providing additional attenuation when corona noise is present. In addition, ambient noise levels can be high during such periods (due to rain hitting foliage or buildings), and can mask corona noise.

The 49-dBA level for the proposed line would meet the BPA design criterion and, hence, the Washington Administrative Code limits for transmission lines.

The computed annual L_{dn} level for transmission lines operating in areas with about 15% foul weather is about $L_{dn} = L_{50}$ - 1 dBA (Bracken, 1987). Therefore, assuming such conditions in the area of the proposed Grand Coulee – Bell 500-kV line, the estimated L_{dn} at the edge of the right-of-way would be approximately 42 to 50 dBA, which is below the EPA L_{dn} guideline of 55 dBA.

7.5 Conclusion

Along the proposed line route where no parallel lines are present, there would be increases in the perceived noise above ambient levels during foul weather at the edges of the right-of-way. Where the proposed line parallels an existing 500-kV line (Configuration 1), the incremental noise contributed by the proposed line would be less than 5 dBA at the edge of the proposed new right-of-way and beyond, and would barely be discernible from existing noise levels. Where the proposed line is located in the center of the existing Grand Coulee – Bell multi-line corridor, changes in AN at the edges of the right-of-way would be perceived as a doubling or less of the existing sound levels.

The corona-generated noise during foul weather would be masked to some extent by naturally occurring sounds such as wind and rain on foliage. During fair weather, the noise off the right-of-way from the proposed line would probably not be detectable above ambient levels. The noise levels from the proposed line would be below levels identified as causing interference with speech or sleep. The audible noise from the transmission line would be below EPA guideline levels and would meet the BPA design criterion that complies with the Washington state noise regulations.

8.0 Electromagnetic Interference

8.1 Basic Concepts

Corona on transmission-line conductors can also generate electromagnetic noise in the frequency bands used for radio and television signals. The noise can cause radio and television interference (RI and TVI). In certain circumstances, corona-generated electromagnetic interference (EMI) can also affect communications systems and other sensitive receivers. Interference with electromagnetic signals by corona-generated noise is generally associated with lines operating at voltages of 345 kV or higher. This is especially true of interference with television signals. The bundle of three 1.3-inch (or 1.602-inch) diameter conductors used in the design of the proposed 500-kV line would mitigate corona generation and thus keep radio and television interference levels at acceptable levels.

Spark gaps on distribution lines and on low-voltage wood-pole transmission lines are a more common source of RI/TVI than is corona from high-voltage electrical systems. This gap-type interference is primarily a fair-weather phenomenon caused by loose hardware and wires. The proposed transmission line would be constructed with modern hardware that eliminates such problems and therefore minimizes gap noise. Consequently, this source of EMI is not anticipated for the proposed line.

No state has limits for either RI or TVI. In the United States, electromagnetic interference from power transmission systems is governed by the Federal Communications Commission (FCC) Rules and

Regulations presently in existence (FCC, 1988). A power transmission system falls into the FCC category of "incidental radiation device," which is defined as "a device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy." Such a device "shall be operated so that the radio frequency energy that is emitted does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interference." For purposes of these regulations, harmful interference is defined as: "any emission, radiation or induction which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with this chapter" (FCC, 1988: Vol II, part 15. 47CFR, Ch. 1).

Electric power companies have been able to work quite well under the present FCC rule because harmful interference can generally be eliminated. It has been estimated that more than 95% of power-line sources that cause interference are due to gap-type discharges. These can be found and completely eliminated, when required to prevent interference (USDOE, 1980). Complaints related to corona-generated interference occur infrequently. This is especially true with the advent of cable television and satellite television, which are not subject to corona-generated interference. Mitigation of corona-generated interference with conventional radio and television receivers can be accomplished in several ways, such as use of a directional antenna or relocation of an existing antenna (USDOE, 1977; USDOE, 1980; Loftness et al., 1981).

8.2 Radio Interference (RI)

Radio reception in the AM broadcast band (535 to 1605 kilohertz (kHz)) is most often affected by corona-generated EMI. FM radio reception is rarely affected. Generally, only residences very near to transmission lines can be affected by RI. The IEEE Radio Noise Design Guide identifies an acceptable limit of fair-weather RI as expressed in decibels above 1 microvolt per meter (dBμV/m) of about 40 dBμV/m at 100 ft. (30 m) from the outside conductor (IEEE Committee Report, 1971). As a general rule, average levels during foul weather (when the conductors are wet) are 16 to 22 dBμV/m higher than average fair-weather levels.

8.3 Predicted RI Levels

Table 9 gives the predicted fair- and foul-weather RI levels at 100 ft. (30 m) from the outside conductor nearest the edge of the right-of-way for the proposed 500-kV line in the ten configurations. Median foul-weather RI levels would be about 17 dB higher than the fair-weather levels. The predicted L_{50} fair-weather level at 100 ft. (30 m) from the outside conductor of the proposed line with no parallel lines (Configurations 2) is 38 dBμV/m for 540-kV line operation. The predicted levels in Table 9 indicate that fair-weather RI will meet the IEEE 40 dBμV/m criterion at distances greater than about 100 ft. (30 m) from the outside conductor of the corridor for all configurations. Predicted fair-weather L_{50} levels are comparable with or lower than those for the existing Grand Coulee – Hanford 500-kV line (39 dBμV/m at 100 ft. [30 m]).

8.4 Television Interference (TVI)

Corona-caused TVI occurs during foul weather and is generally of concern for transmission lines with voltages of 345 kV or above, and only for conventional receivers within about 600 ft. (183 m) of such a line. As is the case for RI, gap sources on distribution and low-voltage transmission lines are the

principal observed sources of TVI. The use of modern hardware and construction practices for the proposed line would minimize such sources.

