Appendix 2.
Electric and Magnetic Fields (EMF)

Appendix 2. Electric and Magnetic Fields

Recognizing that there is a great deal of public interest and concern regarding potential health effects from exposure to electric and magnetic fields (EMFs) from power lines, this section provides information regarding EMF associated with electric utility facilities and the potential effects of the proposed Project related to public health and safety. Potential health effects from exposure to ***electric fields*** from power lines is typically not of concern since electric fields are effectively shielded by materials such as trees, walls, etc.; therefore, the majority of the following information related to EMF focuses primarily on exposure to ***magnetic fields*** from power lines. However, EMF is not considered in the context of CEQA determination of environmental impact, first because there is no agreement among scientists that EMF does create a potential health risk, and second because there are no defined or adopted CEQA standards for defining health risk from EMF. As a result, EMF information is presented in this appendix for the benefit of the public and decision-makers.

2.1 Defining EMF

Electric and magnetic fields are separate phenomena and occur both naturally and as a result of human activity across a broad electrical spectrum. Naturally occurring electric and magnetic fields are caused by the weather and the earth's geomagnetic field. The fields caused by human activity result from technological application of the electromagnetic spectrum for uses such as communications, appliances, and the generation, transmission, and local distribution of electricity.

The frequency of a power line is determined by the rate at which EMFs change their direction each second. For power lines in the United States, the frequency of change is 60 times per second and is defined as 60 Hertz (Hz) power. In Europe and many other countries, the frequency of electric power is 50 Hz. Radio and communication waves operate at much higher frequencies: 500,000 Hz to 1,000,000,000 Hz. The information presented in this document is limited to the EMF from power lines at frequencies of 50 or 60 Hz.

Electric power flows across transmission systems from generating sources to serve electrical loads within the community. The apparent power flowing over a transmission line is determined by the transmission line's voltage and the current. The higher the voltage level of the transmission line, the lower the amount of current needed to deliver the same amount of power. For example, a 115-kV transmission line with 200 amps of current would transmit approximately 40,000 kilowatts (kW), and a 230-kV transmission line requires only 100 amps of current to deliver the same 40,000 kW.

2.2 Electric and Magnetic Fields

Public exposure to EMFs in developed areas is widespread and encompasses a very broad range of field intensities and durations. In developed areas, EMFs are prevalent from the use of electronic appliances or equipment and existing electric power lines. In general, distribution lines exist throughout developed portions of the community and represent the predominant source of public exposure to power line EMF. Transmission lines are much less prevalent in most developed areas and therefore they generally represent a much lower contribution to overall public exposure to power line EMF. In undeveloped and natural areas, only low level naturally occurring EMFs exist.

2.2.1 Electric Fields

Electric fields from power lines are created whenever the lines are energized, with the strength of the field dependent directly on the voltage of the line creating it. Electric field strength is typically described in terms of kilovolts per meter (kV/m). Electric field strength attenuates (reduces) rapidly as the distance from the source increases. Electric fields are reduced at many receptors because they are effectively shielded by most objects or materials such as trees or houses.

Unlike magnetic fields, which penetrate almost everything and are unaffected by buildings, trees, and other obstacles, electric fields are distorted by any object that is within the electric field including the human body. Even trying to measure an electric field with electronic instruments is difficult because the devices themselves will alter the levels recorded. Determining an individual's exposure to electric fields requires the understanding of many variables, one of which is the electric field itself.

At reasonably close distances, electric fields of sufficient strength in the vicinity of power lines can cause the same phenomena as the static electricity experienced on a dry winter day, or with clothing just removed from a clothes dryer, and may result in electric discharges when touching long metal fences, pipelines, or large vehicles. An acknowledged potential impact to public health from electric transmission lines is the hazard of electric shock: electric shocks from transmission lines are generally the result of accidental or unintentional contact by the public with the energized wires.

2.2.2 Magnetic Fields

Magnetic fields from power lines are created whenever current flows through power lines at any voltage. The strength of the field is directly dependent on the current in the line. Magnetic field strength is typically measured in milliGauss (mG). Similar to electric fields, magnetic field strength attenuates rapidly with distance from the source. However, unlike electric fields, magnetic fields are not easily shielded by objects or materials.

The nature of a magnetic field can be illustrated by considering a household appliance. When the appliance is energized by being plugged into an outlet but not turned on so no current would be flowing through it, an electric field is generated around the cord and appliance, but no magnetic field is present. If the appliance is switched on, the electric field would still be present and a magnetic field would also be created. The electric field strength is directly related to the magnitude of the voltage from the outlet and the magnetic field strength is directly related to the magnitude of the current flowing in the cord and appliance.

2.3 Scientific Background and Regulations Applicable to EMF

2.3.1 EMF Research

For more than 20 years, questions have been asked regarding the potential effects within the environment of EMFs from power lines, and research has been conducted to provide some basis for response. Earlier studies focused primarily on interactions with the electric fields from power lines. In the late 1970s, the subject of magnetic field interactions began to receive additional public attention and research levels have increased. A substantial amount of research investigating both electric and magnetic fields has been conducted over the past several decades; however, much of the body of national and international research regarding EMF and public health risks remains contradictory or inconclusive.

Extremely low frequency (ELF) fields are known to interact with tissues by inducing electric fields and currents in these fields. However, the electric currents induced by ELF fields commonly found in our environment are normally much lower than the strongest electric currents naturally occurring in the body such as those that control the beating of the heart.

Research related to EMF can be grouped into three general categories: cellular level studies, animal and human experiments, and epidemiological studies. These studies have provided mixed results, with some studies showing an apparent relationship between magnetic fields and health effects while other similar studies do not.

Since 1979, public interest and concern specifically regarding magnetic fields from power lines has increased. This increase has generally been attributed to publication of the results of a single epidemiological study (Wertheimer and Leeper, 1979). This study observed an association between the wiring configuration on electric power lines outside of homes in Denver and the incidence of childhood cancer. Following publication of the Wertheimer and Leeper study, many epidemiological, laboratory, and animal studies regarding EMF were conducted.

Research on ambient magnetic fields in homes and buildings in several western states found average magnetic field levels within most rooms to be approximately 1 mG, while in a room with appliances present, the measured values ranged from 9 to 20 mG (Severson et al., 1988, and Silva, 1988). Immediately adjacent to appliances (within 12 inches), field values are much higher, as illustrated in Tables 2.3-1 and 2.3-2. These tables indicate typical sources and levels of electric and magnetic field exposure the general public experiences from appliances.

Table 2.3-1. Magnetic Field from Household Appliances

	Magnetic Field (mG)	
Appliance	12" Distant	Maximum
Electric range	3–30	100–1,200
Electric oven	2–25	10–50
Garbage disposal	10–20	850–1,250
Refrigerator	0.3–3	4–15
Clothes washer	2–30	10–400
Clothes dryer	1–3	3–80
Coffee maker	0.8–1	15–250
Toaster	0.6–8	70–150
Crock pot	0.8–1	15–80
Iron	1–3	90–300
Can opener	35–250	10,000–20,000
Mixer	6–100	500–7,000
Blender, popper, processor	6–20	250–1,050
Vacuum cleaner	20–200	2,000–8,000
Portable heater	1–40	100–1,100
Fan/blower	0.4–40	20–300
Hair dryer	1–70	60–20,000
Electric shaver	1–100	150–15,000
Color TV	9–20	150–500
Fluorescent fixture	2–40	140–2,000
Fluorescent desk lamp	6–20	400–3,500
Circular saw	10–250	2,000–10,000
Electric drill	25–35	4,000–8,000

Source: Gauger, 1985

Table 2.3-2. Typical Electric Field Values for Appliances, at 12 Inches

Appliance	Electric Field Strength (kV/m)
Electric Blanket	0.25*
Broiler	0.13
Stereo	0.09
Refrigerator	0.06
Iron	0.06
Hand Mixer	0.05
Phonographs	0.04
Coffee Pot	0.03

*1 to 10 kV/m next to blanket wires.
Source: Enertech, 1985.

2.3.2 Scientific Panel Reviews

Numerous panels of expert scientists have convened to review the data relevant to the question of whether exposure to power-frequency EMF is associated with adverse health effects. These evaluations have been conducted in order to advise governmental agencies or professional standard setting groups. These panels of scientists first evaluate the available studies individually, not only to determine what specific information they can offer, but also in terms of the validity of their experimental design, methods of data collection, analysis, and suitability of the authors' conclusions to the nature and quality of the data presented. Subsequently, the individual studies, with their previously identified strengths and weaknesses, are evaluated collectively in an effort to identify whether there is a consistent pattern or trend in the data that would lead to a determination of possible or probable hazards to human health resulting from exposure to these fields.

These reviews include those prepared by international agencies such as the World Health Organization (WHO, 1984, WHO, 1987, and WHO, 2001) and the international Non Ionizing Radiation Committee of the International Radiation Protection Association (IRPA/INIRC, 1990) as well as governmental agencies of a number of countries, such as the U.S. EPA, the National Radiological Protection Board of the United Kingdom, the Health Council of the Netherlands, and the French and Danish Ministries of Health.

Many of these scientific panels have found that the scientific evidence suggesting that power frequency EMF exposures pose any health risk is weak.

In May 1999 the National Institute of Environmental Health Sciences (NIEHS) submitted to Congress its report titled, Health *Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*, containing the following conclusion regarding EMF and health effects:

> *Using criteria developed by the International Agency for Research on Cancer (IARC), none of the Working Group considered the evidence strong enough to label ELF EMF exposure as a known human carcinogen or <u>probable</u> human carcinogen. However, a majority of the members of this Working Group concluded that exposure to power-line frequency ELF EMF is a <u>possible</u> carcinogen* [emphasis added].

In June 2001, a scientific working group of IARC (an agency of WHO) reviewed studies related to the carcinogenicity of EMF. Using standard IARC classification, magnetic fields were classified as "possibly carcinogenic to humans" based on epidemiological studies. "Possibly carcinogenic to humans" is a classification used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals. Other agents identified as "possibly carcinogenic to humans" include gasoline exhaust, styrene, welding fumes, and coffee (WHO, 2001).

On behalf of the California Public Utilities Commission (CPUC), the California Department of Health Services (DHS) recently completed a comprehensive review of existing studies related to EMF from power lines and potential health risks. This risk evaluation was undertaken by three staff scientists with the DHS, each of these scientists is identified in the review results as an epidemiologist, and their work took place from 2000 to 2002. The results of this review titled, *An Evaluation of the Possible Risks From Electric and*

Magnetic Fields (EMFs) From Power Lines, Internal Wiring, Electrical Occupations, and Appliances, were published in June 2002. The conclusions contained in the executive summary are provided below:

- To one degree or another, all three of the DHS scientists are inclined to believe that EMFs can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage.
- They strongly believe that EMFs do not increase the risk of birth defects, or low birth weight.
- They strongly believe that EMFs are not universal carcinogens, since there are a number of cancer types that are not associated with EMF exposure.
- To one degree or another they are inclined to believe that EMFs do not cause an increased risk of breast cancer, heart disease, Alzheimer's Disease, depression, or symptoms attributed by some to sensitivity to EMFs. However, all three scientists had judgments that were "close to the dividing line between believing and not believing" that EMFs cause some degree of increased risk of suicide.
- For adult leukemia, two of the scientists are "close to the dividing line between believing or not believing" and one was "prone to believe" that EMFs cause some degree of increased risk.

The report indicates that the DHS scientists are more inclined to believe that EMF exposure increased the risk of the above health problems than the majority of the members of scientific committees that have previously convened to evaluate the scientific literature. With regard to why the DHS review's conclusions differ from those of other recent reviews, the report states:

> *The three DHS scientists thought there were reasons why animal and test tube experiments might have failed to pick up a mechanism or a health problem; hence, the absence of much support from such animal and test tube studies did not reduce their confidence much or lead them to strongly distrust epidemiological evidence from statistical studies in human populations. They therefore had more faith in the quality of the epidemiological studies in human populations and hence gave more credence to them.*

While the results of the DHS report indicate these scientists believe that EMF can cause some degree of increased risk for certain health problems, the report did not quantify the degree of risk.

