From:	Peggy Huard
To:	Schuetz, Marissa
Subject:	Comment for Northern Pass NH SEC # 2015-06
Date:	Tuesday, July 18, 2017 10:26:17 PM
Attachments:	induced voltage TO PRINT PAGES.pdf

Marissa,

I would like to submit this report as a comment on the Northern Pass docket.

Thank you.

Peggy Huard

INDUCED VOLTAGE AND CURRENT REPORT

A world of capabilities delivered locally

INDUCED VOLTAGE AND CURRENT REPORT

A Review of Public Hazards Associated with High-Voltage Transmission Lines

Submitted To:

Todd Cornett
Oregon Department of Energy
625 Marion St. NE
Salem, OR 97301-3737 USA

Submitted By:

Golder Associates Inc.
9 Monroe Parkway, Suite 270
Lake Oswego, OR 97035 USA

February 2013

073-99810-29 and 073-99810-31

Golder Associates

EXECUTIVE SUMMARY

The Oregon Department of Energy (ODOE) requested that Golder prepare a summary report identifying hazards presented by induced current and voltage associated with high-voltage transmission lines, as well as recommendations for the review of applications for site certificates, the information necessary to demonstrate compliance with the applicable standard, and proposed mitigation measures that could be imposed as site certificate conditions. This paper identifies potential hazards that can be avoided with appropriate mitigation and education for landowners for the Council's consideration. Alternating current overhead transmission lines produce both electric and magnetic fields which have the potential to create induced voltages and currents in nearby conductive objects. Under certain conditions dictated by the voltage and current on the transmission line, the layout of the conducting wires, and the size, proximity, and grounding of the nearby conductive objects, it is possible for induced voltages and currents to reach hazardous levels for persons contacting the conductive objects. Rules adopted by the Oregon Public Utilities Commission (PUC) and the Oregon Energy Facility Siting Council (Council) for the design, construction, and operation of transmission lines minimize the potential for the public to be exposed to hazardous shocks that could result in injury or death. However, research has shown that even with these design considerations in place, induced voltages and currents can occur at levels that would create a nuisance shock or spark. Additionally, in rural locations where farming and ranching may occur in a transmission line right-of-way, it is possible for normal practices such as upending irrigation pipe, using tall vehicles, fueling vehicles, and operating long parallel conductive fences could lead to more serious consequences. Several agencies and transmission line owners have developed excellent educational materials for landowners regarding safe practices under or near overhead transmission lines. Currently the Council standards regarding transmission lines do not require any ongoing educational programs designed to inform landowners adjacent to transmission lines of safe practices to avoid impacts from induced voltages and currents.

Table of Contents

EXECUTIVE SUMMARY ES-1
1.0 INTRODUCTION 1
2.0 ELECTRIC AND MAGNETIC FIELD EFFECTS OF OVERHEAD HIGH-VOLTAGE TRANSMISSION LINES 3
2.1 Resistive Coupling (Conductive) 3
2.2 Capacitive Coupling (Electric Field) 3
2.3 Inductive Coupling (Magnetic Field) 6
3.0 HAZARDS ASSOCIATED WITH INDUCED CURRENTS AND VOLTAGES 10
3.1 Human Safety Hazards 11
3.2 Physical Hazards 13
4.0 COMMON OBJECTS THAT CAN DEVELOP AN INDUCED CURRENT OR VOLTAGE FROM TRANSMISSION LINES AND MITIGATION 14
4.1 Fences 14
4.2 Vehicles 15
4.3 Buildings, Metal Roofs, and Gutters 15
4.4 Pipelines 15
4.5 Telecommunication Cables 16
4.6 Irrigation Pipe 16
5.0 EXISTING REGULATIONS FOR HIGH-VOLTAGE TRANSMISSION LINE SITING WITH REGARD TO INDUCED VOLTAGE AND CURRENTS 18
6.0 CONCLUSIONS 21
7.0 RECOMMENDATIONS 23
8.0 REFERENCES 25

List of Tables

Table 1 Quantitative Effect of Electric Current on Humans
Table 2 State Transmission Line Standards and Guidelines
Table 3 International Exposure Limit Guidelines

List of Figures

Figure 1 Electric Field Lines from an Above-ground Conductor
Figure 2 Capacitive Coupling
Figure 3 Inductive Coupling
Figure 4 Induced Current in a Fence

List of Appendices

Appendix A Example Educational Materials from Agencies, Utilities, and Generating Companies

List of Key Terms

Capacitance: The property of an object that permits the storage of energy.

Capacitive coupling: Also known as “electrostatic coupling.” This describes the interaction between a transmission line and another conductor in the electric field of the transmission line. Conductive objects that are insulated from ground (such as a vehicle with rubber tires) and are capacitively coupled with the transmission line will build up a charge, or voltage.

Conductance: The readiness with which a conductor transmits an electrical current.

Conductor: A material or object that permits an electric current to flow easily. The term conductor also refers to a single wire strung as part of a circuit on a transmission line.

Current: A flow of electric charge.

Electrical potential difference: The difference in voltage between two points (e.g. between a charged transmission line and a metal fence).

Electrical resistance: The opposition to the passage of an electric current through an object or element; the inverse quantity is electrical conductance, the ease with which an electric current passes.

Electromagnetic field: A field that is made up of associated electric and magnetic components, that results from the motion of an electric charge, and that possesses a definite amount of electromagnetic energy.

Inductive Coupling: Also known as “electromagnetic coupling.” This describes the interaction between a transmission line with a current flowing and a conductive loop in the magnetic field of the transmission line. A conductive loop, such as a wire fence, that is inductively coupled with the transmission line will develop an induced current, a flow of electricity.

Resistive coupling: Also known as “conductive coupling.” This is the coupling between a transmission line and another conductor through a resistor. An example would be when lightning strikes a transmission line: the voltage on the transmission line may rise to a level that exceeds the resistance of the insulator that holds the line to the tower. In this case a flashover will occur between the transmission line conductor and the tower, bypassing the resistor.

Single Phase Electric Power: Single Phase power utilizes a two-wire power circuit with one power conductor and one neutral conductor. In the US, 120V is the standard single phase voltage with one 120V power conductor and one neutral conductor. Household appliances and home wiring use 120 V single phase electric power. In the electrical system in the United States the voltage and current on the energized conductors is cyclic (positive charge to negative and back to positive) with a frequency of 60 Hz (cycles per second).

Three Phase Electric Power: Three Phase power utilizes a power circuit with three power conductors and one neutral conductor. The voltage and current on each of the conductors is cyclic (just as in single phase systems) except that voltage and current in each of the three power conductors is at a different part of the cycle, each offset by 1/3 of the cycle. A cycle is also described as being complete in 360 degrees, so each power conductor is 120 degrees out of phase with the other power conductors. For example, if one conductor is at the beginning of the cycle (at zero degrees), another is a third of the way through the cycle (at 120 degrees), and the third conductor would be two-thirds of the way through the cycle (at 240 degrees).

Voltage: Electrical potential expressed in volts.

1.0 INTRODUCTION

From lighting to air conditioning, the use of electrical energy is ubiquitous in our everyday lives. The delivery of that energy from the point of generation to the point of use requires the transmission of electricity over high-voltage power lines that can be seen along major roadways and across rural landscapes alike. The configuration and installation of high voltage power lines is designed to provide a safe and reliable supply of energy. However, as the landscape has filled in with development, new rights-of-way are harder to develop. This means that power lines are often co-located with pipelines, telecommunication lines, fences, and other conductive infrastructure elements. Additionally, new rural transmission lines often cross land that is already being farmed and will continue to be farmed in areas designated to become right-of-way.

The Council has jurisdiction over the siting of transmission lines in Oregon that are over 10 miles in length and have a capacity of 230 kilovolts (kV) or more, to be constructed in more than one city or county (with certain exceptions) in Oregon. ORS 469.300(11)(a)(C). Facilities meeting these criteria require a site certificate from the Council prior to construction. The Council has adopted standards for the siting of these facilities, intended to ensure the protection of public health and safety. These standards include a limitation on the level of the resulting electric field that may be generated by high-voltage transmission lines. The ODOE has requested that Golder prepare a summary report identifying hazards presented by induced current and voltage associated with high-voltage transmission lines, as well as recommended mitigation measures, for the Council's consideration.

Power in the U.S. is predominantly conducted on transmission lines with an alternating current frequency of 60 hertz (Hz). The flow of power is a product of the current, typically measured in Amperes (A), and the charge, which is known as the voltage. The fact that the electricity is conducted with a frequency of 60 Hz means that at 60 times per second, the voltage on a transmission line conductor cycles from positive charge to negative and back to positive. Electric fields are present whenever a charge (voltage) is present. Magnetic fields are produced wherever there is an electrical current. Electric and magnetic fields commonly result from the use of everything from microwave ovens to high-voltage transmission lines. Electric fields, typically measured in kilovolts per meter (kV/m), result from the voltage on the transmission line, and increase in strength as voltage increases. Magnetic fields, typically measured in milligauss (mG), result from the current in the transmission line's conductors, and increase in strength as the current increases.

While use of electricity is very common, knowledge of the hazards of electromagnetic effects is not. To protect the public, safe standards of design and operation have been adopted in the National Electric Safety Code (NESC). Transmission lines authorized under Oregon Energy Facility Siting Council (Council) jurisdiction are required, under Oregon Administrative Rule (OAR) 345-027-023(4), to be designed and installed in accordance with the NESC (1997 edition). Similarly the Oregon Public Utilities

Commission requires that transmission lines be designed and installed according to the NESC (2012 edition). However, safe design does not always guarantee public health and safety. It is also important that the public be aware of safe practices associated with living and working near transmission lines.

Most of us are aware that contact with a significantly charged object or a wire carrying an electrical current can potentially result in a very dangerous shock. This effect of circuiting the electricity directly through a person to ground either through direct contact, through an object, or by arcing, is known as conductance, or resistive coupling, between the source of electricity and the individual. Safety from shock and possible electrocution from high-voltage transmission lines by conductance requires that transmission lines be designed as safely as possible and that people working or living in or near transmission right-of-ways understand how to safely operate around them.

Fewer individuals are aware that hazards associated with high-voltage transmission lines can also result from invisible electric and magnetic fields. The electromagnetic effects that cause these hazards are known as capacitive coupling and inductive coupling. Capacitive coupling is caused by the invisible electrostatic (electric) field created by the voltage in the transmission line. Capacitive coupling can lead to a build-up of charge on nearby conductive objects that are insulated from ground (e.g. a parked vehicle or metal roof on a shed). Inductive coupling is a result of the changing electromagnetic (magnetic) field created by the oscillating current in a transmission line. This inductive coupling can cause an electrical current to move through nearby conductive circuits (e.g. a parallel fence wire that is grounded at two points).

The following report discusses the electrical hazards of capacitive and inductive coupling for those living and working near 60 Hz alternating current (AC) transmission lines, and summarizes the current regulatory requirements of the Oregon Administrative Rules (OAR) and Oregon Revised Statutes (ORS) concerning transmission line safety. This report also includes recommendations for the review of applications for site certificates, recommendations regarding the information necessary to demonstrate compliance with regulatory requirements, and any additional recommended measures or siting conditions that could be implemented by the Council to further ensure the safety of the public where there is development of new transmission lines. It should be noted that this report does not address direct current (DC) transmission line effects, although a number of these lines exist in the U.S.

2.0 ELECTRIC AND MAGNETIC FIELD EFFECTS OF OVERHEAD HIGH-VOLTAGE TRANSMISSION LINES

Anywhere that an electrical charge or a current is present in a transmission line there can be exposure to electrical shocks through resistive, capacitive, or inductive coupling. With proper transmission line design and safe operating practices in the vicinity of transmission lines, the potential for shock can be limited to non-hazardous levels, if any shock is experienced at all. To understand the safe operating practices, it is important to understand these three effects, how they are caused, and how they can be mitigated.

2.1 Resistive Coupling (Conductive)

Dangerous levels of current can be conducted through a person to ground in the vicinity of a high-voltage transmission line through contact with current-carrying wires or through arcing to a conductive object. Contact refers to touching an energized line directly or touching an energized line with a conductive object, such as a tall piece of equipment like a crane. It is also possible for an arc to be created from the energized line to a nearby object in close proximity that provides a path to ground. Arcing can occur when errant irrigation streams shoot water close to a transmission line conductor, or an object such as an irrigation pipe is raised such that it is too close to the transmission line. Even excessive smoke from field burning can potentially provide a pathway to ground. More commonly, lightning strikes on transmission lines can create an ionized air path from the electrical line to the tower, circumventing the insulators which normally prevent such an occurrence.

Design of high-voltage transmission lines is intended to protect the public from the risk of shock by conductance. This is ensured by running the transmission lines at regulated heights above ground so that direct contact is unlikely and by using appropriate insulators that prevent electricity from passing through the tower to ground. As long as members of the public do not contact a power line either directly or indirectly, electrocution by conductance is highly unlikely due to the safe design of transmission systems. However, a knowledgeable public with regard to potential hazards is critical.

2.2 Capacitive Coupling (Electric Field)

AC transmission lines carrying power create both electric and magnetic fields. The voltage on a transmission line creates an electric field. An example of the field around a single conductor is shown in Figure 1. It has both a direction (toward or away from the energized line) and a magnitude, which is typically defined in terms of kV/m. The electric field is strongest close to the transmission line and decreases with distance. Therefore, the ground level strength of the electric field induced by a transmission line is greatest between supports, where the transmission line sags closest to the earth. Conductive objects in the electric field can become charged if they are insulated from ground.

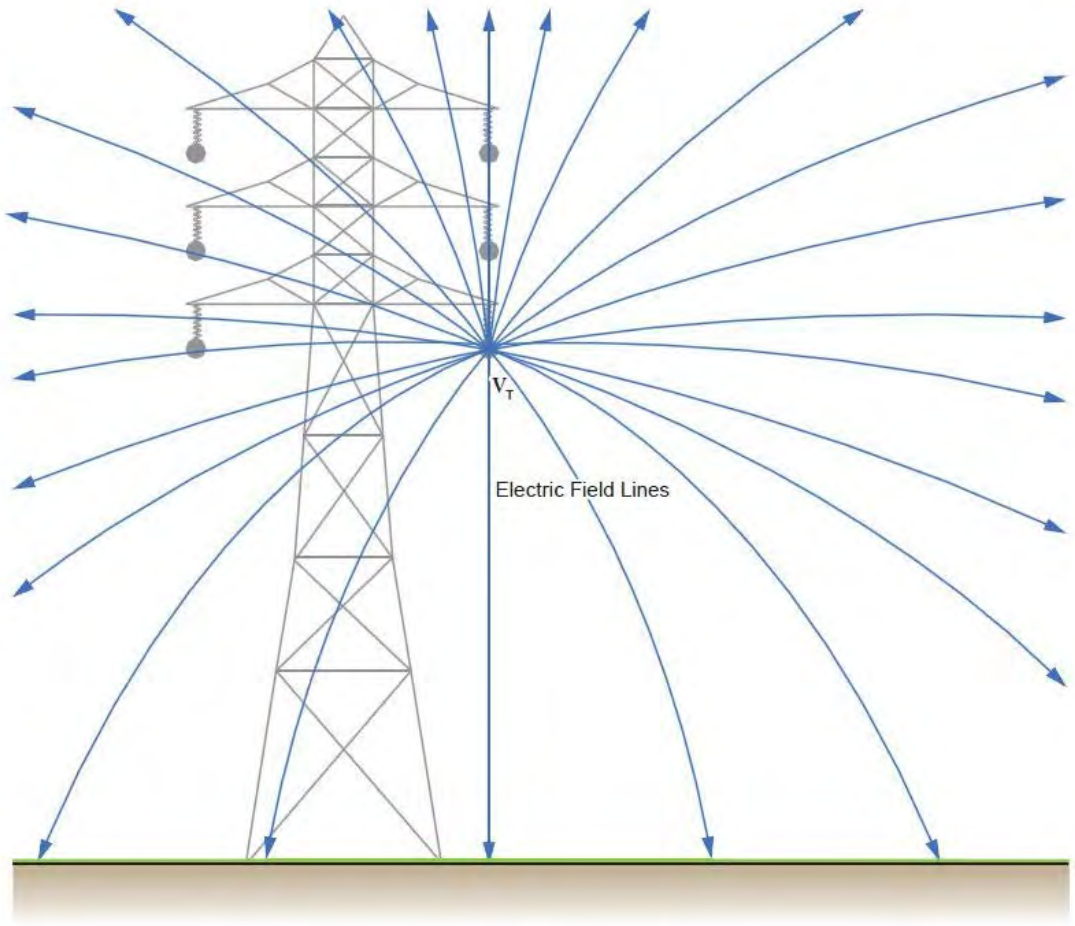


Figure 1. Electric field from an above-ground conductor.

The field can also be blocked (shielded) by common materials such as concrete and earth. For instance, the electric field does not penetrate the ground and therefore has little effect on conductive underground pipes. Because electric field strength diminishes with distance, conductive objects closer to a transmission line can develop a stronger charge than objects further away. As a result, there is a stored energy (capacitance) between isolated conductive objects that are at different field strengths because they have different electrical potentials (their induced voltage is unequal). See Figure 2.

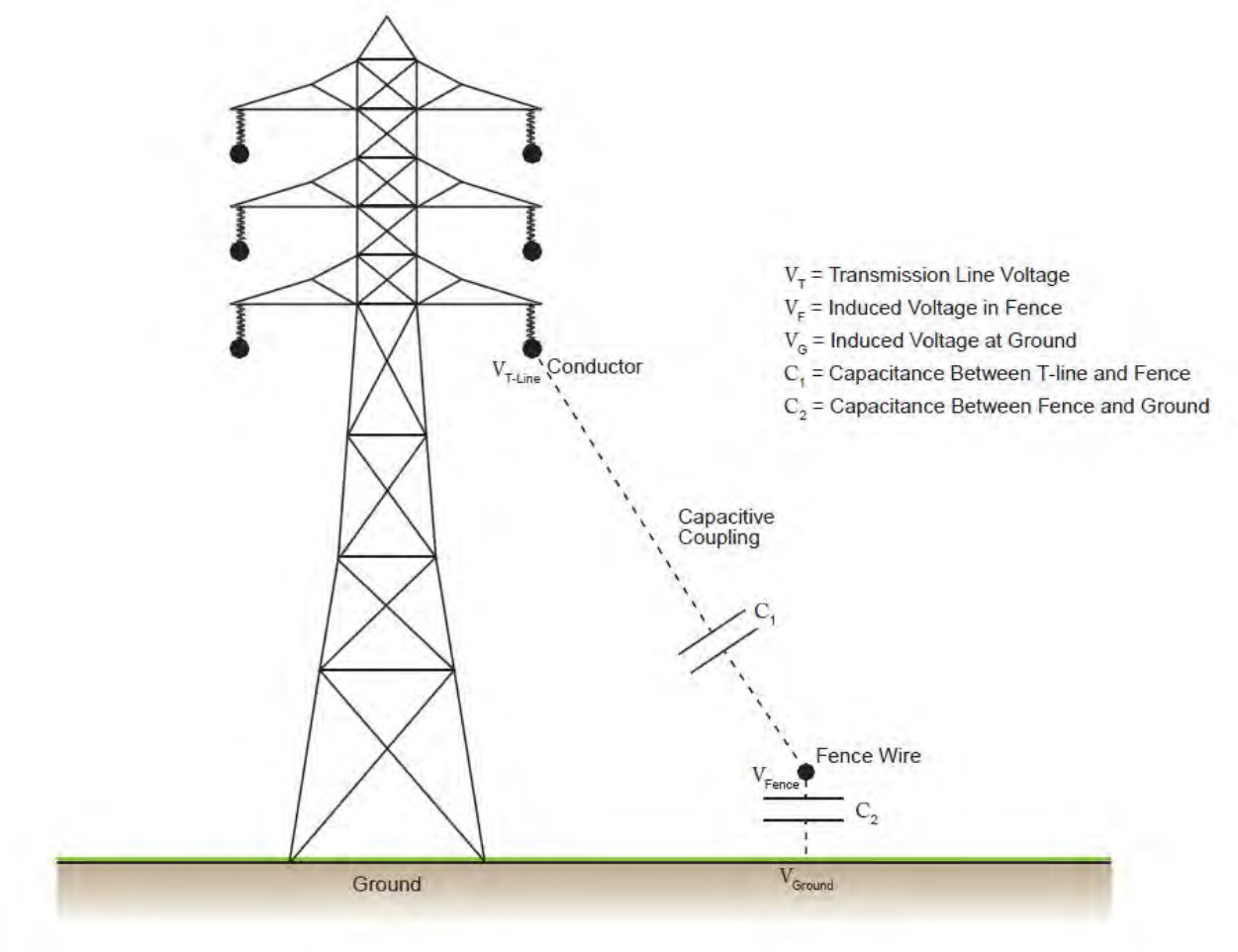


Figure 2. Capacitive coupling.

As an example, there is a difference in voltage (electrical potential difference) between a fence beneath an energized transmission line and the ground under it. This is because the ground is further from the transmission line, where the electric field is weaker, so the induced voltage is lower. If a person touches such a fence, they could experience a low energy shock as the charge from the fence is conducted through them to the ground. This low energy shock could be annoying, but is unlikely to be hazardous because it is quickly dissipated as the electrical potential of the fence and ground equilibrate. This type of shock is similar to the shock one feels when walking across a carpeted room in stocking feet and then touching a metal door knob.

In rural areas a tractor that is left parked under a transmission line could also develop a charge (an induced voltage) if the rubber tires on the tractor were effectively insulating the tractor from ground. The charge would build up on the metal parts of the tractor and a person that touched the tractor body could experience a nuisance shock, provided there was little electrical resistance between their feet and the earth. This is because the induced voltage on the tractor creates a current through the person's body as

the charge dissipates to ground. While annoying and potentially painful, these types of low energy shocks are short lived and rarely dangerous.

Induced voltages can build up in any conductive object near a transmission line, if it is electrically insulated from ground. This can include farm buildings with metal roofs, metal equipment (combines, tractors, cranes, etc.), vehicles, irrigation pipe, dielectrically coated ductile iron gas piping, electrical fences, barbed wire fences with wood posts, telecommunication lines, and a host of other conductive objects. If the conductive object is already grounded (e.g. a grounding wire on a fence) then a small electrical current is created and the induced voltage is safely and continuously conducted to ground. A well-grounded fence, for example, (grounded at reasonable intervals) would not result in a startling shock because induced voltage is continuously drained from the fence and does not build up. The magnitude of an induced voltage on a conductive object depends on the following (USDOA, 1976):

- Transmission line voltage (higher voltage leads to higher electric fields)
- Position of the transmission line conductors relative to one another
- Position of the conductive object relative to the transmission line conductors
- Size of the conductive object
- Quality of the insulation between the conductive object and ground (any electric current leakage to ground drains off some or all of the charge on the conductive object)

These factors can be used to implement mitigation and diminish the likelihood of human exposure to harmful shock from induced voltages, as discussed in Section 4.0 below.

2.3 Inductive Coupling (Magnetic Field)

In the electrical system in the United States the voltage and current on the energized conductors is cyclic (positive charge to negative and back to positive) with a frequency of 60 Hz. Just as the electric field from a transmission line can induce a charge or small current on a nearby conductive object, the magnetic field produced by the current in a transmission line can induce current and create a potential difference in another nearby conductive circuit. The magnetic field is measured in milligauss (mG). The 60-Hz electric current in the transmission line conductors creates a time-varying magnetic field that is at right angles to the conductor as shown in Figure 3. In 60-Hz AC electrical systems the current in the conductors changes direction 120 times per second, resulting in a magnetic field that is continually expanding and collapsing to and from the conductor. If the time-varying magnetic field passes through an area enclosed by another conductor, it will induce a current and voltage in that loop. This phenomenon is known as Faraday's Law.

Like electric fields, magnetic fields have both magnitude and direction. They also decrease in strength with increasing distance from the active transmission line. However, unlike electric fields, which are shielded by most materials, magnetic fields are not. As a result, it is possible to have induced currents in a co-located underground metallic pipe just as in a co-located fence.

