



IN THE MATTER OF THE
APPLICATION OF PUBLIC SERVICE
COMPANY OF COLORADO FOR A
CERTIFICATE OF PUBLIC
CONVENIENCE AND NECESSITY
FOR THE PAWNEE – SMOKY HILL
345KV TRANSMISSION PROJECT

DIRECT TESTIMONY
AND EXHIBITS
OF

DANNY J. PEARSON

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

**IN THE MATTER OF THE APPLICATION OF)
PUBLIC SERVICE COMPANY OF)
COLORADO FOR A CERTIFICATE OF) DOCKET NO.
PUBLIC CONVENIENCE AND NECESSITY)
FOR THE PAWNEE – SMOKY HILL 345KV)
TRANSMISSION PROJECT)**

**DIRECT TESTIMONY AND EXHIBITS OF
DANNY J. PEARSON**

INDEX

<u>SECTION</u>	<u>PAGE</u>
I. INTRODUCTION AND STATEMENT OF PURPOSE	3
II. PROJECT DESIGN	3
III. COLORADO REGULATORY REQUIREMENTS.....	7
IV. AUDIBLE NOISE.....	10
A. BPA/EPRI Noise Model.....	10
V. ELECTROMAGNETIC FIELD MITIGATION	20
A. Prudent Avoidance	21
B. Underground Versus Overhead Transmission Lines	22
C. Projected Electromagnetic Field Levels	26
VI. ALTERNATIVE CHOICES FOR ELECTROMAGNETIC FIELD AND NOISE	30
VII. RECOMMENDATIONS.....	32

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

**IN THE MATTER OF THE APPLICATION OF)
PUBLIC SERVICE COMPANY OF)
COLORADO FOR A CERTIFICATE OF)
PUBLIC CONVENIENCE AND NECESSITY) DOCKET NO.
FOR THE PAWNEE – SMOKY HILL 345KV)
TRANSMISSION PROJECT)**

DIRECT TESTIMONY AND EXHIBITS OF

DANNY J. PEARSON

1 I. INTRODUCTION AND STATEMENT OF PURPOSE

2 Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

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

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

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

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

10 A. I am testifying on behalf of Public Service Company of Colorado (“Public
11 Service” or the “Company”).

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

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

1 **Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?**

2 A. The purpose of my testimony is to address the transmission line design
3 criteria associated with the proposed Pawnee – Smoky Hill 345kV
4 Transmission Project ("the Project"), including structures, right-of-way
5 corridor, Electromagnetic Fields ("EMF"), audible noise, and prudent
6 avoidance measures. I also identify the specific findings regarding
7 electromagnetic field and audible noise levels that the Company is seeking in
8 this proceeding. In this case the Company is requesting that the Commission
9 find as reasonable, the audible noise levels associated with our
10 recommended design for the Pawnee – Smoky Hill Project as described in my
11 testimony. As indicated there, Public Service's recommended design for the
12 Project is expected to result in audible noise under wet conditions that is
13 below 50 dB(A) at the edge of the right-of-way for Section 1, but will result in
14 audible noise, under wet conditions, exceeding 50 dB(A) at the southern edge
15 of the Section 2 right-of-way and at both edges of the right-of-way for the last
16 mile into Smoky Hill Substation (Section 3). The Company also seeks a
17 finding consistent with the Commission's ruling in Docket No. 05A-072E and
18 Docket No. 07A-156E establishing a reasonableness level for
19 Electromagnetic Fields of 150 mG for this Project.

20 **II. PROJECT DESIGN**

21 **Q. PLEASE DESCRIBE THE PROPOSED TRANSMISSION LINE DESIGN**
22 **FOR THE PAWNEE – SMOKY HILL PROJECT.**

1 A. As described in the testimony of Mr. Stellern, the Project consists of three
2 sections. The first section (Section 1) consists of approximately 79 miles of
3 new transmission that will be constructed in new right-of-way. The second
4 section (Section 2) consists of approximately 15 miles of rebuilt transmission
5 utilizing an existing Public Service corridor. I will discuss those two sections
6 in more detail later. However, in addition to the two major sections, I will
7 discuss a smaller one-mile section (Section 3), which is just east of the
8 Smoky Hill Substation.

9 Section 1 consists of new transmission line in a new corridor. It will be
10 constructed as a new double circuit capable 345kV line but we will be
11 stringing only one circuit.

12 Section 2 will entail replacing an existing 230kV line with a double
13 circuit 345kV capable line. One of the circuits of this new double-circuit
14 transmission line will be the proposed Pawnee – Smoky Hill 345kV circuit.
15 The other circuit will be the pre-existing Pawnee – Smoky Hill 230kV circuit.

16 Section 3 is the last one-mile into the Smoky Hill Substation. This will
17 also require new transmission line to be built, but will utilize an existing Public
18 Service corridor. It will be constructed as a new double circuit capable 345kV
19 line but we will be stringing only one circuit.

