APPENDIX C

Electric and Magnetic Fields Supplemental Information

Electric and Magnetic Fields Supplemental Information

Electric and Magnetic Fields Analysis for the Underground

Segment Field Management Plan

ELECTRIC AND MAGNETIC FIELDS SUPPLEMENTAL INFORMATION

OVERVIEW

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 EMF resulting from the proposed project. The CPUC does not consider EMF to be an environmental issue in the context of CEQA because there is no agreement among scientists that EMF creates a health risk, and because CEQA does not define or adopt standards for defining any potential risk from EMF. The following EMF information is therefore presented for the benefit of the public and decision makers, but is not considered within the context of CEQA.

Other concerns related to power lines[1] include nuisance (corona and audible noise; radio; television; electronic equipment interference) and potential health risks (induced currents and shock hazards, and effects on cardiac pacemakers). The effects of audible corona noise are evaluated in Section 4.9: Noise. Impacts regarding radio, television, and electronic equipment interference and impacts to cardiac pacemakers are addressed in Section 8: Additional CEQA Considerations. Induced current and shock hazards are evaluated in Section 4.6: Hazards and Hazardous Materials.

DEFINING ELECTRIC AND MAGNETIC FIELDS

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 EMF 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 electric and magnetic fields 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

[1] The term "power line" in this section refers generally to electric lines of all voltage classes operating in SCE's electric system. However, CPUC GO 131-D distinguishes between distribution lines ("designed to operate under 50 kV"), power lines ("designed to operate between 50 and 200 kV"), and transmission lines ("designed to operate at or above 200 kV").

countries, the frequency of electric power is 50 Hz. Radio and communication waves operate at much higher frequencies: from approximately 3,000 Hz (3 kilohertz) to approximately 300,000,000,000 Hz (300 gigahertz). The information presented in this document is limited to the EMF from power lines operating at frequencies of 50 or 60 Hz.

Electric power flows across utility electric systems from generating sources to serve electrical loads within the community. The power flowing over these lines is determined by the line’s voltage and current. The higher the voltage level of the line, the lower the amount of current needed to deliver the same amount of power. For example, a 115-kV power line with 200 amps of current will 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.

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 in many locations because they are effectively shielded by most objects or materials, such as trees or buildings.

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. 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, with others including how effectively the person is grounded and their body surface area within the electric field.

Electric fields 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 small nuisance electric discharges when touching long metal fences, pipelines, or large vehicles. An acknowledged potential impact to public health from electric lines is the hazard of electric shock: electric shocks from the lines are generally the result of accidental or unintentional human contact with the energized wires. The issue of induced currents and shock hazards is addressed in Section 4.7: Hazards and Hazardous Materials.

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, no current flows through it. Under such circumstances, 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 is still present and a magnetic field is 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.

SCIENTIFIC BACKGROUND AND REGULATIONS APPLICABLE TO EMF

EMF Research

For more than 20 years, questions have been asked regarding the potential effects 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 human 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.[2]

Research related to EMF can be grouped into three general categories: cellular level studies, animal and human experiments, and epidemiological studies. Epidemiological studies have provided mixed results, with some studies showing an apparent relationship between magnetic fields and health effects while other similar studies do not. Laboratory studies and studies investigating a possible mechanism for health effects (mechanistic studies) provide little or no evidence to support this link.

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, N. and Leeper, E., 1979). This study observed a statistical association between the high-current configuration (the “wire code”) of electric power lines outside of homes in Denver and the incidence of childhood cancer. The "wire code" was assumed to be related to current flow of the line. The study did not take measurements of

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[2] The power frequencies (50/60 Hz) are part of the ELF (3 Hz to 300 Hz) bandwidth.

magnetic field intensity. Since publication of the Wertheimer and Leeper study, many epidemiological, laboratory, and animal studies regarding EMF have been 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; Silva, Hummon, Rutter, & Hooper, 1988). Immediately adjacent to appliances (within 12 inches), field values are much higher.

