Chapter 3 Project Components and Construction, Operation, and Maintenance Activities

This chapter provides an overview of the components of the proposed project and the typical area of disturbance created by these components. This chapter also discusses project design activities; and construction, operation, and maintenance requirements for the project, including removing and replacing existing transmission lines; and lists mitigation measures included as part of the project (see Table 3-2 at the end of this chapter).

Words in **bold** and acronyms are defined in Chapter 32, Glossary and Acronyms.

3.1 Easements and Land Purchases

Much of the project area is private property, with some federal and state ownership, and municipal lands such as land owned by cities, counties, and the Port of Portland. Construction of the project would require easements (rights for use and access) for transmission line rights-of-way and access roads in some locations, and land purchases for the substations and possibly the substation access roads.

In general, BPA would need a 150-foot-wide right-of-way easement for the new 500-kV transmission line and a 50-foot-wide easement for new access roads, and would purchase 25 to 50 acres for each new substation. In addition, BPA would purchase rights where needed to remove vegetation off the right-of-way that could interfere with the safe operation of the proposed transmission line (see Section 3.11, Vegetation Clearing). The 150 feet required for the transmission line right-of-way is BPA's standard width for 500-kV transmission line rights-of-way, and is intended to ensure that the line is a safe distance from other objects and structures such as trees and buildings. The entire 150-foot-wide right-of-way required for a transmission line could be disturbed by construction and operation of a new line depending on the existing land use, vegetation, roads, and other elements found in the right-of-way area.

The action alternatives require varying amounts of new right-of-way and are described in more detail in Chapter 4, Proposed Action and Alternatives. Each alternative has specific right-of-way requirements and configurations, including existing right-of-way widths available for a new line, and whether and how a new line could be placed next to, or in place of, an existing line. These configurations would affect how much new right-of-way would need to be acquired, and consequently how many acres might be occupied by proposed transmission facilities. For example, some portions of the West Alternative have space available for a new line within existing BPA right-of-way next to existing lines, so no new right-of-way would be needed. In another section of the West Alternative, an existing line could be torn down (removed) and the new line could be built in its place. No new right-of-way would be needed in this case.

There are other possible configurations for the action alternatives. In some areas, only a small amount (such as about 12 feet) of new right-of-way would be needed to fit the new line into existing BPA right-of-way that is now vacant (BPA has an easement, but no line exists). In other areas, one or more existing lines would need to be completely removed, and different towers for these lines and for the new transmission line would be built. In these cases, the existing and new lines could be carried together on **double**- or **triple-circuit towers** instead of the typical **single-circuit tower** (see Section 3.2, Transmission Towers).

In locations where the new transmission line right-of-way (typically 150-feet wide) and access roads would be outside an existing BPA right-of-way, BPA would purchase easements from the underlying landowner. Easements for the transmission line would give BPA the rights to construct, operate, and maintain the line in perpetuity. Although the underlying landowner would still own and use the property, BPA would not permit any uses of the transmission line right-of-way that are unsafe or might interfere with constructing, operating, or maintaining the transmission facilities. These restrictions would be part of the legal rights that BPA would acquire for the transmission line. Easements for transmission line access roads would give BPA legal rights to use the roads to access the line when needed for maintenance and emergencies.

BPA would purchase the land for the proposed substations at each end of the line. BPA would acquire about 25 to 50 acres for each of the proposed substations, with exact acreage depending on the parcel selected and the substation design. BPA would purchase fee (absolute) title to each substation property so that it has full ownership rights for the property. BPA may do the same for the substation access road or it may just purchase an easement with shared rights to the use of the road.

3.2 Transmission Towers

3.2.1 Tower Types

Generally, BPA is proposing to use single- or double-circuit 500-kV lattice-steel towers for the proposed transmission line (see Figure 3-1 and inset box). In some locations, triple-circuit towers are proposed. Typically, the single-circuit 500-kV tower would be between 120 and 150 feet tall, depending on terrain and right-of-way configuration. Double- or triple-circuit towers between 180 and 200 feet tall are proposed where removing and replacing existing lines would make room for the new 500-kV line on existing right-of-way.

Tower Types

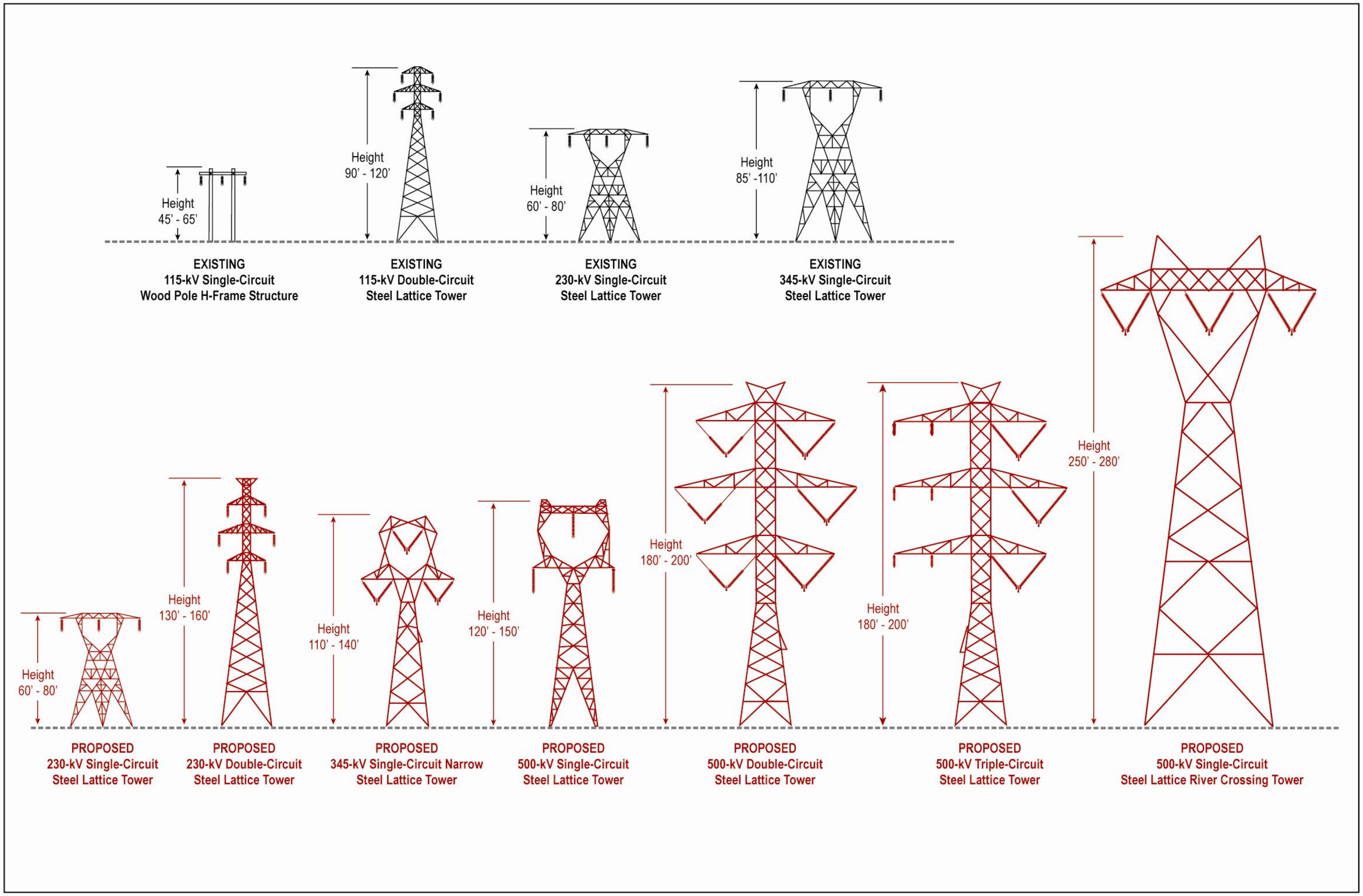
Six types of lattice-steel towers could be constructed for this project (see Figure 3-1):

- single-circuit (SC) 500-kV
- double-circuit (DC) 500-kV
- triple-circuit (TC) 500-kV (would hold one 500-kV line and two 115-kV lines)
- SC 345-kV
- SC 230-kV
- DC 230-kV

Spans between individual towers are typically about 1,150 feet, with about five towers needed for each mile of line. Towers would be made of galvanized steel and may appear shiny for 2 to 4 years before they dull from weathering. About 375 to 390 transmission towers would be needed for the new transmission line. The actual number of towers would depend on the length of the action alternative selected and the actual span length between towers.

