ENVIRONMENTAL ANALYSIS
OF THE
CHANGES TO THE PROPOSED
MEAD-PHOENIX TRANSMISSION PROJECT

SEPTEMBER 1989

U.S. DEPARTMENT OF ENERGY
WESTERN AREA POWER ADMINISTRATION

CHAPTER 3 - ELECTRICAL EFFECTS

The operation of a 500kV AC transmission line causes electrical effects that result from corona and electromagnetic fields (electrical fields and magnetic fields). Corona is the discharge of ions from an energized line that occurs when the voltage gradient at the conductive surface exceeds the breakdown strength of air. Corona activity results in the generation of audible noise, photochemical oxidants, and radio and television interference. Corona activity for an AC transmission line is greatest during rainy weather conditions.

AUDIBLE NOISE

Audible noise results from increased corona activity and is thus greatest during rainy weather conditions. The audible noise from a transmission line is generally a crackling sound with a definite 120 Hz component. The lateral attenuation of noise from a line source attenuates at a rate of 3 decibels per doubling of distance from the line. Because the air absorbs the higher frequency crackling noise more efficiently, this sound attenuates more rapidly than the lower frequency 120 Hz component resulting in an overall attenuation of somewhat greater than 3 decibels with each doubling of distance. In fair weather, the audible noise is expected to be 16 decibels at the edge of the right-of-way. In rainy weather, the audible noise is expected to be 41 decibels at the edge of the right-of-way.

PHOTOCHEMICAL OXIDANTS

Transmission lines generate minute amounts of photochemical oxidants as a result of corona discharge. Approximately 90 percent of the oxidants are ozone, while the remaining 10 percent are composed of nitrogen oxides. In carefully prepared tests, the ozone produced by transmission lines can be detected, but generally the nitrogen oxides have been below the detection limit. The concentrations of each, however, are insignificant and no effects are anticipated as a result of the transmission line.

RADIO AND TELEVISION INTERFERENCE

The radio-noise level of a 500kV transmission line will be highest during heavy rain, lower in fair weather, and lowest just after a rain which has washed foreign particles off the conductors and the water has dried off of the conductors. Radio interference is more pronounced in areas of weak signal strength where the noise generated by the transmission line becomes more significant compared to the radio signal. Antennas located near transmission lines also cause radio interference to be more pronounced.

AM signals are more prone to interference than FM signals. Television pictures are more affected by transmission line noise than is television sound, since the television picture signals are AM and the television sound signals are FM. Television interference is most likely to affect channels 2-6, but is not likely to interfere with channels 7-83. AM radios are also more likely to be affected, since FM signals are highly resistant to transmission line interference.

Mitigation for interference is available upon customer request. Tightening line hardware to eliminate gap discharges, inspecting conductor surface for irregularities, relocating the customer's antenna, and installation of improved antennas are all used where problems occur. Experience with the many existing 500kV AC transmission lines has shown that such problems can be solved on a case-by-case basis.

ELECTROMAGNETIC FIELDS

Electric Fields

The electric field calculated for this transmission line is 8.2kV/m at the centerline of the towers. At the edge of the right-of-way, the electric field is calculated to be 1.7kV/m. The maximum total induced body current in a person would be .13 mA in the 8.2kV/m field and .03 mA in the 1.7kV/m field, both of which are below the level of perception. The induced short circuit current in a camper truck parked directly in the 8.2kV/m electric field would be about 2.3 mA which would be perceptible but only about half of the 5 milliamp standard set by the National Electric Safety Code. Thus, the short circuit current would be perceptible if a grounded person touched a camper truck parked at the maximum electric field point, but would still be far below the let-go threshold of 9 mA for men, 6 mA for women, and 5 mA for children. This short-circuit current would only be about .5 mA for a camper truck parked at the edge of the right-of-way. Thus, ordinary vehicles parked within the right-of-way do not present a shock hazard.

With respect to long-term biological effects of electric fields, years of operating experience with 500kV transmission lines have not revealed any identifiable biological hazard. Numerous studies of employee health and numerous studies of test animals and fundamental biological mechanisms in the laboratory do not indicate that these transmission lines pose a long-term biological hazard. These studies continue, and will continue into the future, but nothing to date indicates any reason to suspect that there is any long-term health effect that can be linked to the effects of electric fields from 500kV transmission lines.

