Xcel Energy[SM]
PUBLIC SERVICE COMPANY

IN THE MATTER OF THE APPLICATION OF PUBLIC SERVICE COMPANY OF COLORADO FOR A CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY FOR MIDWAY-WATERTON 345kV TRANSMISSION PROJECT

DOCKET NO: 07A-156E

AMENDED DIRECT TESTIMONY AND EXHIBITS OF DANNY J. PEARSON

June 1, 2007

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO**

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DANNY PEARSON

I. INTRODUCTION AND STATEMENT OF PURPOSE

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Danny Pearson. My business address is 550 15th Street, Denver, Colorado 80202.

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

A. I am employed by Xcel Energy Services Inc., the service company subsidiary of Xcel Energy Inc., the parent of Public Service Company of Colorado. My title is Principal Transmission Design Engineer, Transmission Engineering.

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

A. I am testifying on behalf of Public Service Company of Colorado ("Public Service" or the "Company").

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

A. Yes. That statement is included as Attachment A.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. The purpose of my testimony is to address design criteria associated with the proposed Midway – Waterton 345kV Transmission Project ("the Project"), including structures, right-of-way corridor ("right-of-way"), Electromagnetic Fields ("EMF"), audible noise, and prudent avoidance measures. As described by Company witness Thomas Green, the Project consists of two sections: a Southern Section and a Northern Section. Because the design criteria associated with the Southern Section of the Project, including structures, right-of-way, EMF, audible noise and prudent avoidance measures have been previously approved by the Commission in Docket No. 05A-072E[1], my testimony focuses only on the design criteria associated with the Northern Section of the Project involving the proposed rebuild of the existing single-circuit 230kV transmission line to a double-circuit 345kV capable transmission facility from Daniels Park Substation to the Waterton Substation.

II. PROJECT DESIGN

Q. WHAT IS THE BASIC DESIGN ENGINEERING DESCRIPTION OF THE MIDWAY – WATERTON PROJECT?

A. The purpose of the Project is to gain additional transmission line capacity from southern Colorado to the Denver metro area. The primary electrical

[1] Although the Comanche – Daniels Park Transmission Project approved in Docket No. 05A-072E involved only the rebuild of the single circuit 230kV transmission line in the west side of the corridor from Midway to Daniels Park Substations to double-circuit 345kV capable transmission facilities and the operation of both those circuits at 230kV, the evidence presented by Mr. Schaller regarding design criteria, including projected EMF and audible noise, anticipated the operation of those facilities at 345kV. Therefore, the Commission has already approved as reasonable the projected audible noise levels and EMF associated with operating the facilities between Midway and Daniels Park at 345kV as is proposed here.

planning objective is to electrically connect the Midway Substation to the Waterton Substation. The testimony of Company witness, Thomas Green, describes the system need for this Project in greater detail. This Project proposes a 345kV capable transmission line and structures spanning the approximately 82 miles from the Midway Substation to Waterton Substation. The Project uses the existing Front Range transmission corridor between Public Service's Midway Substation and the Daniels Park Substation and proposes to rebuild existing transmission facilities in the Daniels Park to Waterton transmission corridor.

Q. PLEASE DESCRIBE THE PROPOSED TRANSMISSION LINE DESIGN FOR THE MIDWAY – WATERTON PROJECT.

A. This Project will consist of two segments; 1) Midway – Daniels Park ("Southern Section")[2] and 2) Daniels Park – Waterton ("Northern Section" or "Daniels Park – Waterton"). As indicated above, the Commission previously approved the design for the Southern Section in Docket No. 05A-072E.

Again, my testimony from this point on will focus on the Northern Section of the Project. The Northern Section of the Project between Daniels Park Substation and Waterton Substation involves rebuilding an existing single circuit 230kV transmission line to a double circuit 345kV capable transmission line with the operation of one circuit at 345kV and the operation of the other at 230kV. The conductor will be placed in a vertical, two

[2] This 345kV capable transmission circuit will bypass the Daniels Park Substation and connect directly to one of the rebuilt Northern Section's 345kV capable circuits terminating at Waterton Substation.

conductor, bundled configuration. The support structure will be self-weathering steel similar in color to wood poles. Support structures will be single pole, about 120-150 feet height, on average as shown in Exhibit No. DJP-1B. Where feasible, the structures will be placed near adjacent structures, to avoid a "picket fence" appearance. The line will use low corona hardware to minimize audible noise. Overall, Public Service engineers attempted to choose a structural style and configuration that balances electrical, structural and aesthetic considerations.

Q. WHAT CONSIDERATIONS GUIDED PUBLIC SERVICE'S DESIGN OF THE DANIELS PARK TO WATERTON TRANSMISSION LINE?

A. The determination of the transmission line style, configuration and height is a difficult balancing issue. Design engineers must consider the aesthetics, the structural capacity, the electrical requirements, prudent avoidance of EMF, mitigation of audible noise, and economics. Public Service attempted to strike a reasonable balance among these issues.

Q. WHY DID PUBLIC SERVICE CHOOSE STEEL AS THE MATERIAL FOR THE SUPPORT STRUCTURES THAT ARE TO BE REBUILT IN THE NORTHERN SECTION?

A. Steel was chosen for its structural capability. Wood is an inadequate material choice for a double-circuit line at 345kV spacing dimensions and with two wires per phase. Wood structures would have to be spaced much closer together in order to carry the weight of the wires. If Public Service were required to use wood poles for the Northern Section, significantly more poles would be required than if the structures are steel - possibly even twice the number of poles would be needed.

