-1.8	-5.3	-11.1	-11.2	-8.5

-136.0	-1.7	-5.2	-11.0	-11.0	-8.4
-132.0	-1.6	-5.1	-10.9	-10.9	-8.3
-128.0	-1.4	-4.9	-10.8	-10.7	-8.1
-124.0	-1.3	-4.8	-10.6	-10.6	-8.0
-120.0	-1.1	-4.6	-10.5	-10.4	-7.8
-116.0	-1.0	-4.5	-10.3	-10.2	-7.7
-112.0	-.8	-4.3	-10.2	-10.0	-7.5
-108.0	-.6	-4.1	-10.1	-9.8	-7.4
-104.0	-.5	-4.0	-9.9	-9.6	-7.2
-100.0	-.3	-3.8	-9.7	-9.4	-7.0
-96.0	-.1	-3.6	-9.6	-9.2	-6.9
-92.0	.1	-3.4	-9.4	-9.0	-6.7
-88.0	.3	-3.2	-9.2	-8.7	-6.5
-84.0	.5	-3.0	-9.1	-8.5	-6.3
-80.0	.7	-2.8	-8.9	-8.2	-6.1
-76.0	.9	-2.6	-8.7	-8.0	-5.9
-72.0	1.2	-2.3	-8.5	-7.7	-5.7
-68.0	1.4	-2.1	-8.3	-7.4	-5.4
-64.0	1.7	-1.8	-8.1	-7.1	-5.2
-60.0	1.9	-1.6	-7.9	-6.7	-4.9
-56.0	2.2	-1.3	-7.7	-6.4	-4.7
-52.0	2.5	-1.0	-7.4	-6.0	-4.4
-48.0	2.8	-.7	-7.2	-5.6	-4.1
-44.0	3.2	-.3	-7.0	-5.2	-3.8
-40.0	3.5	.0	-6.7	-4.7	-3.5
-36.0	3.9	.4	-6.5	-4.2	-3.1
-32.0	4.3	.8	-6.2	-3.8	-2.8
-28.0	4.7	1.2	-5.9	-3.3	-2.4
-24.0	5.1	1.6	-5.7	-2.8	-1.9
-20.0	5.5	2.0	-5.4	-2.4	-1.5
-16.0	5.8	2.3	-5.2	-2.1	-1.1
-12.0	6.1	2.6	-4.9	-1.9	-.6
-8.0	6.4	2.9	-4.7	-2.0	-.1
-4.0	6.6	3.1	-4.5	-2.2	.4
.0	6.8	3.3	-4.4	-2.6	.9
4.0	6.9	3.4	-4.3	-3.0	1.2
8.0	7.0	3.5	-4.2	-3.5	1.5
12.0	6.9	3.4	-4.2	-4.0	1.5
16.0	6.7	3.2	-4.2	-4.5	1.4
20.0	6.4	2.9	-4.3	-4.9	1.1
24.0	6.1	2.6	-4.4	-5.4	.6
28.0	5.7	2.2	-4.6	-5.8	.2
32.0	5.3	1.8	-4.8	-6.2	-.3
36.0	4.8	1.3	-5.1	-6.6	-.8
40.0	4.4	.9	-5.3	-6.9	-1.3
44.0	4.1	.6	-5.6	-7.2	-1.7
48.0	3.7	.2	-5.8	-7.5	-2.2
52.0	3.4	-.1	-6.1	-7.8	-2.6
56.0	3.0	-.5	-6.3	-8.1	-2.9
60.0	2.7	-.8	-6.6	-8.4	-3.3
64.0	2.4	-1.1	-6.8	-8.6	-3.6
68.0	2.1	-1.4	-7.1	-8.9	-3.9
72.0	1.9	-1.6	-7.3	-9.1	-4.3
76.0	1.6	-1.9	-7.5	-9.3	-4.5