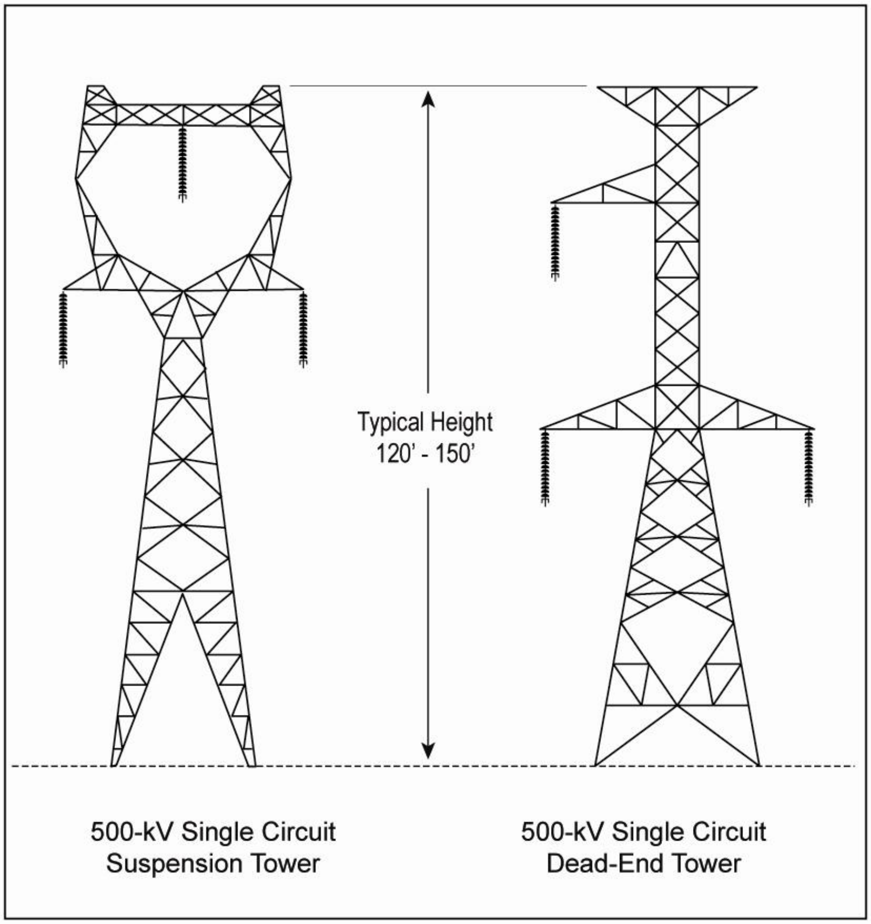
The single-circuit transmission line towers (except for the few river crossing towers) would have a delta configuration where one set of conductors hangs above the other two (see Figure 3-1). Double-circuit towers would have three sets of conductors on either side of the tower. Using the single-circuit delta configuration towers or using double-circuit towers helps reduce electric and magnetic field levels (see Chapter 8, Electric and Magnetic Fields) and uses less right-of-way.

Figure 3-1 Existing and Proposed Structure and Tower Types



Two types of towers would be used for both single- and double-circuit towers: **suspension towers** and **dead-end towers** (see Figure 3-2). Suspension towers would be used to hold the conductors along a straight path. Dead-end towers would be used where the line takes a turn or enters a substation. Dead-end towers are stronger and heavier than suspension towers, and more expensive. Most towers proposed for this project would be suspension towers.

Figure 3-2 500-kV Suspension and Dead-End Towers



Towers at the Columbia River crossing could be up to 280 feet tall (see Figure 3-1). Any towers taller than 200 feet (generally, double-circuit towers and towers used at river crossings) and transmission lines exceeding that height may be considered an obstruction by the Federal Aviation Administration (FAA). Shorter towers and lines can also be considered obstructions depending on their proximity to airport runways. As obstructions, they must be marked according to FAA rules, which may require lighting on each tower and installation of marker balls on the wires that span the space between the tall towers (see Section 3.4, Overhead Ground Wire and Counterpoise and 3.7, Obstruction Lighting and Marking). Specific areas that may require marking are discussed under each alternative (see Chapter 4, Proposed Action and Alternatives).

3.2.2 Tower Footings

Transmission towers would be securely attached to the ground with footings. Footings are assemblies of metal in the ground at each of the four tower corners. Five types of footings could be used to secure the towers: plate, grillage, rock anchor, concrete shaft, and pile footings. Most towers on this project would use either plate or grillage footings.

Plate footings are used for suspension towers. They consist of a 4-foot by 4-foot steel plate buried about 11 feet deep for each tower foot.

Grillage footings are used for dead-end towers. They consist of a 15-foot by 15-foot assembly of steel I-beams that have been welded together and buried 14 to 16 feet deep for each tower foot.

Spread footings with rock anchors are required when suspension towers are built on solid bedrock located less than 2 feet below the surface. Six-inch-diameter holes are drilled into the bedrock about 11 feet deep and steel anchor rods are secured within the hole with concrete.

Concrete shaft footings are used at river crossings or in areas where towers must sustain a higher load and require additional support. Concrete shaft footings can be built on solid bedrock or in soils unfavorable for grillage footings. Concrete shaft footings are engineered columns of concrete reinforced by steel rods about 4 to 10 feet in diameter. Footing depth depends on site-specific engineering requirements.

Micropile footings are used in rare situations where the typically larger excavation for plate and grillage footings is not appropriate. Four to five 4- to 12-inch-diameter holes are augured for each footing so that steel rods can reinforce the base. Those rods are then grouped together and capped with a reinforced concrete pile cap. The tower can then be placed atop the concrete piles.

For plate and grillage footings, a track hoe would be used to excavate an area for the footings. The excavated area would be at least 2 feet larger than the plate or grillage footings to be installed (if the soil is loose or sandy, then a wider hole may be necessary). If the soil and rock removed for plate or grillage footings is suitable, it would be used to backfill the excavated area once the footings are installed. Otherwise, suitable soil would be brought in from another location for backfill.

For spread footings or concrete shaft footings, a drill would be used to make appropriately sized vertical shafts for the footings. Soil and rock removed for rock anchor or concrete shaft footings would either be spread out onto an approved location or removed from the project area. Once foundations are set and cured, each tower would be assembled in multiple sections off-site. The tower sections would be flown in and installed via helicopter or by a large crane.

3.2.3 Tower Disturbance Areas

Typical tower disturbance areas per tower regardless of footing type have been calculated (see Table 3-1). These amounts assume suspension towers are used. Dead-end towers would slightly increase the acreage. The total area could include disturbance from vehicles, construction equipment, crane pads, etc. Compacted soils in most of this disturbance area would be broken up and reseeded after project construction to reestablish close to original conditions. While the area directly below and immediately next to the tower is also reseeded, it is considered unavailable for other uses and therefore a permanently disturbed area and a permanent impact.

Table 3-1 Transmission Tower Estimated Disturbance Areas (Acres)

Tower Type	Type of Disturbance			
	Total Tower Disturbance (Clearance Area) during Construction	Permanent Tower Impact after Construction	Temporary Tower Disturbance during Construction	Extraction Footprint/ Teardown Disturbance
500-kV Single-circuit	0.52	0.08	0.44	0.52
500-kV Triple- or double-circuit	0.69	0.08	0.61	--
345-kV Single-circuit	0.52	0.08	0.44	0.52
230-kV Single-circuit	0.69	0.08	0.61	0.43
230-kV Double-circuit	0.52	0.15	0.37	0.52
115-kV Single-circuit	--	--	--	0.11
115-kV Double-circuit	--	--	--	0.23

Notes:
-- Indicates a tower type that would not be removed or constructed as part of this project.

Along existing right-of-way in the Camas/Vancouver and Lexington areas, some existing wood pole H-frame 115-kV structures, double-circuit 115-kV, single-circuit 354-kV, and single-circuit 230-kV steel towers would be removed and replaced with a new tower configuration to make room for the new line. In most cases, new towers would be constructed on the centerline of the existing line, but not necessarily at the same location as the existing structures or towers, depending on site conditions and land use.

If existing lines are removed, the entire structure or tower footing would only be removed if the footing interfered with placement of the new tower. Otherwise, when the structure or tower is removed, that portion of the footing up to a foot below the surface would be removed (up to 3 feet deep in agricultural areas). The area disturbed when wood pole structures are removed would be about 0.1 acre, and would be about 0.4 acre for lattice-steel towers (see Table 3-1).

3.2.4 Tower Construction in the Columbia River

The Columbia River crossing would include in-water construction activities. Two types of tower footing foundations are proposed: spread footings with rock anchors and micropile-supported footings. For each footing type, construction would likely require a shallow **coffer dam** enclosure to allow **dewatering** of the work zone inside. Work would be conducted from barges stationed near lone Reef (a reef in the middle of the Columbia River at the river crossing where existing towers are located), out of the navigation channel. Barges could be stabilized by gravity weights or rock anchors. All spoils would be collected from within the sealed coffer dam and transferred to a spoils barge.

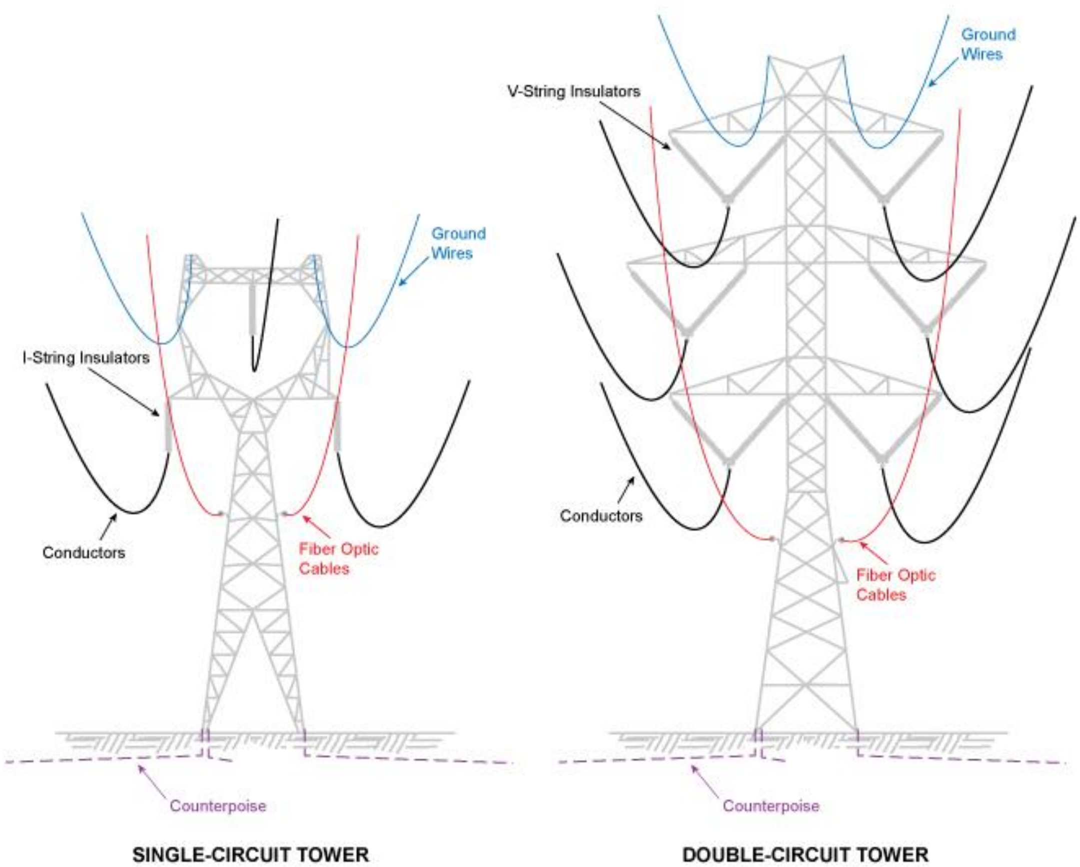
Tower columns would be about 50 feet apart. The cross section would be open to stream flow and round column shapes would allow for large debris passage. Column and framing beam design would accommodate debris impacts (large trees) and impacts from small vessel collisions.