In addition to the uncertainty regarding the level of health risk posed by EMF, individual studies and scientific panels have not been able to determine or reach consensus regarding what level of magnetic field exposure might constitute a health risk. In some early epidemiological studies, increased health risks were discussed for daily time-weighted average field levels greater than 2 mG. However, the IARC scientific working group indicated that studies with average magnetic field levels of 3 to 4 mG played a pivotal role in their classification of EMF as a possible carcinogen.

2.3.3 Policies, Standards, and Regulations

A number of counties, states, and local governments have adopted or considered regulations or policies related to EMF exposure. The reasons for these actions have been varied; in general, however, the actions can be attributed to addressing public reaction to and perception of EMF as opposed to responding to the findings of any specific scientific research. Following is a brief summary of regulatory activity regarding EMF.

International Guidelines

The International Radiation Protection Association, in cooperation with the World Health Organization, has published recommended guidelines (INRC, 1998) for electric and magnetic field exposures. For the general public, the limits are 4.2 kV/m for electric fields, and 833 mG for magnetic fields. Neither of these organizations has any governmental authority nor recognized jurisdiction to enforce these guidelines. However, because they were developed by a broad base of scientists, these guidelines have been given merit and are considered by utilities and regulators when reviewing EMF levels from electric power lines.

National Guidelines

Although the U.S. EPA has conducted investigations into EMF related to power lines and health risks, no national standards have been established. The number of studies sponsored by the U.S. EPA, the Electric Power Research Institute (EPRI), and other institutions has increased in the past few years. Several bills addressing EMF have been introduced at the congressional level and have provided funding for research; however, no bill has been enacted that would regulate EMF levels.

The 1999 NIEHS report to Congress suggested that the evidence supporting EMF exposure as a health hazard was insufficient to warrant aggressive regulatory actions. The report did suggest passive measures to educate the public and regulators on means aimed at reducing exposures. NIEHS also suggested the power industry continue its practice of siting lines to reduce public exposure to EMF and to explore ways to reduce the creation of magnetic fields around lines.

State Guidelines

Several states have adopted limits for electric field strength within transmission line ROWs. Florida and New York are the only states that currently limit the intensity of magnetic fields from transmission lines. These regulations include limits within the ROW as well as at the edge of the ROW and cover a broad range of values. Table 2.3-3 lists the states regulating EMF and their respective limits. The magnetic field limits were based on an objective of preventing field levels from increasing beyond levels currently experienced by the public and are not based upon any link between scientific data and health risks (Morgan, 1991).

Elsewhere in the United States, several agencies and municipalities have taken action regarding EMF policies. These actions have been varied and include requirements that the fields be considered in the siting of new facilities. The manner in which EMF is considered has taken several forms. In a few instances, a concept referred to as “prudent avoidance” has been formally adopted. Prudent avoidance, a concept proposed by Dr. Granger Morgan of Carnegie Mellon University, is defined as “. . . limiting exposures which can be avoided with small investments of money and effort.” (Morgan, 1991) Some municipalities or regulating agencies have proposed limitations on field strength, requirements for siting of lines away from residences and schools, and, in some instances, moratoria on the construction of new transmission lines. The origin of these individual actions has been varied, with some initiated by regulators at the time of new transmission line proposals within their community, and some by public grass-roots efforts.

Table 2.3-3. EMF Regulated Limits (by State)

State	Electric Field (kV/M)	Magnetic Field (mG)	Location	Application
Florida (codified)				
500-kV Lines	10		In ROW	Single circuit
	2	200	Edge of ROW	Single circuit
	2	250	Edge of ROW	Double circuit
230-kV Lines or less	8		In ROW	
	2	150	Edge of ROW	230-kV lines or less
Minnesota	8		In ROW	>200 kV
Montana (codified)	1		Edge of ROW	>69 kV
	7		In ROW	Road crossings
New Jersey	3		Edge of ROW	Guideline for complaints
New York	1.6	200	Edge of ROW	>125 kV, >1 mile
	7		In ROW	Public roads
	11		In ROW	Public roads
	11.8		In ROW	Other terrain
North Dakota	9		In ROW	Informal
Oregon (codified)	9		In ROW	230 kV, 10 miles

Source: Public Utilities Commission of Texas, 1992.

CPUC Guidelines

In 1991, the CPUC initiated an investigation into EMFs associated with electric power facilities. This investigation explored the approach to potential mitigation measures for reducing public health impacts and possible development of policies, procedures or regulations. Following input from interested parties the CPUC implemented a decision (D.93-11-013) that requires that utilities use “low-cost or no-cost” mitigation measures for facilities requiring certification under General Order 131-D. The decision directed the utilities to use a 4 percent benchmark on the low-cost mitigation. This decision also implemented a number of EMF measurement, research, and education programs, and provided the direction that led to the preparation of the DHS study described above. The CPUC did not adopt any specific numerical limits or regulation on EMF levels related to electric power facilities.

Most recently the CPUC issued Decision D.06-01-042, on January 26, 2006, affirming the low-cost/no-cost policy to mitigate EMF exposure from new utility transmission and substation projects. This decision also adopted rules and policies to improve utility design guidelines for reducing EMF. The CPUC stated “at this time we are unable to determine whether there is a significant scientifically verifiable relationship between EMF exposure and negative health consequences.” The CPUC has not adopted any specific limits or regulation on EMF levels related to electric power facilities. Most recently the CPUC issued Decision D.06-01-042, on January 26, 2006, affirming the low-cost/no-cost policy to mitigate EMF exposure from new utility transmission and substation projects. This decision also adopted rules and policies to improve utility design guidelines for reducing EMF. The CPUC stated “at this time we are unable to determine whether there is a significant scientifically verifiable relationship between EMF exposure and negative health consequences.” The CPUC has not adopted any specific limits or regulation on EMF levels related to electric power facilities.

In Decision D.93-11-013, the CPUC addressed mitigation of EMF of utility facilities and implemented the following recommendations:

- No-cost and low-cost steps to reduce EMF levels
- Workshops to develop EMF design guidelines
- Uniform residential and workplace programs
- Stakeholder and public involvement
- A four-year education program
- A four-year non-experimental and administrative research program
- An authorization of federal experimental research conducted under the National Energy Policy Act of 1992.

2.4 EMF along the Proposed Project

For the purpose of examining EMFs, SCE divided the Project into 19 areas, 9 in Segment 2 and 10 in Segment 3, considering changes in characteristics of the transmission corridor (i.e., changes in the number of transmission lines in the corridor, changes to tower type).

2.4.1 Existing EMF Conditions

Segment 3

Area 1 – Mile S3-0.0 to S3-5.2

In Area 1, the existing ROW would be expanded by 160 feet on the east edge of the ROW and the proposed Project would follow the Cal Cement-Monolith-Windpark 66-kV line through undeveloped, open space lands. Although undeveloped, EMFs are present in the vicinity of the existing 66-kV power line corridor. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-4 illustrates the existing and proposed ROW configurations for Area 1.

Area 2 – Mile S3-5.2 to S3-7.2

In Area 2, the existing ROW would be expanded by 160 feet on the north edge of the ROW and the proposed Project would parallel the Cal Cement-Monolith-Windpark 66-kV line and the Cal Cement-Goldtown-Monolith-Windlands line through undeveloped, open space lands. Although undeveloped, EMFs are present in the vicinity of the existing 66-kV power line corridor. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-5 illustrates the existing and proposed ROW configurations for Area 2.

Area 3 – Mile S3-7.2 to S3-7.9

In Area 3, the existing ROW would be expanded by 160 feet on the west edge of the ROW and the proposed Project would parallel the Cal Cement-Monolith-Rosamond-Windfarm 66-kV line, the Cal Cement-Goldtown-Monolith-Windland 66-kV line, and the Cal Cement-Monolith-Windpark 66-kV line through undeveloped, open space lands. Although undeveloped, EMFs are present in the vicinity of the existing 66-kV power line corridor. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-6 illustrates the existing and proposed ROW configurations for Area 3.

Area 4 – Mile S3-7.9 to S3-9.0

In Area 4, the existing ROW would be expanded by 160 feet on the south edge of the ROW and the proposed Project would parallel the private Sagebrush-Skyriver 220-kV transmission line through undeveloped, open space lands. Although undeveloped, EMFs are present in the vicinity of the existing 220-kV power line corridor. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-7 illustrates the existing and proposed ROW configurations for Area 4.

Area 5 – Mile S3-9.0 to S3-9.6

In Area 5, the proposed Project would enter Substation One on a new 160 foot-wide ROW through undeveloped, open space lands. In this area the proposed transmission line would pass through undeveloped lands and no EMFs are present. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-8 illustrates the existing and proposed ROW configurations for Area 5.

Area 6 – Mile S3-9.6 to S3-16.3

In Area 6, the proposed Project would leave Substation One on a new 160 foot-wide ROW through undeveloped, open space and rural lands. In this area the proposed transmission line would pass through undeveloped lands and no EMFs are present. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-9 illustrates the existing and proposed ROW configurations for Area 6.

Area 7 – Mile S3-16.3 to S3-22.1

In Area 7, the proposed Project would traverse rural lands on tubular steel poles with a few scattered residences on a new 160 foot-wide ROW to Mile S3-22.1, where the line would cross under the LADWP transmission lines. In this area the proposed transmission line would pass through largely undeveloped lands and no EMFs are present up to Mile S3-22.1. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-10 illustrates the existing and proposed ROW configurations for Area 7.

Area 8 – Mile S3-22.1 to S3-23.2

In Area 8, the existing ROW would be expanded by 160 feet on the southeast side of the ROW and the proposed Project would parallel the LADWP Sylmar-Celilo 1,000-kV DC transmission line and the Owens Gorge-Rinaldi 220-kV transmission line on lattice steel towers. The line would pass through rural lands with a few scatter residences. Although largely undeveloped, EMFs are present in the vicinity of the existing 220-kV power line corridor. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-11 illustrates the existing and proposed ROW configurations for Area 8.

Area 9 – Mile S3-23.2 to S3-33.8

In Area 9, the proposed Project would be constructed within a new 200 foot-wide ROW through largely undeveloped, rural land with occasional scattered residences. At Mile S3-24.6, the proposed transmission line would cross the existing Sagebrush 220-kV transmission line and at Mile S3-33.8, the proposed transmission line would cross over the Midway-Vincent No. 3 500-kV transmission line, the Antelope-Magunden 200-kV transmission lines No. 1 and No. 2, and the private Sagebrush 220-kV transmission line. While EMFs are present in the vicinity of the Sagebrush, Antelope-Magunden and Midway-Vincent transmission lines, EMFs would be largely absent along this portion of the proposed ROW. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-12 illustrates the existing and proposed ROW configurations for Area 9.

Area 10 – Mile S3-33.8 to S3-35.2

In Area 10, the existing ROW would be expanded by 180 feet on the west edge of the ROW and the proposed Project would parallel the Midway-Vincent No. 3 500-kV transmission line, the Antelope-Magunden No. 1 and No. 2 220-kV transmission lines, the Sagebrush 220-kV transmission line, the Antelope-Cal Cement 66-kV line, and the Antelope-Neenach 66-kV line. The proposed Project would cross the Antelope-Magunden 220-kV transmission line and the Midway-Vincent No. 3 500-kV transmission line and enter Antelope Substation on tubular steel poles (Mile S3-35.0 to S3-35.2). The proposed Project would traverse largely undeveloped, rural areas with scattered residences. Although largely undeveloped, EMFs are present in the vicinity of the existing power line corridor. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-13 illustrates the existing and proposed ROW configurations for Area 10.