Magnetic Fields

The maximum magnetic field calculated for this transmission line when it is carrying 1000 amps is 168 milligauss at the centerline of the towers. At the edge of the right-ofway, the magnetic field is calculated to be 36 milligauss. At 1000 amps, the transmission line would nominally be carrying 1500 megawatts, slightly more than its normal maximum working range. These numbers are similar to those obtained by measuring common household appliances; for instance, 168 milligauss at the centerline of the towers is slightly less than that of a household microwave oven, which was measured at 213 milligauss. Thirty-six milligauss lies between 31 milligauss observed at a computer terminal and 41 milligauss observed near an electric pencil sharpener. Overall levels 200 feet from the transmission line are in the same range as those found in typical public buildings.

Several studies performed in Colorado have suggested a correlation between the incidence of childhood cancer and proximity of homes to high current-carrying distribution and service lines. A similar study done in Rhode Island found no relationship between childhood leukemia and electric power line configurations. Several additional studies are underway to determine if any such effect can be identified, and to identify possible biological mechanisms for any effects. This area of research is extremely active at the present time. Until more is known, projects are proceeding on the basis that exposures to magnetic fields from transmission lines are in the same range as exposures to other electrical equipment encountered in everyday life. Long experience with such equipment has not demonstrated any pattern of health problems. The very difficulty now being experienced in identifying any linkage between magnetic fields and health problems shows that if an effect exists, it is not a strong one.

Based upon a review of the literature and discussions with investigators active in this research area, it can be concluded that magnetic field exposure due to a 500kV transmission line is of the same order of magnitude as normal ambient levels found in everyday life and thus do not cause any significantly greater risk to biological organisms than the environment without a 500kV transmission line. This would suggest that if any hazards do exist, they are certainly small compared to other environmental factors. Finally, no one has proven any physical mechanisms by which magnetic fields could cause harm to biological organisms.

NAVAJO TRANSMISSION PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT

SEPTEMBER 1996

U.S. DEPARTMENT OF ENERGY
WESTERN AREA POWER ADMINISTRATION

ELECTRIC AND MAGNETIC FIELDS AND EFFECTS

Potential impacts from NTP are discussed in the context of electric and magnetic fields and their effects, including corona effects and short- and long-term field effects.

Both current and voltage are required to transmit electrical energy over a transmission line. The current, a flow of electrical charge measured in amperes (A), is the source of a magnetic field. The voltage, which represents the potential for an electrical charge to den work, expressed in units of volts (V) or kV and is the source of an electric field. The maximum current would be approximately 1,385 A. The proposed transmission line would operate at a nominal voltage of 525kV.

The electrical effects of the proposed 500kV transmission line can be characterized as “corona effects” and “field effects.” Corona is the electrical breakdown of air into charged particles; it is caused by the electric field at the surface of the conductors. Effects of corona are audible noise, radio and television interference, visible light, and photochemical oxidants. Field effects are induced currents and voltages, as well as related effects that might occur as a result of electric and magnetic fields at ground level.

Corona Effects

Corona can occur on the conductors, insulators, and hardware of an energized high-voltage transmission line. Corona on conductors occurs at locations where the field has been enhanced by protrusions, such as nicks, insects, or water drops. During fair weather, the number of these sources is small and corona is insignificant. However, during wet weather, the number of these sources increases and corona effects are much greater. The types of corona effects are described below.

Audible Noise—Corona-generated audible noise from transmission lines is generally characterized as a crackling, hissing noise. The noise is most noticeable during wet-weather conditions such as rain, snow, or fog. Such weather is estimated to occur less than two percent of the time in the NTP area. Transmission line audible noise is measured and predicted in decibels (A-weighted), or dBA. Some typical noise levels are as follows: remote areas (no wind), 15 to 20 dBA; moderate rainfall on foliage and normal conversation, 60 dBA; and freeway traffic or freight train at 50 feet, 70 dBA. This last level represents the point at which a contribution to hearing impairment begins.

There are no noise codes applicable to transmission lines in New Mexico, Arizona, or Nevada. In most situations, the level of noise at the edge of the right-of-way of the proposed line would be less than 50 dBA. This level is lower than the EPA standard for outdoor areas—a day-night average sound level of less than 55 dBA (EPA 1978). Where the NTP line would parallel an existing transmission line, noise would be additive but not double. Audible noise from the line(s) most often would be masked by naturally occurring sounds at locations beyond the edge of the right-of-way. Noise levels at the edge of the right-of-way also would be less than those near existing 500kV transmission lines in Arizona.