3.3 Conductors

The wires that carry the electrical current on the transmission line are called conductors. The line carries three sets of conductors, called phases. Each phase consists of a bundle of three 1.3-inch-diameter conductors held in a triangular configuration by spacer brackets 16 to 20 inches apart. From a distance, a bundle looks like a single wire.

Conductors are made of steel and are often modified to reduce their reflectivity and brightness. The conductors are attached to the towers using insulators (see Figure 3-3). Insulators are bell-shaped devices that prevent the electricity from jumping from the conductors to the tower and down to the ground. The insulators are made of porcelain or fiberglass and are non-reflective. The conductor would need to be fitted together where one reel of conductor ends and a new reel begins. Conductor fittings would be made using hydraulic compression. Hydraulic compression uses a press that compresses the fittings on the conductor. Nine conductors (three bundles each with three conductors) would need to be fitted once about every 1.5 to 2 miles, depending on the length of conductor on the reel.

Figure 3-3 Conductor, Insulator, Ground Wire and Fiber Optic Cable Positions on a Typical 500-kV Tower



For safety reasons, BPA has established minimum conductor heights above ground and other obstacles that meet or exceed National Electrical Safety Code (NESC) clearance requirements. For the proposed 500-kV line, standard minimum clearance of the conductor above the ground is 29 feet. The clearance requirement over highways is 45.5 feet; other clearances (logging areas, railroads, rivers, trees, etc.) are determined on a case-by-case basis. The line would be designed to meet or exceed these requirements.

3.4 Overhead Ground Wire and Counterpoise

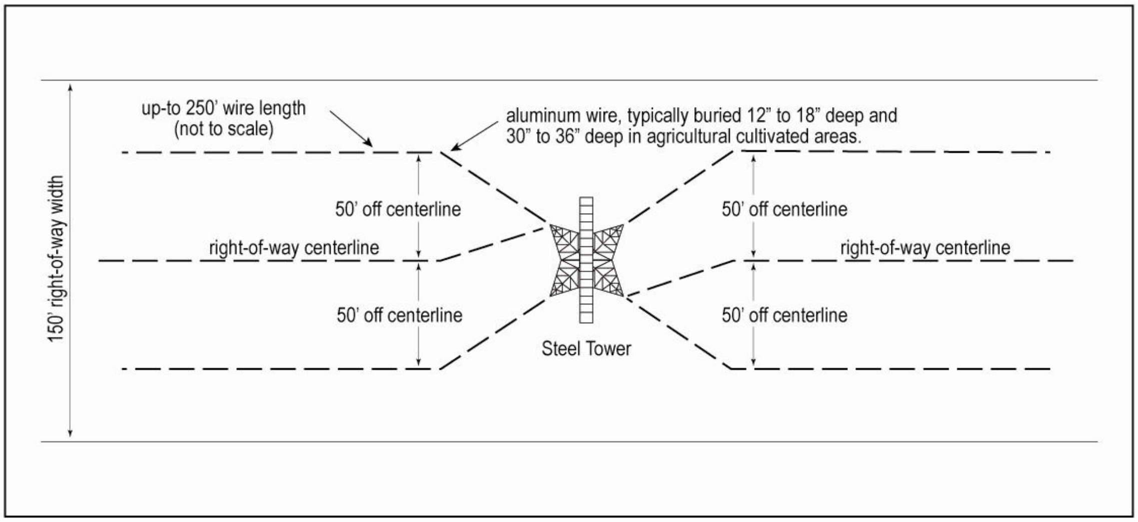
Two small wires (0.5-inch diameter), called overhead **ground wires**, would be attached to and strung between the tops of each transmission tower (see Figure 3-3). Ground wires are used for lightning protection. When lightning strikes, the overhead ground wires take the charge instead of the conductors.

Wires that exceed certain height criteria (such as when spanning rivers or deep ravines) or are within a certain distance of airports are required by the FAA to be marked with marker balls to make them more visible to aircraft in the area. For this project, marker balls would be required on the uppermost ground wires crossing the Columbia River and could be required in other locations where the action alternatives cross deep ravines. The marker balls would be 36 inches in diameter and orange, white, and yellow in varied sequences on the line. They would be placed 400 feet apart on each of the two overhead ground wires, but would be staggered on the two lines about 200 feet apart.

To take the lightning charge from the overhead ground wire and dissipate it into the earth, a series of wires called **counterpoise** would be buried in the ground at the base of the towers. Counterpoise could be needed at most towers, depending on the soil types present. Counterpoise designs vary and are dependent on tower type and site conditions. The most common design would include six runs of wire that extend up to 250 feet from the tower (three counterpoise ahead-on-line and three back-on-line (see Figure 3-4). BPA would use aluminum wire (3/8-inch diameter) typically buried 12 to 18 inches deep, except in cultivated areas where it is buried about 30 inches deep or deeper where farmers use deeper plowing methods. When three counterpoise wires run in the same direction, one counterpoise will run down the centerline of the right-of-way with the other two extending at a 45-degree angle away from the tower, then turning and running along the right-of-way at a distance of 50 feet off centerline. When obstructions or environmentally sensitive areas are encountered, the counterpoise can be redesigned to avoid these areas.

During construction, the counterpoise can be installed in several ways. Installers could use backhoes, trenchers, vibrating plows, or occasionally hand dig trenches depending on the depth, soils, terrain and size of buried rock. With a backhoe, the trench would be 12 or more inches wide. Removed soil and rocks would be piled to the side and placed back in the trench to cover the counterpoise. A trencher would open up a 4- to 6-inch wide trench and lift up the soil to the side, which would be pushed back into the trench after the counterpoise is installed. Large tractors use a vibrating plow to force a blade into the ground. The counterpoise would then run through a hole in the blade and trail out behind the blade at a specified depth. In areas where a tower would be built on solid rock, the counterpoise would be placed in crevices where possible; otherwise counterpoise would not be used.

Figure 3-4 Typical Counterpoise Placement



3.5 Communications and Control Equipment

Fiber optic cable would also be strung on the steel towers (see Figure 3-3) from the new Castle Rock area substation to the existing Troutdale Substation, and from the existing Troutdale Substation to the nearby new Sundial Substation. The cable would be used as part of a communication system that can gather information about the system (such as whether the line is in service, the amount of power being carried, meter readings at interchange points, and status of equipment and alarms). The fiber optic cable allows voice communications between power dispatchers and line maintenance crews and provides instantaneous commands that control power system operation.

The fiber cable would be less than 1 inch in diameter and would be mounted under the conductors. Every 3 to 5 miles there would be a splice box/reeling location that allows tension to be placed on the fiber optic cable. The splice box would be about 22 inches by 8.5 inches by 6 inches and would be installed in a vault in the ground between the tower legs, mounted on the towers, or placed on the ground next to the tower and covered with rock. Vault boxes would be about 4 feet by 4 feet by 4 feet. There would also be fiber vaults outside the fences at the substations and possibly fiber optic wood poles near these vaults to help transition the fiber cable from overhead to underground inside the substations. Once inside the substation, the fiber cable would be underground in conduit and trenches to the substation control house. Changes would be made to equipment inside existing substation control houses to accommodate the new cable.

Between towers that cross the Columbia River, fiber optic cable would be installed above the conductors because the typical placement of the cable below the conductor for safety during maintenance does not meet minimum clearances for ship navigation. The fiber optic cable would also act as the overhead ground wire and is reinforced to be strong enough for the long span required to cross the river.

3.6 Pulling and Tensioning Sites

Pulling and tensioning sites are those areas from which the conductor and fiber optic cable are pulled and tightened to the correct tension once they are mounted on the transmission towers. Conductor is packaged and transported on reels that can hold up to 9,500 feet of conductor. Depending on the size of the reel, pulling and tensioning sites (or reel sites or conductor tensioning sites) can be from 1.75 to 3.5 miles apart. These sites are also dependent on the topography and typically disturb about 0.7 acre each (about 300 feet long by 100 feet wide). A flat area is needed at each pulling site for the large flatbed trailer with the reels of conductor and tensioning machine. Pulling sites are generally placed within the right-of-way; however, where the line takes a turn (at angle points), sites are often outside of the right-of-way. The appropriate areas are determined by the construction contractor using environmental and land use information provided by BPA. Depending on conditions, the site could be graded, graveled with crushed rock, reseeded, or a combination of these activities. Additional environmental review would be conducted for these areas when they are identified, if necessary.