Q. PLEASE DISCUSS THE CONFIGURATION OR STYLE AND HEIGHT OF THE STRUCTURES?

A. Exhibit No. DJP-1A shows the style of the structures as currently configured in the Northern Section of the corridor, and Exhibit No. DJP-1B shows the structures in the Northern Section after the completion of this project.

Public Service has proposed a structure style and height that strikes a reasonable balance among several factors. For many years the majority of all 345kV transmission lines were constructed on "lattice" towers. Public Service ruled out using lattice towers on this right-of-way because of their larger footprints and large visual appearance. Due to the right-of-way configuration on the Daniels Park – Waterton section of this Project, Public Service will utilize a standard construction style on steel poles, with three sets of phase wires stacked in a vertical configuration on each side of the pole, as depicted in my Exhibit No. DJP-1B. Typical structures for this Project should be 120-150 feet tall.

Q. WHAT FACTORS DETERMINE INDIVIDUAL POLE HEIGHTS?

A. Individual pole heights are determined by the terrain, span length, and sag of the adjacent wire and the minimum clearances prescribed in the National Electric Safety Code. Public Service uses a "buffer" above minimum clearances to ensure continued safe operations. The buffer is usually about 3-5 feet. The support structures will be higher than the average where the line crosses other electric lines or highly traveled roads. Some structures, particularly those crossing over other electrical circuits, may need to be over 170 feet tall, but the taller towers are the exception and not the norm for this project.

Q. HOW WILL THE STRUCTURES FOR THE PROJECT BE SPACED?

A. Because the Northern Section of the line from Daniels Park - Waterton replaces an existing line, the choice for structure spacing for this Project is to place the new structures in a similar location to where they were before the rebuild. The new structures will be generally located adjacent to any parallel line structures. If the new structures were placed at different intervals, such as at mid-span to the other line, it could give a "picket fence" appearance.

Q. WHAT CONSIDERATIONS INFLUENCED THE CHOICE OF SELF-WEATHERING STEEL AS THE COLOR FOR THE STRUCTURES?

A. Public Service chose self-weathering steel to minimize the metallic appearance of the poles. This steel has a maintenance-free, earth tone color that is similar to wood poles. It starts as a lighter orange-brown and changes to a dark brown over time. Colors are a personal preference and a highly debatable issue. Public Service finds that the self-weathering brown poles appear to be generally preferred over an industrial gray galvanized finish. Public Service rejected the idea of using a painted finish because paint systems wear through over time and become unsightly until they are repainted, which is an additional expense. The maintenance-free, earth tone color provides the least objectionable color.

Q. WHAT RIGHT-OF WAY CORRIDOR IS NECESSARY FOR THE PROJECT?

A. The right-of-way corridor already exists today on the Midway - Waterton Project. The majority of the corridor is at least 210 feet wide. Portions of the corridor are wider than 210 feet. The Daniels Park to Waterton right-of-way corridor (210 feet or 260 feet in width) is adequate for the type of construction Public Service will use on the Project. With the right-of-way between Daniels Park and Waterton being two different widths, the narrower (210 feet) right-of-way width was used in all calculations for EMF and audible noise, as a worse case scenario.

III. COLORADO REGULATORY REQUIREMENTS

Q. PLEASE DESCRIBE THE REQUIREMENTS OF 4 CCR 723-3102 (c) OF THE CODE OF COLORADO REGULATIONS?

A. Section 4 CCR 723-3102(c) ("Rule 3102(c)") of the Commission's Rules Governing Electric Utilities requires a utility applying for a Certificate Of Public Convenience and Necessity ("CPCN") for transmission facilities to describe its proposed actions and techniques for cost effectively mitigating noise associated with the proposed facilities. The rule further requires the utility to provide computer generated audible noise studies of the proposed transmission line showing the potential noise levels expressed in dB(A) and measured at the edge of the transmission right of way. Some of the techniques recommended to achieve cost-effective audible noise mitigation are larger conductors, bundled conductors, corona free hardware, conductor quality, handling and packaging, construction techniques, conductor tensions and design alternatives considering the spatial arrangement of phasing of conductors.

Q. PLEASE DESCRIBE WHAT PUBLIC SERVICE HAS DONE TO MEET THE REQUIREMENTS OF RULE 3102(c)?

A. Since the primary purpose of the Project is to gain additional transmission line capacity from southern Colorado to the Denver metro area, the first decision is the electrical conductor. Public Service has designed the Daniels Park to Waterton rebuild using 2-1272 Kcmil ACSR "Bittern" conductor. This conductor was chosen based on the increased capacity it created between Daniels Park and Waterton which is consistent with long-range studies that show such additional capacity is warranted. Designing the double circuits between Daniels Park and Waterton using the 2-1272 Kcmil ACSR "Bittern" conductor also reduces noise which supports Public Service's objective to balance a number of issues such as audible noise, EMF and economics. Public Service believes choosing 2-1272 Kcmil conductor is a prudent and sound approach for this corridor. Public Service chose to use "non-specular" wire, which reduces reflection, and adds to the aesthetics at a small incremental cost. The Project will employ a standard bundled conductor configuration with corona free hardware that has been used on several other projects. A bundled configuration refers to the use of two wires per phase, in a vertical configuration. The two wires per phase configuration has the benefit of increased capacity while at the same time reducing the audible noise that would occur with only one wire per phase. An alternative choice would be to use only one larger conductor per phase. Public Service rejected the single large conductor because it would provide less capacity and would emit greater audible noise.