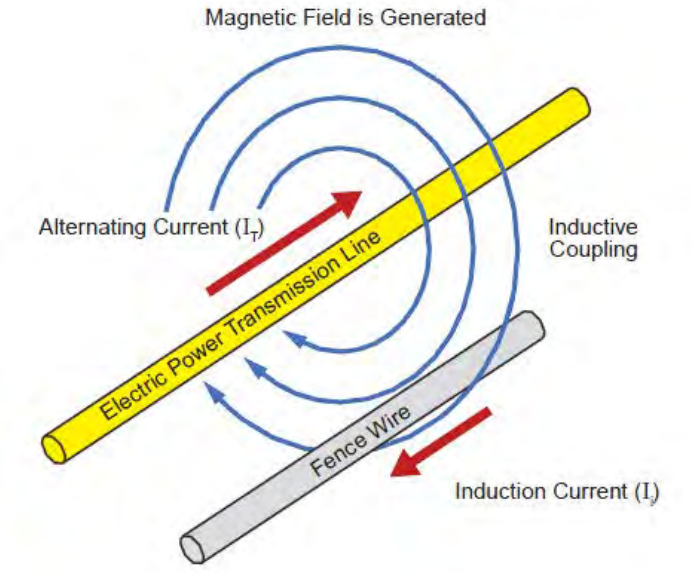


Figure 3. Inductive coupling.

Induced current indicates the flow of electrons in the object that is subject to the magnetic field. This means that a circuit must be present to circulate the electrons. If a long irrigation pipe was above ground and not was not electrically grounded anywhere, then an induced current could not occur. However, if the same irrigation pipe was grounded at both ends a conductive loop would be established with the earth and an induced current would flow in the pipe from the magnetic field passing through the area of the loop. A hazardous situation can occur when a long, conductive object is parallel to the transmission line and grounded in only one location. In this situation a circuit can be made complete by someone touching the object at another point. Even if a long linear parallel conductive object is grounded at two distant points, a hazardous situation can occur if a person touches the object at some point in between, creating a different grounding point to complete the circuit. Unlike a nuisance shock from a charged object in an electric field, the shock associated with a continual induced current is not temporary. Figure 4 demonstrates how an induced current could be created in a fence section that is grounded at the endpoints. The wire fence, posts, and earth for a conductive loop in this situation.

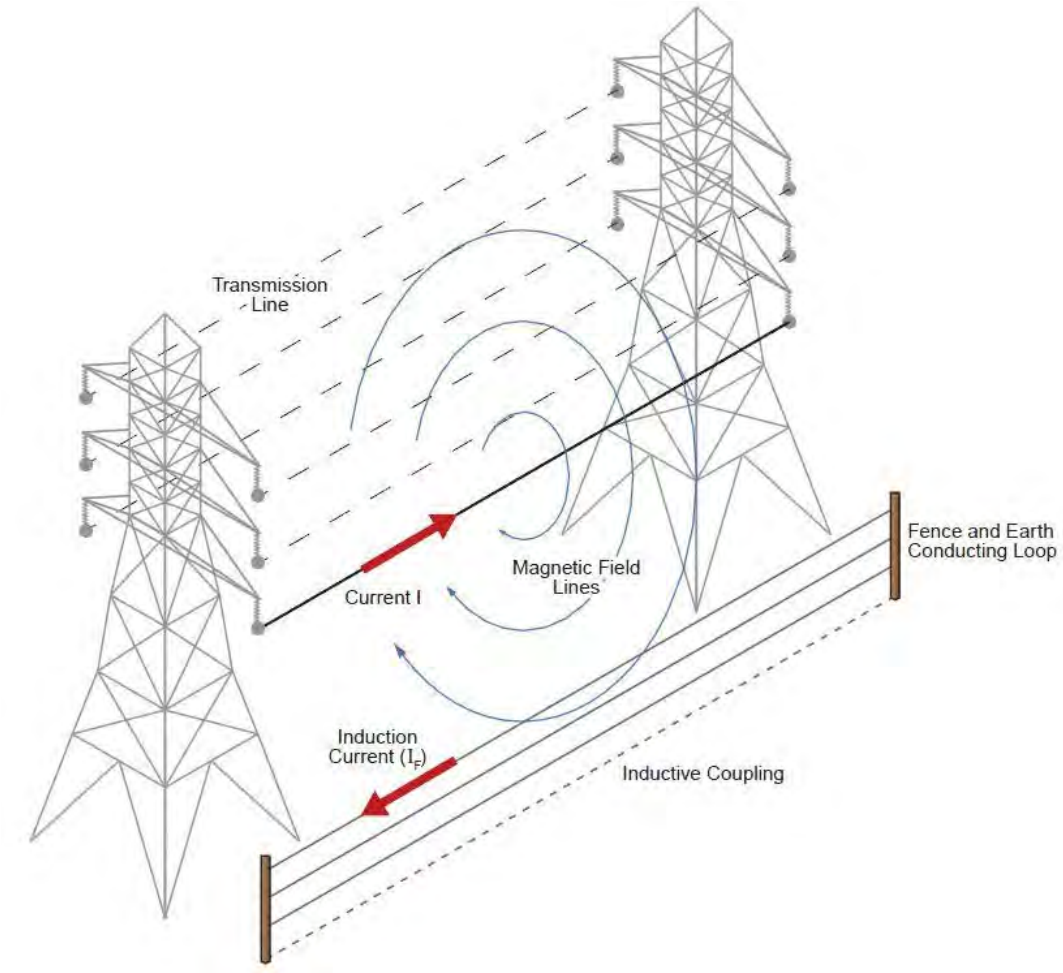


Figure 4. Induced current in a fence.

The magnitude of the induced voltage and current on an object, such as a pipeline, in a magnetic field is a function of the following (Bonds, 1997):

- Physical geometry of separation of the conductors (transmission line) and the conductive object in the magnetic field
- Resistance of the conductive object to ground
- Longitudinal resistance of the object
- Length of the electrically continuous object that parallels the transmission line
- Magnitude of the electric system current flow
- Frequency of the electric system (60 Hz)

- Nature of the electrical system, i.e. single phase or three phase
- Resistivity of the soil
- Discontinuities, i.e. where the conductive object veers away from the transmission line

As with induced voltages from electric fields, these factors can be used to develop mitigation for conductive objects that will be exposed to magnetic fields. Typically mitigation that works for electric field induced voltages, such as the use of grounding wires, is effective at reducing induced currents from magnetic fields as well. See Section 4.0 for a discussion of mitigation for different types of common conductive objects used in transmission line rights-of-way.

3.0 HAZARDS ASSOCIATED WITH INDUCED CURRENTS AND VOLTAGES

Transmission lines in Oregon are designed and constructed to meet the NESC, which dictates the height of the conductors above ground. The Council's Oregon transmission line siting standards provide additional limitations on the strength of the electric field at one meter above ground and require the magnetic field strength to be "as low as reasonably achievable." To minimize the net magnetic field, high voltage three phase (see definitions section) transmission lines are designed such that the three overhead phases are balanced 120 degrees out of phase with one another, 360 degrees being one complete cycle. In other words, each conductor is delivering power at 60 Hz (60 cycles per second), but each is in a different part of the cycle from positive to negative and back to positive voltage, offset by one-third of the cycle from the other two.

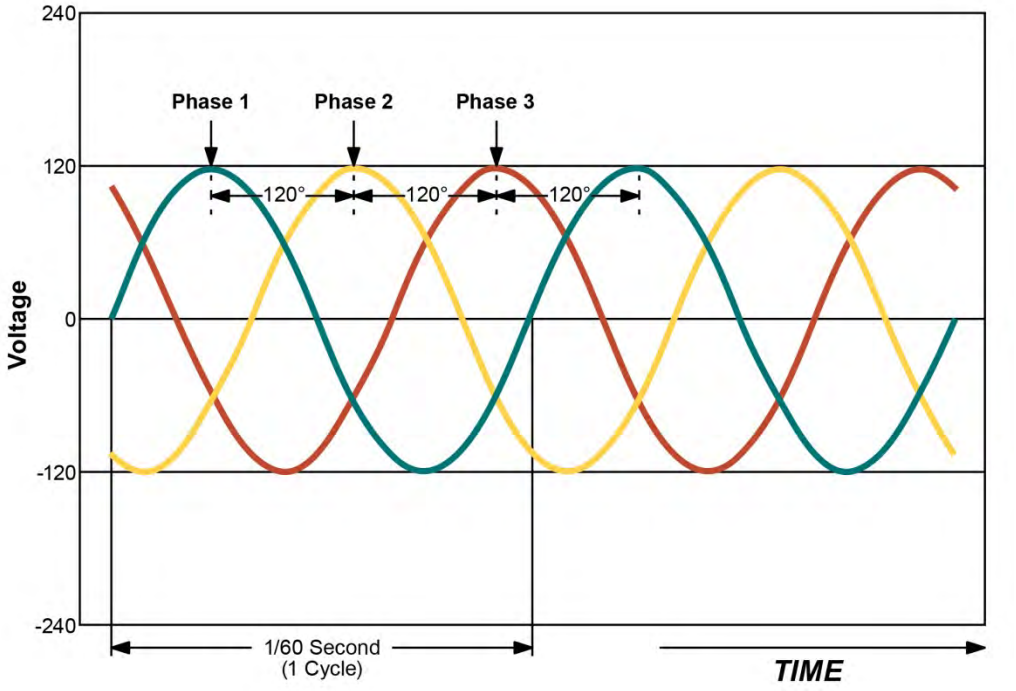


Figure 5. Three Phase Power- Voltage vs. Time.

The three phase nature and framing arrangement of the conductors is a significant factor in the mitigation of magnetic fields. The result is that a conductive object, such as a pipeline, that is equidistant from three perfectly phase-balanced conductors would experience no net magnetic field and would therefore not have an induced current. Unfortunately, the reality is that conductive objects such as co-located pipelines or telecommunication lines are not equidistant from all three phases. Therefore, these types of objects experience a net magnetic field that is reduced by design and standards, but not eliminated, so an

induced current can exist. Also, where there is an electric field present, there is a real possibility of induced voltages on ungrounded conductive objects (e.g. fences, irrigation pipe, etc.).

3.1 Human Safety Hazards

If all conductive objects near a transmission line were relatively small or only a few feet in length, there would be the potential for some nuisance shock to a person, but not a potential safety hazard. However, very long insulated parallel pipelines, electric fences, telecommunication lines and other conductive objects can be of such a length or size that an induced current and voltage from a transmission line could become unsafe to anyone who touches them.

In 1961, Charles Dalziel, a professor of electrical engineering at the University of California, Berkeley, delivered a ground-breaking presentation on the Deleterious Effects of Electric Shock, to a meeting of experts in Geneva, Switzerland (Dalziel, 1961). Professor Dalziel had conducted experiments on men and women to see what effect electrical currents would have if increased in magnitude. What he learned is that humans are very sensitive to electrical shock due to our "highly developed nervous systems" and that humans grasping an energized wire have a threshold electrical current above which they can no longer let go due to involuntary muscle contraction. This "let-go" threshold depends upon the frequency of the electricity. In the U.S. the electrical system uses a frequency of 60 Hz. At this frequency the maximum let-go threshold for men was determined to be 16 mA and for women it is 10.5 mA. The significance of the let-go threshold, according to Dalziel, is that "prolonged exposure to currents only slightly in excess of a person's let-go limit may produce exhaustion, asphyxia, collapse, and unconsciousness followed by death."

Subsequent work by Professor Dalziel and W. R. Lee (Dalziel and Lee, 1968) confirmed that 99.5 percent of men and women are able to let go of an energized conductor (at 60 Hz) if the current is below 9 mA and 6 mA, respectively. Professor Dalziel hypothesized that children would have a let-go threshold approximately half that of an adult male. This research and subsequent research led to the NESC requirement that steady-state (continuous) current between the earth and an insulated object in the magnetic field of a transmission line must be below 5 mA.

Table 1 Quantitative Effects of Electric Current on Humans (Dalziel, 1961)

Effect	Alternating Current (mA) at 60 Hz	
	Men	Women
Slight sensation on hand	0.4	0.3
Perception threshold, median	1.1	0.7
Shock- not painful and muscular control not lost	1.8	1.2
Painful shock, muscular control lost by 1/2% of population	9	6

Painful shock- let-go threshold , median of population	16	10.5
Painful and severe shock- breathing difficult, muscular control lost by 99 1/2% of population	23	15
Possible ventricular fibrillation (short shocks, t=seconds)	165/√t	165/√t

At the 2009 Midwest Rural Energy Council conference, Paul Ortmann, P.E., from Idaho Power Company, provided a presentation concerning "Induced Voltage on Electric Fences." For his presentation, Mr. Ortmann evaluated the situation of an insulated fence that runs parallel to a 138-kV transmission line. In this scenario the fence was three feet above ground and 12 feet beyond the outside conductor of the transmission line. Mr. Ortmann points out that a person standing on the earth that touches the insulated fence may experience a painful shock as charge flows through the individual to ground. The current is likely to be well below the 5 mA limit established by the NESC, and in fact the NESC limit would not be exceeded unless the insulated fence ran parallel to the transmission line for 1.36 miles or further, according to Mr. Ortmann.

While it is unlikely that any fence will parallel a transmission line for such a long distance, it highlights an important concept. Any insulated conductive object may deliver a shock that is relative to the size of the conductive object (e.g. the length it runs along a transmission line). In addition to fences, irrigation pipe, coated (insulated) ductile iron natural gas pipe, and telecommunication lines can similarly develop an induced voltage from the electric field of a transmission line and/or an induced current from the magnetic field. It would not be uncommon for a pipeline or a telecommunication line to parallel a transmission line for sufficient distance to pose a serious hazard (Kirkpatrick, 1997).

Numerous papers have been written about the shock hazards posed to people coming in contact with underground pipes, electric fences, irrigation pipes, and telecommunication cables. Even nuisance shocks can be hazardous if they are unexpected (e.g. someone on a ladder touches an ungrounded metal roof and falls). To prevent even nuisance shocks there are numerous guidelines and recommendations for corrosion engineers, telecommunication line workers, and pipe layers. There is less published for farm workers, but a number of utilities and power companies have developed very good guidance.

In 1976 the Rural Electrification Administration in the United States Department of Agriculture published Bulletin 62-4 titled "Electrostatic and Electromagnetic Effects of Overhead Transmission Lines," which provided an extensive amount of information on grounding intervals for electrified and non-electrified fences and irrigation pipe. It also discussed transmission line conductor heights above which various farm vehicles would not experience an induced current above the 5 mA "let-go" design criteria. In 2002, the Bonneville Power Administration (BPA) published "Guidelines for the Installation and Operation of Irrigation Systems Near High Voltage Transmission Lines." This guidance document provides farmers

with information on the safe use of a variety of irrigation system types. This includes advice on laying out irrigation systems to minimize induced current, recommended distances between equipment and transmission lines, safe maintenance practices, grounding, and recommended distances between irrigation nozzles and high voltage transmission lines.

3.2 Physical Hazards

There is one potential physical hazard of induced voltage that should be noted with regard to transmission line induced voltage: ignition of hydrocarbon vapors from a spark. In theory a large vehicle, electrically insulated from ground, would need to be parked in an electric field of 5 kV/m or greater (Note: Up to 9 kV/m is allowed one meter above ground in Oregon). Additionally, a person holding a fuel container with a metal spout would need to be well grounded so that the induced charge on the vehicle would arc (spark) to the fuel can nozzle. The fuel vapors and air would also need to be optimally mixed (CPUC, 2005).

While researchers have determined that it is extremely unlikely to occur (Deno, 1985), utilities and power companies such as the BPA and Great River Energy have published guidance documents warning that vehicle fueling should not occur near transmission lines due to the possibility of a spark between the fuel nozzle and the vehicle body, which theoretically could cause ignition of the fuel vapors. In fact, BPA does not allow any refueling within their transmission line rights-of-way (BPA, 2007A).

Despite all the design requirements of the NESC and the electric field limitation of the OARs, risks such as fuel ignition and nuisance shocks cannot be avoided without education of the public who will work within rights-of-way. This is a particular concern for new high voltage transmission lines where landowners may not have had prior experience farming and working within a transmission line right-of-way.

4.0 COMMON OBJECTS THAT CAN DEVELOP AN INDUCED CURRENT OR VOLTAGE FROM TRANSMISSION LINES AND MITIGATION

OAR 345-027-0023(4) requires site certificate holders with facilities that include a transmission line to "develop and implement a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line." Common objects that could inadvertently develop an induced current or voltage when located in proximity to transmission lines are discussed below.

4.1 Fences

Wire fences insulated from ground on wooden posts can develop an induced voltage when installed near transmission lines. Fences that are near a transmission line, but are grounded at more than one point, can develop an induced current. As a result, utilities and power companies discourage landowners from locating metal fences in rights-of-way. A common mitigation measure for eliminating the potential for shock is to install grounding wires. The BPA recommends that a fence may need to be grounded if 1) it is located in a right-of-way, 2) it parallels a transmission line within 125 feet of the outside wire and is longer than 150 feet, or 3) it parallels a line 125 to 250 feet outside the outer conductor and is longer than 6,000 feet (BPA, 2007A).

Paul Ortmann, Senior Electrical Engineer for Idaho Power Company, pointed out in his 2009 presentation on "Induced Voltage on Electric Fences," presented at the Midwest Rural Energy Council Conference (Ortmann, 2009) that a single point of grounding on a non-energized fence may reduce voltage due to capacitive coupling, but if someone were to touch the fence at some distance they could experience an induced current from the inductive coupling of the magnetic field. As a result, multiple points of grounding along a parallel metal fence are recommended. The BPA suggests that fences needing grounding should be grounded at each end and every 200 feet along their length. Fences crossing a right-of-way should be grounded at the edge of the right-of-way.

Fences that are energized (electric fences) to keep livestock contained may be insulated from ground. The additional induced voltage from a parallel transmission line could increase the potential for a shock. It should be noted that the NESC requires that the short-circuit current that would flow to ground from an insulated object cannot exceed 5 mA root mean square steady-state. New transmission lines designed and installed in Oregon must meet this criterion. As a result, the hazard posed from induced voltage on an electric fence is unlikely for existing electric fences in a new right-of-way, but ranchers may not be informed of the risk when installing new electric fences after a transmission line has been installed. To mitigate conditions where the NESC 5 mA current criteria cannot be met, a fence filter can be installed to provide a path to ground for the 60 Hz current while leaving the electric fence current, which has a different frequency, unaffected.

4.2 Vehicles

Vehicles parked under a transmission line may develop an induced charge, particularly if they are parked on surfaces that are not very conductive, such as gravel or asphalt, or their tires effectively insulate them from ground. Even for very large vehicles (e.g. semi-truck and trailer) the design standards of the NESC are sufficiently protective that only a nuisance shock is likely when a grounded person contacts the body of a vehicle. However, as previously discussed it is important for those working on or near transmission lines to be aware of the possibility that they could receive a nuisance shock and that no fueling of vehicles should occur in a transmission line right-of-way.

To mitigate the potential for nuisance shocks from vehicles parked below or near a transmission line, including tractors and other farm machinery, the induced voltage can be minimized by attaching a drag chain or leaning a metal bar against the vehicle (BPA, 2007A). Although it is highly discouraged, if vehicles must be fueled in the vicinity of a transmission line, both the vehicle and the fuel container should first be properly grounded to avoid creating a spark during fueling.

4.3 Buildings, Metal Roofs, and Gutters

In accordance with OAR 345-027-0023(4), site certificate holders that install transmission lines are required to "implement a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line." However, landowners may not be aware of requirements for grounding new structures near transmission lines after transmission line construction is completed. Where mitigation is necessary, grounding wires can be used and information about what to use and where to locate them may be provided by the owner of the transmission line.

4.4 Pipelines

In new transmission line rights-of-way, the co-location of conductive pipelines is not a problem. However, the installation of pipelines in existing transmission line rights-of-way requires precaution to prevent a serious hazard condition. When being assembled above-ground, a long parallel and continuous pipeline can develop a significant induced voltage from capacitive coupling (electric field). Once buried, the pipeline will only be affected by the magnetic field, but could develop a significant induced current if it is not grounded at reasonable intervals. Fortunately, pipeline workers are aware of these hazards so this is not something likely to affect the public. Much like a metal fence, the appropriate mitigation for induced voltages and currents is effective grounding at appropriate intervals.

4.5 Telecommunication Cables

Similar to unburied pipelines, conductive telecommunication cables can develop an induced voltage from electric and/or magnetic fields. This can affect the safety of telecommunication workers and can lead to the malfunction of equipment. When the effects are unacceptable, the telecommunication cables may need to be rerouted or buried. However, none of the hazards associated with induced voltage on telecommunication cables are likely to affect the public because they are not accessible unless someone extends a conductive device, such as a piece of irrigation pipe, and contacts exposed cable conductors.

4.6 Irrigation Pipe

Irrigation pipe is used throughout much of rural Oregon due to the dry climate of the western United States. Irrigation pipe used in the vicinity of a high voltage transmission line poses a number of potential hazards for those farming or working in or near a right-of-way. It is not uncommon for objects (e.g. dirt or rodents) to become lodged in sprinkler pipe. The practice of upending the pipe to clear the obstruction could result in electrocution if the section of pipe was long enough to create a path from the transmission line to ground. While this is highly unlikely given minimum height requirements for high-voltage transmission lines, the BPA recommends as a general practice that no objects extend above 14 feet in a right-of-way (BPA, 2007A). This includes irrigation pipe, vehicle antennas, booms on equipment, and any other conductive objects that could extend above 14 feet. Workers moving irrigation pipe should carry the pipe sections horizontally at all times when in the vicinity of the transmission line. Another potential electrocution hazard associated with irrigation pipe exists if the stream from an irrigation nozzle were to contact a transmission line conductor or to spray close enough to create arcing from the transmission line to the water and through the irrigation system to ground. For this reason Great River Energy recommends that farmers have no large nozzles within 150 feet of the outside wires on their transmission lines (GRE, 2012).

Irrigation pipe can also be subject to induced voltages and currents. Fixed type irrigation systems typically are in contact with the ground and therefore do not develop a significant induced voltage or current. However, mobile irrigation systems have gained in popularity and are now common throughout the rural landscape. The types of irrigation systems include: pipe, wheel, circular, and high-volume-high-velocity systems. Each of these has different characteristics and there are different recommended practices for each to protect the public. The BPA produced a detailed twelve page guidance document on installation and operation of irrigation systems for this reason (BPA, 2002). In all cases the handling of parts, orientation, and proper grounding are effective mitigation against shocks from induced voltage and potentially hazardous levels of current from inductive coupling. It is recommended that irrigation systems be set up perpendicular to nearby transmission lines when possible and that they remain perpendicular when performing maintenance. The BPA highlights that personnel should “not touch the sprinkler pipe or

its supporting structures when the system is operating under or parallel to and near a transmission line." (BPA, 2002)

As with many of the objects that can develop an induced voltage or current, the design of the transmission line to meet NESC requirements is only part of the mitigation for public safety. The public working in or near right-of-ways must also be educated on safe practices.

5.0 EXISTING REGULATIONS FOR HIGH-VOLTAGE TRANSMISSION LINE SITING WITH REGARD TO INDUCED VOLTAGE AND CURRENTS

Regulations applying to electric and magnetic fields associated with transmission lines are one of two types, safety standards or codes and field limits or guidelines. Safety standards and codes are designed to protect the public from injury or fatality. Field limits and guidelines generally protect from less hazardous nuisance shocks.

In Oregon, the PUC requires compliance with the 2012 edition of the NESC (OAR, 2012A), while the siting requirements of the Council currently require that the design, construction, and operation of transmission lines comply with the 1997 edition of the NESC (OAR 345-027-0023(4)(a)). In addition to other safety requirements, both versions have specific requirements for transmission line conductor heights and limit the maximum allowable induced current resulting from the transmission line electric and magnetic fields to 5 mA. This protects the public from exposure to currents that could exceed the "let-go" threshold, above which injury or death could result.

The Oregon siting standards for jurisdictional transmission lines also dictate that applicants design, construct and operate transmission lines so that 1) alternating current electric fields do not exceed 9 kV/m at one meter above ground surface in areas accessible to the public and, 2) induced currents resulting from the transmission line and related and supporting facilities are as low as reasonably achievable (OAR 345-024-0090). These standards are designed to protect the public from both injury and nuisance shocks. To ensure that there is ongoing protection for the public, the Council's siting rules (OAR 345-027-0023(4)(b)) require that the certificate holder develop and implement a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line.