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

22 A. Public Service has proposed a structure style and height that strikes a
23 reasonable balance among several factors. For many years the majority of all

1 345kV transmission lines were constructed on "lattice" towers. Public Service
2 ruled out using lattice towers on this right-of-way because of their larger
3 footprints and large visual appearance. Due to the right-of-way configuration
4 on the Pawnee – Smoky Hill Project, Public Service will utilize a standard
5 construction style on steel poles, with three sets of phase wires stacked in a
6 vertical configuration on each side of the pole, as depicted in my Exhibit No.
7 DJP-1. The support structure will be self-weathering steel similar in color to
8 wood poles. Typical structures for this Project should be 100-150 feet tall.
9 Exhibit No. DJP-2 shows the style of the structures as currently configured for
10 the existing Pawnee – Smoky Hill 230kV transmission line in Sections 1 and
11 2. Exhibit No. DJP-3 and Exhibit No. DJP-4 shows the typical proposed
12 structure configuration for Section 1 and 2, respectively.

13 Exhibit No. DJP-5 shows the style of the structure as currently
14 configured in the corridor of Section 3. Exhibit No. DJP-6 shows the typical
15 proposed structure configuration for Section 3.

16 The line will use low corona hardware to minimize audible noise.
17 Overall, Public Service engineers attempted to choose a structural style and
18 configuration that balances electrical, structural and aesthetic considerations.

19 **Q. WHY DID PUBLIC SERVICE CHOOSE STEEL AS THE MATERIAL FOR**
20 **THE SUPPORT STRUCTURES THAT ARE TO BE BUILT FOR THIS**
21 **PROJECT?**

22 A. Steel was chosen for the entire Pawnee – Smoky Hill Project because of its
23 structural capability. Wood is an inadequate material choice for a double-

1 circuit line at 345kV spacing dimensions and with multiple wires per phase.
2 Wood structures would have to be spaced much closer together in order to
3 carry the weight of the wires. If Public Service were required to use wood
4 poles, significantly more poles would be required than if the structures are
5 steel - possibly even twice the number of poles would be needed.

6 **Q. WHAT FACTORS DETERMINE INDIVIDUAL POLE HEIGHTS?**

7 A. Individual pole heights are determined by the terrain, span length, and sag of
8 the adjacent wire and the minimum clearances prescribed in the National
9 Electric Safety Code. Public Service uses a "buffer" above minimum
10 clearances to ensure continued safe operations. The buffer is usually about
11 3-5 feet. The support structures will be higher than the average where the
12 line crosses other electric lines or highly traveled roads. Some structures,
13 particularly those crossing over other electrical circuits, may need to be over
14 170 feet tall, but the taller towers are the exception and not the norm for this
15 project.

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

17 A. Because the Pawnee - Smoky Hill either parallels existing lines or replaces an
18 existing line, the choice for structure spacing for this Project is to place the
19 new structures in a similar location to where they were before the rebuild.
20 The new structures will be generally located adjacent to any parallel line
21 structures to minimize visual impacts and avoid a "picket fence" appearance.

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

1 A. Public Service chose self-weathering steel to minimize the metallic
2 appearance of the poles. This steel has a maintenance-free, earth tone color
3 that is similar to wood poles. It starts as a lighter orange-brown and changes
4 to a dark brown over time. Colors are a personal preference and a highly
5 debatable issue. Public Service has found that the public generally prefers
6 the self-weathering brown poles to an industrial gray galvanized finish. Public
7 Service rejected the idea of using a painted finish because paint systems
8 wear through and become unsightly over time. They must be repainted
9 periodically, resulting in additional expense and additional outage time for
10 repainting. The maintenance-free, earth tone color provides the least
11 objectionable color.

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

13 A. For Section 1, 200 feet of right-of-way will be procured for this project. For
14 Sections 2 & 3, Public Service already has adequate right-of-way to construct
15 the necessary transmission lines. The Section 2 corridor is at least 225 feet
16 wide. The Section 3 corridor is 210 feet in width.

17 III. COLORADO REGULATORY REQUIREMENTS

18
19 **Q. PLEASE DESCRIBE THE REQUIREMENTS OF 4 CCR 723-3102 (c) OF**
20 **THE CODE OF COLORADO REGULATIONS.**

21 A. Section 4 CCR 723-3102(c) ("Rule 3102(c)") of the Commission's Rules
22 Governing Electric Utilities requires a utility applying for a Certificate Of Public
23 Convenience and Necessity ("CPCN") for transmission facilities to describe its
24 proposed actions and techniques for cost-effectively mitigating noise

1 associated with the proposed facilities. The rule further requires the utility to
2 provide computer generated audible noise studies of the proposed
3 transmission line showing the potential noise levels expressed in dB(A) and
4 measured at the edge of the transmission right of way. Some of the
5 techniques recommended to achieve cost-effective audible noise mitigation
6 are larger conductors, bundled conductors, corona-free hardware, conductor
7 quality, handling and packaging, construction techniques, conductor tensions
8 and design alternatives considering the spatial arrangement of phasing of
9 conductors.

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

12 A. Public Service has based its preliminary design of the Project using 2-1272
13 kcmil ACSR "Bittern" conductor. This conductor was chosen based on the
14 increased capacity it created between Pawnee and Smoky Hill, which is
15 consistent with long-range studies. Designing the double circuits between
16 Pawnee and Smoky Hill using the 2-1272 kcmil ACSR "Bittern" conductor
17 also reduces noise, which supports Public Service's objective to balance a
18 number of issues such as audible noise, electromagnetic fields and
19 economics. Public Service believes choosing 2-1272 kcmil "Bittern"
20 conductor is a prudent and sound approach for this corridor. Public Service
21 chose to use "non-specular" wire, which reduces reflection, and adds to the
22 aesthetics at a small incremental cost.