Industry recognized prudent techniques will be used, which significantly reduce the effects of corona and thus corona-generated audible noise. The phases will be spaced adequately apart so as not to create an excessive voltage gradient, which, if not taken into account, would generate constant and excessive corona. Attachment hardware of a corona-free nature will be specified and procured. Conductor of high quality will be specified and procured.

The conductor will be handled and packaged properly so as not to damage it. The construction crews will use great care; they will have well maintained equipment and use proper construction techniques so as not to damage the conductor. Damaged conductor can emit corona and thus emits higher sound levels than undamaged conductor. Proper line tensions will be applied so as not to create loose conductor, as with damaged conductor, loose conductor emits higher sound levels than conductor of proper tension. By using these prudent techniques the transmission line will operate as quietly as possible given the voltage and location. All of these requirements are included in our Construction Specifications, which follows IEEE standard 534, IEEE Guide to the Installation of Overhead Transmission Line conductors.

I should emphasize that there is no overhead construction technique that Public Service can employ to prevent the transmission line from becoming wet and, during wet periods, from emitting audible noise at levels substantially higher than fair weather levels. Fortunately, in Colorado, the wet weather periods are relatively short-lived.

IV. AUDIBLE NOISE

Q. DID YOU PREPARE AN EXHIBIT TO ILLUSTRATE THE AUDIBLE NOISE EXPECTED TO BE GENERATED FROM THE TRANSMISSION LINE?

A. Yes. Exhibit No. DJP-2a and 2b illustrate the expected audible noise generated from the Midway - Waterton Project, specifically the Daniels Park to Waterton section of the Project, by using a sound-modeling program.

A. BPA / EPRI Noise Model

Q. WHAT METHOD DID YOU USE FOR DEVELOPING EXHIBIT NO. DJP-2?

A. I used a sound-modeling program developed by the Bonneville Power Administration ("BPA") and the Electric Power Research Institute ("EPRI").

Q. PLEASE ADDRESS THE ACCURACY OF THE TRANSMISSION LINE MODELING PROGRAM THAT YOU USED.

A. The audible noise modeling program used by Public Service are empirical models that were developed using field-testing as the basis of origin. Sound modeling is an inexact science, but it does provide good insight or predictions on what corona-generated audible noise activity will likely occur. BPA and EPRI did thousands of field measurements of transmission power lines. They then plotted the graphs from those field results and developed equations, algorithms and modeling, which consider the input variables from the field tests. These audible noise modeling programs allow Public Service to predict the audible noise that will be generated from a proposed project by inputting variables such as the conductor and static wire dimensions and spacing, the overall geometry of the project, the elevation of the project, the operating voltage, and the rain rate. The models are statistically based and provide output figures, which are the expected average audible noise levels. Public Service used the same modeling algorithm in the Midway - Daniels Park Rebuild Project, PUC Docket No. 03A-276E and the Comanche – Daniels Park Transmission Project, PUC Docket No. 05A-072E, that I used in developing Exhibit No. DJP-2.

Q. PLEASE PROVIDE A PRACTICAL COMPARISON FOR THE dB(A) SCALE.

A. The following is a reference chart provided in the EPRI Transmission Line Reference Book – 345kV and Above. This chart provides a reasonable and useable guide to how people experience sound at various decibel levels:

130-140 – Threshold of Pain

120-130 – Pneumatic chipper

110-120 – Loud audible horn (1 mi. distance)

100-110 – (no example)

90-100 – inside subway (New York)

80-90 – Inside motorbus

70-80 – Average traffic on street corner
60-70 – Conversational speech
50-60 – Typical business office
40-50 – Living room, suburban area
30-40 – Library
20-30 – Bedroom at night
10-20 – Broadcasting studio
0-10 – Threshold of hearing

Q. IN YOUR OPINION, IS THE SOUND MODELING CALCULATION THAT YOU HAVE PROVIDED ACCURATE?

A. Yes. The sound modeling that I have presented is based upon thousands of field readings in many states and has specific inputs for altitude. The models provide accurate projections of the average level of audible noise expected to emanate from the Project. After developing the model algorithms, BPA and EPRI tested the model results against field readings; the results are reported in what is known to transmission engineers as the "Red Book", the EPRI Transmission Line Reference Book – 345kV and Above. In reviewing this report, I find that modeling versus field verification is usually plus or minus 2 to 3 dB(A).

Q. ARE YOU FAMILIAR WITH THE ELEMENTS OR ASSUMPTIONS THAT ARE USED IN THE SOUND MODELING PROGRAM DEPICTED IN YOUR GRAPH?

A. I am.

Q. PLEASE DESCRIBE THOSE ELEMENTS OR ASSUMPTIONS.

A. The following elements were considered in the sound modeling of Public Service's proposed Project: a) the ENVIRO program calculating the Bonneville Power algorithm was used, a recognized software program in the utility industry typically used for sound analyses; b) readings were predicted for mid-span locations, at conductor low points, without the influence of the transmission structures; c) assumed elevation was 6500 feet between Daniels Park and Waterton; d) the operating voltages are shown on the exhibits; e) "wet" or "rain" signifies when water droplets were formed on the line, the L50 curve is represented (a common statistical indicator); f) audible noise reflection from the ground or other objects is not known (for example, concrete amplifies sound by reflecting sound waves, whereas dirt or grass conditions absorb sound waves or dampen audible noise); g) a "burn in" period exists for a few months after new construction and the model predicts audible noise after the "burn-in" period.