Radio and Television Interference—Corona-generated radio interference is most likely to affect the amplitude modulation (AM) broadcast band (535 to 1,605 kilohertz); frequency modulation (FM) radio reception is rarely affected. Only AM radio receivers located very near to transmission lines have the potential to be affected by radio interference. An acceptable level of maximum fair weather radio interference at 100 feet from the conductors is about 40 dB p volts/meter (V/m) (decibels above 1 microvolt per meter). The predicted.fair weather level for the proposed transmission line is 36 dB µV/m, which is below the acceptable limit. Average levels during foul weather are, as a general rule, 16 to 22 dB higher than average fair weather levels. The predicted average level at 100 feet from the conductors in foul weather is 53 dB µV/m.

Television interference from corona occurs during foul weather, and is generally of concern for transmission lines with voltage of 345kV or above and only for receivers within about 600 feet of the line. The level of corona-generated television interference expected at 100 feet from the conductors of the proposed transmission line is 22 dB µV/m. This level is below that computed for existing 500kV lines in Arizona.

Typical transmission line engineering practice is to design lines to be as free from corona and other sources of interference as possible. However, mitigative techniques exist, if needed, for eliminating adverse impacts on radio and television reception. Individual complaints about radio interference and television interference would be settled by the project proponents.

Other Interference—Corona-generated interference can conceivably cause disruption on other communication 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). 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.

Other Corona Effects-Corona is visible as a bluish glow or as bluish plumes. On the proposed line, corona levels would be so low that corona on the conductors would be observable only under the darkest conditions and probably only with the aid of binoculars. Without a period of adaptation for the eyes and without intentionally looking for the corona, it probably would 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. Approximately 90 percent of the oxidants is ozone, while the remaining ten percent is composed principally of nitrogen oxides. The national primary ambient air quality standard for photochemical oxidants, of which ozone is the principal component, is 235 µg/m3 (micrograms/cubic meter) or 120 ppb (parts per billion). The maximum incremental ozone levels at ground level that would be produced by corona activity on this transmission line during foul weather would be much less than 1 ppb. This level is insignificant when compared with natural levels and fluctuations in natural levels.

Field Effects-Short-term Exposure

Electric Field—The electric field created by a high-voltage transmission line extends from the energized conductors to other conducting objects such as the ground, towers, vegetation, buildings, vehicles, and persons. The electric field is expressed in units of V/m or kilovolts/meter (kV/m).

The maximum electric field, at the minimum 29-foot conductor-to-ground clearance and at a voltage of 500kV, would be 12.2 kV/m. On the ground under a transmission line, the electric field is nearly constant in magnitude and direction over distances of a few meters. The field decreases rapidly as distance from the conductors increases. At the edge of the right-of-way nearest to the line, the field would be 0.9 kV/m. On the other edge of the right-of-way, the field would vary with the line configuration present. Maximum electric fields under the existing parallel transmission lines would vary from 4.7 to 10.8 kV/m, depending on voltage.

Induced Currents—When a conducting object, such as a vehicle or person, is placed in an electric field, current and voltages are induced in the object. The magnitude of the induced current depends on the electric-field strength and the size and shape of the object. If the object is grounded, then the induced current flows to earth and is called the short-circuit current of the object. In this case, the voltage of the object is effectively zero. If the object is insulated (not grounded), then it assumes some voltage relative to ground. These induced currents and voltages represent a potential source of nuisance shocks near a high-voltage transmission line. The proposed line would be designed to meet the NESC criterion of 5 mA for the short-circuit current from the largest anticipated vehicle under the line. To accomplish this, clearance of conductors above road crossings would be increased above the minimum clearance of 29 feet to allow for the large vehicles anticipated on roads and highways. In addition, permanent structures for the right-of-way (such as fences and metal buildings) would be grounded.

Steady-State Current Shocks—Steady-state currents are those that flow continuously after a person contacts an object and provides a path to the ground for the induced current. Primary shocks are those that can result in direct physiological harm. The lowest category of primary shocks is “let go,” which represents the steady-state current that cannot be released voluntarily. The 5 mA maximum induced current criterion for vehicles closely approximates the estimated 4.5 mA let-go threshold for 0.5 percent of children (Keesey and Letcher 1969). Primary shocks would not be possible from the induced currents under the proposed line.

