Arizona G&T Cooperatives

Touchstone Energy® Cooperatives

ARIZONA ELECTRIC POWER COOPERATIVE
ADONIS-MARANA 115KV TRANSMISSION LINE

ANTICIPATED NOISE EMISSION LEVELS AND INTERFERENCE

Revision A

PRELIMINARY – NOT FOR CONSTRUCTION

Project No.: 14323-002

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Sargent & Lundy

ISSUE SUMMARY AND APPROVAL PAGE

This is to certify that this Anticipated Noise Emission Levels and Interference Report has been prepared, reviewed, and approved in accordance with Sargent & Lundy's Standard Operating Procedure SOP-0405, which is based on ANSI/ISO/ASSQC Q9001 Quality Management Systems.

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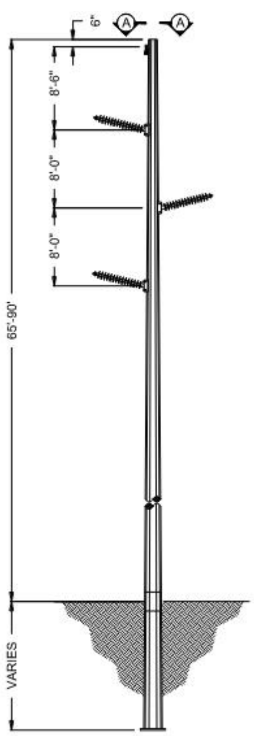
1.0. Purpose and Introduction

The purpose of this document is to provide the information as stipulated by the Arizona Corporation Commission Article 2 - Rules of Practice and Procedure Before Power Plant and Transmission Line Siting Committee Exhibit 1 which states the following under the section titled "Exhibit I":

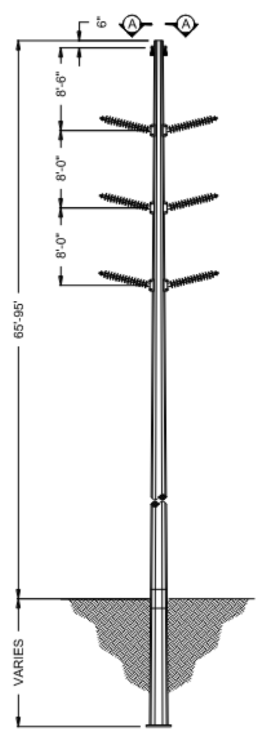
"DESCRIBE THE ANTICIPATED NOISE EMISSION LEVELS AND ANY INTERFERENCE WITH COMMUNICATION SIGNALS WHICH WILL EMANATE FROM THE PROPOSED FACILITIES."

Overhead transmission lines are an inherent source of non-ionizing radiation and extremely low frequency electric and magnetic fields (50-60 Hz range for North America). When the electric field intensity at the conductor surface rises above a certain critical level, corona discharges occur. Corona discharge on conductors produces a number of effects such as radio interference (RI), television interference (TVI), and audible noise (AN). These effects can be minimized by considering transmission line design and location during detailed design.

This project involves two different line configurations which have been evaluated for corona, audible noise, radio interference, television interference, and electric and magnetic field effects using the Bonneville Power Administration (BPA) Corona and Field Effects Program. Corona and Field Effects Program is an industry standard software that determines the magnitude of the above described field effects. The first configuration is a single circuit 115kV delta arrangement and the second configuration is a double circuit vertical arrangement which consists of one (1) 115kV circuit and one (1) 138kV circuit.



115kV SINGLE CIRCUIT TANGENT
STEEL MONOPOLE



115/138kV DOUBLE CIRCUIT TANGENT
STEEL MONOPOLE

2.0. Field Effects

2.1. Corona

Corona discharges occur on transmission lines when the intensity of the electric field at the conductor surface is above a critical value causing the ionization of the air surrounding the conductor. Therefore, corona discharge is a function of the voltage gradient. Corona occurs on all voltages of electric transmission lines, but it becomes larger and more noticeable at higher voltages such as EHV or Extra High Voltage level (345kV and above). It is the intent of utilities and design engineers to minimize corona not only for effects to the surrounding communities but also corona equates to loss of power, and in extreme conditions it can damage transmission line components.