Q. WHAT PHENOMENA PRODUCE AUDIBLE NOISE ON HIGH VOLTAGE TRANSMISSION LINES?

A. Several factors produce audible noise on high voltage transmission lines. The higher the voltage on the transmission circuit, the greater the corona activity on the line. Corona is what creates the hissing, crackling or random popping sound. Corona is a small electrical discharge, not unlike the static electrical charge that a person may experience when touching a metal object when walking on carpeting. Corona increases substantially in wet weather, when water droplets form on a transmission line. All high voltage transmission lines experience significant corona during wet weather. In normal, fair weather conditions, corona and its corresponding audible noise are usually at low levels.

Q. WHAT OTHER CONDITIONS AFFECT THE AUDIBLE NOISE LEVEL?

A. Corona activity is substantially increased at higher altitudes because of the corresponding decrease in air density. A rough rule of thumb is that corona-generated audible noise increases by about 1 dB(A) for every 1000 feet in elevation gain. A transmission line constructed in the Colorado Front Range area will have corona noise about 6 dB(A) higher than a similarly constructed line at sea level.

The second source of audible noise on a transmission line is a 120 Hz synchronous hum created by systems operating at 60 Hz. This 120 Hz hum is generally of little consequence, but it can be a contributor to audible noise. The audible noise generated by corona causes most concerns.

Q. WHAT ARE THE PROJECTED AUDIBLE NOISE LEVELS ASSOCIATED WITH THIS PROJECT?

A. Exhibit No. DJP-2a & 2b sets forth Public Service's projections as to the audible noise that will be expected from the Daniels Park – Waterton Project under both fair and wet/rainy weather conditions. When there is moisture on the line, whether due to rain, snow or fog, the audible noise-modeling program predicts that the audible noise levels can be as high as 25 dB(A) higher than under fair weather conditions, until the line dries. Over 100 different options were modeled to come up with the four cases I am submitting here.

Q. PLEASE DESCRIBE THE PROCESS YOU USED TO COME UP WITH THE 100 DIFFERENT OPTIONS YOU MODELED FOR THIS PROJECT?

A. The existing corridor between Daniels Park and Waterton Substations has a double circuit 230kV capable transmission line and a single circuit 230kV transmission line, see Exhibit No. DJP-1A. First, we modeled the existing lines to come up with current EMF and audible noise values to base our new modeling upon (all circuits at 230kV with existing phasing). The proposed configuration for this corridor is to replace the single circuit 230kV transmission line with a double circuit 345kV capable transmission line and leave the existing double circuit 230kV transmission line, see Exhibit No. DJP-1B.

The phasing arrangement for the lines was the basis for a majority of the different options considered. Step 1) With the phasing for the existing lines held constant, every combination of phasing for the new double circuit line was run. Step 2) The phasing on one of the circuits on the existing line was reversed, and the different combinations of phasing for the new line was run again. The runs made in Steps 1 & 2 established all the EMF values for this project. Using Steps 1 & 2 as the basis, we then changed other variables that have an effect on audible noise. Some of the variables that have an effect on audible noise but do not change the EMF values are: A) Vertical bundle spacers with 18” or 12” spacing (18” is our standard). B) Conductor diameter or different types and number of conductors (2 conductor bundle of 954 kcmil ACSR "Cardinal", 2 conductor bundle of 1272 kcmil ACSR "Bittern" and a 3 conductor bundle of 636 kcmil ACSR "Grosbeak").

Q. WHAT PROCEDURE DID YOU UTILIZE TO REDUCE THE 100 DIFFERENT OPTIONS YOU MODELED FOR THIS PROJECT DOWN TO THE FOUR CASES YOUR ARE PRESENTING WITH YOUR TESTIMONY?

A. After all the runs were completed, the audible noise and the EMF data was entered into a spreadsheet and saved as two different files (one was titled "EMF" the other as "AN" (audible noise)). Each data file was then sorted several different ways. For the "EMF" file, the data was sorted, with the primary sort being on EMF values and the secondary sort being for audible noise values. The 100 different cases were then reduced to approximately 15 different cases based upon the lowest EMF values.

The same process for the "AN" file was followed, with the audible noise values being the primary sort and the EMF values being the secondary sort. The 100 different cases were then reduced to approximately 15 different cases based upon the lowest audible noise values (55 dB(A) or less).

These 30 cases were then reviewed to see if any of the 15 EMF cases matched any of the 15 AN cases, there were no common cases. All of our criteria for audible noise was to have 55 dB(A) or less at the edge of the right-of-way. Reconsidering this criteria, we determined that for a reasonable additional cost we could increase the capacity of the transmission facilities between Daniels Park and Waterton Substations consistent with the long-range planning objectives, reduce the audible noise to close to 50 dB(A) or less at each edge of the right-of-way, and achieve reasonable EMF levels, by using one of our standard, larger diameter bundle conductors.

The 30 different cases were then reduced to the 4 Cases below. I am presenting 2 Cases with 954 kcmil ACSR "Cardinal" conductor and 2 Cases with the larger diameter 1272 kcmil ACSR "Bittern" conductor.

Q. PLEASE EXPLAIN THE INFORMATION THAT IS SET FORTH ON YOUR EXHIBIT No. DJP-2.

A. Exhibits No. DJP-2a & 2b, show the audible noise modeling associated with the segment between Daniels Park and Waterton. Exhibit No. DJP-2a predicts the L5 average audible noise levels in fair weather and Exhibit No. DJP-2b predicts the average L50 audible noise levels when the lines are wet. The wet/rainy weather models assume that the line is saturated with moisture, and therefore predict the average worst-case scenario. As lines begin to dry, from the heat of the current, from the sun and wind, audible noise levels will decrease from the model predictions.