There are currently no nationally enforced standards for electric and magnetic fields, although six states have transmission line siting standards (shown in Table 2) that limit the electric field strength in and/or on the right-of-way. Two states, Florida and New York, also limit the allowable magnetic field. Limits on the magnetic field are precautionary due to the uncertainty about health effects from electromagnetic field (EMF) radiation. However, a discussion of health effects from EMF radiation is beyond the scope of this document. Golder has previously addressed this subject in a report to the EFSC dated November 23, 2009.

As shown in Table 2, the BPA has adopted maximum allowable electric and magnetic fields that are applied to its transmission lines. The maximum allowable electric field corresponds with the Oregon siting standard, 9 kV/m. Neither the BPA nor the State of Oregon have adopted standards with regard to magnetic fields.

Table 2: State Transmission Line Standards and Guidelines

State/BPA	Electric Field		Magnetic Field	
	On R.O.W.*	Edge R.O.W.	On R.O.W.	Edge R.O.W.
Florida	8 kV/m[a]	2 kV/m	--	150 mG[a] (max. load)
	10 kV/m[b]	--	--	200 mG[b] (max. load)
	--	--	--	250 mG[c] (max. load)
Minnesota	8 kV/m	--	--	--
Montana	7 kV/m[d]	1 kV/m[e]	--	--
New Jersey	--	3 kV/m	--	--
New York	11.8 kV/m	1.6 kV/m	--	200 mG (max. load)
	11.0 kV/m[f]	--	--	--
	7.0 kV/m[d]	--	--	--
Oregon	9 kV/m[g]	--	--	--
BPA	9 kV/m	5 kV/m	--	--
	5kV/m[h]	--	--	--
	3.5 kV/m[i]	--	--	--
	2.5 kV/m[j]	--	--	--

Notes:

* R.O.W. = right-of-way (or in the Florida standard, certain additional areas adjoining the right-of way). kV/m = kilovolt per meter. One kilovolt = 1,000 volts.

[a] For lines of 69-230 kV.

[b] For 500 kV lines.

[c] For 500 kV lines on certain existing R.O.W.

[d] Maximum for highway crossings.

[e] May be waived by the landowner.

[f] Maximum for private road crossings.

[g] Areas accessible to the public

[h] Maximum at highway crossings

[i] Maximum for shopping center parking lots

[j] Maximum for commercial/industrial parking lots

(NIEHS, 2002 and USDOE, 1996)

Some national and international organizations have recommended guidelines for occupational and public exposures to electric and magnetic fields as shown in Table 3. These organizations include the American Conference of Government Industrial Hygienists (ACGIH), the International Committee on Non-ionizing Radiation Protection (ICINRP) with the World Health Organization, and the International Committee on

Electromagnetic Safety (ICES) under the auspices of the Institute of Electrical and Electronics Engineers (IEEE). However, these standards are designed to protect workers and the public from the potential effects of electric and magnetic fields on the human body as opposed to protection from shock hazards due to induced electric and magnetic field voltages and currents. The ACGIH recognizes that electric fields greater than 5-7 kV/m can result in spark discharges (nuisance shocks) from induced voltages that result in startle reactions. Therefore the ACGIH recommends grounding practices for electric fields at these levels or higher.

Table 3: International Exposure Limit Guidelines

Agency	Recipient	Electric Field (kV/m)	Magnetic Field (mG)
ACGIH[a]	Workers[e]	25	10,000
	Public	--	--
ICES/IEEE[b]	Workers	20	27,100
	Public	5[d]	9,040
ICNIRP[c]	Workers	8.3	10,000
	Public	4.2	2,000

Notes:

[a] (ACGIH, 2003)

[b] (IEEE, 2002)

[c] (ICNIRP, 2010)

[d] Maximum 10 kV/m below high-voltage transmission lines

[e] Based on maximum of 8 hours of exposure per day

6.0 CONCLUSIONS

Requirements by the Oregon PUC and the Council codified in the Oregon Administrative Rules require that transmission lines be constructed to the standards of the NESC (OAR 345-027-0023(4)(a)). Adherence to these design requirements ensure that transmission lines do not pose an unacceptable risk of shock or death to humans during normal operation. Additionally, the Council standards in OAR 345-024-0090 require that applicants design, construct and operate transmission lines so that 1) alternating current electric fields do not exceed 9 kV/m at one meter above ground surface in areas accessible to the public and 2) induced currents resulting from the transmission line and related and supporting facilities will be as low as reasonably achievable. Compliance with these standards protects the public from nuisance shocks from most routine activities. Department of Energy Project Officers can rely on the applicant's modeling to verify that the electric field will be less than 9 kV/m at the appropriate location provided the modeling is conducted for the lowest point of the transmission line relative to the ground (i.e. where there is maximum sag and/or higher terrain). To ensure that induced currents are as low as reasonably achievable, the reviewing Project Officer must rely on the certificate holder designing and constructing the transmission line in accordance with NESC standards as required by OAR 345-027-0023(4)(a), which establish minimum clearances above ground for transmission line conductors. Compliance of the certificate holder with OAR 345-027-0023(4)(b), which requires certificate holders to "develop and implement a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line" is also critical for public safety. The use of appropriately located grounding devices will minimize the induced current to which a person may be exposed by creating smaller sections of grounded conducting objects. Although induced voltages and currents may only provide a nuisance or "startle" shock, that shock could be hazardous if it causes someone to react unexpectedly (e.g. a person shocked at the top of a ladder when contacting a metal roof).

A review of applicable design, construction, and operating requirements for transmission lines in Oregon, particularly those under Council jurisdiction, indicates that transmission lines designed and built in compliance with the Council's rules do not generally pose a risk to public safety. As mentioned above, objects that could develop an induced voltage or current are required by Council standards to be grounded or bonded throughout the life of the project. However, the Council standards currently do not mandate an ongoing monitoring program that would identify new conductive objects in or near rights-of-way (e.g. new fences and irrigation systems) that are installed after a transmission line has been constructed.

We know that public activities can still jeopardize safety where transmission lines are concerned. Most of the public understands the dangers of direct or indirect contact with a transmission line, such as not to

touch a downed wire or fly a kite near a transmission line. Fewer people are aware of the electromagnetic effects of transmission lines and the potential for induced voltages and currents. While the Council standards limit electric field strengths to 9 kV/m one meter above ground in areas accessible to the public, the vast majority of people are not aware that, for example, a shock could result from touching something as common as a metal fence or irrigation pipe if they are collocated under a transmission line and of sufficient length.

As new transmission line rights-of-way are developed in Oregon, existing rights-of-way will become more crowded with infrastructure. Pipeline and telecommunication workers are well aware of the safety precautions they must take due to the potential for induced voltages and currents. It is less likely that farmers and ranchers with new rights-of-way through their land, or new landowners of existing rights-of-way, are aware of the hazard posed by induced current from high voltage lines. Hired farm workers may also be unaware of the potential for shocks from induced currents and voltages.

Some agencies and utilities have developed excellent educational materials to inform the public of the hazards of living and working near transmission lines, particularly with respect to induced voltage and current impacts. The BPA, the U.S. Rural Electrification Administration, Progress Energy, the American Transmission Company, and Great River Energy, to name a few, have all developed valuable public information documents designed to keep farmers, ranchers, and laborers educated on, and safe from, the effects of induced voltages and currents (see Appendix A for example educational materials).

7.0 RECOMMENDATIONS

Currently the Council's siting standards do not require developers of transmission lines to implement any kind of educational program for property owners of land adjacent to a transmission line right-of-way. Public education programs can contribute to public safety by informing landowners of the risks of common activities when performed near transmission lines, but in some cases members of the public other than landowners may need to be aware of the potential safety risks associated with transmission lines. In particular, agricultural lands are sometimes leased and worked by someone other than the property owner, and activities such as moving irrigation pipe are often performed by employees. In these cases, additional protective measures may be appropriate.

As previously stated, OAR Chapter 345 Division 27 already requires that certificate holders of a transmission line develop a program that provides reasonable assurance that objects and structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the transmission line. After review of the issues associated with induced currents and voltages near transmission lines, Golder recommends the EFSC consider additional site certificate conditions that are not specifically addressed by other OAR requirements. Specifically, Golder recommends that the Council consider the following site certificate conditions:

1. The certificate holder shall develop and provide educational materials, in all languages appropriate to the area, to inform landowners adjacent to transmission line rights-of-way of safe practices in or near the right-of-way prior to construction. Printed copies of such educational materials shall be provided to all landowners adjacent to the transmission line right-of-way prior to energizing the line. These educational materials shall encourage landowners to share the information in the educational materials with any farm workers that may work near transmission lines.

2. The certificate holder shall provide the educational materials required by Condition 1, above, to landowners adjacent to the right-of-way on an annual basis to ensure that new landowners, lessees, and employees are also aware of the need for safe practices in or near the right-of-way.

3. The certificate holder shall perform periodic checks for any new objects or structures that may have been installed by landowners and that could become inadvertently charged with electricity from the certificate holder's transmission line, as part of ongoing maintenance of the transmission line and grounding mechanisms. This could include new fences, fixed irrigation systems, metal roofed buildings, or other new structures.

Golder does not recommend that any of these conditions become mandatory, due to the wide range of varying conditions under which transmission lines may be constructed. Some transmission lines may be in existing rights-of-way or in extremely remote areas where the likelihood of public access is extremely low. The predominance of educational materials found by Golder suggests that the education of rural landowners with active agricultural activities may be the most important, since this part of the public may be more likely to come in contact with induced currents and voltages (e.g. fences, outbuildings with metal roofs, large pieces of parked equipment, irrigation systems, etc.). Applicants for a site certificate should also be able to propose alternate solutions for public education. For instance, applicants may wish to propose the use of signs in the right-of-way that would inform landowners of contact information for educational materials.

Currently the Oregon PUC requires transmission lines to be designed to the 2012 version of the NESC while the EFSC requires transmission lines be designed according to the 1997 version. It is recommended that the Council update OAR Chapter 345 Division 27 to require that site certificate holders design all electrical transmission facilities in compliance with the version of the NESC that is recognized by the Oregon PUC. This measure would help ensure public safety and would eliminate transmission lines under EFSC jurisdiction from being built to two different standards.

In summary, Council and PUC standards for the design and installation of transmission lines are generally protective of public health and safety; however, there are some risks to public safety that could be mitigated further through the implementation of some relatively simple measures, which are summarized above. Some of these measures, such as the development of an educational program for landowners on safe practices near transmission lines, are already voluntarily in use by some utilities/agencies such as the BPA. The BPA and utilities with these programs also make educational materials available for review on their web sites.

8.0 REFERENCES

(ACGIH, 2003) American Conference of Governmental Industrial Hygienists, "TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents. Biological Exposure Indices." 2003

(ATC, 2012) American Transmission Company, "A Guide to Agricultural Use of American Transmission Co. Rights-of-Way," Accessed September 1, 2012, www.atcllc.com.

(APIA, 2011) Australian Pipeline Industry Association, Ltd., "Guidelines for Electrical Hazards," Version 1, August 26, 2011.

(Bonds, 1997) Bonds, Richard W. August 1997. "The Effect of Overhead AC Power Lines Paralleling Ductile Iron Pipelines." Published by Ductile Iron Pipe Research Association.

(BPA 2007A) Bonneville Power Administration. October 2007. "Living and Working Safely Around High-Voltage Power Lines." DOE/BP-3804.

(BPA, 2002) Bonneville Power Administration. February 15, 2002. "Guidelines for the Installation and Operation of Irrigation Systems Near High Voltage Transmission Lines."

(BPA, 2007B) Bonneville Power Administration. July 2007. "Landowner's Guide for Compatible Use of BPA Rights-of-Way." DOE/BP-3657.

(CEC, 2012) California Energy Commission, Victorville 2 Hybrid Power Project Application for Certification, Section 6.14 Transmission Line Safety and Nuisance, February 2007, Accessed September 1, 2012, http://www.energy.ca.gov/sitingcases/victorville2/documents/applicant/afc/

(CPUC, 2005) California Public Utility Commission, Environmental Assessment, PG&E Delta Distribution Planning Area Capacity Increase Substation Project, Chapter 16, Corona and Induced Current Effects, August 2005, pg. 16-5. Accessed on September 1, 2012. http://www.cpuc.ca.gov/Environment/info/aspen/deltasub/pea/16_corona_and_induced_currents.pdf

(Daconti, 2004) Daconti, Jose, R., "Electrical Risks in Transmission Line – Pipeline Shared Rights-of-Way," *Power Technology,* October 2004,

(Dalziel, 1961) Dalziel, C. F., 1961. "Deleterious Effects of Electric Shock, Meeting of Experts on Electrical Accidents and Related Matters," Geneva, October 23-31, 1961.

(Dalziel, 1968) Dalziel, C. F., and Lee, W. R., "Reevaluation of Lethal Electrical Currents," *IEEE Transactions Industry and General Applications*, IGA-4, No. 5 September/October 1968, pp. 467-476.

(Dawalibi, 2000) Dawalibi, F. P., Li, Y., and Ma, J., "Safety of Pipelines in Close Proximity to Transmission Lines," *Electrical Safety in Industry, 2000,* Proceedings of 2000 IEEE IAS Workshop.

(Deno, 1985) Deno, D.W., Silva, J.M. Probability and Consequence of Gasoline Ignition Under HVAC Transmission Lines. IEEE Transactions on Power Apparatus and Systems, Vol. PAS-104, No. 11. 1985.

(GRE, 2012) Great River Energy, "Safety Around Powerlines, Frequently Asked Questions About Power Lines Near Your Property," www.greatriverenergy.com/.../safety/safetyaroundpowerlines.pdf, accessed September 1, 2012.

(ICNIRP, 1998) ICNIRP (International Committee on Non-ionizing Radiation Protection). "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz)," April 1998. *Health Physics*, 74(4, April):1-32.

(ICNIRP, 2010) International Committee on Non-ionizing Radiation Protection. "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (1 to 100 kHz), 2010.

(IEEE, 2002) Institute of Electrical and Electronics Engineers, "C95.6-2002 IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0 to 3 kHz." 2002.

(IPC, 2012) Idaho Power Company, "Working with Your Agricultural Operation," http://www.idahopower.com/pdfs/AboutUs/PlanningForFuture/ProjectNews/AgriOps.pdf, Accessed September 14, 2012.

(King, 2011) King, Kyle G., K&R Consulting, LLC, "Electrical Effects from the North Central Reliability Project," prepared for Richard Crouch and David K. Richter, Esq, Public Service Electric and Gas Services Corporation, May 20, 2011, pg. 45.

(Kirkpatrick, 1997) Kirkpatrick, Earl L., P.E., ELK Engineering Associates, Inc., "Induced AC Voltages on Pipelines May Present a Serious Hazard," *Pipeline & Gas Journal,* October 1997, pp. 67-69.

(NIEHS, 2002) National Institute of Environmental Health Sciences and National Institutes of Health, "Electric and Magnetic Fields Associated with the Use of Electric Power," June 2002, pg. 46.

(NTT, 2007) NTT Technical Review, "Calculation Method to Estimate Electrostatic and Electromagnetic Induction in the Design of Telecommunication Facilities," Vol. 5, No. 8, August 2007.

(Ortmann, 2009) Ortmann, Paul, P.E., Induced Voltage on Electric Fences, presented at Midwest Rural Energy Council Conference, 2009.

(OAR, 2012A) Oregon Administrative Rules, Title 860 (Public Utility Commission) Division 24 Safety Standards, Accessed September 14, 2012, http://arcweb.sos.state.or.us/pages/rules/oars_800/oar_860/860_024.html

(OAR, 2012B) Oregon Administrative Rules, Title 345 (Department of Energy, Energy Facility Siting Council), Divisions 21, 22, 24, and 27, Accessed September 1, 2012, http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_345/345_tofc.html

(Progress, 2012) Progress Energy, Staying Safe Around Transmission Lines, A Guide for Farmers, www.duke-energy.com/pdfs/Transmission-Farmers-Guide.pdf, accessed September 1, 2012.

(PSC, 2008) Public Service Commission of Wisconsin, EMF- Electric and Magnetic Fields, January 2008.

(Shwehdi, 2003) Shwehdi, M. H. and Johar, U. M, Transmission Line EMF Interference with Buried Pipeline: Essential & Cautions, Proceedings of the International Conference on Non-Ionizing Radiation at UNITEM (ICNIR 2003) Electromagnetic Fields and Our Health, October 20-22, 2003.

(USDA, 1976) U.S. Department of Agriculture, Rural Electrification Administration. May 1976. Electrostatic and Electromagnetic Effects of Overhead Transmission Lines. REA Bulletin 62-4.

(USDOE, 1996) U. S. Department of Energy, Bonneville Power Administration. "Electrical and Biological Effects of Transmission Lines: A Review," (DOE/BP 2938 December 1996 1M)

Appendix A:

Example Educational Materials from Agencies, Utilities, and Generating Companies

Staying safe around transmission lines

A guide for farmers

At Progress Energy, we're committed to providing safe and reliable electricity to our customers. But in order to do so, we must be able to maintain safe, unobstructed transmission lines. Interference – even unintentional – from the public can result in electrical flashes that are dangerous to both people and property, and can also cause power outages that affect surrounding industries, potentially resulting in legal action against the offender.

Safety

Because our transmission lines are not insulated, anything that provides a path from wire to wire, or from wire to ground – such as smoke, spray or debris near lines – can cause an electrical flash, which can be extremely dangerous to people and property. If a flash occurs, our equipment shuts the line down immediately, much like the circuit breakers in your home.

Potential liability

When transmission lines are shut down due to interference, the outages can cause serious monetary loss to industries that rely on high power quality for their processes. The consequent loss in productivity can result in legal action against you to recover their losses.

Possible hazards and right-of-way guidelines

In the course of doing your job, you may encounter or perform work near transmission lines, which could potentially shut off the power to the surrounding area. For your safety and the safety of others, please stay aware of these hazards and adhere to right-of-way guidelines, some of which are outlined below.

Hazards

- Smoke from field burning
- Debris piled up under the lines
- Spray from hog waste
- Construction or farming equipment near transmission line facilities
- Agricultural irrigation near lines

Right-of-way guidelines

Structures, equipment or storage

May be allowed with prior written approval if they are temporary in nature, do not obstruct complete access, do not adversely affect public safety, are more than 15 feet horizontally beyond the outside conductor and are less than 12 feet in height.

Grading or earth work

Changes of grade within the right of way require prior written approval (since code violations could result) and will not be allowed under any circumstances within 30 feet of any Progress Energy structure or anchor.

Lakes or ponds

May not be installed without prior written approval and will be subject to limitations, such as minimum distances to Progress Energy structures or anchors, etc. The location of lakes and ponds must not interfere with Progress Energy's access and/or maintenance requirements.

Fences

Must be installed at least 15 feet away from poles or towers and not exceed 8 feet in height. If a fence installation impedes access on the right of way, a gate shall be installed with a Progress Energy lock per Progress Energy specifications.

Trees, shrubs and other vegetation

Trees, shrubs, bushes, hedges, low-growing evergreens, flowers, grasses, low-growing shrubs or gardens that exist or are planted within Progress Energy's transmission line rights of way must not exceed a maximum height of 12 feet at maturity. Any existing tree that can mature at a height greater than 12 feet or potentially interfere with the safe and reliable operation of the line will be evaluated for removal. Progress Energy Carolinas does not object to property owners planting trees or other vegetation on transmission easements, provided it matures at a height of 12 feet or shorter, does not interfere with Progress Energy's access and/or maintenance requirements and is not directly under the conductor. It should also be understood that in the future it may be necessary to cut such trees if switches, structures or other line facilities need to be installed.

If plantings do not meet these criteria, they will be considered an encroachment into the right of way and will require an encroachment application with written approval; otherwise, the plantings may be subject to removal during maintenance activities. A list of low-growing vegetation approved for planting on transmission rights of way is available in Selecting Trees for Transmission Right of Way at www.progress-energy.com/trees.

For a complete list of our right-of-way use guidelines, please visit our Transmission Line Right-of-Way Use Guidelines page at **www.progress-energy.com/trees** *or contact the Progress Energy customer service center at* **1.800.452.2777** *to speak to a transmission right-of-way representative for your area.*

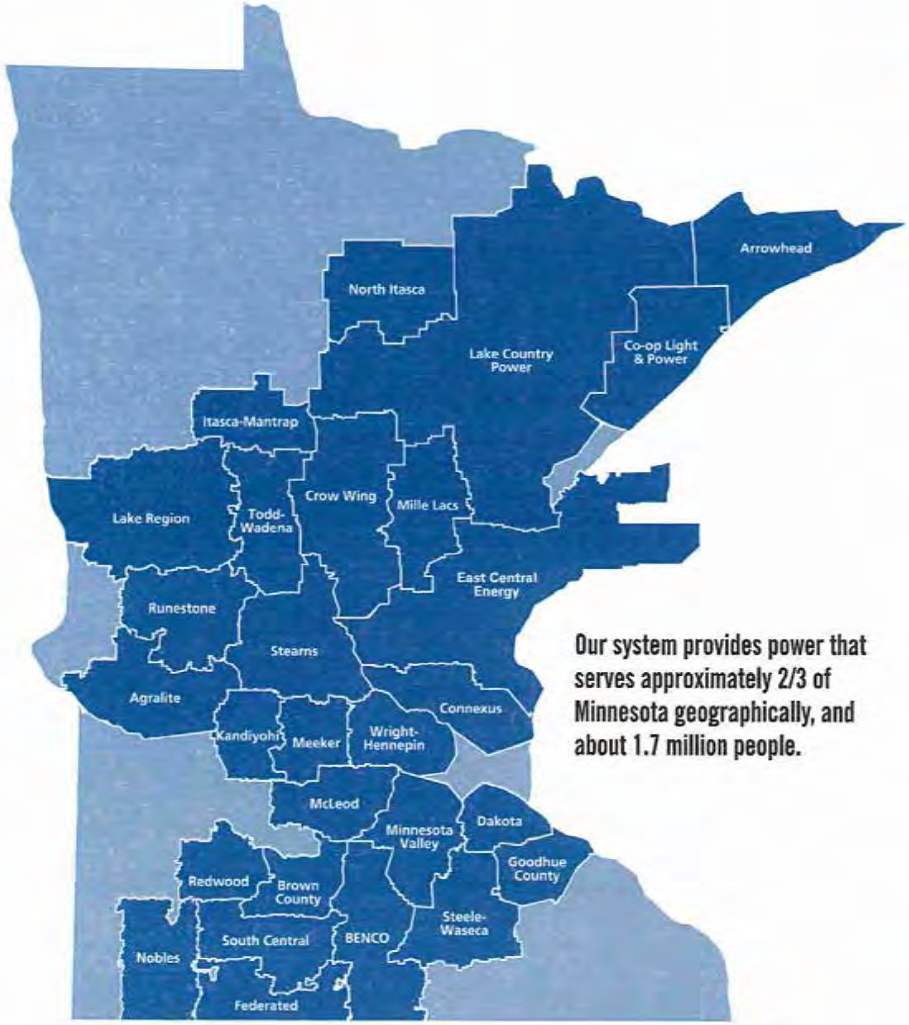
Progress Energy

12-0350 4/12

SAFETY AROUND POWER LINES

Frequently asked questions
about power lines
on or near your property

Great River Energy is a not-for-profit wholesale electric power cooperative which provides electricity to the 28 distribution cooperatives shown below.



Our system provides power that serves approximately 2/3 of Minnesota geographically, and about 1.7 million people.

Learn and follow the safety precautions discussed in this booklet to live, work and play safely near power lines.

GREAT RIVER ENERGY'S transmission lines meet or exceed safety standards, such as those specified by the National Electrical Safety Code (NESC) and the North American Electric Reliability Corporation (NERC).

However, power lines and other electrical installations still must be treated with caution, respect and common sense. By following safety precautions, you can live, work and play safely near power lines. Please save this guide for future reference.

Inside you will find a number of safety precautions and answers to frequently asked questions about:

1. Terms, page 2
2. Machinery and vehicles, page 3
3. Building or planting, page 5
4. Fences, page 7
5. Irrigation, page 8
6. Recreation, page 10
7. Safe construction and maintenance practices, page 12
8. Electric and magnetic fields (EMF), page 13

The following safety guidelines apply to any power line, including smaller distribution lines that serve electricity to your home or business, and transmission lines such as those Great River Energy builds.

If you see a broken power line, DO NOT touch it. Stay away from it and call your local electric utility, 911 or Great River Energy at 1-800-442-3013.

TERMS

Throughout this guide, we will refer to transmission lines, arc flash, grounding, induced charge and volts.