Segment 2

Area 11 – Mile S2-0.0 to S2-1.9

In Area 11, the existing Midway-Vincent No. 3 500-kV ROW would be expanded by 180 feet on the southwest edge of the ROW and the proposed Project would leave Antelope Substation on tubular steel poles crossing under the existing Midway-Vincent No. 3 500-kV transmission line (Mile S2-0.0 to S2-0.2). The proposed Project would parallel the Midway-Vincent No. 3 500-kV transmission line, the Antelope-Vincent 220-kV transmission line, the Antelope-Mesa 220-kV transmission line, the relocated Antelope-Anaverde 66-kV line, the relocated Antelope-Acton-Palmdale-Shuttle 66-kV line, the Antelope-Anaverde-Helijet 66-kV line, and the private Sagebrush 220-kV transmission line. The proposed Project would traverse rural lands with scattered residences. Although largely undeveloped, EMFs are present in the vicinity of the existing power line corridor. Public exposure to EMF in rural areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-14 illustrates the existing and proposed ROW configurations for Area 11.

Area 12 – Mile S2-1.8 to S2-1.9

In Area 12, the phases of the Antelope-Vincent 220-kV and the Antelope-Mesa 220-kV transmission line are transposed. Otherwise, the ROW configuration in Area 12 is the same as described above for Area 11. As with Area 11, the proposed Project would traverse rural lands with scattered residences. Although largely undeveloped, EMFs are present in the vicinity of the existing power line corridor. Public exposure to EMF in rural areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-14 illustrates the existing and proposed ROW configurations for Area 12.

Area 13 – Mile S2-1.9 to S2-4.4

In Area 13, the existing ROW would be expanded by 180 feet along the southwest edge of the ROW and the proposed Project would parallel the Midway-Vincent No. 3 500-kV transmission line, the Antelope-Vincent 220-kV transmission line, the Antelope-Mesa 220-kV transmission line, the relocated Antelope-Anaverde 66-kV line, the relocated Antelope-Acton-Palmdale-Shuttle 66-kV line, the Antelope-Anaverde-Helijet 66-kV line, and the private Sagebrush 220-kV transmission line. The proposed Project would traverse rural lands with scattered residences, potentially traversing a residence in this area. EMFs in the vicinity of the residence are prevalent from the use of electronic appliances or equipment as well as from the existing electric power lines. In general, distribution lines to residences represent the predominant source of public exposure to power line EMF except in the immediate vicinity of transmission corridors. Figure B.2-15 illustrates the existing and proposed ROW configurations for Area 13.

Area 14 – Mile S2-4.4 to S2-8.1

In Area 14, the existing ROW would be expanded by 180-feet along the southwest edge of the ROW and the proposed Project would parallel the Midway-Vincent No. 3 500-kV transmission line, the Antelope-Vincent 220-kV transmission line, the Antelope-Mesa 220-kV transmission line, the Antelope-Anaverde 66-kV line, the Antelope-Acton-Palmdale-Shuttle 66-kV line, and the private Sagebrush 220-kV transmission line. The proposed Project would traverse undeveloped, open space lands with scattered residences, potentially traversing residences in this area. EMFs in the vicinity of the residence are prevalent from the use of electronic appliances or equipment as well as from the existing electric power lines. In general, distribution lines to residences represent the predominant source of public exposure to power line EMF except in the immediate vicinity of transmission corridors. Figure B.2-16 illustrates the existing and proposed ROW configurations for Area 14.

Area 15 – Mile S2-8.1 to S2-10.6

In Area 15, the proposed Project would turn away from the existing ROW onto a new 200-foot-wide ROW through an area proposed for residential development. Currently, however, this area is undeveloped open space and no EMFs are present. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-17 illustrates the existing and proposed ROW configurations for Area 15.

Area 16 – Mile S2-10.6 to S2-14.0

In Area 16, the proposed Project would turn southwest to parallel the existing Midway-Vincent No. 1 ROW to the northeast on a new 180-foot-wide ROW. At Mile S2-12.4, the proposed Project would turn east and parallel the Midway-Vincent No. 1 500-kV transmission line and the Midway-Vincent No. 2 500-kV transmission lines. LADWP transmission lines parallel the ROW to the south for portions of Area 16. As with Area 15, Area 16 would pass through a currently undeveloped open space area and would run alongside proposed residential development. EMFs are present in the vicinity of the existing 500-kV power line corridor. Public exposure to EMF in rural areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-18 illustrates the existing and proposed ROW configurations for Area 16.

Area 17 – Mile S2-14.0 to S2-14.8

In Area 17, the existing ROW would be expanded by 180 feet along the north edge of the ROW and the proposed Project would parallel the Midway-Vincent No. 1 500-kV transmission line. LADWP transmission lines parallel the ROW to the south for portions of Area 17. Like Area 16, Area 17 would pass through a currently undeveloped open space area and would run alongside proposed residential development. EMFs are present in the vicinity of the existing 500-kV power line corridor. Public exposure to EMF in rural areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-19 illustrates the existing and proposed ROW configurations for Area 17.

Area 18 – Mile S2-14.8 to S2-19.5

In Area 18, the existing ROW would be expanded by 180 feet along the northeast edge of the ROW. The portion of the existing Midway-Vincent No. 3 500-kV transmission line between Mile S2-14.8 and Vincent Substation would be cut into the proposed new segment of 500-kV transmission line from Antelope Substation to form the Antelope-Vincent 500-kV transmission line. From Mile S2-14.8, a new segment of 500-kV transmission line would be constructed to the east of the existing Midway-Vincent No. 3 500-kV transmission line to replace the appropriated portion of the Midway-Vincent No. 3 500-kV transmission line, reinstating its route to Vincent Substation. The proposed Antelope-Vincent 500-kV transmission line and Midway-Vincent No. 3 500-kV transmission line would parallel the Midway-Vincent No. 2 500-kV transmission line, the Antelope-Vincent 220-kV transmission line, the Antelope-Mesa 220-kV transmission line, the Sagebrush 220-kV transmission line, the LADWP Adelanto-Rinaldi 500-kV transmission line, and the LADWP Victorville-Rinaldi 500-kV transmission line. The ROW would pass through currently undeveloped open space area but would traverse proposed residential development. EMFs are present in the vicinity of the existing power line corridor. Public exposure to EMF in rural areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-22 illustrates the existing and proposed ROW configurations for Area 18.

Area 19 – Mile S2-19.5 to S2-21.0

In Area 19, the new Midway-Vincent No. 3 500-kV transmission line would cross over the LADWP 500-kV transmission lines and the Sagebrush 220-kV transmission line to occupy a new 180-foot-wide ROW between the Sagebrush 220-kV transmission line and the Antelope-Mesa 220-kV transmission line. At Mile S2-20.3, the proposed transmission line would cross over the existing Antelope-Mesa 220-kV and Antelope-Vincent 220-kV transmission lines to re-align with the existing 500-kV ROWs. The proposed new Midway-Vincent No. 3 500-kV transmission line segment would cross over the existing 220-kV ROW at Mile S2-20.9. The proposed Antelope-Vincent 500-kV transmission line and the proposed new Midway-Vincent No. 3 500-kV transmission line segment would parallel the Midway-Vincent No. 2 500-kV transmission line, the Antelope-Vincent 220-kV transmission line, the Antelope-Mesa 220-kV transmission line, and the Sagebrush 220-kV transmission line. The ROW would traverse undeveloped, open space land. Although undeveloped, EMFs are present the vicinity of the existing power line corridor. Public exposure to EMF in undeveloped areas would be limited primarily due to the absence of the public; however, periodic and transient uses of these areas for activities such as recreation would result in public exposure to EMF when in the vicinity of existing electric transmission lines. Figure B.2-23 illustrates the existing and proposed ROW configurations for Area 19.

2.4.2 EMF with the Proposed Project

SCE's magnetic field computer modeling results graph the calculated magnetic field strength, without the proposed Project (existing conditions) and with the proposed Project, for an area extending 150 to 200 feet each side of the right-of-way. These results are shown in Figures Ap-2-1 through Ap-2-19.

EMF levels in the project area would not change during construction of the proposed Project, since the lines would not be energized during construction. When the transmission lines are energized, there would be permanent changes in the level of EMFs in the existing environment. Table 2.4-1 presents the estimated magnetic field along the proposed Project. In Areas 1, 2, 3, and 10, the magnetic field strength at the right edge of the ROW would go down after construction of the proposed Project. This would occur because while the proposed Project would construct new transmission line along that side of the ROW, the expansion of the ROW and cancellation effects results in lower magnetic field strength at the edge of the ROW. In Areas 4 and

8 the magnetic field strength would be lower on the left side of the ROW due to cancellation effects with the existing transmission line, but would be greater on the right side of the ROW due to the location of the new transmission line. In Areas 5, 6, 7, 9 and 15, the magnetic field strength on both edges of the ROW would increase as there are currently no transmission lines in these areas. The magnetic field strength on the right edge of the ROW for Areas 11, 12, 13, 14, 16, 17, 18, and 19 would all increase as the proposed Project would construct new transmission line along this edge of the ROW.

Table 2.4-1. Comparison of Magnetic Field Levels (mG) – Existing vs. with Proposed Project

		Left Side of ROW				Right Side of ROW		
Area ID	Mileposts	Existing	Proposed	Change		Existing	Proposed	Change
Segment 3B (Mile S3-0.0 to Mile S3-9.6)								
1	Mile S3-0.0 to Mile S3-5.2	49.4	49.4	0.0		49.4	14.5	-34.9
2	Mile S3-5.2 to Mile S3-7.2	60.8	60.6	-0.2		105.5	14.2	-91.3
3	Mile S3-7.2 to Mile S3-7.9	33.6	30.6	-3.0		22.1	14.6	-7.5
4	Mile S3-7.9 to Mile S3-9.0	16.7	8.0	-8.7		1.8	14.3	+12.5
5	Mile S3-9.0 to Mile S3-9.6	0.0	15.0	+15.0		0.0	15.0	+15.0
Segment 3A (Mile S3-9.6 to Mile S3-35.2)								
6	Mile S3-9.6 to Mile S3-16.3	0.0	15.5	+15.5		0.0	15.5	+15.5
7	Mile S3-16.3 to Mile S3-22.1	0.0	8.5	+8.5		0.0	9.5	+9.5
8	Mile S3-22.1 to Mile S3-23.2	2.6	1.2	-1.4		10.9	14.7	+3.8
9	Mile S3-23.2 to Mile S3-33.8	0.0	8.5	+8.5		0.0	9.5	+9.5
10	Mile S3-33.8 to Mile S3-35.2	18.0	18.0	0.0		41.4	4.6	-36.8
Segment 2 (Mile S2-0.0 to Mile S2-21.6)								
11	Mile S2-0.0 to Mile S2-1.8	5.0	5.0	0.0		30.1	2.9	-27.2
12	Mile S2-1.8 to Mile S2-1.9	5.0	5.0	0.0		30.4	2.1	-28.3
13	Mile S2-1.9 to Mile S2-4.4	12.0	12.0	0.0		14.8	9.7	-5.1
14	Mile S2-4.4 to Mile S2-8.1	10.0	10.0	0.0		35.8	26.1	-9.7
15	Mile S2-8.1 to Mile S2-10.6	0.0	28.3	+28.3		0.0	28.3	+28.3
16	Mile S2-10.6 to Mile S2-14.0	10.0	10.0	0.0		28.7	11.6	-17.1
17	Mile S2-14.0 to Mile S2-14.8	10.0	9.0	-1.0		34.6	9.5	-25.1
18	Mile S2-14.8 to Mile S2-19.5	2.0	1.0	-1.0		47.3	39.3	-8.0
19	Mile S2-19.5 to Mile S2-21.6	43.1	30.8	-12.3		21.7	12.2	-9.5

Figure Ap-2-1. Magnetic Field Profiles – Area 1 (Mile S3-0.0 to Mile S3-5.2)

