BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO

IN THE MATTER OF THE APPLICATION OF)
TRI-STATE GENERATION AND TRANSMISSION)
ASSOCIATION, INC. FOR A CERTIFICATE OF)
PUBLIC CONVENIENCE AND NECESSITY FOR) DOCKET NO.
THE SAN LUIS VALLEY-CALUMET-COMANCHE)
TRANSMISSION PROJECT)

DIRECT TESTIMONY AND EXHIBITS OF
DR. ROBERT L. PEARSON

TABLE OF CONTENTS

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Dr. Robert L. Pearson. My business address is 9193 South Jamaica Street, Englewood, CO 80112.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am Vice President of CH2M HILL, a consulting engineering company based in Englewood, Colorado. I am a registered professional engineer in Colorado.

Q. HAVE YOU PREPARED A STATEMENT OF YOUR EXPERIENCE AND QUALIFICATIONS?

A. Yes. My statement of qualifications is attached as **Exhibit No. RLP-1**.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THIS DOCKET?

A. I am testifying on behalf of Tri-State Generation and Transmission Association, Inc. ("Tri-State"). I also understand that my testimony may be used in support of the companion CPCN application filed by Public Service Company of Colorado ("Public Service") in connection with this joint project.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. The purpose of my testimony is to address issues related to electromagnetic field ("EMF") exposure and audible noise produced by the transmission lines associated with the San Luis Valley – Calumet and Calumet – Walsenburg segments of the proposed San Luis Valley-Calumet-Comanche Transmission Line Project (the "Project"). I prepared a report on these issues. My report is attached as **Exhibit No. RLP-2**.

II. COLORADO REGULATORY REQUIREMENTS

Q. WHAT RULES HAVE BEEN ADOPTED BY THE COLORADO PUBLIC

UTILITIES COMMISSION REGARDING NOISE MITIGATION?

A. The Colorado Public Utilities Commission ("CPUC") has adopted rules for the routing and construction of new or upgraded electric transmission lines in Colorado that are subject to a requirement for a Certificate of Public Convenience and Necessity ("CPCN") from the CPUC.

One of these rules, 4 CCR § 723-3102(c), pertains to noise mitigation and requires that in a CPCN application for construction or extension of transmission facilities the applying utility must "describe its actions and techniques relating to cost-effective noise mitigation with respect to the planning, siting, construction, and operation of the proposed transmission construction or extension." The rule requires that the applying utility provide computer studies which show the potential noise levels expressed in dBA and measured at the edge of the transmission line right-of-way. The rule also lists some steps and techniques to reduce audible noise including using: (1) bundled conductors; (2) larger conductors; (3) design alternatives considering the spatial arrangement of phasing of conductors; (4) corona-free attachment hardware; (5) conductor quality; (6) careful handling and packaging of conductor; (7) construction techniques; and (8) line tension.

In summary, the rule requires that the transmission lines be modeled for the generation of audible noise and that design considerations be incorporated into the lines to reduce audible noise. The methods used to reduce noise and the results of the modeling of audible noise from the San Luis Valley – Calumet and Calumet – Walsenburg transmission line segments of the Project are discussed below.

Q. HAS THE COMMISSION ALSO ADOPTED RULES REGARDING EMF LEVELS AND EXPOSURE?

A. Yes. CPUC rule, 4 CCR § 723-3102(d) pertains to public exposure to electromagnetic fields. The rule requires that for a CPCN application for construction or extension of transmission facilities, the utility must describe its "actions and techniques relating to prudent avoidance with respect to planning, siting, construction, and operation of the proposed construction or extension."

Q. WHAT IS MEANT BY "PRUDENT AVOIDANCE?"

A. The rule defines "prudent avoidance" as "the striking of a reasonable balance between the potential health effects of exposure to magnetic fields and the cost and impacts of mitigation of such exposure, by taking steps to reduce the exposure at reasonable or modest cost." The rule also lists some steps and techniques to reduce exposure to EMF including: (1) design alternatives considering the spatial arrangement of phasing of conductors; (2) routing lines to limit exposures to areas of concentrated population and group facilities such as schools and hospitals; (3) installing higher structures; (4) widening right of way corridors; and (5) burying lines.

III. <u>AUDIBLE NOISE</u>

Q. PLEASE DESCRIBE HOW AUDIBLE NOISE IS GENERATED BY ELECTRIC TRANSMISSION LINES.

A. Audible noise is often created by corona. Corona is the electrical ionization of the air that occurs near the surface of the energized conductor and suspension hardware due to very high electric field strength.

Q. WHAT AFFECTS THE AMOUNT OF CORONA PRODUCED?

A. The amount of corona produced by a transmission line is a function of the voltage of the line, the diameter of the conductors, the locations of the conductors in relation to each other, the elevation of the line above sea level, the condition of the conductors and hardware, and the local weather conditions.

Q. WITH REGARD TO THE FIRST FACTOR YOU IDENTIFIED, PLEASE DISCUSS HOW VOLTAGE AFFECTS THE AMOUNT OF CORONA PRODUCED.

A. Corona typically becomes a design concern for transmission lines at 345 kV and above. The San Luis Valley – Calumet segment of the Project is planned to be constructed and operated as a double circuit 230 kV transmission line. The Calumet – Walsenburg segment is also planned to be constructed and operated at 230 kV but as part of a double circuit transmission line that will include the Stem Beach – Walsenburg 115 kV circuit on the same structures. This double circuit transmission line will be located in a transmission corridor consisting of the existing Comanche – Walsenburg 230 kV single circuit line on the east side of the corridor, the new 230/115 kV double circuit line occupying the center of the corridor, and the existing ARCO – Walsenburg 115 kV single circuit line on the west side of the corridor. Given their intended operating voltages, it is expected that corona noise associated with both of these segments will be less than that which can be expected from a transmission line operated at a higher voltage.

Q. PLEASE DISCUSS HOW THE DIAMETER OF THE CONDUCTOR AFFECTS THE CORONA AND AUDIBLE NOISE.

A. The electric field gradient is greatest at the surface of the conductor, therefore, large-diameter conductors will have lower electric field gradients at the conductor surface and, hence, lower corona than smaller conductors, everything else being equal. The lower corona will produce a lower level of audible noise. The conductors chosen for these two Project segments were selected to have large diameters and thus a reduced potential to create audible noise.

Q. HOW DOES THE LOCATION OF THE CONDUCTORS RELATIVE TO EACH OTHER AFFECT CORONA AND AUDIBLE NOISE?

A. The arrangement of the energized phase conductors in relation to each other affects the voltage difference between the conductors. If conductors of like phase are placed near each other the electric field between the conductors will be reduced. The lower electric field will result in lower corona and audible noise. However, for this application given that the projected audible noise levels will not be high, Tri State is planning to rotate the phases of the double circuit lines to minimize magnetic fields.

Q. PLEASE DESCRIBE HOW THE ELEVATION OF THE TRANSMISSION LINE AFFECTS CORONA AND AUDIBLE NOISE.

A. In general, corona increases at higher elevations where the density of the atmosphere is less than at sea level where the air is more easily broken down near an energized conductor producing corona. Audible noise will vary with elevation with the relationship of A/300 where A is the elevation of the line above sea level measured in meters. For example, audible noise at 600 meters elevation will be twice the audible noise at 300 meters, all other things being equal.

The average elevation of the San Luis Valley – Calumet segment is approximately 7,500 feet. However, given that audible noise has the potential to increase with elevation, Tri-State employed a conservative approach and modeled the audible noise that may be produced along this segment by using an elevation of 9,413 feet (2,869 meters) which is the highest elevation along that segment at the summit of La Veta Pass. The audible noise produced at this elevation will be higher than if the lines were constructed at a lower elevation such as sea level or at other lower points along the segment. The average elevation of the Calumet – Walsenburg segment is approximately 5,600 feet (1,707 meters) and this elevation was used for modeling purposes for that segment.

Q. HOW DOES THE CONDITION OF THE CONDUCTOR AND HARDWARE AFFECT CORONA?

A. Irregularities (such as nicks and scrapes on the conductor surface or sharp edges on suspension hardware) concentrate the electric field at these locations and thus increase the electric field gradient and corona at these spots. Similarly, foreign objects on the conductor surface, such as dust or insects, can cause irregularities on the surface that are a source for corona.

