This section of the draft environmental impact statement (EIS) describes what the proposed transmission line poles would look like and how wide the right-of-way (ROW) would have to be for the selected structure type. The section finishes with a discussion on the potential for undergrounding the 345 kilovolt (kV) transmission line and the applicability with regard to this project.

4.1 High-Voltage Transmission Line Basics

High-voltage transmission line (HVTL) circuits generally consist of three phases, each at the end of a separate insulator, and physically supported by structures. A phase consists of one or more conductors (single, double, or bundled). A typical conductor is a cable consisting of aluminum wires stranded around a core of steel wires. There may also be shield wires strung above the phases to prevent damage from potential lightning strikes. The shield wire could also include a fiber optic cable that allows for substation protection equipment to communicate with other terminals on the line.

Explain "phases" of electrical currents

Electricity is generated when a magnet rotates inside the coils in a generator. Because one pole of a magnet will move past one coil and then the subsequent coils, there is a difference in timing of the alternating current induced in each coil. This is called the different "phases" of current. Most high-voltage transmission lines carry three-phase alternating-current power because that is how the electricity is generated at power plants. The transmission line transfers each of the three phases of alternating current on separate wires so that power can be transferred constantly over each cycle. This also makes it possible for electric motors to use electric energy more efficiently.

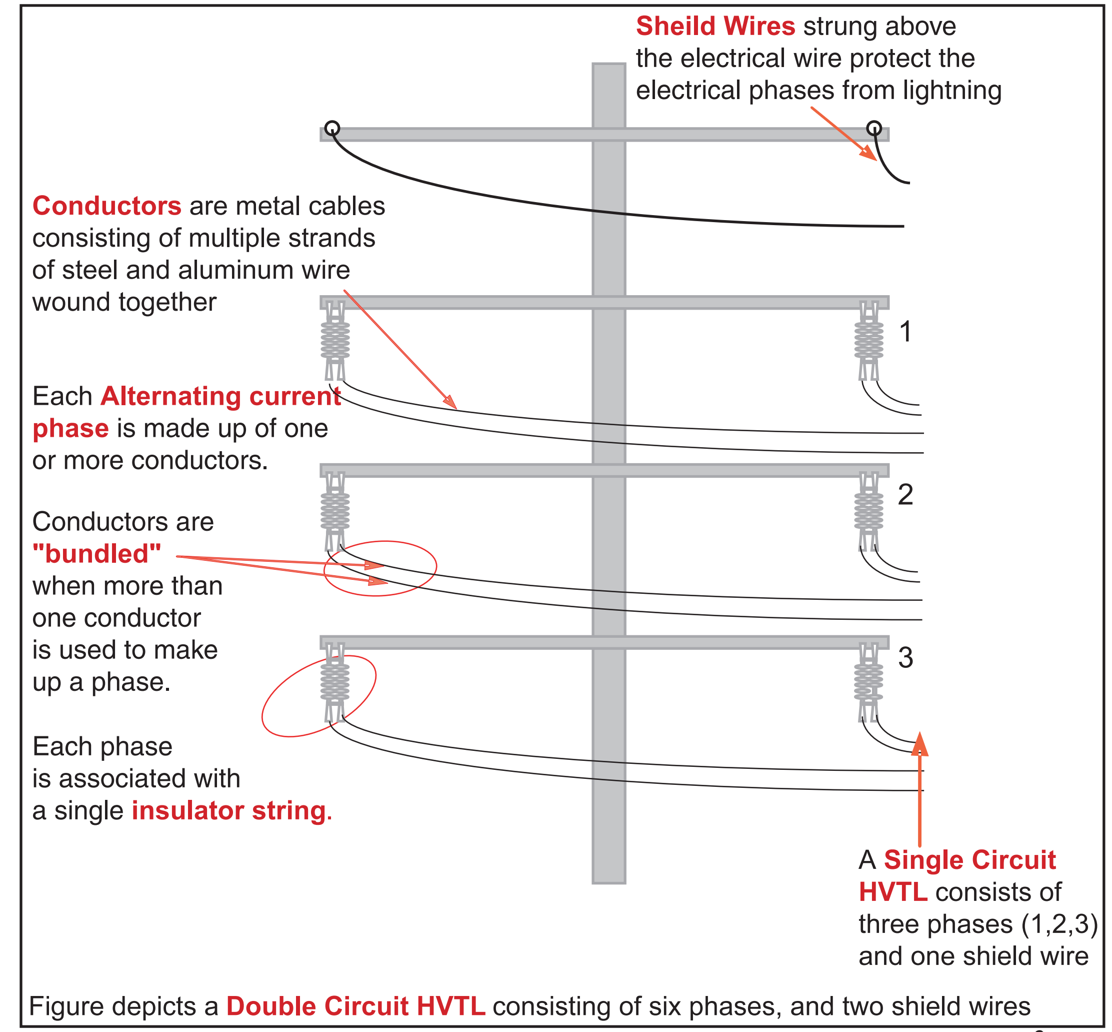
Figure 4.1-1 shows the major components of a typical transmission line. The diagram shows a typical double-circuit HVTL structure. There are three conductors per circuit because most power plants generate electricity such that each of the three conductors operates at a different phase. Second, as shown in the figure, each of the wires hangs from the end of a separate insulator string.

