Exhibit AA

Electromagnetic Frequencies from Transmission Lines

Yellow Rosebush Energy Center
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Prepared for
Yellow Rosebush Energy Center, LLC

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Acronyms and Abbreviations

AC	alternating current
ACSR	Aluminum conductor steel reinforced
Applicant	Yellow Rosebush Energy Center, LLC
BPA	Bonneville Power Administration
dB	decibels
EFSC	Oregon Energy Facility Siting Council
ELF	extremely low frequency
EMF	electromagnetic field
EMR	electromagnetic radiation
Facility	Yellow Rosebush Energy Center
FCC	Federal Communications Commission
gen-tie	generation tie
GHz	gigahertz
GPS	Global Positioning System
Hz	hertz
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
kcmil	thousand of circular mils
kHz	kilohertz
kV	kilovolt
m	meter
mG	milligauss
MHz	megahertz
MVA	Mega volt amp
NIEHS	National Institute of Environmental Health Sciences
OAR	Oregon Administrative Rules
POI	point of interconnect
TV	television
μV / m	microvolt per meter

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1.0 Introduction

The Yellow Rosebush Energy Center, LLC (Applicant) seeks to develop the Yellow Rosebush Energy Center (Facility), a solar energy generation facility, battery energy storage system, and related or supporting facilities in Wasco and Sherman counties, Oregon.

This Exhibit AA was prepared to meet the submittal requirements in Oregon Administrative Rules (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 electric field standard found in OAR 345-024-0090, Siting Standards for Transmission Lines, which requires that the applicant:

> *(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 because 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

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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.

field is measured in units of kilovolts (kV) per meter (m) or 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.

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 (NIEHS) 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 (ICES), and the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which is an affiliate of the World Health Organization (EU 1999, ICES 2002, ICNIRP 2010).

[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.

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
ICES[1]	Occupational	20	27,100
	General public	5	9,040
	General public within right-of-way	10	NA
ICNIRP	Occupational	8.3	10,000
	General public	4.2	2,000
Magnetic fields are measured in gauss (G) and milligauss (mG). 1 G = 1,000 mG NA = Not Applicable (no requirements) 1. ICES recommendations have been adopted as standards by the Institute of Electrical and Electronics Engineers (IEEE); 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 U.S.

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

State	Location	Electric Field (kV/m)	Magnetic Field (mG)
	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 (EFSC) 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) 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 Facility is considering two options for the point of interconnect (POI) to the regional electric grid. The primary POI under consideration is using a proposed Bonneville Power Administration (BPA)-owned switchyard, located south of the Facility collector substation, which is adjacent to BPA's John Day to Grizzly 500-kV transmission line. The route to the primary POI is a short overhead generation tie (gen-tie) line expected to be less than 1,000 feet long.

The alternate POI under consideration will include a 500-kV gen-tie line starting at the western edge of the collector substation within the Facility in Wasco County and connecting to BPA's existing Buckley Substation located in Sherman County north of the Facility. The route to the alternate POI is an overhead transmission line that runs north alongside three existing 500-kV overhead transmission lines to BPA's existing Buckley Substation. The alternate route is expected to run approximately 4.5 miles.

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);

The route to the primary POI is a 500-kV gen-tie line that will be less than 1,000 feet long. There are no occupied buildings, residences, or other sensitive receptors within 200 feet of the center line of the proposed gen-tie line. The areas within 200 feet of the primary segment of the proposed 500-kV gen-tie line are all associated with the Facility, and there are no existing or proposed buildings, residences, or other sensitive receptors.

The route to the alternate POI is a 500-kV gen-tie line approximately 4.5 miles long. There are no occupied buildings, residences, or other sensitive receptors within 200 feet of the center line of the proposed gen-tie line. There are three existing 500-kV transmission lines located to the west of the proposed gen-tie line.

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-3 shows calculated electric field values for the routes to the primary and alternate POIs of the proposed aboveground 500-kV gen-tie lines. Table AA-4 shows calculated magnetic field values for the routes to the primary and alternate POIs of the proposed aboveground 500-kV gen-tie lines.

Table AA-3. Calculated Electric Field Values

Line Description	Figure	Electric Field (kV/m)		
		200 feet Left	Peak Value	200 feet Right
Route to primary POI	AA-1, AA-5	0.155 (west)	3.796, 20 feet right (east) of centerline	0.086 (east)
Route to alternate POI	AA-2, AA-6	0.34 (west)	4.014,186-192 feet right (east) of centerline	0.276 (east)

Table AA-4. Calculated Magnetic Field Values

Line Description	Figure	Magnetic Field (mG)		
		200 feet Left	Peak Value	200 feet Right
Route to primary POI	AA-3, AA-5	3.21 (west)	60.93, 4 feet right (east) of centerline	3.33 (east)
Route to alternate POI	AA-4, AA-6	24.33 (west)	106.5, 60 feet right (east) of centerline	20.41 (east)

The analysis results of the BPA Corona and Fields Effect Program Version 3 (CAFE) model (Table AA-3) demonstrate that the proposed 500-kV gen-tie lines, considering both primary and alternate routes, can be constructed and operated such that the AC electric field will 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 route to the primary POI, and Figure AA-2 for the electric field graph for the route to the alternate POI. See Figure AA-3 for the magnetic field graph for the route to the primary POI, and Figure AA-4 for the magnetic field graph for the route to the alternate POI. The analysis results for the route to the primary POI are provided in Attachment AA-1, and the analysis results for the route to the alternate POI are provided in Attachment AA-2. The modeling assumptions related to the collector line are intentionally conservative, producing worst-case EMF results. EMF levels under normal operating conditions will be lower than indicated by this analysis.

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 analyses of the route to both the primary and alternate POIs. The proposed 500-kV gen-tie line configurations are shown in Figures AA-5 and AA-6.

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.
- Proposed 500-kV collector line information:
  - Overhead pole height – 132.25 feet
  - Line amperage – 560 amps, maximum output value of the Facility (485 mega volt amp [MVA]).
  - Line voltage – 500-kV phase/phase or 288.68-kV phase/ground

  - Conductor type – Single 636 26/7 thousand of circular mils (kcmil) aluminum conductor steel reinforced (ACSR) conductor per phase, 0.990” in diameter
  - Ground wire – two overhead shield wires, 0.5” in diameter, as shown in Figure AA-1. Minimum height from ground is 97.25 feet and one cable is located 9 feet left or right of centerline.
  - A phase is located on the upper arm of the transmission structure at 71.5 feet minimum height and 14.5 feet left of centerline.
  - B phase is located on the lower arm of the transmission structure at 40 feet minimum height and 14.5 feet left of centerline.
  - C phase is located on the lower arm of the transmission structure at 40 feet minimum height and 14.5 feet right of centerline.
  - Elevation of the site is estimated at 2,200 feet above sea level.

Several assumptions were made on the existing 500-kV transmission lines located adjacent to the route to the alternate POI. Those assumptions follow:

- Presumed H-frame transmission lines, unknown tower height.
- Conductor type – single 636 26/7 kcmil ACSR conductor per phase, 0.990” in diameter (same as proposed gen-tie line).
- Line amperage – 789 amps, the maximum amperage for the conductor.
- Line voltage – 500-kV line/line, or 288.68-kV line/ground
- Ground wire – two overhead shield wires, 0.5” in diameter
- Line spacing, conductor locations and minimum heights, ground wire locations and minimum heights – estimated, see Figure AA-2. Aerial imagery was used to estimate centerline location of existing overhead lines and horizontal locations of conductors and ground wires.
- Elevation of the site is estimated at 2,200 feet above sea level.

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;*

No program for mitigating EMF levels is currently proposed.

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; and

No program for monitoring actual EMF levels before or after construction is proposed currently.

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

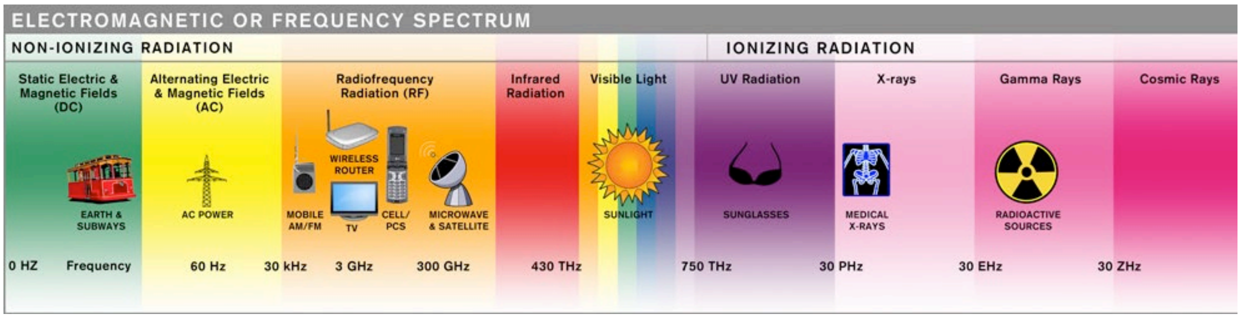
OAR 345-021-0010(1)(aa)(B) An evaluation of alternate methods and costs of reducing radio interference likely to be caused by the transmission line in the primary reception area near interstate, U.S. and state highways.