1 The Project will employ a standard bundled conductor configuration
2 with corona-free hardware that has been used on several other projects. A
3 bundled configuration refers to the use of two wires per phase, in a vertical
4 configuration. The two wires per phase configuration has the benefit of
5 increased capacity while at the same time reducing the audible noise that
6 would occur with only one wire per phase. An alternative choice would be to
7 use only one larger conductor per phase. Public Service rejected the single
8 large conductor because it would provide less capacity and would emit
9 greater audible noise.

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

17 The conductor will be handled and packaged properly so as not to
18 damage it. The construction crews will use great care; they will use well
19 maintained equipment and proper construction techniques so as not to
20 damage the conductor. A damaged conductor can emit corona and thus emit
21 higher sound levels than an undamaged conductor. Proper line tensions will
22 be applied so as not to create a loose conductor; as with a damaged
23 conductor, a loose conductor emits higher sound levels than a conductor of

1 proper tension. By using these prudent techniques the transmission line will
2 operate as quietly as possible given the voltage and location. All of these
3 requirements are included in our Construction Specifications, which follow
4 IEEE standard 534, IEEE Guide to the Installation of Overhead Transmission
5 Line conductors.

6 There is no overhead construction technique that Public Service can
7 employ to prevent the transmission line from becoming wet. Therefore,
8 during wet periods, the transmission will emit audible noise at levels
9 substantially higher than fair weather levels. However, in Colorado, the wet
10 weather periods are relatively short-lived, as the Commission found in the
11 Comanche – Daniels Park Transmission Line docket.¹

12 IV. AUDIBLE NOISE

13
14 **Q. DID YOU PREPARE EXHIBITS TO ILLUSTRATE THE AUDIBLE NOISE**
15 **EXPECTED TO BE GENERATED FROM THE TRANSMISSION LINE?**

16 **A.** Yes. Exhibit Nos. DJP-7, DJP-9, and DJP -11 illustrate the expected audible
17 noise generated from Sections 1, 2 and 3 of the Pawnee - Smoky Hill Project,
18 respectively, based on the BPA/EPRI sound-modeling program.

19 **A. BPA/EPRI Noise Model**

20 **Q. WHAT METHOD DID YOU USE FOR DEVELOPING EXHIBIT NOS. DJP 7,**
21 **9 AND 11?**

¹ See Docket No. 05A-072E (Decision No. C06-0786 at ¶ 191, July 3, 2006) (“the characteristics of the noise are such that this level of noise [in wet or droplet conditions] is likely to occur relatively infrequently over the course of a year”).

1 A. I used a sound-modeling program developed by the Bonneville Power
2 Administration ("BPA") and the Electric Power Research Institute ("EPRI").
3 This program has also been used to calculate noise for previous CPCN
4 filings, including the Midway – Daniels Park 230kV Rebuild Project (Docket
5 No. 03A-276E, Decision No. C05-0051); the Comanche – Daniels Park 345kV
6 Transmission Project (Docket No. 05A-072E, Decision No. C06-0786); and
7 the Midway – Waterton 345kV Transmission Project (Docket No. 07A-156E,
8 Decision No. C07-750). The Commission accepted the methodology used in
9 each of those applications.

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

12 A. The audible noise modeling program used by Public Service consists of
13 empirical models that were developed using field-testing as the basis of
14 origin. Sound modeling is an inexact science, but it does provide good insight
15 or predictions on what corona-generated audible noise activity will likely
16 occur. BPA and EPRI did thousands of field measurements of transmission
17 power lines. They then plotted the graphs from those field results and
18 developed equations, algorithms and modeling, which consider the input
19 variables from the field tests. These audible noise modeling programs allow
20 Public Service to predict the audible noise that will be generated from a
21 proposed project by inputting variables such as the conductor and static wire
22 dimensions and spacing, the overall geometry of the project, the elevation of
23 the project, the operating voltage, and the rain rate. The models are

1 statistically based and provide output figures, which are the expected average
2 audible noise levels. Public Service used the same modeling algorithm in the
3 Midway – Daniels Park Rebuild Project (Docket No. 03A-276E), the
4 Comanche – Daniels Park Transmission Project (Docket No. 05A-072E), and
5 the Midway – Waterton Transmission Project (Docket No. 07A-156E) that I
6 used in developing Exhibit Nos. DJP-7, DJP-9, and DJP-11.