Potential steady-state-current shocks from vehicles under the proposed line are all at or below the secondary shock level, where secondary shocks are defined as those that could cause an involuntary and potentially harmful movement but no direct physiological harm. Steady-state-current shocks are not anticipated to occur very often, and when they do they would represent a nuisance rather than a hazard.

Spark Discharge Shocks—Induced voltages appear on objects such as vehicles when there is an inadequate ground. If the voltage is sufficiently high, a spark-discharge shock will occur as contact is made with the object. This type of shock could occur under the proposed line: However, on much of the right-of-way, the magnitude of the electric field would be low enough that this type of shock would occur rarely, if at all. Only in the area under the line near midspan would fields be high enough for this type of discharge to be perceivable. The occurrence of such nuisance shocks is anticipated to be infrequent. Spark discharges also could occur between persons and plants such as tall grass, between a person and an animal, and between a person and a vehicle in the areas directly under the conductors.

Carrying or handling conducting objects, such as irrigation pipe, under the proposed line also could result in spark discharges that are a nuisance. The primary hazard with irrigation pipe or other long objects, however, is electrical flashover from the conductors if a section of pipe is inadvertently tipped up near the conductors.

Field Perception and Neurobehavioral Responses—When the electric field under a transmission line is sufficiently strong, it can be perceived by hair erection on an upraised hand. At locations directly under the conductors, it would be possible for some individuals to perceive the field while standing on the ground. The mechanism is similar to that involved when our hair responds to a comb indoors on dry winter days. The potential for this to occur under the proposed line would be similar to that under the existing Four Corners-Moenkopi-Eldorado 500kV transmission line. Perception of the field would not occur at or beyond the edge of the right-of-way.

Studies of short-term exposure to electric fields have shown that fields may be perceived (felt, for example on the arms as a result of hair movement) by some people at levels of about 2-10 kV/m, but studies of controlled, short-term exposures to even higher levels in laboratory studies have shown no adverse effects on normal physiology, mood, or ability to perform tasks. Some guidelines (e.g., the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1990) propose that short-term exposures be limited to 10 kV/m for the general public. This level would occur directly below the proposed NTP transmission line, but levels are lower at the edge of the right-of-way. Nevertheless, the research literature suggests that, apart from direct perception of electric fields, few neurobehavioral responses would be expected and none are harmful. Magnetic fields even at levels much greater than those produced by the transmission line cannot be perceived.

Studies of nonhuman primates (e.g., monkeys, baboons) exposed to electric or magnetic fields have shown little evidence of effects on performance of tasks routinely used to assess sensory, memory, and other cognitive functions in animals. While there have been reports of responses of isolated neural tissues and cells, the findings are not consistent and the physiological relevance of responses of isolated tissues to whole organisms is unclear.

In the past, there had been considerable interest in the acute effects of electric field exposures on the hormonal responses of animals and humans (e.g., pituitary, adrenal, and sex hormones). No consistent or replicable responses are reported. Over the past 15 years, there has been a more specialized interest in the effects of both AC electric and magnetic fields on the release and synthesis of melatonin by the pineal gland. There are contradictory findings regarding the ability of electric and magnetic fields to affect melatonin levels in rodents. Electric and magnetic fields do not affect melatonin levels of sheep living underneath a 500kV transmission line. Some preliminary studies of melatonin levels in humans have been completed but provide no clear, reproducible evidence that 10 mG or 200 mG magnetic fields reduce melatonin secretion.

Grounding and Shielding—Induced currents are always present around transmission lines. However, the grounding policies for operation of the line would eliminate the possibility of nuisance shocks because of these currents from stationary objects such as fences and buildings.

Mobile objects cannot be grounded permanently, but coupled currents to persons in contact with mobile objects can be limited through adherence to the NESC and the use of conducting grounds. Conductive shielding reduces electric fields and the potential for induced effects, such as shocks. Persons inside a conducting vehicle cab or canopy will be shielded from the electric field. Similarly, a row of trees or a lower-voltage distribution line will reduce the field on the ground in their vicinity. Metal pipes, wiring, and other conductors in a residence or building will shield the interior from the electric field due to the transmission line. The prevalence of induced current shocks, spark discharge shocks, and field perception under the proposed line is anticipated to be comparable to that under the existing 500kV lines such as the Four Corners-Moenkopi-Eldorado line.