80.0	1.3	-2.2	-7.8	-9.5	-4.8
84.0	1.1	-2.4	-8.0	-9.7	-5.1
88.0	.9	-2.6	-8.2	-9.9	-5.3
92.0	.7	-2.8	-8.4	-10.1	-5.5
96.0	.5	-3.0	-8.6	-10.3	-5.8
100.0	.3	-3.2	-8.8	-10.5	-6.0
104.0	.1	-3.4	-9.0	-10.6	-6.2
108.0	-.1	-3.6	-9.2	-10.8	-6.4
112.0	-.3	-3.8	-9.3	-11.0	-6.6
116.0	-.5	-4.0	-9.5	-11.1	-6.8
120.0	-.7	-4.2	-9.7	-11.3	-7.0
124.0	-.8	-4.3	-9.8	-11.4	-7.1
128.0	-1.0	-4.5	-10.0	-11.6	-7.3
132.0	-1.1	-4.6	-10.1	-11.7	-7.5
136.0	-1.3	-4.8	-10.3	-11.8	-7.6
140.0	-1.4	-4.9	-10.4	-12.0	-7.8
144.0	-1.6	-5.1	-10.6	-12.1	-7.9
148.0	-1.7	-5.2	-10.7	-12.2	-8.1
152.0	-1.8	-5.3	-10.8	-12.3	-8.2
156.0	-2.0	-5.5	-11.0	-12.4	-8.3
160.0	-2.1	-5.6	-11.1	-12.6	-8.5
164.0	-2.2	-5.7	-11.2	-12.7	-8.6
168.0	-2.3	-5.8	-11.3	-12.8	-8.7
172.0	-2.5	-6.0	-11.4	-12.9	-8.8
176.0	-2.6	-6.1	-11.6	-13.0	-9.0
180.0	-2.7	-6.2	-11.7	-13.1	-9.1
184.0	-2.8	-6.3	-11.8	-13.2	-9.2
188.0	-2.9	-6.4	-11.9	-13.3	-9.3
192.0	-3.0	-6.5	-12.0	-13.4	-9.4
196.0	-3.1	-6.6	-12.1	-13.5	-9.5

1ELECTRIC FIELD CALCULATIONS

WHEATRIDGE EAST EMF 2022

	DIST. FROM REFERENCE FEET	HEIGHT FEET	MAXIMUM GRADIENT (KV/CM)	SUBCON. DIAM. (IN)	NO. OF SUBCON.	PHASE ANGLE (DEGREES)
230A	11.00	43.00	9.81	1.35	2	.0
230B	-11.00	25.00	9.64	1.35	2	120.0
230C	11.00	25.00	10.30	1.35	2	240.0
G1	5.00	59.00	4.19	.53	1	.0
G2	-5.00	59.00	2.34	.53	1	.0

SENSOR HT. = 3.3 FEET

DIST FROM REFERENCE FEET	E-FIELD (KV/METER)	THETA (DEGREES)	EY-FIELD (KV/METER)	THETAY (DEGREES)	EX-FIELD (KV/METER)	THETAX (DEGREES)	SPACE POTENTIAL (VOLTS)
-200.0	.036	88.1	.036	-125.9	.001	-102.8	36.5

