BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO

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IN THE MATTER OF THE APPLICATION	**)**	
OF PUBLIC SERVICE COMPANY OF	**)**	
COLORADO FOR A CERTIFICATE OF	**)**	
PUBLIC CONVENIENCE AND	**)**	
NECESSITY FOR COLORADO'S POWER	**)**	**PROCEEDING NO. 21A-XXXXE**
PATHWAY 345 KV TRANSMISSION	**)**	
PROJECT AND ASSOCIATED FINDINGS	**)**	
REGARDING NOISE AND MAGNETIC	**)**	
FIELD REASONABLENESS	**)**	

DIRECT TESTIMONY AND ATTACHMENTS OF BYRON R. CRAIG

ON

BEHALF OF

PUBLIC SERVICE COMPANY OF COLORADO

March 2, 2021

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

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IN THE MATTER OF THE APPLICATION	**)**	
OF PUBLIC SERVICE COMPANY OF	**)**	
COLORADO FOR A CERTIFICATE OF	**)**	
PUBLIC CONVENIENCE AND NECESSITY	**)**	
FOR COLORADO'S POWER PATHWAY	**)**	**PROCEEDING NO. 21A-XXXXE**
345 KV TRANSMISSION PROJECT AND	**)**	
ASSOCIATED FINDINGS REGARDING	**)**	
NOISE AND MAGNETIC FIELD	**)**	
REASONABLENESS	**)**	

DIRECT TESTIMONY AND ATTACHMENTS OF BYRON R. CRAIG

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF ATTACHMENTS

Attachment BRC-1	Typical Structure Drawing
Attachment BRC-2	Electric One-Line Diagram of Pathway Project
Attachment BRC-3	Electric One-Line Diagrams of Pathway Project Substations
Attachment BRC-4	General Arrangements of Pathway Project Substations
Attachment BRC-5	Electric One-Line Diagram of May Valley-Longhorn Extension
Attachment BRC-6	Electric One-Line Diagrams of May Valley-Longhorn Extension Substations
Attachment BRC-7	General Arrangements of May Valley-Longhorn Extension Substations
Attachment BRC-8	Colorado's Power Pathway, 345 kV Line Audible Noise & Magnetic Field Report, prepared by POWER Engineers, February 26, 2021
Attachment BRC-9	Colorado's Power Pathway, Substation Magnetic Field and Audible Noise Study, prepared by POWER Engineers, February 26, 2021
Attachment BRC-10	May Valley-Longhorn Extension of Colorado's Power Pathway Project, Magnetic Field and Audible Noise Study, prepared by POWER Engineers, February 26, 2021

GLOSSARY OF ACRONYMS AND DEFINED TERMS

Acronym/Defined Term	Meaning
3D	Three Dimensional
ACSR	Aluminum conductor steel-reinforced
BPA	Bonneville Power Administration
CadanaA	Computer Aided Noise Abatement software package
CAFEP	Corona and Field Effects Program
CDEGS	Current Distribution, Electromagnetic fields, Grounding and Soil
Commission	Colorado Public Utilities Commission
CPCN	Certificate of Public Convenience and Necessity
dBA	A-weighted decibels
Extension	May Valley-Longhorn Extension
Hz	Hertz
kV	Kilovolt
mG	Milligauss
MVA	Mega Volt Amp
NESC	National Electric Safety Code
OPGW	Optical Ground Wire

Acronym/Defined Term	**Meaning**
Pathway Project or Project	Power Pathway 345 kV Transmission Project
PEARs	Power Engineers Analysis Reports
PEI	Power Engineers, Inc.
Public Service or Company	Public Service Company of Colorado
ROW	Right of Way
T2	Twisted pair 556 ACSR Dove conductors
Xcel Energy	Xcel Energy Inc.
XES or Service Company	Xcel Energy Services Inc.

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 FOR COLORADO'S POWER PATHWAY 345 KV TRANSMISSION PROJECT AND ASSOCIATED FINDINGS REGARDING NOISE AND MAGNETIC FIELD REASONABLENESS	**))))) PROCEEDING NO. 21A-XXXXE))))**

DIRECT TESTIMONY AND ATTACHMENTS OF BYRON R. CRAIG

I. INTRODUCTION, QUALIFICATIONS, AND PURPOSE OF TESTIMONY

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Byron R. Craig and my business address is 1800 Larimer Street, Suite 500, Denver, Colorado 80202.

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

A. I am employed by Xcel Energy Services Inc. ("XES") as Director, Substation & Transmission Engineering and Design in the Transmission business. XES is a wholly owned subsidiary of Xcel Energy Inc. ("Xcel Energy") and provides an array of support services to Public Service Company of Colorado ("Public Service" or the "Company") and the other utility operating company subsidiaries of Xcel Energy on a coordinated basis.

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

A. I am testifying on behalf of Public Service.

Q. PLEASE SUMMARIZE YOUR RESPONSIBILITIES AND QUALIFICATIONS.

A. As the Director of the Substation and Transmission Engineering organization, I am responsible for engineering and design functions for transmission lines and transmission and distribution substations. A description of my qualifications, duties, and responsibilities is included after the conclusion of my testimony in my Statement of Qualifications.

Q. WHAT IS THE PURPOSE OF YOUR DIRECT TESTIMONY?

A. The purpose of my Direct Testimony is to support the Company's Application for a Certificate of Public Convenience and Necessity ("CPCN") for Colorado's Power Pathway 345 kilovolt ("kV") Transmission Project ("the Project" or "the Pathway Project") from an engineering and design perspective. In doing so, I will discuss the following topics in my Direct Testimony:

- The planned engineering design of the Project, including the planned transmission structures and conductor; the planned new and expanded substations; and re-termination of the existing facilities;
- Alternative engineering designs considered;
- Key engineering design assumptions that informed the Project's cost estimates; and
- The results of the noise and magnetic field analyses that were performed for the Project.

The Company is also requesting that the Commission find that consistent with Commission Rules 3206(e) and (f), the expected maximum noise and magnetic field levels associated with the Project are reasonable and require no further mitigation or prudent avoidance measures.

Q. ARE YOU SPONSORING ANY ATTACHMENTS AS PART OF YOUR DIRECT TESTIMONY?

A. Yes. I am sponsoring Attachments BRC-1 through BRC-10, which are described as follows:

- Attachment BRC-1 is a typical double circuit structure drawing;
- Attachment BRC-2 is an electric one-line diagram of the Pathway Project;
- Attachment BRC-3 includes electric one-line diagrams of the seven Power Pathway substations;
- Attachment BRC-4 includes General Arrangement drawings of the seven Power Pathway substations;
- Attachment BRC-5 is an electric one-line diagram of the Pathway Project and the May Valley-Longhorn Extension;
- Attachment BRC-6 includes electric one-line diagrams of the May Valley-Longhorn Extension substations;
- Attachment BRC-7 includes General Arrangement drawings of the May Valley-Longhorn Extension substations;
- Attachment BRC-8 is the Colorado's Power Pathway 345 kV Transmission Line Audible Noise & Magnetic Field Report, prepared by POWER Engineers, dated February 26, 2021;
- Attachment BRC-9 is the Colorado's Power Pathway Substation Magnetic Field and Audible Noise Study, prepared by POWER Engineers, dated February 26, 2021; and
- Attachment BRC-10 is the May Valley-Longhorn Extension of Colorado's Power Pathway Project Magnetic Field and Audible Noise Study, prepared by POWER Engineers, dated February 26, 2021.

II. PATHWAY PROJECT DESIGN

Q. WHAT IS THE PURPOSE OF THIS SECTION OF YOUR TESTIMONY?

A. The purpose of this section of my Direct Testimony is to provide an overview of the planned design for: (1) the transmission line components of the Project, and (2) the new and expanded substation facilities. First, I describe the transmission line design, including structure types and configuration, and the planned conductor type. Next, I describe the design and equipment associated with the new and expanded substations. In this section of my Direct Testimony, I also discuss engineering design considerations that the Company has evaluated and will continue to evaluate.

Q. PLEASE PROVIDE A BRIEF DESCRIPTION OF THE PROJECT AND THE TRANSMISSION FACILITIES PUBLIC SERVICE IS PLANNING TO CONSTRUCT.

A. The Pathway Project involves constructing an approximately 560-mile, 345 kV double circuit transmission network between seven substations. The Project will connect the Front Range to areas of northeastern, eastern, and southeastern Colorado that are rich with renewable energy resource development potential, but do not currently have a backbone[1] network transmission system that can integrate new renewable energy resources. The northern terminus of the Pathway Project will be at the Company's existing Fort St. Vrain Substation

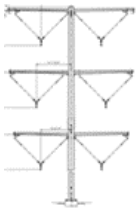
[1] A "backbone" system generally refers to bulk transmission lines networked together that can move large amounts of energy from a distant location to load areas. Backbone transmission systems support the reliability of the transmission system because of the networked nature of these systems. A grid supported by backbone transmission is better positioned to withstand outages without losing generation resource or load.

(located at the Fort St. Vrain Generating Station) in Platteville in western Weld County. The Pathway Project then extends east to a new Canal Crossing Substation near the existing Pawnee Substation and Pawnee Generating Station; then extends east/southeast to a new Goose Creek Substation south of the City of Burlington; then extends south to a new May Valley Substation northeast of the City of Lamar; then extends west to the planned Tundra Substation near the Comanche Generating Station. The Project then extends north to the Company's existing Harvest Mile Substation, located adjacent to the City of Aurora in Arapahoe County. The Project also involves expansion of the Fort St. Vrain, Pawnee, and Harvest Mile Substations; expansion of the planned but not yet in-service Tundra Substation; and construction of the new Canal Crossing, Goose Creek, and May Valley Substations. The three new substations will be 345 kV switching stations.[2] An electric one-line diagram of the Project is included as Attachment BRC-2 to my Direct Testimony.

For purposes of its CPCN filing, the Company presents and describes the transmission line Project in five segments (Segments 1 through 5) between the existing or new substations. The Project Segments and components are summarized in Table BRC-D-1 below.

[2] A switching station is a type of substation that operates at a single voltage level (and, therefore, does not have transformers that change or "transform" voltage from one voltage level to another).