Finally, transmission lines are usually either single-circuit, (carrying one three-phase conductor set), or double-circuit (carrying two three-phase conductor sets, totaling six conductors). The various structure configurations and conductors proposed for this project are shown and described in the following sections.

4.2 Conductors

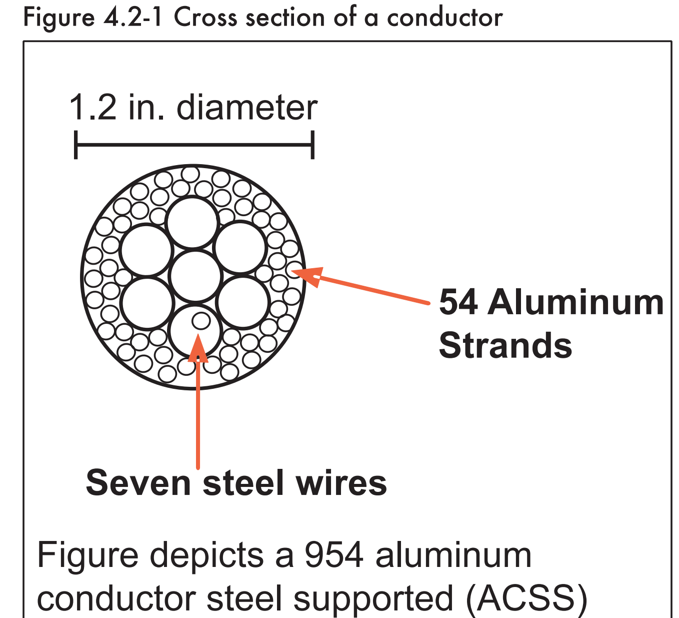
For the proposed 345 kV transmission lines, each phase would consist of bundled conductors composed of two 954 aluminum conductor steel supported (ACSS) cables or conductors of comparable capacity. Each phase of the 161 kV transmission line would consist of a single conductor using 795 ACSS cable or a conductor of comparable capacity. An ACSS consists of seven steel wires surrounded by 54 aluminum strands. Each conductor is approximately 1.2 inches in diameter (Figure 4.2-1). As indicated by the applicant, the same conductor and bundled configuration would be used for all the 345 kV and 161 kV transmission line sections.