When stringing conductor, a **sock line** (thick rope) is placed in the travelers (small wheels hung from the towers) by hand or by helicopter from tensioning site to pulling site (one pull). The end of the sock line is then attached to a hard line (wire thinner than conductor but stronger than sock line) and pulled back to the end of the pull where the conductor is sitting in a reel. The hard line is connected to a "gator" plate that holds the three wires in each bundle (a phase). Each gator and triple bundle is pulled through the travelers to the other end of the pull and before the conductor is pulled to its final tension, it is often "snubbed."

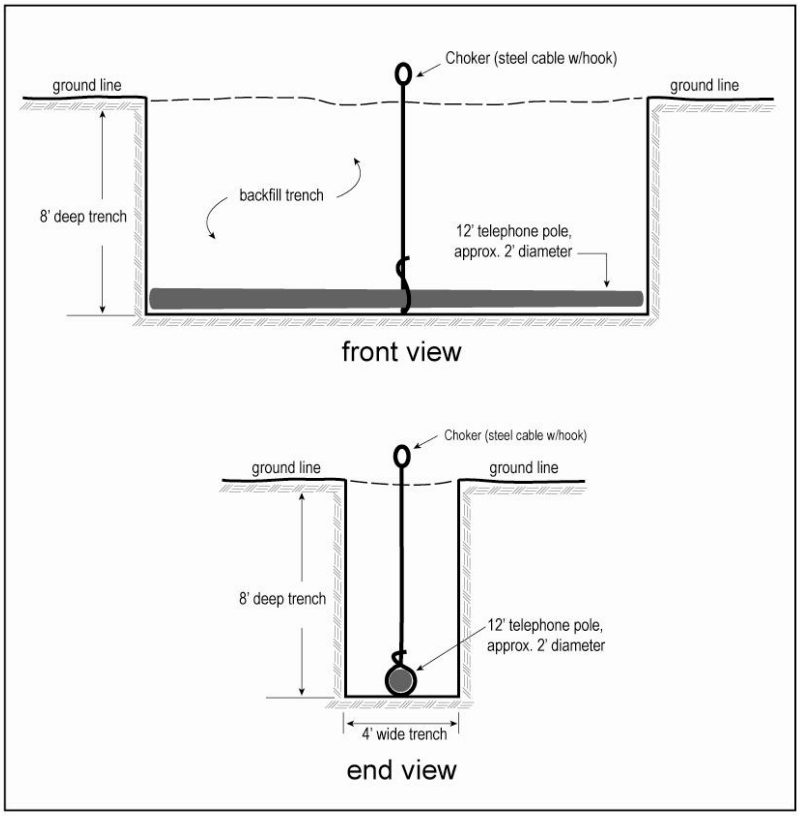
Snubs are trenches about 8 feet deep by 4 feet wide by 12 feet long used to tie off the conductor after it is pulled through the towers and before it is strung under tension (see Figure 3-5). These trenches are excavated and then backfilled to weigh down the snub so line tension can be maintained without breaking. In some instances, a concrete slurry mix is added to the top 2 feet of the trench to add density to hold the tension. After the snubs are used, the choker (a steel cable with a hook) is snipped below the surface and the wood pole is left behind. In some instances, such as in agricultural fields, the pole is reclaimed and the trench is backfilled.

In areas where conductor is strung over existing roads, highways, railroads, or water, guard structures are installed as a safety precaution. Guard structures are similar to 115-kV H-frame wood structures and are usually installed within the right-of-way on either side of the road, highway, etc. during construction and then removed once the conductor stringing is complete. The temporary disturbance area is about 0.11 acre. Additional environmental review would be conducted for these areas when they are identified and if they need to be positioned outside of the proposed right-of-way.

Conductors are not put under designed tension until all conductors are hung. When all conductors have been installed (hung) on the line and one end of the conductor has been connected to a tower (usually a dead-end tower), the conductor is pulled by equipment (usually a bulldozer or tractor) on the other end of the conductor (up to 3 or more miles away depending on the location of the next dead-end tower or the end of the conductor, whichever is closest) to the correct amount of tension (conductor sag). The correct conductor sag ensures proper ground clearance, and that supporting towers are not overloaded under ice and wind.

Jumpers are then installed. Jumpers are wires that connect conductors on one side of a dead-end tower to conductors on the other side of the same tower. Putting tension on the fiber optic cable would occur at the same pulling sites used for the conductor and would require smaller equipment to pull the cable (no "snubs" required) because the fiber optic cable has a smaller diameter and is lighter than the conductor.

Figure 3-5 Typical Snub Placement



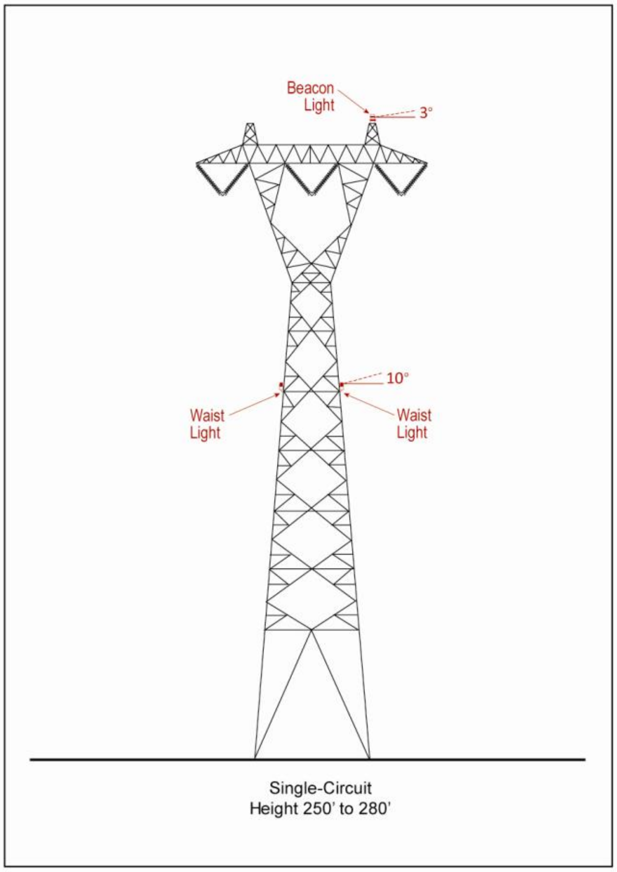
3.7 Obstruction Lighting and Marking

The FAA requires transmission structures, such as steel towers, that exceed certain criteria to have lighting and/or marking. These criteria are usually based on (but not limited to) the structure's height, proximity to an airport, river crossing, or a combination of these factors depending on the situation. The lighting and marking of structures and the conductors between them serve as a visual aid to help pilots avoid accidents. In the past few years, BPA has carried out a lighting program that uses the latest technology for structure lights to meet FAA's requirements, while minimizing visual impacts to landowners and others on the ground.

The most common lighting scheme BPA uses is a dual color (white/red) "medium- intensity" beacon on top of the structure and two red "low-intensity" waist lights mid-structure (see Figure 3-6). The top beacon flashes white during daylight hours and red when daylight diminishes to a level defined by the FAA. When the light turns red the intensity is reduced, but the light remains visible to pilots.

The beacon is designed to emit light straight out horizontally from the structure and upwards at a 3 degree angle. This means that most of the light emitted is visible from only above the towers. The low-intensity waist lights do not operate during daylight hours. At night they burn red steadily and at a lower intensity than the top beacon. The low-intensity lights are also designed to emit light straight out horizontally, and upwards at a 10 degree angle. Similarly, they are not typically seen except when level with the lights or from above the tower.

Figure 3-6 Example of Beacon and Waist Lighting for a Typical 500-kV Tower[1]



[1] Single-circuit 500-kV towers used to cross the Columbia River may be different (see Figure 3-1).

An alternative lighting solution sometimes required by the FAA is known as a “Catenary” scheme. This configuration has a dual color (white/red) medium-intensity beacon at the top, middle, and bottom levels. This eliminates the low-intensity lighting at the middle level. This lighting scheme is usually installed on two structures forming a crossing of some type (i.e., river or canyon) alerting pilots of an obstruction between the two structures.

Occasionally, the FAA requires marking spheres (balls) be installed on the conductors between two structures. These are often required in addition to structure lighting. The FAA has approved 36-inch spheres in three colors (orange, white and yellow), specifically patterned based on the length of the crossing, with a certain spacing between each one. The spheres emit no light and serve strictly as a daytime warning.

3.8 Substations

Substations are vital hubs for transmission lines. Among other things, they can connect different transmission lines together, allow switching between lines and isolate lines when necessary. The substations proposed for this project would not be traditional substations, that is, they would not have transformers. Instead they would operate as switching stations and would have equipment for controlling power flow only.

About 25 to 50 acres would be required for each substation, depending on the site and design used. Each substation area would include the substation yard (equipment within the fence) and grading outside of the fence. Construction crews would first clear and grade the substation site.

Conduits, drainage pipes, and the grounding system would be trenched or dug several feet into the ground. Footings for the equipment and the foundation for the control house would be dug up to 8 feet into the ground (substation dead-end tower footings would be deeper). All equipment would then be placed in appropriate positions. A chain-link fence would be installed around the substation. About 6 inches of rock would be laid, with a 10-foot gravel buffer extending outside the substation fence.