Table BRC-D-1: Project Segment Description Overview

Project Segment	Project Segment Description (approximate length in miles)
All Segments	**Colorado's Power Pathway 345 kV Transmission Project** Total 560 miles
	➢ The Project consists of five transmission line segments (Segments 1-5) as detailed below, with each segment bounded by substations. <u>Transmission Facilities:</u> ➢ The overall Project involves construction of approximately 560 miles of new 345 kV double circuit transmission line in new 150-foot wide right of way. ➢ Each segment of transmission line will be constructed using single pole, double circuit tangent structures (see typical structure diagram at left) and two-pole dead-end structures. The Project will utilize two-bundle 1272 kcmil ACSR Bittern conductor. <u>Substation Facilities:</u> ➢ The Project involves expansion of three existing substations (Fort St. Vrain, Pawnee, and Harvest Mile), expansion of a planned substation (Tundra), and construction of three new substations which will be 345 kV switching stations (Canal Crossing [near and interconnected to existing Pawnee Substation], Goose Creek [near and interconnected to Cheyenne Ridge Wind Project, and May Valley [near but not interconnected to existing Lamar Substation]).
Fort St. Vrain Substation expansion	**Expand existing Fort St. Vrain Substation**: The existing 230 kV Fort St. Vrain Substation will be expanded, and a new 345 kV station arrangement will be established on land currently owned by Public Service.

Segment 1	**Fort St. Vrain Substation to Canal Crossing / Pawnee Substations** 75 miles
	Segment 1 involves constructing approximately 75 miles of new 345 kV double circuit transmission line from the existing Fort St. Vrain Substation to the new Canal Crossing and existing Pawnee Substations.
Canal Crossing Substation new construction	**Construct New Canal Crossing Substation:** A new 345 kV switching station will be constructed adjacent to the existing Pawnee Substation to accommodate new 345 kV line terminations and equipment on land currently owned by Public Service. The new Canal Crossing Substation is essentially an expansion of the Pawnee Substation and will interconnect to the Pawnee Substation *via* two short transmission ties.
Pawnee Substation expansion	**Expand existing Pawnee Substation:** The existing 345 kV Pawnee Substation will be expanded to accommodate new 345 kV line terminations and equipment on land currently owned by Public Service.

Segment 2	**Canal Crossing / Pawnee Substations to Goose Creek Substation** 160 miles
	Segment 2 involves constructing approximately 160 miles of new 345 kV double circuit transmission line from the new Canal Crossing and existing Pawnee Substations to a new 345 kV Goose Creek Substation located near the existing Cheyenne Ridge Wind Project.
Goose Creek Substation new construction	**Construct New Goose Creek Substation:** A new 345 kV switching station will be constructed on approximately 40 acres of land to be acquired by Public Service near the existing Cheyenne Ridge Wind Project. The new switching station will accommodate new 345 kV line terminations and equipment. This substation will electrically tap the Shortgrass – Cheyenne Ridge West line to effectively network the Rush Creek Gen-Tie.
Segment 3	**Goose Creek Substation to May Valley Substation** 65 miles
	Segment 3 involves constructing approximately 65 miles of new 345 kV double circuit transmission line from the new Goose Creek Substation to a new 345 kV May Valley Substation.
May Valley Substation new construction	**Construct New May Valley Substation:** A new 345 kV switching station will be constructed on approximately 40 acres of land to be acquired by Public Service near the existing Lamar Substation. The new switching station will accommodate new 345 kV line terminations and equipment, but will not interconnect to the existing Lamar Substation.

Segment 4	**May Valley Substation to Tundra Substation** 140 miles
	Segment 4 involves constructing approximately 140 miles of new 345 kV double circuit transmission line from the new May Valley Substation to the planned Tundra Substation.
Tundra Substation expansion	**Tundra Substation:** The Tundra Substation is a 345 kV switching station planned to interconnect a solar with storage project approved as part of the Company's approved Colorado Energy Plan Portfolio that will be in service by the end of 2022. This Project will expand the planned Tundra Substation to accommodate new 345 kV line terminations and equipment. No new land acquisition is required for the expansion.
Segment 5	**Tundra Substation to Harvest Mile Substation** 120 miles
	Segment 5 involves constructing approximately 120 miles of new 345 kV double circuit transmission line from the Tundra Substation to the existing Harvest Mile Substation.
Harvest Mile Substation expansion	**Harvest Mile Substation:** The existing 345 kV Harvest Mile Substation will be expanded to accommodate new 345 kV terminations and equipment. No new land acquisition is required for the expansion.

Q. BEFORE DESCRIBING THE DESIGN OF THE PROJECT, PLEASE PROVIDE AN OVERVIEW OF THE COMPANY'S ENGINEERING DESIGN PROCESS.

A. As part of the preliminary engineering design process, the transmission engineering team compiled data from all 345 kV transmission line projects completed by Xcel Energy in the last five years. As described in the Direct Testimony of Ms. Brooke A. Trammell, Xcel Energy has a well-established history of successfully developing, constructing, and managing large-scale transmission projects across our eight-state footprint, including hundreds of miles of recently constructed 345 kV transmission lines in our upper Midwest service

area, in Texas and New Mexico, and here in Colorado. Specifically, Public Service's more recent experience with complex, large-scale projects include the 115-mile, 345 kV Pawnee-Daniels Park project plus substations (approved in Proceeding No. 14A-0287E), the 90-mile, 345 kV Rush Creek Gen-Tie plus substations (approved in Proceeding No. 16A-0117E), and the 70-mile, 345 kV Rush Creek Gen-Tie extension plus substations (approved in Proceeding No. 18A-0905E). The transmission engineering team also conducted preliminary desktop soil analysis,[3] developed preliminary structure design, engaged with existing vendors to obtain preliminary pricing on major components (e.g., steel poles, conductor, etc.), and received high-level pricing input from construction vendors. The substation engineering team developed conceptual general arrangements, obtained preliminary vendor pricing, and conferred with construction subject matter experts. This preliminary work formed the basis of the inputs and assumptions to develop the overall cost estimates for the Pathway Project as detailed by Company witness, Mr. Brian J. Richter.

A. <u>Transmission Line Facilities</u>

Q. DESCRIBE THE DESIGN AND CONFIGURATION OF THE TRANSMISSION STRUCTURES FOR THE PROJECT.

A. The Pathway Project will include double circuit, back to back, vertical stack, single pole structures for the tangent structures. A typical structure drawing is provided as Attachment BRC-1 to my Direct Testimony. Small to medium angle

[3] A desktop soil analysis is a study using publicly available data to provide guidance on potential soils encountered and any major impacts (e.g., rock, karst pockets, high water table, etc.). Soil borings will be required once the route is determined to complete final design of the foundations.

structures will also be single pole with a similar geometry. Dead-end structures and large angles will be two pole structures, one for each circuit, which is generally more cost-effective than one larger structure. There may also be special structures required to allow for transpositions, line crossings, flight path limitations, etc. All structures will be installed on reinforced concrete drilled piers. This structure configuration is commonly used for the transmission systems throughout Xcel Energy's entire eight-state service territory footprint and is also consistent with common electric utility industry practice across the United States.

Q. DESCRIBE THE CONDUCTOR TYPE THE COMPANY PLANS TO INSTALL FOR THE PATHWAY PROJECT.

A. The selected conductor for the Project is a two-bundle of 1272 kcmil ACSR ("Bittern") in an 18" vertical configuration. The shield wires for the Project are two 48 count fiber optical ground wire ("OPGW"), which will support lightning and grounding protection and allow for communication to the substations.

Q. PLEASE EXPLAIN WHY THE COMPANY SELECTED THIS STRUCTURE AND CONDUCTOR DESIGN.

A. The selected structure configuration is used widely across the industry to efficiently carry two circuits. This configuration is also used on several of Public Service's existing double circuit 345 kV transmission lines. This makes storing of maintenance material and making emergency repairs easier and faster across the system. The conductor is a standard conductor used on most of the Company's 230 kV and 345 kV circuits in Colorado. Utilizing this conductor allows for efficient repairs in case of an emergency.

Q. WHAT WILL BE THE APPROXIMATE HEIGHT OF THE TRANSMISSION STRUCTURES IN PROJECT SEGMENTS INVOLVING NEW STRUCTURES?

A. The structures will vary in height but are expected to be in the range of 120 to 190 feet above ground. An average height of 135 feet for the tangents is expected.

Q. WHAT FACTORS DETERMINE INDIVIDUAL STRUCTURE HEIGHT?

A. Individual structure height is determined by the terrain, span length, and sag of the conductor, as well as by the minimum electrical clearances prescribed by the National Electric Safety Code ("NESC"). Taller structures are typically utilized when the transmission line crosses other transmission lines, major roadways, or other topographic features. For example, taller structures will likely be used where the transmission line crosses other transmission lines and major roadways.

Q. HOW WILL THE STRUCTURES BE SPACED ALONG THE RIGHT OF WAY?

A. The Project assumes an average span length of 950 feet between structures. This structure span length assumption was based on an analysis of recent 345 kV transmission line projects across Xcel Energy's operating footprint.

Q. WHAT COLOR AND MATERIAL WILL BE USED IN THE DESIGN OF THE NEW STRUCTURES?

A. All structures are expected to be weathering steel, which is brown in color. Local jurisdictions may request or require galvanized steel poles in some locations, although none are anticipated at this time.

Q. ARE THERE ANY OTHER TRANSMISSION LINE ENGINEERING DESIGN CONSIDERATIONS THAT THE COMPANY HAS EVALUATED OR WILL CONTINUE TO EVALUATE?

A. Yes.

Q. PLEASE EXPLAIN.

A. The Company will continue to evaluate twisted pair 556 ACSR Dove conductors as a potential engineering design alternative to the 1272 kcmil ACSR Bittern conductor. Twisted pair conductor is used to reduce line galloping (which is a jumping or oscillating motion) that can occur due to windy conditions and the formation of ice on the conductor during freezing rain or snow events. The Company will perform further engineering analysis as to whether anti-galloping conductor would be appropriate based on the final routing of the transmission lines to limit potential outages from galloping movement of the conductors. Twisted pair 556 ACSR Dove, is a standard conductor widely used in the Xcel Energy service territory footprint as well as across the industry in territories where conductor galloping can be problematic. In Section V of my testimony, I discuss the noise and magnetic field analysis results associated with this conductor type.

Q. CONSISTENT WITH RULE 3206(G), TO THE EXTENT THERE ARE ANY SERVICE CONNECTIONS THAT INTERCONNECT WITH THE PATHWAY PROJECT, WILL PUBLIC SERVICE INSTALL AND MAINTAIN SUCH SERVICE CONNECTIONS CONSISTENT WITH THE COMPANY'S TARIFF?

A. Yes. Commission Rule 3206(g) provides:

> Service connections. The utility shall install and maintain service connections from transmission extensions, which is any construction of transmission facilities and appurtenant facilities, including meter installation facilities (except meters) that is connected to and enlarges the utility's transmission system and is necessary to supply transmission service to one or more additional customers, consistent with conditions contained in the utility's tariff.