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

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

- 13 130-140 – Threshold of Pain
- 14 120-130 – Pneumatic chipper
- 15 110-120 – Loud audible horn (1 mi. distance)
- 16 100-110 – (no example)
- 17 90-100 – inside subway (New York)
- 18 80-90 – Inside motorbus
- 19 70-80 – Average traffic on street corner
- 20 60-70 – Conversational speech
- 21 50-60 – Typical business office
- 22 40-50 – Living room, suburban area
- 23 30-40 – Library

1 20-30 – Bedroom at night

2 10-20 – Broadcasting studio

3 0-10 – Threshold of hearing

4 **Q. IN YOUR OPINION, ARE THE SOUND MODELING CALCULATIONS THAT**
5 **YOU HAVE PROVIDED ACCURATE?**

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

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

18 A. I am.

19 **Q. PLEASE DESCRIBE THOSE ELEMENTS OR ASSUMPTIONS.**

20 A. The following elements were considered in the sound modeling of Public
21 Service’s proposed Project: a) the ENVIRO program calculating the
22 Bonneville Power algorithm, a recognized software program in the utility
23 industry typically used for sound analyses, was used; b) readings were

1 predicted for mid-span locations, at conductor low points, without the
2 influence of the transmission structures; c) maximum elevation of 6,000 feet
3 between Pawnee and Smoky Hill; d) the operating voltages are shown on the
4 exhibits; e) "wet" or "rain" signifies when water droplets were formed on the
5 line, the L50 curve is represented (a common statistical indicator); f) audible
6 noise reflection from the ground or other objects is not known (for example,
7 concrete amplifies sound by reflecting sound waves, whereas dirt or grass
8 conditions absorb sound waves or dampen audible noise); g) a "burn in"
9 period exists for a few months after new construction and the model predicts
10 audible noise after the "burn-in" period.

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

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

23 **Q. WHAT OTHER CONDITIONS AFFECT THE AUDIBLE NOISE LEVEL?**

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

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

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

13 A. All studies were based on the complete build out of each Section. For
14 Section 1 and 3 the studies modeled 2-230kV transmission lines and 2-345kV
15 transmission lines. For Section 2 the studies modeled 1-230kV transmission
16 line and 2-345kV transmission lines. Exhibit Nos. DJP-7, 9 & 11 set forth
17 Public Service's projections as to the audible noise that will be expected from
18 the Pawnee – Smoky Hill Project under both fair and wet/rainy weather
19 conditions. When there is moisture on the line, whether due to rain, snow or
20 fog, the audible noise-modeling program predicts that the audible noise levels
21 can be as high as 25 dB(A) higher than under fair weather conditions, until
22 the line dries. Over 100 different options were modeled to come up with the
23 cases I am submitting here.

1 **Q. PLEASE DESCRIBE THE PROCESS YOU USED TO COME UP WITH THE**
2 **100 DIFFERENT OPTIONS YOU MODELED FOR THIS PROJECT.**

3 A. The existing corridor for Section 1 and Section 2 has two single circuit 230kV
4 transmission lines (see Exhibit No. DJP-2), and the existing corridor for
5 Section 3 has a double circuit 230kV transmission line (see Exhibit No.DJP-
6 5). First, we modeled the existing lines to come up with current
7 electromagnetic field and audible noise values to base our new modeling
8 upon (all circuits at 230kV with existing phasing).

9 The phasing arrangement for the lines was the basis for a majority of
10 the different options considered. With the phasing for the existing lines held
11 constant, every combination of phasing for the new double circuit line was run
12 for each of the three Sections. Some of the variables that have an effect on
13 audible noise but do not change the electromagnetic field values are: A)
14 Vertical bundle spacers with 18" or 12" spacing (18" is our standard). B)
15 Conductor diameter or different types and number of conductors (2 conductor
16 bundle of 954 kcmil ACSR "Cardinal," 2 conductor bundle of 1272 kcmil
17 ACSR "Bittern," and a 3 conductor bundle of 636 kcmil ACSR "Grosbeak").

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

21 A. After all the runs were completed, the audible noise and the electromagnetic
22 field data was entered into a spreadsheet and saved as two different files
23 (one was titled "Magnetic Field" the other as "AN" (audible noise)). Each data

1 file was then sorted several different ways. For the “Magnetic Field” file, the
2 data was sorted: with the primary sort being on electromagnetic field values
3 and the secondary sort being for audible noise values.

4 The same process for the “AN” file was followed with the audible noise
5 values being the primary sort and the electromagnetic field values being the
6 secondary sort. The 100 different cases were then reduced to the different
7 cases based upon the lowest audible noise values (55 dB(A) or less).

8 These cases were then reviewed to see if any of the electromagnetic
9 field cases matched any of the AN cases. There were several cases that had
10 the lowest electromagnetic field values and audible noise levels below 55
11 dB(A). Our criteria for audible noise is 55 dB(A) or less at the edge of the
12 right-of-way (and, if possible, 50 dB(A) or less). For Sections 2 and 3 of the
13 line, we include four Cases for comparison. For Section 1 of line, we include
14 two Cases for comparison.

15 **Q. PLEASE EXPLAIN THE INFORMATION THAT IS SET FORTH ON YOUR**
16 **EXHIBIT Nos. DJP-7, 9 & 11.**

17 A. Exhibit Nos. DJP-7, 9 & 11 show the audible noise modeling associated with
18 the three different Sections for the Pawnee – Smoky Hill Project. Exhibit Nos.
19 DJP-7a, 9a & 11a predict the L5 average audible noise levels in fair weather
20 and Exhibit Nos. DJP-7b, 9b & 11b predict the average L50 audible noise
21 levels when the lines are wet. The wet/rainy weather models assume that the
22 line is saturated with moisture, and therefore predict the average worst-case

1 scenario. As lines begin to dry, from the heat of the current, from the sun and
2 wind, audible noise levels will decrease from the model predictions.