Figure 4.1-1 Major components of typical transmission line



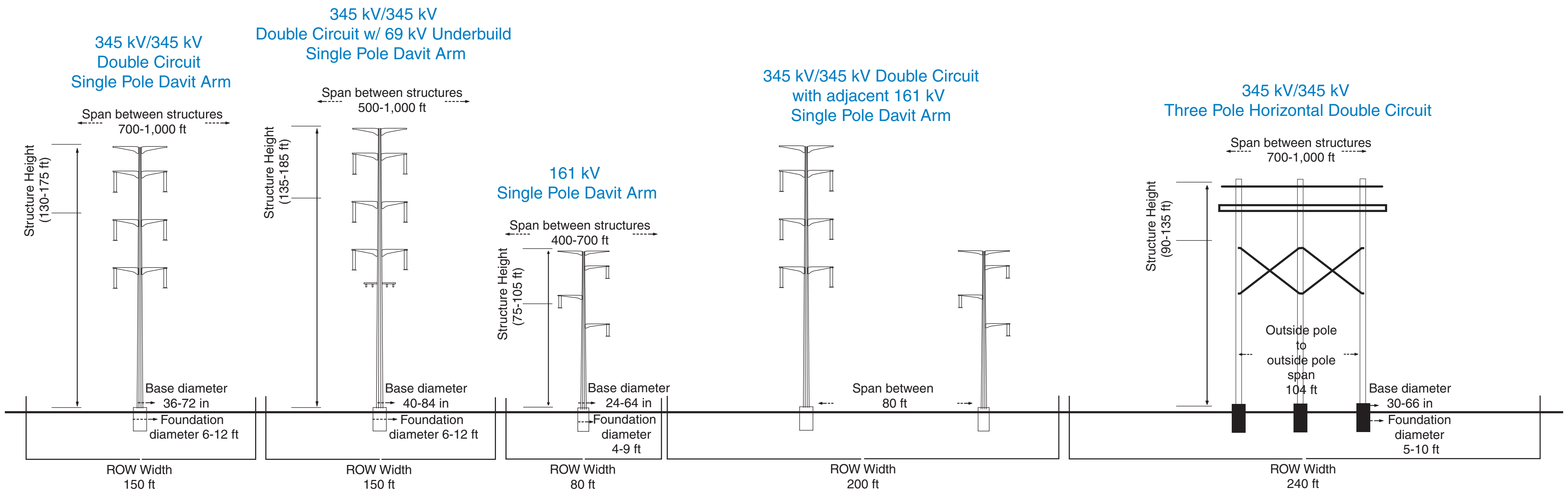
Source: Barr figure, 2009

Figure 4.2-1 Cross section of a conductor



Source: Barr figure, 2009

Figure 4.3-1 Structure designs and foundations being proposed for the project



Source: Barr figure, 2011

4.3 Transmission Line Structures

There are many different types of structures/configurations used for transmission lines, including single steel-pole structures and H-frame structures. The exact width of ROW required for the transmission line, in turn, depends on structure design, span length, and the electrical safety requirements associated with the transmission line's voltage. Figure 4.3-1 shows the proposed structure types for the project.

For this project, the applicant is proposing to use self-weathering single-pole double-circuit structures to carry the 345 kV transmission line for the majority of the project. Self-weathering single pole single-circuit structures would be used for the 161 kV transmission line.

The single-pole steel structures would range from 130 to 175 feet in height for the 345 kV structures (Figure 4.3-1), and 70 to 105 feet for the 161 kV structures (Figure 4.3-1). Spans would typically be 700 to 1,000 feet between structures on the 345 kV transmission line, and 400 to 700 feet on the 161 kV transmission line. For the 345 kV transmission line, only one circuit would be strung and the other side of the pole would be available for adding a second circuit in the future, if and when conditions warrant. Adding a second circuit would require approval from the Public Utilities Commission (commission). Single-pole steel structures are typically placed on large pier foundations of cast-in-place, reinforced concrete.

Multiple-circuit structures are proposed in two areas of the Segment 1-B route alternatives:

- on the Hampton–North Rochester 345 kV section along US-52 between Cannon Falls and Zumbrota, and
- on the North Rochester–Mississippi River 345 kV section near Plainview.

These proposed triple-circuit structures would hold one 345 kV circuit, provide a location for a future 345 kV circuit, and carry an existing 69 kV circuit under the 345 kV transmission lines (a configuration know as "underbuilding"). These structures would range in height from 135 to 185 feet and have spans of approximately 500 to 1,000 feet. The triple-circuit structures may require an additional pole mid-span to support the 69 kV circuit.

Several comments received during the EIS scoping process suggested other areas of the applicant's preferred and alternate route segments where double or triple-circuit structures should be considered and evaluated. These route alternatives are described in Sections 8.2 and 8.3; in those sections these route alternatives are referred to as the "C Routes." Figure 4.3-1 illustrates a representative double-circuit 345/345 kV structure with 69 kV underbuild.

One or two shield wires would be used to protect the conductors from lightning strikes. One of these shield wires would likely incorporate a fiber optic cable to facilitate control communications between substations and between substations and utility control centers. Fiber optics would be used only for utility purposes.