We have included four Cases (1, 2, 3, and 4) in Exhibit No. DJP-2. The Company believes these four Cases give the most reasonable balance between audible noise, EMF (magnetic fields) and costs. Public Service is recommending we construct the Daniels Park – Waterton double circuit transmission line utilizing Case 4.

Q. PLEASE EXPLAIN THE VERTICAL DOTTED LINES ON EXHIBIT NO. DJP-2.

A. The vertical dotted lines are the edge of Public Service's right-of-way, applying the conservative assumption that all of the right-of-way in the Daniels Park to Waterton corridor is 210 feet. I show the edge of the right-of-way because this is the location that the Commission rules specify is to be used to measure audible noise limits for transmission lines.

Q. WHAT IS THE LEGAL STANDARD THAT APPLIES TO THIS PROJECT?

A. The Colorado State law, C.R.S. § 25-12-103 (12), provides that the Commission can determine whether the projected audible noise levels for electric transmission lines are reasonable when reviewing applications for certificates of public convenience and necessity, without regard to the audible noise levels otherwise set forth in the state statute.

Q. HOW CAN THE COMMISSION DETERMINE WHETHER THE PROJECTED AUDIBLE NOISE LEVELS OF THE PROJECT ARE REASONABLE?

A. Colorado Revised Statutes §25-12-103 sets forth audible noise levels for various "zones" that the General Assembly found acceptable for uses other than electric transmission lines. They are as follows (measured from 25 feet or more from the property line of the audible noise generator):

Zone	**7:00 a.m. to next 7:00 p.m.**	**7:00 p.m. to next 7:00 a.m.**
Residential	55 dB(A)	50 dB(A)
Commercial	60 dB(A)	55 dB(A)
Light Industrial	70 dB(A)	65 dB(A)

Industrial	80 dB(A)	75 dB(A)

However, in passing this new law, the General Assembly stated that it was a matter of statewide interest and concern that the State of Colorado have an adequate, reliable, and cost-effective electricity infrastructure to serve the needs of the people of Colorado for their homes, businesses and industries. The general assembly found that electric transmission facilities are linear and may pass through several local jurisdictions and zoning districts. So, the General Assembly left it up to the Commission to determine whether the predicted audible noise levels from proposed transmission facilities were reasonable.

As I mentioned earlier, Public Service is proposing Case 4. As can be seen in Exhibit No. DJP-2a, when the line is not wet, the predicted audible noise levels are well below the most stringent limits set for residential zone use. When the lines are saturated with moisture, as seen in Exhibit No. DJP-2b, the lines will temporarily be noisier than the most stringent limits set for residential zone use, but the audible noise will diminish as the line dries. The saturated line case shows that the noise level of the Northern Section will be on average 49.8 dB(A) on the south edge of the existing right-of-way corridor and will be on average 50.1 dB(A) on the north edge of the existing right-of-way corridor. The predicted audible noise levels on the north side of the corridor are only slightly above the most restrictive zone (50 dB(A)) and will only be temporary until the line dries. It should be noted, in the area where we expect noise levels to be as high as 50.1 dB(A) on average when the line is saturated and wet, the right-of-way width is 210 feet. Just west of US Highway 85, there is an additional fifty feet of right-of-way along the north edge and the noise level will drop below 50 dB(A).

Q. IS IT POSSIBLE TO CONSTRUCT THE NORTHERN PORTION OF THE PROJECT TO DECREASE THE AUDIBLE NOISE AT ALL LOCATIONS SO THAT IT IS PREDICTED TO BE 50 dB(A) OR LESS EVEN WHEN WET?

A. Yes. Audible noise can be slightly reduced by arranging the phasing to meet the 50 dB(A), however such a configuration results in significantly higher EMF (magnetic fields levels). Public Service believes taking measures to mitigate 0.1 dB(A) is not in the public interest and thus the Company recommends Case 4.

V. ELECTROMAGNETIC FIELD MITIGATION

Q. CAN YOU DESCRIBE THE REQUIREMENTS OF SECTION 4 CCR 723-3102 (d) OF THE CODE OF COLORADO REGULATIONS?

A. Yes. When applying for a CPCN, Rule 3102(d) of the Commission's Rules Governing Electric Utilities requires a utility to describe the actions and techniques applied when they were planning, siting, constructing and operating the line, relating to prudent avoidance of EMF.

A. Prudent Avoidance

Q. WHAT IS PRUDENT AVOIDANCE?

A. Prudent Avoidance: "means 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 of modest cost. " Rule 3102(d).

Q. PLEASE DESCRIBE WHAT PUBLIC SERVICE HAS DONE TO MEET THE REQUIREMENTS OF SECTION 3102(d) OF THE CODE OF COLORADO REGULATIONS?

A. Public Service has been using "prudent avoidance" concepts for many years. Of course, not all of the prudent avoidance concepts listed in Section 3102(d) can be implemented on every project because it is not cost effective to do so. On many transmission projects only one or two of the techniques can be reasonably applied.

In this case Public Service proposes to use two basic avoidance techniques. First, Public Service has studied and will use the technique of reverse phasing (referenced in the Commission rule as "design alternatives considering the arrangement of phasing of conductors"). The reverse phasing application will reduce the EMF created by the Project.

The second minimization avoidance technique Public Service can reasonably employ for the Project is the use of higher structures. The structures that we will use are about five feet higher than the minimums required for ground clearance by the National Electric Safety Code. This small height increase will provide an additional EMF reduction along with increased safety clearances.