3 **Q. PLEASE EXPLAIN THE VERTICAL DOTTED LINES ON EXHIBIT NOS.**
4 **DJP-7, 9 AND 11.**

5 A. The vertical dotted lines are the edge of Public Service's existing/proposed
6 right-of-way. I show the edge of the right-of-way because this is the location
7 that the Commission rules specify is to be used to measure audible noise
8 limits for transmission lines.

9 **Q. WHAT IS THE LEGAL STANDARD THAT APPLIES TO NOISE LEVELS**
10 **FOR THIS PROJECT?**

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

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

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

22

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)	55dB(A)
Light Industrial	70 dB(A)	65 dB(A)
Industrial	80 dB(A)	75 dB(A)

1 However, in passing the new law allowing for PUC determination of
2 reasonable noise levels for electric transmission lines (§ 25-12-103(12)
3 described above), the General Assembly stated that it was a matter of
4 statewide interest and concern that the State of Colorado have an adequate,
5 reliable, and cost-effective electricity infrastructure to serve the needs of the
6 people of Colorado for their homes, businesses and industries. The general
7 assembly found that electric transmission facilities are linear and may pass
8 through several local jurisdictions and zoning districts. Therefore, the
9 General Assembly left it up to the Commission to determine whether the
10 predicted audible noise levels from proposed transmission facilities were
11 reasonable.

12 Public Service is proposing Case 1 (Section 1), Case 3 (Section 2) and
13 Case 7 (Section 3). As can be seen in Exhibit Nos. DJP-7a, 9a & 11a, when
14 the line is not wet, the predicted audible noise levels are well below the most
15 stringent limits set for residential zone use. When the lines are saturated with
16 moisture, as shown in Exhibit Nos. DJP-9b & 11b, the lines in Section 2 and
17 Section 3 will temporarily be noisier than the most stringent limits (50 dB(A))

1 set for residential zone use, but the audible noise will diminish as the line
2 dries. When the lines in Section 1 (Exhibit No. DJP-7b) are saturated with
3 moisture, the audible noise will be below the most stringent limits (50 dB(A))
4 set for residential zone use.

5 It should be noted that the most stringent residential noise limits (50
6 dB(A)) can be met for Section 2 (see Exhibit No. DJP-9b, Case 5) and
7 Section 3 (see Exhibit No. DJP-11b, Case 9), but the electromagnetic fields
8 will be significantly higher (3 to 4 times higher) to meet the 50 dB(A) value
9 (see Section 2, Exhibit Nos. DJP-10a, Case 5 and Section 3, DJP-12a, Case
10 9). Since most residences next to these Sections are located at least 100
11 feet or more from the edge of the existing right-of-way, and the audible noise
12 level for wet conductors is for relatively short periods of time, our preference
13 is for the lower electromagnetic fields associated with Cases 3 and 7, not
14 Cases 5 and 9. However, if the Commission determines that AN should
15 control (50 dB(A) or less), Public Service is willing to construct the line based
16 upon this criteria, i.e., construct Cases 5 and 9.

17 V. ELECTROMAGNETIC FIELD MITIGATION

18 **Q. CAN YOU DESCRIBE THE REQUIREMENTS OF SECTION 4 CCR 723-**
19 **3102(d) OF THE CODE OF COLORADO REGULATIONS?**

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

1 **A. Prudent Avoidance**

2 **Q. WHAT IS PRUDENT AVOIDANCE?**

3 A. Prudent Avoidance “means the striking of a reasonable balance between the
4 potential health effects of exposure to electromagnetic fields and the cost and
5 impacts of mitigation of such exposure, by taking steps to reduce the
6 exposure at a reasonable and modest cost. “ Rule 3102(d).

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

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

15 In this case Public Service proposes to use two basic avoidance
16 techniques. First, Public Service has studied and will use the technique of
17 reverse phasing (referenced in the Commission rule as “design alternatives
18 considering the arrangement of phasing of conductors”). The reverse
19 phasing application will reduce the electromagnetic fields created by the
20 Project.

21 The second minimization avoidance technique Public Service can
22 reasonably employ for the Project is the use of higher structures. The
23 structures that we will use are about five feet higher than the minimums

1 required for ground clearance by the National Electric Safety Code. This
2 small height increase will provide an additional electromagnetic field reduction
3 along with increased safety clearances.

4 For Section 2 of the Pawnee – Smoky Hill Project, Public Service plans
5 to use its existing right-of-way to upgrade the existing 230kV single circuit
6 transmission line to a double circuit 345kV capable transmission line. For
7 Section 3 of the Project, Public Service plans to use its existing right-of-way to
8 construct a new double-circuit 345kV capable transmission line. As such, the
9 prudent avoidance measures that would be used in acquiring new right-of-
10 way, like for Section 1, are not applicable for Sections 2 and 3. The existing
11 Pawnee - Smoky Hill corridor (Section 2) is 225 feet in width and the existing
12 corridor for Section 3 is 210 feet in width. This width is more than sufficient to
13 support the lines and to keep electromagnetic fields and audible noise within
14 reasonable levels. Concerning Sections 2 and 3 of the Project, the populated
15 areas grew up around the existing transmission corridor. Therefore,
16 additional widening of the right-of-way in Sections 2 and 3 could require the
17 condemnation of property, which would be very expensive and unpopular,
18 and is not recommended by Public Service. For Section 1 of line, Public
19 Service models reflect its proposal of purchasing an additional 200 feet of
20 right-of-way adjacent to the existing right-of-way. Burial of the line, which is
21 listed as an avoidance technique in Section 3102(d), is also not available at a
22 reasonable or modest cost.