Transmission line – A transmission line is a set of wires, called conductors, that carry large or "bulk" amounts of electricity. When you think of the power line system that delivers electricity to you, think of the large transmission lines as interstate freeways, and the distribution lines that carry electricity to homes, farms and businesses as the smaller state or county highways.

Arc flash – In basic terms, an arc flash is a short circuit through air that flashes over from an energized conductor to another conductor, producing intense heat and light.

Transmission lines, such as those Great River Energy builds, deliver large or "bulk" amounts of electricity. After that, smaller distribution lines carry electricity to homes, farms and businesses. Pictured is a common structure for 69-kV and 115-kV transmission lines.

For example, power lines and people both can be conductors of electricity, meaning electricity can flow through them. If a person gets too close to a power line that is energized – *even without actually touching the power line* – an arc of electricity can form in the air connecting the two and cause very serious burns. Arcs heat the air around them to up to four times the surface temperature of the sun. *Serious burns are not uncommon even 10 feet from an electric arc.*

Grounding – A conducting path between an electrical circuit or equipment and the earth is known as a "ground". Because electricity typically follows the path of least resistance to the ground, an easy path from the circuit to the ground must be in place to help prevent the risk of electrical shock, fires, and damage to appliances and motors.

Induced charge – An induced charge is a charge that forms on an area of a neutral object when a charged object is placed near it. For instance, because electric fences are specially insulated from the ground, they can sometimes pick up an electrical charge if they are near a power line.

Volts – The force of an electrical current is measured in volts. The voltage at which a transmission line operates is expressed in kilovolts (kV). One kilovolt equals 1,000 volts.

MACHINERY AND VEHICLES

One of the most important rules to follow when working around power lines with tall equipment is simple … LOOK UP. Know where the power lines are and stay away from them.

Q. How can farm equipment and other machinery be safely operated near power lines?

A. If you are considering operating a vehicle within a height greater than 14 feet, please contact your local electric utility or Great River Energy. Be

LOOK UP! Equipment that can be extended, such as a grain elevator or stack mower, requires the utmost care when near a power line.

sure to call first even if it appears the line has clearance exceeding 14 feet.

And always remember…

- Physical contact with a power line is extremely hazardous and may cause a lethal shock. Equipment SHOULD NOT be operated under a power line in a manner that would cause contact or near-contact with the wires.
- DO NOT lift, elevate, build or pass under a power line any object, tool or vehicle that may make contact or near-contact with the wires.
- To help prevent arc flashing, it is recommended that equipment, antennas and people stay at least 15 feet away from any energized power line wire.
- Equipment that can be extended, such as a stack mower or grain elevator, requires the utmost care when in the vicinity of a power line.

Q. Can I put fuel in my machinery safely near a power line?

A. Fueling vehicles under transmission lines is not recommended. If you must fuel a vehicle under a transmission line, both the fuel container and the vehicle should be grounded in order to eliminate any source of sparks.

BUILDING OR PLANTING

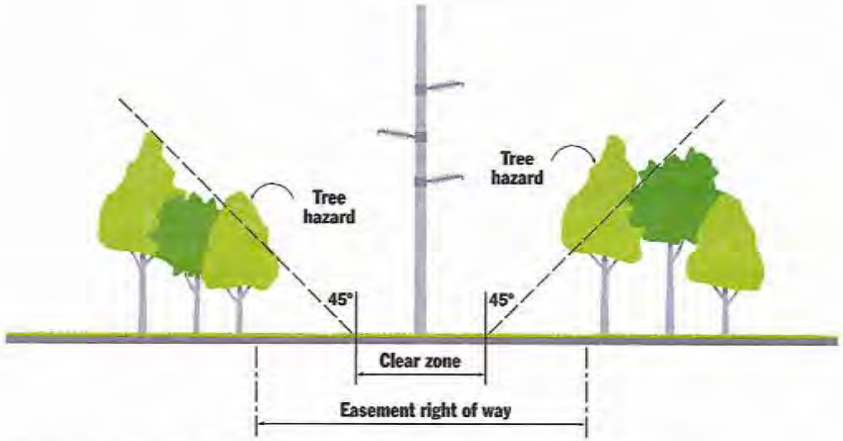
The North American Electric Reliability Corporation (NERC) requires electric utilities to meet hundreds of requirements which are designed to keep our electrical system safe and reliable. Among the requirements are standards for maintaining proper clearances. In other words, it is our responsibility to keep a certain amount of distance around power lines clear of anything that may make contact or near-contact with a power line. This includes buildings and tall-growing trees.

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

You must call Great River Energy before planting any trees or building any structures in transmission line right of way areas. We are required to maintain a proper clearance and we do not want to have to remove your new addition.

Q. How much of a clearance do you need for safe operation?

A. The larger the power line, the larger the clearance required. Transmission lines operate at high enough voltages that actual contact with an object may not be necessary to cause an outage. Additionally, summer temperatures and higher electric use cause lines to sag, sometimes as much as 5 to 10 feet. We need to maintain 15- to 20-foot clearances between transmission lines and trees or other objects, and sometimes more.



The North American Electric Reliability Corporation (NERC) requires utilities to maintain proper clearances along transmission rights of way.

Q. Can I plant anything in the right of way area?

A. DO NOT plant any trees in the right of way area before talking to Great River Energy. Great River Energy is obligated to maintain proper clearances within the right of way and we do not want to have to remove your new tree.

Activities in the right of way that do not interfere with the safe construction, operation and maintenance of the line are permitted. For example, you can use the land for:

- Pastureland
- Farming
- Gardening

Q. Can buildings be built beneath a power line?

A. Generally, buildings are not permitted within the right of way because:

- The building may interfere with access to the line for maintenance and emergency repairs.
- A fire in a building within the right of way could damage the transmission line.
- A building may be closer to a line than electrical codes allow.

Q. Are there any hazards to existing metal buildings after a power line is constructed?

A. Again, Great River Energy designs transmission lines to meet or exceed safety codes and standards, including those specified in the NESC and required by NERC. If you plan to construct, or have constructed, a metal building near a transmission line, contact Great River Energy. If you have concerns as to whether or not a building is properly grounded or need information on proper grounding requirements, contact your local electric utility or Great River Energy.

FENCES

Fence wires that are mounted on wood posts can build up an electrical charge near power lines. Important factors are:

- Length of fence paralleling the line
- Distance between the line and the fence
- Amount of moisture in the fence posts and the ground
- Presence of grounding devices such as metal fence posts or weeds growing next to the fence

Q. What do I need to know about non-electric fences?

A. Non-electric fences made of barbed wire or similar material that is directly attached to steel posts are adequately grounded and will not collect an electric charge. If you are planning to install a wire fence parallel to and near a power line, use at least one steel post every 150 to 200 feet to ground the fence.

Q. Can electric fences build up an electrical charge?

A. Electric fences, being specially insulated from the ground, can pick up a charge from transmission lines. Usually, the charge will drain off when

Electric fences are specially insulated from the ground and can pick up an induced charge from transmission lines.

the charger unit is connected to the fence; however, when the charger is disconnected either for maintenance or when the fence is being built, a small shock may be produced. Contact your local electric cooperative for assistance. Typically such a shock can be prevented by:

- Shorting out one or more of the fence insulators to the ground with a wire when the charger is disconnected, or
- Installing an electric filter which will ground charges induced from a power line while still allowing the charger to be effective.

Again, contact Great River Energy or your local electric utility for assistance if you have any questions; every situation is unique.

IRRIGATION AND WATERING

The potential for water and metal to conduct electricity makes it important to take safety precautions when irrigating near power lines. Additionally, fertilizers and pesticides tend to increase the conductivity of water, making extra precautions necessary. Watering the lawn at your home or business is not problematic; however, you still must prevent a direct, solid stream of water from contacting a transmission line.

Q. Can I irrigate near transmission lines?

A. Yes, as long as you take these precautions:

- **Prevent a solid stream of water from hitting the wires.** Equipment with nozzles that are small in diameter or spray a fine mist is typically not problematic because the solid part of the water stream will not reach the power line wires. Also, an intermittent spray of water will not conduct significant amounts of electricity. Even large diameter nozzles operating at their normal spray angle typically will not reach the wires with a solid stream.

However, at no time should the solid part of a water stream touch power line wires. Should that happen, turn the water off by switching the pump off before trying to correct the problem. Large nozzles should be at least 150 feet from the outside wires of power lines.

- **Make sure the irrigation system is well grounded.** If you have questions as to whether or not your irrigation system is adequately grounded, contact your local electric utility or Great River Energy.
- **Do NOT let irrigation pipes touch power lines.** Each system should be reviewed on a case-by-case basis; questions about the installation and operation of an irrigation system adjacent to or under a power line should be directed to your electric utility or Great River Energy.
- **DO NOT install long lengths of pipe parallel and adjacent to transmission lines.** They should be laid out at right angles to power lines, if possible, to reduce risk of the pipes building up an induced charge.
- **Be careful when moving the pipes.** When unloading irrigation pipes, stay at least 50 feet from power lines to avoid any chance of raising them too close to the wires.

You should never allow a solid stream of water to hit a transmission line wire. Be sure to note the guidelines in this section.

RECREATION

DO NOT fly kites or model planes near any power line.

When the weather is nice, we want to get outside and play. You can enjoy many recreational activities near power lines but some activities require caution. Be careful when flying kites, hunting or building fires near power lines. Additionally, never climb towers, fences, or any other structure near a power line or an electrical substation. During storms, stay away from all tall objects.

Q. Can I play with a kite or a model plane near a power line?

A. No. Here are some rules to follow:

- Do not fly kites or model planes near any power line.
- Always fly kites and planes so the wind carries them away from power lines, and television or radio antennas.
- Call Great River Energy or your electric utility if a kite or plane becomes snagged in a power line. DO NOT pull the string or climb a tower or pole to get it down.
- If a plane is caught in the line, let go of the control line immediately and call Great River Energy or your electric utility for assistance. DO NOT attempt to retrieve it yourself.

Q. Can I hunt in areas where there is a power line?

A. Power lines cross many remote areas so be sure to look for them before aiming or firing a gun. Additionally, shooting at power lines is illegal. Shooting insulators or conductors can break a wire or cause hazards such as an electrical discharge or arc through the air.

If you see a broken power line, DO NOT touch it. Stay away from it and call your local electric cooperative, 911 or Great River Energy at 1-800-442-3013.

Q. Can I build a bonfire, burn leaves or build another type of fire under a power line?

A. No. Fires should not be started under a power line. Smoke and hot gases from fires can create a conductive path for electricity.

- A fire could damage the poles or wires and result in an outage.
- It is possible that the power line could flash to the ground through hot air and smoke, which is a serious safety hazard.

During storms, stay away from ALL tall objects. Lightning tends to strike the highest point in an area and travels through it to reach the ground.

SAFE CONSTRUCTION AND MAINTENANCE PRACTICES

printed with permission from IEEE

Great River Energy's transmission lines are built and maintained to meet or exceed standards, such as those specified by the National Electrical Safety Code (NESC) and the North American Electric Reliability Corporation (NERC). Ensuring safety and reliability is our highest priority.

Q. How do I know the lines are safe?

A. Again, our lines are built and maintained to the standards mentioned above. Every effort is made to ensure safety in construction, operation and maintenance of transmission lines. Lines and line infrastructure are designed to withstand extreme weather conditions. Protective devices such as at line terminals stop the electricity flow under abnormal operating circumstances.

Q. How do you monitor the safety of the line?

A. Great River Energy follows strict transmission line maintenance standards. We regularly inspect lines by ground (usually during fall or winter months) and by air to look for:

- Tall-growing trees within the right of way area
- Equipment needing repair or replacement
- Right of way encroachments which are hazardous to safety and reliable operation
- Anything that might jeopardize safe, reliable operation of the line

We may need to visit the right of way area for these inspections but visits will be minimal and landowners will be contacted prior to inspections or maintenance. However, in cases of emergency, we may be unable to contact you first.

ELECTRIC AND MAGNETIC FIELDS (EMF)

Great River Energy follows third-party EMF research efforts closely. We recognize that those who live or work near power lines may have questions about EMF, and we have employees who work near power lines and substations every day.

Q. What is EMF?

A. Electric and magnetic fields (EMF) are created by anything that conducts electricity, including transmission lines, household appliances and business equipment.

These fields are strongest closest to their source; the farther away you are from the source the less EMF. EMF exposure from transmission lines, which are high in the air and outside the negotiated easement area, is minimal. Decades of scientific and medical research, reviewed by science organizations and government agencies, have found no cause/effect evidence of adverse health outcomes from EMF.

More detailed information on EMF is available online from:

- World Health Organization at www.who.int
- Minnesota Department of Health at www.health.state.mn.us/
- National Institute of Environmental Health Sciences – National Institute of Health at www.niehs.nih.gov/

HOW TO CONTACT US

Great River Energy
12300 Elm Creek Boulevard
Maple Grove, Minnesota 55369-4718
E-mail – landrights@grenergy.com
Phone – 763-445-5000
1-888-521-0130

To report a broken or damaged piece of transmission equipment or line, or any other unusual condition, please report it at once to us at 1-800-442-3013.

GREAT RIVER ENERGY®
A Touchstone Energy® Cooperative

www.GreatRiverEnergy.com

GUIDELINES FOR THE INSTALLATION AND OPERATION OF IRRIGATION SYSTEMS NEAR HIGH VOLTAGE TRANSMISSION LINES

BONNEVILLE POWER ADMINISTRATION

TRANSMISSION MAINTENANCE
&
ELECTRICAL EFFECTS
TNLD

FEBRUARY 15, 2002

This guideline is intended to assist the public in planning and installing irrigation systems near BPA transmission lines. It is also intended for use by BPA employees in answering questions from the public, reviewing applications for right-of-way use, and for locating transmission lines in irrigated areas. Information in this guide is intended only as general guidelines.

Irrigation systems fall into two categories: fixed and mobile. Fixed irrigation systems include the fixed pipe-type systems and the row and rill-type systems. Mobile systems, which have gained in popularity, can be broken down into roughly four types: pipe-type, wheel-type, circular irrigation system, and high volume, high velocity systems. Each of the types has its own characteristics which the installer and operator should be aware of when working adjacent to high voltage transmission lines. For each type of system, installation suggestions and safe working practices near high voltage transmission lines will be presented.

I. FIXED-TYPE SYSTEMS

A. Pipe-Type and Row and Rill-Type

Fixed pipe-type irrigation systems are used for long term watering of landscaping, such as golf courses and playing fields, or crops such as orchards and vineyards. The irrigation piping is usually installed underground, and sprinkler heads are permanently or temporarily connected to the feed piping by risers of various lengths. The length of a riser depends on the type of vegetation and the purpose for the sprinkling. The row and rill-type of irrigation uses long trenches dug in the surface of the soil, and fed by gates, valves, or siphon tubes installed in a canal or ditch at the head of each trench.

Installation Suggestions

Equipment used to install fixed-type irrigation systems should never be closer than the minimum distance to transmission line conductors as shown on Table I (page 11). The sprinkler heads should be located so that they never spray water on the transmission line conductors. All underground water supply piping crossing BPA right-of–way should do so at an angle of not less than 60 degrees to the centerline of the transmission lines. It should be buried, whenever possible, a minimum of 24 inches underground, and should be marked, when practical, where it enters and leaves the right-of-way and at all angle points within the right-of way. These last two conditions will prevent damage to the piping due to movement of heavy equipment on the right-of way.

All metal pipelines, above or below ground, should be kept 50 feet (15 m) from any part of a BPA structure, and 15 feet (5 m) from any grounding system.

Any movement of earth on a transmission line right-of-way which might reduce the stability of a transmission tower or pole or would permanently decrease the conductor to ground distance, shall not be allowed unless approved by the appropriate BPA area office.

Safe Working Practices

The fixed pipe-type sprinkler systems are always in contact with the ground. There is very little chance of feeling even a small electrical shock while contacting one of these systems, which is close to a transmission line. Care must be exercised when installing and removing the riser pipes so that an adequate distance is maintained between the overhead conductors and the riser pipes. The recommended minimum distances are shown on Table I (page 11).

II. MOBILE SYSTEMS

A. Pipe-Type Systems

Mobile pipe-type irrigation systems are assembled, disassembled, and moved by hand. The pipes in these systems are laid on the surface of the ground and the water supply is usually connected to the irrigation system through valves in a header pipe. The header pipe is often located at one side of the field, and taps are located in the header pipe at convenient intervals so that moving the pipe from one tap to another assures coverage of the whole field. Sprinkler heads are installed along the irrigation piping and apply water to circular areas, the diameters of which are governed by the nozzle size and water pressures.

Installation Suggestions

Equipment used to install mobile systems should never be closer than the minimum distance to transmission line conductors as shown on Table I (page 11). All underground water supply piping crossing BPA right-of-way should do so at an angle of not less than 60 degrees to the centerline of the transmission lines. It should be buried, whenever possible, a minimum of 24 inches underground, and should be marked, when practical, where it enters and leaves the right-of-way and all angle points within the right-of-way. These last two conditions will prevent damage to the piping due to movement of heavy equipment on the right-of-way.

All metal pipelines, above or below ground, should be kept 50 feet (15 m) from any part of a structure, and 15 feet (5 m) from any grounding system.

Any movement of earth on a transmission line right-of-way which might reduce the stability of a transmission tower or pole or would permanently decrease the conductor to ground distance, shall not be allowed unless approved by the appropriate BPA area office.

Safe Working Practices

Because this type of system is laid on the ground surface when operating, the chance of feeling even a small shock when picking up a length of pipe that was lying under or near a transmission line is unlikely.

A person carrying a length of pipe from one location to another should always carry the pipe in the horizontal position, especially while crossing under any power line. Standing pipe on end to remove dirt or small animals should never be done before a careful check has been made to see if the pipe could come close to any overhead lines. After carrying a pipe section under the transmission line to a new setup point, the operator may experience a nuisance shock when he touches the header pipe if the ground is very dry. A slight shock may also be felt if a piece of pipe is being unloaded from a rubber-tired vehicle located near a transmission line.

The likelihood of shocks and incidents of contacts between upended pipes and power lines can be greatly reduced if the pipe is never unloaded under the transmission line. A distance of more than 50 feet (15 m) from the centerline of the transmission line is recommended for unloading the pipe. If very dry soil conditions exist, such as at the beginning of the irrigating season, connecting the first length of pipe to the head pipe and proceeding by connecting short lengths to the first is a good practice especially when within 50 feet (15 m) of the transmission line centerline.

B. Wheel-Type Systems

Wheel-type systems are very similar to the pipe-type system previously addressed (i.e., a long straight length of 4-5 inch (10-13 cm) pipe equipped with distributed sprinkler heads). However, in this case, instead of the pipe being disassembled to be moved, it is rolled down the field on 4-5 foot (1.2-1.5 m) diameter wheels (usually metal). The pipe actually forms the axle for the group of wheels supporting it. In this case, the pipe is suspended 2-2.5 feet (60-80 cm) off the ground (see Fig. 1, page 8). The motive power can either be manpower for short lengths or a power unit for long lengths. The power unit is usually located close to the center of the pipe run.

Installation Suggestions

When possible, the system should be installed with its length perpendicular to the transmission line. Equipment used to install wheel-type systems should never be closer than the minimum distance to transmission line conductors as shown on Table I (page 11). All underground water supply piping crossing BPA right-of-way should do so at an angle of not less than 60 degrees to the centerline of the transmission lines. It should be buried, whenever possible, a minimum of 24 inches underground, and should be marked, when practical, where it enters and leaves the right-of-way and at all angle points within the right-of-way. These last two conditions will prevent damage to the piping due to movement of heavy equipment on the right–of-way.

All metal pipelines, above or below ground, should be kept 50 feet (15 m) from any part of a BPA structure and 15 feet (5 m) from any grounding system.

Any movement of earth on a transmission line right-of–way which might reduce the stability of a transmission tower or pole or would permanently decrease the conductor to ground distance, shall not be allowed unless approved by the appropriate BPA area office.

Safe Working Practice

When a wheel-type system is to be operated near or under a transmission line, the assembling of the system should follow the same procedure as mentioned for pipe-type systems. In many cases, the wheel-type system will be operated with its length parallel to the transmission lines. For wet soil conditions and because of the good ground contact through at least one or two of the metal wheels, very few shock sensations will be experienced when touching the pipe. A simple precaution should be observed during dry soil conditions when the long system is being connected to header pipe valves within 50 feet (15 m) of the centerline of the transmission line.

Under these conditions, the operator should connect the pipe to the valve with a short length of wire equipped with a clamp on each end (see Fig. 1, page 8). This will effectively drain off any accumulated charge on the irrigation pipe. This wire connection should be made to the header pipe valve connecting the irrigation pipe.

C. Circular Irrigation Systems

This system consists of water pipe held above ground with sprinkler heads distributed along its length (see Fig. 2, page 9). The system is often 1/4 mile (400 m) long and pivots around a center point, which is the water source. The pipe is carried on motor-propelled supports spaced along the pipe. Rotation of the system irrigates a circular area or with special equipment, odd-shaped areas. The system will not cover a 360-degree rotation when an obstruction such as a transmission line structure intersects the pattern. For these cases, reversing travel to avoid obstructions or a special guidance system is used. Unlike the wheel system, the circular system is rarely disconnected from the source point, except for periodic maintenance.

Installation Suggestions

Equipment used to install circular irrigation systems should never be closer than the minimum distance to transmission line conductors as shown on Table I (page 11). All underground water supply piping, electric power cables, and communication cables crossing BPA right-of-way should do so at an angle of not less than 60 degrees to-the centerline of the transmission lines. It should be buried, whenever possible, a minimum of 24 inches underground, and should be marked, when practical, where it enters and leaves the right-of-way and at all angle points within the right-of-way. These last two conditions will prevent damage to the piping and cables due to movement of heavy equipment on the right-of-way.

All metal pipelines, pivots, electrical power cables, and communication cables, above or below ground, should be kept 50 feet (15 m) from any part of a BPA structure and 15 feet (5 m) from any grounding system. The center point or pivot point of the irrigation system should be located 20 feet (6.5 m) laterally outside the outermost conductor.

Any movement of earth on a transmission line right-of-way which might reduce the stability of a transmission tower or pole or would permanently decrease the conductor to ground distance, shall not be allowed unless approved by the appropriate BPA area office.

Nozzles should be positioned so that they do not spray water on the transmission line conductors. When this is not practical, distances given in Table II (page 12) should be used between nozzle and centerline of the transmission line. The circular irrigation system should be installed so that the minimum distance given in Table I (page 11) is maintained between conductors and sprinkler system hardware. All nozzle risers, which pass under a transmission line, should be equipped with spoilers or automatic shut-offs in case a nozzle breaks or drops off. This will insure that that a solid stream of water is not projected into the transmission line.

Safe Working Practices

If the pivot point of a circular irrigation system is near or under a transmission line, the irrigation system could acquire an electrostatic charge during operation. To prevent this electrostatic charge buildup, the pivot point should provide a good electrical ground for the sprinkler system. This will eliminate electrostatic shock nuisances during operation.

This electrical ground, however, does not eliminate hazards due to inductive coupling between the transmission line and the sprinkler pipe. With the irrigation system near or under a transmission lines, the pipe could rotate to two locations parallel or nearly parallel to the transmission line. This situation is similar to the position of the wheel-type system in Fig. 1, page 8.

It is recommended that personnel not touch the sprinkler pipe or its supporting structures when the system is operating under or parallel to and near a transmission line.

The pipe used in circular irrigation systems is larger, higher off the ground, and generally longer than wheel-type systems. Also, the driving wheels are usually rubber-tired and under dry conditions, could insulate the pipe from ground. With the sprinkler pipe parallel and close or under the transmission line, the inductive coupling between the transmission line and the sprinkler boom can result in hazardous shock currents if a person touches the system while the boom is connected to the pivot point. For these reasons, any maintenance work should be done with the sprinkler pipe perpendicular to the transmission lines. This situation is illustrated in Fig. 2, page 9. When this is not practical, the ends of the pipe should be electrically grounded (connected to or in contact with earth) before beginning maintenance work and each disjoined length of the system should be individually grounded on both sides of the coupling before it is decoupled. Metallic ground rods are recommended for this grounding procedure.