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 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 not effective 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 portions of the proposed project, cancellation can be accomplished by arranging phase wires from the different circuits that are near each other. In underground lines, the three phases typically can be placed much closer together than for overhead lines because the cables are placed in dielectric conduits.

The distance between the source of fields and the public can be increased by either placing the wires higher aboveground, 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.

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; WHO, 2001; WHO, 2007), the international Non-Ionizing Radiation Committee of the International Radiation Protection Association (IRPA/INIRC, 1990), and governmental agencies of a number of countries, such as the U.S. Environmental Protection Agency (EPA), the National Radiological Protection Board of the United Kingdom, the Health Council of the Netherlands, and the French and Danish Ministries of Health.

As noted below, these scientific panels have varied conclusions on the strength of the scientific evidence suggesting that power frequency EMF exposures pose any health risk.

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 probable human carcinogen. However, a majority of the members of this Working Group concluded that exposure to power-line frequency ELF-EMF is a possible carcinogen.

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 of 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 CPUC, the California Department of Health Services (DHS) 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 or make any specific recommendations to the CPUC.

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.

The 2007 WHO [Environmental Health Criteria 238] report concluded that:

- Evidence for a link between Extremely Low Frequency (50 to 60 Hz) magnetic fields and health risks is based on epidemiological studies demonstrating a consistent pattern of increased risk for childhood leukemia. However, "…virtually all of the laboratory evidence and the mechanistic evidence fail to support a relationship between low-level ELF magnetic fields and changes in biological function or disease status…the evidence is not strong enough to be considered causal but sufficiently strong to remain a concern."
- "For other diseases, there is inadequate or no evidence of health effects at low exposure levels."

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 the guidelines and regulatory activity regarding EMF.

International Guidelines

The International Radiation Protection Association, in cooperation with the World Health Organization, has published recommended guidelines (ICNIRP, 2010) for electric and magnetic field exposures. For the general public, the limits are 5 kV/m for electric fields and 2,000 mG for magnetic fields. Neither of these organizations has any governmental authority or 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 EPA has conducted investigations into EMF related to power lines and health risks, no national standards have been established. There have been a number of studies sponsored by the EPA, the Electric Power Research Institute, and other institutions. 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. 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 grassroots efforts.

California has not adopted exposure limits for power frequency electric or magnetic fields.

California Department of Education's Standards for Siting New Schools Adjacent to Electric Power Lines Rated 50-kV and Above

The California Department of Education (CDE) evaluates potential school sites under a range of criteria, including environmental and safety issues. There are no EMF guidelines that apply to existing school sites; this information is presented to demonstrate the range of existing guidelines that address EMF. Exposures to power-frequency EMF are one of the criteria. CDE has established "setback" limits for locating any part of a school site property line near the edge of easements for any electrical power lines rated 50-kV and above.

The setbacks from overhead transmission line easements are:

- 100 feet for lines from 50- to 133-kV
- 150 feet for lines from 220- to 230-kV
- 350 feet for lines from 500- to 550-kV

The setbacks from underground transmission line easements are:

- 25.0 feet for lines from 50- to 133-kV (interpreted by CDE up to 200-kV)
- 37.5 feet for lines from 220- to 230-kV
- 87.5 feet for lines from 500- to 550-kV

School districts that have sites that do not meet the CDE setbacks may still obtain construction approval from the State by submitting an EMF mitigation plan. The mitigation plan should consider possible reductions of EMF from all potential sources, including power lines, internal wiring, office equipment, and mechanical equipment.

CPUC Guidelines

In 1991, the CPUC initiated an investigation into electric and magnetic fields 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 GO 131-D.4. 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.

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 4-year education program
- A 4-year non-experimental and administrative research program
- An authorization of federal experimental research conducted under the National Energy Policy Act of 1992.