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 television (TV) interference.

Modern communications systems all rely on electromagnetic radiation (EMR) to transmit information. AM and FM radio, TV, shortwave radio, cellular telephones, radar, Global Positioning System (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. The diagram below provides a visual representation of typical communications frequencies.



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

Diagram AA-1. 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 very 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, interstate, U.S., 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 transmission 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 Electric Power Research Institute 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 transmission 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 the Project will ensure public health and safety with respect to EMFs. Also, this exhibit, together with the data provided in Exhibit DD, demonstrates that the Facility's AC electric fields and induced currents will comply with the Siting Standards for Transmission Lines provided under OAR 345-024-0090.

7.0 Submittal Requirements and Approval Standards

7.1 Submittal Requirements

Table AA-5. Submittal Requirements Matrix

Requirement	Location
OAR 345-021-0010(1)(aa) If the proposed energy facility is a transmission line or has, as a related or supporting facility, a transmission line of any size:	–
(A) Information about the expected electric and magnetic fields, including:	Section 2.0
(i) The distance in feet from the proposed center line of each proposed transmission line to the edge of the right-of-way;	Section 2.1
(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;	Section 2.1
(iii) The approximate distance in feet from the proposed center line to each structure identified in (A);	Section 2.1
(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;	Section 2.2
(v) Any measures the applicant proposes to reduce electric or magnetic field levels;	Section 3.0
(vi) The assumptions and methods used in the electric and magnetic field analysis, including the current in amperes on each proposed transmission line;	Section 2.3
(vii) The applicant's proposed monitoring program, if any, for actual electric and magnetic field levels; and	Section 4.0
(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.	Section 5.0

7.2 Approval Standards

OAR 345 Division 21 does not provide an approval standard specific to Exhibit AA. However, compliance with OAR 345-024-0090 is demonstrated by the analysis above, as described in Exhibit DD.

8.0 References

BPA (Bonneville Power Administration). Undated. "Corona and Field Effects" Computer Program – Version 3.0, Public Domain Software. Bonneville Power Administration, Vancouver, WA.

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Figures

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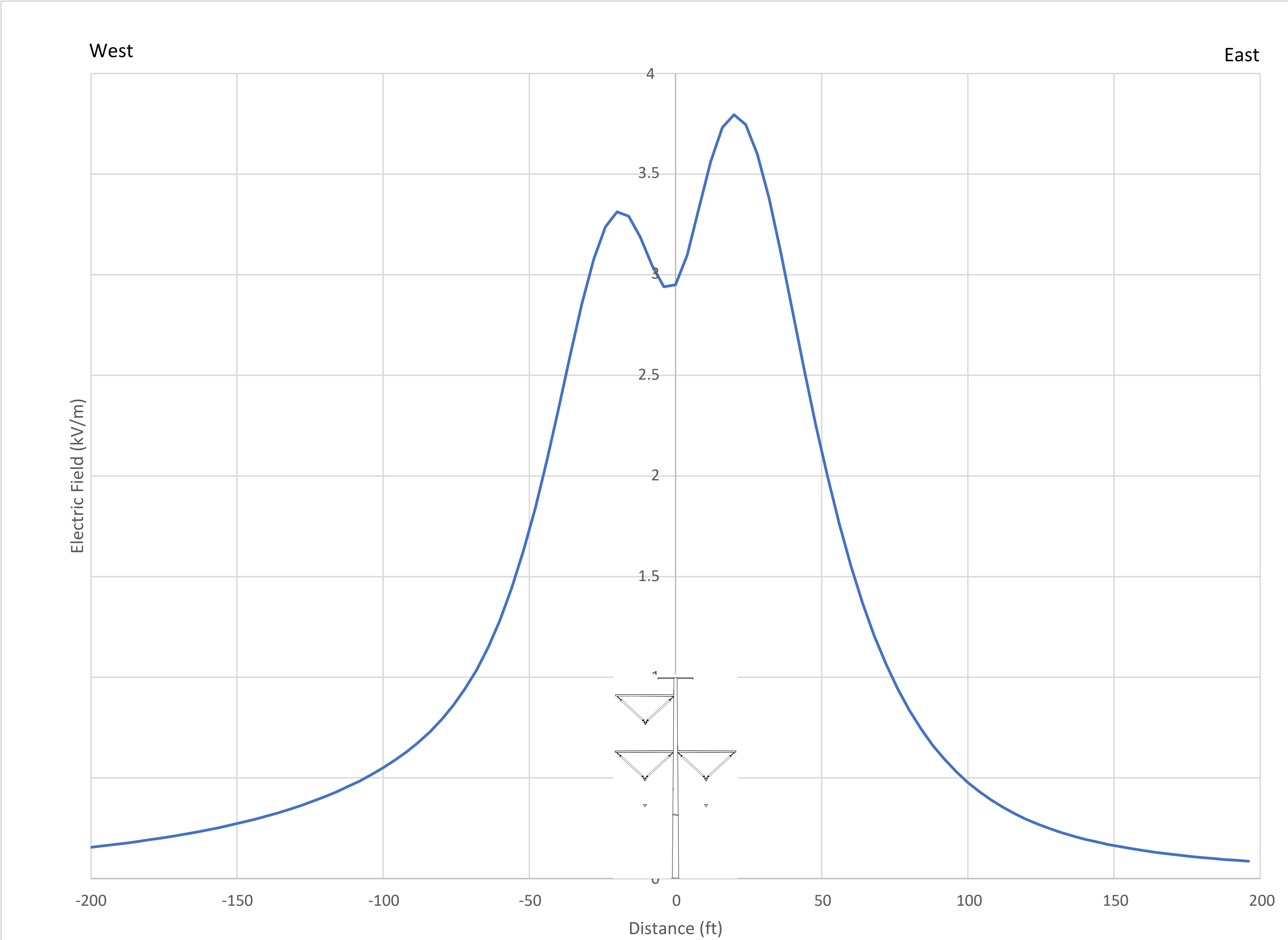