Q. FINALLY, HOW DO LOCAL WEATHER CONDITIONS AFFECT CORONA AND ASSOCIATED AUDIBLE NOISE?

A. Raindrops, snow, fog, hoarfrost, and condensation accumulated on the conductor surface are also sources of surface irregularities that can increase corona. During fair weather, the number of these condensed water droplets or ice crystals is usually small and the corona effect is also small. However, during wet weather, the number of these sources increases (for instance due to rain drops standing on the conductor) and corona effects are therefore temporarily greater. During wet or foul weather conditions, the conductor will produce the greatest amount of corona noise. However, during heavy rain the noise generated by the falling rain drops hitting the ground will typically be greater than the noise generated by corona and thus will mask the audible noise from the transmission line.

Q. WHAT MEASURES CAN BE TAKEN TO REDUCE CORONA?

A. Corona produced on a transmission line can be reduced by the design of the transmission line and the selection of hardware and conductors used for the construction of the line. For instance, the use of conductor hangers that have rounded rather than sharp edges and no protruding bolts with sharp edges will reduce corona. The conductors themselves can be made with larger diameters and handled so that they have smooth surfaces without nicks or burrs or scrapes in the conductor strands.

Q. WHAT MEASURES WILL TRI-STATE EMPLOY TO MITIGATE AUDIBLE NOISE LEVELS?

A. Several methods will be used in the Project to reduce the audible noise from the transmission lines. The transmission lines proposed for these two segments of the Project are designed to reduce corona generation. The materials used in construction of the lines will be a low corona design to eliminate sharp edges and burrs on the metal. The conductors will have a larger diameter than is necessary to carry the anticipated power flows in the lines. In addition, the lines will be routed away from houses so as to lower audible noise at the closest residence.

Q. DID YOU PREPARE ANY ILLUSTRATIONS OF THE AUDIBLE NOISE THAT MAY BE GENERATED BY THE SAN LUIS VALLEY – CALUMET AND THE

CALUMET – WALSENBURG TRANSMISSION LINE SEGMENTS OF THE PROJECT?

A. Yes. CPUC Rule 3102(c) requires that the applicant for a CPCN for a new transmission line model the potential noise levels that the line could produce. The results of the audible noise modeling program I employed are depicted in graphs illustrating the audible noise from each of these two transmission line segments. These graphs and related data are included in my report in Figures 3 and 4 (**Exhibit No. RLP-2**).

Q. WHAT MODEL DID YOU USE FOR PREDICTING THESE NOISE LEVELS?

A. The audible noise from the proposed transmission lines was predicted using EMFWorkstation: ENVIRO (Version 3.52), a Windows-based model developed by the Electric Power Research Institute ("EPRI").

Q. WHAT INPUT INFORMATION DOES THE ENVIRO MODEL REQUIRE?

A. The ENVIRO model requires as input several design characteristics of the line including the location of the phase conductors and ground wires, their voltage relative to ground potential, the geometry of the conductor bundles for each phase, the diameter of the conductors, and the elevation of the line above sea level.

Q. PLEASE DISCUSS THE ACCURACY OF THE ENVIRO MODEL.

A. Because the equations that predict audible noise were created from empirical measurements, the accuracy of the model is as good as the measurements that produced the original equations. In addition, the model is as good as the accuracy of the parameters input to the model (e.g., the actual elevation of the transmission line at a particular location rather than the average elevation of the entire project of 5000 feet). Therefore given these potential uncertainties, the resulting field plots are within a few percent of the true value for the conditions modeled.

Q. WHAT ARE THE PROJECTED NOISE LEVELS ASSOCIATED WITH THE SAN LUIS VALLEY – CALUMET SEGMENT OF THE PROJECT?

A. The expected noise levels produced by the proposed San Luis Valley – Calumet transmission lines are depicted in my report in Figure 3 (**Exhibit No. RLP-2**). Figure 3 shows two conditions, fair and rain. This is to show the range in corona effects due to changing weather. The center vertical line represents the transmission line. The vertical dotted lines show the edges of the right of way. The blue solid curved line shows the audible noise during wet weather, and the red dotted curved line shows the audible noise during fair weather. The numbers up the center of the graph indicate the noise level measured in dBA, and the numbers across the bottom of the graph indicate the distance from the transmission line measured in feet.

Audible noise plots were created for a double circuit, 230 kV transmission line using 1272 ACSR "Bittern" conductors having a diameter of 1.345 inches and located on a 150 foot wide right-of-way.

The highest audible noise expected from the San Luis Valley – Calumet transmission lines at the edge of the right-of-way at the summit of La Veta Pass will range from 25.5 dBA in fair weather to 50.5 dBA in wet weather. The maximum noise levels are predicted to occur near the center of the right-of-way and will range from 29.3 dBA in fair weather to 54.3 dBA in wet weather. Audible noise produced at other locations along this segment at lower elevations will be lower, as will be the audible noise at locations further from the edge of the right-of-way.

Q. WHAT ARE THE PROJECTED NOISE LEVELS ASSOCIATED WITH THE CALUMET – WALSENBURG SEGMENT OF THE PROJECT?

A. Unlike the proposed San Luis Valley – Calumet segment which will be a "stand-alone" double circuit transmission line within the corridor, the Calumet – Walsenburg segment will be located in the same right-of-way as two existing transmission lines. Therefore, it is appropriate to model the projected noise levels for all of the lines within the entire Calumet – Walsenburg transmission corridor rather than looking solely at the new double circuit 230/115 kV transmission line that will be constructed as part of the Project.

The expected noise levels produced by the proposed Calumet – Walsenburg transmission corridor are depicted in my report in Figure 4 (**Exhibit No. RLP-2**). As with Figure 3, Figure 4 shows two conditions, fair and rain. This figure, however, also shows the location of the three transmission lines relative to each other and their positions within the overall 350 foot wide corridor as oriented when viewed looking south from the Calumet Substation.

Audible noise plots were created for the transmission corridor including the following transmission lines:

- a new double circuit, 230/115 kV transmission line using 1272 ACSR "Bittern" conductors having a diameter of 1.345 inches for both circuits;
- the existing Comanche – Walsenburg 230 kV single circuit transmission line with 1272 ACSR "Bittern" conductors having a diameter of 1.345 inches; and

- the existing ARCO – Walsenburg 115 kV single circuit transmission line with 477 ACSR "Hawk" conductors having a diameter of 0.858 inches.

The highest audible noise expected from the Calumet –Walsenburg transmission lines at the eastern edge of the corridor will range from 19.5 dBA in fair weather to 44.5 dBA in wet weather. The highest audible noise expected from the Calumet –Walsenburg transmission lines at the western edge of the corridor will range from 15.9 dBA in fair weather to 40.9 dBA in wet weather. The maximum noise levels are predicted to occur near the existing Comanche – Walsenburg 230 kV transmission line and will range from 24.4 dBA in fair weather to 49.4 dBA in wet weather.

Q. IS THERE A WAY TO COMPARE THE AUDIBLE NOISE LEVELS FROM THE MODELING WITH COMMON NOISES?

A. Yes. The EPRI "AC Transmission Line Reference Book—200 kV and Above," Third Edition Technical Report, provides a reference list indicating common noise levels for certain environmental conditions and the corresponding dBA levels:

140	Threshold of pain
130	Pneumatic chipper
120	Loud automobile horn (at 1 m)
100	Inside (New York) subway train
90	Inside motor bus
80	Average traffic on street corner
70	Conversational speech
60	Typical business office
50	Living room suburban area

40	Library
30	Bedroom at night
20	Broadcasting studio
10	Threshold of hearing

Q. HOW DO THE PROJECTED NOISE LEVELS FROM THE SAN LUIS VALLEY – CALUMET AND THE CALUMET – WALSENBURG TRANSMISSION LINE SEGMENTS COMPARE WITH THESE COMMON NOISE LEVELS?