Magnetic Field—A 60-Hz magnetic field is created in the space around transmission line conductors by the electric current flowing in the conductors. The magnetic field is expressed in units of gauss or milligauss (mG), where one milligauss is one thousandth of a gauss.

The calculated 60-Hz magnetic field at 3.3 feet above ground for the proposed line is 318 mG. This field is calculated based on a maximum current of approximately 1,385 *A* and for conductors at a height of 29 feet. For this condition, the calculated magnetic field at the edge of the right-of-way nearest to the NTP line is about 35 mG. Slightly higher values would occur where the line parallels the Four Corners-Moenkopi-Eldorado 500kV line (44 mG) and the Glen Canyon-Shiprock 230kV line (39 mG). The maximum level is comparable with the maximum magnetic fields of other transmission lines and with levels of magnetic field measured near some common household appliances. The actual level of magnetic field will vary as the current on the transmission line varies and as the height above the ground changes.

The magnetic field at the edge of the right-of-way of the proposed line would be less than field levels set in other states. There are no limits established for peak magnetic fields. *A* possible short-term impact associated with the magnetic fields from an AC transmission line is induced voltages and currents in long conducting objects such as fences and pipelines. Grounding practices and the availability of mitigation measures would minimize these effects of the line. In areas where other lines would parallel the proposed line, such measures may already be in place. No adverse impact is expected from magnetically induced currents and voltages.

<u>Field Effects—Long-term Exposure</u>

Studies of the effects of long-term exposure to environmental agents on health include both epidemiology and laboratory research. Epidemiology is the study of diseases and potentially health-related exposures of people in their normal environment; laboratory research is the study of exposures to whole animals, or to cells or tissues isolated from the organism, under controlled laboratory cond-Hz electric and magnetic fields from transmission lines on health.

Standards—There are no national standards for electric or magnetic fields from transmission lines, and the states of New Mexico, Arizona, and Nevada have not set recommended field limits for transmission lines. However, several states have established recommended field limits for maximum field on the right-of-way and field at the edge of right-of-way. The maximum electric field from the proposed line on the right-of-way would be along the centerline and would exceed the recommended limits of New York, Florida, Minnesota, Montana, and Oregon. The electric field at the edge of the right-of-way of the proposed line would be below limits set in these states, except Montana. Magnetic fields at the edge of the right-of-way would not exceed limits set by Florida and New York.

Several scientific organizations have proposed voluntary limits to exposure. These organizations include the American Conference of Governmental Industrial Hygienists (ACGIH 1995), ICNIRP (1990), and National Radiological Protection Board of Great Britain (NRPB 1993). Exposure guidelines are based on considerations of both the intensity of the field and the duration of exposure. The recommended intensity levels for daily electric field exposure are not exceeded at the edge of the right-of-way or at distances farther from the line.

The exposure guidelines of ICNIRP for electric fields could be exceeded on portions the right-of-way (even those specified for occupational exposures) unless the time spent on the right-of-way is limited and precautions are taken to prevent current discharges from charged objects. Furthermore, compliance with both ICNIRP and ACGIH guidelines for electric field exposures on the right-of-way would call for persons with implanted pacemakers and other similar devices to be discouraged from unshielded exposures (a passenger in an automobile underneath the transmission line would be shielded from the electric field). These guidelines are basically designed to (1) minimize the possibility of perception and annoyance from surface charge effects and shocks from contact with large ungrounded objects with short-term exposures and (2) minimize the possibility of electrical interference with implanted medical devices. No adverse e-of-way. Moreover, the likelihood for long-term exposure is very small. Persons entering the right-of-way who are annoyed by detection of the electric field would move off the right-of-way; also, in general, there is no reason for people to spend extended periods of time on the right-of-way.

Recommended intensity limits for daily magnetic field exposure (ICNIRP 1990) are not exceeded within or at the edge of the right-of-way or at distances further from the line. The levels produced by this line are several fold below the recommended limit of 1,000 milligauss (mG).