Public Service will comply with its tariffs to the extent applicable as set forth in Rule 3206(g).

B. <u>Substation Facilities</u>

Q. PLEASE PROVIDE A BRIEF DESCRIPTION OF THE SUBSTATION FACILITIES PUBLIC SERVICE IS PROPOSING TO CONSTRUCT OR EXPAND AS PART OF THE PROJECT.

A. The Project involves the various new and expanded substation facilities as summarized in Table BRC-D-1 above. I discuss the planned design and layout for each facility below, in turn.

1. <u>Fort St. Vrain Substation Expansion</u>

Q. PLEASE DESCRIBE THE LAYOUT AND DESIGN OF THE FORT ST. VRAIN SUBSTATION EXPANSION.

A. This portion of the Project includes improvements in the existing 230 kV yard and establishment of a new 345 kV yard at the existing Fort St. Vrain Substation.

The 345 kV and 230 kV yards will be interconnected through two 345/230 kV autotransformers. The 345 kV yard arrangement will consist of five bay positions. Two bay positions will terminate new 345 kV lines to the new Canal Crossing Substation, two bay positions will connect to the new autotransformers, and one bay position will connect to new 345 kV shunt capacitor banks. Two new bay positions will be added in the existing 230 kV yard to connect to the new transformers. Also included are grading, fencing, equipment, structures, and bus work required to support the installation and operation of these additions. See Attachment BRC-3, Page 1 for a conceptual one-line diagram and Attachment BRC-4, Page 1 for a general arrangement of this site.

2. Pawnee Substation Expansion and New Canal Crossing Substation

Q. PLEASE DESCRIBE THE LAYOUT AND DESIGN OF THE PAWNEE SUBSTATION EXPANSION AND THE NEW CANAL CROSSING SUBSTATION.

A. This portion of the Project includes improvements in the existing 230 kV and 345 kV yards (at the existing Pawnee Substation) and establishment of an additional, separately fenced 345 kV yard (at the new Canal Creek Substation). The existing 345 kV and 230 kV yards will be interconnected through one additional 345/230 kV autotransformer.

The new Canal Crossing Substation will essentially be an expansion of the existing Pawnee Substation. However, constraints on the land owned by the Company require new facilities for the Pathway Project to be sited on land adjacent to the existing Pawnee Substation. Canal Crossing's 345 kV yard

arrangement will consist of seven bay positions. Two bay positions will terminate new 345 kV lines to Fort St. Vrain, two bay positions will terminate new 345 kV lines to Goose Creek Substation, two bay positions will terminate interconnections to the existing Pawnee 345 kV yard, and one bay position will connect to new 345 kV shunt capacitor banks.

Improvements at the existing Pawnee 345 kV yard include three new bay positions. Two bay positions will terminate interconnections to the new Canal Crossing 345 kV yard and one bay position will connect to the new autotransformer. Improvements at the existing 230 kV yard include addition of one new bay position for connection to the new autotransformer. Also included are grading, fencing, equipment, structures, and bus work required to support the installation and operation of these additions. See Attachment BRC-3, Pages 2 and 3 for a conceptual one-line diagram, and Attachment BRC-4, Pages 2 and 3 for a general arrangement of this site.

3. <u>New Goose Creek Substation</u>

Q. PLEASE DESCRIBE THE LAYOUT AND DESIGN OF THE NEW GOOSE CREEK SUBSTATION.

A. This portion of the Project includes establishment of a new 345 kV substation. The 345 kV yard arrangement will consist of seven bay positions. Two bay positions will terminate new 345 kV lines to the new Canal Crossing Substation, two bay positions will terminate new 345 kV lines to the new May Valley Substation, one bay position will terminate the existing 345 kV line to Shortgrass, one bay position will terminate the existing 345 kV line to the Cheyenne Ridge

West Collector Station, and one bay position will connect to new 345 kV shunt capacitor banks.[4] Up to five additional 345 kV bay positions could be accommodated in the plan for this site. Also included are grading, fencing, equipment, structures, and bus work required to support the installation and operation of these additions. See Attachment BRC-3, Page 4 for a conceptual one-line diagram, and Attachment BRC-4, Page 4 for a general arrangement of this site.

4. New May Valley Substation

Q. PLEASE DESCRIBE THE LAYOUT AND DESIGN OF THE NEW MAY VALLEY SUBSTATION.

A. This portion of the Project includes establishment of a new 345 kV substation. The 345 kV yard arrangement will consist of five bay positions. Two bay positions will terminate new 345 kV lines to Goose Creek, two bay positions will terminate new 345 kV lines to Tundra, and one bay position will connect to new 345 kV shunt capacitor banks. Up to five additional 345 kV bay positions could be accommodated in the plan for this site. Also included are grading, fencing, equipment, structures, and bus work required to support the installation and operation of these additions. See Attachment BRC-3, Page 5 for a conceptual

[4] The existing circuit from Shortgrass will be split and brought into the new Goose Creek Substation. This circuit is part of the existing 345 kV Radial Gen-Tie that connects Missile Site to Pronghorn to Shortgrass to Cheyenne Ridge West (wind project collector station) to Cheyenne Ridge East (wind project collector station). These existing circuits currently comprise a radial line that is interconnected with the Company's transmission system only at the Missile Site Substation. Through the interconnection with the Pathway Project at the new Goose Creek Substation, the circuits between Missile Site and the new Goose Creek Substation will be networked. Because the circuit from Cheyenne Ridge will terminate (and be metered) at the new Goose Creek Substation, rather than at Shortgrass, the Company will perform some work at the Shortgrass Substation, including removing metering equipment for this circuit.

one-line diagram, and Attachment BRC-4, Page 5 for a general arrangement of this site.

5. Tundra Substation Expansion

Q. PLEASE DESCRIBE THE LAYOUT AND DESIGN OF THE TUNDRA SWITCHING STATION EXPANSION.

A. Please note that the Tundra Substation is not yet in service. As noted in Company witness Ms. Brooke A. Trammell's Direct Testimony, the initial phase of the facility has been planned separately from the Pathway Project and is expected to be in service approximately June of 2022. The expansion described herein for the Project assumes the initial phase to already be complete, with those initial facilities considered "existing" for purposes of the Project. This portion of the Project includes improvements in what will be the existing 345 kV yard. Seven new bay positions will be added to the existing 345 kV yard. Two bay positions will terminate new 345 kV lines to the new May Valley Substation, two bay positions will terminate new 345 kV lines to Harvest Mile, one bay position will terminate the existing line to Comanche, one bay position will terminate the existing line to Daniels Park, and one bay position will connect to new 345 kV shunt capacitor banks.[5] Up to two additional bay positions could be accommodated in the 345 kV plan for this site. Also included are grading, fencing, equipment, structures, and bus work required to support the installation and operation of these additions. See Attachment BRC-3, Page 6 for a

[5] Related to the work at the Tundra Substation for terminating the existing line between Daniels Park and Comanche, the Company will need to perform remote end work at the Daniels Park and Comanche Substations.

conceptual one-line diagram, and Attachment BRC-4, Page 6 for a general arrangement of this site.

6. Harvest Mile Substation Expansion

Q. PLEASE DESCRIBE THE LAYOUT AND DESIGN OF THE HARVEST MILE SUBSTATION EXPANSION.

A. This portion of the Project includes improvements in the existing 230 kV and 345 kV yards. The existing 345 kV and 230 kV yards will be interconnected through one additional 345/230 kV autotransformer. Improvements at the existing 345 kV yard include four new bay positions. Two bay positions will terminate new 345 kV lines to Tundra, one bay position will connect to the new autotransformer and one bay position will connect to new 345 kV shunt capacitor banks. Improvements at the existing 230 kV yard include addition of one bay position for connection to the new autotransformer. Also included are grading, fencing, equipment, structures, and bus work required to support the installation and operation of these additions. See Attachment BRC-3, Page 7 for a conceptual one-line diagram, and Attachment BRC-4, Page 7 for a general arrangement of this site.

Q. PLEASE DESCRIBE THE REPEATER STATIONS SHOWN ON ATTACHMENT BRC-2.

A. The repeater stations are associated with the fiber optic communications system of the transmission line and are necessary in certain locations due to the long distances between transmission line segments. As the data signal is passed through the fiber optic cable, the signal degrades with distance. Signal repeater

stations are used to amplify the signal in areas where the transmission line distance exceeds the effectiveness of the communication equipment. The repeater stations include the repeater equipment, an equipment enclosure, AC and DC auxiliary power systems, fencing, and other security features. The Company has assumed the construction of one repeater station for each Project segment for purposes of developing the Project cost estimate. However, once routing is complete, final line lengths and engineering design characteristics will determine which of the five Project segments require a repeater station.

C. Reactive Support (Voltage Control) Facilities

Q. PLEASE DESCRIBE WHAT REACTIVE SUPPORT OR VOLTAGE CONTROL FACILITIES ARE INCLUDED AS PART OF THE PATHWAY PROJECT.

A. Shunt reactors and shunt capacitors will be required for the Project. As currently designed and estimated, the Pathway Project includes a 50 MVAr shunt reactor at each end of each transmission line and a 2x120 MVAr shunt capacitor bank at each substation, except Pawnee Substation. These specific sizes and locations were assumed based on typical system requirements and will be verified based on system performance assessment studies as described in the Direct Testimony of Company witness Ms. Amanda R. King.

Q. ARE THESE REACTIVE SUPPORT FACILITIES INCLUDED IN THE PROJECT COST ESTIMATES?

A. Yes. These reactive support facilities are included in the Project cost estimate.

III. PATHWAY PROJECT COST ESTIMATE DEVELOPMENT PROCESS

Q. WHAT IS THE PURPOSE OF THIS SECTION OF YOUR TESTIMONY?

A. In this section of my Direct Testimony, I explain how the cost estimates were developed that are discussed in additional detail in the Direct Testimony of Company witness, Mr. Richter.

Q. PLEASE EXPLAIN HOW YOUR TEAM DEVELOPED THE COST ESTIMATES FOR THE PROJECT.

A. Company witness Mr. Richter presents the cost estimates for the Pathway Project. The cost estimates were developed using an industry-recognized cost-management software program called "InEight." InEight is an estimating software that is set up to catalog major and minor items used for transmission line and substation projects at Xcel Energy. The catalog includes rolling average prices for material items which are pulled from Xcel Energy's supply chain software ("SAP"). It is also populated with construction alliance partners' typical pricing for installing the items.

For some cost categories, InEight has starting material and labor costs that Company engineers adjust for project specific requirements. For example, InEight may have a cost for a steel pole based on an assumption that the pole will have a weight of 10,000 lbs. But if the Company's preliminary calculations show that the project will require the poles to be 20,000 lbs., the engineer would update the weight in the estimate to account for the added cost.