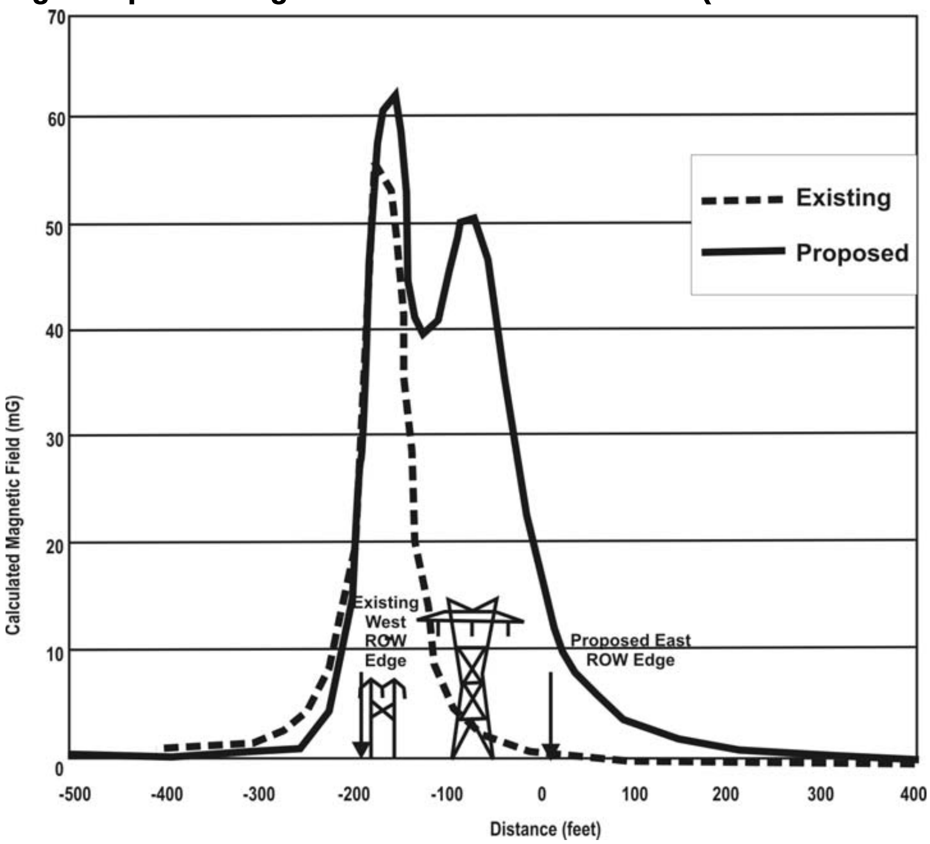


Figure Ap-2-2. Magnetic Field Profiles – Area 2 (Mile S3-5.2 to Mile S3-7.2)

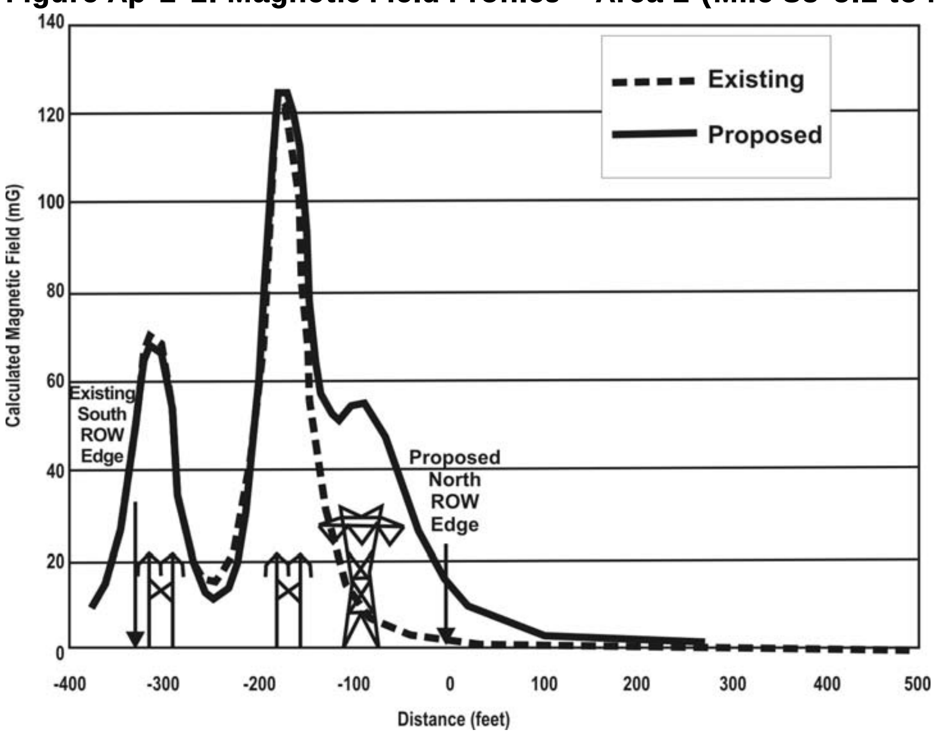


Figure Ap-2-3. Magnetic Field Profiles – Area 3 (Mile S3-7.2 to Mile S3-7.9)

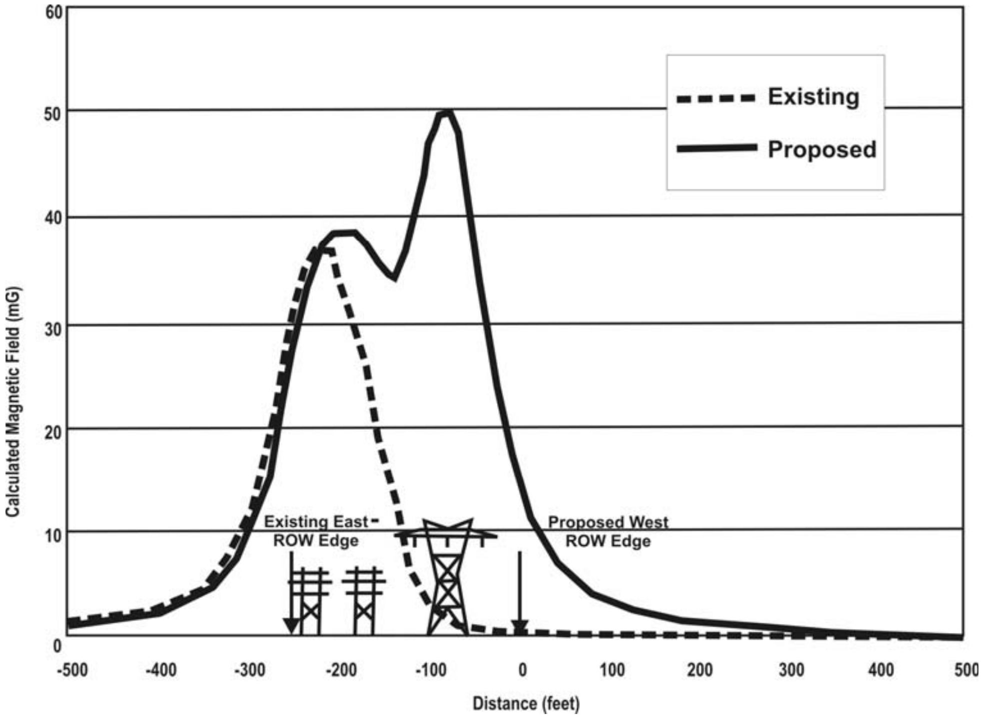


Figure Ap-2-4. Magnetic Field Profiles – Area 4 (Mile S3-7.9 to Mile S3-9.0)

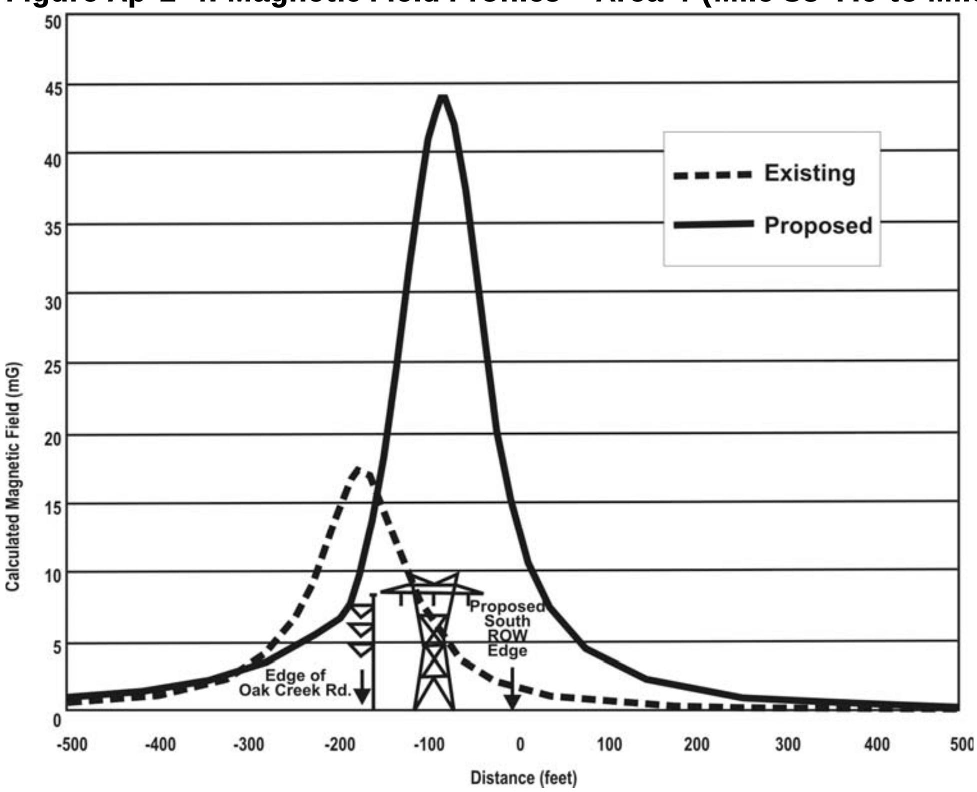


Figure Ap-2-5. Magnetic Field Profiles – Area 5 (Mile S3-9.0 to Mile S3-9.6)

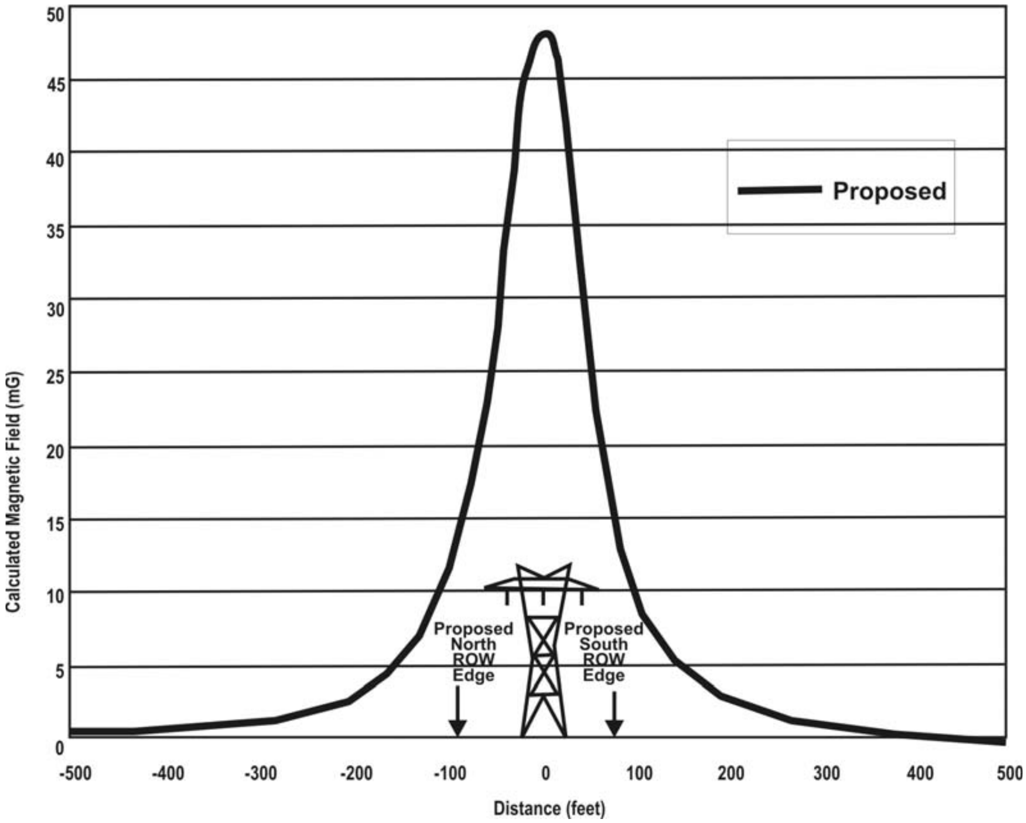


Figure Ap-2-6. Magnetic Field Profiles – Area 6 (Mile S3-9.6 to Mile S3-16.3)