Figure AA-1. Yellow Rosebush Primary Interconnect Electric Field

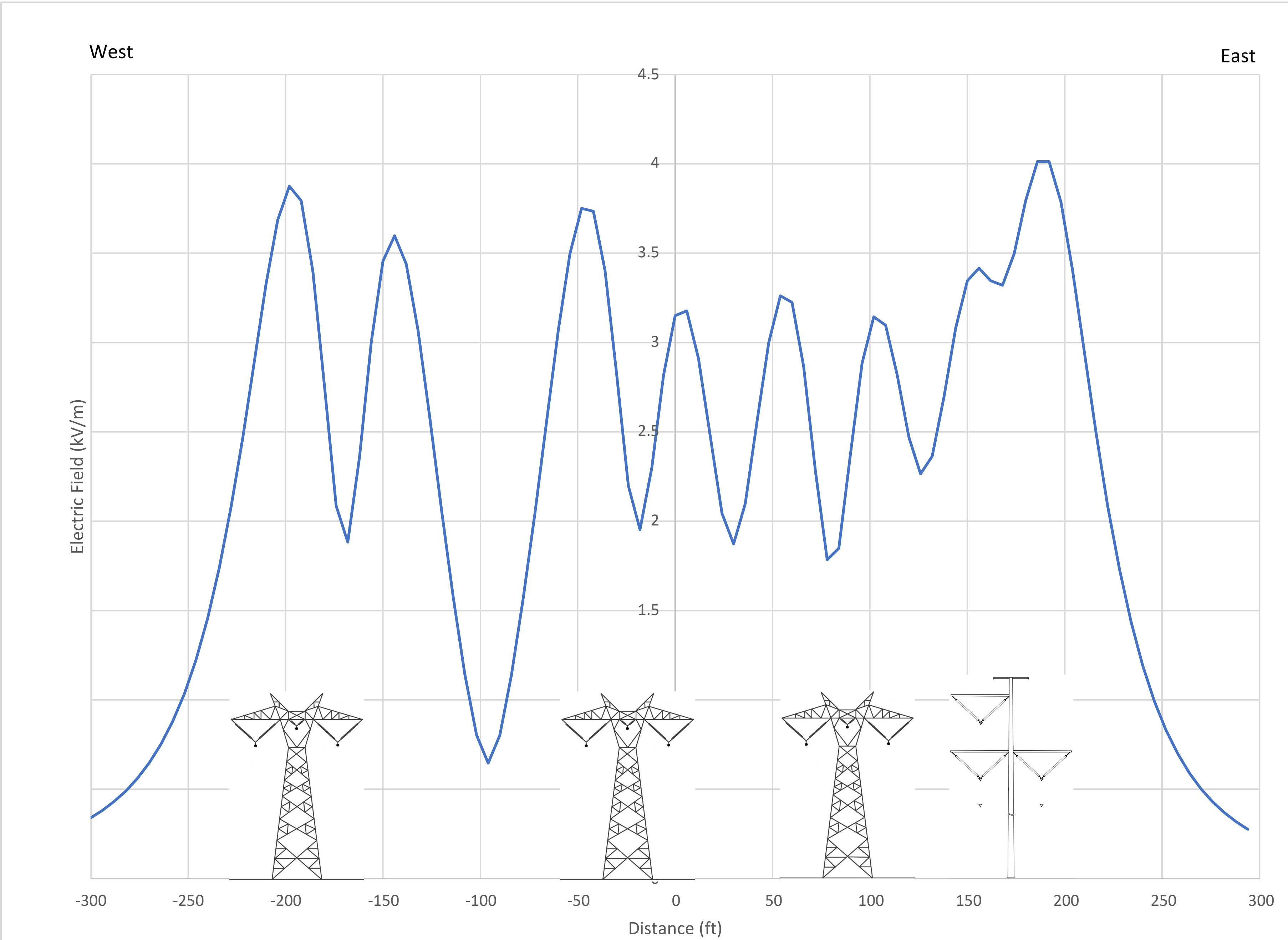

Figure AA-2. Yellow Rosebush Alternate Interconnect Electric Field

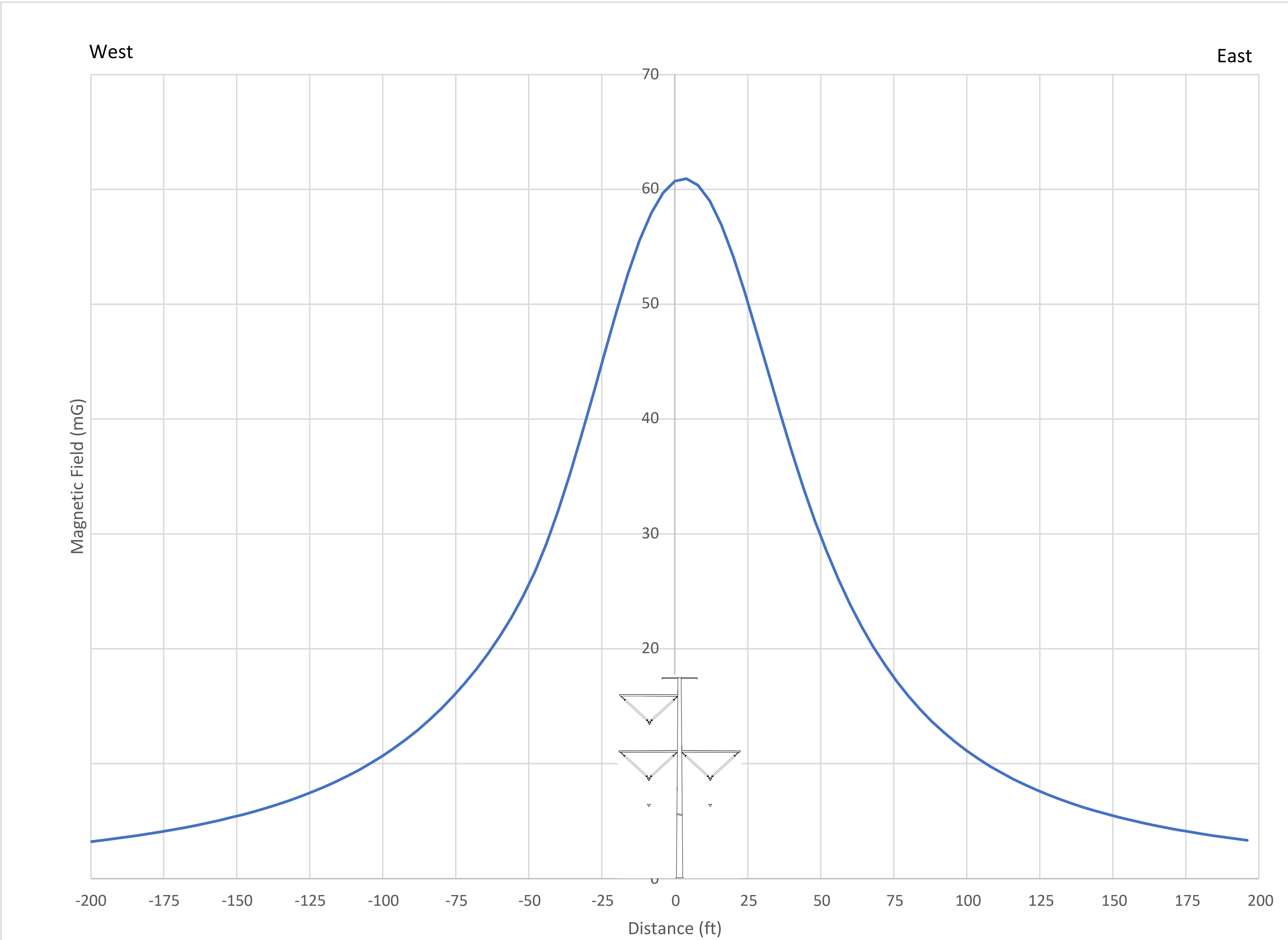

Figure AA-3. Yellow Rosebush Primary Interconnect Magnetic Field

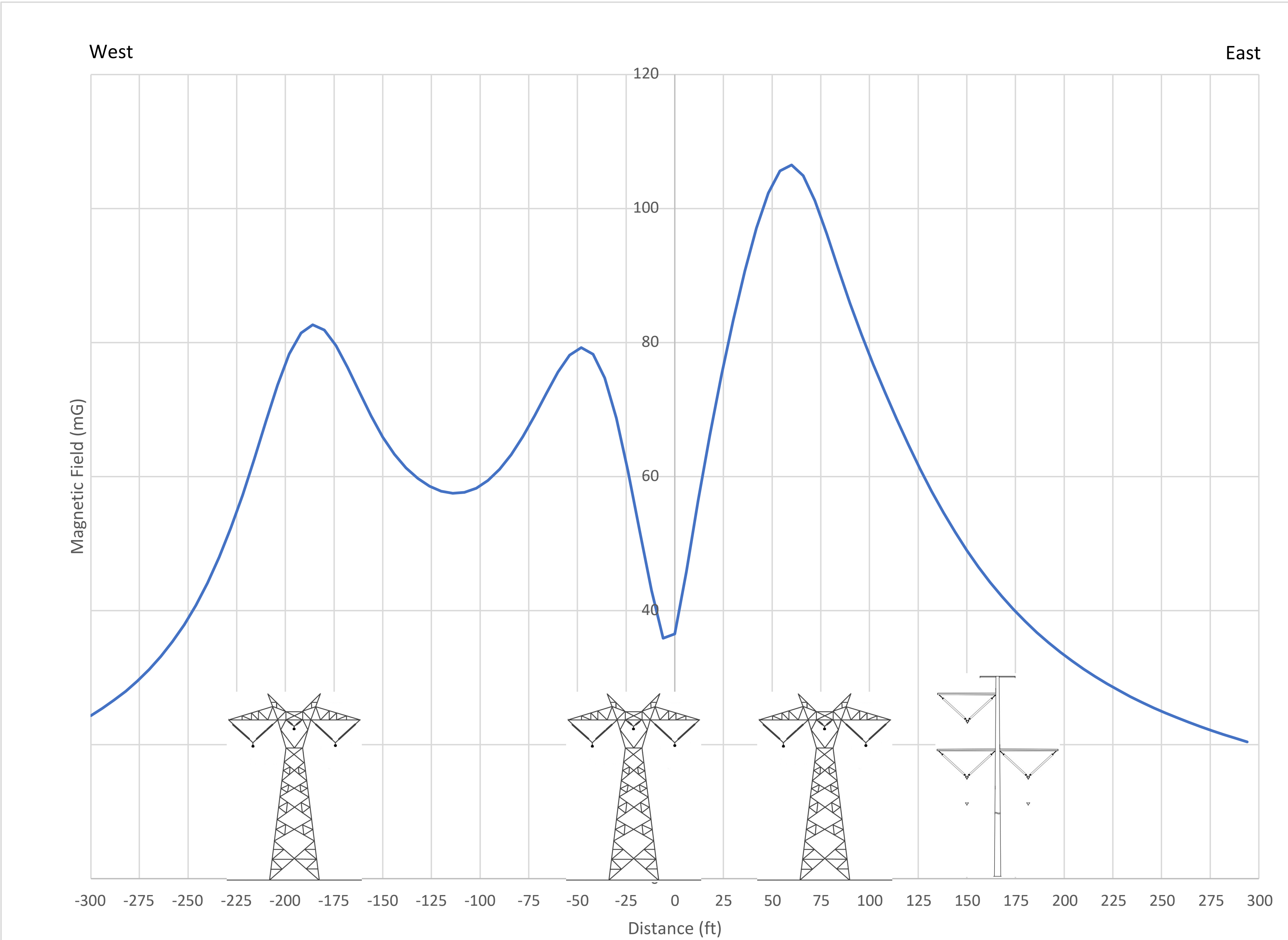

Figure AA-4. Yellow Rosebush Alternate Interconnect Magnetic Field

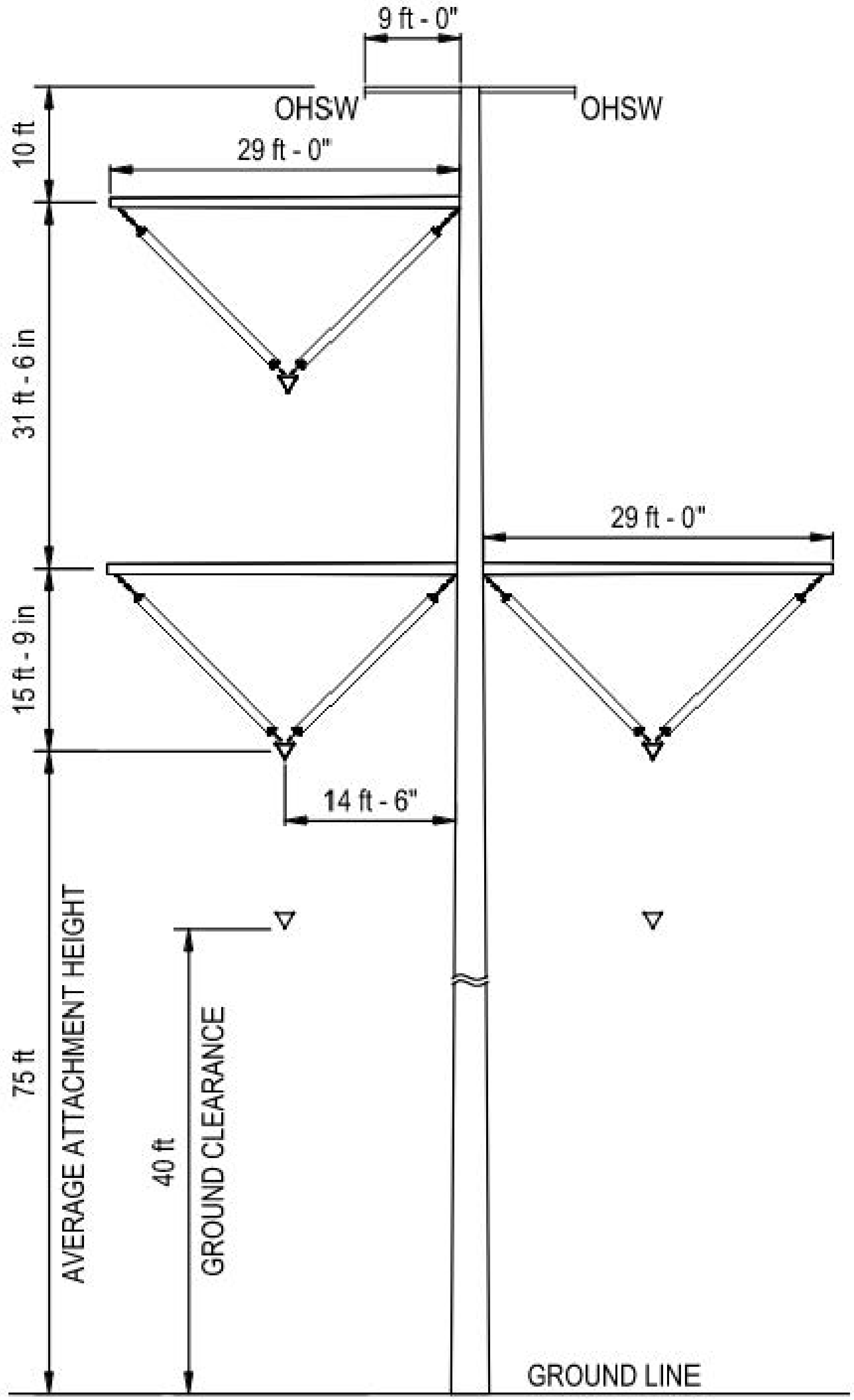

Figure AA-5. Planned 500-kV Gen-Tie Line Configuration

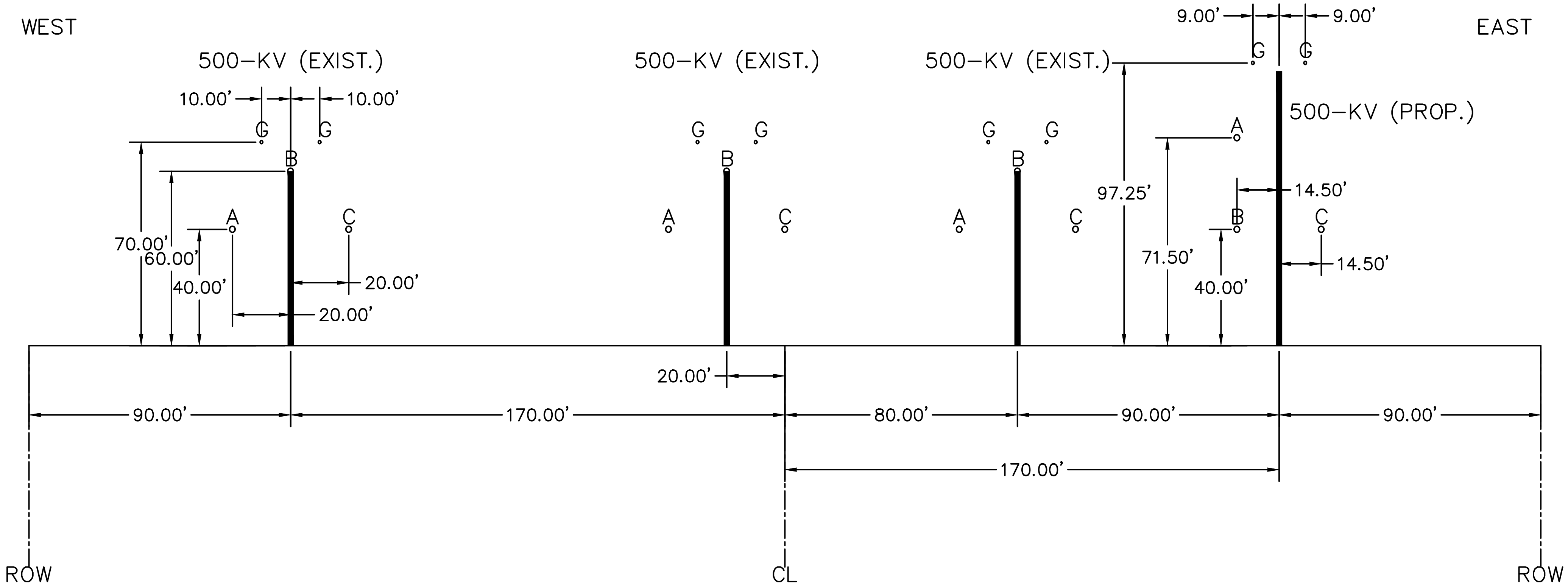

Figure AA-6. Estimated Layout of Transmission Lines to Alternate POI

Attachment AA-1. CAFE EMF Output - Route to Primary POI

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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
ÛÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÛ
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INPUT DATA LIST

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             5/15/2024          14:25:42
 Yellow Rosebud EMF
 Main Route
1,0, 3, 5,0.0,   2.00,   1.00,2200.00