The engineering team determines the required components based on the project scope. The engineering team populates the material, construction,

engineering hours, project management hours, among other line items. The estimated values for each line item are developed from preliminary design and other engineering inputs including information from past projects, third party assistance, leadership input, and information from other organizations within Xcel Energy (e.g., Siting and Land Rights, Construction, Project Management). These values are then reviewed with members from other groups within the Company, including Construction, Supply Chain, Engineering, Project Management, Siting and Land Rights, and at times third party vendors.

The engineering team then develops the schedule dates for major activities to calculate the durations of the activities and support overall cashflow. Engineering takes the escalation and overheads rates from the finance organization and applies them to the project. All of this is combined to develop the estimate for the project.

Finally, the engineering team takes the assumptions and develops them into risk categories to support the development of the risk register with Project Management. The developed risk is then added to the cost estimate to have the final estimated cost. Estimated costs associated with permitting and land use activities are also incorporated into the estimates as provided by the Siting and Land Rights group. Company witness, Ms. Carly R. Rowe discusses the components of these estimated costs in more detail in her Direct Testimony.

Q. PLEASE DISCUSS THE KEY ENGINEERING DESIGN ASSUMPTIONS THAT INFORMED THE PROJECT COST ESTIMATES FOR THE TRANSMISSION LINE.

A. There are many assumptions included in the cost estimates. I will highlight a few of the key assumptions here. Regarding the structures, the Company assumed 950 feet spans between transmission structures, with 80 percent Tangents, 10 percent Angles, and 10 percent Dead Ends. This is based on the Company's previously completed 345 kV projects.

The Company's cost estimates also made assumptions about work schedule durations to estimate hours required for some labor resources. For example, with compressed timelines in the early years of the Project, more resources are needed to complete the engineering and construction work. In recent years, construction resources have been scarce as many utilities construct major projects, which has led to higher labor rates, per diem, and guaranteed weekly hours. Estimated work duration also informs cost components such as overheads and escalation. These factors are reflected in the Company's cost estimates.

Our estimates are also based on assumed steel costs based on information from previous similar projects with a freight cost of 4 percent of the steel cost. Previous structure designs were used with updated budgetary costs for those designs in December 2020 from steel vendors. However, steel is a commodity that is subject to significant variability in price.

Our estimates also consider soil conditions that have been evaluated from a Terracon desktop study. Specifically, our estimates assume 25 percent of the line has Good Soil, 50 percent has Average Soil, and 25 percent has Poor Soil. These soil condition assumptions inform foundation depth assumptions, which are based on ratios of pier depth to diameter for each soil type. For example, with poor soils the depth of the foundations has to increase to resist the overturning moment produced from the loading.

Q. PLEASE DISCUSS THE KEY ENGINEERING DESIGN ASSUMPTIONS THAT INFORMED THE PROJECT COST ESTIMATES FOR THE SUBSTATIONS AND REPEATER STATIONS.

A. There are many detailed assumptions incorporated in the cost estimates for substations. I will highlight some of the key assumptions here. Foremost, it is assumed that no significant deviations from Xcel Energy substation design and construction standards, materials, and practices will be necessary. These substation design standards include foundation types and sizes, structure types and configurations, electrical equipment types, ratings, physical arrangements, control and protection equipment types, and availability of secure and reliable sources of station service auxiliary power. Additionally, it is assumed that material availability, costs, and lead times will be consistent with historical experience. The estimated footprints of each substation are based on the conceptual general arrangements provided as Attachment BRC-4 to my Direct Testimony. Stormwater detention facilities are assumed to be required and have been estimated based on prior experience. The costs associated with civil site

development assume that the characteristics of the soil and subsurface conditions will not require special design approaches or remediation methods and that the terrain of the site is such that no unusual erosion control provisions, tiered grades, or retaining walls will be required. The location of each site is expected to be located near existing developed roads and will not require unusually long driveways or improvements of public thoroughfares to support construction traffic. The estimates for construction, testing, and commissioning activities are based on experience, input from internal and external resources, and expected construction durations. The expected locations of the work were also considered and influenced the per-diem and overtime portions of the cost estimate.

Q. ARE ANY OF THESE ASSUMPTIONS SUBJECT TO CHANGE AS THE ENGINEERING DESIGN PROCESS PROCEEDS?

A. All transmission line, substation, and repeater station assumptions are subject to modification as the Project proceeds. For example, evolving design requirements, results of field investigations, siting and routing activities, and other drivers are captured in the Project risk register. The risk register is an effort to capture and quantify potential assumption changes.

Q. HAS THE COMPANY COMPLETED THE ENGINEERING DESIGN PROCESS FOR THE PROJECT?

A. No. Although we have identified the scope of the Pathway Project, we have not completed the engineering design work for the Project. The project team has evaluated the likely transmission line structure types, completed a preliminary

desktop soil analysis, completed the conceptual one-line diagrams and general arrangements for each substation, and developed estimates based on the Pathway Project's known elements and assumptions at this time.

Q. WHAT ARE THE NEXT STEPS IN THE PROJECT DEVELOPMENT PROCESS FROM AN ENGINEERING DESIGN PERSPECTIVE?

A. Key next steps in the Project development process from an engineering design perspective, include:

- supporting routing and permitting of the Project to finalize site boundaries and ROW for the substations and transmission line;
- developing drawings for the substations (e.g., civil drawings, structural drawings, physical drawings, control and protection drawings) and transmission line (e.g., plan and profile drawings for the entire line length);
- finalizing structure and foundation details, and conductor, insulator and hardware details for the transmission line;
- developing stormwater management plans and performing other environmental studies;
- completing detailed engineering and material sourcing;
- producing a construction package;
- working with vendors on material delivery strategy; and
- supporting construction of the Project.

The engineering teams will work closely with the project management organization to keep construction schedules and budgets on track throughout the Project. The individual Project segments and substations will be designed by individual teams under the guidance of an overall project lead engineer. This

approach to the transmission line and substation design will result in a Project with consistency across all components.

Q. HAS THE COMPANY INCORPORATED "RISK RESERVE" INTO THE COST ESTIMATES FOR THE TRANSMISSION LINE AND SUBSTATIONS?

A. Yes. The Company has included risk reserve into the transmission line and substation Project cost estimates. The Company's approach to the development of the risk register and the cost estimate's risk reserve amounts is discussed in the Direct Testimony of Company witness Mr. Richter.

IV. MAY VALLEY-LONGHORN EXTENSION

Q. WHAT IS THE PURPOSE OF THIS SECTION OF YOUR DIRECT TESTIMONY?

A. The purpose of this section of my Direct Testimony is to describe the May Valley-Longhorn Extension (or "Extension") option and the engineering design associated with this extension. This information is provided for the Commission's consideration as to whether to include the May Valley-Longhorn Extension in a CPCN in addition to the Pathway Project.

Q. IS THE COMPANY BRINGING FORWARD ANY OTHER OPTIONS FOR THE COMMISSION'S CONSIDERATION IN ADDITION TO THE PATHWAY PROJECT?

A. Yes. The Company is presenting for Commission consideration in this proceeding an optional extension of the Pathway Project referred to as the May Valley-Longhorn Extension.

Q. PLEASE SUMMARIZE THE MAY VALLEY-LONGHORN EXTENSION.

A. The May Valley-Longhorn Extension is a 90-mile, 345 kV double circuit transmission line that would extend from the southeastern corner of the Pathway Project at the new May Valley Substation south to the new Longhorn Substation near Vilas. An electric one-line diagram of the Pathway Project including the May Valley-Longhorn Extension is provided as Attachment BRC-5.

Q. PLEASE PROVIDE A BRIEF DESCRIPTION OF THE TRANSMISSION LINE FACILITIES PUBLIC SERVICE WOULD CONSTRUCT FOR THE MAY VALLEY-LONGHORN EXTENSION.

A. The May Valley-Longhorn Extension transmission line is bounded by the new May Valley Substation and the new Longhorn Substation near Vilas. The May Valley-Longhorn Extension would include the same type of structures and conductor as the Pathway Project's transmission line that I described in Section II.A, above.

Q. PLEASE PROVIDE A BRIEF DESCRIPTION OF THE SUBSTATION FACILITIES THAT WOULD BE CONSTRUCTED OR EXPANDED AS PART OF THE MAY VALLEY-LONGHORN EXTENSION.

The Project involves an expansion of the planned May Valley Substation, which will be a new substation constructed for the Pathway Project, and the construction of a new Longhorn Substation at the southern terminus of the May Valley-Longhorn Extension. These constitute the same types of facilities that I described above in Section II.B regarding the Pathway Project's substations.

Q. PLEASE DESCRIBE THE LAYOUT AND DESIGN OF THE MAY VALLEY SUBSTATION EXPANSION.

A. This portion of the Project includes an expansion of the planned 345 kV May Valley Substation. In addition to the facilities I described above in Part II.B.4, the May Valley Substation would include two additional line positions to terminate the new 345 kV May Valley-Longhorn lines. Up to three additional 345 kV bay positions could still be accommodated in the plan for this site. Also included are

grading, fencing, equipment, structures, and bus work required to support the installation and operation of these additions. See Attachment BRC-6, Page 1 for a one-line diagram, and Attachment BRC-7 for a general arrangement of this site.

Q. PLEASE DESCRIBE THE LAYOUT AND DESIGN OF THE LONGHORN SUBSTATION.

A. This portion of the Project includes a new 345 kV yard comprising the Longhorn Substation at the southern terminus of the May Valley-Longhorn Extension. The Longhorn Substation will consist of three bay positions. Two bay positions would terminate the new 345 kV May Valley-Longhorn line and one bay position will connect to new 345 kV shunt capacitor banks. Up to five additional 345 kV bay positions could be accommodated in the plan for this site. Also included are grading, fencing, equipment, structures, and bus work required to support the installation and operation of these additions. Similar to the rest of the Pathway Project, the engineering design process for the May Valley-Longhorn Extension is not complete, but a preliminary one-line diagram and general arrangement have been completed based on the assumptions for the Project. See Attachment BRC-6, Page 2 for a one-line diagram, and Attachment BRC-7, Page 2 for a general arrangement of this site.

Q. HOW DID YOUR TEAM DEVELOP THE COST ESTIMATE FOR THE MAY-VALLEY-LONGHORN EXTENSION?

A. The Company has completed the same types activities to develop the cost estimate for the May Valley-Longhorn Extension as I described above in Part III

for the Pathway Project. The Company also relied on the same types of assumptions to develop the cost estimate for the May Valley-Longhorn Extension. The Company has also developed a risk reserve for the cost estimates for the May Valley-Longhorn Extension and substation improvements, which is reflected in the cost estimate presented by Company witness Mr. Richter.