A. As indicated in the table, the sound level of 50 dBA is comparable to the noise level of a typical living room. This level of sound will only occur along the San Luis Valley – Calumet segment at the edge of the right-of-way at the top of La Veta Pass and only during wet weather conditions. Similarly, the noise level along the Calumet – Walsenburg transmission corridor will be near but less than this level only during wet weather conditions. It should be noted that these noise levels are predicted to occur only when the weather conditions are such that a person in a nearby home will likely have their windows closed to keep out the moisture and thus will have the benefit of the sound absorption by the walls and closed windows of the house.

In fair weather, when a person may have their windows open, the sound levels at the edge of the right-of-way for both segments will range from 15.9 dBA (western edge of corridor along Calumet – Walsenburg segment) to 25.5 dBA (edge of right-of-way for San Luis Valley – Calumet segment) – all comparable to the level of noise in a bedroom at night or inside a broadcasting studio.

The audible noise produced by the lines will be at a level noticeable at the edge of the right-of-way in both fair and rain conditions. However at further distances where the closest houses will be located, the noise from the lines will be unnoticeable. At these distances, the sound levels will be much reduced and in most cases unobservable.

Q. ARE THERE OTHER SIMILAR CASES THAT TRI-STATE USED AS A GUIDE REGARDING ACCEPTABLE LEVELS OF AUDIBLE NOISE?

A. Yes. In connection with Public Service's Midway to Daniels Park transmission line, the CPUC determined that a noise level at the edge of the right-of-way of 55 dBA was reasonable for that project. It should be noted that, unlike this Project, Public Service's Midway to Daniels Park transmission line has some residences located very close to the edge of the right-of- way. (Docket No. 05A-072E, Decision No. C06-1101, dated August 29, 2006) More recently, in connection with Public Service's Pawnee – Smoky Hill transmission line project, the CPUC issued reasonableness determinations for audible noise levels ranging from 47.4 dB(A) to 51.5 dB(A). It should be noted that these noise levels were found to be reasonable at a point 25 feet from the edge of the right-of-way. By comparison, the predicted noise levels for the San Luis Valley – Calumet and the Calumet – Walsenburg transmission line segments at the edge of the right-of-way in fair weather will be substantially less than these levels and will be comparable to these levels only during wet conditions. If measured 25 feet from the edge of the right-of-way, even the wet condition noise levels will be less than those found to be reasonable in the Pawnee – Smoky Hill project.

The audible noise produced by the San Luis Valley – Calumet and the Calumet – Walsenburg transmission lines will be well within the same reasonableness standards previously adopted by the CPUC for these other Public Service transmission line projects.

Q. HOW CAN THE COMMISSION DETERMINE WHETHER THE PROJECTED NOISE LEVELS FOR THIS PROJECT ARE REASONABLE?

A. The Colorado General Assembly has established a set of acceptable noise levels for various zones for uses other than power transmission lines (*see* C.R.S, §25-12-103 (1)). Although the CPUC is authorized to determine "whether projected noise levels for electric transmission facilities are reasonable" (*see* C.R.S. § 25-12-103(12)), the noise levels provided in the statute are useful as a frame of reference:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 dBA	50 dBA
Commercial	60 dBA	55 dBA
Light industrial	70 dBA	65 dBA
Industrial	80 dBA	75 dBA

Even though these noise levels do not legally apply to the Project, the transmission line design proposed for the San Luis Valley – Calumet and the Calumet – Walsenburg transmission line segments complies with the statute at the locations of all residences along the route. At the edge of the right-of-way for both segments, the night time residential audible noise level will be met even during a rain storm. (The wet weather noise level at the edge of the San Luis Valley – Calumet right-of-way could exceed this level by 0.5 dBA at the elevation of the top of La Veta Pass.) Furthermore, since no houses can be located within the right of way, no residences will be subjected to noise levels that violate the statute.

IV. ELECTRIC AND MAGNETIC FIELDS (EMF)

Q. WHAT IS EMF?

A. EMF is a term that refers to electric and magnetic fields. Electric transmission lines produce EMF when they are in operation. These fields are caused by different aspects of the operation of a transmission line and can be evaluated separately.

Q. WHAT CAUSES EMF?

A. Electric fields are produced whenever a conductor is connected to a source of electrical voltage. An example of this is the plugging of a lamp into a wall outlet in a home. When the lamp is plugged in, a voltage is induced in the cord to the lamp which causes an electric field to be created around the cord. Magnetic fields are produced whenever an electrical current flows in a conductor. In the lamp example, if the lamp is turned on allowing electricity to flow to the lamp, a magnetic field is created around the lamp cord in addition to the electric field.

Q. WHAT ARE THE CONCERNS RELATED TO EMF?

A. Some concern has been expressed in the past about adverse health effects resulting from people being exposed to various levels of EMF. Many thousands of studies have been conducted around the world investigating this subject. No study or series of studies have demonstrated a biological mechanism to link human exposure to EMF at the levels occurring with the San Luis Valley – Calumet and the Calumet – Walsenburg transmission line segments and the occurrence of any disease. Therefore, it is not likely that anyone living near these lines will have any sort of an adverse health effect.

Q. WHAT MEASURES HAVE BEEN EMPLOYED BY TRI-STATE TO MEET THE PRUDENT AVOIDANCE REQUIREMENTS OF COMMISSION RULE 3102(d)?

A. The siting, design and construction of the San Luis Valley – Calumet and the Calumet – Walsenburg transmission lines will employ various prudent avoidance steps and techniques suggested in Rule 3102(d). For example, the transmission lines will be routed away from populated areas as well as schools and hospitals so as to minimize EMF exposure. Conductor phasing can also be adjusted so as to reduce the magnetic fields. Specific prudent avoidance measures related to siting are discussed in the testimony of Tri-State witness Mark Murray and those related to design and construction are discussed in the testimony of Tri-State witness Stephen Mundorff.

Q. HOW DID YOU DETERMINE THE PROJECTED MAGNETIC FIELD LEVELS ASSOCIATED WITH THE SAN LUIS VALLEY – CALUMET AND THE CALUMET – WALSENBURG TRANSMISSION LINES?

A. To determine these levels, detailed information was received from Tri State on the proposed design of each of these lines, which included projected electrical power flows, operating voltage, tower configuration, conductor size and type, the height and horizontal location of each conductor, conductor sag, and conductor phasing. The modeling was conducted with three cases of power flows: Case #1 with no generation injection into the line, Case #2 with 2,000 megawatts (MW) of total injection (1,000 MW to the San Luis Valley, and 1,000 MW to Calumet), and Case #3 with current flowing at the full thermal limit capacity of the conductors.

Table A-1 of Appendix A in my report (**Exhibit No. RLP-2**) shows the power flows for each circuit in Cases #1, #2, and #3, and the conductor size and type and operating voltage used for each circuit in the two locations modeled. Table A-2 of Appendix A presents the height and horizontal location of each conductor, conductor sag, and conductor phasing.

The new San Luis Valley to Calumet 230 kV double circuit line was modeled with a single steel pole structure. I understand that a lattice steel structure is being considered as well for certain portions of the line. While I did not model this circuit using a lattice steel structure, the slight differences in configuration should not significantly alter the modeling results. The Calumet to Walsenburg Transmission Corridor was modeled assuming that: the existing Comanche to Walsenburg 230 kV single circuit line would be located on the east side of the corridor with an H-frame structure; the new double circuit 230/115 kV transmission line would occupy the center of the corridor using a single steel pole structure and with the new Calumet to Walsenburg 230 kV circuit on the east side of the structure and the rebuilt Stem Beach to Walsenburg 115 kV circuit on the west side of the structure; and the existing ARCO to Walsenburg 115 kV single circuit line would be located on the west side of the corridor on an H-frame structure.

Q. WHAT MODEL DID YOU USE?

A. The model used was the EMFWorkstation: ENVIRO (Version 3.52), a new Windows-based model developed by the Electric Power Research Institute (EPRI). It is a program that accurately predicts the electric and magnetic fields produced by linear transmission lines such as the Project. The data I received was input into the ENVIRO program which produced the lateral profiles of the electric and magnetic fields. The program calculated the profiles at mid-span, the lowest point of conductor sag between structures. For the two locations modeled, a span length of 800 feet was used; therefore, mid-span occurred at approximately 400 feet from each structure. The accuracy of the modeling is dependent on the accuracy of the input data (i.e., if the average phase current is higher than what was modeled, so will be the resulting magnetic fields). As a result, the resulting field plots are within a few percent of the true value for the conditions modeled.