(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,  1.000, 75.000,  3.280,  6.700,  3.280
'500NA   ','A',  -14.50,   71.50, 1,    .990,    .000, 288.680,    .000,    .560,    .000
'500NB   ','A',  -14.50,   40.00, 1,    .990,    .000, 288.680,-120.000,    .560,    .000
'500NC   ','A',   14.50,   40.00, 1,    .990,    .000, 288.680, 120.000,    .560,    .000
'500NG1  ','A',   -9.00,   97.25, 1,    .500,    .000,    .000,    .000,    .000,    .000
'500NG2  ','A',    9.00,   97.25, 1,    .500,    .000,    .000,    .000,    .000,    .000
100 -200.0    4.0
```

ELECTRIC FIELD CALCULATIONS

Yellow Rosebud EMF
Main Route

	DIST. FROM REFERENCE FEET	HEIGHT FEET	MAXIMUM GRADIENT (KV/CM)	SUBCON. DIAM. (IN)	NO. OF SUBCON.	PHASE ANGLE (DEGREES)
500NA	-14.50	71.50	34.08	.99	1	.0
500NB	-14.50	40.00	35.61	.99	1	-120.0
500NC	14.50	40.00	34.70	.99	1	120.0
500NG1	-9.00	97.25	6.45	.50	1	.0
500NG2	9.00	97.25	3.85	.50	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	.155	88.1	.155	158.1	.005	147.1	155.3
-196.0	.162	88.1	.162	157.7	.006	146.3	161.8

-192.0	.169	88.0	.169	157.2	.006	145.5	168.7
-188.0	.176	88.0	.176	156.7	.006	144.6	175.9
-184.0	.184	88.0	.184	156.1	.007	143.7	183.7
-180.0	.192	87.9	.192	155.6	.007	142.8	191.9
-176.0	.201	87.9	.200	155.0	.008	141.7	200.6
-172.0	.210	87.9	.210	154.4	.008	140.6	209.8
-168.0	.220	87.8	.220	153.7	.009	139.4	219.7
-164.0	.230	87.8	.230	153.0	.009	138.2	230.1
-160.0	.241	87.8	.241	152.3	.010	136.8	241.3
-156.0	.253	87.7	.253	151.5	.010	135.3	253.2
-152.0	.266	87.7	.266	150.7	.011	133.8	265.9
-148.0	.280	87.6	.279	149.8	.012	132.1	279.5
-144.0	.294	87.6	.294	148.9	.013	130.3	294.0
-140.0	.310	87.6	.309	147.9	.014	128.3	309.5
-136.0	.326	87.5	.326	146.8	.015	126.2	326.1
-132.0	.344	87.5	.344	145.6	.016	123.9	344.0
-128.0	.363	87.4	.363	144.3	.018	121.4	363.2
-124.0	.384	87.4	.384	142.9	.019	118.7	383.9
-120.0	.406	87.3	.406	141.5	.021	115.8	406.1
-116.0	.430	87.3	.430	139.8	.023	112.7	430.2
-112.0	.457	87.2	.456	138.1	.025	109.4	456.3
-108.0	.485	87.1	.484	136.1	.028	105.9	484.7
-104.0	.516	87.0	.515	134.0	.031	102.2	515.7
-100.0	.550	87.0	.549	131.7	.035	98.3	549.7
-96.0	.588	86.8	.587	129.2	.039	94.3	587.2
-92.0	.629	86.7	.628	126.4	.045	90.1	628.9
-88.0	.676	86.5	.675	123.3	.051	85.9	675.7
-84.0	.729	86.4	.728	120.0	.059	81.7	728.7
-80.0	.790	86.1	.788	116.4	.068	77.6	789.2
-76.0	.860	85.9	.858	112.5	.079	73.6	859.1
-72.0	.942	85.6	.939	108.4	.092	69.7	940.6
-68.0	1.038	85.3	1.034	104.0	.108	65.9	1036.4
-64.0	1.151	85.0	1.147	99.5	.126	62.3	1149.4
-60.0	1.285	84.7	1.280	94.8	.147	58.8	1282.9
-56.0	1.444	84.4	1.437	90.2	.169	55.4	1440.2
-52.0	1.628	84.3	1.620	85.5	.193	51.9	1623.5
-48.0	1.840	84.3	1.831	81.0	.217	48.3	1833.8
-44.0	2.078	84.4	2.068	76.6	.239	44.3	2069.3
-40.0	2.335	84.7	2.325	72.4	.254	39.5	2323.9
-36.0	2.601	85.3	2.592	68.3	.261	33.2	2586.1
-32.0	2.856	86.1	2.850	64.3	.256	24.0	2837.9
-28.0	3.078	87.1	3.074	60.1	.244	10.0	3055.2
-24.0	3.238	88.3	3.236	55.7	.239	-10.8	3211.3
-20.0	3.313	89.7	3.313	50.6	.266	-35.4	3283.1
-16.0	3.291	91.0	3.291	44.3	.335	-55.5	3260.6
-12.0	3.187	92.0	3.185	36.3	.426	-68.4	3158.6
-8.0	3.045	92.1	3.043	25.9	.513	-76.3	3023.3
-4.0	2.940	90.9	2.940	13.1	.573	-81.3	2927.3
.0	2.950	88.7	2.950	-1.1	.592	-84.8	2939.5
4.0	3.097	86.9	3.093	-14.6	.566	-88.1	3079.5
8.0	3.329	86.5	3.323	-25.7	.498	-92.2	3302.5
12.0	3.563	87.2	3.559	-34.1	.400	-98.6	3531.6
16.0	3.732	88.4	3.730	-40.2	.293	-110.2	3699.2

20.0	3.796	89.9	3.796	-44.7	.206	-132.0	3765.7
24.0	3.747	91.2	3.747	-48.0	.173	-165.3	3721.1
28.0	3.600	92.4	3.597	-50.5	.191	166.8	3577.7
32.0	3.378	93.4	3.372	-52.4	.220	151.3	3359.9
36.0	3.110	94.2	3.102	-54.1	.239	142.8	3095.6
40.0	2.821	94.8	2.811	-55.6	.244	137.8	2809.9
44.0	2.531	95.3	2.521	-56.9	.237	134.5	2522.3
48.0	2.253	95.6	2.243	-58.1	.223	132.2	2246.3
52.0	1.996	95.8	1.985	-59.3	.204	130.5	1990.0
56.0	1.762	95.9	1.752	-60.5	.183	129.1	1757.2
60.0	1.553	95.9	1.544	-61.8	.163	127.9	1549.2
64.0	1.368	95.9	1.361	-63.0	.143	126.9	1365.3
68.0	1.206	95.9	1.200	-64.3	.126	125.9	1204.1
72.0	1.065	95.8	1.060	-65.6	.110	125.0	1063.3
76.0	.942	95.7	.937	-66.9	.095	124.2	940.7
80.0	.835	95.6	.831	-68.3	.083	123.3	834.1
84.0	.743	95.5	.739	-69.7	.072	122.5	741.5
88.0	.662	95.3	.659	-71.1	.063	121.6	661.1
92.0	.592	95.2	.589	-72.6	.055	120.8	591.0
96.0	.531	95.1	.528	-74.1	.048	119.9	530.0
100.0	.477	94.9	.475	-75.7	.042	119.1	476.7
104.0	.431	94.8	.429	-77.2	.037	118.2	430.1
108.0	.390	94.6	.388	-78.8	.033	117.3	389.3
112.0	.354	94.5	.353	-80.5	.029	116.3	353.4
116.0	.322	94.3	.321	-82.1	.025	115.4	321.9
120.0	.294	94.2	.293	-83.8	.023	114.4	294.0
124.0	.270	94.0	.269	-85.5	.020	113.5	269.3
128.0	.248	93.9	.247	-87.2	.018	112.5	247.5
132.0	.228	93.8	.228	-88.8	.016	111.5	228.0
136.0	.211	93.6	.210	-90.5	.014	110.4	210.7
140.0	.195	93.5	.195	-92.2	.013	109.4	195.3
144.0	.182	93.4	.181	-93.9	.012	108.3	181.4
148.0	.169	93.3	.169	-95.6	.010	107.2	169.0
152.0	.158	93.2	.158	-97.3	.009	106.2	157.8
156.0	.148	93.0	.148	-98.9	.009	105.1	147.7
160.0	.139	92.9	.138	-100.6	.008	103.9	138.6
164.0	.130	92.8	.130	-102.2	.007	102.8	130.4
168.0	.123	92.7	.123	-103.8	.006	101.7	122.9
172.0	.116	92.6	.116	-105.3	.006	100.5	116.1
176.0	.110	92.5	.110	-106.9	.005	99.4	109.8
180.0	.104	92.5	.104	-108.4	.005	98.2	104.1
184.0	.099	92.4	.099	-109.9	.005	97.1	98.9
188.0	.094	92.3	.094	-111.3	.004	95.9	94.1
192.0	.090	92.2	.090	-112.8	.004	94.7	89.7
196.0	.086	92.1	.086	-114.1	.004	93.5	85.6

1MAGNETIC FIELD CALCULATIONS

SENSOR HT. = 3.3 FEET

DIST FROM

REFERENCE FEET	B-FIELD (GAUSS)	THETA	BY-FIELD (GAUSS)	THETAY	BX-FIELD (GAUSS)	THETAX
-200.0	.00321216	-4.2	.00213336	79.1	.00320732	-14.5
-196.0	.00333580	-3.5	.00221979	78.2	.00333241	-14.8
-192.0	.00346651	-2.7	.00231202	77.2	.00346440	-15.1
-188.0	.00360482	-1.9	.00241059	76.2	.00360375	-15.4
-184.0	.00375131	-1.0	.00251614	75.1	.00375098	-15.7
-180.0	.00390662	-.2	.00262934	74.0	.00390661	-16.1
-176.0	.00407143	.8	.00275098	72.9	.00407124	-16.5
-172.0	.00424650	1.7	.00288193	71.7	.00424548	-16.9
-168.0	.00443268	2.7	.00302318	70.5	.00443002	-17.3
-164.0	.00463087	3.8	.00317584	69.3	.00462556	-17.8
-160.0	.00484209	4.9	.00334117	68.0	.00483288	-18.3
-156.0	.00506743	6.0	.00352058	66.7	.00505281	-18.8
-152.0	.00530811	7.2	.00371568	65.3	.00528623	-19.3
-148.0	.00556549	8.5	.00392830	63.9	.00553407	-19.9
-144.0	.00584104	9.9	.00416050	62.5	.00579734	-20.5
-140.0	.00613640	11.3	.00441461	61.0	.00607711	-21.2
-136.0	.00645338	12.8	.00469328	59.5	.00637451	-22.0
-132.0	.00679399	14.4	.00499951	57.9	.00669074	-22.8
-128.0	.00716043	16.1	.00533670	56.3	.00702707	-23.6
-124.0	.00755517	17.9	.00570865	54.7	.00738486	-24.6
-120.0	.00798090	19.8	.00611969	53.0	.00776555	-25.6
-116.0	.00844063	21.8	.00657463	51.3	.00817069	-26.7
-112.0	.00893768	24.0	.00707886	49.5	.00860198	-27.9