V. NOISE AND MAGNETIC FIELDS ANALYSIS

Q. WHAT IS THE PURPOSE OF THIS SECTION OF YOUR TESTIMONY?

A. The purpose of this section of my Direct Testimony is to explain the noise and magnetic field analyses conducted for the Pathway Project and the May Valley-Longhorn Extension pursuant to Rules 3206(e)-(f).

Q. DOES THE COMMISSION REQUIRE NOISE AND MAGNETIC FIELD STUDIES FOR CONSTRUCTION OR EXPANSION OF TRANSMISSION FACILITIES?

A. Yes. Commission Rules 3206(e)-(f) require an applicant to evaluate the expected maximum level of magnetic fields and projected level of noise from a proposed project involving construction or expansion of transmission facilities.

Q. DID THE COMPANY RETAIN A CONSULTANT TO STUDY THE EXPECTED NOISE AND MAGNETIC FIELD LEVELS FROM THE PATHWAY PROJECT AND THE EXTENSION?

A. Yes. POWER Engineers, Inc. ("PEI") was retained to complete the required studies. PEI provided three separate audible noise and magnetic field reports, including for: (1) the Power Pathway 345 kV transmission line; (2) the seven Power Pathway Substations; and (3) the May Valley-Longhorn Extension Substations and 345 kV transmission line. The PEI analysis reports ("PEARs") are attached to my testimony as Attachments BRC-8, BRC-9, and BRC-10. I discuss the conclusions regarding noise and magnetic field levels associated with the Pathway Project and the May Valley-Longhorn Extension in my testimony below.

A. Noise Analysis

Q. DO THE COMMISSION'S RULES REQUIRE THE SUBMISSION OF INFORMATION CONCERNING NOISE FROM PROPOSED TRANSMISSION PROJECTS?

A. Yes. Rule 3206(f) requires CPCN applications for transmission projects to include the projected level of noise radiating beyond the property line or right-of-way ("ROW") (as applicable) at a distance of 25 feet.

Q. ARE THERE STANDARDS FOR DETERMINING WHETHER PROJECTED TRANSMISSION NOISE LEVELS ARE REASONABLE?

A. Yes. Section 25-12-103(12), C.R.S., provides that the Commission can determine whether the projected noise levels for electric transmission lines are reasonable when reviewing CPCN applications. The requirements of § 25-12-103(12), C.R.S. are reflected in Rule 3206(f), which establishes values for four zoning designations that are "deemed reasonable by rule" and do not require mitigation to a lower level.[6] Table BRC-D-2 below shows the reasonable noise thresholds are as follows for four standard zoning areas:

[6] *See* 4 CCR 723-3-3206(f)(II).

Table BRC-D-2: Noise Level Deemed Reasonable

Zone	Noise Level Deemed Reasonable
Residential	50 dBA
Commercial	55 dBA
Light Industrial	65 dBA
Industrial	75 dBA

In addition, a noise level below 50 dBA is not subject to further review regardless of the use of land.[7] Rule 3206(f)(III) further provides:

> If the zoning designation that has been assigned by the local zoning regulatory agency for a specific segment of the transmission project is not listed … the applicant shall reference the noise threshold corresponding to the zoning designation that most closely represents the predominant use of the lands in question, with consideration given to the surrounding area.

If a projected noise level is 50 dBA or below, it will not be subject to further review regardless of the use of land.

Q. DID THE COMPANY CONDUCT A NOISE STUDY AS REQUIRED BY RULE 3206(f)?

A. Yes. PEI modeled the projected noise level that would radiate beyond the transmission line ROW and substation property lines at a distance of 25 feet in fair conditions and L_{50} rain conditions, as required by Commission Rule 3206(f).

[7] *See* 4 CCR 723-3-3206(f)(III).

To conduct its analysis of the transmission line, PEI used a utility standard program known as the Bonneville Power Administration ("BPA") Corona and Field Effects Program ("CAFEP"), software version 3. CAFEP uses the electrical and physical characteristics of the transmission line to calculate resulting fields and interference effects from the transmission lines. For the substations, Power Engineers modeled audible noise levels using the DataKustik GmbH, Computer Aided Noise Abatement ("CadnaA") software package, version 4.5.151, which is a utility standard program.

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

A. Corona is the primary cause of noise from transmission lines. The higher the voltage on a transmission circuit, the greater the corona activity on the line. Corona is what creates the hissing or crackling sound that often emanates from transmission lines. 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 because the water droplets alter the voltage gradient at the surface of the conductor resulting in increased corona and thus increase in noise. 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 OF A TRANSMISSION LINE?

A. Corona activity is substantially higher at higher altitudes because of the corresponding decrease in air density. Corona-generated audible noise increases by about 1 dBA for every 1000 feet in elevation gain. A transmission line constructed in the eastern plains of Colorado area will have corona noise about 3-7 dBA higher than a similarly constructed line at sea level. A second source of audible noise on a transmission line is a 120 Hertz ("Hz") synchronous hum created by systems operating at 60 Hz. This 120 Hz hum is generally of little consequence, but it can contribute to audible noise.

Q. WHAT WILL CAUSE AUDIBLE NOISE AT THE SUBSTATIONS?

A. The predominant cause of noise at the substations will be equipment such as the reactors and transformers. Corona from transmission lines will also be a source of noise but will be minimal compared to noise from reactors and transformers.

Q. PLEASE PROVIDE A PRACTICAL COMPARISON FOR THE dBA SCALE.

A. Table BRC-D-3 below is a decibel level reference chart provided in the EPRI Transmission Line Reference Book – 200 kV and Above, Third Edition.[8] This chart provides a reasonable and useable guide to how people experience sound at various decibel levels on the A-weighted scale ("dBA"):

[8] R. Lings, Electric Power Research Institute; EPRI AC Transmission Line Reference Book – 200 kV and Above, Third Edition (Dec. 2005), Table 10.5-1: Common Noise Levels, at 10-27.

Table BRC-D-3: Noise Levels in dBA

Decibel	Experience
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. WHAT ARE THE REQUIREMENTS OF RULE 3102(c)?

A. When an electric utility applies for a CPCN to construct or extend transmission facilities, Rule 3102(c) requires it to "describe its actions and techniques relating to cost-effective noise mitigation with respect to the planning, siting, construction, and operation of the proposed transmission construction or extension." The

Commission lists eight steps and techniques a utility may employ to reduce noise.

Q. WHAT WILL PUBLIC SERVICE DO TO MEET THE REQUIREMENTS OF COMMISSION RULE 3102(c) WITH RESPECT TO THE PROJECT?

A. Public Service will employ these techniques to varying extents to mitigate noise in a cost-effective manner. Specifically, we have chosen large, high-quality conductors. Moreover, we will phase the conductors in the most cost-effective manner taking into account noise mitigation, utilize corona-free attachment hardware, carefully handle the conductor, utilize industry-standard construction techniques, and utilize a line tension that maximizes our ability to cost-effectively mitigate noise.

1. Transmission Line

Q. PLEASE SUMMARIZE THE RESULTS OF THE ANALYSIS REGARDING PROJECTED NOISE LEVELS FROM THE PATHWAY PROJECT TRANSMISSION LINE.

A. Power Engineers analyzed projected audible noise levels for both conductor types discussed above—the two bundle 1272 ACSR Bittern and the alternate twisted pair ("T2") 556 ACSR Dove. For the two bundle 1272 ACSR Bittern conductor, the maximum projected noise level measured at 25 feet from the edge of the transmission line ROW is 49.8 dBA. The analysis assumed the same structure configuration and 150-foot ROW for all five transmission line segments of the Project. The 49.8 dBA noise level is projected for L_{50} rain conditions, during which the noise level is louder than fair conditions.

For the alternate T2 Dove conductor, the maximum projected noise level measured at 25 feet from the edge of the transmission line ROW is 47.6 dBA. The analysis assumed the same structure configuration and 150-foot ROW for all five transmission line segments of the Project. The 47.6 dBA noise level is projected for L_{50} rain conditions, during which the noise level is louder than fair conditions.

Q. PLEASE SUMMARIZE THE RESULTS OF THE ANALYSIS REGARDING PROJECTED NOISE LEVELS FROM THE MAY VALLEY-LONGHORN EXTENSION.

A. Power Engineers analyzed projected audible noise levels for both conductor types discussed above—the two bundle 1272 ACSR Bittern and the alternate twisted pair ("T2") 556 ACSR Dove for the May Valley-Longhorn Extension transmission line. The analysis assumed the same structure configuration and 150-foot ROW for the Extension as for all five transmission line segments of the Pathway Project. Accordingly, the analysis determined the same results as for the Pathway Project. For the two bundle 1272 ACSR Bittern conductor, the maximum projected noise level measured at 25 feet from the edge of the transmission line ROW is 49.8 dBA projected for L_{50} rain conditions, during which the noise level is louder than fair conditions.

For the alternate T2 Dove conductor, the maximum projected noise level measured at 25 feet from the edge of the transmission line ROW of the Extension is 47.6 dBA projected for L_{50} rain conditions.

Q. ARE THE MAXIMUM PROJECTED NOISE LEVELS REASONABLE UNDER RULE 3206(f)?

A. Yes. As noted above and in the Direct Testimony of Company witness Ms. Rowe, the Pathway Project transmission line will be approximately 560 miles and cross 13 counties and municipalities, and the Extension will be approximately 90 miles and cross two counties. Given the length of the transmission line, the Pathway Project transmission line has the potential to be located on land with several different zone designations. However, because the projected noise level of the Pathway Project transmission line and the Extension transmission line is below 50 dBA, the most stringent noise level deemed reasonable by Rule 3206(f), it is not necessary to identify the specific zoning designation for each portion of the entire transmission line.

Rule 3206(f)(III) provides that a noise level below 50 dBA is not subject to further review regardless of the use of land. As described in the PEAR, the projected noise levels in both fair and rainy conditions are projected to be below 50 dBA for both conductor types studied. As such, the projected noise levels from the Pathway Project transmission line and the Extension transmission line are deemed reasonable and not subject to further review.

Q. IS THERE ANY NEED FOR ADDITIONAL MITIGATION OF AUDIBLE NOISE LEVELS ASSOCIATED WITH THE TRANSMISSION LINE?

A. No. Because the projected audible noise levels from the transmission line do not exceed the Commission's most conservative 50 dBA level at any location 25 feet beyond the edge of the transmission line ROW, the noise levels from the

transmission line are within the Commission's deemed-reasonable levels and require no further review. Therefore, no additional mitigation is warranted.