In areas of poor soil strength and for angle and dead-end structures, a rock-filled galvanized steel culvert or drilled pier concrete foundation may also be inserted for additional stability. Support cables (guying) may also be used for angle structures.

Table 4.3-1 summarizes the proposed structure types for the project. In addition to the structures described in the table, the applicant may elect to use H-frame structures in certain areas. H-frame structures consist of two poles connected with cross-braces and a beam that supports the conductors. H-frame structures may be used in certain areas where longer spans are desired, such as in environmentally sensitive areas, areas of difficult topography and elevation changes, or where poor soil conditions exist. These structures, when used, typically minimize the overall total number of structures required in an area as well (e.g., minimizing the number of structures in a river's riparian zone). H-frames also allow all of the conductors to be strung in a single horizontal plane, therefore minimizing the vertical barrier that avian wildlife would cross.

Why use single-pole steel structures?

Steel single-pole structures, also known as monopoles, require only one pole along the ROW, with a relatively narrow footprint compared to steel lattice or other types of structures. This reduces the impact on farming operations and other impacts compared to the two poles required for H-frames, or the wide bases of steel lattice structures. Steel monopoles are more durable and longer-lasting, because they are self-weathering, which means that the steel oxidizes or rusts to form a dark reddish brown surface coating which protects the structure from further weathering.

4.4 Right-of-Way Requirements

The applicant has indicated that a 150-foot wide ROW would be required for the proposed 345 kV transmission lines and an 80-foot-wide ROW would be required for the proposed 161 transmission lines. As noted above, H-frame or other specialty structures may be used for long spans or in environmentally sensitive areas, such as large wetland complexes. In that case, an up to 180-foot wide ROW may be needed. H-frames may also be used for crossing the Upper Mississippi River National Wildlife and Fish Refuge to minimize the potential for avian impacts near the point where the 345 kV transmission line would cross the Mississippi River. In that case, an up to 280-foot wide ROW may be needed; this would require an expansion of the existing U.S. Fish and Wildlife Service (USFWS) permitted 180-foot ROW.

Figure 4.3-1 shows the designs and foundations for the structures the applicant is proposing for the 345 kV and 161 kV portions of this project, respectively, along with the typical ROW required for each.

When a transmission line is placed across private land, a ROW agreement, typically an easement, is required (see Appendix C). When a transmission line is placed entirely across private land, an easement for the entire 150-foot ROW (for 345 kV transmission lines) or 80-foot ROW (for 161 kV transmission lines) would need to be acquired from the landowner(s). The applicant has indicated a preference for locating poles as close to property division lines as reasonably possible to reduce the amount of ROW on a particular property.

When a transmission line parallels roads, railroads, or other transmission lines, a landowner may be able to have a narrower easement. When paralleling existing roadways, for example, the general practice is to place the poles on the adjacent private property, a few feet inside the existing road ROW. So, although the pole is still located on private property, the transmission line can share some of the public ROW, thereby reducing the size of the easement required from the private landowner. For example, if the normally required ROW width is 150 feet, and the pole is placed five feet off of an existing road ROW, only an 80-foot easement would be required from the landowner. The roadway and transmission line would share the other 70-foot-wide section of ROW.

Siting transmission lines along existing ROWs can minimize the proliferation of new utility corridors and private landowner impacts. However, in order to share ROW, the applicant would have to acquire necessary approvals from the ROW owner (e.g. railroad) or the agency overseeing use of a particular ROW (e.g., Minnesota Department of Transportation (DOT)).

The DOT's Utility Accommodation Policy outlines the policies and procedures governing use and sharing of state trunk highway ROWs by utilities. The policy was developed in accordance with the requirements of state and federal law (Code of Federal Regulations, Title 23, Part 645, Subpart B). It is designed to ensure that the placement of utilities does not interfere with the flow of traffic and the safe operation of vehicles.

DOT has a responsibility to preserve the public investment in the transportation system and to ensure that non-highway uses of the ROW do not interfere with the ability of the state to make long-term highway improvements, such as adding lanes, interchanges, or bridges, or to safely operate and maintain the existing system. In addition, state law requires DOT to reimburse the utility if a utility must be relocated from ROW along an interstate highway as a result of future expansion or new interchanges (Minnesota Statutes 161.46 Reimbursement of Utility).