-196.0	.038	88.0	.038	-124.8	.001	-101.6	38.0
-192.0	.040	87.9	.040	-123.8	.002	-100.4	39.7
-188.0	.042	87.9	.042	-122.7	.002	-99.2	41.5
-184.0	.043	87.8	.043	-121.5	.002	-98.0	43.5
-180.0	.046	87.7	.046	-120.3	.002	-96.7	45.6
-176.0	.048	87.7	.048	-119.1	.002	-95.5	47.9
-172.0	.050	87.6	.050	-117.9	.002	-94.2	50.4
-168.0	.053	87.5	.053	-116.6	.003	-93.0	53.1
-164.0	.056	87.4	.056	-115.2	.003	-91.7	56.0
-160.0	.059	87.3	.059	-113.8	.003	-90.4	59.3
-156.0	.063	87.2	.063	-112.4	.003	-89.1	62.8
-152.0	.067	87.1	.067	-110.9	.004	-87.8	66.7
-148.0	.071	87.0	.071	-109.4	.004	-86.5	71.1
-144.0	.076	86.9	.076	-107.8	.004	-85.2	75.9
-140.0	.081	86.7	.081	-106.2	.005	-83.9	81.2
-136.0	.087	86.6	.087	-104.6	.006	-82.6	87.2
-132.0	.094	86.4	.094	-102.9	.006	-81.3	93.9
-128.0	.101	86.3	.101	-101.1	.007	-80.0	101.4
-124.0	.110	86.1	.110	-99.4	.008	-78.7	110.0
-120.0	.120	85.9	.119	-97.6	.009	-77.4	119.6
-116.0	.131	85.8	.130	-95.8	.010	-76.2	130.6
-112.0	.143	85.6	.143	-93.9	.012	-74.9	143.3
-108.0	.158	85.4	.157	-92.1	.013	-73.7	157.8
-104.0	.175	85.1	.174	-90.2	.015	-72.5	174.5
-100.0	.194	84.9	.193	-88.3	.018	-71.3	193.9
-96.0	.217	84.7	.216	-86.4	.021	-70.1	216.6
-92.0	.243	84.4	.242	-84.6	.025	-68.9	243.1
-88.0	.275	84.2	.273	-82.7	.029	-67.8	274.5
-84.0	.312	83.9	.310	-80.8	.034	-66.7	311.6
-80.0	.356	83.6	.354	-79.0	.041	-65.6	355.8
-76.0	.409	83.3	.407	-77.2	.049	-64.6	408.8
-72.0	.473	83.0	.470	-75.4	.059	-63.5	472.7
-68.0	.551	82.7	.547	-73.6	.071	-62.5	550.3
-64.0	.646	82.4	.640	-71.9	.087	-61.5	644.9
-60.0	.763	82.0	.755	-70.3	.107	-60.6	761.1
-56.0	.907	81.7	.897	-68.7	.132	-59.6	904.3
-52.0	1.085	81.4	1.073	-67.1	.163	-58.7	1081.8
-48.0	1.306	81.2	1.291	-65.6	.203	-57.8	1301.9
-44.0	1.581	81.0	1.561	-64.2	.251	-56.8	1574.8
-40.0	1.920	80.9	1.896	-62.8	.307	-55.6	1911.3
-36.0	2.333	81.0	2.304	-61.4	.369	-54.3	2320.3
-32.0	2.823	81.3	2.791	-60.1	.429	-52.5	2804.0
-28.0	3.378	82.1	3.346	-58.7	.467	-49.7	3348.3
-24.0	3.951	83.5	3.926	-57.1	.455	-44.3	3908.1
-20.0	4.455	85.7	4.442	-55.1	.363	-30.7	4392.4
-16.0	4.751	88.8	4.750	-52.4	.259	15.1	4667.6
-12.0	4.706	92.6	4.701	-47.9	.445	71.0	4603.5
-8.0	4.279	96.6	4.252	-40.0	.792	87.6	4170.7
-4.0	3.622	98.6	3.584	-25.6	1.069	92.6	3544.0
.0	3.139	93.0	3.136	-2.0	1.174	94.8	3122.9
4.0	3.287	84.2	3.272	24.0	1.080	97.8	3234.9
8.0	3.768	84.1	3.749	42.2	.823	105.5	3669.1
12.0	4.094	87.9	4.092	53.2	.526	126.7	3993.4
16.0	4.079	91.9	4.077	60.5	.398	170.2	3995.0

