APPENDIX A

OVERVIEW OF ELECTRICAL TRANSMISSION SYSTEMS

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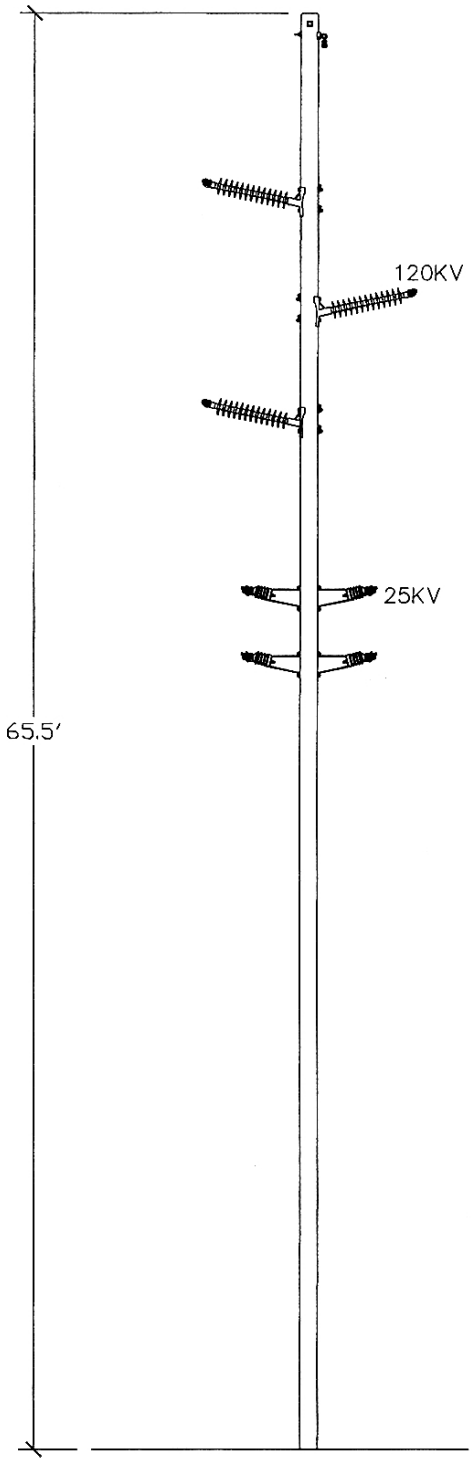
The three main structural elements that make up an electrical distribution system are (1) transmission lines, which convey high voltage electricity from power generation facilities, (2) substations, which reduce the voltage in the transmission lines to distribution levels, and (3) distribution lines, which convey the electricity to customers. (The Proposed Action evaluated in this EIS involves construction of transmission lines and substations).

Transmission Lines

Transmission lines are high-voltage lines (60-kV or greater) that convey bulk power from remote power sources to the electrical service area. These lines may be overhead or underground; underground transmission lines are discussed separately below. Overhead high-voltage conductors are approximately an inch in diameter and are made of aluminum strands or a mixture of aluminum and steel strands. The lines are isolated electrically by the surrounding air and are not wrapped with insulation material.

Support structures for overhead transmission lines range from single wood or metal poles and H-frame towers between 50 and 90 feet tall for lower voltage lines (i.e., 60-kV and 120-kV), to metal H-framed or lattice frame towers between 75 and 130 feet tall for higher voltage lines (i.e., 345-kV). As described in Chapter 2 of the EIS, SPPCo proposes to use single wood and metal poles for the Tracy to Silver Lake 120-kV transmission line (Figure A-1). SPPCo's transmission system consists of approximately 4,000 miles of high-voltage power lines.

It is not desirable for circuits that serve the same substation to be located or double circuited in the same proximity to each other (e.g., in the same corridor or on the same pole). This results in less reliability because both circuits could be compromised by the same event (e.g., wind storm or lighting strike). In addition, safety issues would increase from maintenance activities including working on energized lines because one circuit would always have to be carrying power. In cases where the circuits are serving separate substations, double circuit configurations would not have the same reliability issues provided that they are each serving other load centers and there is existing redundancy built into the distribution system. In some cases, these circuits can be located on the same structure.



ELEVATION

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120 kV poles are typically 70 feet tall, although pole heights may vary from 50 to 90 feet in order to avoid obstructions or to account for variable terrain along the route.

Typical Single Pole 120 kV Staggered Underbuild Configuration

Washoe County, Nevada

Tetra Tech, Inc.