For the Northern Section of the Project between Daniels Park and Waterton Substations, Public Service plans to use its existing right-of-way to upgrade the existing 230kV single circuit transmission line to a double circuit 345kV capable transmission line. As such, the prudent avoidance measures that would be used in acquiring new right-of-way are not applicable. On this section of the Project, the populated areas grew up around the existing transmission corridor. The Daniels Park - Waterton corridor is 210 feet in width from Daniels Park to a point just west of US Highway 85 and then it is 260 feet in width from that point to the Waterton Substation. This width is more than sufficient to support the lines and to keep EMF and audible noise within reasonable levels. Additional widening of the right-of-way could require the condemnation of property, which would be very expensive and unpopular, and is not recommended by Public Service.

Burial of the line, which is listed as an avoidance technique in Section 3102(d) is also not available at reasonable or modest cost.

Constructing transmission lines underground is often perceived as a way to accomplish the electrical objectives of a transmission project while minimizing environmental impacts. However, undergrounding entails significant costs as well as significant environmental and technological impacts associated with burying the transmission line. It should also be noted that underground transmission lines do not eliminate EMF; the lines simply have a different EMF profile that is more concentrated. When looking at an EMF cross-section profile of an overhead transmission line, it is generally a bell-shaped curve with low value tails that dissipate with distance. The EMF cross-section profile for an underground line is shaped like a sharp spike and the tails dissipate much quicker on the sides. This means the EMF field associated with underground transmission is elevated and concentrated in a much tighter band.

B. Underground Versus Overhead Transmission Lines

Q. WHAT CHALLENGES ARE PRESENTED BY UNDERGROUNDING A TRANSMISSION LINE?

A. Placing a high voltage transmission line underground requires electrically insulating each of the three phases (wires) and dissipating the heat generated by the wires. Public Service generally uses underground construction only with low voltage distribution lines that operate at 25kV or less. At these relatively low voltages, the problems of electrically insulating each wire and dissipating the heat generated by the wires is not a concern. With lines of greater voltage, such as those associated with the Northern Section of the Project, material costs, construction costs and the heating of the wire all become a greater concern.

Public Service has buried short lengths of 230kV and 115kV transmission lines in other parts of its service territory when required by technical constraints or paid for by those requesting burial. Public Service has not constructed underground transmission lines in rural areas, nor has the Company constructed any transmission line underground for the distance required by this Project.

Q. HOW DO THE COST AND RELIABILITY OF UNDERGROUND TRANSMISSION LINES COMPARE TO OVERHEAD LINES?

A. Historically, the cost of constructing a high voltage line underground can be up to ten times as expensive as overhead construction. When planning to construct high voltage, underground transmission lines in rolling hills and rugged terrain, such as exists along the transmission path for the Northern Section of this Project, the engineering and technical challenges may increase the cost to more than ten times that of overhead construction. Public Service only considers underground construction if the difference in cost between overhead construction and underground construction is paid for by those requesting it or if technical constraints make it impossible to construct the line overhead. Out of a total of over 3,000 miles of transmission lines, Public Service has only about 40 miles of transmission lines constructed underground, most of which are in high load and density areas and in and around airports.

The reliability of overhead and underground transmission lines is generally comparable. While underground lines are immune to the effects of weather, this type of facility is susceptible to damage from geologic or subsoil instabilities, as well as inadvertent damage resulting from excavations. Underground lines also present challenges during outages. Faults occurring in underground installations are typically more difficult to locate and repair than on overhead lines. The increased difficulty and duration for repairs cause significantly longer power outages than with overhead power lines. Repair of solid dielectric cables or high-pressure fluid-filled conduits would require pulling in a new section of cable and splicing it into the existing cable at two vaults. Such a repair would take weeks or months. In contrast, overhead line outages can often be repaired within hours, because any damage is readily visible and accessible.

Q. WHAT OTHER CONSIDERATIONS LED PUBLIC SERVICE TO REJECT UNDERGROUNDING THIS PROJECT?

A. The impacts of underground transmission lines on soils, surface water, vegetation and wildlife resources are usually greater than those of a similarly located overhead line. This is because any underground technology used would require a continuous trench 4 feet wide by 5 or more feet deep with intermediate vaults 7 feet wide by 20 feet long every 2,000 to 3,000 feet. Additional tree and vegetation cutting within the right-of-way would be required to facilitate construction and overland travel of equipment. Additionally, all rivers, streams and wetland areas must be crossed with equipment and a trench excavated through them to required specifications.

In summary, the risks to reliability, environmental impacts, and associated costs outweigh the advantages of burying lines. Burial of transmission lines is considered an acceptable alternative only in areas where overhead right-of-way is not available or where a landowner or developer pays for burial, a second reliable source of transmission exists, and it is technically feasible.

C. Projected EMF Levels

Q. WHAT ARE THE EMF LEVELS ASSOCIATED WITH THE PROJECT?

A. The EMF curves shown in Exhibit No. DJP-3 provide an accurate representation, using the preliminary design of what can be expected during daily peaks in the near future. The load used to calculate the transmission line magnetic fields is developed from projected system normal peak conditions. Higher currents could occur under certain system operating conditions, however the vast majority of time that the Midway – Waterton project operations will be at steady state.

Q. PLEASE DESCRIBE WHAT YOU HAVE DEPICTED ON EXHIBIT NO. DJP-3.

A. Exhibit No. DJP-3 shows the EMF model results for the same four Cases as were presented for audible noise. The EMF from the existing facilities is shown by the thick solid blue lines on each graph. The vertical dotted lines show the edge of Public Service's right-of-way. As I stated previously, over 100 different options were modeled to come up with the four cases I am presenting here.