-108.0	.00947570	26.3	.00763834	47.7	.00906129	-29.3
-104.0	.01005874	28.8	.00825959	45.9	.00955078	-30.8
-100.0	.01069122	31.5	.00894972	44.0	.01007300	-32.5
-96.0	.01137802	34.4	.00971624	42.2	.01063114	-34.4
-92.0	.01212445	37.6	.01056696	40.3	.01122933	-36.5
-88.0	.01293630	41.0	.01150971	38.3	.01187314	-38.9
-84.0	.01381983	44.8	.01255182	36.3	.01257032	-41.6
-80.0	.01478179	49.0	.01369950	34.2	.01333180	-44.6
-76.0	.01582946	53.7	.01495690	32.1	.01417314	-48.0
-72.0	.01697073	59.0	.01632472	29.9	.01511627	-51.8
-68.0	.01821443	65.1	.01779854	27.6	.01619148	-56.0
-64.0	.01957124	72.4	.01936673	25.1	.01743922	-60.7
-60.0	.02105621	81.3	.02100824	22.3	.01891077	-65.8
-56.0	.02269491	92.6	.02269088	19.3	.02066635	-71.2
-52.0	.02453590	107.2	.02437138	15.8	.02276854	-76.8
-48.0	.02665816	124.7	.02600003	11.8	.02526901	-82.6
-44.0	.02913291	-37.7	.02753402	6.9	.02818707	-88.3
-40.0	.03196783	-22.4	.02896555	.9	.03148021	266.1
-36.0	.03512206	-9.0	.03036848	-6.5	.03501044	260.8
-32.0	.03853378	3.2	.03195311	-15.4	.03851499	255.8
-28.0	.04211912	14.9	.03408322	-25.7	.04159812	250.9
-24.0	.04576511	26.6	.03717218	-36.8	.04376792	245.9
-20.0	.04933034	38.4	.04143067	-47.5	.04454152	240.4
-16.0	.05265560	50.3	.04662026	-56.9	.04362554	233.9
-12.0	.05558197	62.4	.05202951	-64.6	.04114820	225.4
-8.0	.05796887	74.5	.05668537	-70.6	.03788164	213.7
-4.0	.05970502	86.7	.05964176	-75.5	.03529726	198.1

.0	.06071005	98.9	.06021462	-79.5	.03503534	180.0
4.0	.06093208	110.9	.05812115	-83.4	.03762669	163.0
8.0	.06034903	122.7	.05353161	-87.5	.04195902	149.9
12.0	.05897694	134.3	.04704732	267.4	.04632724	140.8
16.0	.05688069	145.4	.03960884	260.5	.04943168	134.5
20.0	.05417715	156.1	.03234029	250.9	.05063674	130.1
24.0	.05102438	166.2	.02633941	237.7	.04988193	126.8
28.0	.04759851	175.6	.02237999	221.4	.04749084	124.2
32.0	.04406758	-175.6	.02053854	204.4	.04396530	121.9
36.0	.04057170	-167.5	.02015226	189.8	.03981904	119.8
40.0	.03721384	-160.2	.02036569	178.8	.03547846	117.7
44.0	.03406008	-153.4	.02060710	170.8	.03124710	115.6
48.0	.03114565	-147.3	.02062891	165.1	.02731172	113.4
52.0	.02848285	-141.7	.02037710	161.0	.02376738	111.1
56.0	.02606855	-136.6	.01988342	157.8	.02064564	108.6
60.0	.02389026	-132.0	.01920686	155.4	.01793856	106.0
64.0	.02193045	-127.7	.01840732	153.5	.01561634	103.2
68.0	.02016954	-123.8	.01753565	152.0	.01363902	100.2
72.0	.01858770	-120.3	.01663140	150.7	.01196371	97.1
76.0	.01716590	-117.0	.01572355	149.6	.01054866	93.8
80.0	.01588651	-113.9	.01483234	148.7	.00935539	90.5
84.0	.01473354	-111.1	.01397128	147.9	.00834954	87.0
88.0	.01369262	-108.4	.01314876	147.1	.00750111	83.5
92.0	.01275105	-106.0	.01236955	146.5	.00678425	80.0
96.0	.01189760	-103.7	.01163579	145.9	.00617694	76.5
100.0	.01112239	-101.6	.01094785	145.4	.00566059	73.0
104.0	.01041674	-99.6	.01030486	144.9	.00521957	69.6
108.0	.00977307	-97.7	.00970520	144.4	.00484089	66.4
112.0	.00918468	-95.9	.00914676	143.9	.00451374	63.2
116.0	.00864573	-94.3	.00862720	143.5	.00422922	60.2
120.0	.00815107	-92.7	.00814404	143.1	.00398002	57.4
124.0	.00769617	-91.2	.00769479	142.8	.00376014	54.7
128.0	.00727705	-89.8	.00727702	142.4	.00356469	52.2
132.0	.00689017	-88.5	.00688842	142.1	.00338969	49.8
136.0	.00653242	-87.3	.00652676	141.7	.00323189	47.5
140.0	.00620104	-86.1	.00618998	141.4	.00308863	45.4
144.0	.00589357	-84.9	.00587616	141.1	.00295777	43.5
148.0	.00560782	-83.8	.00558349	140.8	.00283753	41.6
152.0	.00534186	-82.8	.00531033	140.5	.00272647	39.9
156.0	.00509393	-81.8	.00505516	140.2	.00262340	38.3
160.0	.00486249	-80.9	.00481657	140.0	.00252733	36.8
164.0	.00464613	-80.0	.00459329	139.7	.00243744	35.4
168.0	.00444361	-79.1	.00438415	139.4	.00235305	34.1
172.0	.00425377	-78.3	.00418805	139.2	.00227358	32.9
176.0	.00407563	-77.5	.00400402	139.0	.00219855	31.7
180.0	.00390823	-76.7	.00383115	138.7	.00212754	30.6
184.0	.00375076	-76.0	.00366861	138.5	.00206019	29.6
188.0	.00360246	-75.3	.00351565	138.3	.00199620	28.6
192.0	.00346264	-74.6	.00337157	138.0	.00193530	27.7
196.0	.00333068	-74.0	.00323574	137.8	.00187725	26.9

1

Attachment AA-2. CAFE EMF Output - Route to Alternate POI

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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
ÛÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÜÛ

                              INPUT DATA LIST


                 5/15/2024          14:17:42
  Yellow Rosebud EMF
  Alternate Route
 1,0,12,20,0.0,   2.00,   1.00,2200.00

 (ENGLISH UNITS OPTION)

 (GRADIENTS ARE COMPUTED BY PROGRAM)

 PHYSICAL SYSTEM CONSISTS OF 20 CONDUCTORS, OF WHICH 12 ARE ENERGIZED PHASES

 OPTIONS:  EF MF AN
   4.921,  6.562,  9.842,  1.000,  1.000, 75.000,  3.280,  6.700,  3.280
 '500WA   ','A', -190.00,   40.00, 1,    .990,    .000, 288.680,    .000,    .789,    .000
 '500WB   ','A', -170.00,   60.00, 1,    .990,    .000, 288.680,-120.000,    .789,    .000
 '500WC   ','A', -150.00,   40.00, 1,    .990,    .000, 288.680, 120.000,    .789,    .000
 '500WG1  ','A', -180.00,   70.00, 1,    .500,    .000,    .000,    .000,    .000,    .000
 '500WG2  ','A', -160.00,   70.00, 1,    .500,    .000,    .000,    .000,    .000,    .000
 '500CA   ','A',  -40.00,   40.00, 1,    .990,    .000, 288.680,    .000,    .789,    .000
 '500CB   ','A',  -20.00,   60.00, 1,    .990,    .000, 288.680,-120.000,    .789,    .000
 '500CC   ','A',     .00,   40.00, 1,    .990,    .000, 288.680, 120.000,    .789,    .000
 '500CG1  ','A',  -30.00,   70.00, 1,    .500,    .000,    .000,    .000,    .000,    .000
 '500CG2  ','A',  -10.00,   70.00, 1,    .500,    .000,    .000,    .000,    .000,    .000
 '500EA   ','A',   60.00,   40.00, 1,    .990,    .000, 288.680,    .000,    .789,    .000
 '500EB   ','A',   80.00,   60.00, 1,    .990,    .000, 288.680,-120.000,    .789,    .000
 '500EC   ','A',  100.00,   40.00, 1,    .990,    .000, 288.680, 120.000,    .789,    .000
 '500EG1  ','A',   70.00,   70.00, 1,    .500,    .000,    .000,    .000,    .000,    .000
 '500EG2  ','A',   90.00,   70.00, 1,    .500,    .000,    .000,    .000,    .000,    .000
 '500NA   ','A',  155.50,   71.50, 1,    .990,    .000, 288.680,    .000,    .560,    .000
 '500NB   ','A',  155.50,   40.00, 1,    .990,    .000, 288.680,-120.000,    .560,    .000
 '500NC   ','A',  184.50,   40.00, 1,    .990,    .000, 288.680, 120.000,    .560,    .000
 '500NG1  ','A',  161.00,   97.25, 1,    .500,    .000,    .000,    .000,    .000,    .000
 '500NG2  ','A',  179.00,   97.25, 1,    .500,    .000,    .000,    .000,    .000,    .000
 100 -300.0    6.0

ELECTRIC FIELD CALCULATIONS


  Yellow Rosebud EMF
  Alternate Route
             DIST. FROM            MAXIMUM   SUBCON.   NO. OF     PHASE
              REFERENCE    HEIGHT  GRADIENT   DIAM.    SUBCON.    ANGLE
                FEET        FEET   (KV/CM)    (IN)               (DEGREES)
```