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 and upgraded utility power lines, transmission line and substation projects. This decision also included 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." At this time, the CPUC has not implemented a general requirement that utilities include non-routine mitigation measures, or other mitigation measures that are based on numeric values of EMF exposure, and has not adopted any specific limits or regulation on EMF levels related to electric power facilities. Mitigation measures may be determined on a project-by-project basis by the CPUC.

EMF DATA APPLICABLE TO THE PROPOSED PROJECT

The proposed project consists of the installation of approximately 10 miles of new 230-kV transmission line. The project alignment includes developed areas and agricultural lands. Public exposure to EMFs in developed areas is more widespread and encompasses a very broad range of field sources, intensities, and durations.

The magnetic field levels along the proposed ROW from the proposed project can be modeled. The values calculated in an EMF model represent the magnetic field intensities for a hypothetical set of power flow conditions. The current flowing over a transmission line continuously varies based on customer demand, both over the course of a day and over the decades the transmission line will be in service, and the associated magnetic fields vary with the current flows. The periods during the day when the highest power use occurs are referred to as "daily peaks." These peaks will vary seasonally. In Southern California, the highest daily peaks occur typically during the summer when air conditioning use is at its highest. Further, over the years as communities and electric consumption grow, the magnitude of daily and seasonal peaks may also increase over time.

As noted, the magnetic field information for the project is not based on field measurement; rather it is based on modeling, which does not predict actual field levels. In CPUC Decision D.06-01-042 (p. 11), the CPUC acknowledged that the purpose of magnetic field modeling is "to measure the relative differences between alternative mitigation measures." Modeling also allows for comparison of magnetic fields in the existing environment and from the proposed project.

For the proposed project, SCE modeled magnetic fields for the proposed project with and without EMF mitigation. The model calculated existing EMF values (where applicable) and predicted EMF values before and after implementation of mitigation measures to reduce EMF; these values are presented in Table C-1. EMF values were modeled for both sides of the ROW. The EMF values are presented in mG as calculated at both edges of the 100-foot-wide ROW.

Table C-1 Existing, Proposed, and Mitigated EMF Values for the Proposed Project[1]

Location	Vista-Wildlife Side of ROW				Mira Loma-Wildlife Side of ROW			
	Existing (mG)	Proposed (mG)	Mitigated (mG)[2]	Change (%)	Existing (mG)	Proposed (mG)	Mitigated (mG)[2]	Change (%)
230-kV LST structures throughout the transmission route (certain locations)	---	18.6	13.0	30.1	---	12.6	6.7	46.8
230-kV TSP structures throughout the transmission route (all locations)	---	18.8	13.1	30.3	---	13.0	6.9	46.9
Underground transmission route [3]	---	63.4	9.5 - 10.1	85.0 - 84.1	---	15.5	3.0 - 4.4	80.7 - 71.6

Note:

1 EMF values were not modeled for the proposed Wildlife Substation.

2 The mitigated EMF value represents EMF value after adopted mitigation only; it does not include any additional decrease in EMF value from mitigation not adopted. For the underground transmission route, the mitigated EMF values consider design options

3 Magnetic field strength was modeled at a height of 1 meter above ground. Phase cable arrangement option 1 from SCE's EMF Analysis for the Underground Segment represents unmitigated EMF values for the proposed project. Phase cable arrangement options 2 and 3 represent mitigated values.

Sources: (SCE, 2015; SCE, 2016)

SCE'S PROPOSED EMF MITIGATION

SCE reviewed all portions of the transmission line in the scope of the proposed project for implementation of magnetic field reduction measures. SCE would implement low- and no-cost measures to reduce magnetic field levels for the proposed project using the 4 percent CPUC benchmark, and SCE's *RTRP Field Management Plan* filed with the CPUC in compliance with CPUC Decisions 93-11-013 and 06-01-042. These low- and no-cost measures are described in the Field Management Plan SCE submitted as part of its application for a CPCN, which is enclosed in Appendix C. The measures SCE considered for the proposed project are summarized in Table C-2.