D. High Volume, High Velocity Systems

These systems use large high-pressure nozzles to sprinkle large areas. The Vermeer mobile irrigator is an example of this type of system (see Fig. 3, page 10). High velocity, high volume nozzles are located at each end of two arms approximately 70 feet (21 m) in length. The arms rotate due to discharge of water through the nozzles. They rotate on a base attached to a small chassis, which can be towed or pushed to different points in the field. Nozzle diameters normally vary from 3/4 inch (2 cm) to 1 15/16 inch (5 cm). Water pressures used are in the range of 80-100 psi. The nozzles discharge a high velocity solid stream of water from the ends of the arms. The water stream may reach a height of 30-35 feet (9-11 m), and may be projected as much as 200 feet (60 m) horizontally. Other systems using single nozzles (water cannons) with clapper have similar characteristics.

Installation Suggestions

Maintaining an adequate distance between the irrigation equipment and transmission line conductors is essential for safe operation of these types of systems. The irrigation equipment should be positioned so that water is not projected into transmission line conductors. When this is not practical, distances given in Table II (page 12) should be used between nozzle and centerline of the transmission line. The irrigation systems should be located so that the recommended minimum distance given in Table I (page 11) are maintained between the conductors and the sprinkler system hardware. All underground water supply piping crossing BPA right-of-way should do so at an angle of not less than 60 degrees to the centerline of the transmission lines. It should be buried, whenever possible, a minimum of 24 inches underground, and should be marked, when practical, where it enters and leaves the right-of-way and at all angle points within the right-of-way. These conditions will prevent damage to the piping due to movement of heavy equipment on the right-of-way.

All metal pipelines, above or below ground, should be kept 50 feet (15 m) from any part of a BPA structure and 15 feet (5 m) from any grounding system.

Any movement of earth on a transmission line right-of-way which might reduce the stability of a transmission tower or pole or would permanently decrease the conductor to ground distance, shall not be allowed unless approved by the appropriate BPA area office.

Safe Working Practices

Great caution should be exercised when moving these types of systems under transmission lines. The small wheel bases tend to be unstable on rough ground and could cause the equipment to swing off balance lifting a piece of the system into the overhead conductors. If mobile surface piping is used for supply, a person carrying a length of pipe from one location to another should always carry the pipe in a horizontal position especially while crossing under any power line. Standing the pipe on end to remove dirt or small animals should never be done before a careful check has been made to see if the pipe could come close to any overhead lines.

II. NOTE

This document is the result of editing and modifications of the original document "Guidelines for the Installation and Operation of Irrigation Systems near High Voltage Transmission Lines," February 21, 1978, authored by D.J. Nichols.

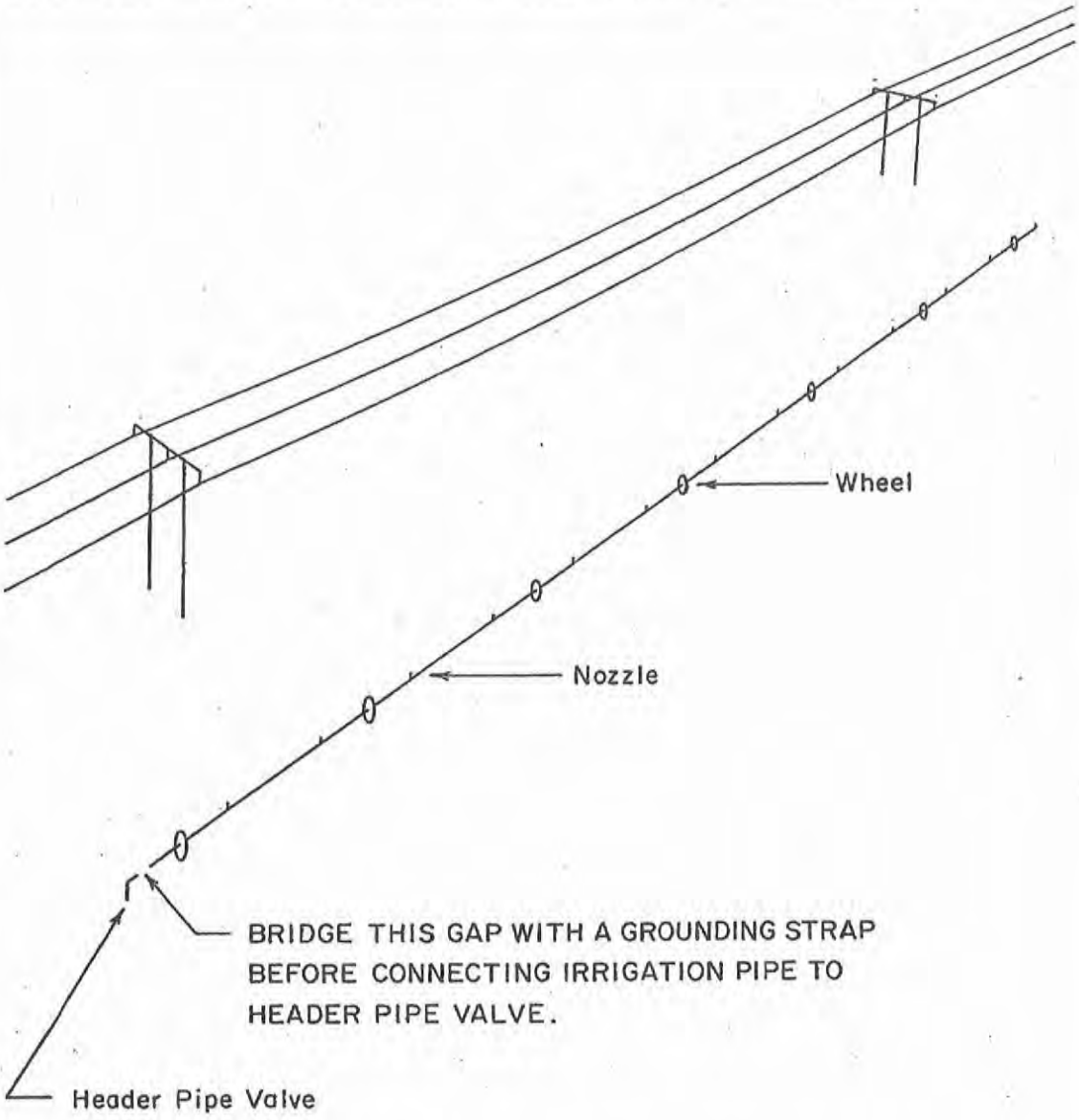


FIGURE 1

WHEEL TYPE IRRIGATION SYSTEM
PARALLEL TO TRANSMISSION LINE

JC/ERM 10-22-76

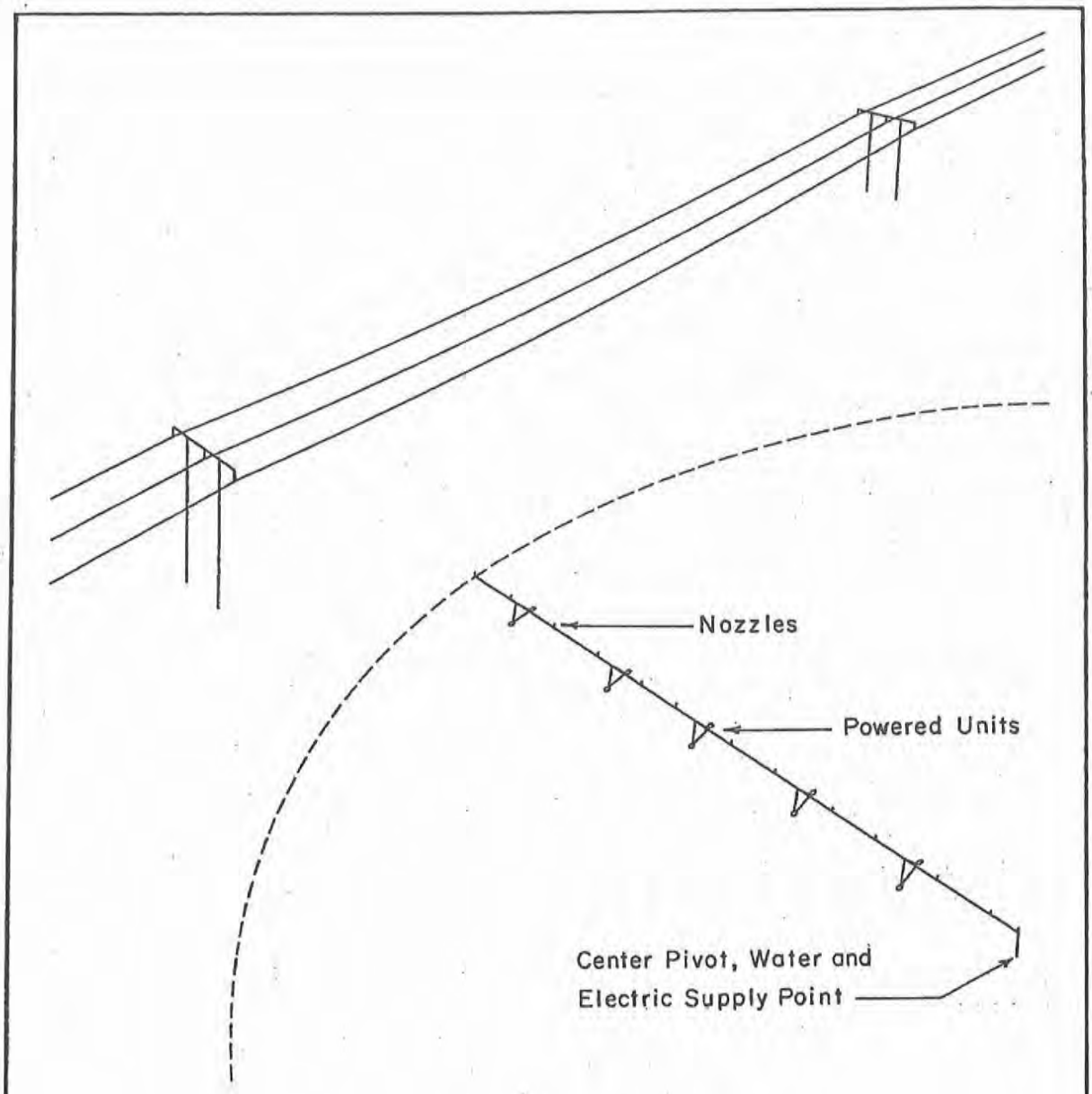


FIGURE 2

CIRCULAR TYPE IRRIGATION SYSTEM SHOWING SAFE MAINTENANCE POSITION AT 90° TO TRANSMISSION LINE

JC/ERM 10-22-76

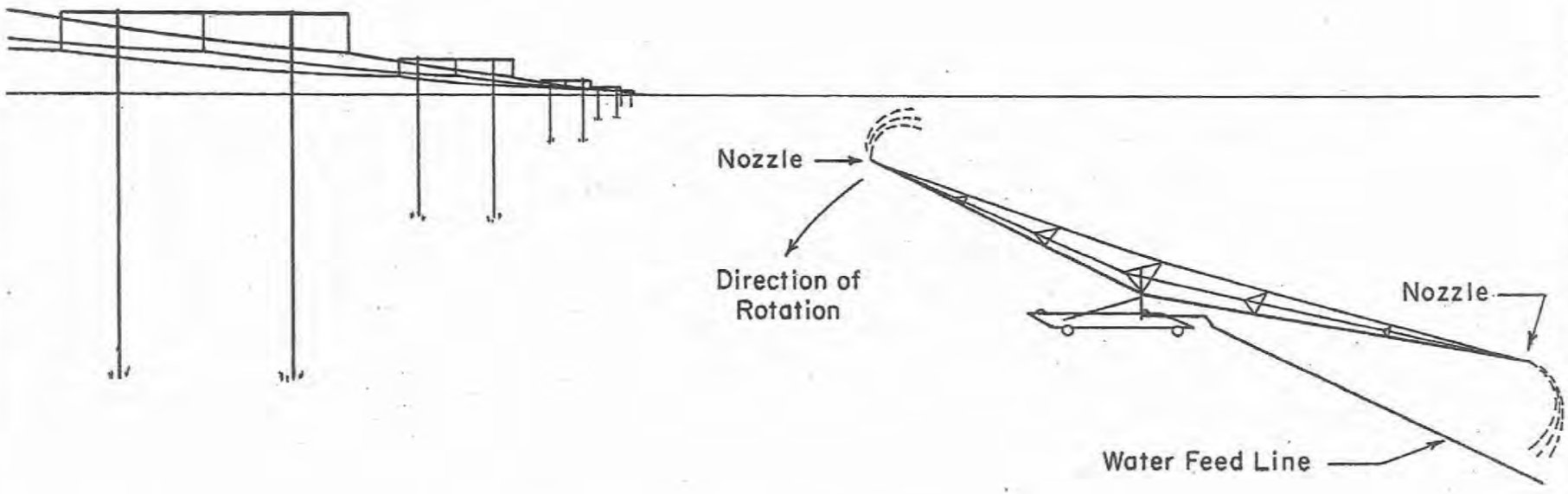


FIGURE 3

VERMEER TYPE IRRIGATION SYSTEM

JC/ERM 10-29-76

TABLE I

RECOMMENDED MINIMUM DISTANCES BETWEEN EQUIPMENT AND TRANSMISSION LINE CONDUCTORS

TRANSMISSION LINE VOLTAGE	DISTANCE BETWEEN CONDUCTOR AND EQUIPMENT	
	FEET	METERS
287 KV AC and below	15	4.6
345 KV AC	16	4.9
500 KV AC	20	6.1
± 400 KV DC	17	5.2
± 500 KV DC	21	6.4

NOTE: NEVER PHYSICALLY MEASURE THESE DISTANCES WITH DEVICES SUCH AS TAPE MEASURES, POLES, ETC.

TABLE II

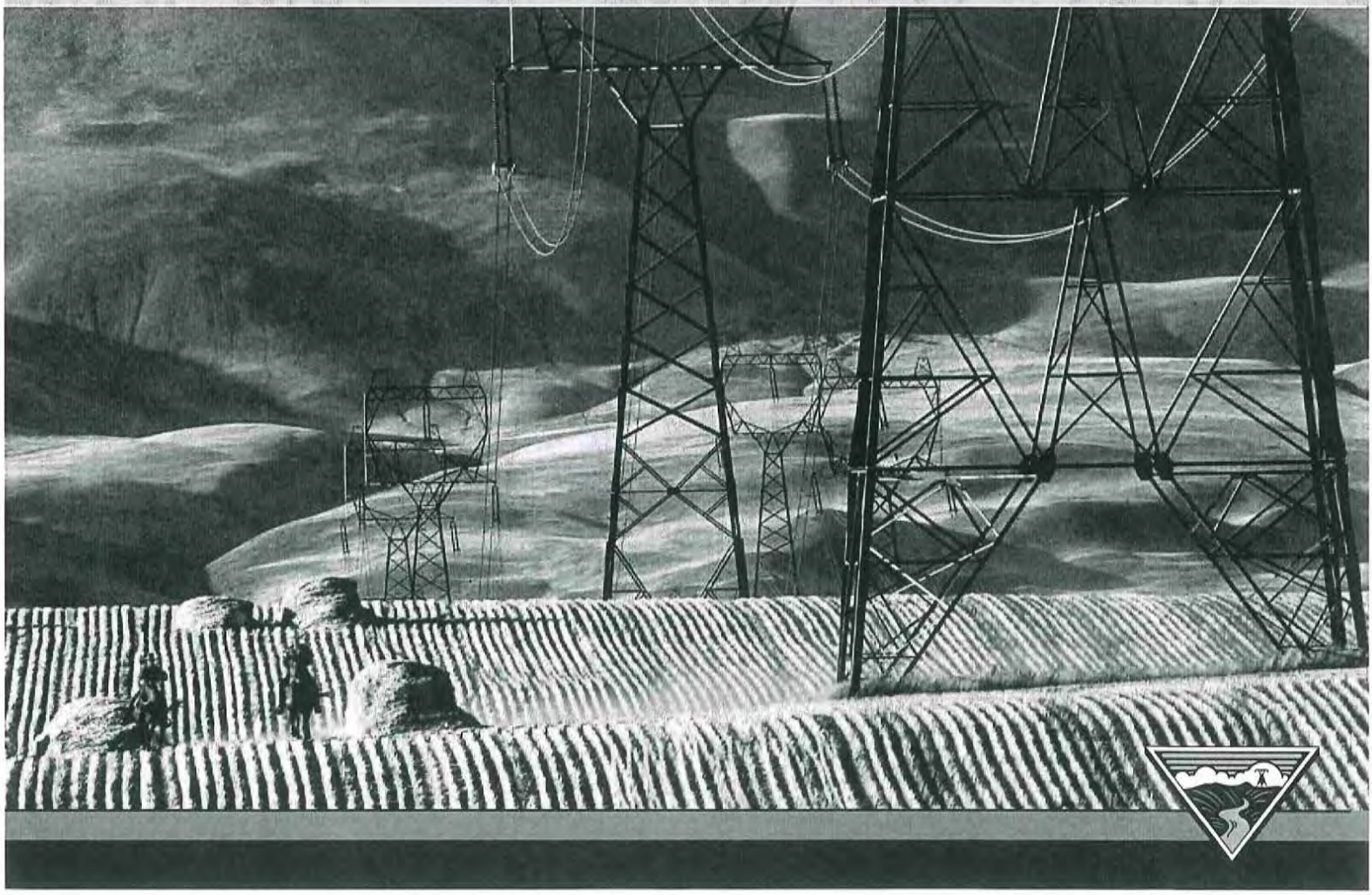
RECOMMENDED MINIMUM DISTANCES BETWEEN HIGH PRESSURE IRRIGATION NOZZLES AND HIGH VOLTAGE TRANSMISSION LINES

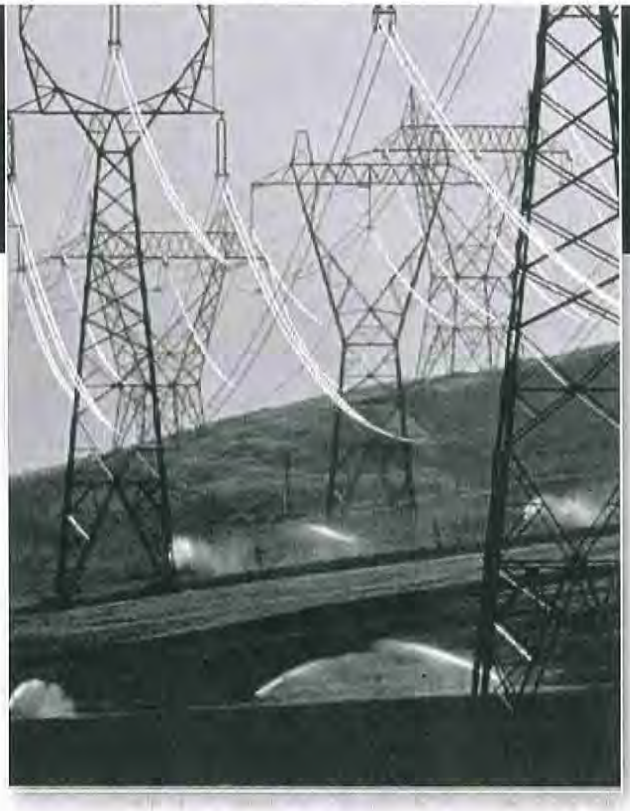
SPRINKLER NOZZLE DIAMETER		HORIZONTAL DISTANCE NOZZLE TO CENTER LINE OF POWER LINE											
		115 KV AC LINE		230 KV AC LINE		345 KV AC LINE		500 KV AC LINE		±400 KV DC LINE		±500 KV DC LINE	
in.	cm.	ft.	m.	ft.	m.	ft.	m.	ft.	m.	ft.	m.	ft.	m.
1/4	0.635	29	8.8	43	13.0	51	15.4	61	18.4	40	12.2	50	15.2
3/8	0.952	37	11.1	51	15.5	63	19.0	73	22.2	42	12.8	54	16.4
1/2	1.270	44	13.1	60	18.1	68	20.5	82	24.8	53	16.1	67	20.3
5/8	1.587	51	15.5	69	20.8	80	24.2	92	27.9	65	19.7	79	24.1
3/4	1.905	53	16.1	73	22.2	87	26.5	106	32.3	80	24.4	100	30.2
7/8	2.222	68	20.7	84	25.6	97	29.6	106	32.3	80	24.4	100	30.2
1	2.540	68	20.7	89	27.1	97	29.6	111	33.8	87	26.4	107	32.5
1 1/8	2.857	84	25.6	104	31.7	118	36.0	132	40.2	110	33.5	136	41.2
1 3/8	3.492	89	27.1	109	33.2	123	37.5	137	41.7	115	35.0	142	43.1
1 5/8	4.127	99	30.2	125	38.1	138	42.1	157	47.8	138	41.9	169	51.5
1 15/16	4.928	124	37.8	150	45.7	164	50.0	182	55.5	166	50.6	204	62.3

BONNEVILLE POWER ADMINISTRATION

LIVING AND WORKING SAFELY

AROUND HIGH-VOLTAGE POWER LINES





High-voltage power lines can be just as safe as the electrical wiring in our homes — or just as dangerous. The key is learning to act safely around them.

This booklet is a basic safety guide for those who live and work around power lines. It deals primarily with nuisance shocks caused by induced voltages and with possible electric shock hazards from contact with high-voltage lines.

In preparing this booklet, the Bonneville Power Administration has drawn on more than 70 years of experience with high-voltage power lines. BPA operates one of the world's largest networks of long-distance, high-voltage lines, ranging from 69,000 volts to 500,000 volts. This system has more than 200 substations and more than 15,000 miles of power lines.

BPA's lines make up the main electrical grid for the Pacific Northwest. The grid delivers large blocks of power to substations located near load centers. Public and investor-owned utilities and rural cooperatives take delivery of the power at these points and deliver it to the ultimate customers.

BPA's lines cross all types of property: residential, agricultural, industrial, commercial and recreational.

If you have questions about safe practices near power lines, call BPA.

Due to safety considerations many of the practices suggested in this booklet are restrictive. This is because they attempt to cover all possible situations, and the worst conditions are assumed. In certain circumstances, the restrictions can be re-evaluated. To determine what practices are applicable to your case, contact BPA at 1-800-836-6619 or find the contact information for the local BPA office at *www.transmission.bpa.gov/LanCom/Real_Property.cfm*.

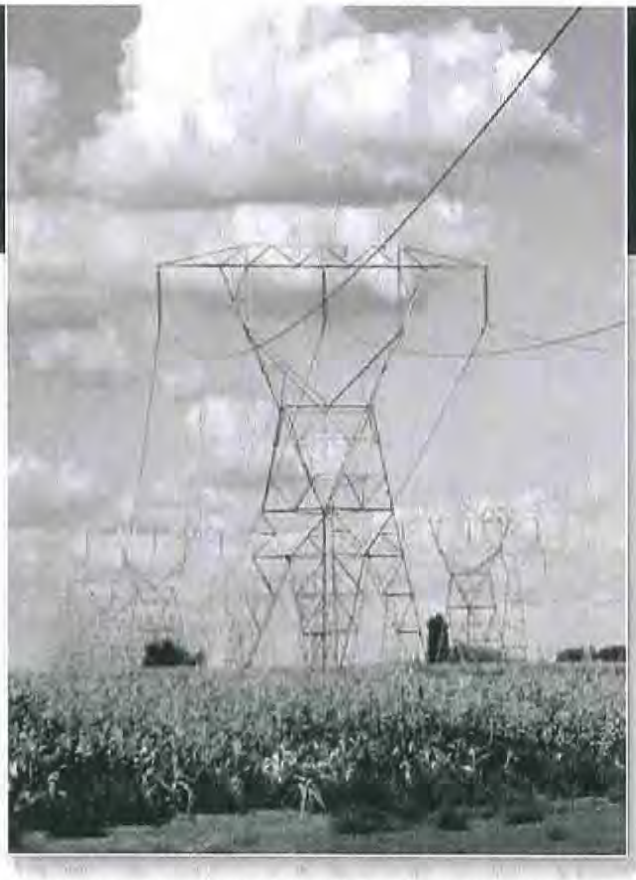
Using the Right-of-Way

Before a power line is built, BPA negotiates with the landowner for the right to cross the land as required for the construction, operation and maintenance of the line. Usually, BPA acquires right-of-way rights to construct, operate and maintain a power line and the right to keep the right-of-way clear of all structures, fire hazards, vegetation and any other use that may interfere with the operation or maintenance of the line. Most crops, less than 10 feet in height, can be grown safely under power lines. Orchards, Christmas trees and structure-supported crops (i.e., trellises) require special consideration.