20.0	3.757	95.2	3.742	66.5	.456	-156.1	3693.9
24.0	3.265	97.4	3.237	72.3	.500	-140.8	3220.4
28.0	2.735	98.7	2.704	78.4	.477	-132.5	2706.6
32.0	2.254	99.1	2.226	84.9	.415	-126.5	2236.2
36.0	1.855	99.0	1.832	91.8	.340	-121.1	1843.9
40.0	1.539	98.4	1.523	98.8	.271	-115.8	1532.7
44.0	1.295	97.7	1.283	105.5	.212	-110.1	1291.1
48.0	1.106	97.0	1.098	111.8	.166	-104.1	1103.6
52.0	.958	96.4	.952	117.6	.131	-97.9	956.4
56.0	.840	95.9	.835	122.7	.105	-91.6	838.5
60.0	.743	95.6	.740	127.2	.085	-85.4	742.1
64.0	.662	95.2	.660	131.1	.070	-79.4	661.6
68.0	.594	95.0	.592	134.5	.059	-73.7	593.5
72.0	.535	94.8	.534	137.5	.050	-68.6	534.9
76.0	.485	94.6	.483	140.2	.043	-63.9	484.1
80.0	.440	94.4	.439	142.5	.037	-59.7	439.7
84.0	.401	94.3	.400	144.5	.032	-56.0	400.6
88.0	.366	94.2	.365	146.3	.028	-52.7	366.1
92.0	.336	94.0	.335	148.0	.025	-49.8	335.5
96.0	.308	93.9	.308	149.5	.022	-47.1	308.2
100.0	.284	93.8	.283	150.8	.020	-44.8	283.9
104.0	.262	93.7	.262	152.0	.018	-42.7	262.0
108.0	.243	93.6	.242	153.2	.016	-40.8	242.4
112.0	.225	93.5	.224	154.2	.014	-39.1	224.8
116.0	.209	93.4	.209	155.2	.013	-37.5	208.8
120.0	.194	93.3	.194	156.0	.012	-36.1	194.4
124.0	.181	93.2	.181	156.9	.010	-34.8	181.3
128.0	.169	93.1	.169	157.7	.009	-33.6	169.4
132.0	.159	93.1	.158	158.4	.009	-32.5	158.6
136.0	.149	93.0	.149	159.1	.008	-31.4	148.7
140.0	.140	92.9	.140	159.7	.007	-30.5	139.6
144.0	.131	92.8	.131	160.4	.007	-29.6	131.3
148.0	.124	92.8	.124	160.9	.006	-28.7	123.7
152.0	.117	92.7	.117	161.5	.006	-27.9	116.7
156.0	.110	92.6	.110	162.0	.005	-27.2	110.3
160.0	.104	92.6	.104	162.5	.005	-26.5	104.3
164.0	.099	92.5	.099	163.0	.004	-25.8	98.8
168.0	.094	92.5	.094	163.5	.004	-25.2	93.7
172.0	.089	92.4	.089	163.9	.004	-24.6	88.9
176.0	.085	92.4	.084	164.4	.004	-24.0	84.5
180.0	.080	92.3	.080	164.8	.003	-23.4	80.4
184.0	.077	92.3	.077	165.2	.003	-22.9	76.6
188.0	.073	92.2	.073	165.6	.003	-22.4	73.0
192.0	.070	92.2	.070	165.9	.003	-21.9	69.7
196.0	.067	92.1	.067	166.3	.002	-21.4	66.6

1MAGNETIC FIELD CALCULATIONS

SENSOR HT. = 3.3 FEET

DIST FROM
REFERENCE B-FIELD THETA BY-FIELD THETAY BX-FIELD THETAX
FEET (GAUSS) (GAUSS) (GAUSS)