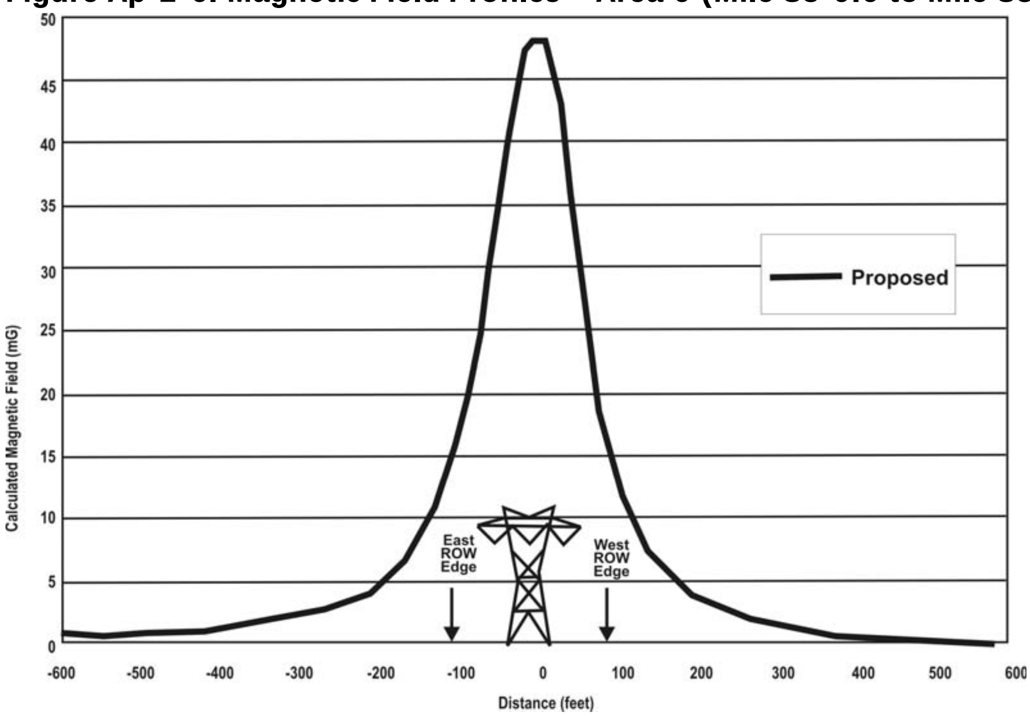


Figure Ap-2-7. Magnetic Field Profiles – Area 7 (Mile S3-16.3 to Mile S3-22.1)

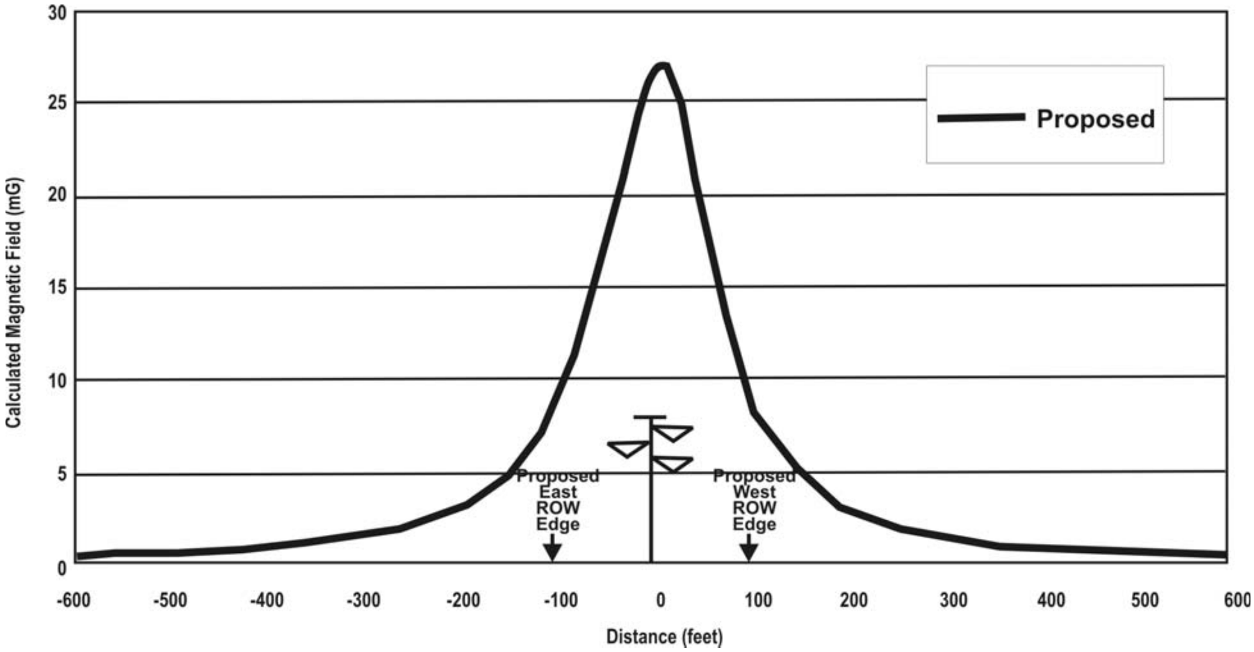


Figure Ap-2-8. Magnetic Field Profiles – Area 8 (Mile S3-22.1 to Mile S3-23.2)

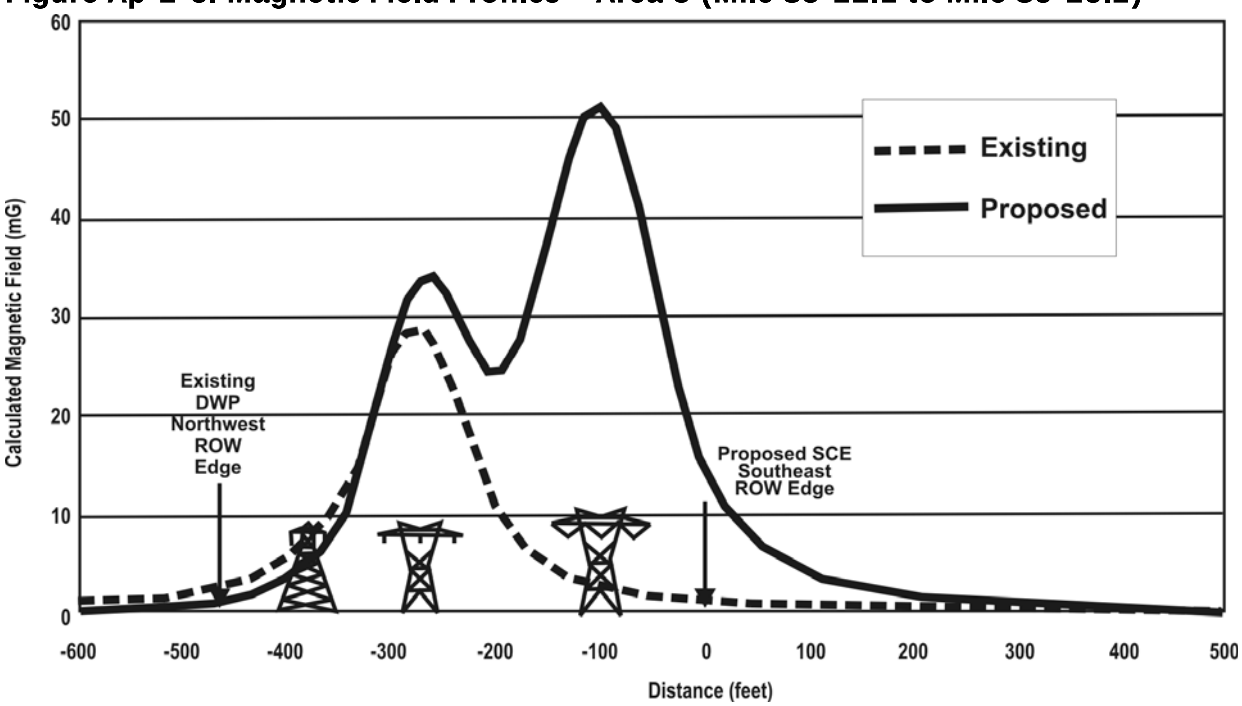


Figure Ap-2-9. Magnetic Field Profiles – Area 9 (Mile S3-23.2 to Mile S3-33.8)

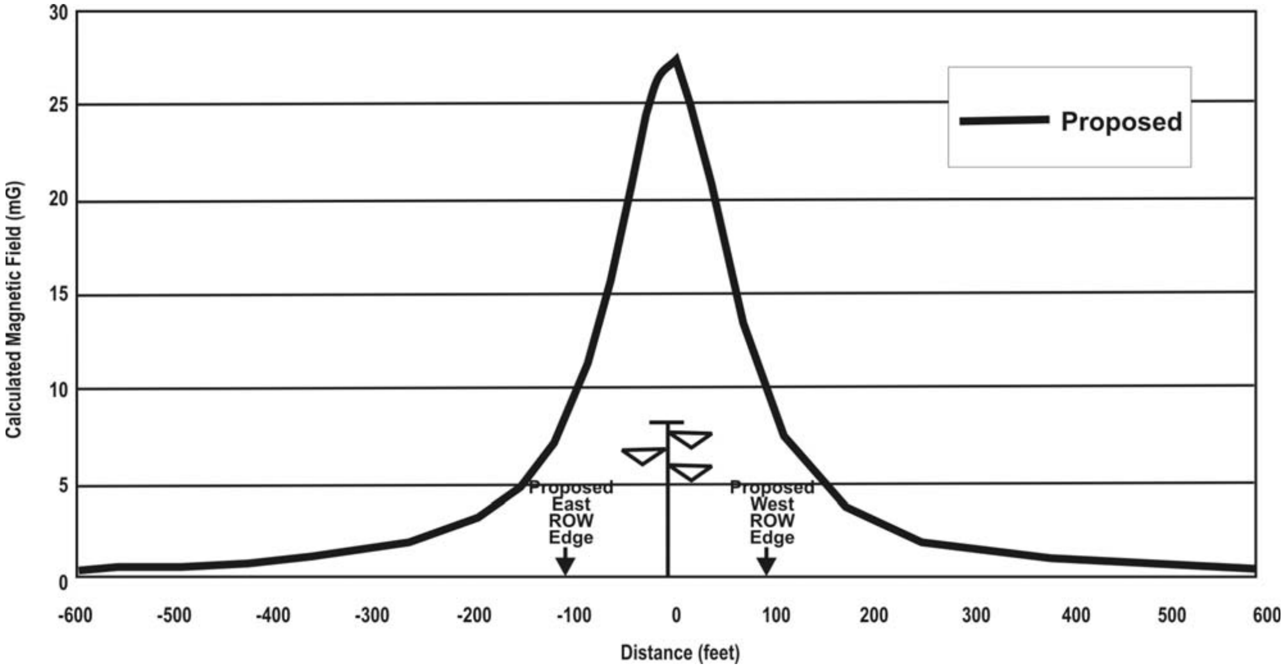


Figure Ap-2-10. Magnetic Field Profiles – Area 10 (Mile S3-33.8 to Mile S3-35.2)