Call BPA if you plan to use the right-of-way for any use.

BPA's "Landowner's Guide for Compatible Use of BPA Rights-of-Way" explains how to apply for permission to use a portion of a BPA right-of-way for approved purposes. This document can be found online at *www.transmission.bpa.gov/LanCom/Real_Property.cfm* or by contacting BPA at 1-800-836-6619.

Construction and maintenance of any structures are specifically prohibited within a BPA right-of-way. Coordinating with BPA early in your planning process can keep you safe and avoid wasting time and money.



Most crops, less than 10 feet in height, can be grown safely under power lines.

General Safe Practices

BPA designs and maintains its facilities to meet or exceed the rules set forth in the National Electrical Safety Code. BPA provides information on safe practices because serious accidents involving power lines can be avoided if simple precautions are taken. Every kind of electrical installation — from the 110-volt wiring in your home to a 500,000-volt power line — must be treated with respect.

The most significant risk of injury from a power line is the danger of electrical contact. Electrical contact between an object on the ground and an energized wire can occur even though the two do not actually touch. In the case of high-voltage lines, electricity can arc across an air gap. The gap distance varies with the voltage at which the line is

operated. Unlike the wiring in a home, the wires of overhead power lines are not enclosed by electrical insulating material.

The most important safe practice is this:

Avoid bringing yourself, or any object you are holding, too close to an overhead power line.

In other words, do not lift, elevate, build or pass under a power line with any object, equipment, facility or vehicle that could come close to the energized wires.

BPA does not recommend that anyone attempt to calculate how close they can come to a power line. As a general precaution, when under a line, never put yourself or any object any higher than 14 feet above the ground.

The National Electrical Safety Code specifies a minimum safe clearance for each operating voltage. BPA builds its lines so the clearance between the wires of a power line and the ground meets or exceeds the minimum safe clearance set forth in the code. Therefore, do not alter the ground elevation; without first applying to BPA, call 1-800-836-6619 to ensure safe distances are maintained.

Vehicles and large equipment that do not extend more than 14 feet in height, such as harvesting combines, cranes, derricks and booms, can be operated safely under all BPA lines that pass over roads, driveways, parking lots, cultivated fields or grazing lands.

For your safety, coordinate with BPA if you need to exceed the 14-foot limitation.

Possible Shock Hazards

The previous section discussed dangerous electrical contact conditions that can occur when getting too close to the high-voltage wires. This section

Farm equipment or large machinery 14 feet or less in height may be operated safely under all BPA lines in cultivated fields.

will discuss the possible electrical shock hazards that can occur when touching transmission towers or metallic objects near the power line but away from the high-voltage wires.

These types of shocks are caused by a voltage induced from the power line into the nearby metallic objects. Typically the shocks can be avoided when the nearby metallic objects are grounded or connected to earth. The severity of these shocks depends on the operating voltage of the power line, the distance from the conductor, the size or length of the object, its orientation to the line and how well the object is grounded.

Normally, shocks do not occur when BPA's guidance is followed (see the following sections). However, under certain conditions, non-hazardous nuisance shocks can still occur and possibly cause discomfort.

The severity of nuisance shocks can vary in sensation from something similar to a shock you might receive when you cross a carpet and then touch a door knob to touching the spark-plug ignition wires on your lawnmower or car. The nuisance shock, however, would be continuous as long as you are touching the metallic object. Such objects include vehicles, fences, metal buildings or roofs and irrigation systems that are near the line or parallel the line for some distance.

The possibility of nuisance shocks can be eliminated by grounding metal pipe when unloading near BPA lines.

Irrigation Systems

All types of irrigation systems have been operated safely near BPA power lines for years. Nonetheless, caution should be used in storing, handling and installing irrigation pipe, and in operating spray irrigation systems near power lines.

To avoid electrical contact with power lines, two very important safety practices should be observed at all times:

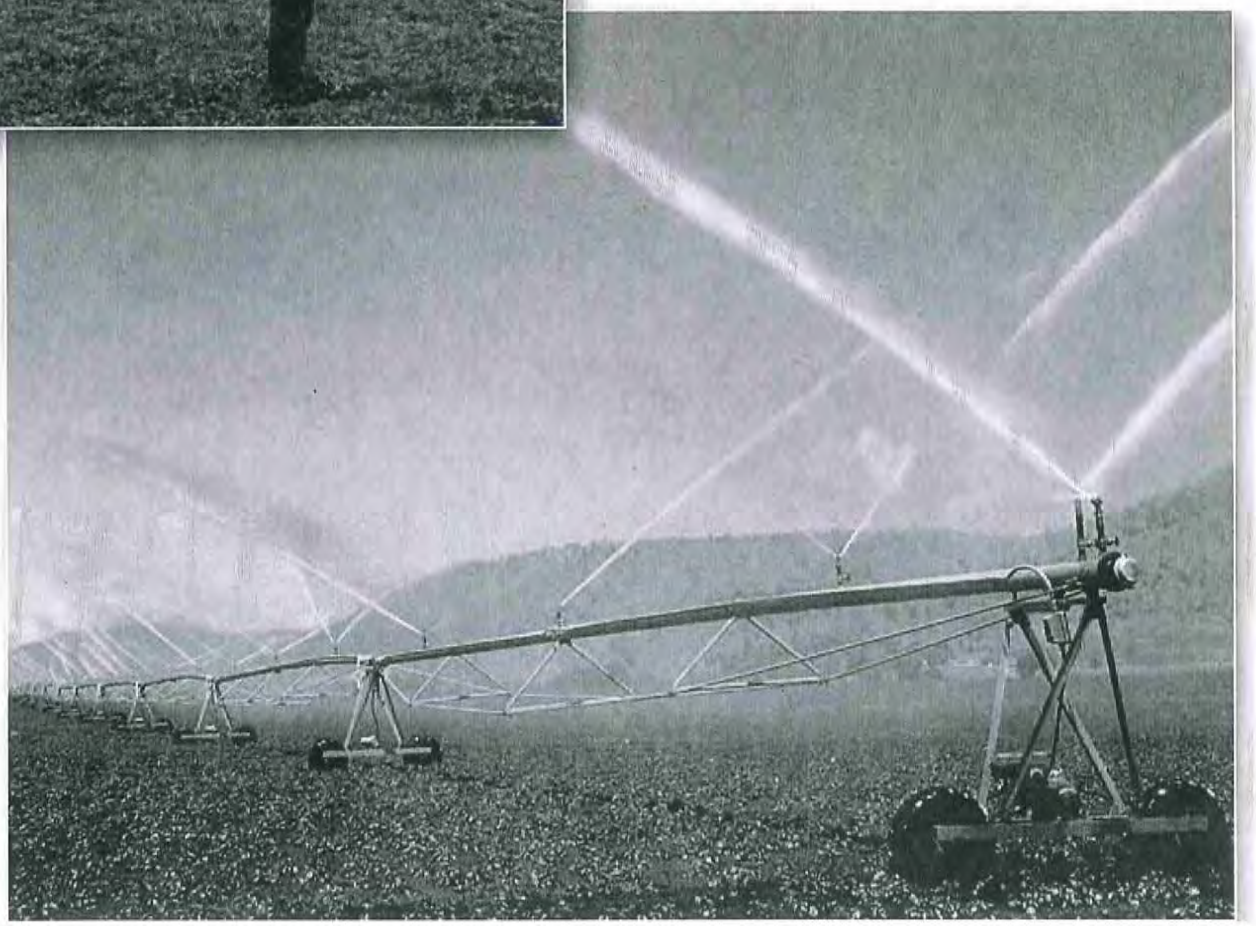
1. While moving irrigation pipe under or near power lines, keep the equipment in a horizontal position to keep it away from overhead wires.
2. Electricity can be conducted through water so never allow the irrigation system to spray a continuous stream onto power lines or towers.

In addition, central pivot circular irrigation systems installed near or under power lines can develop hazardous shock potentials during operation and maintenance. To eliminate these hazards:

- Provide a good electrical ground for the pivot point.
- Do not touch the sprinkler pipe or its supporting structures when the system is operating under or parallel to and near a power line.
- Perform repairs/maintenance of the system with the sprinkler pipe perpendicular to the power line.

For more information on storing, handling, installing or operating an irrigation system on BPA rights-of-way and to apply to use BPA's right-of-way please contact BPA at 1-800-836-6619. A copy of "Guidelines for Installation and Operation of Irrigation Systems" will be provided when you contact BPA for approval. This document describes methods for safely installing and operating an irrigation system under high-voltage power lines. This document also can be obtained at *www.transmission.bpa.gov/LanCom/Real_ Property.cfm.*

Irrigation pipe should be moved in a horizonal position under and near all power lines to keep it away from the lines overhead.



Underground Pipes, Telephone Cables and Electric Cables

Underground pipes and cables may be compatible with power lines provided installation and maintenance are done properly. Pipes and cables should not be installed closer than 50 feet to a BPA tower, any associated guy wires or grounding systems. These grounding systems are long, buried wires that are sometimes attached to the structures and can run up to 300 feet along the right-of-way. These grounding systems are not visible above ground and must be located before installing any underground utilities.

Proper positioning of underground utilities is required to prevent an accident in an extreme case when an unusual condition might cause electricity to arc from the high-voltage wire to the tower and then to ground. This could produce a dangerous voltage on underground piping or cable system. Contact BPA at 1-800-836-6619 to apply before installing any underground utilities within a BPA power line right-of-way.

Fences

BPA strongly discourages locating fences within the right-of-way as they can cause a potential safety hazard and an access problem (particularly in high-density subdivisions). Contact BPA at 1-800-836-6619 if you are interested in submitting an application to place a fence on the right-of-way using the guideline that the location must be a minimum of 50 feet from BPA structures as well as other considerations discussed below.

Wire Fences

Barbed wire and woven wire fences insulated from ground on wood posts can assume an induced voltage when located near power lines. If you are having a shock-related problem, call BPA for an investigation. The fence may need to be grounded if:

- it is located within the right-of-way;
- it parallels the line within 125 feet of the outside wire and is longer than 150 feet; or
- it parallels the line 125 to 250 feet from the outside wire and is longer than 6,000 feet.

These fences should be grounded at each end and every 200 feet with a metal post driven at least 2 feet into the ground. Attach all wire strands of the fence to the metal post. Install the ground-

ing posts at least 50 feet from the nearest transmission tower. If shocks are experienced when contacting a fence or gate, or if you have any questions about the need for grounding, call BPA at 1-800-836-6619.

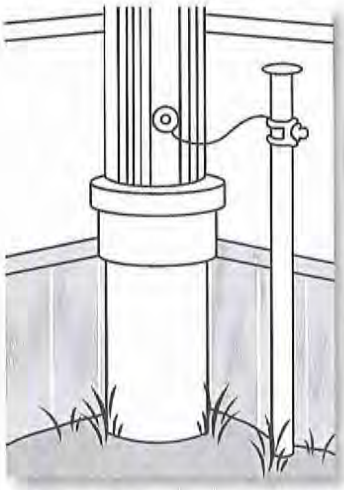
Electric Fences

In situations where a fence cannot be grounded (electric fences, for example), a filter may be installed to remove voltages induced by the power lines. BPA may provide this filter after an investigation has been conducted. Do not use fence chargers that are not approved by Underwriters' Laboratories, Inc. They may carry voltages and currents that are hazardous to anyone touching the fence — even if power lines are not present. For more information about fences, fence chargers or filters, call BPA at 1-800-836-6619.

Buildings

This section applies to buildings outside BPA's rights-of-way, since BPA prohibits buildings within a right-of-way.

Buildings located off BPA's rights-of-way may collect an induced voltage. This voltage is often drained through the building's plumbing, electrical service, metal sheeting or metal frame. If the voltage does not drain through the systems described above, then it can result in a nuisance shock situation.



Example of grounding a metal building at a down spout.

BPA recommends grounding metallic components on buildings near a power line when:

- the building is within 100 feet of the outside wire;
- the building has more than 2,000 square feet of metal surface and is within 100 to 150 feet of the outside wire; or
- the building is used to store flammable materials and is within 250 feet of the outside wire.

BPA will assist in grounding metallic objects after receiving a request and an investigation has been conducted. Call BPA at 1-800-836-6619 if you are having shock-related problems or if you have any question on grounding a building.

Vehicles

Under some high-voltage lines, vehicles can collect an induced voltage. This is particularly true if the vehicle is parked on a nonconductive surface such as asphalt or dry rock. You can drain the voltage from your vehicle to the ground by attaching a chain that reaches the ground or by leaning a metal bar against your vehicle. The only way to be sure you won't get shocked is to park your car away from the high-voltage power line.

BPA has specific restrictions for parking and roads within the right-of-way to keep possible shocks at a low level. Contact BPA at 1-800-836-6619 to apply before locating roads and parking areas within the BPA right-of-way.

Refueling vehicles is not allowed on BPA rights-of-way because there is a chance that a spark from an induced voltage could ignite the fuel.

LIGHTNING

Lightning will usually strike the highest nearby object, which might be a power line tower or wire. Transmission facilities are designed to withstand lightning strikes by channeling them to ground at the tower.

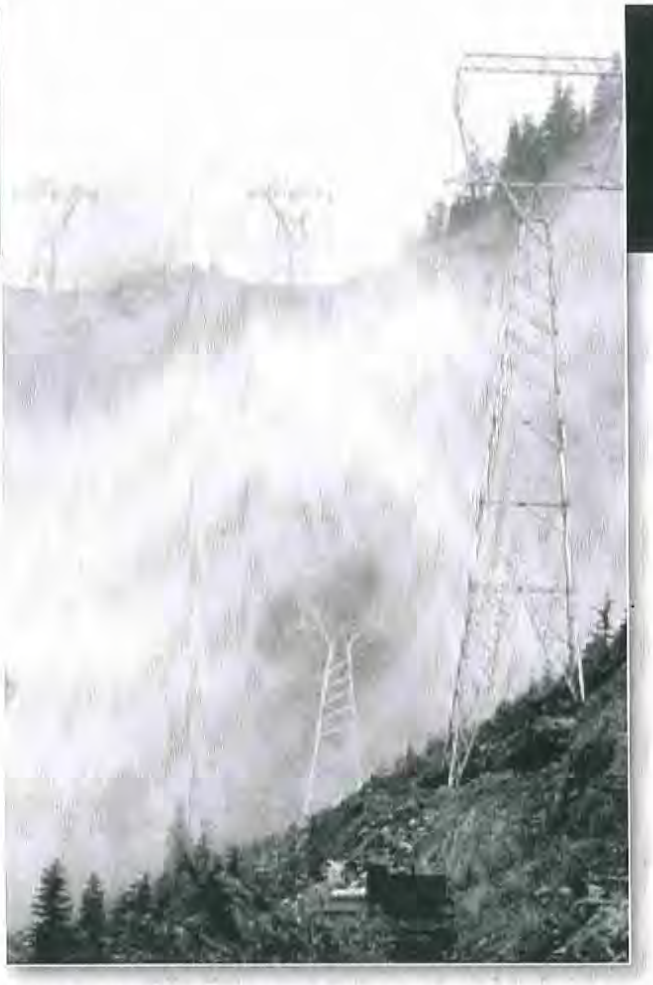
Play it safe. Stay away from power lines and other tall objects during electrical storms. Lightning is dangerous if you are standing near where it enters the ground.

FIRES

Smoke and hot gases from a large fire can create a conductive path for electricity. When a fire is burning under a power line, electricity could arc from the wire, through the smoke and to the ground, endangering people and objects near the arc. BPA does not permit burning within the right-of-way.

Field burning and other large fires in and around power lines can damage power lines and cause power outages. Water and other chemicals used to extinguish those fires should never be directed toward a power line.

Contact BPA at 1-800-836-6619 if you need to burn near a BPA right-of-way.



A fire burning under a power line can create a dangerous situation. Stay away from lines if a fire is nearby.

KITE FLYING AND MODEL AIRPLANES

BPA strongly discourages anyone from flying a kite or model airplane anywhere near a power line. The electricity from the line can travel through the string or hand line and electrocute a person on the other end. If your kite or model airplane is about to touch a power line, drop the string or hand line instantly, before it touches the line. Do not try to pull the kite or airplane down or climb up after it. Call the nearest electric utility.

VANDALISM, SHOOTING AND TRESPASSING

People entering high-voltage electrical facilities, such as substations and power line rights-of-way,

for the purpose of vandalism or theft, run the risk of serious injury or death. For example, when hunting, do not shoot at transmission facilities. Gunshot damage can cause flashovers or may cause the wire to fall to the ground. This could be a serious hazard to anyone close to the power line. It could also cause a power outage and a fire.

Removal of equipment from substations or power line facilities can result in unsafe operating conditions and put people nearby at risk of serious injury or death. Those who cause willful damage to BPA transmission facilities or associated property can be prosecuted by the federal government, the property owner, or both.

Please report damage to transmission facilities to BPA's Crime Witness Program at 1-800-437-2744. The Crime Witness Program allows you to confidentially report an illegal activity that you witness against BPA's transmission system, property or personnel. This includes:

- Shooting at power lines, transmission towers or substation equipment.

- Dumping any waste or material on BPA property.
- Vandalism to BPA property, buildings and vehicles.
- Theft of BPA equipment, supplies, tools or materials.

This program offers rewards of up to $25,000 for information leading to the arrest and conviction of the perpetrator(s).

Tall Objects

Facilities

Temporary or permanent facilities within the right-of-way such as, light standards, signs, above-ground utilities, etc., can create unsafe situations when constructed too close to BPA power lines and structures. Permissable heights for such facilities can vary depending on site specfic conditions. Call BPA at 1-800-836-6619 to apply for these uses.

Activities

As a precautionary practice, do not raise any metal object more than 14 feet in the air underneath a power line. For example, when you mount an antenna on a vehicle that you plan to operate on a BPA right-of-way, do not let it extend more than 14 feet above the ground.

Before you sail a boat on a lake or river, check the allowable clearance under any power line. We recommend that all masts or guy wires above the deck be connected electrically to an underwater metallic part such as the keel or centerboard.

This precaution, which protects against lightning or accidental contact with a power line, may save your life.

Remember, if you plant, dig or build within the right-of-way an application is required. Any activities or use with a reach capacity greater than 14 feet (eg. cranes, dump trucks, irrigation systems, etc.) may cause safety concerns. Please specifically identify these uses and equipment in your application. Contact BPA to apply at 1-800-836-6619.

POOLS

BPA does not permit the building of swimming pools within BPA rights-of-way because it impedes our ability to operate and maintain the power line and presents a potential safety hazard to the public. Hazards range from possible electrical contact with the wires (with pool skimmers or rescue poles, for example) to dangers that can be encountered during and after lightning strikes on transmission facilities.

CLIMBING

Climbing on power line towers or guy wires can be extremely hazardous. Do not do it under any circumstance. It is dangerous and illegal.

PACEMAKERS

Under some circumstances, voltages and currents from power lines and electrical devices can interfere with the operation of some implanted cardiac pacemakers. However, we know of no case where a BPA line has harmed a pacemaker patient.

As a precaution, people who may have reason to be very near high-voltage facilities should consult with a physician to determine whether their particular implant may be susceptible to power line interference.

If a person with a pacemaker is in an electrical environment and the pacemaker begins to produce a regularly spaced pulse that is not related to a normal heartbeat, the person should leave the environment and consult a physician.

Cutting trees within power line rights-of-way can be dangerous. It is safer to have BPA do it for you.

TREES AND LOGGING

No logging or tree cutting should be done within BPA's right-of-way without first contacting BPA at 1-800-836-6619 to apply. In many cases, BPA owns the timber within its rights-of-way.

Additionally, logging or tree cutting near power lines can be very hazardous and requires special caution. Since trees conduct electricity, if one should fall into or close to a power line, the current could follow the tree trunk to the ground and endanger anyone standing near its base. Here are two simple rules:

1. If you come upon a tree that has fallen into a power line, stay away from it.
2. If you accidentally cause a tree to fall into a power line, run for your life! Do not go back to retrieve your saw or equipment. Call BPA or your local utility immediately.

If you have trees either on or close to the right-of-way that need to be cut, contact BPA at 1-800-836-6619. It is unsafe to do it yourself.

Since power line rights-of-way usually are not owned by BPA but are acquired through easements from landowners, trees or logs stacked within or alongside the rights-of-way are not public property. People removing trees and logs without permission are stealing and can be prosecuted.

Explosives

If you plan to detonate explosives near a BPA power line, apply to BPA well in advance by calling 1-800-836-6619 or find the contact information for your local office at *www.transmission.bpa.gov/LanCom/Real_ Property.cfm.* BPA will tell you if any special precautionary measures must be taken at a particular blasting site.

Any blasting near or within BPA rights-of-way must not damage any BPA facilities or permitted uses within the rights-of-way. Do not use electric detonating devices when blasting within 1,000 feet of a power line. Use of non-electric methods of detonation will avoid the danger of accidentally discharging an electric blasting cap due to induced voltages from energized transmission facilities.

Towers and Wires

- Do not climb towers.
- Do not shoot or otherwise damage transmission facilities.
- Never touch a fallen wire.
- Do not attempt to dismantle towers.
- Do not attach anything to towers.
- Stay away from towers and lines during extreme windstorms, thunderstorms, ice storms or under other extreme conditions.

Preventive measures include:

- Report any suspicious activities to BPA at 1-800-437-2744 or to your nearest electrical utility.
- Stay away from and report damage to transmission facilities to BPA at 1-800-437-2744 or your nearest electrical utility.
- Stay away from and report broken, damaged or abnormally low-hanging wires to BPA at 1-800-437-2744 or your nearest electrical utility.

Conclusion

We live in an age of electric power. Almost everything we do requires it. Consequently, high-voltage power lines have become about as commonplace as the wiring in our homes. Nevertheless, every year people are killed or seriously injured by power lines and home wiring. In almost every case, lives could have been saved and injuries avoided if the basic safety practices outlined in this booklet had been followed. BPA and your local utilities make every effort to design and build power lines that are safe to live and work around. Ultimately, however, the safety of high-voltage lines depends on people behaving safely around them. No line can practicably be made safe from a person who, through ignorance or foolishness, violates the basic principles of safety. Please take time now to learn the practices outlined in this booklet and share your knowledge with your family, friends and colleagues. Your own life, or that of a loved one, might well hang in the balance.

Related BPA Publications and Guidelines

For more information, call BPA at 1-800-836-6619 for the following publications:

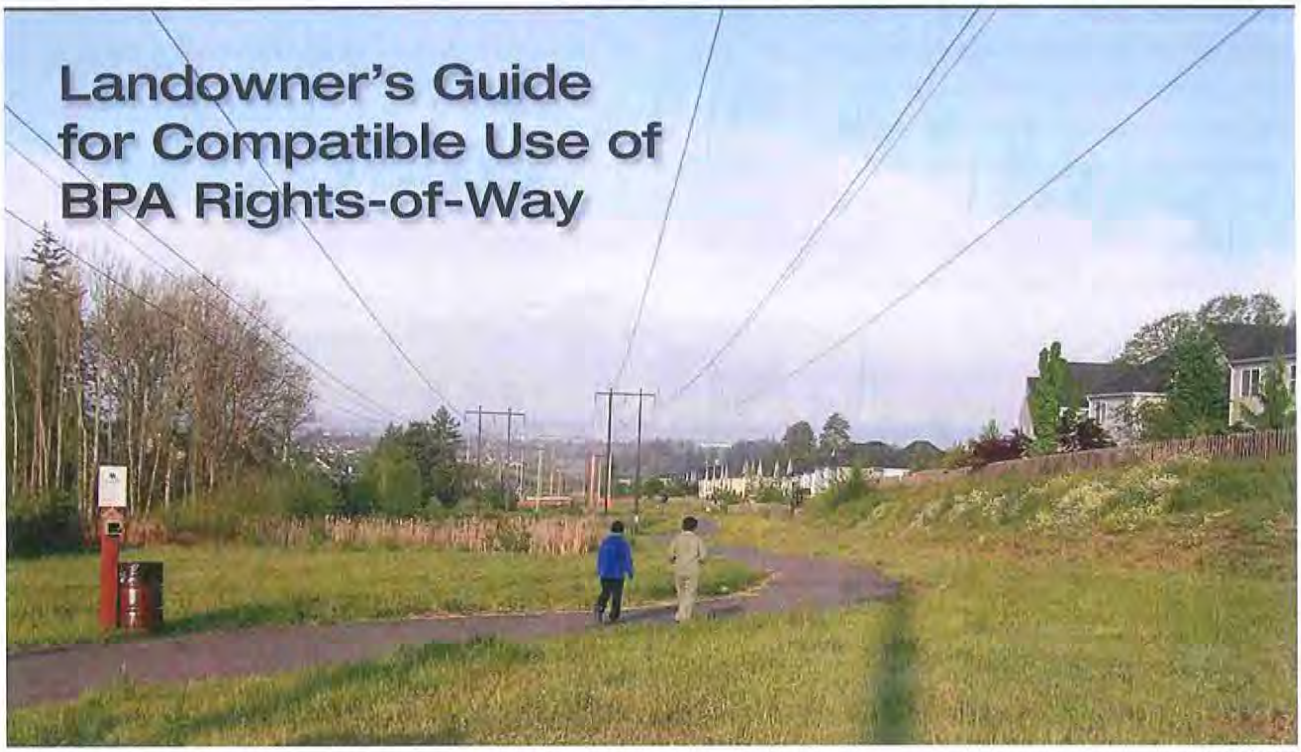
1. **"Landowner's Guide for Compatible Use of BPA Rights-of-Way"** (DOE/BP-3657)
2. **"Landowner's Guide to Trees and Transmission Lines"** (DOE/BP-3076)
3. **"Keeping the Way Clear for Better Service"** (DOE/BP-2816)
4. **"Guidelines for Installation and Operation of Irrigation Systems"**

These documents also can be found at *www.transmission.bpa.gov/LanCom/Real_Property.cfm.*

BONNEVILLE POWER ADMINISTRATION
PO Box 3621 Portland, Oregon 97208-3621

DOE/BP-3804 • October 2007 • 3M

Landowner's Guide for Compatible Use of BPA Rights-of-Way



July 2007

We need your help to keep the way clear for safe and reliable service

Keeping transmission lines safe and reliable is a critical priority for the Bonneville Power Administration. The key element in achieving those objectives is BPA's ability to construct, operate and maintain its transmission lines and rights-of-way — the area under and around the lines.