The Project proposed by Public Service is shown in EMF Case 4. Under the projected system normal peak conditions expected in 2015, EMF levels will be slightly higher than the levels that exist today on this corridor, as shown on Exhibit No. DJP-3.

Q. WHY DID YOU MODEL DIFFERENT CONFIGURATIONS FOR EMF?

A. Public Service examined various configurations for the Daniels Park - Waterton section of the project to determine the configuration that has a reasonable balance for lowering both EMF and audible noise. As explained by other Public Service witnesses, after this Project is constructed, the Daniels Park - Waterton corridor will contain one double circuit 345kV capable facility and one double circuit 230kV capable facility. However, at this time, Public Service needs to operate only one of the two rebuilt circuits at 345kV; the other circuit will be operated, for the time being, at 230kV. In all my cases, I looked at the effects of operating both of the 345kV capable circuits at 345kV. The Project proposed by Public Service's Application is represented as EMF Curve 1 in Case 4.

Q. THE RESULTS OF THE EMF MODELING REFLECTED IN EXHIBIT NO. DJP-3 FOR CASE 4 IS BASED UPON TYPICAL 2015 POWER FLOWS. COULD THE POWER FLOWS AND RESULTING EMF VALUES ON THE LINE BE HIGHER?

A. Yes. Although we believe the models represent typical power flows and EMF values for many years to come, the lines have the potential to carry higher flows, and therefore higher EMF values.

Q. WHAT WOULD YOU EXPECT THE MAXIMUM POWER FLOWS ON THE PROPOSED FACILITIES AND ASSOCIATED EMF VALUES TO BE?

A. Each of the lines will be constructed to carry approximately 2800 amps. However, as a general rule, Public Service operators will only allow enough power to flow on each line, so that if one of the lines is lost (N-1), the remaining line would be capable of carrying the power flows of both lines at its rated capacity of 2800 amps. Therefore, as a practical matter, the highest continuous loading for each line under system intact conditions would be half of the line's rated capacity, or 1400 amps. Although we don't expect to ever see power flows as high as half of the line's rated capacity, we have also modeled Case 4 to reflect the EMF values assuming the maximum potential loading scenario described above (Alternate Loading Case 4). Exhibit No. DJP-4 shows the EMF values for the existing transmission line, Case 4 and the Alternate Loading Case 4. Again, it should be noted that the loadings modeled as Alternate Loading Case 4 are not likely. Due to the nature of the regional transmission system, we would not expect to transfer that much power between the Daniels Park and Waterton Substations. Nevertheless, the Company believes that it is prudent, in ruling on the reasonable EMF levels, for the Commission to consider the EMF levels at maximum loading.

Q. HAVE ANY STATES OR AGENCIES IN THE UNITED STATES ESTABLISHED EMF EXPOSURE LIMITS?

A. Yes. Two states, Florida and New York, have set EMF exposure limit values, as measured at the edge of ROW. In Florida, a range from 150 to 250 milli-Gauss (mG) exists for transmission lines ranging in voltage from 69 to 500kV, and in New York an EMF value of 200mG is the limit for any transmission line regardless of voltage. In addition, the American Conference of Governmental Industrial Hygienists[3] has set a not-to-exceed value of 10,000mG for occupational exposure, and 1,000mG for those workers with pacemakers. The International Commission on Non-Ionizing Radiation Protection[4] has set exposure limits of 4,200mG for occupational exposure and 833mG for the general public.

Q. WHAT FINDING IS THE COMPANY ASKING THE COMMISSION TO MAKE IN THIS PROCEEDING REGARDING EMF?

A. The Company seeks a finding consistent with the Commission's ruling in Docket No. 05A-072E establishing a reasonableness level of 150 mG for this project.

Q. WHY DOES THE COMPANY BELEIVE IT IS APPROPRIATE TO ESTABLISH THE SAME EMF REASONABLENESS LEVEL FOR THIS PROJECT AS IT DID FOR THE COMANCHE – DANIELS PARK TRANSMISSION PROJECT?

A. These projects are very similar in design. Both are double circuit 345 kV. In addition, just as in the case of the Comanche – Daniels Park Transmission Project, while the estimated EMF levels under typical projected peak power flows are significantly below 150 mG at the edge of the right of way, the Company's Alternate Loading Case 4 shows that EMF levels could increase

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[3] The American Conference of Governmental Industrial Hygienists is a professional organization that facilitates the exchange of technical information about worker health protection. It is not a governmental regulatory agency.

[4] The International Commission on Non-Ionizing Radiation Protection is an organization of 15,000 scientists from 40 nations who specialize in radiation protection.

to as high as 89.4 mG at the edge of the right of way at maximum loadings (one half of the lines' rated capacity). Given these modeling results and in view of the EMF limits that have been prescribed in other jurisdictions and for the Comanche-Daniels Park Transmission Project that includes the Southern Section of this Project, the Company seeks the same reasonableness finding as the Commission made in that case.

VI. ALTERNATIVE CHOICES FOR EMF AND NOISE

Q. PLEASE EXPLAIN THE DIFFERENCES IN CASES 1, 2, 3, AND 4?

A. Case 1, this is a typical 2 conductor bundle with 954 Kcmil ACSR "Cardinal". This configuration provides an EMF value lower than the existing line. However, this configuration has wet/rainy L50 audible noise levels of 54.6 dB(A), on the south edge of right-of-way and 52.8 dB(A) on the north edge of right-of-way.