Figure A-1

Transmission lines, including those constructed by SPPCo, are designed in accordance with requirements of the National Electrical Safety Code (NESC), which address design issues such as the following:

- Clearances between the lines and other features, such as ground or water surfaces, roadways and railways, other conductors or communication wires, and buildings;

- Use of shield wires along the top of the transmission line to shield the conductors from lightning strikes;

- If an energized line falls to the ground, high-speed relay equipment will sense this condition and actuate breakers that would de-energize the line a tenth of a second to half a second;

- Connection of metallic parts to an electrode in the ground (grounding) in order to safeguard employees and the public from the hazard of electric potential; and

- Standards for mechanical and structural design, selection of materials, and construction practices to ensure that towers, conductors, and insulators are strong enough to withstand normal and unusual loads, such as ice and wind, to ensure that pole spans are adequate to prevent conductor or structure failure, and to ensure that adequate clearances are maintained.

Substations

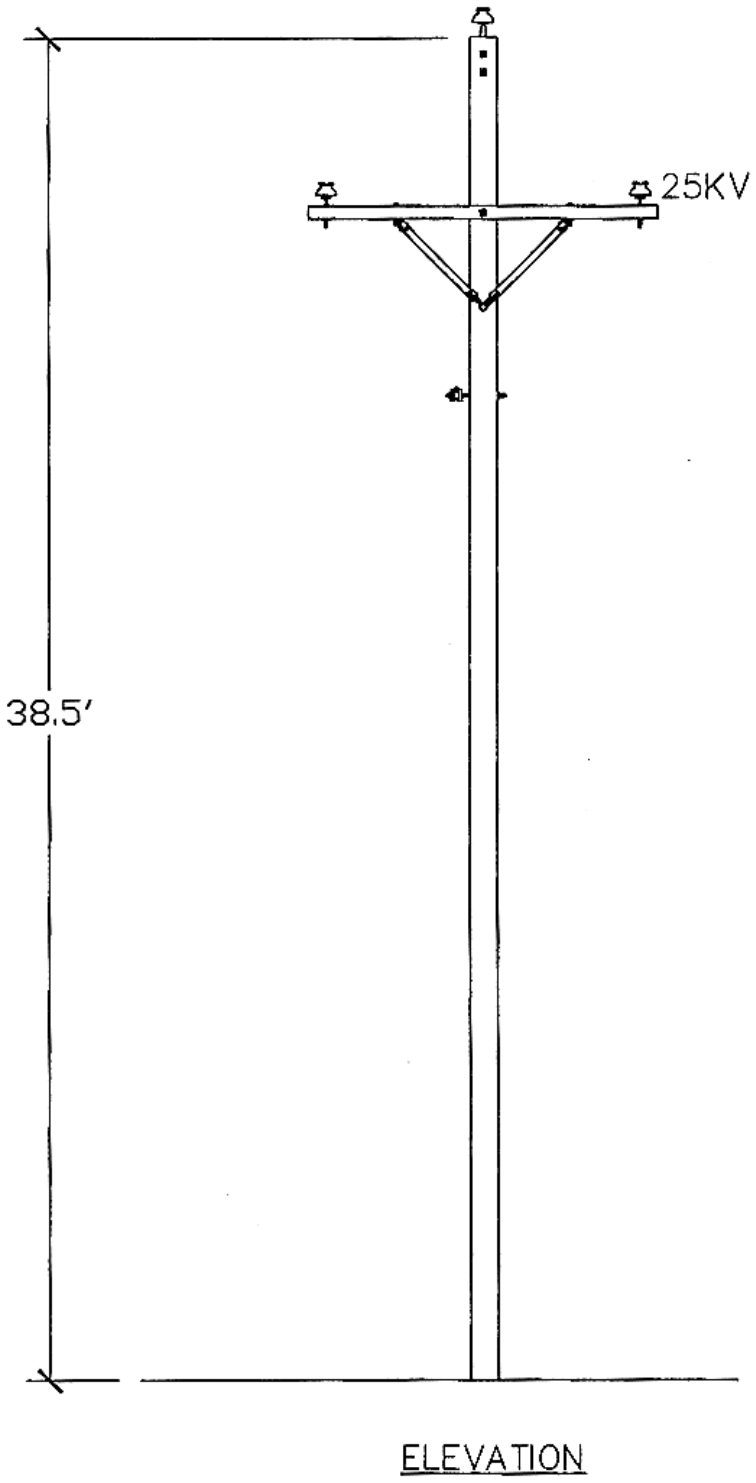
Because electricity in the transmission lines is at voltages greater than what the customer can use, the transmission lines are first directed through substations, which regulate or reduce the electric voltage to levels that can be conveyed to the customer. Substations generally consist of a control building and steel structures that support the necessary electrical equipment, including the terminals to receive transmission lines and transformers that convert power to a different voltage. Substations are generally located in the central part of a service area, defined by the level of customer demand, or load, in order to permit efficient distribution of power to customers. SPPCo operates 178 substations in its service area.