Several factors have influence on the voltage gradient including conductor surface roughness (nicks, burrs, scratches), meteorological conditions, voltage, phase spacing, phase configuration and the conductor position in regard to the ground. Furthermore, when water is deposited on the transmission line conductors due to condensation or rain this increases the conductor surface irregularity and increases corona discharge. For the transmission line design configurations considered for this project, the calculated peak voltage gradient for the single circuit configuration at the conductor surface is 8.57kV/cm. For the double circuit line configuration, the calculated peak voltage gradient at the 115kV and 138kV conductor surfaces is 9.53kV/cm and 11.50kV/cm, respectively. For the purpose of comparison, the breakdown strength of air is 21.1 kVrms/cm at 25 °C and 76 mm barometric pressure.

2.2. Audible Noise

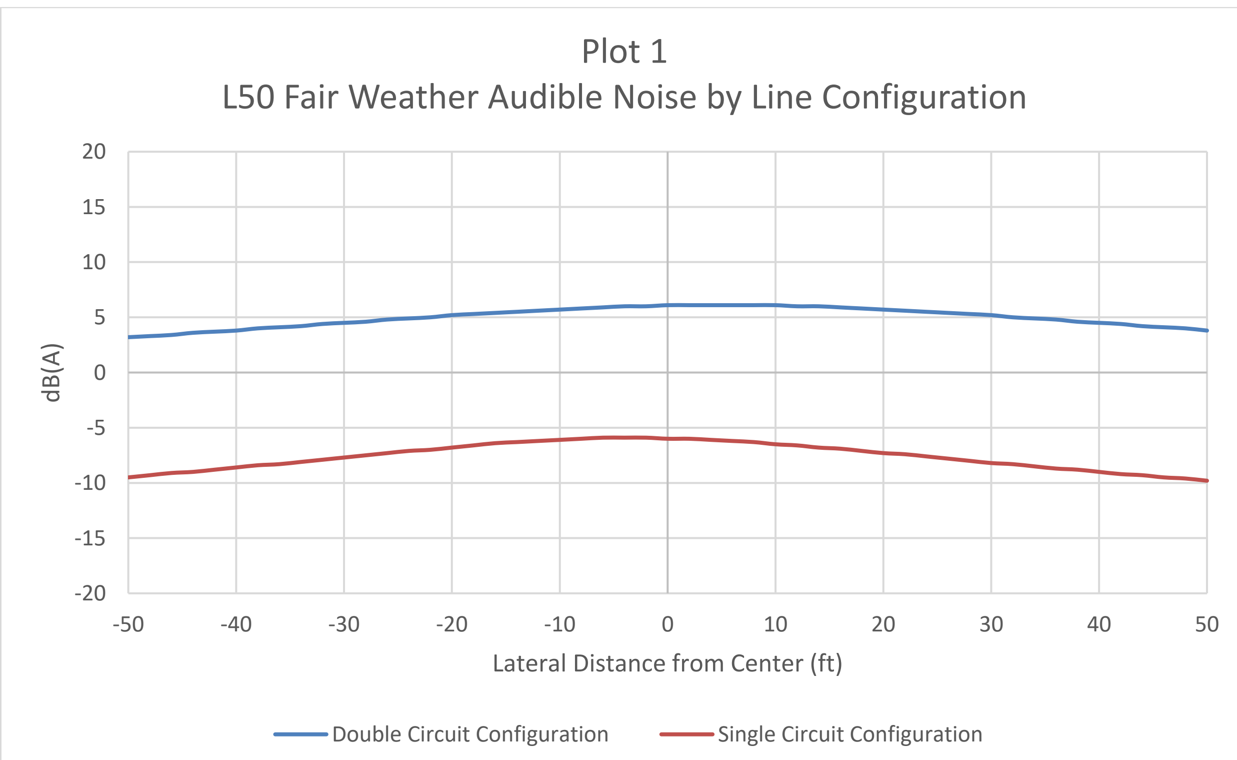
Audible Noise of a transmission line is directly correlated to corona discharge on a transmission line. Therefore, an increase in corona has a subsequent increase in Audible Noise. Audible Noise generated by corona has two major components: the “broadband noise” and the “hum.” The “broadband noise” has a significant high-frequency content that results in the cracking, frying, or hissing characteristics of transmission line noise. The “hum” has the low-frequency components which are equal to twice the power frequency (120 Hz for a 60-Hz system). Audible noise from transmission lines is most notable in poor weather conditions, rain in particular. Water drops striking or collecting on the conductors produce a large number of corona discharges, each of them creating a burst of noise. In dry conditions, the conductors usually operate below the corona-inception level, and very few corona sources are present.