Q. WHAT FINDINGS IS THE COMPANY REQUESTING WITH RESPECT TO AUDIBLE NOISE?

A. Because all projected audible noise level values for the transmission line are at or below the 50 dBA "deemed reasonable" threshold, the Company requests the Commission find the audible noise levels associated with the Pathway Project transmission line and Extension transmission line are reasonable pursuant to Rule 3206(f) and require no further mitigation.

2. Substations

Q. DID THE ANALYSIS ALSO MODEL THE POTENTIAL NOISE AT THE SUBSTATIONS THAT WILL BE CONSTRUCTED OR EXPANDED FOR THE PATHWAY PROJECT AND THE MAY VALLEY-LONGHORN EXTENSION?

A. Yes. As I described above, the Pathway Project includes expansions at the existing Fort St. Vrain, Pawnee, Tundra, and Harvest Mile Substations on land already owned by the Company. We will also construct a new Canal Crossing Substation adjacent to the existing Pawnee Substation on land already owned by the Company. The Project also includes two new greenfield substations: Goose Creek and May Valley. The Extension would enlarge the planned May Valley Substation and also includes a new substation: Longhorn. PEI conducted a noise analysis for each substation. For the sites where the Company already owns the land, PEI used the planned locations for the new substation facilities.

For the new substations, hypothetical locations were modeled based on the facilities that will be required and the parcel size the Company intends to acquire.

Q. PLEASE SUMMARIZE THE RESULTS OF THE ANALYSIS REGARDING PROJECTED NOISE LEVELS AT THE SUBSTATIONS.

A. The results of Power Engineers' noise analysis for each site are set forth in the PEAR. Table BRC-D-4 below provides a summary of the results presented in the PEAR:

Table BRC-D-4: Summary of Projected Substation Noise Levels

Substation	Projected maximum noise level 25 feet from substation property line [dBA]	Zoning designation of substation site	Rule 3206(f) deemed reasonable level [dBA]
Pathway Project Substations			
Fort St. Vrain	62	Industrial	75
Pawnee	62	Industrial	75
Canal Crossing	61	Industrial	75
Goose Creek	62	Agricultural	N/A
May Valley	60	Agricultural	N/A
Tundra	61	Agricultural	N/A
Harvest Mile	57	Agricultural	N/A
May Valley – Longhorn Extension Substations			
May Valley (Extension)	64	Agricultural	N/A
Longhorn	63	No Zoning	N/A

Q. ARE THE MAXIMUM PROJECTED NOISE LEVELS REASONABLE UNDER RULE 3206(f)?

A. Yes. As set forth below, the projected audible noise levels from the Fort St. Vrain, Pawnee, and Canal Crossing Substations do not exceed the 75 dBA level deemed reasonable for land with a zoning designation of Industrial at any location 25 feet beyond the edge of those substation property lines.

The other substations sites (Goose Creek, May Valley, Tundra, and Harvest Mile) will be on land with an Agricultural zoning designation. The Longhorn site does not have a zoning designation, but surrounding land uses include agricultural and industrial operations. The projected audible noise levels at locations 25 feet from the property lines of each of these substations do not exceed 65 dBA, which is consistent with the 65 dBA level deemed reasonable for land with a zoning designation of Light Industrial. Finding that noise levels are reasonable where they are below the deemed reasonable level for land with a Light Industrial zoning is consistent with recent Commission decisions concerning transmission and substation facilities located on land with a zoning designation of Agricultural.[9] The results for the individual substations are set forth in more detail below:

Fort St. Vrain: The facilities for the substation expansion will be constructed on land already owned by the Company. As set forth in the PEAR, audible noise was modeled at 25 feet from an identified substation property line. The highest projected noise level was on the northern edge on land owned by the Company. The projected noise level at this location is 62 dBA. The substation site, which is adjacent to an existing electric generating station, is zoned as Heavy Industrial. Under Rule 3206(f)(II)(D), a projected noise level of 75 dBA or less is deemed reasonable in Industrial zones. The projected

[9] *See* Decision No. C19-0367, Proceeding No. 18A-0905E, at ¶ 43 (mailed date Apr. 25, 2019); Decision No. C19-0175, Proceeding No. 18A-0860E, at ¶ 17 (mailed date Feb. 19, 2019).

maximum noise level of 62 dBA is deemed reasonable by rule and need not be mitigated.

Pawnee and Canal Crossing: The expansion of the Pawnee Substation and the construction of the new Canal Crossing Substation will be on land already owned by the Company. As set forth in the PEAR, audible noise was modeled at 25 feet from an identified property line of the substations. For Pawnee, the highest projected noise level was on the northern edge of the Substation, on land owned by the Company. The projected noise level at this location is 62 dBA. For Canal Crossing, the highest projected noise level was on the northern edge of the planned Substation, on land owned by the Company. The projected noise level at this location is 61 dBA. The substation sites, which are adjacent to the existing Pawnee and Manchief Generating Stations, are zoned as Heavy Industrial. Under Rule 3206(f)(II)(D), a projected noise level of 75 dBA or less is deemed reasonable in Industrial zones. The projected maximum noise levels of 62 dBA and 61 dBA are deemed reasonable by rule and need not be mitigated.

Goose Creek and May Valley: The new Goose Creek and May Valley Substations will be located at new sites. As explained by Company witness Ms. Rowe, the facilities for both substations will be constructed on approximately 40 acres of land that will be acquired in fee by the Company. As set forth in the PEAR, audible noise for both new substations was modeled using assumptions concerning the needed facilities for each substation based on a conceptual substation general arrangement provided by the Company and the assumed land

acquisition for the substation. The highest projected noise level at a distance of 25 feet from the respective hypothetical substation property lines was 62 dBA for Goose Creek and 60 dBA for May Valley. When the facilities for the Extension are modeled, the highest projected noise level 25 feet from the hypothetical property line for May Valley is 64 dBA. Based on current land zoning designations in Cheyenne County (Goose Creek) and Prowers County (May Valley), both substations will be located on land zoned as Agricultural.

Tundra: The facilities for the substation expansion will be constructed on land already owned by the Company. As I described above, the Tundra Substation is a planned facility for the interconnection of certain solar generation resources selected through the Company's 2016 ERP and Colorado Energy Plan, but it is not yet in service. The Tundra Substation will be expanded as part of the Pathway Project to accommodate the 345 kV transmission lines. As set forth in the PEAR, audible noise was modeled at 25 feet from the substation property line, assuming both the originally planned Tundra substation facilities and the expansion facilities. The highest projected noise level at a distance of 25 feet from the substation property line was at the northeastern edge. The projected noise level at this location is 61 dBA. The Tundra Substation site is zoned as Agricultural.

Harvest Mile: The facilities for the substation expansion will be constructed on land already owned by the Company. As set forth in the PEAR, audible noise was modeled at 25 feet from the substation property line. The highest projected noise level at a distance of 25 feet from the substation property line was on the

southern edge of the substation. The projected noise level at this location is 57 dBA. The Harvest Mile Substation site is zoned as Agricultural.

Longhorn: The new Longhorn Substation will be located at a new site. As set forth in the PEAR, audible noise was modeled with the assumption that the Longhorn Substation will contain two reactors. The highest projected noise level at a distance of 25 feet from hypothetical substation property lines is 63 dBA. As stated in the PEAR report, there is no County zoning designation for the Longhorn Substation location. The surrounding land uses include agriculture, oil and gas infrastructure, and industrial operations.

Q. ARE THE PROJECTED SOUND LEVELS FOR THE GOOSE CREEK, MAY VALLEY, TUNDRA, HARVEST MILE, AND LONGHORN SUBSTATIONS DEEMED REASONABLE BY COMMISSION RULE?

A. No. Under Rule 3206(f)(II) and (III), projected noise levels may be deemed reasonable by rule if the transmission or substation facilities meet applicable thresholds and are located on land zoned as Residential, Commercial, Light Industrial, or Industrial, or if the projected noise level is below the most stringent threshold of 50 dBA regardless of the use of the land.

The zoning designation for each of the Goose Creek, May Valley, Tundra, and Harvest Mile Substations is Agricultural, and the maximum projected noise levels modeled at 25 feet from each substation property line is not below the 50 dBA threshold. The Longhorn Substation does not have a specified zoning designation, and the maximum projected noise levels modeled at 25 feet from the substation property line is not below the 50 dBA threshold.

Q. HOW SHOULD THE COMMISSION EVALUATE THE PROJECTED NOISE LEVELS FOR THESE SUBSTATIONS, SINCE THE ZONING DESIGNATION OF AGRICULTURAL IS NOT LISTED IN RULE 3206(f)(II)?

A. Rule 3206(f)(III) provides that if the zoning designation is not listed in Rule 3206(f)(II), the CPCN applicant shall reference the noise threshold corresponding to the zoning designation that most closely represents the predominant use of the land in question, with consideration given to the surrounding area. In promulgating Rule 3206(f)'s noise thresholds, the Commission found that appropriate noise levels for agricultural areas (and other areas not listed in Rule 3206(f)(II) and Section 25-12-203, C.R.S.) should be determined on a case-by-case basis in consideration of the predominant land use and the closest corresponding zoning designation listed in the statute.[10]

Q. SHOULD THE COMMISSION FIND THAT THE PROJECTED AUDIBLE NOISE FROM THE SUBSTATIONS IN AREAS ZONED AS AGRICULTURAL, OR ON LAND THAT IS NOT ZONED, ARE REASONABLE CONSISTENT WITH RULE 3206(f)?

A. Yes. The Company believes that a finding that the projected audible noise levels from these substations are reasonable would be consistent with the intent of the Commission's rules. Although the maximum projected audible noise levels for these substations of 57 dBA to 64 dBA are above the levels deemed reasonable

[10] *See* Decision No. R10-0430, Proceeding No. 09R-904E, at ¶ 44 (mailed date May 7, 2010). Recommended Decision No. R10-0430 became a Commission decision by operation of law.

for residential and commercial zones, these levels are consistent with the levels deemed reasonable for light industrial and industrial zones.

The land uses surrounding the areas under consideration for the greenfield Goose Creek and May Valley substations are primarily agricultural. The Company's existing Cheyenne Ridge Wind Project is located in Cheyenne County near where the Goose Creek Substation is likely to be sited. With respect to the likely location of the May Valley Substation in Prowers County, the surrounding land uses include oil and gas well infrastructure and abandoned wells.

The land surrounding the Tundra Substation site in Pueblo County consists largely of grassland. The Pueblo Chemical Depot, a U.S. Army site for the storage of chemical weapons, is east of the substation site, and the Pueblo Memorial Airport is located to the southwest.