-200.0	.00561997	74.3	.00546153	-50.6	.00307509	17.6
-196.0	.00584816	74.6	.00569046	-50.5	.00318134	18.1
-192.0	.00609044	75.0	.00593384	-50.3	.00329316	18.6
-188.0	.00634801	75.4	.00619287	-50.2	.00341098	19.1
-184.0	.00662215	75.8	.00646890	-50.0	.00353522	19.7
-180.0	.00691432	76.2	.00676342	-49.9	.00366639	20.3
-176.0	.00722612	76.7	.00707808	-49.7	.00380503	20.9
-172.0	.00755934	77.1	.00741473	-49.5	.00395174	21.6
-168.0	.00791596	77.6	.00777539	-49.4	.00410721	22.3
-164.0	.00829822	78.1	.00816236	-49.2	.00427218	23.1
-160.0	.00870862	78.7	.00857819	-49.0	.00444751	23.9
-156.0	.00914994	79.2	.00902573	-48.8	.00463416	24.7
-152.0	.00962537	79.8	.00950820	-48.6	.00483323	25.7
-148.0	.01013847	80.4	.01002920	-48.4	.00504597	26.6
-144.0	.01069328	81.1	.01059281	-48.2	.00527384	27.7
-140.0	.01129441	81.7	.01120363	-48.0	.00551854	28.9
-136.0	.01194710	82.5	.01186688	-47.8	.00578203	30.1
-132.0	.01265734	83.2	.01258847	-47.5	.00606669	31.4
-128.0	.01343203	84.0	.01337515	-47.3	.00637532	32.9
-124.0	.01427909	84.9	.01423459	-47.0	.00671134	34.4
-120.0	.01520770	85.8	.01517557	-46.8	.00707888	36.1
-116.0	.01622851	86.8	.01620813	-46.5	.00748311	38.0
-112.0	.01735394	87.8	.01734381	-46.2	.00793042	40.0
-108.0	.01859855	88.9	.01859583	-45.9	.00842890	42.2
-104.0	.01997944	90.1	.01997942	-45.6	.00898888	44.6
-100.0	.02151684	91.4	.02151206	-45.3	.00962365	47.2
-96.0	.02323481	92.7	.02321387	-44.9	.01035046	50.0
-92.0	.02516207	94.2	.02510794	-44.6	.01119191	53.0
-88.0	.02733311	95.8	.02722065	-44.2	.01217778	56.4
-84.0	.02978964	97.5	.02958200	-43.8	.01334756	59.9
-80.0	.03258230	99.4	.03222571	-43.3	.01475377	63.8
-76.0	.03577300	101.5	.03518903	-42.9	.01646648	67.8
-72.0	.03943790	103.7	.03851202	-42.4	.01857929	72.0
-68.0	.04367118	106.2	.04223555	-41.8	.02121735	76.4
-64.0	.04858996	109.0	.04639741	-41.2	.02454784	80.9
-60.0	.05434057	112.1	.05102494	-40.5	.02879395	85.4
-56.0	.06110618	115.5	.05612133	-39.6	.03425286	89.9
-52.0	.06911640	119.4	.06164201	-38.7	.04131817	94.2
-48.0	.07865725	123.9	.06745346	-37.4	.05050519	98.3
-44.0	.09008047	128.9	.07326604	-35.9	.06247264	102.1
-40.0	.10380580	134.8	.07853066	-33.7	.07802215	105.7
-36.0	.12030420	141.5	.08230680	-30.5	.09802953	108.9
-32.0	.14003600	149.4	.08319148	-25.3	.12321000	111.7
-28.0	.16329840	158.7	.07973307	-16.0	.15354210	114.3
-24.0	.18992890	169.5	.07300287	2.1	.18714720	116.7
-20.0	.21885580	-177.9	.07494854	34.5	.21872210	119.0
-16.0	.24770820	-163.5	.10697930	67.0	.23872680	121.7
-12.0	.27301180	-147.6	.16609200	84.8	.23600160	125.5
-8.0	.29136080	-130.7	.23074760	93.4	.20525060	132.5
-4.0	.30084000	-113.2	.27996760	98.0	.15609480	147.7
.0	.30125870	-95.4	.30012660	101.4	.12137020	180.0
4.0	.29315080	-77.6	.28755080	105.4	.13815330	217.2
8.0	.27704180	-59.8	.24846200	112.0	.17979310	237.4