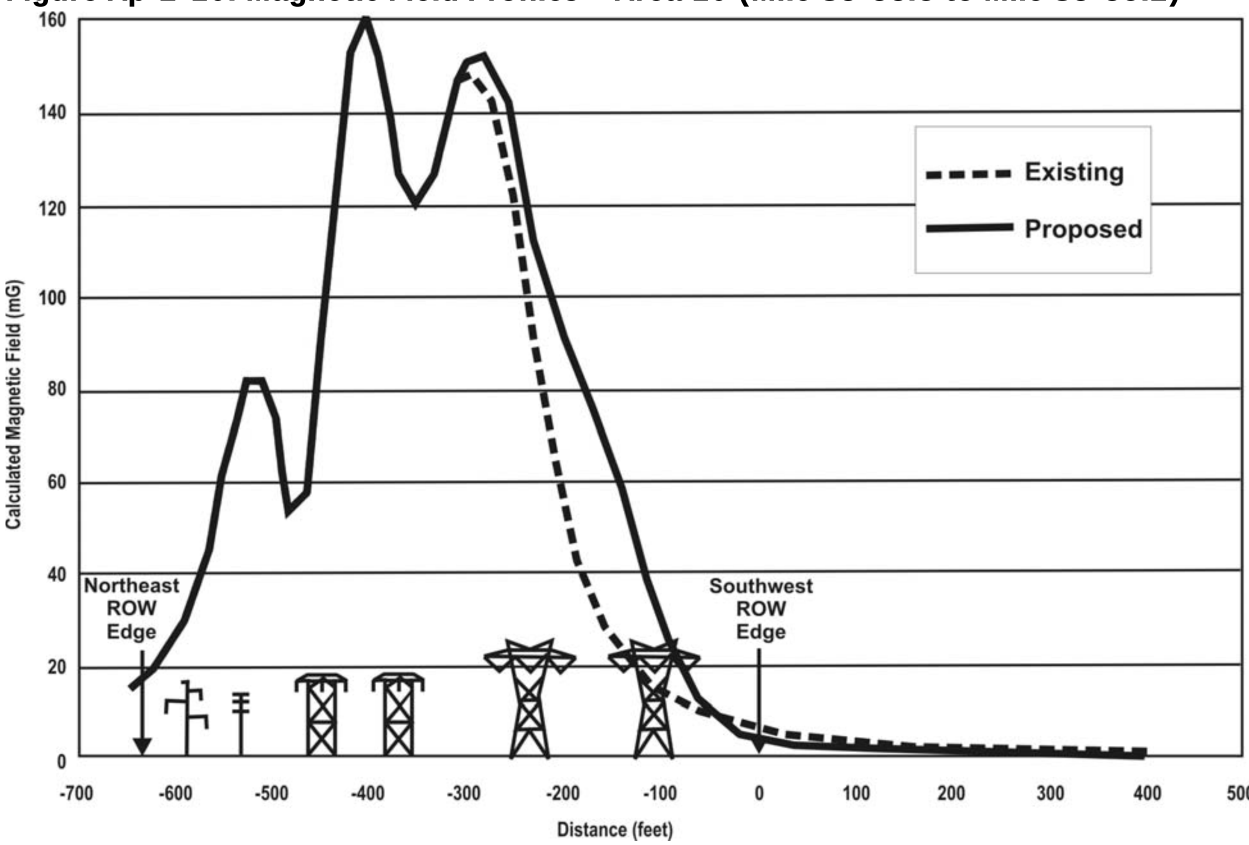


Figure Ap-2-11. Magnetic Field Profiles – Area 11 (Mile S2-0.0 to Mile S2-1.8)

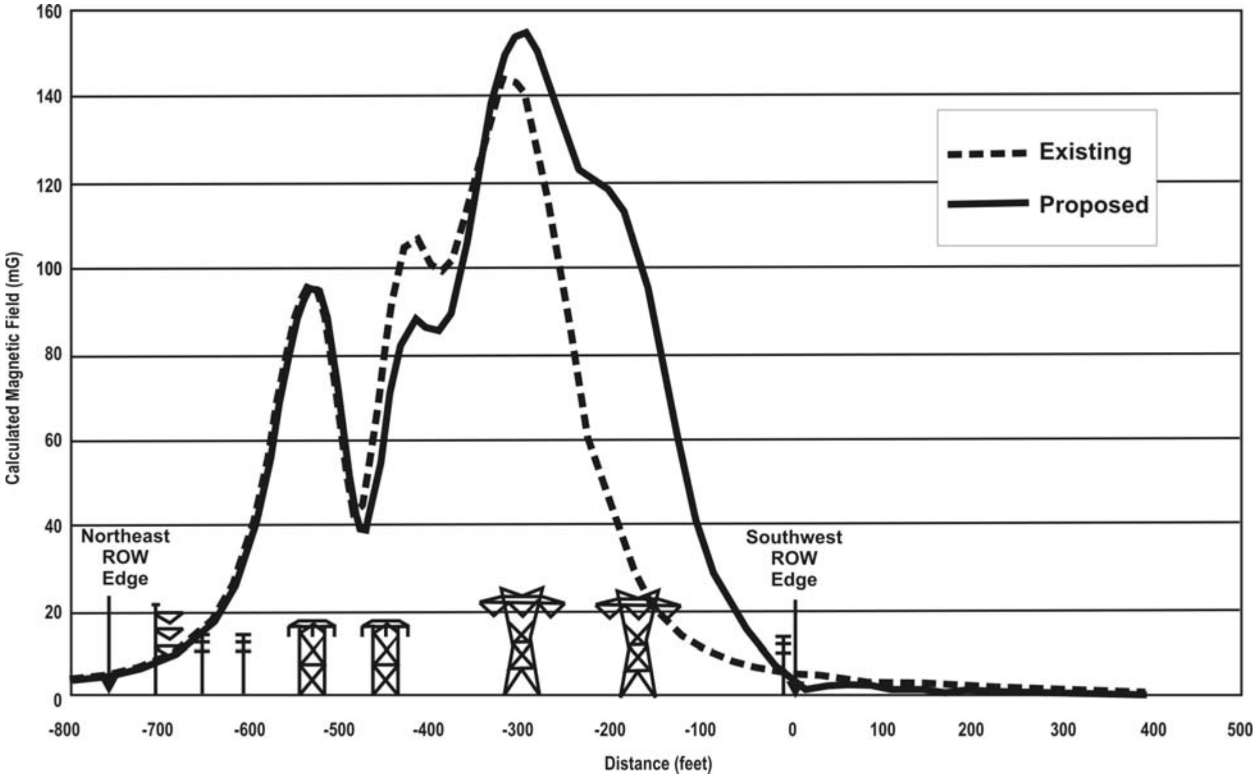


Figure Ap-2-12. Magnetic Field Profiles – Area 12 (Mile S2-1.8 to Mile S2-1.9)

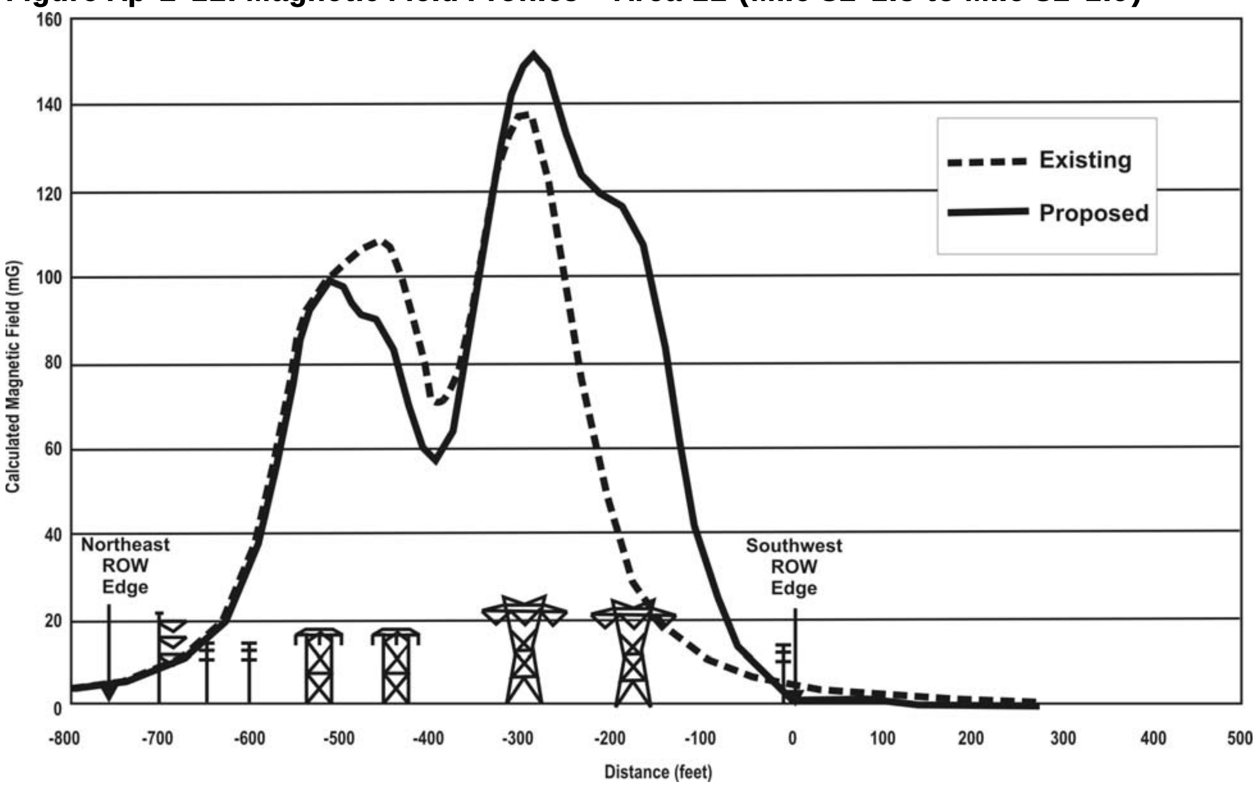


Figure Ap-2-13. Magnetic Field Profiles – Area 13 (Mile S2-1.9 to Mile S2-4.4)

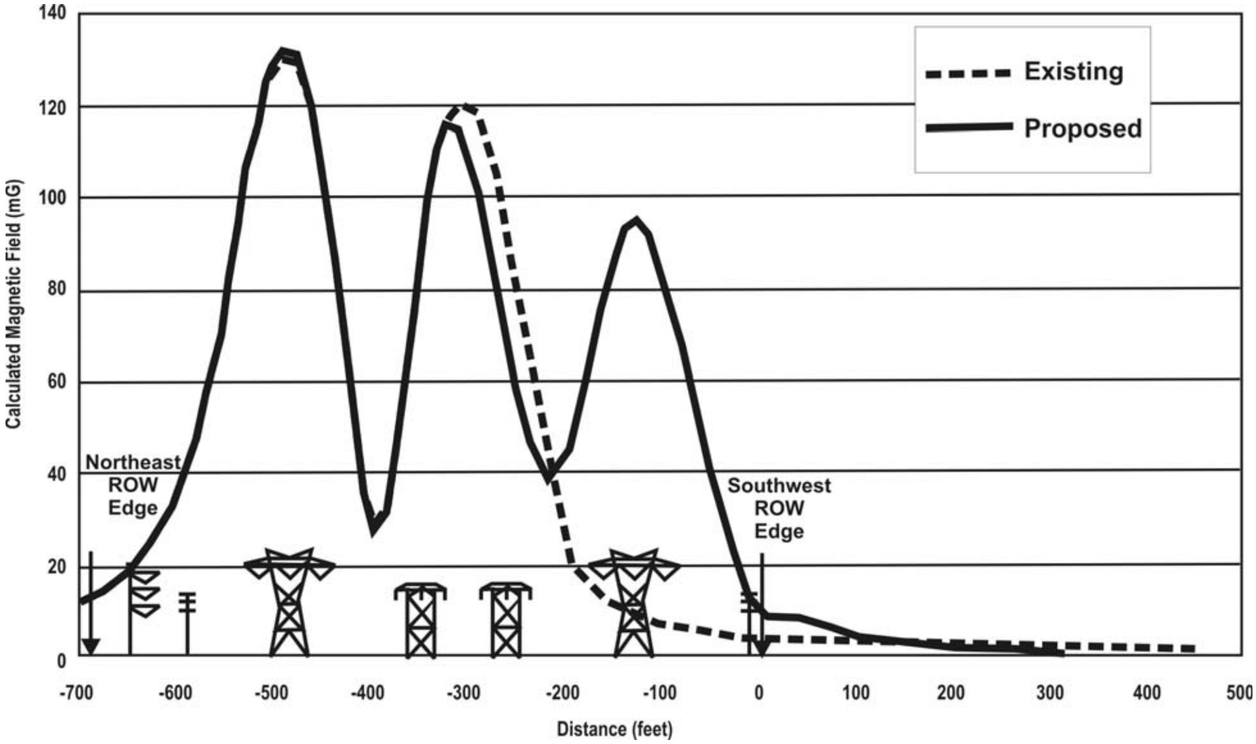


Figure Ap-2-14. Magnetic Field Profiles – Area 14 (Mile S2-4.4 to Mile S2-8.1)