Q. DID YOU PREPARE ANY ILLUSTRATIONS OF THE MAGNETIC FIELDS GENERATED BY THE SAN LUIS VALLEY – CALUMET AND THE CALUMET – WALSENBURG TRANSMISSION LINES?

A. Yes. Each of these two Project segments have been modeled for their resulting magnetic fields. The results of such modeling are depicted in graphs illustrating the magnetic fields for the San Luis Valley – Calumet transmission lines and for the Calumet – Walsenburg Transmission Corridor. These graphs and related data are included in my report in Figures 1 and 2 (**Exhibit No. RLP-2**).

Q. PLEASE DESCRIBE THE COMPONENTS OF THE GRAPHS IN YOUR REPORT.

A. The center vertical line represents the transmission line. The vertical dotted lines show the edges of the right-of-way. On the magnetic field graphs: the blue dotted line represents Case #1 which depicts magnetic fields associated with no generation injection; the red line represents Case #2 which depicts magnetic fields associated with 2,000 megawatts (MW) of total injection (1,000 MW to the

San Luis Valley, and 1,000 MW to Calumet); and the blue solid line represents Case #3 which depicts magnetic fields associated with operation at the full thermal limit capacity of the conductors. The numbers up the center of the graphs indicate the level of magnetic field and the numbers across the bottom of the graphs indicate the distance from the transmission line.

Q. WHAT ARE THE PROJECTED MAGNETIC FIELD LEVELS ASSOCIATED WITH THE SAN LUIS VALLEY – CALUMET TRANSMISSION LINES?

A. The expected magnetic field plots for the three cases studied in connection with the San Luis Valley – Calumet double circuit 230 kV transmission lines are depicted in my report in Figure 1 (**Exhibit No. RLP-2**). The results of the magnetic field modeling plotted in Figure 1 show that on both the right and left right-of-way edge the magnetic field is 1.8 mG for Case #1, 11.0 mG for Case #2, and 30.8 mG for Case #3. The maximum magnetic field within the right-of-way, occurring at the approximate centerline of the right-of-way, is 17.6 mG for Case #1, 107.5 mG for Case #2, and 300.6 mG for Case #3.

In each case, the conductor phasing in the proposed structure configuration has been rotated as shown in Table A-2 of Appendix A (**Exhibit No. RLP-2**) to reduce the magnetic fields.

The magnetic field levels that will be produced by these transmission lines will diminish rapidly with distance from the line. At the edge of the 150 foot wide right of way (75 feet on either side of the centerline), the EMF levels will be at or less than levels that are typically seen in homes. Further out, the EMF levels will be too low to be measured.

Q. WHAT ARE THE PROJECTED MAGNETIC FIELD LEVELS ASSOCIATED WITH THE CALUMET – WALSENBURG TRANSMISSION CORRIDOR?

A. The expected magnetic field plots for the three cases studied in connection with the Calumet – Walsenburg Transmission Corridor are depicted in my report in Figure 2 (**Exhibit No. RLP-2**). The results of the magnetic field modeling plotted in Figure 2 show that on the eastern edge of the corridor the magnetic field is 9.9 mG for Case #1, 17.5 mG for Case #2, and 59.1 mG for Case #3. At the western edge of the corridor, the magnetic field will be 4.4 mG for Case #1, 7.3 mG for Case #2, and 35.1 mG for Case #3. The maximum magnetic field within the corridor for Case #1 is 65.0 mG, 115.1 mG for Case #2, and 384.2 for Case #3. Because there are several lines in this corridor, representative structure drawings are included in the figure to show the locations of the structures relative to the projected magnetic field levels within the corridor.

Q. HOW DO THE PROJECTED EMF LEVELS ON THESE TWO TRANSMISSION SEGMENTS COMPARE WITH LEVELS CONSIDERED REASONABLE IN OTHER CASES?

A. In its decision concerning Public Service's Midway to Daniels Park transmission line, the CPUC determined that a magnetic field level of 150 mG for the project was reasonable. Also, in its decision in connection with the Pawnee – Smoky Hill transmission project, the CPUC approved magnetic field levels ranging from 22.71 mG to 34.58 mG. In all three cases modeled for the San Luis Valley – Calumet transmission line, the predicted magnetic field levels at the edge of the right-of-way are less than those the CPUC found reasonable for the Pawnee – Smoky Hill project. Similarly, in all but one instance, the predicted magnetic field levels at the edges of the transmission corridor along the Calumet – Walsenburg segment will be less than those the CPUC found reasonable for the Pawnee – Smoky Hill project. It should be noted that the one instance that exceeds the previously approved levels (i.e., Case #3 depicting operation at the full thermal limit of the conductors) represents a system operating condition that is unlikely to occur and even then the previously approved levels are exceed by more than 1 mG only on one side of the corridor.

As shown in the plots, under almost all operating conditions, the transmission line designs used for these two Project segments, even at the highest possible power carrying level, will be much lower at the edges of the right-of-way and at the edges of the transmission corridor than the 150 mG level determined previously to be reasonable in the Midway – Daniels Park project.

Q. HOW DOES THIS EMF LEVEL COMPARE TO WHAT OTHER JURISDICTIONS HAVE FOUND TO BE REASONABLE?

A. Florida and New York have set maximum exposure standards for magnetic fields at the edge of the right of way for similar transmission lines in those states. All of the alternatives in the San Luis Valley – Calumet and Calumet – Walsenburg segments of the Project will generate magnetic fields that are lower than allowed for similar transmission lines in both Florida (150 mG) and New York (200 mG).

V. RECOMMENDATION

Q. WHAT IS YOUR CONCLUSION CONCERNING THE REASONABLENESS OF THE AUDIBLE NOISE LEVELS AND MAGNETIC FIELD EXPOSURE LEVELS ASSOCIATED WITH THE SAN LUIS VALLEY – CALUMET AND THE CALUMET – WALSENBURG TRANSMISSION LINES?

A. In my opinion, the transmission line designs proposed by Tri-State and Public Service for these two Project segments are reasonable. The EMF and audible noise effects from the transmission lines on nearby houses fully comply with the rules and guidelines set out in 4 CCR § 723-3102(c & d). The transmission line designs employ a number of the mitigation steps and techniques suggested in the rules. In addition, the modeling performed for these segments used a model required in these regulations that indicates that the line design will create noise and EMF levels that are less than other line designs approved by the CPUC in prior cases and by public utility commissions in other states.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

EXHIBIT RLP-1

CURRICULUM VITAE OF ROBERT L. PEARSON, Ph.D., P.E.

Education

Ph.D., Remote Sensing of Natural Resources, Colorado State University, 1973.
M.S., Remote Sensing of Natural Resources, Colorado State University, 1971.
Professional Geophysical Engineer, Colorado School of Mines, 1968.

Professional Registrations/Certifications

Qualified Environmental Professional, Institute of Professional Practice (Air and Waste Management Association)
Registered Professional Engineer in Colorado (12582)

Experience

Vice President and Principal Technologist, CH2M HILL, Denver, CO, 2000 to Present
Project Manager, Radian International, LLC, Denver, CO, 1994-2000.
Senior Staff Scientist, Radian Corporation, Denver, CO, 1992-1994.
Administrator, Environmental Affairs, Public Service Company of Colorado, Denver, CO, 1979-1992.
Senior Environmental Engineer, Public Service Company of Colorado, Denver, CO, 1973-1979.
Project Geophysicist, Chevron Oil Company, Geophysical Division, Los Angeles, CA and Houston, TX, 1968-1969.

Fields of Experience

Dr. Pearson is currently a Vice President and Principal Technologist in the Southwest Region Denver operations staff of CH2M HILL with responsibility for developing programs to respond to clients in all areas of environmental services with a particular emphasis to clients in the electric utility industry. Previously, he was a Project Manager and Senior Staff Scientist on the Denver technical staff of Radian International LLC responsible for the technical conduct of research and analysis projects for these clients. He has over 33 years of experience in environmental and technical engineering, regulatory review and assessment, preparation of industrial compliance policy, and environmental consulting. He has proven ability to work with clients to assess regulatory programs, define needs, and develop programs to satisfy those needs. His program administrative experience includes projects in health effects of electric and magnetic fields, air pollution control and assessment, water quality control, environmental permitting, and environmental research and development. Prior to joining Radian, Dr. Pearson was a nationally recognized expert concerning environmental issues in the electric utility industry. He was also a state water quality regulatory commissioner and commission chairman appointed by the Governor of Colorado, as well as a member and chairman of a water quality operator certification board, also governor appointed.