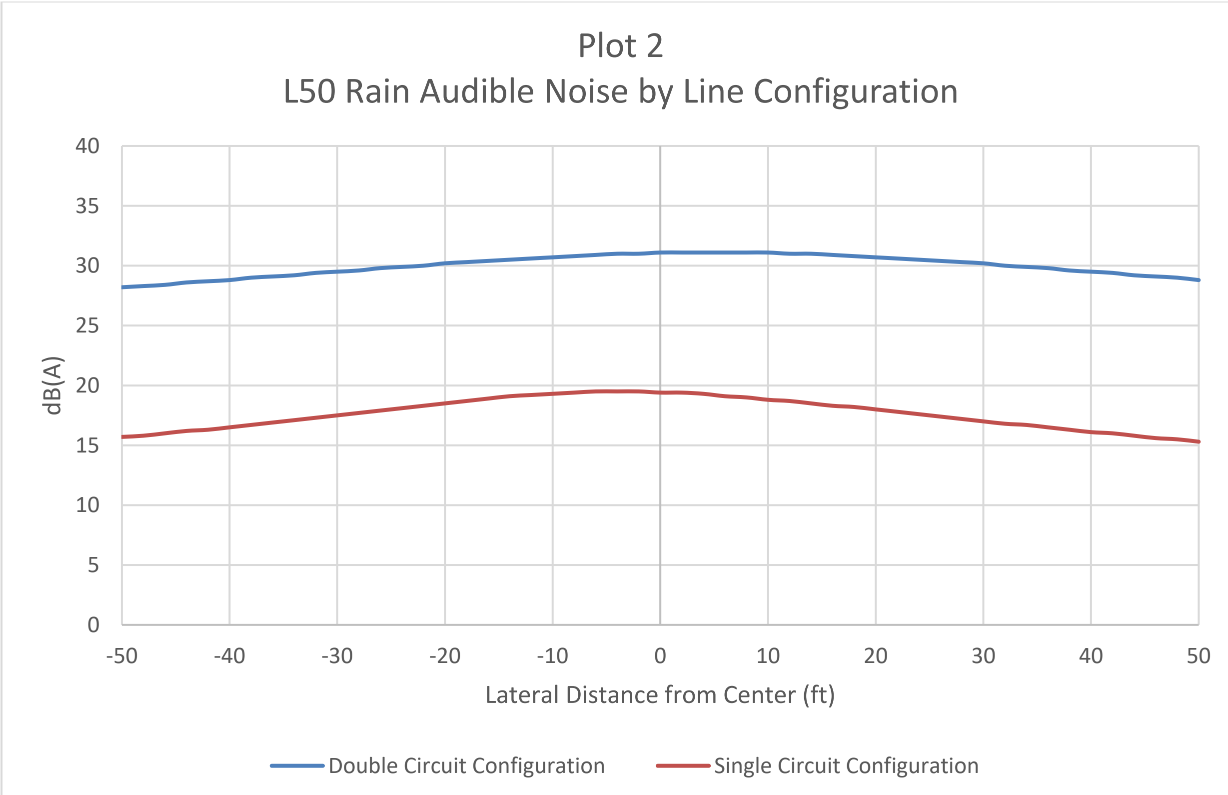
The most important weather condition, from a design point of view, is rain because of all foul-weather conditions this is the one most often encountered. Audible noise is usually masked during falling rain, and complaints are expected to be minimal. A greater awareness of the noise emanating from the lines occur during light rain and fog conditions, especially early morning, when the ambient noise is relatively low. However, a transmission line designed to have an acceptable audible noise level in rain will usually not generate appreciable audible noise in fair weather. In addition to the weather condition, other design aspects affecting corona-induced audible noise are conductor surface gradient, conductor diameter, number of conductors, line geometry and conductor surface conditions.