You can help BPA keep these rights-of-way clear of trees, brush and structures that could affect the safety or reliability of the transmission system.

Prior to planting, digging, or constructing within BPA's rights-of-way, fill out BPA's Land Use Application Form. The information you provide on the application helps BPA understand your proposed use and the potential impacts to public safety, and the safety of our crews. BPA also reviews the application to determine whether a proposed use of land is compatible with the construction, operation and maintenance of BPA transmission lines. Coordinating with BPA early in your planning process can keep you safe and avoid wasting time and money.

Coordination of land uses

BPA's rights-of-way can sometimes be available for other, compatible, uses. BPA wants to help you carry out your plans in ways that are safe and satisfactory for everyone. Therefore, you are encouraged to make prior arrangements with BPA through the Land Use Application process.

BPA takes several factors into consideration when applications for use of the right-of-way are reviewed. Our transmission lines were designed

to take topography, physical features, environmental and cultural constraints into consideration. BPA's land rights as they relate to the location of your proposed use are also reviewed. If your project is not compatible with BPA's transmission lines, you may be asked to modify your design. In extreme cases, BPA may be able to modify its transmission facilities; however, you would be required to pay for the modifications.

Please consider the following guidelines when preparing your application:

- Maintain at least 50 feet of clearance from BPA's poles, structures or guy wires, whether it be vegetation, roads, fences, utilities, pipelines, or any other improvements.
- Maintain at least 30 feet of clearance from the top of any vegetation and the lowest point of BPA's wires. Do not attempt to measure this distance yourself! You only need to identify the species of the vegetation you propose to plant in the right-of-way so that BPA can consider the mature height of the vegetation.
- Design underground utilities to withstand HS-20 loadings (a federal highway standard).
- Design roads, utilities and pipelines to cross BPA's rights-of-way, rather than a long, linear alignment.
- Ensure concurrence of underlying property owner when not BPA.

Who we are

The Bonneville Power Administration is a federal agency headquartered in Portland, Ore., that markets wholesale electricity and transmission services to the Pacific Northwest's public and private utilities as well as to some large industries.

BPA provides about 40 percent of the electricity used in the Northwest and operates more than 15,000 circuit miles of transmission lines. To deliver power, BPA operates and maintains a transmission network throughout Oregon, Washington, Idaho and Montana with small portions into Wyoming, Nevada, Utah and California.

Three important steps

There are three important steps that you can take to keep safe and avoid wasting time and money:

1. Call BPA before you plant, dig or construct: 1-800-836-6619.
2. Fill out BPA's Land Use Application: *www.transmission.bpa.gov/LanCom/Real_Property.cfm.*
3. Obtain a permit from BPA before proceeding with your project.

Location surveys

You are encouraged to have a licensed surveyor determine the location of the BPA easement before beginning any construction activities. Unfortunately, many people inadvertently build structures on BPA easements because they believe they know the boundaries of their property, and believe measuring off the conductor or centerline of the towers is sufficient to fix the location of the easement. Without survey instruments, knowledge of survey law and an understanding of BPA's right-of-ways, it is impossible to accurately locate property boundaries. By having your surveyor coordinate with the BPA Survey Section, we can prevent many of the encroachment problems that BPA experiences (call 1-800-836-6619 and ask to be connected to BPA's Survey Section).

Danger trees

BPA must identify and arrange to cut trees that, although outside the right-of-way, may threaten the transmission line because they could fall into the conductor (wires) or structures. Trees that are unstable, diseased, dead or leaning toward the transmission facilities don't need to touch power lines to be dangerous. Electricity can "arc" or

Never cut or trim a tree near a power line. Call BPA!

"flashover" from wires, through the air, to trees or equipment, where it can cause fires, injuries or even fatalities to anyone near the tree or equipment. BPA will arrange to remove these trees.

Available uses of BPA-owned land

Although BPA acquired most of its transmission line rights-of-way as easements, some of BPA's transmission lines are constructed on property BPA owns in fee. BPA also has fee ownership of most of its substation sites as well as other properties BPA acquired to meet its responsibilities. There are three possible options if you wish to use land that BPA owns in fee. You will need to fill out BPA's Land Use Application so that we can determine whether your proposed use interferes with BPA's use. Easements may be granted for permanent uses such as private road crossings or utilities. Leases may be granted primarily for agricultural purposes on occupied or vacant BPA property. Nontransferrable Land Use Agreements may also be granted for use of BPA's fee owned property. Current market value of the land is the basis for the consideration for these transactions.

Information resources

For more information, including regional realty specialist contacts, or access to BPA's electronic Land Use Application form visit BPA's Web site at: *www.transmission.bpa.gov/LanCom/Real_Property.cfm*

Should you have any questions or would like assistance in completing the application, please call 1-800-836-6619. A BPA realty representative will return your call within two business days.

DOs and DON'Ts

BPA does not permit any use of rights-of-way that are unsafe or might interfere with constructing, operating or maintaining our facilities. These restrictions are part of the legal rights BPA acquires for its rights-of-way. Even when no transmission line has been constructed on the easement area, BPA's rights are maintained for future use. You can avoid or minimize incurring redesign or removal costs and benefit from developing reasonable construction schedules by being aware of the prohibited uses and by applying early in your planning process to BPA for concurrence.

DO call BPA before planting, digging or constructing.

DO check your property and review your property records for transmission right-of-way easements.

DO take the time to plan projects that conform to proper use of the rights-of-way which includes submitting a BPA Land Use Application form for approval.

DO comply with the terms and conditions of the agreement provided by BPA for your safety.

DO consult with BPA when planning subdivisions. Backyards and BPA rights-of-way are not compatible.

DO report criminal or suspicious activities to local authorities and to BPA's federal Crime Witness Hotline at 1-800-437-2744.

DON'T cut or trim a tree near a power line. Call BPA!

DON'T plant, dig or construct in BPA's rights-of-way without first contacting BPA and submit a BPA Land Use Application for approval.

DON'T store equipment, materials, waste, flammable material or anything that would cause a fire hazard or other safety issue or impede access by line crews to towers and lines.

DON'T assume the location of BPA's fee-owned or easement boundaries without first contacting a licensed surveyor and having them coordinate with BPA's surveyors by calling 1-800 836-6619.

Vandalizing BPA property is a crime.

Please report any vandalism or theft to BPA property by calling BPA's 24-hour toll-free hotline at 1-800-437-2744. All information reported through the Crime Witness Program is kept confidential. Cash rewards of up to $25,000 will be paid to those providing information that leads to the arrest and conviction of persons committing the crime.

Bonneville Power Administration
DOE/BP-3657 • July 2007 • Fifth Printing • 3M

Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208-3621

A guide to **agricultural use** of American Transmission Co. rights-of-way

AMERICAN TRANSMISSION COMPANY

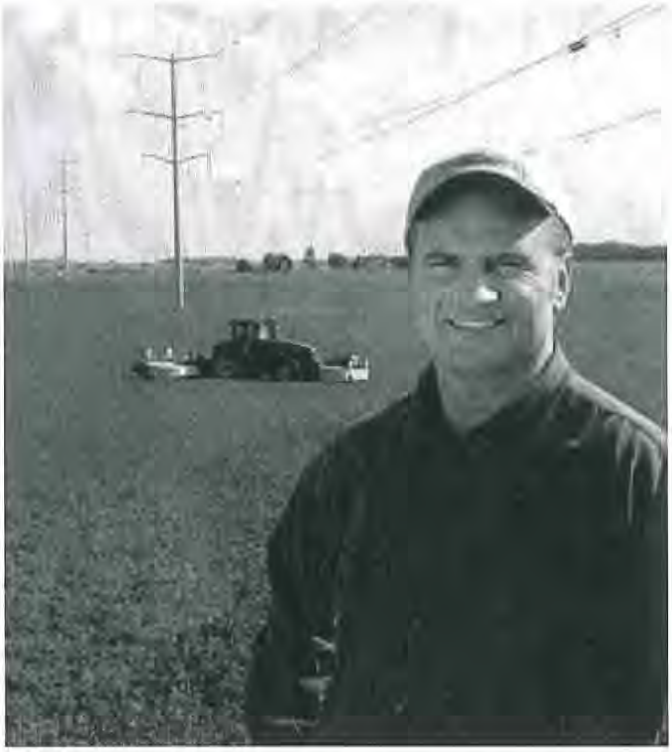
The following information answers some commonly asked questions related to land use around transmission facilities. This information is not exhaustive, and does not cover every scenario. ATC staff have a wealth of experience related to agricultural use of transmission line rights-of-way and the issues that arise, so please contact ATC if you have questions about this material or a related topic.

Fences

As a rule, ATC discourages locating fences within the right-of-way as they can interfere with access to the line and may pose safety hazards. However, the use of fences will not be unreasonably denied. If you need to build a fence in the right-of-way, whether it is wooden, wire or electric, contact ATC prior to designing and constructing the fence. Our staff will help identify an appropriate type of fence for the location and ensure that the design complies with the terms of the easement and ATC policies. The following are a few general guidelines:

- If a fence exists within the easement area prior to a new line being constructed, all or part of it may be removed to allow crews full access to the right-of-way. After construction, fences will be replaced with a fence of equivalent or greater quality.
- Fences in ATC rights-of-way may have height restrictions.
- Fences must be erected a proper distance away from any transmission structure.
- Grounding requirements will be established on a case-by-case basis, but grounding is usually recommended for metal fences without metal posts that are located in or near the right-of-way.
- During maintenance activities, fences that make it difficult or impossible to access ATC facilities for maintenance purposes may be removed to allow access to the transmission line.
- Fences that are planned to span the total easement or right-of-way width must have a gate at least 14 feet wide to allow for linear access to the easement area. A method that allows both property owners and ATC contractors to open the gate without disturbing the other's lock, such as double-locking gate, is recommended. ATC will supply a lock for use in conjunction with the owner's lock at no cost.
- Electric fences located within the right-of-way may require installation of special grounding and/or filtering equipment to counteract potential induced voltages. ATC will install and maintain grounding or filter units for existing electric fences (in place

prior to the transmission line) within the right-of-way. Property owners are responsible for costs associated with the installation and maintenance of the grounds or filter units for new (did not previously exist) electric fences built within ATC rights-of-way. Contact ATC's real estate department if you plan to build an electric fence within the right-of-way, or have concerns about induced voltages related to an existing electric fence.



Irrigation systems and wells

Many types of irrigation systems can be operated safely near ATC transmission lines, including central-pivot and other systems. However, it is important to maintain proper clearances from the transmission wires when installing irrigation systems near ATC facilities.

Water conducts electricity, so it is essential that irrigation systems do not spray a continuous solid stream on transmission wires. Electricity has been known to flow from the wire through the stream of water to the ground, causing outages and endangering people and property nearby. The risk of an electric fault is reduced or eliminated when the solid water stream breaks up and becomes a spray.

Improper irrigation installation may cause shocks. Before installing an irrigation system near an ATC transmission facility, contact ATC to have your plans reviewed. ATC staff will provide valuable information on storing, handling, installing and operating irrigation systems near ATC transmission facilities. Also keep in mind that wells are not permitted in the right-of-way.

www.atcllc.com

Clearances

The Occupational Safety and Health Administration requires various minimum safe working clearances based on transmission line voltage. If you plan to work or operate machinery under ATC transmission lines, contact ATC to verify the voltage of the line and ensure you know the required OSHA clearance. While working near ATC transmission lines, verify that the required clearances are maintained at all times.

The height of the wires above the ground may vary depending on the type of structure and span length of the line on your property. In addition, wires sag with temperature and electric load changes so sufficient clearance may exist one day but may be much less the next. The following are some additional points to consider when working near or under transmission lines:

- When operating machinery that extends vertically, such as sprayers, augers, hay elevators and fertilizer applicators, remember that additional clearance is needed beyond the truck height. Maintain proper clearance from the highest point on your equipment to the transmission line above.
- Use a spotter to keep an eye on how far tall equipment is from the wires.
- Historically, transmission lines were built assuming 14-foot vehicle heights, a standard that complies with electric codes. Grades under transmission lines may change over the years, so to ensure safety please contact ATC to verify clearances.
- Do not store or pile material or equipment within the easement area without prior approval.

Conservation Reserve Program land

Transmission structures can impact the amount of right-of-way acreage eligible for Conservation Reserve Program payments. Landowners whose right-of-way land is part of the program are responsible for contacting the Farm Service Agency to find out if and how ATC's easement may impact their CRP contract. ATC will work with landowners on this topic.

Crops

As a general rule after construction, agricultural crops excluding trees may be grown within transmission line rights-of-way, but must not hinder access to transmission facilities. Tree farms and orchards are prohibited within ATC rights-of-way. Any crops within the right-of-way are at risk of being damaged when crews need to access the line for maintenance or emergency repair purposes. ATC will follow up with landowners to pay for any crop and/or property damage caused by our work.

Electric fields

Electric fields from transmission lines can cause induced voltage and current on insufficiently grounded equipment that is near 345-kilovolt transmission lines. This is more common when larger vehicles and equipment are parked on nonconductive surfaces such as asphalt or dry rock. Induced voltage and current can cause discomfort to people who touch the equipment while standing on the ground, but can be minimized by installing a grounding strap or chain on the equipment, or simply by parking farther away from the line. Also, please avoid refueling vehicles within the easement area.

Fires and field burning

Fire and smoke can be harmful to wires and insulators, and also can cause damage by igniting wood structures or damaging steel structures. Smoke and hot gasses from a fire near a transmission line can create a conductive path for electricity. Burning under the wires has been known to cause an arc from the wire through the smoke to the ground, causing outages and endangering people and property nearby. The smoke and airborne particles can also cause a coating to form on the wires. Under law, the person causing damages to facilities could be held liable for those damages. If you plan to burn near an ATC right-of-way, contact ATC to learn proper burning methods and to inform ATC of when the burn will take place.

GPS and communication equipment

With GPS increasingly being used in the farming industry, there has been speculation about the impact transmission lines may have on effective operation of GPS equipment. Major manufacturers of GPS navigation systems have not found any degradation of the GPS signal as a direct result of transmission lines. In addition, a 2002 study by the Institute of Electronics and Electrical Engineers found that transmission lines are unlikely to degrade GPS signals. GPS receivers rely on a dispersed constellation of at least four satellites, and the study found no loss of satellite signals as a GPS receiver was moved across a transmission line easement.

The Electric Power Research Institute AC Transmission Line Book –200kV and Above, Third Edition states that under some conditions, high-voltage lines may interfere with the Nationwide Differential GPS System, a system which consists of a network of broadcast stations operated by the United States and other governments between 283.5-325 kilohertz.

Transmission lines may interfere with AM receivers, TV receivers, amateur radio receivers, aircraft communications receivers and specialized devices such as radio astronomy antennas. If you experience any interference that you suspect is caused by ATC transmission facilities, please contact ATC.

Livestock
If construction or maintenance activities will interfere with pasturing or livestock areas, ATC will work with livestock owners to temporarily fence livestock out of the right-of-way during construction. Livestock owners are asked not to spread manure in the right-of-way during construction to minimize the potential spread of disease.

In general, ATC discourages the penning of animals beneath our transmission lines. ATC performs multiple flyovers with low-flying helicopters each year to inspect lines for damage and rights-of-way for obstructions. If areas near the transmission lines are fenced for animal confinement purposes, it is possible for animals to be startled and/or injured during helicopter inspections.

Manure pits
Due to the various access, clearance and other issues associated with manure pits, they typically are not permitted within ATC rights-of-way.

Organic farming
ATC applies herbicides with the property owner's written permission to minimize re-growth of trees and woody species within the transmission line right-of-way. Organic farmers or landowners concerned with the use of herbicides may request that herbicidal sprays not be used and vegetation be managed by mechanical methods. Contact ATC to coordinate proper identification of your property as a non-herbicide area or as an organic farm.

Property or crop damage
In most situations, barring emergencies, we notify landowners in advance and provide a description of our work plans, the reason for the work and the time frame. If ATC maintenance or construction activities damage your property, including drain tile, rutting, compaction and crops, ATC will pay you a reasonable amount for damages caused by ATC when the project is complete. The *USDA Custom Rate Guide* is used as a guideline for crop damage payments.

Soil compaction and excavation
During construction, heavy truck traffic may cause soil compaction depending upon soil moisture and axle load. ATC crews frequently use construction mats to minimize soil compaction and limit land damage. As part of restoration, landowners may be reimbursed for subsoiling the right-of-way, if needed, to mitigate soil compaction.

ATC may use concrete footings for the transmission structures, and excavated subsoil is temporarily piled off to the side of the excavation. Excess soils from excavation in upland areas are hauled to an off-site disposal location, unless the landowner requests that the soils remain on the property.

Stray voltage
On-farm stray voltage investigations are performed by the local distribution company. The local utilities and ATC work together on individual investigations to better understand the interactions between both systems where the local transmission line configuration is parallel to the distribution neutral system. If you think stray voltage may be an issue on your property, contact your local electric utility.

Trees and landscaping
Prior to beginning construction or maintenance activities, the easement area is typically cleared of trees and brush to allow access for construction and maintenance equipment. ATC has tree trimming and clearing rights within the easement area, and the right to remove trees outside the easement area that might fall or grow into the transmission lines. Any plantings in the right-of-way that hinder access to the line or do not meet ATC specifications for height and density will be trimmed or removed. ATC retains the right to remove vegetation as needed, and is not obligated to restore or replace it.

Encroachment review request form
Landowners who wish to inquire about safe permitted use of right-of-way easements are asked to contact ATC real estate for information about submitting an Encroachment Request Form. Call 866-899-3204

Who we are
ATC owns and operates the electric transmission system that moves electricity at high voltages over long distances in the region. The transmission system is made up of wires, insulators and structures that support the wires. Our system consists of lattice towers, large steel poles, two-pole wood structures, single wood poles, substation facilities and in some areas, underground transmission lines.

Questions?
Contact ATC's real estate department at 866-899-3204.

ATC service area


AMERICAN TRANSMISSION COMPANY®

Helping to **keep the lights on,** businesses running and communities strong®

P.O. Box 47 ▪ Waukesha, WI 53187-0047 ▪ Toll-free: 866.899.3204 ▪ 262.506.6700

www.atcllc.com

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

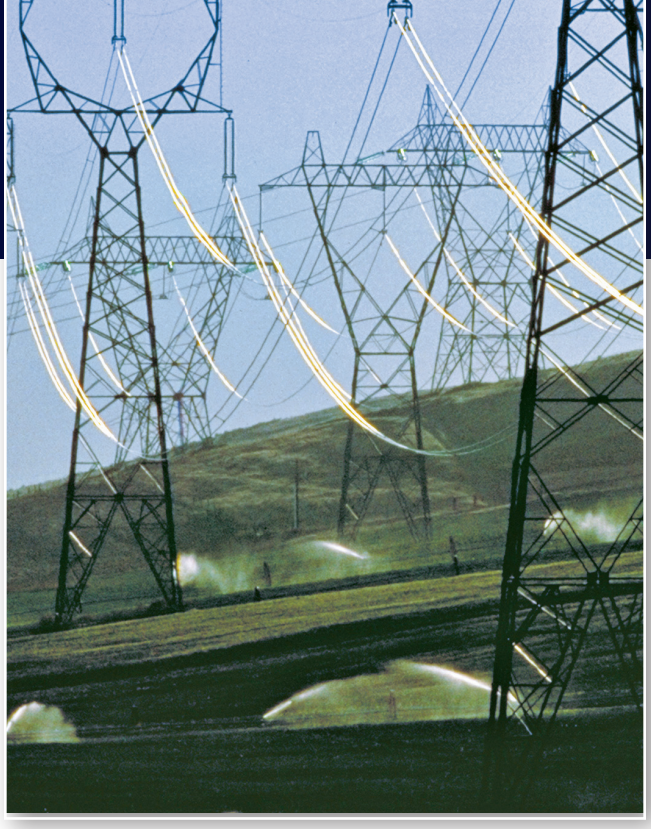
Golder Associates Inc.
9 Monroe Parkway, Suite 270
Lake Oswego, OR 97035 USA
Tel: (503) 607-1820
Fax: (503) 607-1825

Golder Associates

BONNEVILLE POWER ADMINISTRATION

LIVING AND WORKING SAFELY

AROUND HIGH-VOLTAGE POWER LINES



High-voltage power lines can be just as safe as the electrical wiring in our homes — or just as dangerous. The key is learning to act safely around them.

This booklet is a basic safety guide for those who live and work around power lines. It deals primarily with nuisance shocks caused by induced voltages and with possible electric shock hazards from contact with high-voltage lines.

In preparing this booklet, the Bonneville Power Administration has drawn on more than 70 years of experience with high-voltage power lines. BPA operates one of the world's largest networks of long-distance, high-voltage lines, ranging from 69,000 volts to 500,000 volts. This system has more than 200 substations and more than 15,000 miles of power lines.

BPA's lines make up the main electrical grid for the Pacific Northwest. The grid delivers large blocks of power to substations located near load centers. Public and investor-owned utilities and rural cooperatives take delivery of the power at these points and deliver it to the ultimate customers.

BPA's lines cross all types of property: residential, agricultural, industrial, commercial and recreational.

If you have questions about safe practices near power lines, call BPA.

Due to safety considerations many of the practices suggested in this booklet are restrictive. This is because they attempt to cover all possible situations, and the worst conditions are assumed. In certain circumstances, the restrictions can be re-evaluated. To determine what practices are applicable to your case, contact BPA at 1-800-836-6619 or find the contact information for the local BPA office at *www.transmission.bpa.gov/LanCom/Real_Property.cfm*.