23 **B. Underground Versus Overhead Transmission Lines**

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

3 A. Constructing transmission lines underground is often perceived as a way to
4 accomplish the electrical objectives of a transmission project while minimizing
5 environmental impacts. However, undergrounding entails significant costs as
6 well as significant environmental and technological impacts associated with
7 burying the transmission line. Also, underground transmission lines do not
8 eliminate electromagnetic fields; the lines simply have a different
9 electromagnetic field profile that is more concentrated. When looking at a
10 electromagnetic field cross-section profile of an overhead transmission line, it
11 is generally a bell-shaped curve with low value tails that dissipate with
12 distance. The electromagnetic field cross-section profile for an underground
13 line is shaped like a sharp spike and the tails dissipate much quicker on the
14 sides. This means the electromagnetic field associated with underground
15 transmission is elevated and concentrated in a much tighter band.

16 In addition, placing a high voltage transmission line underground
17 requires electrically insulating each of the three phases (wires) and
18 dissipating the heat generated by the wires. Public Service generally uses
19 underground construction with low voltage distribution lines that operate at
20 25kV or less. At these relatively low voltages, the problems of electrically
21 insulating each wire and dissipating the heat generated by the wires is not a
22 concern. With lines of greater voltage, such as those associated with this

1 Project, material costs, construction costs and the heating of the wire all
2 become a greater concern.

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

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

11 A. Historically, the cost of constructing a high voltage line underground can be
12 up to ten times as expensive as overhead construction. When planning to
13 construct high voltage, underground transmission lines in rolling hills and
14 rugged terrain, such as exists along the transmission path for this Project, the
15 engineering and technical challenges may increase the cost to more than ten
16 times that of overhead construction. Public Service only considers
17 underground construction if the difference in cost between overhead
18 construction and underground construction is paid for by those requesting it
19 or if technical constraints make it impossible to construct the line overhead.
20 Out of a total of over 4,000 miles of transmission lines, Public Service has
21 only about 50 miles of transmission lines constructed underground, most of
22 which are in high load and density areas and in and around airports.

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

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

16 A. The impacts of underground transmission lines on soils, surface water,
17 vegetation and wildlife resources are usually greater than those of a similarly
18 located overhead line. This is because any underground technology used
19 would require a continuous trench 4 feet wide by 5 or more feet deep with
20 intermediate vaults 7 feet wide by 20 feet long every 2,000 to 3,000 feet.
21 Additional tree and vegetation cutting within the right-of-way would be
22 required to facilitate construction and overland travel of equipment.

1 Additionally, all rivers, streams and wetland areas must be crossed with
2 equipment and a trench excavated through them to required specifications.

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

9 **C. Projected Electromagnetic Field Levels**

10 **Q. WHAT ARE THE ELECTROMAGNETIC FIELD LEVELS ASSOCIATED**
11 **WITH THE PROJECT?**

12 A. The Electromagnetic Field curves shown in Exhibit Nos. DJP-8, 10 and 12
13 provide an accurate representation of electromagnetic field levels, using the
14 preliminary design of what can be expected during daily peaks in the near
15 future. Electromagnetic fields are directly proportional to the electric current
16 flowing in the conductor. The load used to calculate the transmission line
17 electromagnetic fields is developed from projected system normal peak
18 conditions. Higher currents could occur under certain system operating
19 conditions; however, for the vast majority of time, Pawnee – Smoky Hill
20 project operations will be at steady state.

21 **Q. PLEASE DESCRIBE WHAT YOU HAVE DEPICTED ON EXHIBIT NOS.**
22 **DJP-8, 10 AND 12.**

1 A. Exhibit Nos. DJP-8, 10 & 12 show the electromagnetic field model results for
2 the same Cases as were presented for audible noise (Section 1 - Case 1,
3 Section 2 - Case 3, and Section 3 – Case 7). The electromagnetic fields from
4 the existing facilities are shown by the thick solid blue lines on each graph.
5 The vertical dotted lines show the edge of Public Service’s existing/proposed
6 right-of-way. As I stated previously, over 100 different options were modeled
7 to come up with the cases I am presenting here.

8 The Project proposed by Public Service is shown in the
9 Electromagnetic Field graphs, Section 1 (DJP-8a - Case 1), Section 2 (DJP-
10 10a - Case 3), and Section 3 (DJP-12a - Case 7). Electromagnetic field
11 levels will be slightly lower than the levels that exist today on this corridor for
12 the Cases proposed by Public Service, as shown in Exhibit Nos. DJP-8a -
13 Case 1, DJP-10a - Case 3 and DJP-12a - Case 7. If the alternate Cases to
14 lower the audible noise levels below 50 dB(A) at the edge of right-of-way
15 (Section 2 - Case 5 & Section 3 – Case 9) are utilized, the electromagnetic
16 field levels will be significantly higher than what exists today on the corridor,
17 see Exhibit Nos. DJP-10a - Case 5 and DJP-12a - Case 9. (As noted above,
18 no alternate Case is presented for Section 1 because it is below 50 dB(A) as
19 proposed.)