For this project, audible noise is calculated using an “A” weighted scale for a 100 ft width centered at the structure centerline. Under foul (rain) conditions, the maximum calculated audible noise for the single circuit and double circuit configurations at a 37.5ft offset is 16.7 dB(A) and 29.8 dB(A), respectively. At a 50 ft offset under foul (rain) conditions, the maximum calculated audible noise for the single circuit and double circuit configurations is 15.5 dB(A) and 28.8 dB(A), respectively.

Under fair conditions, the maximum calculated audible noise for the single circuit and double circuit configurations at a 37.5ft offset is -8.3 dB(A) and 4.8 dB(A), respectively. At a 50 ft offset under fair conditions, the maximum calculated audible noise for the single circuit and double circuit configurations is -9.5 dB(A) and 3.8 dB(A), respectively. A negative dB(A) value represents a noise that is below the threshold of the human ear, therefore the transmission line will have no audible noise to the average human ear.

In locations where there are no state, county or city regulations available, best engineering practice limits audible noise at the edge of the right of way to no more than L50 = 53 dB(A) during measurable rain. This design limit is based on the audible noise complaint guidelines published by Perry from BPA in 1972. His findings are based on probability of receiving noise complaints and concluded that an audible noise level less than or equal to 53 dB(A) at the edge of right of way generated no complaints. Plots 1 and 2 show the calculated L50 fair weather and L50 rain audible noise levels for the single circuit and double circuit line configurations, these values fall well under the best engineering practice limit of 53 dB(A). In addition, the audible noise calculated for this transmission line is consistent with other similar 115kV/138kV lines, no issues with noise generated from the transmission line are anticipated.





2.3. Radio Interference

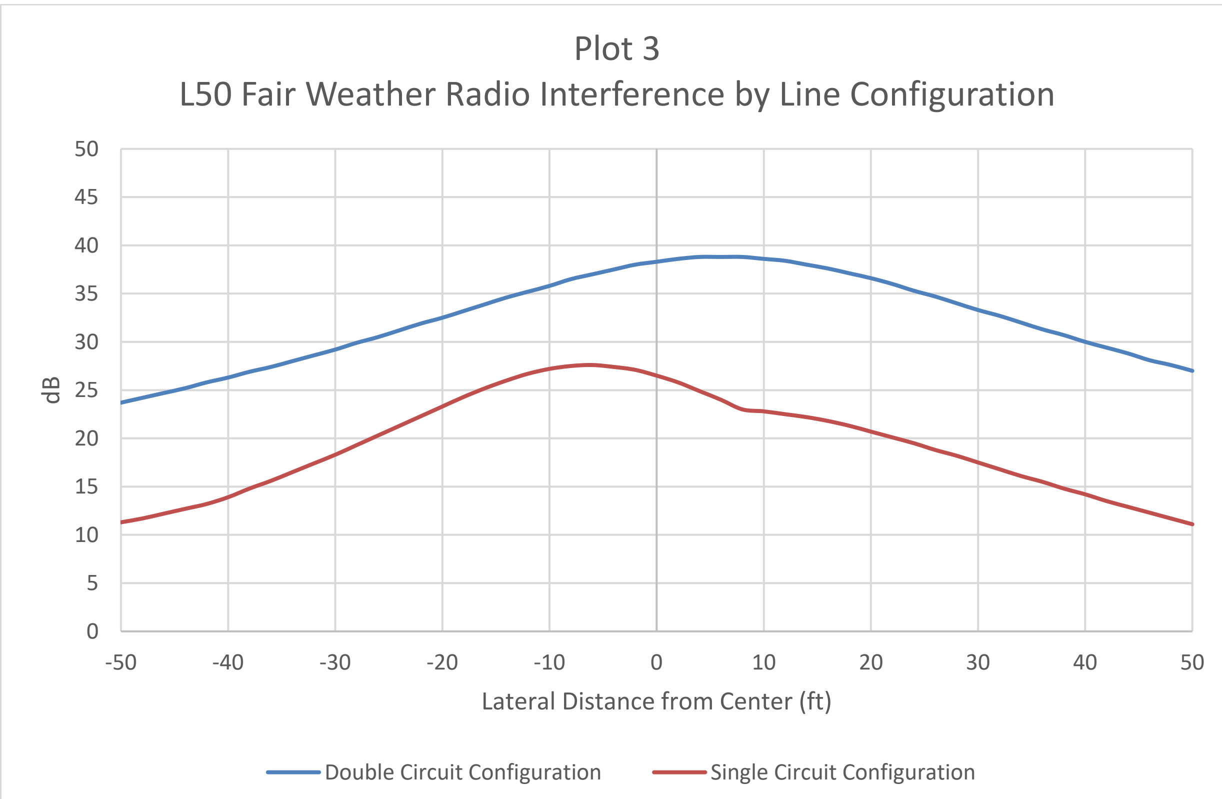
Radio interference from transmission lines occurs when the electric field at the conductor surface exceeds a critical value resulting in the ionization of the air surrounding the conductor followed by corona discharge. It is defined by EPRI as the degradation of the reception of a wanted signal caused by radio frequency (RF) disturbance. This radio frequency disturbance affects the amplitude modulated (AM) radio band, but not the frequency modulated (FM) radio band. It is difficult to assess the significance of corona interference to AM radio band because the complaint experience of the utility industry is nearly zero. One reason for this is the popularity of FM Broadcasting which is not affected, for the most part, by man-made electromagnetic interference. FM Broadcast signals are for all practical purposes immune from broadband interference since their carrier signals are frequency modulated.