The land surrounding the Harvest Mile Substation includes grasslands to the north, active agricultural land to the west/northwest, a transmission line to the west, the Arapahoe County Fairgrounds Event Center to the east, and a residential development to the south. A transmission line lies between the existing Substation and the residential development.

The land uses surrounding the area under consideration for the greenfield Longhorn Substation is primarily agricultural.

Four of the substation sites (Goose Creek, May Valley, Tundra, and Longhorn) are in remote locations. For all of these substations, much of the surrounding land uses are consistent with a Light Industrial zoning designation,

including agricultural activities, wind farm generating stations, oil and gas infrastructure, chemical weapons storage, airport, and an events center. The Light Industrial category most closely represents the predominant use of the land in question, consistent with Rule 3206(f)(III). Furthermore, many of these land uses are not undertaken immediately adjacent to, or 25 feet away from, the substation property lines. In addition, other land uses include open space and grassland, which suggests that mitigation of noise is not necessary.

The Harvest Mile Substation is also located on land zoned as Agricultural. The Light Industrial category most closely represents the predominant land uses on three sides of the substation—grasslands, agricultural activity, transmission lines, events center. The 57 dBA level, which is slightly higher than the 55 dBA threshold deemed reasonable for commercially zoned land, was modeled at a location 25 feet from the Substation property line, which is on a parcel of land crossed by an existing Company transmission line. Although there are residences near the Harvest Mile Substation, the nearest residences are approximately 585 feet from the substation, separated from the substation by a transmission line corridor and roadway. Accordingly, these residences are less likely to be impacted from the incremental noise associated with the Substation expansion. The modeled sound levels take into account Public Service's typical design process that employs techniques included in Rule 3102(c) to varying extents to cost-effectively mitigate noise from substations.

Accordingly, the Commission should find the proposed noise levels at these substations to be reasonable.

Q. IS THERE ANY NEED FOR ADDITIONAL MITIGATION OF AUDIBLE NOISE LEVELS ASSOCIATED WITH THE SUBSTATIONS?

A. No. Because the projected audible noise levels from the Fort St. Vrain, Pawnee, and Canal Crossing Substations do not exceed the 75 dBA level deemed reasonable for land with a zoning designation of Industrial at any location 25 feet beyond the edge of those substation property lines, the noise levels from those substations are within the Commission's deemed-reasonable level. Therefore, no additional mitigation is warranted.

With respect to the Goose Creek, May Valley, Tundra, Harvest Mile, and Longhorn Substations, which are or will be located on land with a zoning designation of Agricultural (or on land where the surrounding land uses are predominantly agricultural, as in the case of Longhorn which is not specifically zoned), the projected audible noise levels at locations 25 feet from the substation property lines do not exceed 64 dBA, which is consistent with the 65 dBA level deemed reasonable for land with a zoning designation of Light Industrial. As I explained above, the land uses around the substations most closely correspond to the Light Industrial level. As such, no additional mitigation is required.

Q. WHAT FINDINGS IS THE COMPANY REQUESTING WITH RESPECT TO AUDIBLE NOISE PROJECTED FROM THE SUBSTATIONS?

A. The Company requests the Commission find the audible noise levels associated with the substations to be reasonable pursuant to Rule 3206(f) and require no further mitigation. The projected noise from the substations located on land with a zoning designation of Industrial (Fort St. Vrain, Pawnee, and Canal Crossing)

should be deemed reasonable by rule, consistent with Rule 3206(f)(II). The projected noise from the substations on land with a zoning designation of Agricultural (Goose Creek, May Valley, Tundra, and Harvest Mile) should be found reasonable where the projected noise is within with the noise level deemed reasonable for Light Industrial zones, consistent with recent Commission decisions concerning transmission and substation facilities located on land with a zoning designation of Agricultural.[11] Similarly, the projected noise from the Longhorn Substation, which does not have a zoning designation, should be found reasonable where the projected noise and the predominant land uses in the area are consistent with the noise level deemed reasonable for Light Industrial zones.

B. <u>Magnetic Field Analysis</u>

Q. PLEASE PROVIDE AN OVERVIEW OF ELECTROMAGNETIC FIELDS, MAGNETIC FIELDS AND ELECTRIC FIELDS.

A. The term electromagnetic field refers to electric and magnetic fields that are coupled, as in high-frequency radiating fields. When the frequency of these fields is sufficiently low, electromagnetic fields should be separated into electric fields or E Fields (related to voltage) and magnetic fields or B Fields (related to current).

[11] *See* Decision No. C19-0367, Proceeding No. 18A-0905E, at ¶ 43 (mailed date Apr. 25, 2019); Decision No. C19-0175, Proceeding No. 18A-0860E, at ¶ 17 (mailed date Feb. 19, 2019).

Q. DO THE COMMISSION'S RULES REQUIRE THE SUBMISSION OF INFORMATION CONCERNING MAGNETIC FIELDS FROM PROPOSED TRANSMISSION PROJECTS?

A. Yes. Rule 3206(e) requires CPCN applications for transmission projects to include the expected maximum level of magnetic fields that could be experienced under design conditions at the edge of the transmission line ROW or substation boundary at a location one meter above the ground.

Q. ARE THERE STANDARDS FOR DETERMINING WHETHER EXPECTED LEVELS OF MAGNETIC FIELDS ARE REASONABLE?

A. Yes. Rule 3206(e)(III) provides that a proposed magnetic field level of 150 milliGauss ("mG") or below is "deemed reasonable by rule and need not be mitigated." Magnetic field levels above 150 mG will be subject to further review.

Q. DID THE COMPANY CONDUCT A MAGNETIC FIELD STUDY AS REQUIRED BY RULE 3206(e)?

A. Yes. The PEARs, provided as Attachments BRC-8, BRC-9, and BRC-10, include an analysis of the expected maximum level of magnetic fields that could be experienced under design conditions at the edge of the transmission ROW and substation boundaries at a location one meter above the ground.

1. <u>Transmission Line</u>

Q. PLEASE SUMMARIZE THE RESULTS OF THE MAGNETIC FIELD ANALYSIS FOR THE PATHWAY PROJECT TRANSMISSION LINE.

A. PEI analyzed expected magnetic field levels for both conductor types discussed above—the two bundle 1272 ACSR Bittern and the alternate twisted pair (T2)

556 ACSR Dove. As shown in the PEAR for the transmission line (provided as Attachment BRC-8), under a maximum loaded condition for the two bundle 1272 ACSR Bittern conductor (based on the thermal design limit of the conductor) the magnetic field level value at the edge of the transmission line ROW will be 54.7 mG. The analysis assumed the same structure configuration, thermal limit, and proposed ROW width for all five transmission line segments of the Project.

For the alternate T2 Dove conductor, under a maximum loaded condition (based on the thermal design limit of the conductor) the magnetic field level value at the edge of the transmission line ROW will be 59.5 mG. The analysis assumed the same structure configuration, thermal limit, and proposed ROW width for all five transmission line segments of the Project.

Q. PLEASE SUMMARIZE THE RESULTS OF THE MAGNETIC FIELD ANALYSIS FOR THE MAY VALLEY-LONGHORN EXTENSION TRANSMISSION LINE.

A. PEI analyzed expected magnetic field levels for both conductor types discussed above—the two bundle 1272 ACSR Bittern and the alternate twisted pair (T2) 556 ACSR Dove. As shown in the PEAR for the Extension transmission line (provided as Attachment BRC-10), under a maximum loaded condition for the two bundle 1272 ACSR Bittern conductor (based on the thermal design limit of the conductor) the magnetic field level value at the edge of the transmission line ROW will be 54.7 mG. The analysis assumed the same structure configuration, thermal limit, and proposed ROW width for the Extension as for all five transmission line segments of the Pathway Project.

For the alternate T2 Dove conductor, under a maximum loaded condition (based on the thermal design limit of the conductor) the magnetic field level value at the edge of the transmission line ROW will be 59.5 mG. The analysis assumed the same structure configuration, thermal limit, and proposed ROW width for the Extension as for all five transmission line segments of the Pathway Project.

Q. ARE THE MAGNETIC FIELD LEVELS AT MAXIMUM LOADED CONDITIONS REASONABLE UNDER RULE 3206(e)?

A. Yes. Because the magnetic field levels of the Project transmission line and the Extension transmission line are below 150 mG, they are deemed reasonable by rule and do not need to be mitigated to a lower level.

Q. HOW DID YOU CALCULATE THE VALUES AT THE EDGE OF THE ROW IF THE COMPANY HAS NOT YET SELECTED A ROUTE?

A. As I stated above regarding noise, the same hold true for magnetic fields. As Company witness Ms. Rowe describes, the Company anticipates acquiring a 150-foot-wide ROW, and we will center the transmission line in the ROW. As set forth in the PEARs, the transmission line was centered in the ROW for the magnetic field analysis in order to analyze what the magnetic fields will be at the edge of the right of way.

2. Substations

Q. DID THE PEI ANALYSIS EVALUATE PROJECTED MAGNETIC FIELDS FROM THE SEVEN POWER PATHWAY SUBSTATIONS?

A. Yes. The PEI Analysis included a three-dimensional magnetic field modeling analysis using Safe Engineering Services and technologies ltd.'s Current Distribution, Electromagnetic fields, Grounding and Soil ("CDEGS") structure analysis software, version 16.2.9680. The CDEGS software modeled the potential impact of magnetic fields from the new bus conductors within the Pathway Project's expanded and new Substations to the edge of the substation boundaries consistent with Rule 3206(e). As explained in more detail in the PEAR provided as Attachment BRC-9, the magnetic fields produced within each substation will be a function of the total power flowing into and out of the substation.