The 500-kV equipment that would be installed at the substations includes the following:

- Power circuit breakers: A breaker is a switching device that can automatically interrupt power flow on a transmission line at the time of a fault, such as a lightning strike, tree limb falling on the line, or other unusual events. The breakers would be installed at the substation to redirect power as needed. Several types of breakers have been used in BPA substations over the years. The breakers planned for this project, called gas breakers, are insulated by special non-conducting gas (sulfur hexafluoride). These breakers would contain no oil, but would contain a small amount of hydraulic fluid. Power circuit breakers are about 24-feet tall and about 22-feet long.
- Generator and coupling capacitor voltage transformers (CCVT): A CCVT is used to step down high voltage signals to low voltage signals for the purpose of measurement or to operate a protective relay. A **protective relay** is a safety measure designed to calculate operating conditions on an electrical circuit and to trip circuit breakers when a fault is detected.
- Shunt reactor: A shunt reactor is an electromagnetic device used to absorb reactive power (**capacitance**) and to lower system voltage. Shunt reactors need oil containment. If required, a shunt reactor would be constructed at the Sundial substation site to maximize the electrical performance of the transmission system.
- Series capacitor bank: A capacitor is a device that stores electrical energy and releases it back into the power system when required. Transmission lines, like any other wire, have an inherent property called **impedance**, which causes some resistance to the flow of power. Series capacitor banks compensate for some of this impedance, reducing power losses and allowing the line to carry more power. A series capacitor bank would be used at Sundial Substation.
- Surge arrestors: A surge arrestor is an electrical device used to protect equipment from lightning.
- Buswork: Buswork is a series of flat strips of copper or hollow tubes of aluminum that conduct large currents of electricity and allow heat to dissipate more efficiently over short distances. They are not insulated.

- Switches: These devices are used to mechanically disconnect or isolate equipment. Switches are normally located on both sides of circuit breakers. Switches are about 23 feet tall and about 16 feet long.
- Substation dead-end towers: These are the towers within the substation where incoming or outgoing transmission lines end. Substation dead-ends are typically the tallest structure within the substation.
- Substation rock surfacing: A 6-inch layer of rock (extending about 10 beyond the fence line), selected for its insulating properties, is placed on the ground within the substation to protect operation and maintenance personnel from electric shock during substation electrical failures.
- Control house: The substation control house contains electrical panels, meters, relays, and other equipment needed to control the transmission line operation.
- Ground mat: A system of interconnected bare conductors arranged in a pattern or grid, normally buried below the surface of the substation, primarily to provide safety for workers by limiting voltage differences within its perimeter to safe levels. Also called a ground grid.
- Stormwater retention system: Stormwater management involves measures to prevent sediment and other pollutants from entering surface or groundwater, treatment of runoff to reduce pollutants, and flow controls to reduce the impact of altered hydrology. All Castle Rock substations would include a stormwater detention pond (a pond is not needed at Sundial Substation).
- Substation electrical service: Substations need local electrical service to power the lights, fans, and equipment in the substation. That service is provided by the local utility via a wood pole electric line similar to lines that provide service to local area homes and businesses.
- Back-up generator: The back-up generator has a 2,500-gallon diesel tank and would be used if the local substation electrical service fails.

3.9 Access Roads

Access roads are the system of roads that BPA's construction and maintenance crews would use to get to the towers or tower sites along the transmission line route and to substations. BPA has a policy and standards for access road design and construction. Engineers design the roads to be used by cranes, excavators, supply trucks, boom trucks, log trucks, and line trucks. Roads are built within the transmission line right-of-way as much as possible if terrain and land use allow. The road system used to access the transmission towers and substations would be a mix of public, private, and BPA access roads across public and private land. BPA typically purchases 50-foot-wide easements for new roads and access roads in areas off the right-of-way. Access roads typically require a 14-foot-wide travel surface (wider on curves). Typically, easements for existing private roads (such as driveways, farm roads, and timber roads) are about 20 feet.

Access roads to substations are wider and are built for a heavier weight load than those for the transmission line. Substation access roads would be graveled and would require a 30-foot-wide travel surface, with about a 75-foot-wide total area disturbed. A 75-foot-wide substation access road would typically be purchased in fee. In some cases, though, only an easement would be purchased for the road that would allow construction and maintenance activities (similar to roads that access towers).

A new transmission line would also require some improvements of existing roads and construction of new roads (including spurs to individual tower sites), with the following requirements:

- Road improvements: Roads would be graded, and rock would be placed where the soil is unstable. Vegetation removal could be required if roads have become overgrown or need to be widened. Improved roads typically require up to a 20-foot-wide disturbance area (including drainage ditches). Dirt roads often become slippery and impassible when wet. Depending on the season, roads would be graveled where needed for load bearing, stability, and dust abatement.
- New roads: New roads typically include up to a 30-foot-wide disturbance area (including travel surface and drainage ditches). New road sites are cleared and graded. Maximum road grades vary depending on the erosion potential of the soil: 6 to 8 percent on erodible soils, 10 to 15 percent for erosion-resistant soils, and steeper grades for access to towers where the road would have no joint use. When wet, the soil on most dirt roads in the project area becomes slippery and can become impassable; these roads would be graveled to make them passable. Where new roads cross year-round, seasonal, or fish-bearing streams, open bottomed culverts or bridges would be needed. **Drain dips** or **water bars** may also be needed on steep slopes or where access roads cross drainages that carry seasonal runoff. New stream and drainage crossings would be avoided where possible.

In coordination with landowners, BPA installs gates across entrances to access roads to prevent public access to private lands and the transmission line right-of-way. Gates in the project area are also used to separate animals or denote property lines. Swing gates would be installed or would replace barbed-wire or broken gates. Gate locks would be coordinated with the landowners to ensure that both BPA and the landowner could unlock the gates.

If towers are placed in agricultural fields, BPA would typically only build temporary access to the tower site to construct the line. Once construction is complete, the road would be removed and compacted soil would be broken up for continued agricultural use. If the tower needed to be accessed later for maintenance or emergency situations, and BPA affects crops, BPA would pay the landowner, as appropriate, for any crop damage resulting from BPA activities.

During construction, additional other private local roads or public roads and highways would be used to move materials, equipment and workers to the construction area. If these roads could accommodate construction vehicles and materials, these roads would not need to be improved. As mentioned previously, BPA would obtain rights to use private roads.

3.10 Staging Areas

Several temporary staging areas would be needed along or near the transmission line for construction crews to store materials and construction vehicles, and to assemble tower segments for helicopter erection. Staging areas can be from 5 to 15 acres depending on the amount of materials and number of locations needed. The contractors hired to construct the transmission line would be responsible for determining appropriate staging area locations.

Often the contractor rents empty parking lots or already developed sites for use as staging areas, which may be located within and outside of the right-of-way. Environmental review of staging areas would be conducted prior to approval for use.

3.11 Vegetation Clearing

BPA would develop contract specifications to guide the construction contractor hired for vegetation clearing. The specifications would identify the area within and next to the right-of-way and access roads where existing vegetation would need to be removed and specific types and locations of vegetation that could be left.

As a general rule, all tall-growing vegetation would be removed from the 150-foot right-of-way at the time of construction. All low-growing vegetation over 4 feet would typically be removed depending on the vegetation and specific construction, operation, or mitigation requirements. All vegetation in construction areas for substations and for access roads, pulling sites, and staging areas outside of the right-of-way would be disturbed or removed. At the tower sites, all brush below 4 feet and stumps more than 22 inches in diameter would be removed. This removal includes root systems from a typically 50-foot by 50-foot area.

Any tree (stable or unstable) outside of the acquired transmission line right-of-way deemed a present or future hazard to the transmission line is considered a **danger tree** and is removed prior to construction of the line. A tree would be identified as a danger tree if it could fall into, bend into, or grow into the conductor or be close enough to the conductor as it swings to cause a flashover of current from the conductor.

The greatest potential for the removal of danger trees for this project would be in cases where the line crosses forest lands with stands of trees over 20 years old. In these locations, danger trees could be taken from as far away as 200 feet from the edge of the right-of-way depending on the topography and condition of the trees. Tall-growing trees may be left or topped where the right-of-way crosses drainages or stream crossings if there is adequate safety clearance (considering a number of years of growth) between the trees and the transmission line. Fewer danger trees are cleared where the line crosses recent clearcuts or forests less than 20 years old, although scattered large trees or snags that may be hazards to the transmission line could be removed. Typically, about 80 percent of the trees that need to be removed are found within 20 feet of the edge of the right of-way.

When an existing stand of trees next to the right-of-way is found to be so highly compromised that it is unstable as a whole, all trees from outside the right-of-way from the last tree tall enough to hit a conductor to the edge of the right-of-way would be removed. This strip of removed trees outside the edge of the right-of-way is called a **safety backline**. Creating a safety backline ensures that no trees will fall into the line in the future and provides reliability for the line. A safety backline is used only when necessary. Unlike trees in the right-of-way, trees removed for a safety backline are allowed to grow back unless they are later determined to be a danger to the transmission line.

Because of this project's location west of the Cascades, existing trees would need to be cleared along new and existing rights-of-way, new and improved access roads, staging areas, pulling sites, and substations. Vegetation has been allowed to grow on vacant areas of existing right-of-way as long as it has not created hazardous conditions for existing lines.

For safe and uninterrupted operation of a transmission line, vegetation within a right-of-way is not allowed to grow above a certain height. If vegetation grows or falls close to a transmission line it can cause an electrical arc, which can start a fire, cause an outage of the line, and or injure or kill someone. Management of right-of-way vegetation varies depending on many factors, including line voltage; vegetation species, height, and growth rates; ground slope and topography; conductor elevation above ground and conductor swing; clearance distance required between the conductors and other objects; and electrical loading on the line.