Scientific Reviews, Guidelines, and Standards—A number of different groups of scientists and technical organizations have reviewed the epidemiology and the laboratory research studies. No group has concluded that adverse health effects occur from long-term exposures to power frequency fields at levels associated with transmission lines. No Federal regulatory agencies have set standards to limit exposures to power-frequency electric and magnetic fields.

International and United States technical groups have developed guidelines to limit exposures based on the potential for biological effects from exposures for a few hours or a day to levels of 1,000 mG or higher, and 10 kV/m (see discussion above, under short-term exposure). Magnetic fields associated with the proposed transmission line would be well below this level.

Electric Fields and Human Health—Because electric fields are shielded by buildings and vegetation, transmission lines outside of the home are not a significant source of electric fields in the residence. Therefore, questions about health and long-term exposure to sources of fields generally are not focused on electric fields.

The function of some models of cardiac pacemakers or defibrillators, which are implanted in persons to correct abnormalities in heartbeat, may be affected by electric fields greater than 2kV/m. Electric fields at this intensity and higher would occur in the right-of-way of NTP and are already present along existing transmission lines that would be paralleled by the alternative routes in the eastern and western portions of the study area for 60 to 100 percent of their entire length.

Modern pacemakers are designed to filter out electrical stimuli from sources other than the heart (e.g., muscles of the chest, currents encountered from touching household appliances, or currents induced by electric or magnetic fields). There remains a very small possibility that some pacemakers, particularly those of older designs and with single-lead electrodes, may sense potentials induced on the electrodes and leads of the pacemaker and provide unnecessary stimulation to the heart. For brief periods of time, at least, this reversion to a fixed pacing rate is not generally believed to be harmful. Less likely is the possibility that the pacemaker may not stimulate the heart when it is needed during the period of interference. Wearers of pacemakers are instructed by pacemaker manufacturers and physicians about potential incompatibilities of pacemakers with fields produced by a variety of electrical and medical devices. The sensitivity and operating mode of pacemakers can be programmed to virtually eliminate the possibility of potential interference by electric fields. As pointed out by cardiologists who have reviewed this issue (e.g., Griffin et al.), the opportunity and risk of pacemaker interference from power frequency fields is very small compared to that of contact currents from household appliances and other sources. From their perspective, an induced current of 25 µA induced by a 2kV/m electric field is of lesser concern than a household appliance that in normal operation is permitted to "leak" up to 500µA upon contact.

There is no practical way to determine whether persons living near, or traversing the right-of-way would have such devices, and whether an individual's particular device is susceptible to interference from electric fields. However, the likelihood of such an event is judged to be extremely small based upon three considerations that are summarized below.

Firstly, the alternative routes are generally located away from areas where large numbers of people live or congregate, and would parallel existing high-voltage transmission lines. Based on an initial review of existing land use within proximity to alternatives, it appears that only Link 580, along alternative routes GC1 and K1 in the vicinity of the town of Shonto, would require further study if selected as the final route, to consider whether it is advisable to limit access to the right-of-way or devise other mitigation strategies. However, the possibility for interference to pacemakers in this area already exists based on the presence of the Shiprock-to-Glen Canyon 230kV transmission line that would be paralleled along much of alternative routes GC 1 and K1.

Secondly, only a small fraction of the population in the United States have implanted pacemakers. Among the Navajo population living in Arizona, New Mexico, and Utah, the fraction of the population that has pacemakers is estimated to be at least 20-fold smaller than the national percentage. Also, very few pacemakers are in use by Hopi and Hualapai populations.

Thirdly, only a small fraction (less than three percent) of pacemakers in use potentially might be susceptible to electrical fields because of recent design improvements that detect and filter out electrical interference.

Once a final route is selected, detailed studies would be conducted to verify assumptions and determine appropriate mitigation measures.

Magnetic Fields and Human Health—Over the past 17 years, many epidemiology studies have examined whether transmission lines could affect health or cause cancer. The focus of these studies was the magnetic fields from transmission lines, largely because electric fields from transmission lines are shielded by buildings and vegetation. Earlier studies raised the question of whether living near transmission lines that produced higher magnetic fields—those that carried higher current—could affect the risk of cancer, particularly childhood leukemia.