Distribution Lines

Electricity from substations is conveyed to the customer through medium-voltage 25-kV distribution lines. Because distribution lines carry lower voltages, they require less substantial lines and support structures than transmission lines. Distribution conductors are generally half an inch to an inch in diameter and are supported by T-shaped wood poles approximately 40 feet tall (Figure A-2). Because distribution lines are most prevalent in highly developed areas, and because they operate at lower voltages, distribution lines are more easily and frequently placed underground. Because distribution lines serve all electrical customers, they are the largest component of the electrical system. SPPCo's distribution system consists of approximately 13,500 miles of overhead and underground lines.

Underground Transmission Lines

Underground construction of transmission lines generally involves placing the transmission line beneath the ground in a concrete encased PVC conduit system. Underground construction is an effective technique to avoid certain potential hazards associated with overhead lines, such as downed lines or interference with aircraft (Table A-1). It is also effective in avoiding certain impacts associated with



Source: Sierra Pacific 2003

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Typical distribution conductors are generally half an inch to an inch in diameter and are supported by T-shaped wood poles approximately 40 feet tall.

Typical Distribution Line Structure

Washoe County, Nevada

Tetra Tech, Inc.

Figure A-2

overhead power lines, such as visual impairment. Underground construction does have certain associated impacts that are greater than aboveground construction due to the amount of ground disturbance associated with trenching.

Table A-1
Relative Reliability of Overhead and Underground Transmission Lines

	Overhead	Underground
	Frequency of Failure	
Failure Type		
Insulation failure	Lower	Higher
Splice failure	Lower	Higher
Termination failure	Lower	Higher
Dig-in	None	Higher
Tree contact	Higher	None
Vehicle accident	Higher	None
Storm (high wind)	Higher	None
Storm (lightning)	Higher	Lower
Moisture/Erosion Damage	None	Higher
Bird contact	Higher	None
	Time to Address Failure	
Locate fault	Faster	Slower
Repair fault	Days	Weeks
Temporary fix (if required)	Faster	None