Vegetation is not allowed to grow in substation electric yards or in the 10-foot buffer around the yard because it could interfere with the operation of the ground mat. A ground mat is a metal grid buried under the soil to “ground” the electrical equipment of the substation. A plant growing up through the ground mat could provide another grounding path for electricity. If a person were to touch the plant when there is a fault (like a short circuit) on the system in the substation he or she could be electrocuted.

3.12 Mitigation Measures

Mitigation measures are actions that can be taken to minimize or avoid potential impacts to the human and natural environment from a proposed project. A table of all mitigation measures that BPA has included as part of the project is at the end of this chapter (see Table 3-2 at the end of this chapter). Mitigation measures in this table are categorized by resource; some are repeated under more than one resource. All mitigation measures included as part of the project would be implemented prior to, during, or immediately after construction.

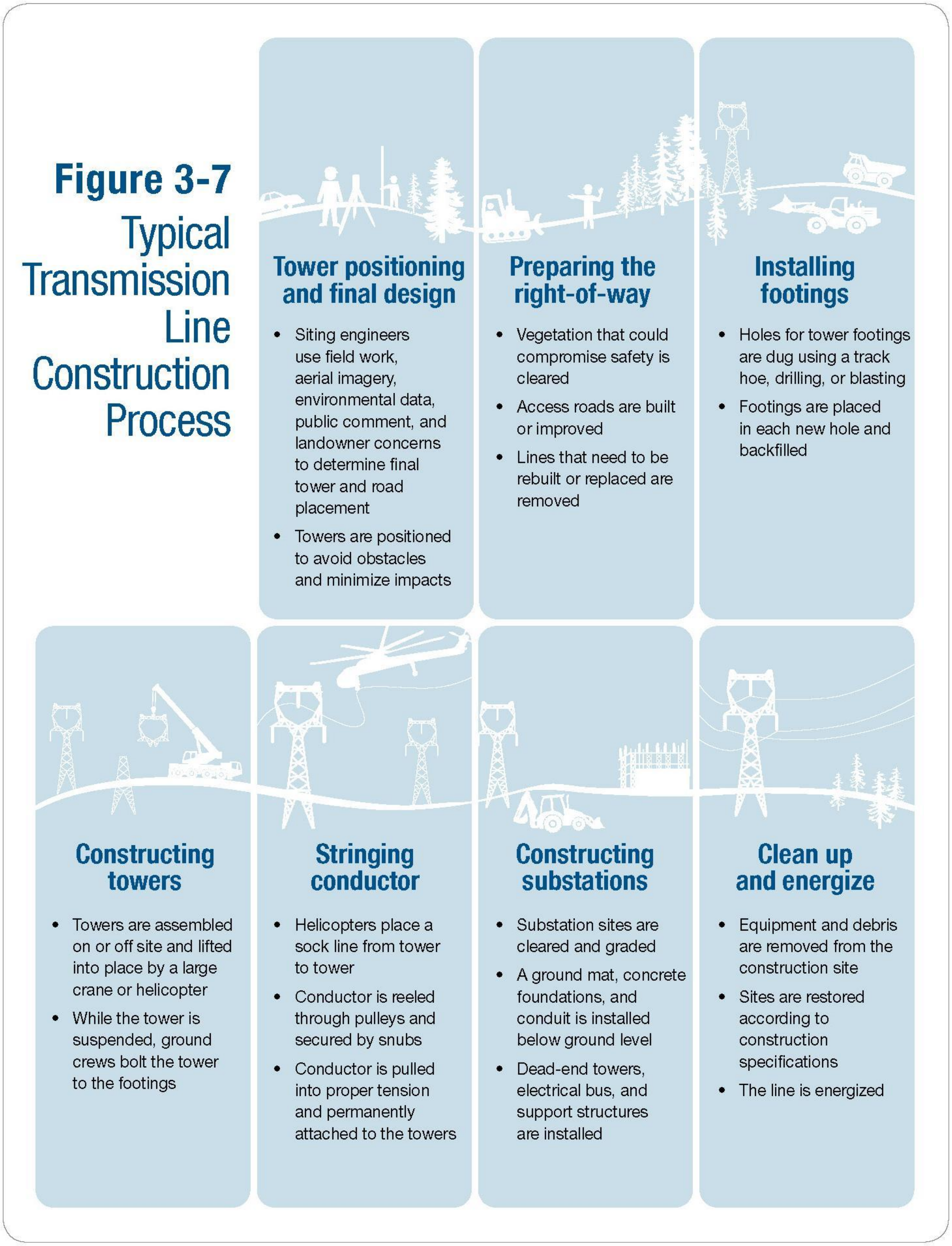
In addition to mitigation measures included as part of the project, other mitigation measures, including compensatory mitigation, have or will be identified through preparation of this EIS. These additional mitigation measures could also be implemented to reduce, eliminate, or offset potential adverse impacts of the project. These additional mitigation measures, if known at this time, are identified in the EIS resource chapter to which they apply (see Chapters 5 through 22).

If BPA decides to build the I-5 project, a Mitigation Action Plan (MAP) would be prepared for the project at the time of that decision and before implementing the project. The MAP would explain how mitigation measures identified for the project will be planned and implemented. Monitoring during and after construction would help ensure implementation and success of the mitigation measures.

3.13 Final Project Design and Construction Process

After completion of environmental review under NEPA, if a decision is made to construct the project, final design of the transmission line, including the precise location of towers, would be completed (see Figure 3-7). To determine exact tower locations along a transmission line right-of-way, BPA typically uses field information from siting engineers and collects terrain data using Light Detection and Ranging (LiDAR) data, a remote sensing technology employing eye-safe laser pulses originating from a helicopter or airplane. BPA augments these sources as necessary with other terrain data collection methods such as photogrammetry and survey crews working on the ground. High-resolution aerial imagery is also collected to aid in tower siting.

Figure 3-7 Typical Transmission Line Construction Process



Towers are positioned using the terrain data and aerial imagery to provide adequate conductor clearances above ground and avoid obstacles while generally minimizing the frequency, height, and impact of the towers. This same data is also used to locate access roads. Engineers also use environmental information and discussions with landowners to help determine tower and access road locations.

Construction begins with preparation of the right-of-way. Vegetation would be cleared as described in Section 3.11, Vegetation Clearing, and access to the right-of-way would be established or improved where necessary. If the proposed new line would be constructed by rebuilding an existing line, any existing wood pole structure or steel tower transmission line that needs to be replaced would be taken out of service and existing conductor and structures or towers removed. Existing poles would be cut off at ground level and removed. Guy anchors and counterpoise would be cut 1 foot below ground and removed. In instances where a new tower is placed in the same location as the old structure, the construction contractor would remove as much old pole, guy anchor and counterpoise as is necessary and the area then would be further excavated for the new tower footings.

Holes for tower footings would be dug with a track hoe (drilling or blasting may also occur if rock is present) and footings would be put in place at each tower site. Towers would be either assembled at the tower site and lifted into place by a large crane (30- to 100-ton capacity) or assembled at a staging area off site and set in place by a large skycrane helicopter. The towers or tower segments would then be bolted to the footings.

The conductor would then be strung from tower to tower through pulleys on the towers using a sock line (see Section 3.6, Pulling and Tensioning Sites). The sock line is placed in the pulleys and pulled through by a helicopter much smaller than the skycrane. The fiber optic cable would also be strung using a helicopter, with pulling sites on the ground to tighten the cable.

When one reel of conductor ends and a new one begins, the conductor has to be fitted together. Hydraulic compression is used to compress the fittings on the conductor. Three conductors would need to be fitted about once every 1.5 to 2 miles.

After the towers, conductors, and fiber optic cable are installed, the construction contractor would remove construction equipment and debris and restore the disturbed areas. Soils used for agriculture in the temporary disturbance area that become compacted would be restored and reseeded after project construction to reestablish close to original conditions.

At the substation site, several construction activities would occur. The site would be excavated to bring the topography to grade. Once a layer of soil material is laid down, the concrete foundations for all the high voltage equipment and structures would be installed. The stormwater retention system and ground mat and conduit for control cables would also be installed.

After all the below grade substation work is completed, the above grade construction work would begin with the erection of the dead-end towers and aluminum pedestals to support the electrical bus. Then, other support structures would be installed for the high voltage equipment. The high voltage equipment would be bolted on the support structures and connected to the electrical bus by seismic flexible jumpers. Control cables would be attached to the high voltage equipment and routed to the control house.

3.14 Construction Schedule and Work Crews

The timeframe needed for construction of the project is about 30 months. Under the current schedule, if a decision is made to proceed with the project after completion of the NEPA process, construction could begin as early as 2014. Line construction generally would occur after road construction. Construction work would be staged with one type of activity taking place in one area (such as road construction) and another activity taking place in another area where roads exist (such as vegetation removal and tower construction). A typical crew can usually construct about 10 miles of transmission line in 4 months. In areas where terrain is steep, progress may be slower. Construction of roads and tower pads (if required) usually takes about 3 to 5 months including close-out repairs of any roads damaged during construction. The remainder of the construction period would include substation work including connecting the new line and other existing lines into the substations, and tower site restoration work.

Helicopters could be used for clearing and would be used intermittently for 6 to 7 months during removal of existing lines and construction of new lines. A small helicopter would be used to remove wood poles in inaccessible areas and for stringing the sock line.