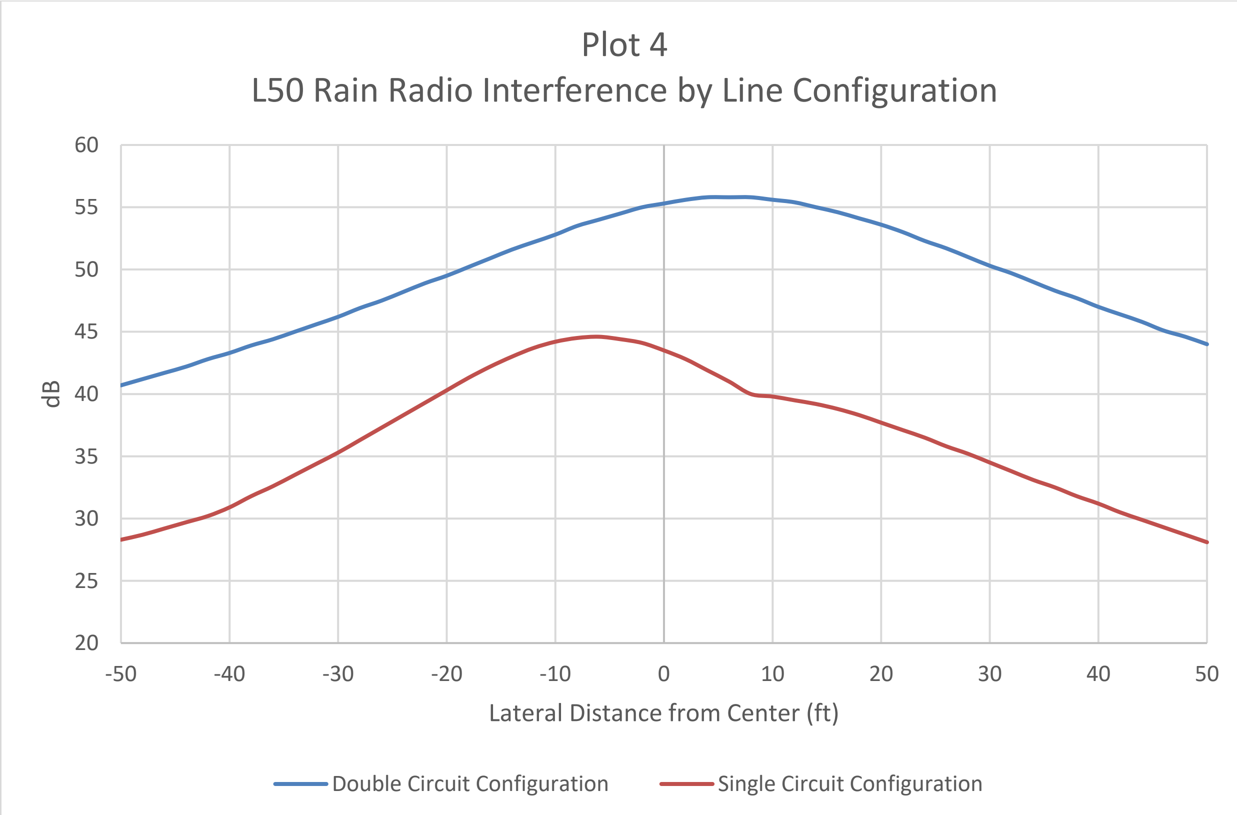
A frequency of 1 MHz is commonly used in calculating the anticipated transmission line radio interference. It is typically measured in decibels (dB) of one microvolt per meter, which is a logarithmic scale. The values provided in Plot 3 show that the anticipated fair weather radio interference for the single circuit and double circuit configurations fall below the maximum IEEE guideline of 40 dB. The values provided in Plot 4 show the anticipated foul (rain) weather radio interference levels.