20 **Q. WHY DID YOU MODEL DIFFERENT CONFIGURATIONS FOR**
21 **ELECTROMAGNETIC FIELD?**

22 A. Public Service examined various configurations for the Pawnee - Smoky Hill
23 Project to determine the configuration that has a reasonable balance for

1 lowering both electromagnetic fields and audible noise. As explained by other
2 Public Service witnesses, after this Project is constructed, the Pawnee -
3 Smoky Hill corridor will contain: Section 1 - one double circuit 345kV capable
4 facility (only one circuit constructed & energized at 345kV) and two single
5 circuit 230kV capable facilities; Section 2 - one double circuit 345kV capable
6 facility (one circuit energized at 230kV & one circuit energized at 345kV), and
7 one single circuit 230kV capable facility; and Section 3 - one double circuit
8 345kV capable facility (only one circuit constructed and energized at 345kV),
9 and one double circuit 230kV capable facility. In all these cases (audible
10 noise and electromagnetic fields), I looked at the effects of operating both of
11 the 345kV capable circuits at 345kV. The Project proposed by Public
12 Service's Application is represented as Electromagnetic Field Curves Exhibit
13 Nos. DJP-8a - Case 1, DJP-10a - Case 3 & DJP-12a - Case 7.

14 **Q. YOUR ELECTROMAGNETIC FIELD MODELING IS BASED UPON**
15 **TYPICAL 2015 LOAD FLOWS. COULD THE POWER FLOWS AND**
16 **RESULTING ELECTROMAGNETIC FIELD VALUES ON THE LINE BE**
17 **HIGHER?**

18 A. Yes. Although we believe the models represent typical flows and
19 electromagnetic field values for many years to come, the lines have the
20 potential to carry higher flows, and therefore electromagnetic field values.

21 **Q. WHAT WOULD YOU EXPECT THE MAXIMUM POSSIBLE LINE FLOWS**
22 **AND ELECTROMAGNETIC FIELD VALUES TO BE?**

1 A. Each of the lines will be constructed to carry approximately 2900 amps. As a
2 general rule, Public Service operators would only allow enough power to flow
3 on each line so that if one of the lines is lost (N-1), the remaining line will only
4 carry its rated power of 2900 amps. Therefore, the highest continuous
5 loading for each line under system intact conditions would be half of that, or
6 1450 amps. Although we don't expect to ever see these types of flows, we
7 modeled each of our proposed Cases (Case 1, Case 3 & Case 7) and
8 alternate Cases (Case 5 & Case 9) using this maximum potential loading
9 scenario. For Section 1, Exhibit No. DJP-8a shows a comparison of our
10 proposed Case 1 and maximum potential loading Case 2. For Section 2,
11 Exhibit No. DJP-10a shows a comparison of our proposed Case 3 and
12 maximum potential loading Case 4, alternate Case 5 (lower audible noise but
13 higher electromagnetic fields), and alternate maximum potential loading Case
14 6. For Section 3, Exhibit No. DJP-12a shows a comparison of our proposed
15 Case 7 and maximum potential loading Case 8, alternate Case 9 (lower
16 audible noise – higher electromagnetic fields), and alternate maximum
17 potential loading Case 10. Again, it should be noted that these loadings are
18 not likely. Due to the nature of the regional transmission system, we wouldn't
19 expect to transfer that much power between the Pawnee and Smoky Hill
20 Substations.

21 **Q. HAVE ANY STATES OR AGENCIES IN THE UNITED STATES**
22 **ESTABLISHED ELECTROMAGNETIC FIELD EXPOSURE LIMITS?**

1 A. Yes. Two states, Florida and New York, have set electromagnetic field
2 exposure limit values, as measured at the edge of right-of-way. In Florida, a
3 range from 150 to 250 milli-Gauss (mG) exists for transmission lines ranging
4 in voltage from 69 to 500kV, and in New York an electromagnetic field value
5 of 200 mG is the limit for any transmission line regardless of voltage. In
6 addition, the American Conference of Governmental Industrial Hygienists²
7 has set a not-to-exceed value of 10,000 mG for occupational exposure, and
8 1,000 mG for those workers with pacemakers. The International Commission
9 on Non-Ionizing Radiation Protection³ has set exposure limits of 4,200 mG for
10 occupational exposure and 833 mG for the general public.

11 **VI. ALTERNATIVE CHOICES FOR ELECTROMAGNETIC FIELD AND NOISE**

12 **Q. PLEASE EXPLAIN THE DIFFERENCES IN CASES.**

13 A. All the cases run for this Project utilize a typical two conductor bundle with
14 1272 kcmil ACSR "Bittern" with 18" vertical bundle spacing. This
15 configuration, for Cases 1, 3 and 7, provide an electromagnetic field value
16 less than the existing line. However, the configuration for Section 3 (Case 7)
17 has wet/rainy L50 audible noise levels of more than 50 dB(A) on both edges
18 of right-of-way (50.1 dB(A) & 52.7 dB(A)), and the configuration for Section 2
19 (Case 3) has wet/rainy L50 audible noise levels of more than 50 dB(A) on the

² 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.