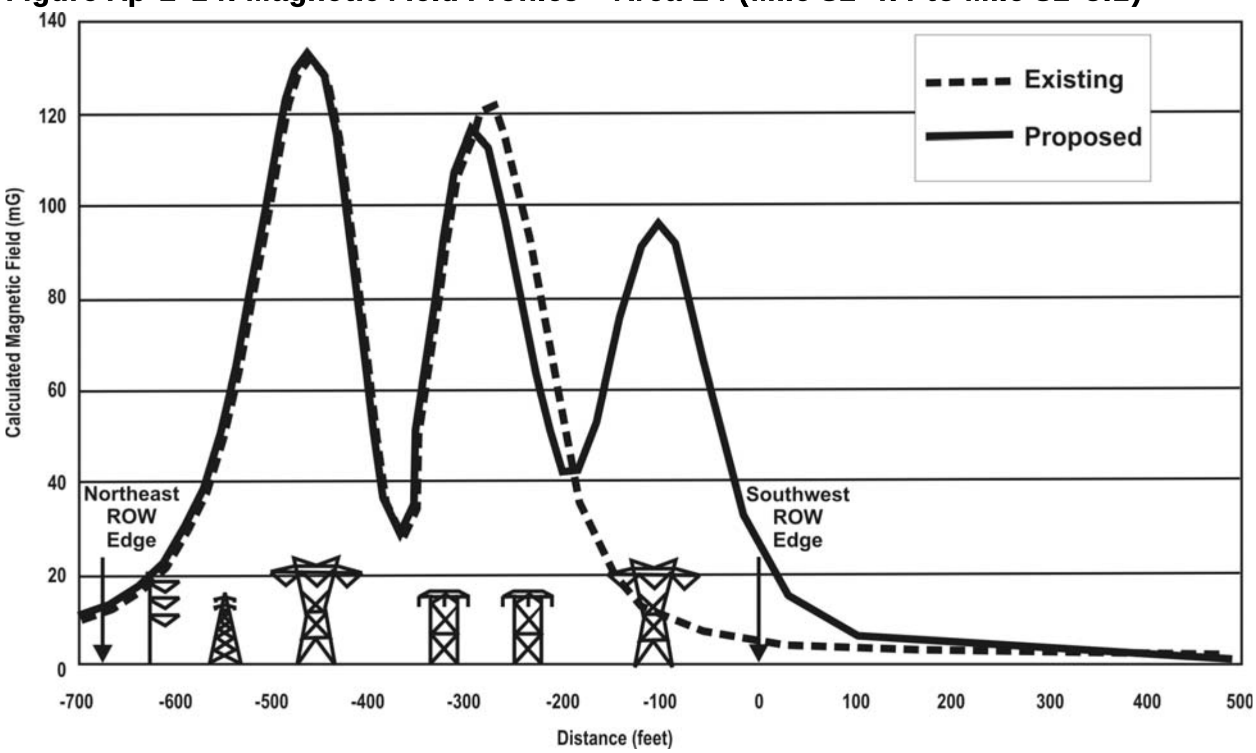


Figure Ap-2-15. Magnetic Field Profiles – Area 15 (Mile S2-8.1 to Mile S2-10.6)

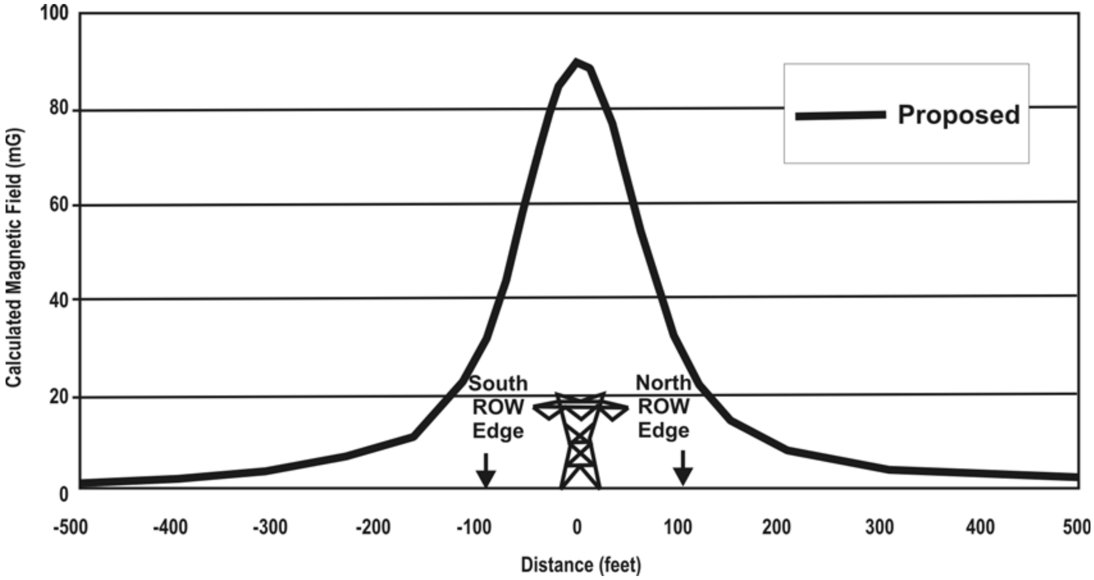


Figure Ap-2-16. Magnetic Field Profiles – Area 16 (Mile S2-10.6 to Mile S2-14.0)

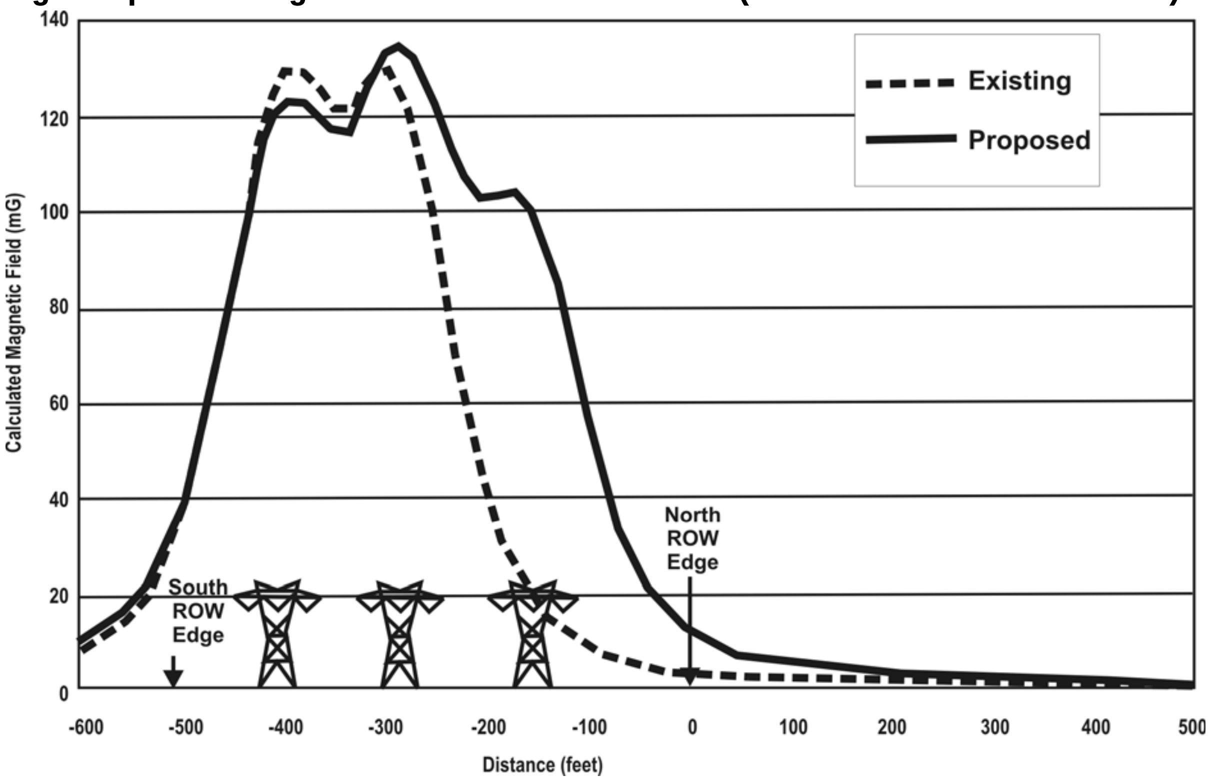


Figure Ap-2-17. Magnetic Field Profiles – Area 17 (Mile S2-14.0 to Mile S2-14.8)

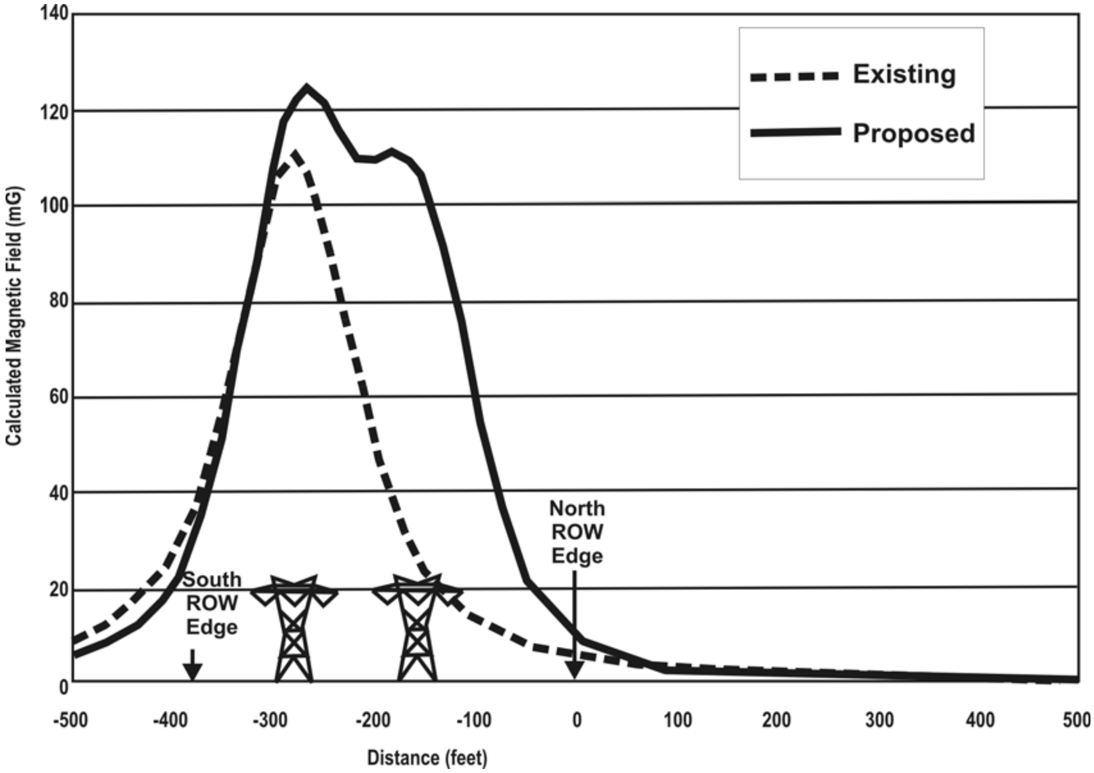


Figure Ap-2-18. Magnetic Field Profiles – Area 18 (Mile S2-14.8 to Mile S2-19.5)