Case 2 is also a typical 2 conductor bundle with 954 Kcmil ACSR "Cardinal". This configuration provides an EMF value slightly more than the values of the existing line. This configuration has wet/rainy L50 audible noise levels of 51.1 dB(A), on the south edge of right-of-way and 50.8 dB(A) on the north edge of right-of-way.

Case 3 reflects a typical 2 conductor bundle with 1272 Kcmil ACSR "Bittern. This configuration provides an EMF value more than twice the values of the existing line. This configuration has wet/rainy L50 audible noise levels of 48.9 dB(A), on the south edge of right-of-way and 49.0 dB(A) on the north edge of right-of-way.

Case 4 reflects a typical 2 conductor bundle with 1272 Kcmil ACSR "Bittern. This configuration provides an EMF value slightly more than the values of the existing line. This configuration has wet/rainy L50 audible noise levels of 49.8 dB(A), on the south edge of right-of-way and 50.1 dB(A) on the north edge of right-of-way. Public Service is recommending we construct the line utilizing Case 4.

By utilizing a bundle of 1272 Kcmil ACSR "Bittern", one of our standard conductors, we expect the differential cost to be between $600,000 and $700,00 more than the cost for constructing the line with a bundle of 954 Kcmil ACSR "Cardinal" (Note: this is for only the segment between Daniels Park and Waterton). This differential cost would be considerably less than acquiring additional right-of-way in the residential areas along this route. The larger conductor will have no effect on the power flow from Midway and Waterton (due to the Southern section being built with a bundle of 954 Kcmil ACSR "Cardinal"), but will allow for more power flow on the new circuit between Daniels Park and Waterton.

Q. HOW DO THE AUDIBLE NOISE VALUES THAT YOU PRESENT ON YOUR EXHIBIT NO. DJP-2 FOR THIS PROJECT COMPARE WITH THE AUDIBLE NOISE LEVELS ASSOCIATED WITH OTHER HIGH VOLTAGE LINES ON PUBLIC SERVICE SYSTEM?

A. Public Service uses similar techniques as those described here to mitigate audible noise when it constructs all of its high voltage transmission lines. However, as I indicated earlier, audible noise levels from a particular facility are dependent upon numerous factors, such as voltage level, altitude, surrounding structures and ground cover. Therefore, it would not be appropriate to use the measures in my Exhibit No. DJP-2 as the expected audible noise levels from any other line. However, in constructing this Daniels Park to Waterton Project, Public Service is using good utility practice to employ all of the reasonable prudent techniques of which I am aware in an attempt to minimize audible noise impacts.

Q. ARE THERE RISKS ASSOCIATED WITH REBUILDING A LINE IN AN EXISTING CORRIDOR, SUCH AS PUBLIC SERVICE IS PLANNING FOR THE SEGMENT BETWEEN DANIELS PARK AND WATERTON?

A. Yes. The primary risk involves a construction accident, which would trip out the parallel energized line and could potentially cause a personal injury. However, the construction crews who perform this work are very skilled in working around energized equipment. Due to the limited capacity of existing transmission systems, it is becoming a common practice for contractors to construct a new line next to an existing energized line. Good safety measures are applied and outages are arranged when needed. Other safety precautions, such as grounding the un-energized new line that is being constructed to protect the construction crews from induced current, will be strictly followed

V. RECOMMENDATIONS

Q. GIVEN ALL YOUR STUDIES, WHY DOES PUBLIC SERVICE BELIEVE THAT CASE 4 IS THE MOST REASONABLE DESIGN TO PURSUE?

A. Case 4 has a reasonable balance between EMF, audible noise impacts and costs. The lines are generally very quiet, emitting audible noise far below the most restrictive zone standard unless wet. Without burying the lines, Public Service cannot prevent the lines from becoming wet from time to time. When the lines are wet, the audible noise levels will be temporarily as high or slightly higher than the most restrictive zone.

The bundle of 1272 Kcmil ACSR “Bittern” will be slightly higher in cost than building the line with a bundle of 954 Kcmil ACSR “Cardinal”, but the larger conductor will allow for an increased power flow on the new circuit between Daniels Park and Waterton and allow for a reduction in audible noise to a level that is close to 50db(A) even when the line is wet.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

Attachment A

Statement of Qualifications
DANNY PEARSON

I graduated from the University of Nebraska with a BS degree in Electrical Engineering in 1976. Subsequently, I began my employment with Public Service Company of Colorado as a Staff Engineer. I am licensed as a Professional Engineer and Professional Land Surveyor in the State of Colorado. I have held positions of increasing responsibility in the Transmission Engineering Department throughout my career. In 1984-1985, I was acting Supervisor, Transmission Engineering. From 1990 to 1992 I was Supervisor of Transmission Engineering. I currently am a Principal Transmission Design Engineer in Transmission Engineering Department, providing the engineering services needed to construct new PSCo transmission lines as well as the engineering expertise required to maintain existing transmission facilities.

In the past ten years, I have been responsible for the design, construction and Project Management of over 400 miles of energized 345kV transmission lines (Texas – Colorado 345kV transmission line) and 76 miles of 345kV designed (operated at 230kV) double circuit transmission line (Daniels Park – Midway). I have been responsible for the design of over 100 miles of 345kV designed transmission lines (presently energized at 230kV) in the Colorado Front Range (Ft St Vrain – Green Valley and Green Valley – Spruce). I am presently designing a 115kV line and a 345kV line in Minnesota and South Dakota for Northern State's Power's Wind Project.