If the revised project or an alternative is approved, the CPUC would monitor implementation of the measures included in SCE's *RTRP Field Management Plan*. These measures would be included in the Mitigation Monitoring and Compliance Reporting Program (MMCRP).

Table C-2 Low- and No-Cost Mitigation Measures SCE Proposed for the Proposed Project

Project Component(s)	EMF Reduction Design Option Considered	Estimated Cost to Adopt[1]	Design Option Adopted?
230-kV LST structures throughout the transmission route (certain locations)	Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction	No-cost	Yes
	Phase (arrange) conductors of the proposed transmission line for magnetic field reduction	No-cost	Yes
	Raise the lowest conductor ground clearance	Low-cost	Yes[2]
230-kV TSP structures throughout the transmission route (all locations)	Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction	No-cost	Yes
	Phase conductors of the proposed transmission line for magnetic field reduction	No-cost	Yes
	Raise the lowest conductor ground clearance	Low-cost	Yes[2]
Underground Transmission Line Segment	Arrange underground conductors to reduce magnetic field	No-cost	Yes

Notes:

1 "No-cost" options were included in the preliminary design and continue to be included in the design of the proposed project.

2 Preliminary engineering for the proposed project suggests this design option may be reasonable; however, the feasibility of this design option will be determined during final engineering.

Sources: (SCE, 2015; SCE, 2016)

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APPENDIX C

Electri and Magnetic Fields Supplemental Information

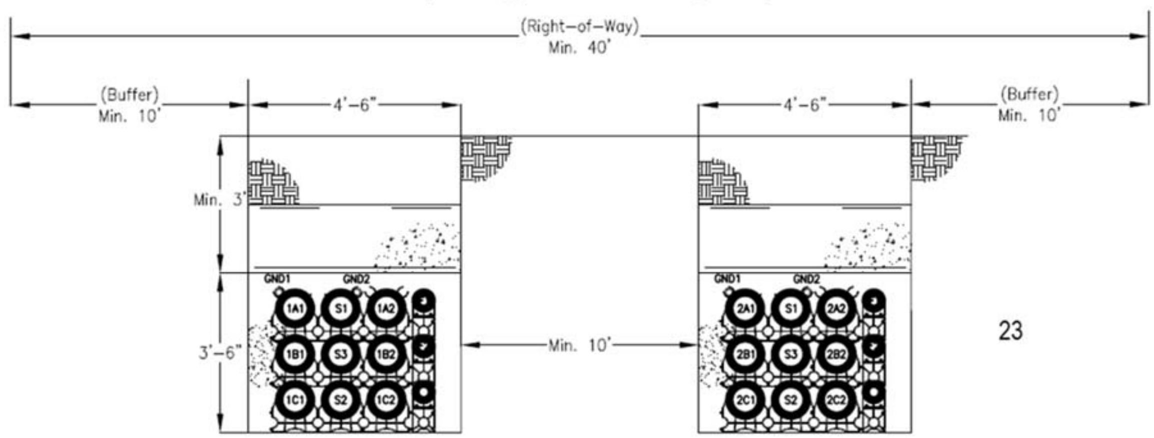
Riverside Transmission Reliability Project (RTRP) Hybrid Route

EMF Analysis for the Underground Segment

In response to the CPUC data request A. 15-03-013 Question 19, the following EMF analysis is based on preliminary engineering design with a set of assumptions. The purpose of the EMF analysis is not to predict the actual magnetic field levels of the underground construction transmission line (T/L) segment, but to compare various design options for no-cost and low-cost field reduction measures.

Typical cross-sectional of the proposed 230 kV T/L construction method is shown in the figure below. Magnetic field levels at the edge of the right-of-way (ROW) were evaluated for no-cost and low-cost field reduction measures.