Under foul (rain) conditions, the maximum calculated radio interference for the single circuit and double circuit configurations at a 37.5ft offset is 32.6 dB and 48.3 dB, respectively. At a 50 ft offset under foul (rain) conditions, the maximum calculated audible noise for the single circuit and double circuit configurations is 28.3 dB and 44.0 dB, respectively.

Under fair conditions, the maximum calculated audible noise for the single circuit and double circuit configurations at a 37.5ft offset is 15.6 dB and 31.3 dB, respectively. At a 50 ft offset under fair conditions, the maximum calculated audible noise for the single circuit and double circuit configurations is 11.3 dB and 27.0 dB, respectively. These calculated values fall well below the IEEE specified maximum of 38 dB.

Experience for lines similar in design spanning similar terrain has shown radio interference to be acceptable. If radio interference caused by the transmission line were to become unacceptable in each situation, the utility is willing to work with the complainant to resolve the interference problem.





2.4. Television Interference

Television interference effects due to transmission effects analog television. Typically, television interference (TVI) only affects the lower VHF band (Channels 2 through 6) and no interference will be experienced in the upper VHF (Channels 7 - 13) and UHF bands (Channels 14 - 83) even during foul weather. Under the Digital Transition and Public Safety Act of 2005 full power analog TV broadcast ended in June of 2009. Given that present-day television broadcast primarily occurs over a digital medium, television interference problems warranting any sort of corrective action are extremely unlikely.

Experience for lines similar in design spanning similar terrain has shown television interference to not be an issue. If TVI caused by the transmission line were to become unacceptable in each situation, the utility is willing to work with the complainant to resolve the interference problem. No transmission line generated TVI is expected along the lines, even during periods of foul (rain) weather.

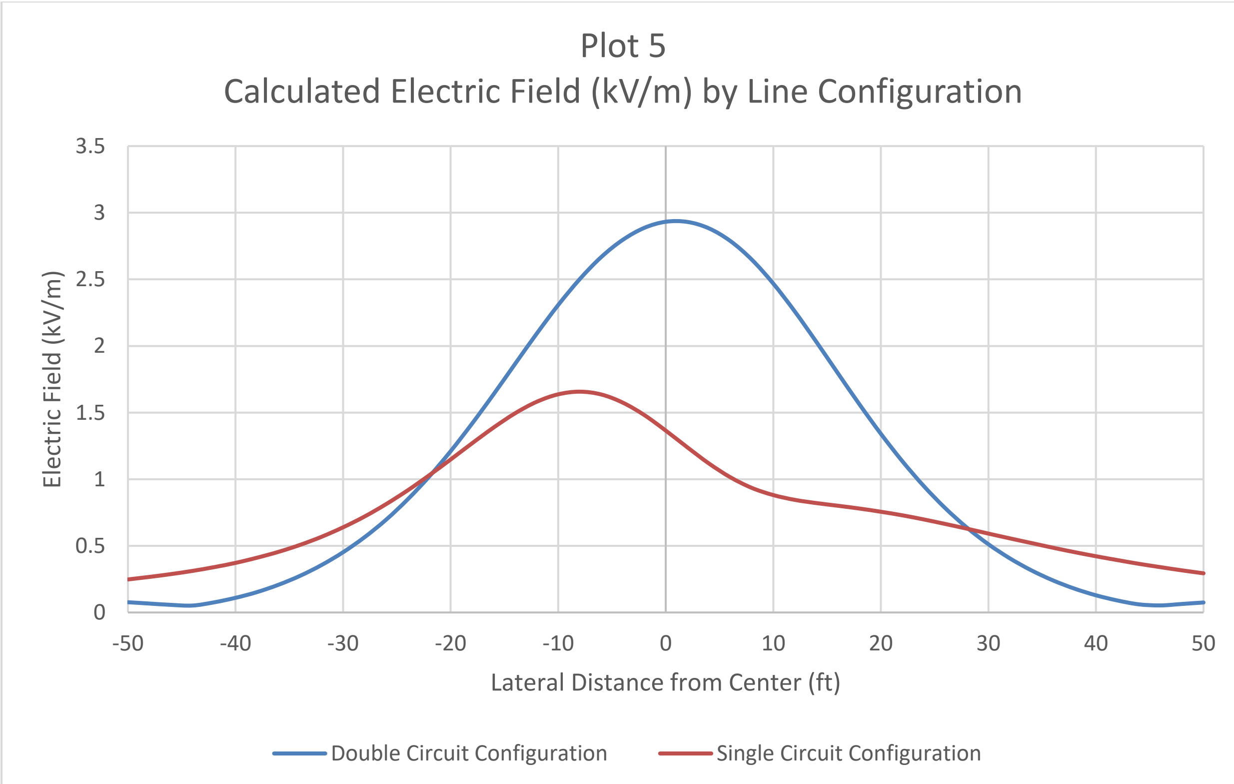
2.5. Electric and Magnetic Field Effects