12.0	.25388200	-42.6	.19814040	123.4	.20787140	247.6
16.0	.22582400	-26.3	.15554990	140.7	.21079920	254.6
20.0	.19599660	-11.7	.13094800	161.1	.19365860	261.1
24.0	.16733860	.9	.11916660	178.7	.16732870	268.1
28.0	.14171050	11.1	.11069070	191.5	.14064370	-84.2
32.0	.11983930	18.5	.10130160	200.5	.11790750	-76.1
36.0	.10172830	22.2	.09082160	207.3	.09999558	-68.1
40.0	.08709886	20.3	.08017424	212.9	.08618785	-60.6
44.0	.07563961	11.9	.07014760	217.7	.07540569	-54.1
48.0	.06676041	3.4	.06116384	222.1	.06674115	-48.5
52.0	.05956519	-.1	.05335779	226.2	.05956517	-43.8
56.0	.05347583	-.3	.04669555	230.1	.05347560	-39.8
60.0	.04822058	.9	.04106258	233.8	.04821902	-36.5
64.0	.04364578	2.7	.03631701	237.3	.04363073	-33.8
68.0	.03964327	4.8	.03231782	240.6	.03959721	-31.4
72.0	.03612787	6.8	.02893771	243.7	.03603468	-29.4
76.0	.03302949	8.9	.02606745	246.7	.03287754	-27.6
80.0	.03028946	10.8	.02361609	249.4	.03007221	-26.1
84.0	.02785824	12.6	.02150918	252.0	.02757359	-24.8
88.0	.02569395	14.4	.01968634	254.5	.02534320	-23.6
92.0	.02376107	16.0	.01809886	256.7	.02334783	-22.5
96.0	.02202940	17.5	.01670741	258.8	.02155880	-21.6
100.0	.02047324	18.9	.01548028	260.8	.01995115	-20.7
104.0	.01907062	20.3	.01439175	262.6	.01850326	-19.9
108.0	.01780277	21.5	.01342093	264.3	.01719630	-19.2
112.0	.01665355	22.7	.01255069	265.9	.01601390	-18.6
116.0	.01560910	23.8	.01176696	267.3	.01494180	-17.9
120.0	.01465741	24.8	.01105809	268.7	.01396757	-17.4
124.0	.01378814	25.8	.01041438	270.0	.01308037	-16.9
128.0	.01299227	26.7	.00982768	-88.9	.01227069	-16.4
132.0	.01226195	27.5	.00929113	-87.8	.01153024	-15.9
136.0	.01159035	28.4	.00879894	-86.7	.01085173	-15.5
140.0	.01097145	29.1	.00834609	-85.8	.01022876	-15.1
144.0	.01039999	29.9	.00792836	-84.9	.00965569	-14.7
148.0	.00987133	30.6	.00754204	-84.0	.00912755	-14.4
152.0	.00938137	31.2	.00718396	-83.2	.00863995	-14.0
156.0	.00892648	31.8	.00685132	-82.4	.00818899	-13.7
160.0	.00850345	32.4	.00654170	-81.7	.00777122	-13.4
164.0	.00810941	33.0	.00625296	-81.1	.00738358	-13.1
168.0	.00774181	33.5	.00598322	-80.4	.00702332	-12.8
172.0	.00739836	34.1	.00573079	-79.8	.00668800	-12.6
176.0	.00707702	34.6	.00549419	-79.3	.00637544	-12.3
180.0	.00677594	35.0	.00527210	-78.7	.00608369	-12.1
184.0	.00649350	35.5	.00506334	-78.2	.00581098	-11.8
188.0	.00622818	35.9	.00486684	-77.7	.00555574	-11.6
192.0	.00597864	36.3	.00468163	-77.3	.00531654	-11.4
196.0	.00574369	36.7	.00450687	-76.8	.00509209	-11.2

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