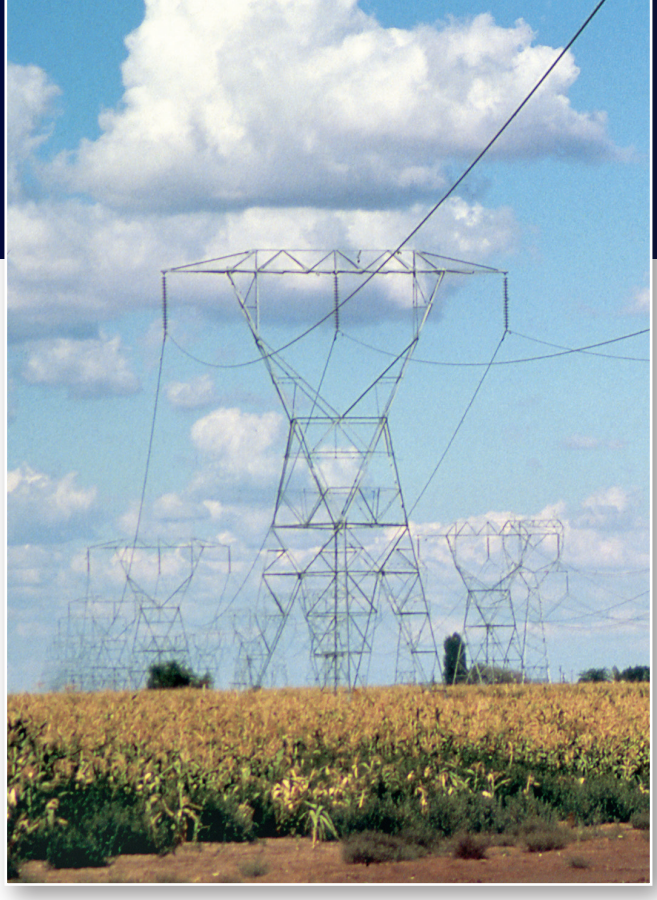
Using the Right-of-Way

Before a power line is built, BPA negotiates with the landowner for the right to cross the land as required for the construction, operation and maintenance of the line. Usually, BPA acquires right-of-way rights to construct, operate and maintain a power line and the right to keep the right-of-way clear of all structures, fire hazards, vegetation and any other use that may interfere with the operation or maintenance of the line. Most crops, less than 10 feet in height, can be grown safely under power lines. Orchards, Christmas trees and structure-supported crops (i.e., trellises) require special consideration.

Call BPA if you plan to use the right-of-way for any use.

BPA's "Landowner's Guide for Compatible Use of BPA Rights-of-Way" explains how to apply for permission to use a portion of a BPA right-of-way for approved purposes. This document can be found online at *www.transmission.bpa.gov/LanCom/Real_ Property.cfm* or by contacting BPA at 1-800-836-6619.

Construction and maintenance of any structures are specifically prohibited within a BPA right-of-way. Coordinating with BPA early in your planning process can keep you safe and avoid wasting time and money.



Most crops, less than 10 feet in height, can be grown safely under power lines.

General Safe Practices

BPA designs and maintains its facilities to meet or exceed the rules set forth in the National Electrical Safety Code. BPA provides information on safe practices because serious accidents involving power lines can be avoided if simple precautions are taken. Every kind of electrical installation — from the 110-volt wiring in your home to a 500,000-volt power line — must be treated with respect.

The most significant risk of injury from a power line is the danger of electrical contact. Electrical contact between an object on the ground and an energized wire can occur even though the two do not actually touch. In the case of high-voltage lines, electricity can arc across an air gap. The gap distance varies with the voltage at which the line is

operated. Unlike the wiring in a home, the wires of overhead power lines are not enclosed by electrical insulating material.

The most important safe practice is this:

Avoid bringing yourself, or any object you are holding, too close to an overhead power line.

In other words, do not lift, elevate, build or pass under a power line with any object, equipment, facility or vehicle that could come close to the energized wires.

BPA does not recommend that anyone attempt to calculate how close they can come to a power line. As a general precaution, when under a line, never put yourself or any object any higher than 14 feet above the ground.

The National Electrical Safety Code specifies a minimum safe clearance for each operating voltage. BPA builds its lines so the clearance between the wires of a power line and the ground meets or exceeds the minimum safe clearance set forth in the code. Therefore, do not alter the ground elevation; without first applying to BPA, call 1-800-836-6619 to ensure safe distances are maintained.

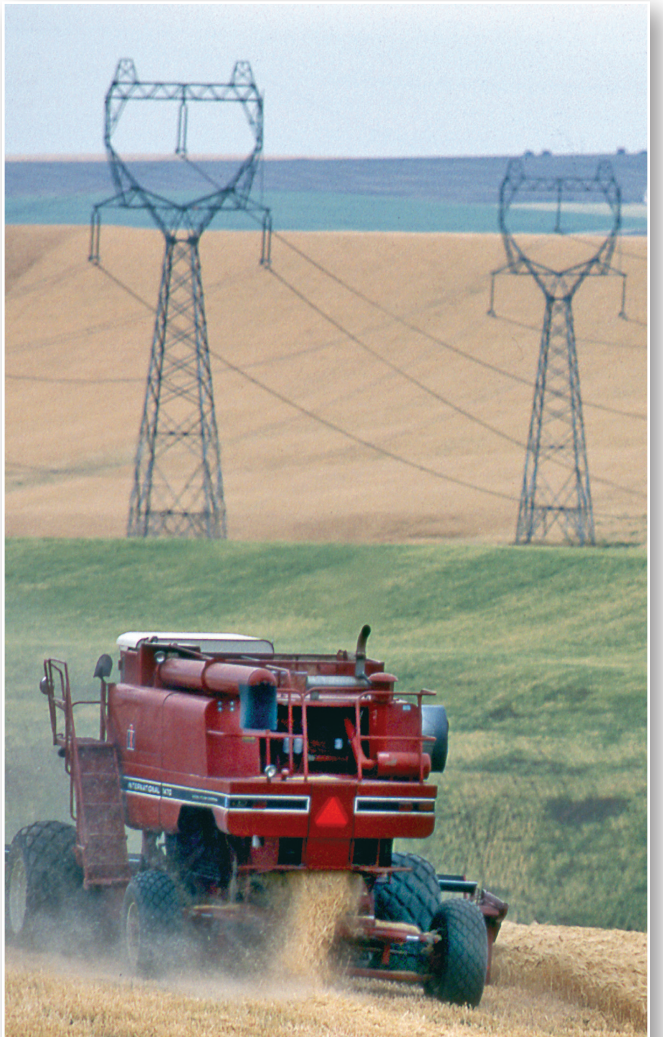
Vehicles and large equipment that do not extend more than 14 feet in height, such as harvesting combines, cranes, derricks and booms, can be operated safely under all BPA lines that pass over roads, driveways, parking lots, cultivated fields or grazing lands.

For your safety, coordinate with BPA if you need to exceed the 14-foot limitation.

Possible Shock Hazards

The previous section discussed dangerous electrical contact conditions that can occur when getting too close to the high-voltage wires. This section

Farm equipment or large machinery 14 feet or less in height may be operated safely under all BPA lines in cultivated fields.



will discuss the possible electrical shock hazards that can occur when touching transmission towers or metallic objects near the power line but away from the high-voltage wires.

These types of shocks are caused by a voltage induced from the power line into the nearby metallic objects. Typically the shocks can be avoided when the nearby metallic objects are grounded or connected to earth. The severity of these shocks depends on the operating voltage of the power line, the distance from the conductor, the size or length of the object, its orientation to the line and how well the object is grounded.

Normally, shocks do not occur when BPA's guidance is followed (see the following sections). However, under certain conditions, non-hazardous nuisance shocks can still occur and possibly cause discomfort.

The severity of nuisance shocks can vary in sensation from something similar to a shock you might receive when you cross a carpet and then touch a door knob to touching the spark-plug ignition wires on your lawnmower or car. The nuisance shock, however, would be continuous as long as you are touching the metallic object. Such objects include vehicles, fences, metal buildings or roofs and irrigation systems that are near the line or parallel the line for some distance.

The possibility of nuisance shocks can be eliminated by grounding metal pipe when unloading near BPA lines.

Irrigation Systems

All types of irrigation systems have been operated safely near BPA power lines for years. Nonetheless, caution should be used in storing, handling and installing irrigation pipe, and in operating spray irrigation systems near power lines.

To avoid electrical contact with power lines, two very important safety practices should be observed at all times:

1. While moving irrigation pipe under or near power lines, keep the equipment in a horizontal position to keep it away from overhead wires.

2. Electricity can be conducted through water so never allow the irrigation system to spray a continuous stream onto power lines or towers.

In addition, central pivot circular irrigation systems installed near or under power lines can develop hazardous shock potentials during operation and maintenance. To eliminate these hazards:

- Provide a good electrical ground for the pivot point.
- Do not touch the sprinkler pipe or its supporting structures when the system is operating under or parallel to and near a power line.
- Perform repairs/maintenance of the system with the sprinkler pipe perpendicular to the power line.

For more information on storing, handling, installing or operating an irrigation system on BPA rights-of-way and to apply to use BPA's right-of-way please contact BPA at 1-800-836-6619. A copy of "Guidelines for Installation and Operation of Irrigation Systems" will be provided when you contact BPA for approval. This document describes methods for safely installing and operating an irrigation system under high-voltage power lines. This document also can be obtained at *www.transmission.bpa.gov/LanCom/Real_ Property.cfm.*

Irrigation pipe should be moved in a horizonal position under and near all power lines to keep it away from the lines overhead.

Underground Pipes, Telephone Cables and Electric Cables

Underground pipes and cables may be compatible with power lines provided installation and maintenance are done properly. Pipes and cables should not be installed closer than 50 feet to a BPA tower, any associated guy wires or grounding systems. These grounding systems are long, buried wires that are sometimes attached to the structures and can run up to 300 feet along the right-of-way. These grounding systems are not visible above ground and must be located before installing any underground utilities.

Proper positioning of underground utilities is required to prevent an accident in an extreme case when an unusual condition might cause electricity to arc from the high-voltage wire to the tower and then to ground. This could produce a dangerous voltage on underground piping or cable system. Contact BPA at 1-800-836-6619 to apply before installing any underground utilities within a BPA power line right-of-way.

Fences

BPA strongly discourages locating fences within the right-of-way as they can cause a potential safety hazard and an access problem (particularly in high-density subdivisions). Contact BPA at 1-800-836-6619 if you are interested in submitting an application to place a fence on the right-of-way using the guideline that the location must be a minimum of 50 feet from BPA structures as well as other considerations discussed below.

Wire Fences

Barbed wire and woven wire fences insulated from ground on wood posts can assume an induced voltage when located near power lines. If you are having a shock-related problem, call BPA for an investigation. The fence may need to be grounded if:

- it is located within the right-of-way;
- it parallels the line within 125 feet of the outside wire and is longer than 150 feet; or
- it parallels the line 125 to 250 feet from the outside wire and is longer than 6,000 feet.

These fences should be grounded at each end and every 200 feet with a metal post driven at least 2 feet into the ground. Attach all wire strands of the fence to the metal post. Install the ground-

ing posts at least 50 feet from the nearest transmission tower. If shocks are experienced when contacting a fence or gate, or if you have any questions about the need for grounding, call BPA at 1-800-836-6619.

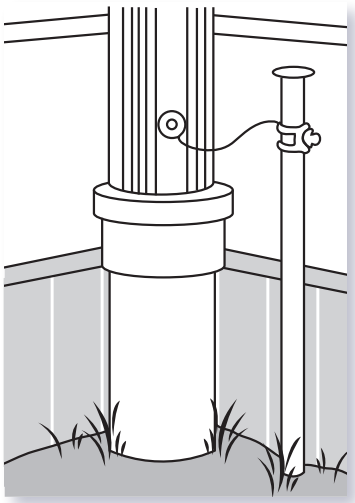
Electric Fences

In situations where a fence cannot be grounded (electric fences, for example), a filter may be installed to remove voltages induced by the power lines. BPA may provide this filter after an investigation has been conducted. Do not use fence chargers that are not approved by Underwriters' Laboratories, Inc. They may carry voltages and currents that are hazardous to anyone touching the fence — even if power lines are not present. For more information about fences, fence chargers or filters, call BPA at 1-800-836-6619.

Buildings

This section applies to buildings outside BPA's rights-of-way, since BPA prohibits buildings within a right-of-way.

Buildings located off BPA's rights-of-way may collect an induced voltage. This voltage is often drained through the building's plumbing, electrical service, metal sheeting or metal frame. If the voltage does not drain through the systems described above, then it can result in a nuisance shock situation.



Example of grounding a metal building at a down spout.

BPA recommends grounding metallic components on buildings near a power line when:

- the building is within 100 feet of the outside wire;
- the building has more than 2,000 square feet of metal surface and is within 100 to 150 feet of the outside wire; or
- the building is used to store flammable materials and is within 250 feet of the outside wire.

BPA will assist in grounding metallic objects after receiving a request and an investigation has been conducted. Call BPA at 1-800-836-6619 if you are having shock-related problems or if you have any question on grounding a building.

Vehicles

Under some high-voltage lines, vehicles can collect an induced voltage. This is particularly true if the vehicle is parked on a nonconductive surface such as asphalt or dry rock. You can drain the voltage from your vehicle to the ground by attaching a chain that reaches the ground or by leaning a metal bar against your vehicle. The only way to be sure you won't get shocked is to park your car away from the high-voltage power line.

BPA has specific restrictions for parking and roads within the right-of-way to keep possible shocks at a low level. Contact BPA at 1-800-836-6619 to apply before locating roads and parking areas within the BPA right-of-way.

Refueling vehicles is not allowed on BPA rights-of-way because there is a chance that a spark from an induced voltage could ignite the fuel.

Lightning

Lightning will usually strike the highest nearby object, which might be a power line tower or wire. Transmission facilities are designed to withstand lightning strikes by channeling them to ground at the tower.

Play it safe. Stay away from power lines and other tall objects during electrical storms. Lightning is dangerous if you are standing near where it enters the ground.

Fires

Smoke and hot gases from a large fire can create a conductive path for electricity. When a fire is burning under a power line, electricity could arc from the wire, through the smoke and to the ground, endangering people and objects near the arc. BPA does not permit burning within the right-of-way.

Field burning and other large fires in and around power lines can damage power lines and cause power outages. Water and other chemicals used to extinguish those fires should never be directed toward a power line.

Contact BPA at 1-800-836-6619 if you need to burn near a BPA right-of-way.

A fire burning under a power line can create a dangerous situation. Stay away from lines if a fire is nearby.

Kite Flying and Model Airplanes

BPA strongly discourages anyone from flying a kite or model airplane anywhere near a power line. The electricity from the line can travel through the string or hand line and electrocute a person on the other end. If your kite or model airplane is about to touch a power line, drop the string or hand line instantly, before it touches the line. Do not try to pull the kite or airplane down or climb up after it. Call the nearest electric utility.

Vandalism, Shooting and Trespassing

People entering high-voltage electrical facilities, such as substations and power line rights-of-way,

for the purpose of vandalism or theft, run the risk of serious injury or death. For example, when hunting, do not shoot at transmission facilities. Gunshot damage can cause flashovers or may cause the wire to fall to the ground. This could be a serious hazard to anyone close to the power line. It could also cause a power outage and a fire.

Removal of equipment from substations or power line facilities can result in unsafe operating conditions and put people nearby at risk of serious injury or death. Those who cause willful damage to BPA transmission facilities or associated property can be prosecuted by the federal government, the property owner, or both.

Please report damage to transmission facilities to BPA's Crime Witness Program at 1-800-437-2744. The Crime Witness Program allows you to confidentially report an illegal activity that you witness against BPA's transmission system, property or personnel. This includes:

- Shooting at power lines, transmission towers or substation equipment.

- Dumping any waste or material on BPA property.
- Vandalism to BPA property, buildings and vehicles.
- Theft of BPA equipment, supplies, tools or materials.

This program offers rewards of up to $25,000 for information leading to the arrest and conviction of the perpetrator(s).

Tall Objects

Facilities

Temporary or permanent facilities within the right-of-way such as, light standards, signs, above-ground utilities, etc., can create unsafe situations when constructed too close to BPA power lines and structures. Permissable heights for such facilities can vary depending on site specfic conditions. Call BPA at 1-800-836-6619 to apply for these uses.

Activities

As a precautionary practice, do not raise any metal object more than 14 feet in the air underneath a power line. For example, when you mount an antenna on a vehicle that you plan to operate on a BPA right-of-way, do not let it extend more than 14 feet above the ground.

Before you sail a boat on a lake or river, check the allowable clearance under any power line. We recommend that all masts or guy wires above the deck be connected electrically to an underwater metallic part such as the keel or centerboard.

This precaution, which protects against lightning or accidental contact with a power line, may save your life.

Remember, if you plant, dig or build within the right-of-way an application is required. Any activities or use with a reach capacity greater than 14 feet (eg. cranes, dump trucks, irrigation systems, etc.) may cause safety concerns. Please specifically identify these uses and equipment in your application. Contact BPA to apply at 1-800-836-6619.

Pools

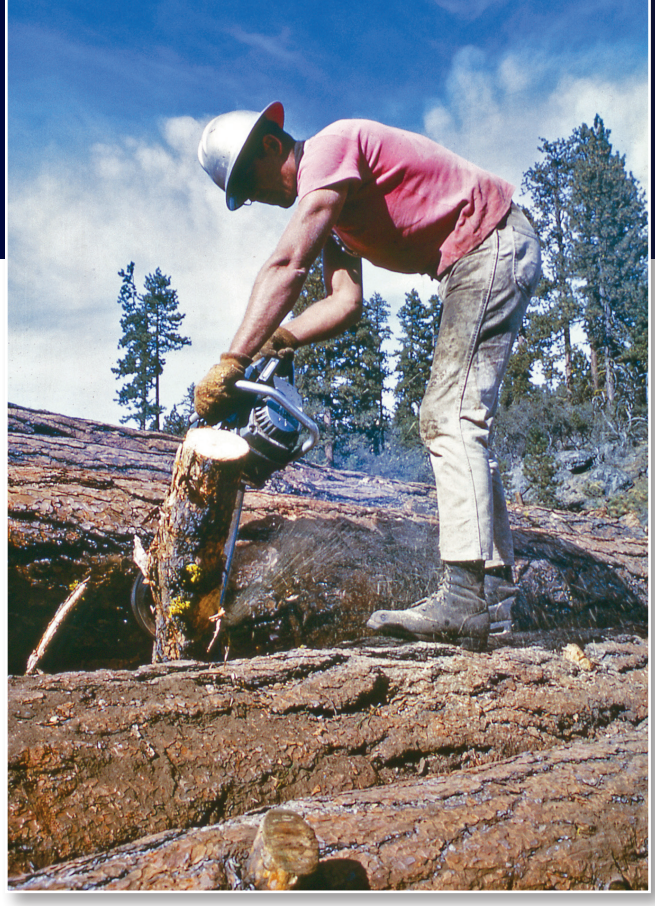
BPA does not permit the building of swimming pools within BPA rights-of-way because it impedes our ability to operate and maintain the power line and presents a potential safety hazard to the public. Hazards range from possible electrical contact with the wires (with pool skimmers or rescue poles, for example) to dangers that can be encountered during and after lightning strikes on transmission facilities.

Climbing

Climbing on power line towers or guy wires can be extremely hazardous. Do not do it under any circumstance. It is dangerous and illegal.

Pacemakers

Under some circumstances, voltages and currents from power lines and electrical devices can interfere with the operation of some implanted cardiac pacemakers. However, we know of no case where a BPA line has harmed a pacemaker patient.



Cutting trees within power line rights-of-way can be dangerous. It is safer to have BPA do it for you.

As a precaution, people who may have reason to be very near high-voltage facilities should consult with a physician to determine whether their particular implant may be susceptible to power line interference.

If a person with a pacemaker is in an electrical environment and the pacemaker begins to produce a regularly spaced pulse that is not related to a normal heartbeat, the person should leave the environment and consult a physician.

Trees and Logging

No logging or tree cutting should be done within BPA's right-of-way without first contacting BPA at 1-800-836-6619 to apply. In many cases, BPA owns the timber within its rights-of-way.

Additionally, logging or tree cutting near power lines can be very hazardous and requires special caution. Since trees conduct electricity, if one should fall into or close to a power line, the current could follow the tree trunk to the ground and endanger anyone standing near its base. Here are two simple rules:

1. If you come upon a tree that has fallen into a power line, stay away from it.
2. If you accidentally cause a tree to fall into a power line, run for your life! Do not go back to retrieve your saw or equipment. Call BPA or your local utility immediately.

If you have trees either on or close to the right-of-way that need to be cut, contact BPA at 1-800-836-6619. It is unsafe to do it yourself.

Since power line rights-of-way usually are not owned by BPA but are acquired through easements from landowners, trees or logs stacked within or alongside the rights-of-way are not public property. People removing trees and logs without permission are stealing and can be prosecuted.

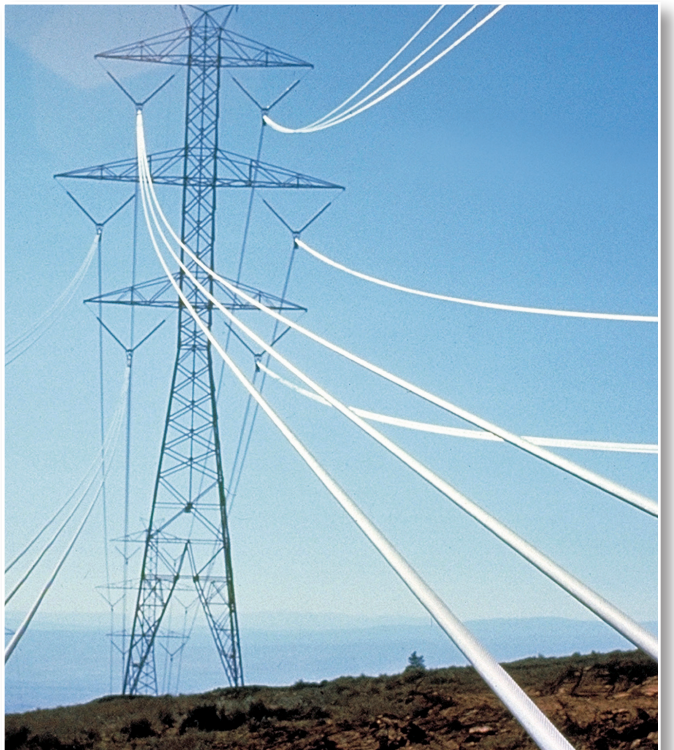
Explosives

If you plan to detonate explosives near a BPA power line, apply to BPA well in advance by calling 1-800-836-6619 or find the contact information for your local office at *www.transmission.bpa.gov/LanCom/Real_ Property.cfm.* BPA will tell you if any special precautionary measures must be taken at a particular blasting site.

Any blasting near or within BPA rights-of-way must not damage any BPA facilities or permitted uses within the rights-of-way. Do not use electric detonating devices when blasting within 1,000 feet of a power line. Use of non-electric methods of detonation will avoid the danger of accidentally discharging an electric blasting cap due to induced voltages from energized transmission facilities.

Towers and Wires

- Do not climb towers.
- Do not shoot or otherwise damage transmission facilities.
- Never touch a fallen wire.
- Do not attempt to dismantle towers.
- Do not attach anything to towers.
- Stay away from towers and lines during extreme windstorms, thunderstorms, ice storms or under other extreme conditions.



Preventive measures include:

- Report any suspicious activities to BPA at 1-800-437-2744 or to your nearest electrical utility.
- Stay away from and report damage to transmission facilities to BPA at 1-800-437-2744 or your nearest electrical utility.
- Stay away from and report broken, damaged or abnormally low-hanging wires to BPA at 1-800-437-2744 or your nearest electrical utility.

Conclusion

We live in an age of electric power. Almost everything we do requires it. Consequently, high-voltage power lines have become about as commonplace as the wiring in our homes. Nevertheless, every year people are killed or seriously injured by power lines and home wiring. In almost every case, lives could have been saved and injuries avoided if the basic safety practices outlined in this booklet had been followed. BPA and your local utilities make every effort to design and build power lines that are safe to live and work around. Ultimately, however, the safety of high-voltage lines depends on people behaving safely around them. No line can practicably be made safe from a person who, through ignorance or foolishness, violates the basic principles of safety. Please take time now to learn the practices outlined in this booklet and share your knowledge with your family, friends and colleagues. Your own life, or that of a loved one, might well hang in the balance.

Related BPA Publications and Guidelines

For more information, call BPA at 1-800-836-6619 for the following publications:

1. **"Landowner's Guide for Compatible Use of BPA Rights-of-Way"** (DOE/BP-3657)
2. **"Landowner's Guide to Trees and Transmission Lines"** (DOE/BP-3076)
3. **"Keeping the Way Clear for Better Service"** (DOE/BP-2816)
4. **"Guidelines for Installation and Operation of Irrigation Systems"**

These documents also can be found at *www.transmission.bpa.gov/LanCom/Real_Property.cfm.*

BONNEVILLE POWER ADMINISTRATION
PO Box 3621 Portland, Oregon 97208-3621

DOE/BP–3804 • October 2007 • 3M