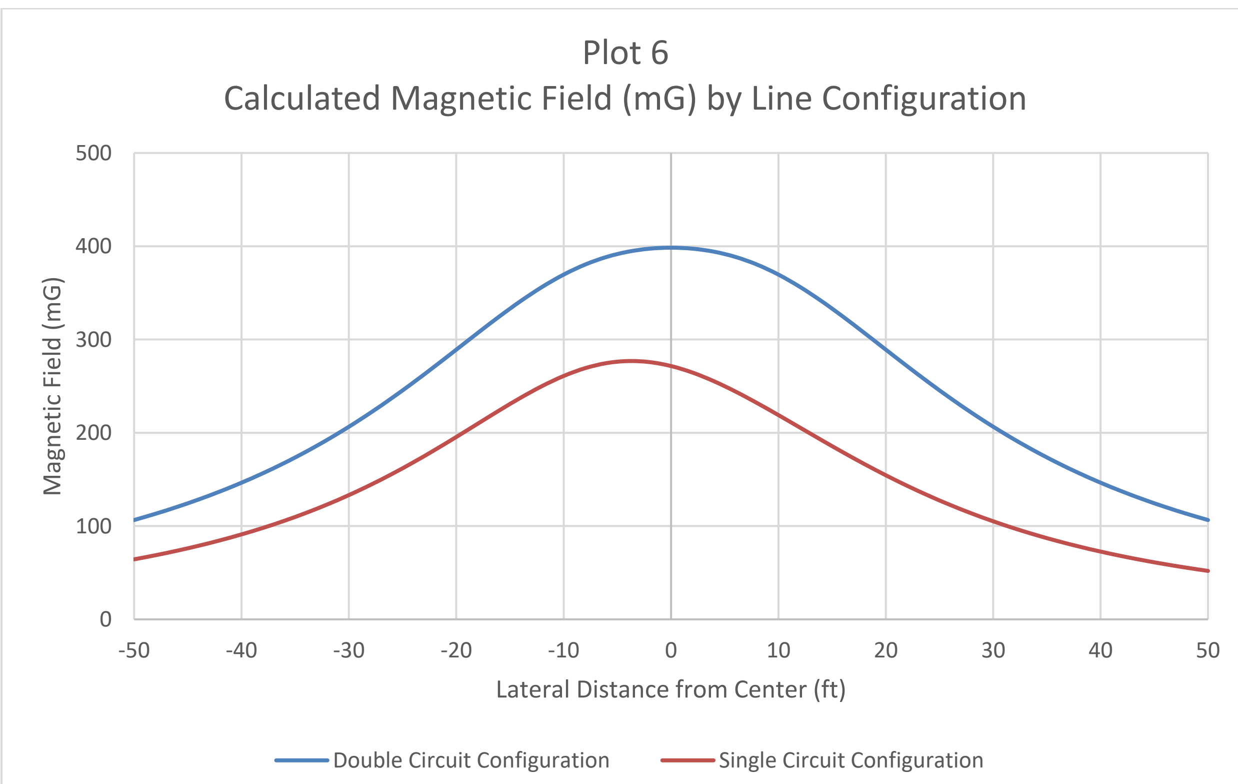
Transmission line electric and magnetic field (EMF) effects are predominantly electric and magnetic fields which induce voltages and currents on conductive objects which are located near transmission lines. Electric and magnetic fields are generated by electrical charges and by their movement (electric currents). Voltage is the source of electric fields and current is the source of magnetic fields. A source of EMF may be considered important because of the level of the electric and magnetic field that is generated or because of the duration of the exposure to that source's field.