In the earlier epidemiologic studies, long-term exposure to magnetic fields was based only on assumptions about exposures from the transmission lines, rather than on measurements, creating uncertainty about actual exposures to magnetic fields and preventing clear interpretation of the results. Recent studies have used detailed calculations to improve the estimates of exposures to transmission line magnetic fields at residences, but any associations with childhood cancer are weak, and inconsistent across studies. Studies of transmission lines and cancer in adults have not provided evidence of an association with cancer in general or with any particular type of cancer.

Earlier epidemiology studies of workers in "electrical" occupations, jobs that were believed to include exposure to electric and magnetic fields, reported increased risks for leukemia or for brain cancer. However, since 1993, several larger and better designed studies of these cancers have been completed. Overall, these workers had less cancer than people in the general population, and associations with leukemia in one of the studies and brain cancer in another were weak. Thus, even in populations with high exposures to electric and magnetic fields, there is not consistent or convincing evidence that the occurrence of these rare cancers is changed.

In the laboratory, magnetic field exposures can be controlled by the researcher, and known steps in the process of cancer development can be studied. Cancer-related changes have not been found in cells exposed to electric and magnetic fields, and cancer was not increased in animals exposed to magnetic fields even after the cancer process had been started, or initiated, by chemicals known to cause this change. Long-term studies of exposures of laboratory animals to magnetic fields are in progress. Preliminary results from one completed study report no increase in cancer.

Both epidemiology and laboratory studies have examined the effect of exposure to magnetic fields on pregnancy. A recent, large epidemiology study estimated exposure from various sources in homes, including higher sources of exposure such as electric blankets and water beds. Pregnancy in those who used these heating sources progressed at the normal rate, and the infants were not different in birth weight than babies whose mothers were not exposed. This absence of effect is supported by the results of several long-term studies in pregnant laboratory animals. Animals exposed to electric or to magnetic fields during pregnancy had litters of normal size and healthy offspring no different from unexposed animals.

Effects on Agriculture and Wildlife—The electric fields from the proposed transmission line would be below levels where effects have been observed on crops.

High electric fields (IS kV/m) have been observed to induce corona on the uppermost parts of plants resulting in minor damage to the leaf tips. Electric fields of 16 kV/m did not affect growth, yield, or plant height under a high-voltage test line. The maximum electric field under the proposed line would be well below the level where induced corona has been observed on crop plants. Therefore, the phenomenon is very unlikely to occur on crops under the line.

Induced currents caused by electric fields under the transmission lines have been observed to disrupt performance of bees in hives. Unless hives are shielded, similar effects could occur under the proposed line. Hives located off the right-of-way would not be affected.

The plants and animals in the natural environment of this line would not be disturbed or affected by the electric and magnetic fields from the line. Domestic livestock including sheep, dairy cattle, swine, and beef grow and function normally on farms near transmission lines. A study of sheep kept for several months in electric and magnetic fields under a transmission line at the edge of the right-of-way showed normal growth, behavior, and wool production. Large mammals in the wild have been observed to pass through and to forage under transmission lines. Laboratory studies indicate that small mammals such as rats and mice would not be disturbed by or avoid electric and magnetic fields, even at levels higher than associated with the proposed line. In addition, species that live at ground level are shielded from the electric fields by vegetation. Birds routinely fly over transmission lines during migration, with no interference in that migration.

Safety

The greatest hazard from a transmission line is direct electrical contact with the conductors. Therefore, extreme caution must be exercised when operating vehicles and equipment for any purpose, including recreation near transmission lines. Maintaining safe electrical clearance from the lines is imperative. Therefore, long objects, such as irrigation pipes and antenna masts, should not be tipped up under the proposed line (or any line).

In high electric fields, it is theoretically possible for a spark discharge from the induced voltage on a large vehicle to ignite gasoline vapor during refueling. The probability for the precise conditions for ignition occurring is extremely remote. The additional clearance of conductors provided at road crossings reduces the electric field in areas where vehicles are common and reduces the chances for such events. Vehicles should not be refueled under the proposed line unless specific precautions are taken to ground the vehicle and the fueling source.

Because of the hazards associated with fires, storage of flammables, construction of flammable structures, and other activities that have the potential to cause or provide fuel for fires on rights-of-way are prohibited.

Transmission line towers, wires, and other tall objects are the most likely points to be hit.by lightning during a thunderstorm. Therefore, the area near towers and other tall objects should be avoided during thunderstorms. The proposed line is designed with overhead ground-wires and well-grounded towers to protect the system from lightning.