Electric and Magnetic Field Health Effects

- Managed utility company participation in two state of the art epidemiological research studies on the relationship between electric power lines and the occurrence of childhood cancer. These studies were done in Denver by Wertheimer and Leeper in 1978 and Savitz et al. in 1985. Much of the data required for the studies were provided from company data files and the overall design and execution of both studies was critiqued for its correctness and appropriateness.

- Provided electromagnetic field (EMF) analysis and testimony for a 115 kV underground electric transmission project In Denver which had been stalled by community opposition. As a result, the concerns of the citizens were allayed and the project was allowed to be constructed and placed into operation on schedule.

- Provided EMF analysis and expert testimony to governmental bodies for an overhead electric transmission project being relocated due to construction of the new Denver International Airport. The EMF concerns raised by the governmental bodies were reduced to a level allowing them to approve the project to be built on schedule.

- Chaired the EMF Health Studies Task Force of the Electric Power Research Institute. This industry advisory committee directs the EMF health studies research program of the Institute which is the largest such basic EMF research program in the world.

- Served as Vice Chairman of the Electric and Magnetic Fields Task Force of the Edison Electric Institute. This trade association industry committee of the investor-owned electric utilities in the United States provided policy preparation and issue management for this largest sector of the American electric utility industry.

- Participated in the organization and conduct of annual EMF scientific meetings for the Electric Power Research Institute (EPRI). These annual meetings are the principle informational meetings for representatives of the electric utility industry.

- Provided analysis and expert opinion on the EMF effects of a proposed Regional Transportation District light rail transportation system. This system, which is electrically powered, runs through several residential neighborhoods as well as commercial and industrial districts in the Denver area.

Robert L. Pearson

- Analyzed and provided expert opinion on a proposed university high energy physics facility. This facility proposed to be constructed on the campus of the University of California at Los Angeles (UCLA), will house state of the art high energy particle accelerators. The analysis provided information regarding the exposure to the surrounding neighborhood of magnetic fields from the facility as well as within the facility laboratories.

- Analyzed and provided expert opinion on a proposed electric cogeneration facility. This facility, also to be constructed on the campus of the UCLA, will provide electric power to the University. The analysis provided information regarding the potential interference with adjoining telephone switching equipment, as well as exposure to workers in nearby offices.

- Served as co-principal investigator and Project Manager of a study to investigate the "wire code paradox", sponsored by the Electric Power Research Institute. The apparent paradox was revealed when earlier EMF epidemiological studies done in Denver and elsewhere demonstrated a relationship between a surrogate measure of magnetic fields exposure, the wire code, and the occurrence of childhood cancer. Actual measures of magnetic fields showed no such relationship. The study investigated the nature of the wire code paradox and to determine if the wire code is related to other parameters of the neighborhood such as its layout or of the house such as its age where the child lived. Several papers on the design and status of this project were presented to the Annual DOE/EPRI Contractor's Review Meetings and Annual Meetings of the Bioelectromagnetics Society.

- Served as co-principal investigator and Project Manager of a study to investigate the feasibility of conducting an epidemiological investigation of children living in very high current configuration residences, sponsored by the Electric Power Research Institute. This study is exploring the feasibility of identifying children who live near larger power lines who could be surveyed for their incidence of contracting various forms of cancer including leukemia.

- Serving as co-principal investigator and Project Manager of a study to further investigate the earlier observation that children who live near high traffic streets have a significantly elevated risk of cancer. This study is looking at a distance weighted traffic density metric of exposure as a risk factor for cancer and leukemia. The study will then use standard EPA air pollution models to transform the traffic density metric to an estimate of exposure to volatile organic compounds emitted by motor vehicles and test them as a cancer risk.

- Served as Project Director of an assessment of the magnetic fields to be generated by the proposed high speed electric rail system to be built in Texas. This project determined the background levels of magnetic fields and the field levels which will be generated by the transit system when it is placed into service. Areas which will be exposed to an elevated magnetic field as a result of the operation of the transit system were determined. These magnetic field levels were then screened to determine if existing occupational or environmental guidelines or standards will be exceeded and if so what health implications there may be given the current scientific knowledge on the subject. As a portion of this project, measurements were made of the magnetic fields produced by the Spanish high speed rail train, the AVE, which operates between Madrid and Seville. This rail system is identical to the system proposed to be constructed in Texas. Measurements were made both on the train as well as along side the tracks and at a power substation which supplies electricity for the AVE rail system.

- Conducted two surveys of magnetic fields produced by 25 kV distribution power lines for an electric utility in Granada, Spain. The utility had received two requests to relocate two primary voltage distribution power lines, one from the local government and one from a group of concerned neighbors. Measurements were made of the magnetic fields produced by each of these lines which demonstrated the magnetic fields to be very low. Reports were produced for the utility for presentation to the city government and the group of concerned neighbors.

- Representing two electric utilities in Colorado at public meetings on the construction of new 115 and 230 kV electric transmission lines to be built to serve eight separate areas in Colorado and New Mexico. Presented information on the expected magnetic field levels to be produced by the transmission lines and the broader issue of the status of scientific knowledge on human health effects of electric and magnetic fields. That information was specifically requested by the public to be presented by a recognized expert in the field other than an employee of the utilities.

- Modeled the magnetic fields in the transmission switchyard and in an underground power transmission cable at the Protrero Power plant in California. The project is to add a seventh unit to the power plant. The California Energy Commission requested that the modeling be done as part of the environmental impact analysis for the plant.

- Served as Principle Investigator of an EMF research project on the Denver area for the Electric Power Research Institute. The project measured the voltages induced in grounded water pipes and electric neutrals along with magnetic fields in the homes and wire codes from nearby power lines in 191 homes selected from the Denver metropolitan area.

- Testified as an expert EMF witness for Tri State Generation and Transmission in the Eighth District Court in Raton, New Mexico, January 2006. The issue was a condemnation proceeding: Tri-State Generation and Transmission Association, Inc. v.

Faver, King, Sierra Grande, and Spanish Trail Ranches, [consolidated] and the damages to the ranches from the construction and operation of the new power line. .

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Wachtel, H., and R.L. Pearson. "An Approach to Unraveling the Wire Code Paradox." Presented at The Annual Review of Research on Biological Effects of Electric and Magnetic Fields From the Generation, Delivery and Use of Electricity; Savannah, Georgia; November 1993.

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H. Wachtel and R. Pearson. Interactions of traffic density and wire codes as cancer risk factors—a comparison of results in Los Angeles with those in Denver. Presented to the Annual Meeting of the Bioelectromagnetics Society; Munich, Germany; June 2000.

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SAN LUIS VALLEY-CALUMET-COMANCHE PROJECT

Introduction

The Tri State Generation and Transmission Association, Inc. (Tri State) in partnership with Xcel Energy (Xcel) are building a new set of electric transmission lines to connect the San Luis Valley of South Central Colorado to the Colorado Front Range. The project is called the San Luis Valley-Calumet-Comanche Project.

Three segments of lines will be built. The first lines will run from the San Luis Valley Substation north of Alamosa east over La Veta pass to a new Calumet Substation to be built north of Walsenburg. The Calumet Substation will then be connected by Tri State to the existing Walsenburg Substation. The Calumet Substation will also be connected by Xcel Energy to the Comanche Substation at the Comanche Power Plant near Pueblo.

This report describes the modeling of magnetic fields and audible noise produced from corona for the two segments from San Luis Valley to Calumet and from Calumet to Walsenburg. Xcel will model and report on the magnetic fields and audible noise for the Calumet to Comanche 345 kilovolts (kV) double circuit line segment of the project.

Magnetic Fields from San Luis Valley-Calumet-Comanche Project

Electric transmission lines produce EMF when they are in operation. EMF is a term that refers to electric and magnetic fields. These fields are caused by different aspects of the operation of a transmission line and can be evaluated separately. Magnetic fields are evaluated in this report.