The transmission line and substations would be constructed by two or more construction contractors. A typical transmission line construction crew and equipment for a 500-kV line would include the following:

- 50 to 60 construction workers (70-100 at the peak of construction; actual workforce numbers would vary over time)
- 45 vehicles (pickups, vans, trucks)
- 3 bucket trucks
- 1 conductor reel machine
- 3 large excavators (bulldozers, backhoes)
- 1 line **tensioner**, 1 puller, 1 reel trailer
- 2 helicopters (small helicopter and skycrane; size dependent on lifting required)
- 1 to 2 large (210-ton) and mid-sized (50-ton) cranes
- Road construction equipment (dump trucks, rollers, graders, dozers, excavators, water truck)

A typical substation construction crew and equipment for a 500-kV line would include the following:

- 20 to 30 construction workers (40-50 at the peak of construction)
- 5 vehicles (pickups, vans, trucks)
- 2 bucket trucks
- 3 scrapers
- 2 large excavators (bulldozers, backhoes)
- 2 water trucks
- 1 mid-sized (50-ton) crane

A crew can typically construct a 500-kV substation in 13 to 24 months in three phases. The first phase would include site leveling and bringing in appropriate ground materials such as soil and rock, then completing work below ground (ground mat, footing, drainage and foundations). The second phase would complete outdoor work (set structures and equipment, install bus between equipment, build control house, and run cable to control house). The third phase would complete indoor work (install electronic controls, install telecommunications system, and perform testing on all substation equipment).

3.15 Maintenance

During the life of the project, BPA would perform routine, periodic maintenance and emergency repairs to the transmission line. For lattice-steel towers, maintenance usually involves replacing insulators.

BPA typically conducts routine inspection patrols of its transmission lines throughout the Pacific Northwest by helicopter. BPA has conducted these types of inspection patrols by helicopter since 1950. Patrols are essential to determine where line maintenance is needed and ensure the continued reliability of the transmission system. Helicopter teams look for damaged insulators, damaged support members, washed-out roads, hazardous vegetation, encroachments, and problems indicating that a repair may be needed. Helicopter inspection of the new line would occur twice annually.

BPA's aerial inspections of its lines are typically followed by annual ground inspections for each line. Maintenance vehicles would use access roads where established and maintenance workers may walk through agricultural fields to avoid damage to crops. In emergencies and some other situations, vehicles and equipment would need to be driven through fields and could cause damage to crops, vegetation, and other property. BPA determines the damages and, if appropriate, compensates landowners for these damages.

Vegetation also would be maintained along the line for safe operation and to allow access to the line. The project area would need continual vegetation maintenance because of its location west of the Cascades. BPA's vegetation management would be guided by its Transmission System Vegetation Management Program EIS (available at http://efw.bpa.gov/environmental_services/Document_Library/Vegetation_Management). BPA adopted an integrated vegetation management strategy for controlling vegetation along its transmission line rights-of-way. This strategy involves choosing the appropriate method for controlling the vegetation based on its type and density, the natural resources present at a particular site, landowner requests or agreements, regulations, and costs. BPA may use a number of different methods: manual (hand-pulling, clippers, chainsaws), mechanical (roller-choppers, brush-hogs), biological (insects or fungus for attacking noxious weeds), and herbicides.

Herbicides used at substations would likely be applied in granular form or with a backpack sprayer to spot treat individual plants. As with any BPA herbicide use, label instructions for application rates and weather conditions would be adhered to, which would eliminate potential run-off or air drift issues. Prior to controlling vegetation, BPA would send notices to landowners and request information that might help in determining appropriate methods and mitigation measures (such as herbicide-free buffer zones around springs or wells).

Noxious weed control is also part of BPA's vegetation maintenance program. In general, BPA controls weeds on BPA fee-owned rights-of-way (mostly substations and some transmission lines), except where agricultural easements exist. Along easements, the underlying landowner is responsible for noxious weed control, but BPA works with landowners and county weed control districts and incorporates weed control measures into regularly scheduled maintenance.

Table 3-2 Mitigation Measures Included as Part of the Project[1]

Resource	Mitigation Measures
Land and Recreation	• Compensate landowners for any new BPA land rights required for right-of-way or access road easements. • Compensate landowners for any damage to property during construction. • Compensate landowners for reconfiguration of irrigation systems due to placement of towers or access roads. • Provide relocation services and benefits pursuant to Public Law 91-646 and other related regulations to affected owner occupants, tenants, and businesses, ensuring that the eligible parties have a clear understanding of the relocation process and assist these parties in filing claims for relocation benefits. • Provide compensation to restore compacted cropland soils, as needed. • Reseed disturbed areas (see mitigation measures in Vegetation). • Implement measures to reduce the possible spread of noxious weeds (see mitigation measures in Vegetation). • Implement measures to control dust (see mitigation measures in Geology and Soils). • Implement measures to control construction noise (see mitigation measures in Noise). • Minimize or eliminate public access to project facilities through postings and installation of gates and barriers at appropriate access points, and at the landowner's request. • Stay on established access roads and designated access road areas across agricultural fields during routine operation and maintenance activities. • Submit final tower locations and conductor heights to the FAA for review. Install lights and/or marker balls as required (see mitigation measures in Transportation).
Visual Resources	• Implement construction site maintenance and clean-up. Keep construction areas free of debris. • Provide regular maintenance of access roads and gates within and leading to the corridor. • Reseed disturbed areas (see mitigation measures in Vegetation). • Implement measures to reduce the possible spread of noxious weeds (see mitigation measures in Vegetation). • Implement measures to control erosion and dust (see mitigation measures in Geology and Soils, and Greenhouse Gas). • Use non-reflective conductors. • Use non-reflective insulators (i.e., non-ceramic or porcelain). • Locate new access roads within previously disturbed areas wherever possible. • Revegetate disturbed areas with approved species (see mitigation measures in Vegetation).
Public Health and Safety, EMF	• Notify landowners located along the corridor prior to construction activities, including blasting. • If blasting is required, take appropriate safety measures and follow all state and local codes and regulations. Lock up or remove all explosives from work sites at the end of the workday.

Resource	Mitigation Measures
Public Health and Safety, EMF (continued)	• Hold crew safety meetings at the start of each construction workday to review potential safety issues. • Prepare and implement a Spill Prevention and Control (SPC) plan (see mitigation measures in Water) to manage hazardous materials and respond to emergency situations. • Prepare and maintain an on-site safety plan in compliance with state requirements. • Prepare for fire control (see mitigation measures in Vegetation).Fueling of construction vehicles and equipment on-site will be done in accordance with applicable construction permits, regulated construction practices, and state and local laws. Helicopters will be fueled and housed at local airfields or at staging areas. • Secure the site at the end of each workday to protect equipment and the general public. Ensure that BPA contractors flying helicopters prioritize public safety during flights. • Implement appropriate airport safety measures. • Clear vegetation according to BPA standards to avoid contact with transmission lines. • Manage construction waste through reuse and recycling. • Report possible hazardous materials, toxic substances, or petroleum products discovered within the transmission line or access road right-of-ways that would pose an immediate threat to human health or the environment, including large dump sites, drums of unknown substances, suspicious odors, stained soil, etc. • Adhere to appropriate specifications for grounding fences and other objects on and near existing and proposed rights-of-way. • Construct and operate the new transmission line according to the NESC. • Use established access roads during routine operation and maintenance activities. • As part of the Storm Water Pollution Prevention Plan (SWPPP), an SPC plan will be prepared to address petroleum and hazardous materials handling and emergency spill response (see mitigation measures in Water). • Use transmission line designs that keep EMF levels and corona generation as low as reasonably practical. • Restore reception quality if radio or television interference occurs as a result of constructing the transmission line so that reception is as good as or better than before the interference.
Noise	• Ensure standard sound-control devices, including mufflers, are on all construction equipment and vehicles. • Notify landowners located along the corridor prior to construction activities, including blasting.
Socioeconomics	• Compensate landowners at market value for any new BPA land rights for right-of-way or access road easements. • Compensate landowners for damage to property or crops during construction or operation and maintenance activities. • Compensate landowners for irrigation systems that must be reconfigured to accommodate new transmission infrastructure. • Prepare for fire management (see mitigation measures in Vegetation). • Initiate discussions with local fire districts prior to construction and work with the districts and other appropriate emergency response entities to develop a Fire and Emergency Response Plan that addresses potential wildland fires and other emergencies.

Resource	Mitigation Measures
Transportation	• Coordinate with county road departments where upgrades of county roads are necessary. • Coordinate routing and scheduling of construction traffic with state and county road staff, Columbia River operators, and railroad operators. • Employ traffic control flaggers and post signs warning of construction activity and merging traffic, when necessary for short interruptions of traffic. • Conduct regular maintenance on access roads and gates within and leading to the corridor. • Prepare and implement a SWPPP to prevent sediment from being transported onto adjacent roadways (see mitigation measures in Geology and Soils). • Limit tracking of soil onto paved roads (see mitigation measures in Geology and Soils). • Design roads to limit erosion (see mitigation measures in Geology and Soils).Restore public roadways to preconstruction conditions upon completion of project construction activities. Coordinate with the Washington State Department of Transportation (WSDOT) Aviation Division and comply with FAA regulations for marking or lighting (including painting and/or lighting towers and installing marker balls on overhead ground wires in specific locations). • Ensure standard sound-control devices, including mufflers, are on all construction equipment and vehicles. • Notify landowners located along the corridor prior to construction activities, including blasting. • Obtain a Haul Road Agreement and any additional permits or approvals from state and local agencies prior to construction. These documents will identify any special conditions to be addressed by BPA and their contractors during construction and operation of the project. • Route traffic around affected intersections if construction vehicles cause temporary traffic blockages on local roadways. • Comply with applicable seasonal road restrictions for construction traffic, where practicable.
Cultural Resources	• Locate transmission line towers and access roads to avoid cultural resources and minimize the potential for trespass access, where possible. • Use existing access roads where possible to limit possibility of new disturbances. • Develop an Inadvertent Discovery Plan that details crew member responsibilities for reporting in the event of a discovery during construction. This plan should include directives to stop work immediately and notify local law enforcement officials (if appropriate), appropriate BPA personnel, Tribes, and the Washington Department of Archaeology and Historic Preservations (DAHP) or Oregon State Historic Preservation Officer (SHPO) if cultural resources are discovered. • Plan for survey and review as needed of additional disturbance areas not identified during the NEPA process (e.g., staging areas, stringing and pulling sites, guard structure areas, etc.). • Improve the existing road system in a manner that minimizes new roads and avoids cultural resource sites. If improvements are needed on existing roads that cross through cultural resources sites, such improvements would be constructed in a manner to avoid/minimize impacts, such as using fabric and rock or other mitigation agreed to during the consultation process.