Requirements of the Utility Accommodation Policy vary based on whether the utility is crossing the highway or being installed parallel to it and based on the type of highway. For controlled access highways or freeways, "the installation of new utility facilities shall not be allowed longitudinally within the ROW of any freeway, except in special cases under strictly controlled conditions." (DOT 2005). This means that the transmission structure–the poles and davit arms–must be completely outside of the freeway ROW. For this project, this would mean placing a pole approximately 20 to 25 feet outside the ROW.

The Utility Accommodation Policy does provide for exceptions where special circumstances exist. If the highway is part of the National Highway System, the exception must be approved by the Federal Highway Administration and would be considered a federal action, meaning that the requirements of the National Environmental Policy Act (NEPA) must be met.

The percentage and type of shared (or "accommodated") ROW for each route alternative is discussed in Section 8 of this draft EIS.

Table 4.3-1 Proposed structure design summary

Line Type (Design Configuration)	Initial Configuration	Structure Type	Structure Material	ROW Width (feet)[c]	Structure Height (feet)[c]	Structure Width (outside pole-to-outside pole) (feet)	Structure Base Diameter (inches)[c]	Foundation Diameter (feet)[c]	Span Between Structures (feet)[c]
345 kV/345 kV Double-Circuit	345 kV circuit operational	Single Pole Davit Arm Vertical	Steel	150	130–175	n/a	36–48 (tangent structures) 48–72 (angle structures)	6–12	700–1,000
	345 kV circuit operational/ 161 kV circuit operational	Single Pole Davit Arm Vertical	Steel	150	130–175	n/a	36–48 (tangent structures) 48–72 (angle structures)	6–12	700–1,000
	345 kV circuit operational/ 161 kV circuit operational	Three pole Horizontal Double Circuit	Steel	240	90—135	104	30-42 (tangent structures) 42—66 (angle structures)	5-10	700—1,000
345 kV Single Circuit	345 kV	Two pole Horizontal H-frame	Steel	170	90—135	27	30-42 (tangent structures) 42—66 (angle structures)	5-10	700—1,000
345 kV/345 kV Double-Circuit w/69 kV Underbuild	345 kV circuit and 69 kV underbuild circuit operational	Single Pole Davit Arm Vertical	Steel	150	135-185	n/a	40–52 (tangent structures) 48–84 (angle structures	6-12	500-1,000
161 kV Single Circuit	161 kV circuit operational	Single Pole Davit Arm	Steel	80	70-105	n/a	24–36 (tangent structures) 32–64 (angle structures)	4-9	400-700

[c] Typical range for specified line type.

4.5 Underground Options

Undergrounding of transmission lines can be a feasible option, especially for lower voltage transmission lines. However, at higher voltages, undergrounding becomes progressively more complex. It is common today to see lower-voltage distribution lines that connect to homes and businesses buried directly in the ground using less invasive construction methods. In these cases, undergrounding offers aesthetic and environmental benefits while posing relatively few construction, maintenance, and operational challenges.

A number of factors are involved in the consideration of undergrounding a HVTL, including: construction, electromagnetic fields (EMF), cost, and maintenance.

Construction

Installation generally includes direct burial in backfilled trenches and concrete trenches with covers or concrete ductbanks. Constructing the trench for the underground transmission line would result in greater temporary construction impacts than the proposed overhead line. Underground transmission construction as compared to overhead lines increases noise, dust, and traffic disruption. Considerable clearing and grading would be expected in suburban and rural settings, and dust and noise from construction would last three to six times the duration of an overhead line.

Concrete manholes or large splice vaults are needed at recurring intervals. During repairs, a whole segment between these vaults may need to be excavated again.

A typical progression rate for underground construction would be two to three days for each 200-foot section of trench. Approximately 500 to 700 feet of trench is open at one time. Steel plates are typically placed over open sections of trench when crews are not at that location. Access to homes (driveways, front yards, sidewalks, and street parking) may be limited for several days to weeks during construction and local traffic would likely be rerouted to other streets, or redirected by a traffic monitor. According to the applicant, underground conductors of the size appropriate for this project are generally limited to approximately 1,000-foot-long segments, due to the state of the technology, materials, and shipping weight and size restrictions.

Electromagnetic Fields

The calculated EMF profiles for underground transmission lines generally show a higher EMF level directly above the line, but the fields decrease faster with distance compared to levels under overhead lines.