Magnetic fields are produced whenever an electrical current flows in a conductor. An example of this is the plugging of a lamp into a wall outlet in a home. When the lamp is plugged in and turned on allowing electricity to flow to the lamp, a magnetic field is created around the lamp cord.

Modeling Methodology

The transmission lines of the San Luis Valley-Calumet-Comanche Project were modeled for their resulting magnetic fields using EMF Workstation: ENVIRO (Version 3.52), a Windows-based model developed by the Electric Power Research Institute (EPRI). It is a program that accurately predicts the magnetic fields produced by linear transmission lines such as those in the San Luis Valley-Calumet-Comanche project.

Two locations were modeled: the new San Luis Valley to Calumet 230 kV double circuit line, and the Calumet to Walsenburg Transmission Corridor, which consists of the existing Comanche to Walsenburg 230 kV single circuit line on the east side of the corridor, the new double circuit line occupying the center of the corridor with the Calumet to Walsenburg 230 kV circuit on the east side of the structure and the Stem Beach to Walsenburg 115 kV circuit on the west side of the structure, and the existing ARCO to Walsenburg 115 kV single circuit line on the west side of the corridor.

To perform this modeling, detailed information was received from Tri State on the design of each of these lines, which included projected electrical power flows, operating voltage, tower configuration, conductor size and type, the height and horizontal location of each conductor, conductor sag, and conductor phasing. The modeling was conducted with three cases of power flows: Case #1 with no generation injection, Case #2 with 2,000 megawatts (MW) of total injection (1,000 MW to the San Luis Valley, and 1,000 MW to Calumet), and Case #3 with full thermal limit capacity of the conductors. Table A-1 of Appendix A shows the power flows for each circuit in Cases #1, #2, and #3, and the conductor size and type and operating voltage used for each circuit in the two locations modeled. Table A-2 of Appendix A presents the height and horizontal location of each conductor, conductor sag, and conductor phasing.

The new San Luis Valley to Calumet 230 kV double circuit line was modeled with a single steel pole structure; however a lattice steel structure is being considered as well. The slight differences in configuration should not significantly alter the modeling results. For the Calumet to Walsenburg Transmission Corridor, the existing Comanche to Walsenburg 230 kV single circuit line on the east side of the corridor was modeled with an H-frame structure, the new double circuit line occupying the center of the corridor with the Calumet to Walsenburg 230 kV circuit on the east side of the structure and the Stem Beach to Walsenburg 115 kV circuit on the west side of the structure was modeled with a single steel pole structure, and the existing ARCO to Walsenburg 115 kV single circuit line on the west side of the corridor was modeled with an H-frame structure.

These data were input into the ENVIRO program which produced the lateral profiles of the electric and magnetic fields. These profiles were then plotted to produce the graphs that are presented below. The program calculated the profiles at mid-span, the lowest point of conductor sag. For the two locations modeled a span length of 800 feet was used, therefore mid-span occurred at approximately 400 feet. The accuracy of the modeling is dependent on the accuracy of the input data (i.e., if the average phase current is higher than what was modeled, so will the resulting magnetic fields). The resulting field plots are within a few percent of the true value for the conditions modeled.

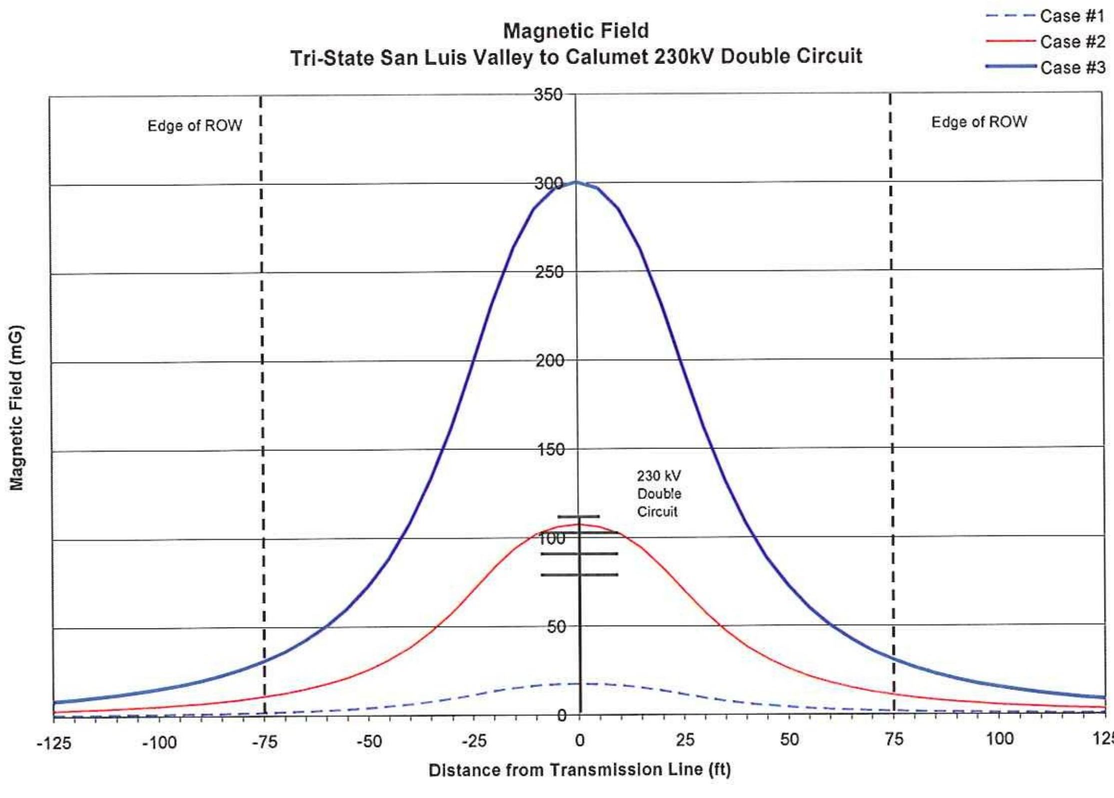
Modeling Results

The magnetic field plots for Case #1, Case #2, and Case #3 for the new San Luis Valley to Calumet 230 kV double circuit line are presented in Figure 1.

The magnetic field plots for Case #1, Case #2, and Case #3 for the Calumet to Walsenburg Transmission Corridor are presented in Figure 2.

San Luis Valley to Calumet

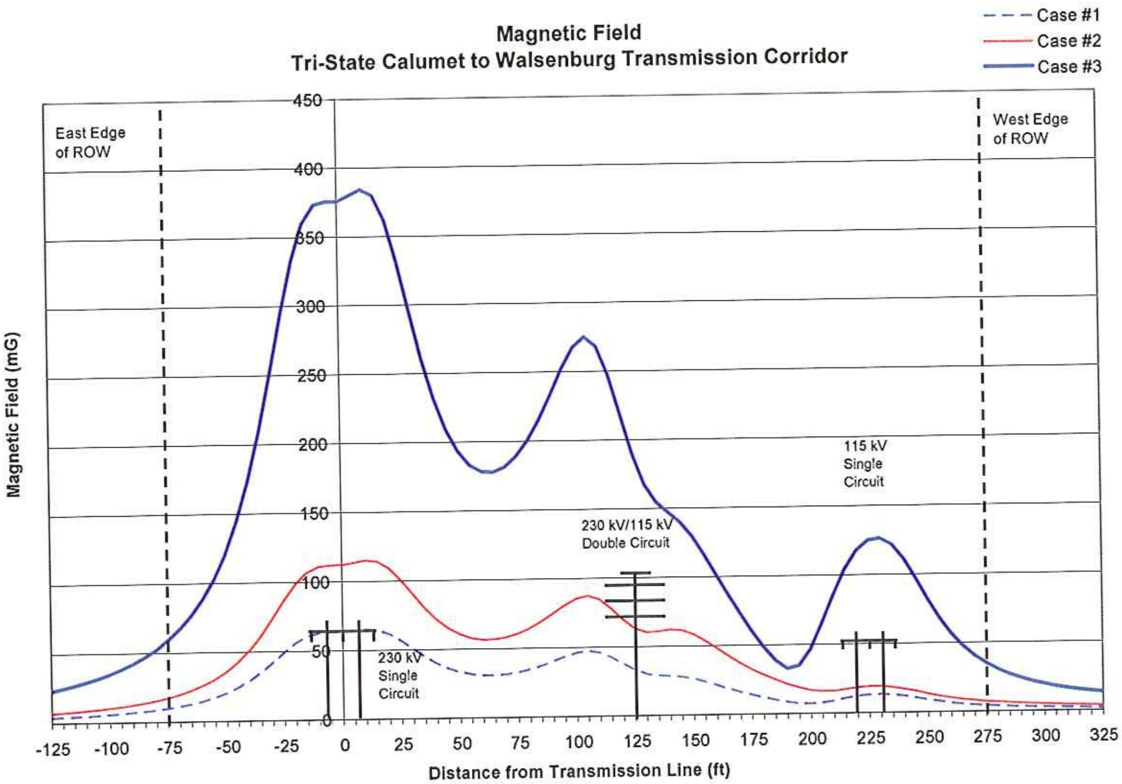
Figure 1, Magnetic field plot for Case #1, Case #2, and Case #3 for San Luis Valley to Calumet 230 kV double circuit line. The conductor phasing on this structure configuration have been rotated as shown in Table A-2 of Appendix A to reduce the magnetic fields.