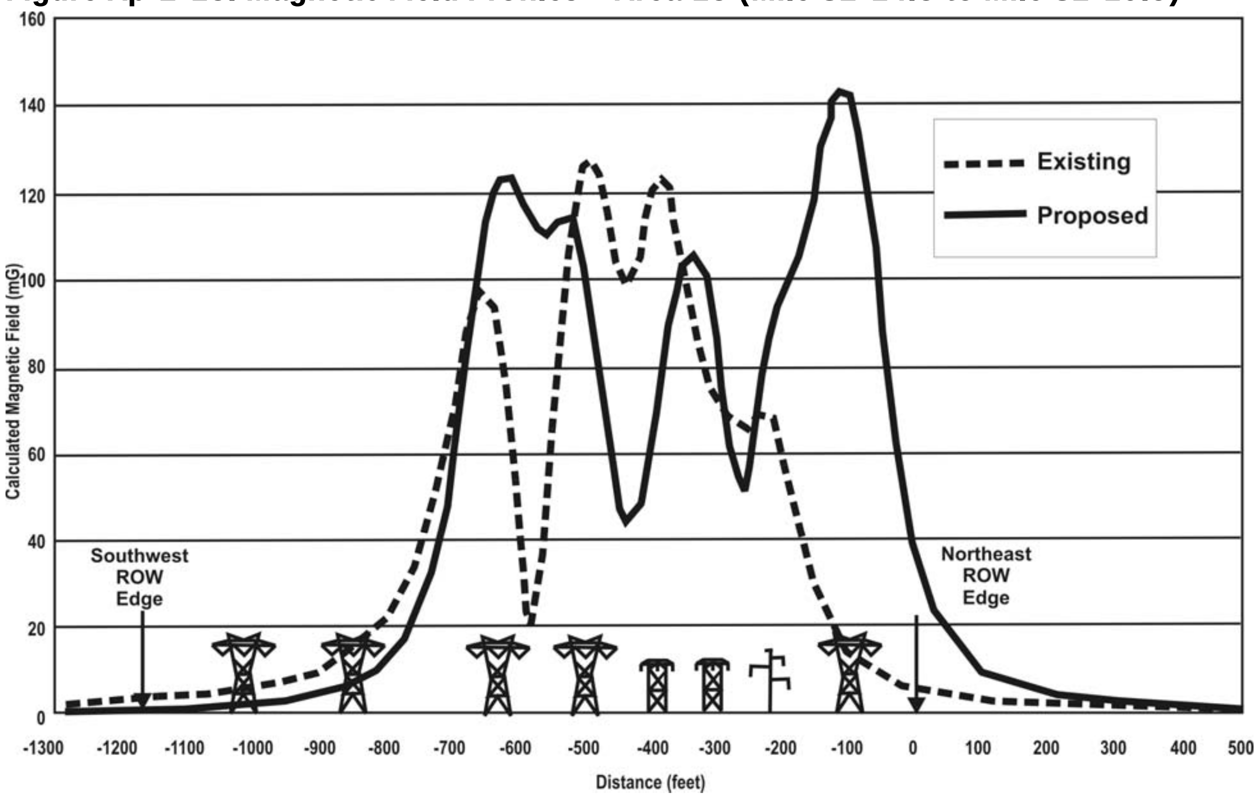
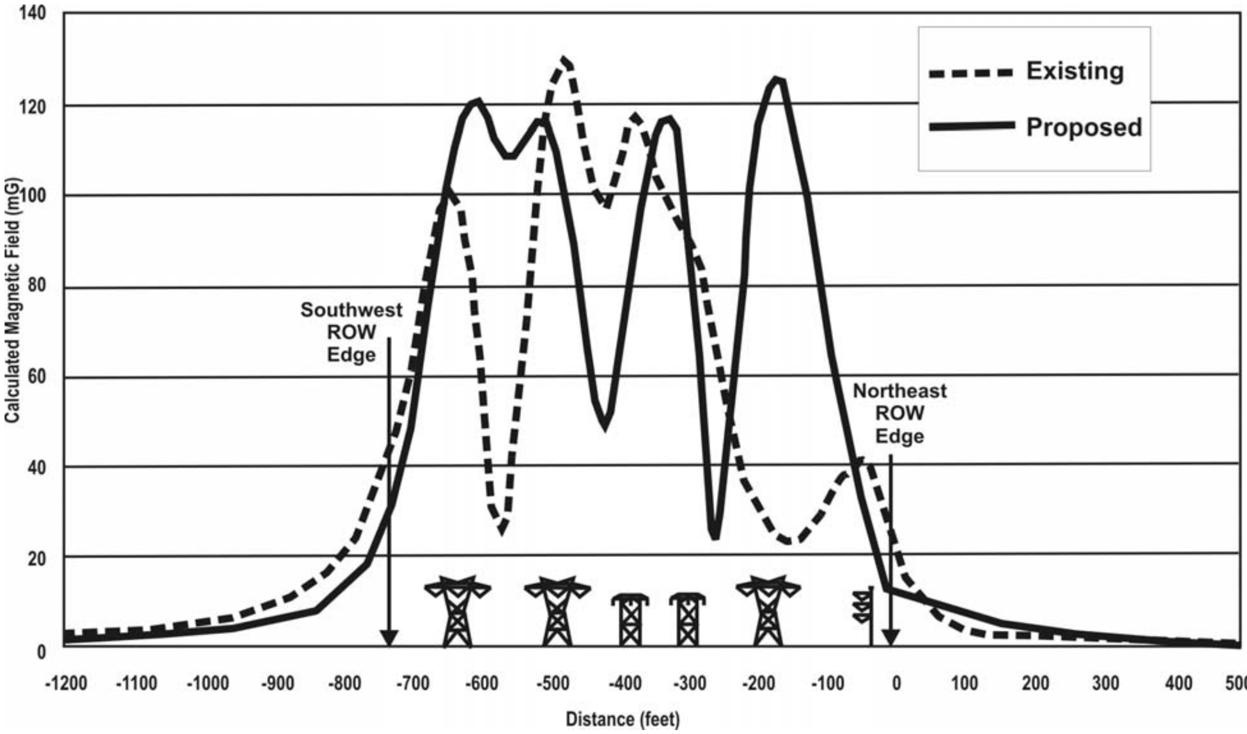


Figure Ap-2-19. Magnetic Field Profiles – Area 19 (Mile S2-19.5 to Mile S2-21.6)



Electric fields from power lines do not typically pose interference problems for electronic equipment in businesses since the equipment is shielded by buildings and walls. However, magnetic fields can penetrate buildings and walls thereby interacting with electronic equipment. Depending upon the sensitivity of equipment, the magnetic fields can interfere with equipment operation. Review of this phenomenon in regard to the sensitivity of electrical equipment identifies a number of thresholds for magnetic field interference. Interference with typical computer monitors can be detected at magnetic field levels of 10 mG and above, while large screen or high-resolution monitors can be susceptible to interference at levels as low as 5 mG. Other specialized equipment, such as medical equipment or testing equipment can be sensitive at levels below 5 mG. Equipment that may be susceptible to very low magnetic field strengths is typically installed in specialized and controlled environments, since even building wiring, lights, and other equipment can generate magnetic fields of 5 mG or higher.

The most common electronic equipment that can be susceptible to magnetic field interference is probably computer monitors. Magnetic field interference results in disturbances to the image displayed on the monitor, often described as screen distortion, “jitter,” or other visual defects. In most cases, it is annoying and, at its worst, it can prevent use of the monitor. This type of interference is a recognized problem in the video monitor industry. As a result, there are manufacturers who specialize in monitor interference solutions and shielding equipment. Possible solutions to this problem include: relocation of the monitor, use of magnetic shield enclosures, software programs, and replacement of cathode ray tube monitors with liquid crystal displays that are not susceptible to magnetic field interference.

2.5 Methods to Reduce EMF

EMF levels from transmission lines can be reduced in three primary ways: shielding, field cancellation, or increasing the distance from the source. Shielding, which primarily reduces exposure to electric fields, can be actively accomplished by placing trees or other physical barriers along the transmission line ROW. Shielding also results from existing structures the public may use or occupy along the line. Since electric fields can be blocked by most materials, shielding is effective for the electric fields but is of limited effectiveness for magnetic fields.

Magnetic fields can be reduced either by cancellation or by increasing distance from the source. Cancellation is achieved in two ways. A transmission line circuit consists of three “phases”: three separate wires (conductors) on a transmission tower. The configuration of these three conductors can reduce magnetic fields. First, when the configuration places the three conductors closer together, the interference, or cancellation, of the fields from each wire is enhanced. This technique has practical limitations because of the potential for short circuits if the wires are placed too close together. There are also worker safety issues to consider if spacing is reduced. Second, in instances where there are two circuits (more than three phase wires), such as in the Proposed Project, cancellation can be accomplished by arranging phase wires from the different circuits near each other. In underground lines, the three phases are typically much closer together than in overhead lines because the cables are insulated (coated).

The distance between the source of fields and the public can be increased by either placing the wires higher above ground, burying underground cables deeper, or by increasing the width of the ROW. For transmission lines, these methods can prove effective in reducing fields because the reduction of the field strength drops rapidly with distance.

SCE’s Proposed EMF Mitigation

In accordance with CPUC Decision D.93-11-013, SCE proposes to incorporate “no-cost” and “low-cost” magnetic field reduction steps in the proposed transmission and substation facilities. SCE proposed specific measures to reduce EMF in its Field Management Plan for the proposed Project. Following are the measures that would reduce magnetic fields:

Segment 3

- Phasing the proposed Antelope-Substation One 500-kV transmission line for magnetic field cancellation with existing transmission lines and subtransmission lines
- Utilizing compact conductor configuration (500-kV tubular steel poles) for portions of the line route
- Routing the proposed Antelope-Substation One 500-kV transmission line and Substation One-Substation Two 220-kV transmission line away from residences
- Phasing the proposed Substation One-Substation Two 220-kV transmission line for field cancellation with the existing Sagebrush-Skyriver 220-kV transmission line and subtransmission lines (Transpositions would be required to phase portions of the transmission line routes for field reduction. The cost for these transpositions would be low-cost).
- Widening existing subtransmission ROWs by 160 feet for the proposed Substation One-Substation Two 220-kV transmission line route

- Locating transformers to maintain distances greater than 50 feet away from the substation property lines at Substation One and Substation Two
- Locating switchracks, capacitors and busses to maintain distances greater than 40 feet away from the substation property lines at Substation One and Substation Two.

Segment 2

- Phasing the proposed Antelope-Vincent 500-kV transmission line for magnetic field cancellation with existing transmission lines and subtransmission lines
- Constructing the relocated Antelope-Anaverde 66-kV line and the Antelope-Acton-Palmdale-Shuttle 66-kV on 75-foot-tall steel poles that are 5 feet taller than existing structures
- Constructing the relocated Antelop-Anaverde 66-kV line and the Antelope-Acton-Palmdale-Shuttle 66-kV utilizing compact TO 352 construction meeting the preferred design specification for 66-kV lines as defined in SCE's EMF Design Guidelines
- Phasing the relocated Antelope-Anaverde 66-kV line and the Antelope-Acton-Palmdale-Shuttle 66-kV for magnetic field cancellation with existing and proposed transmission lines
- Widening the existing ROW by 180 feet
- Routing portions of the proposed 500-kV transmission line further away from future residential development
- Phasing the replacement for the Midway-Vincent 500-kV No. 3 transmission line for magnetic cancellation with existing transmission lines (Transpositions would be required to phase portions of the transmission line routes for field reduction. The cost for these transpositions would be below 4% of the project cost.)
- Placing the replacement for the existing Midway-Vincent 500-kV No. 3 transmission line between the Sagebrush 220-kV transmission line ROW and the existing SCE 200-kV transmission lines for portions of the line route.

SCE's plan for reducing magnetic fields for the proposed Project is consistent with the CPUC's Interim EMF Opinion Decision No. 93-11-013 ("1993 CPUC Decision") and also with recommendations made by the U.S. National Institute of Environmental Health Sciences. Furthermore, the recommendations above meet CPUC-approved EMF Design Guidelines as well as all national and state safety standards for new electric facilities.