500WA	-190.00	40.00	34.60	.99	1	.0
500WB	-170.00	60.00	36.77	.99	1	-120.0
500WC	-150.00	40.00	34.94	.99	1	120.0
500WG1	-180.00	70.00	7.98	.50	1	.0
500WG2	-160.00	70.00	7.72	.50	1	.0
500CA	-40.00	40.00	34.68	.99	1	.0
500CB	-20.00	60.00	36.80	.99	1	-120.0
500CC	.00	40.00	35.40	.99	1	120.0
500CG1	-30.00	70.00	7.97	.50	1	.0
500CG2	-10.00	70.00	7.60	.50	1	.0
500EA	60.00	40.00	35.20	.99	1	.0
500EB	80.00	60.00	36.74	.99	1	-120.0
500EC	100.00	40.00	35.49	.99	1	120.0
500EG1	70.00	70.00	7.75	.50	1	.0
500EG2	90.00	70.00	7.56	.50	1	.0
500NA	155.50	71.50	34.97	.99	1	.0
500NB	155.50	40.00	35.86	.99	1	-120.0
500NC	184.50	40.00	34.38	.99	1	120.0
500NG1	161.00	97.25	5.26	.50	1	.0
500NG2	179.00	97.25	3.09	.50	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)
-300.0	.340	86.4	.339	148.8	.022	161.6	339.5
-294.0	.382	86.3	.381	150.3	.025	162.9	381.4
-288.0	.431	86.1	.430	151.9	.030	164.3	431.0
-282.0	.490	85.9	.489	153.5	.036	165.6	490.1
-276.0	.561	85.7	.560	155.1	.043	167.0	561.0
-270.0	.647	85.4	.645	156.8	.052	168.4	646.4
-264.0	.751	85.2	.748	158.5	.064	169.8	750.2
-258.0	.877	85.0	.874	160.3	.078	171.2	876.6
-252.0	1.033	84.8	1.028	162.0	.095	172.6	1031.5
-246.0	1.223	84.6	1.217	163.8	.116	174.1	1221.2
-240.0	1.456	84.5	1.449	165.6	.142	175.5	1453.3
-234.0	1.738	84.4	1.730	167.3	.171	177.0	1734.9
-228.0	2.076	84.5	2.066	169.0	.202	178.6	2071.1
-222.0	2.467	84.8	2.457	170.7	.229	-179.5	2460.2
-216.0	2.898	85.3	2.888	172.3	.242	-177.0	2886.9
-210.0	3.328	86.2	3.320	173.9	.227	-172.8	3312.1
-204.0	3.686	87.6	3.683	175.6	.168	-162.2	3664.7
-198.0	3.875	89.5	3.874	177.6	.091	-113.4	3845.6
-192.0	3.793	92.0	3.791	-179.6	.185	-42.8	3756.4
-186.0	3.398	95.1	3.385	-174.9	.365	-29.4	3354.0
-180.0	2.754	98.2	2.726	-165.5	.520	-27.3	2708.3
-174.0	2.086	98.1	2.066	-145.4	.610	-28.6	2065.2
-168.0	1.883	86.7	1.880	-111.9	.621	-31.0	1883.0
-162.0	2.366	81.4	2.340	-84.4	.550	-32.9	2328.8
-156.0	3.004	83.8	2.987	-70.9	.407	-32.5	2959.4