The results of the magnetic field modeling plotted in Figure 1 show that on both the right and left ROW edge the magnetic field is 1.8 mG for Case #1, 11.0 mG for Case #2, and 30.8 mG for Case #3. The maximum magnetic field within the ROW is 17.6 mG for Case #1, 107.5 mG for Case #2, and 300.6 mG for Case #3.

Calumet to Walsenburg Transmission Corridor

Figure 2, Magnetic field plot for Case #1, Case #2, and Case #3 for the Calumet to Walsenburg Transmission Corridor. The corridor is depicted looking south from the Calumet Substation.



The results of the magnetic field modeling plotted in Figure 2 show that on the east ROW edge the magnetic field is 9.9 mG for Case #1, 17.5 mG for Case #2, and 59.1 mG for Case #3. On the west ROW edge the magnetic field 4.4 mG for Case #1, 7.3 mG for Case #2, and 35.1 mG for Case #3. The maximum magnetic field within the ROW for Case #1 is 65.0 mG, 115.1 mG for Case #2, and 384.2 for Case #3. Because there are several lines in this corridor, representative structure drawings are included in the figure to show the locations of the structures.

Corona Audible Noise from San Luis Valley-Calumet-Comanche Project

Corona is the electrical ionization of the air that occurs near the surface of the energized conductor and suspension hardware due to very high electric field strength. Corona may result in audible noise being produced by the transmission lines.

The amount of corona produced by a transmission line is a function of the voltage of the line, the diameter of the conductors, the locations of the conductors in relation to each other, the elevation of the line above sea level, the condition of the conductors and hardware, and the local weather conditions. Power flow does not affect the amount of corona produced by a transmission line therefore only one set of corona results is predicted for each modeled location: the new San Luis Valley to Calumet 230 kV double circuit line, and the Calumet to Walsenburg Transmission Corridor. Corona typically becomes a design concern for transmission lines at 345 kV and above and is less noticeable from lines like these that are operated at lower voltages.

The electric field gradient is greatest at the surface of the conductor. Large-diameter conductors have lower electric field gradients at the conductor surface and, hence, lower corona than smaller conductors, everything else being equal. The conductors chosen for the SLV to Calumet line were selected to have large diameters and thus a reduced potential to create audible noise.

Irregularities (such as nicks and scrapes on the conductor surface or sharp edges on suspension hardware) concentrate the electric field at these locations and thus increase the electric field gradient and the resulting corona at these spots. Similarly, foreign objects on the conductor surface, such as dust or insects, can cause irregularities on the surface that are a source for corona.

Corona also increases at higher elevations where the density of the atmosphere is less than at sea level. Audible noise will vary with elevation with the relationship of A/300 where A is the elevation of the line above sea level measured in meters (EPRI 2005). Audible noise at 600 meters elevation will be twice the audible noise at 300 meters, all other things being equal. The new San Luis Valley to Calumet 230 kV double circuit line was modeled with an elevation of 9,413 feet (2869 meters), the highest elevation of La Veta Pass. The Calumet to Walsenburg Transmission Corridor was modeled with an elevation of 5,600 feet (1707 meters), which is approximately the average elevation along the corridor.

Raindrops, snow, fog, hoarfrost, and condensation accumulated on the conductor surface are also sources of surface irregularities that can increase corona. During fair weather, the number of these condensed water droplets or ice crystals is usually small and the corona effect is also small. However, during wet weather, the number of these sources increases (for instance due to rain drops standing on the conductor) and corona effects are therefore greater. During wet or foul weather conditions, the conductor will produce the greatest amount of corona noise. However, during heavy rain the noise generated by the falling rain drops hitting the ground will typically be greater than the noise generated by corona and thus will mask the audible noise from the transmission line.

Corona produced on a transmission line can be reduced by the design of the transmission line and the selection of hardware and conductors used for the construction of the line. For instance the use of conductor hangers that have rounded rather than sharp edges and no protruding bolts with sharp edges will reduce corona. The conductors themselves can be made with larger diameters and handled so that they have smooth surfaces without nicks or burrs or scrapes in the conductor strands. The transmission lines proposed here are designed to reduce corona generation.

Modeling Methodology

CPUC Rule 3102 requires that the applicant for a CPCN for a new transmission line model the potential noise levels that the line could produce.

The audible noise from the proposed transmission lines was predicted using EMF Workstation: ENVIRO (Version 3.52), a Windows-based model developed by the Electric Power Research Institute (EPRI).

The data presented in Tables A-1 and A-2 of Appendix A were input into the ENVIRO program to calculate the corona audible noise, with the addition of elevation of the line above sea level. The new San Luis Valley to Calumet 230 kV double circuit line was modeled with an elevation of 9,413 feet (2869 meters), the highest elevation of La Veta Pass. The Calumet to Walsenburg Transmission Corridor was modeled with an elevation of 5,600 feet (1707 meters), which is approximately the average elevation along the corridor. Because the equations that predict audible noise were created from empirical measurements, the accuracy of the model is as good as these measurements that produced the original equations. In addition, the model is as good as the accuracy of the parameters input to the model (e.g. the actual elevation of the transmission line at a particular location rather than the average elevation of the entire project). Therefore given these potential uncertainties, the resulting field plots are within a few percent of the true value for the conditions modeled.

Modeling Results

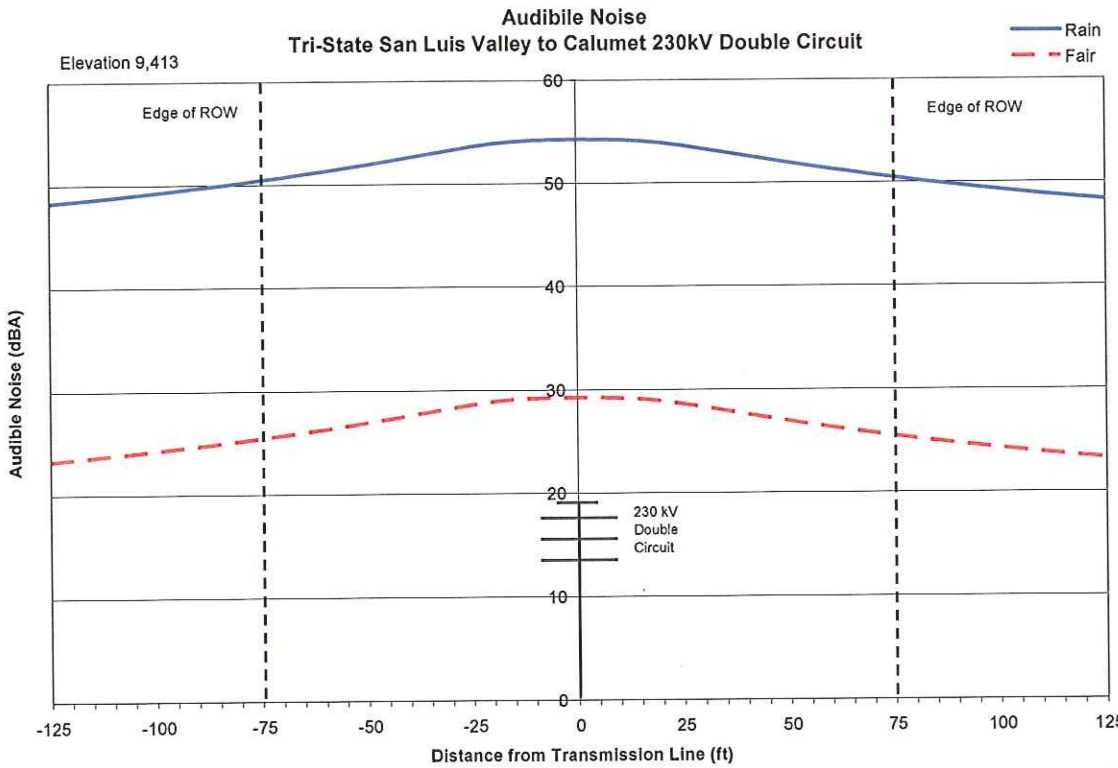
Figure 3 shows the audible noise modeled for the new San Luis Valley to Calumet 230 kV double circuit line at the top of La Veta Pass.