Electric fields created by transmission lines can be blocked by different objects such as trees, structures, cars, and soil; therefore, electric fields may be significantly diminished by undergrounding transmission lines. Magnetic fields, however, are difficult to block and would continue to pass through the ground. Regardless of overhead or underground construction, magnetic and electric field intensity decrease with distance.

Cost

An underground transmission line is expected to cost up to 10 times more per mile compared to construction of an overhead transmission line, due to time, materials, process, and the use of specialized labor. An underground transmission line must also be routed to avoid other underground installations such as water, gas, and sewer lines. Unstable slopes, hazardous material sites, wetlands, and bedrock must be avoided. Going under a road, highway, or river requires expensive construction techniques such as directional boring. All of these aspects of underground transmission line construction lead to a higher cost than overhead transmission line construction. For example, the applicant engaged an engineering firm to determine the feasibility of underground installation for the double circuit 345 kV line at the river crossing near Kellogg, Minnesota. The length of the underground alternative studied is 1.3 miles and has an estimated cost of $90 million. This is approximately $70 million per mile for underground **single** circuit 345 kV compared to approximately **$12** million per mile for **an** overhead **triple circuit river crossing. The river crossing costs more per mile than conventional overhead construction because of the triple circuit design and more difficult construction access** (see Appendices E-F of the Route Permit Application (RPA) or Appendix D of the draft EIS).

Maintenance

Although failure of underground transmission lines is rare, a major disadvantage of building underground transmission lines is the difficulty of finding and repairing failures. It can be difficult to determine the location of a failure on an underground line. Overhead failures can usually be found through visual inspection. And while overhead failures can usually be repaired in hours or days, repairs on an underground system can be more complex. Underground cable failures must first be located, then excavated and repaired. These excavated repairs can take weeks or months, depending on the extent of damage and the availability of replacement materials. Thus the cost for maintenance on an underground transmission line compared to an above ground transmission line can be significantly higher.

Undergrounding of High-Voltage Transmission Lines Requires Greater Infrastructure

Underground lines require additional equipment to compensate for voltage rise along the distance of the transmission line. The additional equipment translates to a higher overall cost, limits the length of the underground installation, and increases the likelihood of failure due to additional components. Depending on the type of cable system used, cooling equipment may be required at underground transmission line substations. The cooling equipment increases noises above ground. Overhead lines are air cooled and widely spaced for safety. In general, there are three major types of underground transmission facilities: high- and low-pressure oil-filled systems, solid dialectic systems, and compressed gas insulated systems. These systems may require the installation of additional cables to meet the equivalent capacity requirements of the overhead line. Because of these challenges, placing high-voltage transmission lines, like the lines proposed for this project, underground is a practice generally used only when there is no viable overhead corridor and for very limited distances.

4.5.1 Undergrounding at River Crossings

Two different construction methods are available for undergrounding a transmission line at a river crossing: submarine cable and directional boring.

- Submarine cable: The transmission line can be laid along the bottom of the river using a hydro-plowing procedure that partially imbeds the line on the bottom of the river. Submarine cables can be susceptible to damage from floods, river debris, and boat anchors. Submarine cables also create a potential safety hazard for boaters.
- Directional boring: A casing could be directionally bored at each river crossing and the conductor could be installed in the casing. Unknown bedrock or boulders may be encountered during the drilling phase, which may result in damage to drilling equipment and sometimes requires new boring paths to be started.

Whether installed using submarine cable or directional drilling, underground HVTLs present some obstacles. First, either installation method would require a transition structure at each end, where the transmission line transitions from overhead to underground and from underground to overhead. Because of the high voltage, these transition structures would likely be low to the ground and enclosed by a fence, typically requiring approximately one acre of land. Accessing construction and excavation sites and the associated belowground vaults and transition structures may be complicated by the challenging topography of the Mississippi River area.

Second, the submarine cable underground construction method would disturb the riverbed and aquatic vegetation and could impact water quality and aquatic organisms. The directional boring underground construction method would require significant excavation and relatively large work areas at each end of the bore. In addition, depending on the location needed for construction, vehicles and equipment and materials for directional drilling may impact the surrounding environment more than the equipment required for installation of overhead lines. Options for an underground crossing of the Mississippi River are discussed in detail in Section 6.3.2.

This page intentionally left blank.