Q. PLEASE SUMMARIZE THE RESULTS OF THE MAGNETIC FIELD ANALYSIS AT THE POWER PATHWAY SUBSTATIONS.

A. The results of PEIs' magnetic field analysis for each substation site are set forth in the PEAR. As explained in the PEAR, PEI first performed a more conservative modeling, calculating magnetic field strengths at each substation's fence lines. For the substations where magnetic field levels were calculated above the 150 mG level deemed reasonable by Rule 3206(e), PEI also calculated magnetic field levels at the substation property line. For Pawnee Substation, although the magnetic field strength at two fence lines is projected to be above the level deemed reasonable by Rule 3206(e), Public Service owns the land adjacent to

and surrounding the substation, and the magnetic field strength at the property line is well below the level deemed reasonable by Rule 3206(e). Similarly, for Harvest Mile Substation, although the magnetic field strength at one fence line is projected to be above the level deemed reasonable by Rule 3206(e), the magnetic field strength at that property line is below the level deemed reasonable by Rule 3206(e). Table BRC-D-5 below provides a summary of the results presented in the PEAR, showing the maximum value at the fence line or property line of each substation:

Table BRC-D-5: Summary of Projected Power Pathway Substations Magnetic Field Levels

Substation	Projected maximum magnetic field value at the substation boundary* at a height of one meter above the ground [mG]
Fort St. Vrain	112
Pawnee	0.2**
Canal Crossing	69
Goose Creek	89
May Valley	82
Tundra	105
Harvest Mile	32**
* Calculations at substation fence line shown for Fort St. Vrain, Canal Crossing, Goose Creek, May Valley, and Tundra. Calculations at property line shown for Pawnee and Harvest Mile. ** For the Pawnee and Harvest Mile Substations, although the magnetic field strength levels at the substation fence line for each substation were above the level deemed reasonable by Rule 3206(e), for both substations, Public Service owns the land adjacent to the fence line and the magnetic field strength at the applicable property line is below the level deemed reasonable by Rule 3206(e).	

Q. DID THE PEI ANALYSIS EVALUATE PROJECTED MAGNETIC FIELDS FROM THE MAY VALLEY-LONGHORN EXTENSION SUBSTATIONS?

A. Yes. The PEI Analysis included a three-dimensional magnetic field modeling analysis of the May Valley and Longhorn Substations using the same software and methodology described above for the Power Pathway Substations.

Q. PLEASE SUMMARIZE THE RESULTS OF THE MAGNETIC FIELD ANALYSIS AT THE MAY VALLEY-LONGHORN EXTENSION SUBSTATIONS.

A. The results of PEIs' magnetic field analysis for each substation site are set forth in the PEAR provided as Attachment BRC-10. Table BRC-D-6 below provides a

summary of the results presented in the PEAR, showing the maximum value at the fence line or property line of the substations:

Table BRC-D-6: Summary of Projected May Valley-Longhorn Extension Substations Magnetic Field Levels

Substation	Projected maximum magnetic field value at the substation boundary* at a height of one meter above the ground [mG]
May Valley	42
Longhorn	63
* Calculations shown at substation fence lines.	

Q. ARE THE EXPECTED MAXIMUM LEVELS OF MAGNETIC FIELDS AT THE EDGE OF THE SUBSTATION BOUNDARIES REASONABLE UNDER RULE 3206(e)?

A. Yes. The results for the individual substations are set forth in the PEAR and described below:

Fort St. Vrain: The facilities for the substation expansion will be constructed on land already owned by the Company. The magnetic field levels at each of the proposed fence lines for the expansion portion of the Substation are below 150 mG. However, the analysis modeled magnetic field values higher than 150 mG at certain points along the northern fence line of the existing 230 kV yard. These points are immediately adjacent to the Fort St. Vrain generating station and are within the Public Service property line. Because the adjacent land is owned by Public Service and occupied by the adjacent generating station, it is reasonable to consider all of this land as within the “substation boundary” for

purposes of Rule 3206(e). Access to the area between the substation and the generating station is restricted and the public is not permitted entry.

Pawnee: The expansion of the Pawnee Substation will be constructed on land already owned by the Company. PEI's analysis modeled magnetic field values higher than 150 mG at certain points along the western and southern fence lines of the existing Pawnee Substation, where the Company will install new facilities. These points are on the inside of an access road that surrounds the existing Substation and a canal that is adjacent to that portion of the access road, all of which are within the Public Service property line. PEI also modeled the magnetic field strengths at Public Service's property line, which is several thousand feet from the Substation and found that magnetic field levels would be well below the 150 mG deemed reasonable at the property line. Because the land adjacent to the substation fence line is owned by Public Service and is either open space, parking lot, or occupied by the adjacent generating station, it is reasonable to consider all of this land as within the "substation boundary" for purposes of Rule 3206(e). Members of the public are not expected or invited to the areas immediately adjacent to the Substation.

Canal Crossing: The new Canal Crossing Substation will be constructed on land already owned by the Company. As described in the PEAR, magnetic fields along all the fence lines of the substation are expected to be well below 150 mG.

Goose Creek, May Valley, and Tundra: As described in the PEAR, magnetic fields along all the fence lines of all three substations (including the currently planned, but not yet in-service, facilities and expansion facilities at Tundra) are expected to be well below 150 mG.

Harvest Mile: The facilities for the substation expansion will be constructed on land already owned by the Company. Although the expected magnetic field levels along portions of the existing southern fence lines for the Substation are above 150 mG, the expected magnetic field levels along the entire Substation property line are well below 150 mG. It is reasonable to consider land within Public Service's property line as within the "substation boundary" for purposes of Rule 3206(e). Although access to the area outside of the substation fence line, but still within the Company's property line, is not physically restricted, members of the public are not expected or invited to the areas immediately adjacent to the Substation.

3. Prudent Avoidance Requirements and Summary of the Company's Request

Q. CAN YOU DESCRIBE THE REQUIREMENTS OF COMMISSION RULE 3102(d)?

A. Yes. When an electric utility applies for a CPCN to construct or extend transmission facilities, Commission Rule 3102(d) requires it to "describe its actions and techniques relating to prudent avoidance with respect to planning, siting, construction, and operation of the proposed construction or extension."

Q. WHAT IS PRUDENT AVOIDANCE?

A. As set out in Commission Rule 3102(d), 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 a reasonable and modest cost." The rule lists the following five examples of prudent avoidance steps and techniques: 1) design alternatives to all phasing of conductors; 2) routing of lines to limit exposure; 3) use of higher structures; 4) the widening of corridors; and 5) the burying of lines.

Q. WHAT HAS PUBLIC SERVICE DONE TO MEET THE REQUIREMENTS OF COMMISSION RULES 3102(d) AND 3206(e)(IV) WITH RESPECT TO THE PROJECT?

A. Public Service has been incorporating "prudent avoidance" techniques into its transmission line designs for many years. However, implementation of all prudent avoidance concepts listed in Rule 3102(d) and potential alternatives identified in Rule 3206(e)(IV) are not possible or practical for this Project either because of physical limitations or because it is not cost-effective. On many transmission projects only one or two of the techniques can be reasonably applied.

For this Project, the Company's Project design, including the phasing of conductors and height of the structures, is sufficient to meet the threshold of less than 150 mG at the substation boundaries established by Rule 3102(d).

Therefore, we do not find it necessary to apply any additional prudent avoidance techniques to the Project design and construction.

Q. WHY IS PUBLIC SERVICE NOT PROPOSING TO UNDERGROUND THE PROJECT?

A. As I stated above, the Project as designed is sufficient to meet the 150 mG reasonableness threshold set forth in Rule 3102(d). Undergrounding would entail significantly higher costs and environmental and technological impacts associated with burying the transmission line. Also, underground transmission lines do not eliminate magnetic fields; the lines simply have a different, albeit more concentrated magnetic field profile. In addition, placing a high voltage transmission line underground requires electrically insulating each of the three phases (wires) and dissipating the heat through the cable insulation layers and soil to ambient earth. To construct the Project underground with the same ampacity conductor we have proposed, we would have to install multiple underground conductor cables for each phase thereby increasing the cost. In the Company's experience, the cost of constructing a high voltage line underground can range as much as 15 to 30 times the amount of overhead construction depending on the configuration.

Underground lines also present challenges during outages. Faults that occur in underground installations are typically more difficult to locate and repair than overhead lines. And, the increased difficulty and duration for repairs can cause significantly longer power outages than with overhead power lines.

Q. IS THERE ANY NEED FOR MITIGATION OF MAGNETIC FIELD LEVELS ASSOCIATED WITH THE PROJECT?

A. No. The PEI Analysis concluded that magnetic field levels do not exceed the 150 mG level at either the edge of the substation boundaries or at the edge of the transmission line ROW for the Project.

Q. WHAT FINDINGS IS THE COMPANY REQUESTING WITH RESPECT TO MAGNETIC FIELDS?

A. The Company requests the Commission find the expected magnetic field levels associated with the Project to be reasonable because the projected magnetic field levels at the applicable locations associated with the Project fall below 150 mG, which is deemed reasonable by Commission Rule 3206(e)(III).

VI. RECOMMENDATIONS AND CONCLUSION

Q. PLEASE SUMMARIZE YOUR RECOMMENDATIONS AND FINDINGS THE COMPANY IS ASKING THE COMMISSION TO MAKE IN THIS PROCEEDING.

A. The Company is requesting that the Commission approve the recommended design of the Pathway Project as described in my Direct Testimony. I also recommend the Commission find that the projected noise levels and maximum magnetic field levels associated with the Pathway Project and the May Valley-Longhorn Extension are reasonable and that no further mitigation measures are necessary.

Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY?

A. Yes, it does.

Statement of Qualifications

Byron Craig

Mr. Craig is currently the Director of Substation & Transmission Engineering & Design in Xcel Energy's Electric Transmission organization. His organization provides engineering design and procurement activities needed to enable the execution of Xcel Energy's transmission and substation capital portfolio, including for Public Service Company of Colorado and the other Xcel Energy operating companies.

Mr. Craig has over 35 years of experience in the electric power industry, including general management, business development, project management, customer relations, technical instruction, design, standards, procurement and reliability. He has provided strategic direction as well as engineering and project management for a broad range of utility programs, projects, and studies associated with distribution, substations, and transmission, including facilities through 500 kV.

Mr. Craig holds a Bachelor of Science degree in Electrical Engineering from the University of Colorado. He is a registered professional engineer in Colorado.

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 FOR COLORADO'S POWER PATHWAY 345 KV TRANSMISSION PROJECT AND ASSOCIATED FINDINGS REGARDING NOISE AND MAGNETIC FIELD REASONABLENESS	)	**PROCEEDING NO. 21A-XXXXE**

AFFIDAVIT OF BYRON R. CRAIG
ON BEHALF OF
PUBLIC SERVICE COMPANY OF COLORADO

I, Byron R. Craig, being duly sworn, state that the Direct Testimony and attachments were prepared by me or under my supervision, control, and direction; that the Direct Testimony and attachments are true and correct to the best of my information, knowledge and belief; and that I would give the same testimony orally and would present the same attachments if asked under oath.

Dated at Denver, Colorado, this 2nd day of March, 2021.

Byron R. Craig, Director
Substation Transmission Engineering and Design

Subscribed and sworn to before me this 2nd day of March 2021.

AMANDA CLARK
Notary Public
State of Colorado
Notary ID # 20164004880
My Commission Expires 03-25-2024

Notary Public

My Commission expires 3/25/2024