Resource	Mitigation Measures
Cultural Resources (continued)	• Consult with the Washington DAHP, the Oregon SHPO as applicable, the Confederated Tribes of the Chehalis, Cowlitz Indian Tribe, Confederated Tribes of Grand Ronde, Nez Perce Tribe, Quinault Indian Nation, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and Confederated Tribes and Bands of the Yakama Nation regarding NRHP eligibility of historic and cultural sites and if eligible, consult on addressing any adverse effects.
Geology and Soils	• Minimize the project ground disturbance footprint, particularly in sensitive areas (i.e., steep slopes and landslides areas). • Prepare and implement a SWPPP for construction activities to lessen soil erosion and control stormwater runoff. • For the SWPPP, use management practices contained in the Washington State Department of Ecology, Stormwater Management Manual for Western Washington (e.g., use silt fences, straw wattles, interceptor trenches, or other perimeter sediment management devices; place them prior to the onset of the rainy season and monitor and maintain them as necessary throughout construction) (http://www.ecy.wa.gov/pubs/0510030.pdf). • Use water trucks or BPA approved palliatives on exposed soil surfaces in areas disturbed during construction. • Construction materials and stockpiles will be managed to prevent impacts by the erosive forces of wind and rain. Stabilize access road surfaces in areas of sustained wind and potential dust erosion. • Ensure construction vehicles travel at low speeds on access roads and at construction sites to minimize dust. • Limit the amount of time soils are left exposed. • Design roads to limit water accumulation and erosion; install appropriate access road drainage (ditches, water bars, cross drainage, or roadside berms) to control and disperse runoff. • Design substations to accommodate seismic shaking, per BPA's seismic policy (STD-DS-000001). This policy references the International Code Council's International Building Code (IBC) (2009) for buildings in substations and the Institute of Electrical and Electronics Engineers (IEEE) 693(2005) for electrical equipment in the substations.
Water and Wetlands	• Minimize the project ground disturbance footprint, particularly in sensitive areas such as stream crossings and wetlands, and stream and wetland buffers. • Develop and implement a SPC plan to minimize the potential for spills of hazardous materials, including provisions for storage of hazardous materials and refueling of construction equipment outside of riparian zones, spill containment and recovery plan, and notification and activation protocols. • Prepare and implement a SWPPP to control stormwater runoff (see mitigation measures in Geology and Soils). • Properly manage drilling fluids, muds, and dewatering activities so as not to impact surface waters, including wetlands. • Properly manage concrete waste. • Take all necessary precautions to ensure that sediment, debris, petroleum products, chemicals, cement-like materials, or other contaminants do not enter wetlands and flowing or dry watercourses. • Install culverts or bridges for access roads in the dry season or during low-flow conditions if possible to minimize sediment delivery to streams.

Resource	Mitigation Measures
Water and Wetlands (continued)	• Limit tracking of soil onto paved roads by gravelling road approaches, washing vehicle wheels, and cleaning mud and dirt from paved roads to reduce sediment delivery to roadside ditches and nearby streams. • Avoid use of heavy equipment and vegetation removal, if possible, in wetlands and wetland buffer zones to avoid soil compaction, destruction of live plants, and potential alteration of surface water patterns. Use track equipment or matting, if appropriate. • Avoid placing staging areas in wetlands or stream buffers. • Fence, flag, or otherwise mark wetland buffer zones in the field to avoid inadvertent activity (e.g., parking and driving) in wetlands or buffers or streams. • Reseed disturbed areas (see mitigation measures in Vegetation). • Design culverts and drainage controls placed in non-fish bearing streams to preserve natural drainage patterns. • Maintain unobstructed passage for water at all culverts placed in non-fish bearing streams and promptly remove any blockages to protect the roadbed and prevent sedimentation of downstream water bodies. • Install and maintain water and sediment control measures at all water bodies (including dry water bodies) crossed by access roads or otherwise impacted by surface disturbance. • Regularly inspect and maintain the condition of access roads, culverts, and sediment control measures to prevent long-term impacts during operation and maintenance. Avoid storing, transferring, or mixing of oils, fuels, or other hazardous materials where accidental spills could enter surface or groundwater. Have spill response and clean-up materials on site and clean up all spills immediately. • Maintain, fuel, and repair heavy equipment and vehicles using spill prevention and control measures. Clean contaminated surfaces immediately following any spill incident. • Fixed bulk fuel storage facilities will be designed with impervious secondary containment berms capable of capturing spills that may occur during fueling operations. • All equipment fueling operations shall use pumps and funnels and absorbent pads. Refuel equipment away from natural or manmade drainage conveyance including ditches, catch basins, ponds, wetlands, and pipes. Additional fueling requirements apply in some sensitive resource areas. Do not store equipment near water bodies and secure equipment when not in use overnight.
Vegetation	• Limit tree removal in sensitive areas such as stream crossings to the extent possible. • Cut or crush vegetation rather than blade in areas that would remain vegetated to maximize the ability of native plants to resprout. • Conduct invasive weed surveys prior to and following construction to determine potential weed spread and appropriate corrective actions. • Use weed-free mulch, if mulch is used for erosion control. • Equip all vehicles with basic fire-fighting equipment, including extinguishers and shovels to prevent fires that could encourage weed growth. • Limit ground-disturbing activities to tower sites, access roads, staging areas, and other necessary construction sites.

Resource	Mitigation Measures
Vegetation (continued)	• Limit road improvements to the minimum amount necessary to safely move equipment, materials, and personnel into and out of the construction area. • Consult with the U.S. Fish and Wildlife Service (USFWS) concerning any federally listed threatened and endangered plant species that are identified and implement mitigation measures to eliminate or reduce adverse impacts to these species. • Limit herbicide application to hand spraying at least 100 feet from all fish-bearing stream channels and use only EPA-approved herbicides that are non-toxic to aquatic resources. • Maintain a 164-foot no-spray buffer around well head locations. These locations are identified on all BPA plan and profile drawings and identified in work instructions to vegetation maintenance contractors. • Seed all disturbed areas to prevent colonization by weeds and facilitate reestablishment of the preconstruction plant community. Use approved (local Farm Service Agency) native seed mixtures in high quality vegetation communities and a combination of native and non-native seed in disturbed vegetation communities. Include the dominant native species from the impacted community in the seed mix.
Wildlife and Fish	• Limit tree removal in sensitive areas such as stream crossings to the extent possible. • Reseed disturbed areas (see mitigation measures in Vegetation). • Equip all vehicles with basic fire-fighting equipment, including extinguishers and shovels to prevent fires that could potentially harm wildlife habitats. • Minimize the project's ground disturbance area, reseed disturbed areas, and install culverts during appropriate in-water work window (see mitigation measures in Vegetation and Water) to limit sedimentation affecting fish habitat. Prepare and implement a SWPPP and a SPC plan (see mitigation measures for Geology and Soils and Water) to protect wildlife, fish, and wetland habitats. • Consult with the USFWS and National Oceanic Atmospheric Administration (NOAA Fisheries) concerning any federally listed threatened and endangered wildlife species that are identified and implement mitigation measures to eliminate or reduce adverse impacts to these species.
Climate	• Design and construct transmission facilities for worst-case wind-, snow-, and ice-loading. • Design transmission facilities to accommodate sagging during prolonged hot weather. • Design and construct access roads to withstand predicted climatic events.
Air Quality	• Use water trucks and/or palliatives to control dust during construction operations where appropriate. • Stabilize construction materials if they are a source of blowing dust. • Limit the amount of exposed soil, including dirt piles and open pits, to a minimum. • Dispose of trees and brush by means other than burning. • Ensure construction vehicles travel at low speeds on gravel roads and at the construction sites to minimize dust. • Comply with applicable state tailpipe standards for all on-road vehicles. • Ensure all vehicle engines are in good operating condition to minimize exhaust emissions.

Resource	Mitigation Measures
Air Quality (continued)	• Use low sulfur fuel when available for on-road diesel vehicles.
Greenhouse Gases	• Implement vehicle idling and equipment emissions measures, where practicable. • Encourage carpooling and the use of shuttle vans among construction workers to minimize construction-related traffic and associated emissions. • Locate all staging areas as close to construction sites as practicable to minimize driving distances between staging areas and construction sites. • Locate staging areas in previously disturbed or graveled areas to minimize soil and vegetation disturbance where practicable. • Use the properly sized equipment for the job, when practicable. • Use alternative fuels for generators at construction sites, or use electrical power where practicable. • Reduce electricity use in the construction office by using compact fluorescent bulbs, and powering off computers every night. • Recycle or salvage non-hazardous construction and demolition debris. • Use locally sourced rock for road construction, where available. • During construction, all vehicles will comply with applicable federal and state air quality regulations for tailpipe emissions. • Maintain all construction equipment is in proper working condition according to manufacturer's specifications. • Train equipment operators in the proper use of equipment.
Notes: 1. For additional mitigation measures that have been identified through preparation of this EIS and that also could be implemented to reduce or eliminate potential adverse impacts of the project, please see Chapters 5 to 22 of this EIS.	