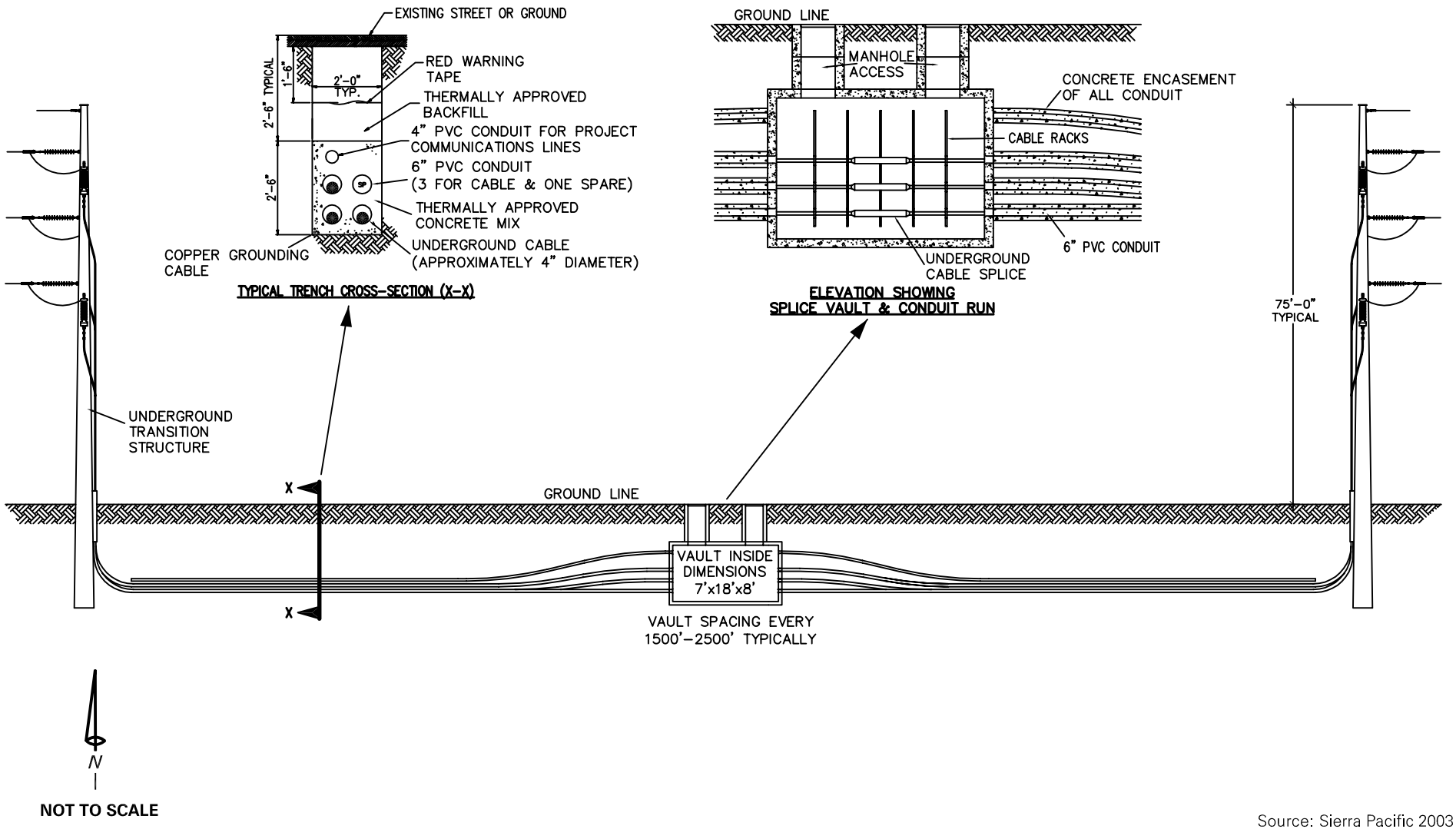
Source: SPPCo 2002

An underground transmission system consists of the electrical cable, cable duct bank systems (conduits), splice vaults, and transition structures (Figure A-3).

Underground Conductor—A 120-kV underground cable consists of an aluminum or copper conductor wire covered with insulating and protective materials approximately four inches in diameter, which is larger than overhead cables of comparable capacity. Unlike overhead conductors, underground cables must be covered with electrical insulation and a moisture impervious sheath for electrical properties and to protect them from moisture intrusion or other physical contact.

Cable Duct Bank Systems—Cable duct bank systems are plastic conduits that house the underground cable. For a 120-kV transmission line, a duct bank system would typically consist of four 6-inch conduits, three for the cable and an unused conduit for emergency repair or replacement, and one 4-inch conduit for project or other communication purposes. The conduits are encased in thermally engineered concrete and are backfilled with soil that meets prescribed thermal properties. The ground surface above the trench is restored to pre-existing conditions (typically street pavement or native vegetation).

Splice Vaults—Splice vaults are compartments approximately 8 feet wide, 9 feet deep, and 19 feet long that provide access for installing and splicing cable. Splice vaults are generally located every 1,500 to 2,500 feet along the line, depending on the length of the cable to be installed and the availability of a suitable location for the facility.



Source: Sierra Pacific 2003

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An underground transmission system consists of the electrical cable, cable duct bank systems (conduits), splice vaults, and transition structures.

Typical 120 kV Underground System
Tracy to Silver Lake 120 kV Transmission Line

Washoe County, Nevada

Tetra Tech, Inc.

Figure A-3

Transition Structures—There is a common misconception that "undergrounding" entails directing lines underground straight off of an aboveground transmission line. However, in order to run a line underground, a transmission line must first travel through a transition structure. Also referred to as riser poles or termination structures, transition structures are poles located at each end of the underground cable section to transition the underground cable to overhead lines or substation equipment. Transition structures are about the same height as poles on an overhead section of line (approximately 75 feet) and are highly visible to surrounding receptors (Figure A-4). Termination structures are made of self-weathering steel, are set in a concrete foundation, and are installed in much the same way as other overhead transmission line poles.

Underground construction trenches are typically two feet wide and five feet deep, although the trench must often be deeper or wider to avoid existing utilities. Approximately 25 feet of ground disturbance on either side of the trench (or 50 to 60 feet total) is also required, in flat terrain, to permit use of equipment along the trench and for placing excavated material. Width requirements can be reduced to between 20 and 30 feet if the excavated materials are hauled off-site. The area under construction at any one time is typically 300 feet long. Traffic control is required for construction within city or county streets.

Figure A-4 View of a typical underground transition structure