-150.0	3.456	87.2	3.451	-64.6	.222	-25.0	3416.7
-144.0	3.598	90.1	3.598	-61.5	.077	33.1	3565.5
-138.0	3.439	92.5	3.436	-59.9	.156	106.6	3413.1
-132.0	3.066	94.5	3.057	-59.2	.241	118.8	3044.7
-126.0	2.582	96.2	2.567	-59.4	.278	124.0	2563.9
-120.0	2.070	97.7	2.052	-60.8	.280	128.0	2053.2
-114.0	1.582	99.3	1.561	-64.3	.266	132.2	1564.8
-108.0	1.148	101.0	1.127	-72.0	.248	137.1	1131.2
-102.0	.803	101.0	.789	-89.0	.234	142.8	793.2
-96.0	.646	90.0	.646	-121.1	.228	149.0	650.3
-90.0	.802	79.2	.788	-152.9	.231	155.3	792.6
-84.0	1.141	79.2	1.120	-169.7	.243	161.2	1124.7
-78.0	1.565	80.8	1.545	-177.3	.260	166.4	1549.3
-72.0	2.046	82.3	2.028	179.3	.278	170.8	2030.4
-66.0	2.560	83.7	2.545	178.0	.283	174.8	2543.4
-60.0	3.067	85.1	3.056	177.8	.262	179.2	3047.7
-54.0	3.497	86.8	3.492	178.3	.196	-172.9	3473.0
-48.0	3.751	88.9	3.751	179.6	.092	-139.1	3721.9
-42.0	3.734	91.5	3.732	-178.1	.148	-45.8	3698.4
-36.0	3.401	94.5	3.391	-173.9	.327	-29.7	3360.9
-30.0	2.819	97.3	2.796	-165.2	.480	-27.7	2779.0
-24.0	2.198	97.3	2.181	-147.3	.567	-29.3	2180.3
-18.0	1.953	88.6	1.952	-118.0	.572	-32.3	1956.8
-12.0	2.301	83.0	2.285	-92.1	.493	-35.3	2276.0
-6.0	2.815	84.8	2.803	-78.9	.337	-37.4	2778.1
.0	3.150	88.1	3.148	-73.6	.133	-36.4	3114.7
6.0	3.177	91.3	3.176	-72.9	.078	132.7	3145.1
12.0	2.912	94.0	2.905	-76.0	.249	138.6	2884.3
18.0	2.474	95.9	2.461	-83.9	.362	141.7	2452.1
24.0	2.045	95.2	2.037	-99.3	.421	145.5	2038.8
30.0	1.872	89.5	1.872	-122.4	.439	149.7	1877.7
36.0	2.098	84.3	2.088	-144.8	.421	153.8	2088.8
42.0	2.552	84.1	2.539	-159.1	.361	157.3	2529.4
48.0	3.000	86.0	2.992	-166.6	.249	159.5	2970.8
54.0	3.262	88.8	3.262	-169.6	.078	159.4	3230.1
60.0	3.225	92.0	3.223	-169.3	.130	-17.3	3188.6
66.0	2.864	95.6	2.851	-165.1	.333	-19.2	2823.6
72.0	2.287	98.4	2.263	-153.8	.486	-21.5	2250.7
78.0	1.785	95.2	1.778	-129.1	.563	-24.1	1780.1
84.0	1.848	83.4	1.837	-95.3	.556	-25.8	1834.4
90.0	2.376	82.3	2.355	-72.8	.469	-24.5	2335.0
96.0	2.885	85.5	2.877	-61.3	.326	-15.0	2843.6
102.0	3.144	88.9	3.144	-54.1	.204	19.0	3107.4
108.0	3.097	91.8	3.095	-47.5	.235	67.2	3065.7
114.0	2.817	93.8	2.811	-38.9	.332	84.9	2794.1
120.0	2.469	93.9	2.463	-26.1	.395	88.3	2459.8
126.0	2.265	90.8	2.265	-8.4	.411	85.9	2270.1
132.0	2.363	86.8	2.359	9.9	.385	80.3	2363.6
138.0	2.698	85.5	2.690	22.9	.317	71.5	2686.9
144.0	3.081	86.5	3.075	29.1	.206	53.9	3061.3
150.0	3.346	88.4	3.345	29.4	.119	-10.1	3323.1
156.0	3.416	90.2	3.416	24.4	.250	-68.4	3394.6
162.0	3.346	90.8	3.346	13.8	.421	-82.3	3332.0

168.0	3.321	89.4	3.321	-1.7	.523	-87.8	3313.7
174.0	3.497	87.6	3.494	-18.1	.520	-92.2	3482.7
180.0	3.797	87.6	3.794	-31.3	.421	-99.4	3771.5
186.0	4.014	89.0	4.014	-40.2	.278	-116.3	3984.8
192.0	4.014	90.9	4.014	-45.9	.187	-155.6	3987.1
198.0	3.787	92.6	3.783	-49.6	.206	163.7	3765.1
204.0	3.403	93.9	3.395	-52.2	.244	145.5	3386.9
210.0	2.952	94.8	2.941	-54.2	.254	137.4	2940.2
216.0	2.501	95.4	2.490	-55.9	.239	133.1	2493.0
222.0	2.090	95.7	2.080	-57.4	.211	130.5	2084.7
228.0	1.735	95.9	1.726	-58.8	.179	128.6	1731.5
234.0	1.438	95.9	1.430	-60.2	.148	127.1	1435.2
240.0	1.193	95.8	1.187	-61.5	.122	125.8	1191.2
246.0	.993	95.7	.988	-62.9	.099	124.7	991.8
252.0	.831	95.5	.827	-64.2	.081	123.6	829.5
258.0	.698	95.4	.695	-65.6	.066	122.5	697.4
264.0	.590	95.2	.588	-67.0	.054	121.4	589.5
270.0	.502	95.0	.500	-68.4	.044	120.4	501.2
276.0	.429	94.8	.427	-69.8	.037	119.3	428.4
282.0	.369	94.7	.367	-71.2	.030	118.3	368.2
288.0	.318	94.5	.317	-72.7	.025	117.2	318.1
294.0	.276	94.4	.276	-74.1	.021	116.2	276.2