Figure 4 shows the audible noise modeled for the Calumet to Walsenburg Transmission Corridor.

The figures show two conditions, fair and rain. This is to show the range in corona effects due to changing weather.

San Luis Valley to Calumet

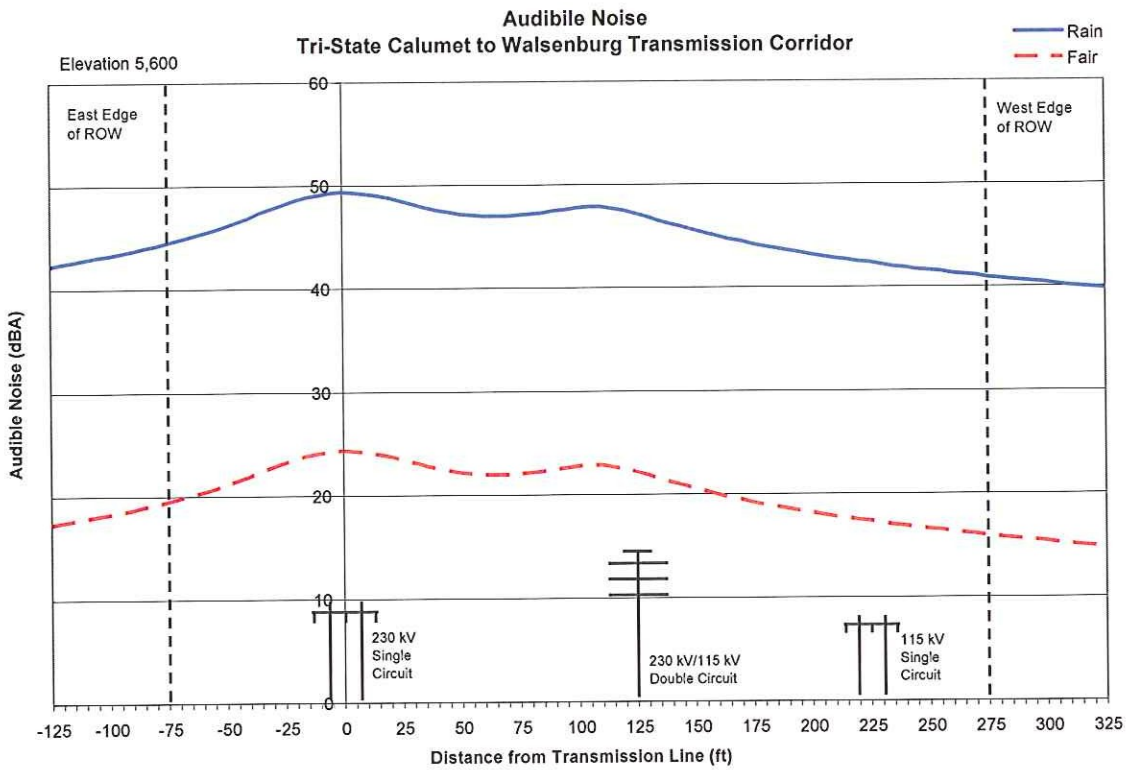
Figure 3, Audible noise for the San Luis Valley to Calumet 230 kV double circuit line.



The audible noise at both the right and left ROW edge is 25.5 dBA in fair weather and 50.5 dBA in wet weather. The maximum noise that occurs within the ROW is 29.3 dBA in fair weather and 54.3 dBA in wet weather.

Calumet to Walsenburg Transmission Corridor

Figure 4, Audible noise for the Calumet to Walsenburg Transmission Corridor. Corridor is depicted looking south from Calumet Substation.



The audible noise that is modeled at the east ROW edge is 19.5 dBA in fair weather and 44.5 dBA in wet weather. At the west ROW edge the audible noise is 15.9 dBA in fair weather and 40.9 dBA in wet weather. The maximum noise that occurs within the ROW is 24.4 dBA in fair weather and 49.4 dBA in wet weather.

APPENDIX A
ENVIRO Modeling Inputs

Table A-1 – Projected Electrical Power Flows, Conductor Size and Type, and Operating Voltage

		New SLV – Calumet 230 kV Double Circuit		Calumet to Walsenburg Transmission Corridor			
					New Double Circuit		
	Line	#1 line	#2 line	Existing Comanche – Walsenburg 230 kV Single Circuit	Calumet – Walsenburg 230 kV	Stem Beach – Walsenburg 115 kV	Existing ARCO – Walsenburg 115 kV Single Circuit
	Conductor Type	One conductor 1272 MCM ACSR Bittern[1]	One conductor 1272 MCM ACSR Bittern[1]	One conductor 1272 MCM ACSR Bittern[1]	One conductor 1272 MCM ACSR Bittern[1]	Stem Beach – Calumet 477ACSR Hawk Calumet – Walsenburg 1272 ACSR Bittern[1]	477 ACSR Hawk[2]
	No injections in the Valley						
CASE #1	Maximum forecasted 2015 peak flow, (Amperes)	90	90	260	260	110	40
	1000 MW of New injections in the Valley & 1000 MW of New injections in the Calumet						
CASE #2	Maximum forecasted 2015 peak flow, (Amperes)	550	550	460	460	280	40
	Full Thermal Capacity of the Line						
CASE #3	Maximum forecasted 2015 peak flow, (Amperes)	1538	1538	1538	1538	477	477

[1] 1272 ACSR Bittern conductor has a diameter of 1.345 inches.
[2] 477 ACSR Hawk conductor has a diameter of 0.858 inches.

Table A-2 – Conductor Height and Horizontal Location, Conductor Sag, and Conductor Phasing

Line		Phase (top to bottom/ left to right)	Horizontal Location (ft)	Height (ft)	Sag (ft)
New SLV - Calumet 230 kV Double Circuit					
#1 line		A	-14.5	100	34
		B	-16	80.5	34
		C	-14.5	61	34
		Ground	-10	120	44
#2 line		C	14.5	100	34
		B	16	80.5	34
		A	14.5	61	34
		Ground	10	120	44
Calumet to Walsenburg Transmission Corridor					
Existing Comanche - Walsenburg 230 kV Single Circuit		C	-19.5	62	35
		B	0	62	35
		A	19.5	62	35
		Ground	-9.75	79	35
		Ground	9.75	79	35
New Double Circuit	Calumet - Walsenburg 230 kV	A	109.5	97.5	31.5
		B	108	78	31.5
		C	109.5	58.5	31.5
		Ground	115	115	31.5
	Stem Beach - Walsenburg 115 kV	C	140.5	97.5	31.5
		B	142	78	31.5
		A	140.5	58.5	31.5
		Ground	135	115	31.5

Existing ARCO - Walsenburg 115 kV Single Circuit	C	212.5	47	20
	B	225	47	20
	A	237.5	47	20
	Ground	218.75	56.5	20
	Ground	231.25	56.5	20