³ The International Commission on Non-Ionizing Radiation Protection is an organization of 15,000 scientists from 40 nations who specialize in radiation protection.

1 southern edge of right-of-way (52.2 dB(A)). Section 1 (Case 1) has wet/rainy
2 L50 audible noise levels less than 50 dB(A) at the edge of right-of-way.

3 For Sections 2 and 3 of this project, a 12" vertical bundle spacing was
4 also considered. The 12" vertical bundle spacing would reduce the audible
5 noise level by 0.7 dB(A) at the edge of right-of-way.

6 **Q. HOW DO THE AUDIBLE NOISE VALUES THAT YOU PRESENT ON YOUR**
7 **EXHIBIT NOS. DJP-7, 9 AND 11 FOR THIS PROJECT COMPARE WITH**
8 **THE AUDIBLE NOISE LEVELS ASSOCIATED WITH OTHER HIGH**
9 **VOLTAGE LINES ON PUBLIC SERVICE SYSTEM?**

10 A. Public Service uses similar techniques as those described here to mitigate
11 audible noise when it constructs all of its high voltage transmission lines.
12 However, as I indicated earlier, audible noise levels from a particular facility
13 are dependent upon numerous factors, such as voltage level, altitude,
14 surrounding structures, line configuration and ground cover. Therefore, it
15 would not be appropriate to use the audible noise levels in Exhibit Nos. DJP-
16 7, 9 & 11 as the expected audible noise levels from any other line. However,
17 in constructing this Pawnee to Smoky Hill Project, Public Service is using
18 good utility practices to employ reasonably prudent techniques to minimize
19 audible noise impacts.

20 **Q. ARE THERE RISKS ASSOCIATED WITH REBUILDING A LINE IN AN**
21 **EXISTING CORRIDOR, SUCH AS PUBLIC SERVICE IS PLANNING FOR**
22 **THE PAWNEE – SMOKY HILL PROJECT?**

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

11 VII. RECOMMENDATIONS

12 **Q. GIVEN ALL YOUR STUDIES, WHY DOES PUBLIC SERVICE BELIEVE**
13 **THAT CASE 1, CASE 3 AND CASE 7 ARE THE MOST REASONABLE**
14 **DESIGNS TO PURSUE?**

15 A. Cases 1, 3 and 7 represent a reasonable balance between electromagnetic
16 fields, audible noise impacts and costs. The lines are generally very quiet,
17 emitting audible noise far below the most restrictive zone standard unless
18 wet. Without burying the lines, Public Service cannot prevent the lines from
19 becoming wet from time to time. When the lines are wet, the audible noise
20 levels will be temporarily higher than the most restrictive zone but have
21 significantly lower electromagnetic field values than alternate Cases that meet
22 the 50 dB(A) at edge of right-of-way.

1 **Q. WHAT FINDING IS THE COMPANY ASKING THE COMMISSION TO MAKE**
2 **IN THIS PROCEEDING?**

3 A. The Company is requesting that the Commission approve the recommended
4 design of the Pawnee – Smoky Hill Project as described in my testimony.
5 The Company also seeks a finding consistent with the Commission’s ruling in
6 Docket No. 05A-072E and Docket No. 07A-156E establishing a
7 reasonableness level of 150 mG for this project.

8 **Q. WHY DOES THE COMPANY BELIEVE IT IS APPROPRIATE TO**
9 **ESTABLISH THE SAME ELECTROMAGNETIC FIELD**
10 **REASONABLENESS LEVEL FOR THIS PROJECT AS IT DID FOR THE**
11 **COMANCHE – DANIELS PARK TRANSMISSION PROJECT AND THE**
12 **MIDWAY – WATERTON TRANSMISSION PROJECT?**

13 These projects are very similar in design. All of these lines are designed to
14 accommodate a double circuit 345kV capacity. In addition, just as in the case
15 of the Comanche – Daniels Park and Midway – Waterton Transmission
16 Projects, while the estimated electromagnetic field levels under typical
17 projected peak power flows are significantly below 150 mG at the edge of
18 right of way, the Company’s Alternate Loading Cases 2, 4, 6, 8 & 10 show
19 that electromagnetic field levels could increase to as high as 97.4 mG at the
20 edge of right of way at maximum loadings (one half of the lines’ rated
21 capacity). Given these modeling results and the electromagnetic field limits
22 that have been prescribed in other jurisdictions and for the Comanche-
23 Daniels Park and Midway – Waterton Transmission Projects, the Company

1 seeks the same reasonableness finding as the Commission made in those
2 cases.

3 **Q. DOES THIS CONCLUDE YOUR TESTIMONY?**

4 **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 Public Service 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 have completed construction of a 115kV line and a 345kV line in Minnesota and South Dakota for Northern State's

Power's Wind Project. We have started construction on a 120 mile, 345kV line, Comanche – Daniels Park for the Comanche 3 power plant in Pueblo.