MAGNETIC FIELD CALCULATIONS

SENSOR HT. = 3.3 FEET

DIST FROM REFERENCE FEET	B-FIELD (GAUSS)	THETA	BY-FIELD (GAUSS)	THETAY	BX-FIELD (GAUSS)	THETAX
-300.0	.02433003	-70.8	.02304480	145.7	.00934865	-69.8
-294.0	.02541691	-69.9	.02393699	146.9	.01012496	-67.8
-288.0	.02662414	-68.8	.02490302	148.2	.01102223	-65.5
-282.0	.02797196	-67.5	.02594802	149.6	.01206926	-63.1
-276.0	.02948476	-66.1	.02707512	151.1	.01330361	-60.4
-270.0	.03119192	-64.4	.02828337	152.7	.01477466	-57.5
-264.0	.03312867	-62.5	.02956426	154.4	.01654741	-54.4
-258.0	.03533695	-60.2	.03089572	156.2	.01870728	-51.0
-252.0	.03786588	-57.6	.03223230	158.1	.02136535	-47.4
-246.0	.04077137	-54.4	.03348907	160.2	.02466312	-43.7
-240.0	.04411380	-50.6	.03451626	162.5	.02877332	-39.9
-234.0	.04795158	-46.0	.03506109	164.9	.03388988	-36.0
-228.0	.05232777	-40.6	.03471591	167.6	.04019331	-32.3
-222.0	.05724425	-33.9	.03286315	170.9	.04776618	-28.7
-216.0	.06261933	-26.0	.02866237	175.3	.05642663	-25.5
-210.0	.06822883	-16.5	.02123613	183.5	.06546120	-22.7
-204.0	.07365163	-5.4	.01105021	211.5	.07333118	-20.4
-198.0	.07827388	7.4	.01302597	-58.4	.07762166	-18.7
-192.0	.08142448	21.8	.03115787	-33.2	.07564315	-17.3
-186.0	.08263745	37.5	.05072924	-27.3	.06571465	-16.0
-180.0	.08188010	54.3	.06666711	-25.7	.04829623	-13.1
-174.0	.07955074	72.0	.07571171	-25.5	.02632069	-2.4
-168.0	.07626075	90.7	.07625549	-25.6	.01181674	68.7
-162.0	.07260292	110.5	.06818246	-24.7	.02862531	123.8
-156.0	.06904230	131.4	.05286942	-21.1	.04722356	132.5
-150.0	.06589510	152.9	.03375068	-9.6	.05919757	135.5
-144.0	.06331159	174.1	.01868535	28.7	.06300158	137.4
-138.0	.06128130	-166.1	.02202977	87.5	.05963729	139.7
-132.0	.05971892	-148.6	.03389799	110.4	.05160506	142.7
-126.0	.05856454	-133.4	.04368323	119.7	.04152022	147.0
-120.0	.05781242	-120.4	.05029223	125.2	.03125425	153.2
-114.0	.05748842	-109.3	.05440101	129.2	.02185886	163.0
-108.0	.05762550	-99.6	.05684023	132.7	.01403389	181.1
-102.0	.05825287	-91.1	.05824287	135.9	.00935346	219.3
-96.0	.05939363	-83.3	.05899027	138.8	.01078261	268.2
-90.0	.06106292	-75.8	.05923015	141.6	.01651755	-65.2
-84.0	.06326163	-68.5	.05889130	144.3	.02389423	-51.6
-78.0	.06596080	-60.9	.05767277	146.7	.03236221	-43.0
-72.0	.06907286	-52.7	.05501319	148.6	.04188794	-36.8
-66.0	.07240630	-43.7	.05007765	150.0	.05231104	-32.0
-60.0	.07560911	-33.6	.04185602	150.1	.06297468	-28.3
-54.0	.07812791	-22.1	.02955204	147.2	.07240579	-25.5
-48.0	.07924245	-9.1	.01376970	130.8	.07825583	-23.7
-42.0	.07823963	5.4	.01064620	23.8	.07789379	-22.8
-36.0	.07469771	21.3	.02822853	-3.9	.06966906	-22.6

-30.0	.06870099	38.5	.04314319	-10.0	.05397674	-22.6
-24.0	.06081800	57.2	.05115129	-12.4	.03317614	-21.3
-18.0	.05191275	77.8	.05074120	-12.7	.01102965	-6.4
-12.0	.04302791	101.7	.04217535	-8.8	.01220983	124.2
-6.0	.03587903	134.5	.02824278	6.8	.02795029	135.9
.0	.03650936	-172.7	.02020931	57.1	.03630369	137.9
6.0	.04581117	-138.3	.03253153	102.1	.03569715	139.2
12.0	.05634389	-116.9	.05044922	116.9	.02699070	141.2
18.0	.06623601	-100.0	.06523390	123.0	.01250692	146.8
24.0	.07519404	-85.6	.07496808	126.2	.00582970	-56.2
30.0	.08330216	-72.6	.07950392	127.6	.02528461	-41.5
36.0	.09064645	-60.5	.07905166	127.4	.04543054	-38.2
42.0	.09711143	-48.8	.07381686	125.0	.06503180	-36.5
48.0	.10230070	-37.3	.06443180	118.7	.08254927	-35.8
54.0	.10561450	-25.8	.05307432	105.9	.09594881	-36.4
60.0	.10651700	-14.7	.04444971	83.9	.10343010	-38.5
66.0	.10488480	-4.6	.04313573	56.9	.10460710	-42.4
72.0	.10117500	4.2	.04722352	35.1	.10096580	-47.9
78.0	.09624465	11.1	.05144273	20.0	.09492459	-54.7
84.0	.09095791	16.2	.05334384	8.5	.08840613	-61.9
90.0	.08586390	20.1	.05305837	-1.3	.08221580	-68.8
96.0	.08113279	23.6	.05157529	-10.5	.07637409	-74.7
102.0	.07671727	27.0	.04976815	-19.2	.07068871	-79.5
108.0	.07253489	30.6	.04809878	-27.1	.06506281	-83.3
114.0	.06854445	34.1	.04668184	-34.0	.05953240	-86.2
120.0	.06474371	37.5	.04545689	-39.9	.05419941	-88.4
126.0	.06114721	40.8	.04432411	-44.7	.04916785	269.9
132.0	.05776999	43.8	.04320763	-48.7	.04451191	268.6
138.0	.05462046	46.6	.04206858	-51.8	.04026905	267.5
144.0	.05169903	49.2	.04089672	-54.3	.03644571	266.7
150.0	.04899947	51.6	.03969838	-56.4	.03302677	266.1
156.0	.04651083	53.7	.03848704	-58.0	.02998417	265.6
162.0	.04421943	55.6	.03727761	-59.3	.02728369	265.1
168.0	.04211029	57.4	.03608349	-60.4	.02488926	264.8
174.0	.04016816	59.0	.03491550	-61.3	.02276579	264.5
180.0	.03837822	60.5	.03378163	-62.0	.02088061	264.3
186.0	.03672649	61.9	.03268737	-62.6	.01920416	264.1
192.0	.03520000	63.1	.03163610	-63.0	.01771017	263.9
198.0	.03378687	64.2	.03062956	-63.4	.01637559	263.7
204.0	.03247639	65.3	.02966826	-63.8	.01518035	263.6
210.0	.03125884	66.3	.02875179	-64.0	.01410703	263.5
216.0	.03012556	67.2	.02787912	-64.3	.01314058	263.4
222.0	.02906873	68.0	.02704878	-64.4	.01226798	263.3
228.0	.02808140	68.8	.02625905	-64.6	.01147800	263.2
234.0	.02715735	69.5	.02550803	-64.7	.01076094	263.1
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246.0	.02547737	70.8	.02411425	-64.9	.00951304	263.0
252.0	.02471199	71.4	.02346759	-65.0	.00896859	263.0
258.0	.02399086	72.0	.02285186	-65.0	.00846950	262.9
264.0	.02331037	72.5	.02226526	-65.0	.00801097	262.9
270.0	.02266729	73.0	.02170607	-65.1	.00758880	262.8
276.0	.02205869	73.5	.02117264	-65.1	.00719928	262.8
282.0	.02148196	73.9	.02066344	-65.1	.00683917	262.7

288.0	.02093469	74.3	.02017701	-65.1	.00650561	262.7
294.0	.02041473	74.7	.01971201	-65.1	.00619607	262.7

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