Electric fields are considered in line design and operation. They are important in terms of induction on vehicles and other conductive objects, shocks caused by spark discharges, line impedances, power losses, pole fires, railroad signal interference, and corrosion of pipelines running in parallel with the transmission lines. For transmission line clearances affected by fields, NESC rule 232C1c states the following: "For voltages exceeding 98 kV ac to ground, either the clearances shall be increased or the electric field, or the effects thereof, shall be reduced by other means as required to limit the steady-state current due to electrostatic effects to 5 mA rms if the largest anticipated truck, vehicle, or equipment under the line were short-circuited to ground." Therefore, the transmission line is designed to limit the electrostatic effects of the transmission line on objects to 5mA or below. For this project, no electrostatic induction problems are anticipated. Should any problems arise with electrostatic induction due to the transmission line, the problem can easily be remedied by grounding the affected objects.

Magnetic fields are important in terms of induction in parallel wires, interference with the proper operation of computer monitors and pacemakers. However, the major focus of attention is on the long-term exposure of people to electric and magnetic fields and its possible health effects. For most health outcomes, there is no definitive evidence that extended periods of low frequency EMF exposures have adverse effects. There is some evidence from epidemiological studies that exposure to power-frequency magnetic field is associated with an increased risk of childhood leukemia. However, to date, no health effect of alternate EMF fields of the type and value as those existing in transmission-line and station environments has been conclusively found nor accepted by the scientific community. The anticipated magnetic fields (calculated at 1 meter) for the single circuit and double circuit configurations are shown in Plot 6, the magnetic fields shown in Plot 6 are consistent with similar transmission lines at 115kV/138kV.

The anticipated electric fields (calculated at 1 meter) for the single circuit and double circuit configurations are shown in Plot 5. IEEE C95.6 specifies a maximum electric field of 10kV/m within right of way, easement, or power line corridor and 5kV/m for persons in unrestricted environments. The values shown in Plot 5 are well within these limits for both configurations.


Plot 5
Calculated Electric Field (kV/m) by Line Configuration
Electric Field (kV/m)
3.5
3
2.5
2
1.5
1
0.5
0
-50
-40
-30
-20
-10
0
10
20
30
40
50
Lateral Distance from Center (ft)
Double Circuit Configuration
Single Circuit Configuration


Plot 6
Calculated Magnetic Field (mG) by Line Configuration
Magnetic Field (mG)
500
400
300
200
100
0
-50
-40
-30
-20
-10
0
10
20
30
40
50
Lateral Distance from Center (ft)
Double Circuit Configuration
Single Circuit Configuration

3.0. Evaluation Tools

All calculations performed for the purpose of generating this report were performed using the Bonneville Power Administration Corona & Field Effects Program v3.1.

4.0. References

1. EPRI AC Transmission Line Reference Book – 200 kV and Above, 2015 Edition (November 2015)
2. National Electrical Safety Code (NESC) - 2017 Edition (C2-2017)
3. IEEE C95.6 – Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz.", 2019
4. IEEE - "Review of Technical Considerations on Limits to Interference from Power Lines and Stations", IEEE Radio Noise and Corona Subcommittee Report, RI Limits Task Force, Working Group #3, IEEE Transactions on Power Apparatus and Systems, Vol. PAS-99, No. 1, Jan./Feb. 1980, pages 365-388.