8.5 Predicted TVI Levels

Table 10 shows TVI levels predicted at 100 ft. (30 m) from the outside conductor of the line nearest the edge of the right-of-way. TVI levels are shown for the ten configurations with existing lines and with the addition of the proposed line operating at 540 kV. At 100 ft. (30 m) from the outside conductor of the proposed line, the predicted foul-weather TVI level is 25 dBμV/m (Configuration 2). This is comparable with TVI levels from the existing Grand Coulee - Hanford 500-kV line (26 dBμV/m at 100 ft. [30 m] from the outside conductor). For Configurations 3 to 10, where the proposed line would be in a corridor with lower-voltage lines, the TVI level at 100 feet (30 m) from the outside conductor in the corridor would range from 6 to 18 dBμV/m. Although these would be increases above existing levels due to the proposed line, the TVI levels would still be well below those near existing 500-kV lines.

There would be a potential for interference with television signals at locations very near Configurations 1 and 2 in fringe reception areas. However, several factors reduce the likelihood of occurrence. Corona-generated TVI occurs only in foul weather; consequently, signals would not be interfered with most of the time, which is characterized by fair weather. Because television antennas are directional, the impact of TVI is related to the location and orientation of the antenna relative to the transmission line. If the antenna were pointed away from the line, then TVI from the line would affect reception much less than if the antenna were pointed towards the line. Since the level of TVI falls off with distance, the potential for interference becomes minimal at distances greater than several hundred feet from the centerline of the proposed 500-kV line. Where the proposed line parallels the existing 500-kV line with higher TVI levels, interference issues may have already been addressed and the potential for impacts would be less than where a new line with no parallel lines is built. These same mitigative factors also apply to Configurations 3 to 10, except that, in these cases, the possible sites for TV receivers are farther from the proposed line than when under those circumstances when it abuts the edge of the right-of-way.

Other forms of TVI from transmission lines are signal reflection (ghosting) and signal blocking caused by the relative locations of the transmission structure and the receiving antenna with respect to the incoming television signal. Television systems that operate at higher frequencies, such as satellite receivers, are not affected by corona-generated TVI. Cable television systems are similarly unaffected.

Interference with television reception can be corrected by any of several approaches: improving the receiving antenna system; installing a remote antenna; installing an antenna for TV stations less vulnerable to interference; connecting to an existing cable system; or installing a translator (cf. USDOE, 1977). BPA has an active program to identify, investigate, and mitigate legitimate RI and TVI complaints. It is anticipated that any instances of TVI caused by the proposed line could be effectively mitigated.

8.6 Interference with Other Devices

Corona-generated interference can conceivably cause disruption on other communications bands such as the citizen's (CB) and mobile bands. However, mobile-radio communications are not susceptible to transmission-line interference because they are generally frequency modulated (FM). Similarly, cellular telephones operate at a frequency of about 900 MHz, which is above the frequency where corona-generated interference is prevalent. In the unlikely event that interference occurs with these or other communications, mitigation can be achieved with the same techniques used for television and AM radio interference.

8.7 Conclusion

Predicted EMI levels for the proposed 500-kV transmission line are comparable to, or lower, than those that already exist near 500-kV lines; no impacts of corona-generated interference on radio, television, or other reception are anticipated. Furthermore, if interference should occur, there are various methods for correcting it: BPA has a program to respond to legitimate complaints.

9.0 Other Corona Effects

Corona is visible as a bluish glow or as bluish plumes. On the proposed 500-kV line with 3-conductor bundles, corona levels would be very low, so that corona on the conductors would be observable only under the darkest conditions and only with the aid of binoculars, if at all. Without a period of adaptation for the eyes and without intentional looking for the corona, it would probably not be noticeable.

When corona is present, the air surrounding the conductors is ionized and many chemical reactions take place, producing small amounts of ozone and other oxidants. Ozone is approximately 90% of the oxidants, while the remaining 10% is composed principally of nitrogen oxides. The national primary ambient air quality standard for photochemical oxidants, of which ozone is the principal component, is a one-hour average not to exceed 235 micrograms/cubic meter or 120 parts per billion. The maximum incremental ozone levels at ground level produced by corona activity on the proposed transmission line during foul weather would be much less than 1 part per billion. This level is insignificant when compared with natural levels and fluctuations in natural levels.

10.0 Summary

Electric and magnetic fields from the proposed transmission line have been characterized using well-known techniques accepted within the scientific and engineering community. The expected electric-field levels from the proposed line at minimum design clearance would be comparable to those from existing 500-kV lines in Washington, and elsewhere. The expected magnetic-field levels from the proposed line would be comparable to, or less than, those from other 500-kV lines in Washington, and elsewhere.

The peak electric field expected under the proposed line would be less than 9.0 kV/m; the maximum value at the edge of the right-of-way would be about 2.5 kV/m. Clearances at road crossings would be increased to reduce the peak electric-field value to 4.4 kV/m or less. Along the multi-line Grand Coulee – Bell corridor, electric fields at the edges of the right-of-way would remain very comparable with existing levels and would range from 0.1 to 1.4 kV/m.

Under maximum current conditions, the maximum magnetic fields under the proposed line would be 333 mG; at the edge of the right-of-way of the proposed line the maximum magnetic field would be 83 mG. However, along the multi-line Grand Coulee – Bell corridor, the magnetic field at the edges of the right-of-way would be comparable with, or less than, existing levels and would range from 3 to 41 mG.

The electric fields from the proposed line would meet regulatory limits for public exposure in most other states that have limits, but could exceed the regulatory limits or guidelines for peak fields established in one other state and by ICNIRP. The magnetic fields from the proposed line would be within the regulatory limits of the two states that have established them and within guidelines for public exposure