(Looking South or Looking East)



Double Circuit 230 kV Duct Bank
(Typical)

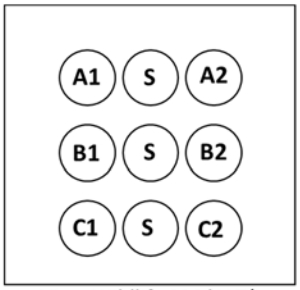
Vista-Wildlife 230 kV T/L **Mira Loma-Wildlife 230 kV T/L**

Assumptions in EMF Analysis:

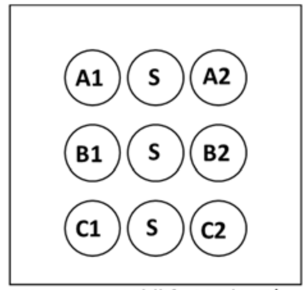
- Forecasted peak load flows for Year 2024 are used in EMF calculations
- Vista-Wildlife and Mira Loma-Wildlife 230 kV T/L have opposite load flow directions under normal operating conditions
- Each T/L circuit has two sub-circuits
- Edges of duct banks were assumed to be at least 10 feet from ROW edges
- Evaluations are done for majority of the underground segment, not for areas with vault or horizontal directional drillings (HDD)
- Magnetic field strength was calculated at a height of 1 meter (3.28 feet) above ground
- Underground T/L cables are assumed to be flat and infinitely long
- Terrain was assumed to be flat
- EMF unit is milliGauss (mG)

Four options of phase cable arrangement were chosen for evaluation for the range of EMF levels. EMF levels of all other arrangement options would be equivalent or fall in between these four options.

Option 1 (ABC-ABC and ABC-ABC)

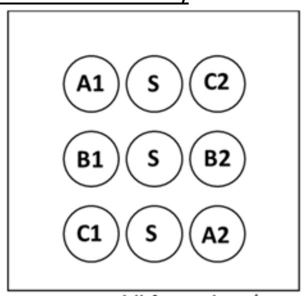


Vista-Wildlife 230 kV T/L

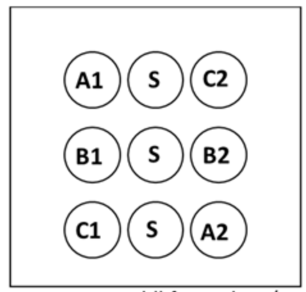


Mira Loma-Wildlife 230 kV T/L

Option 2 (ABC-CBA and ABC-CBA)

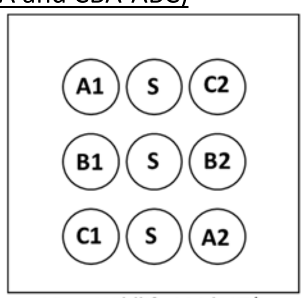


Vista-Wildlife 230 kV T/L

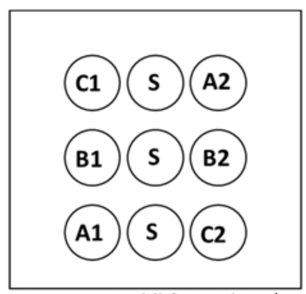


Mira Loma-Wildlife 230 kV T/L

Option 3 (ABC-CBA and CBA-ABC)

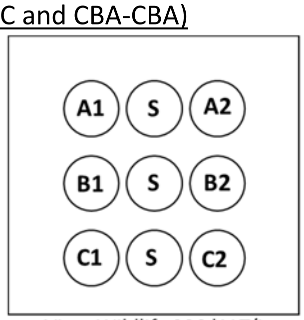


Vista-Wildlife 230 kV T/L

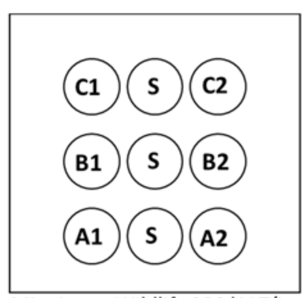


Mira Loma-Wildlife 230 kV T/L

Option 4 (ABC-ABC and CBA-CBA)



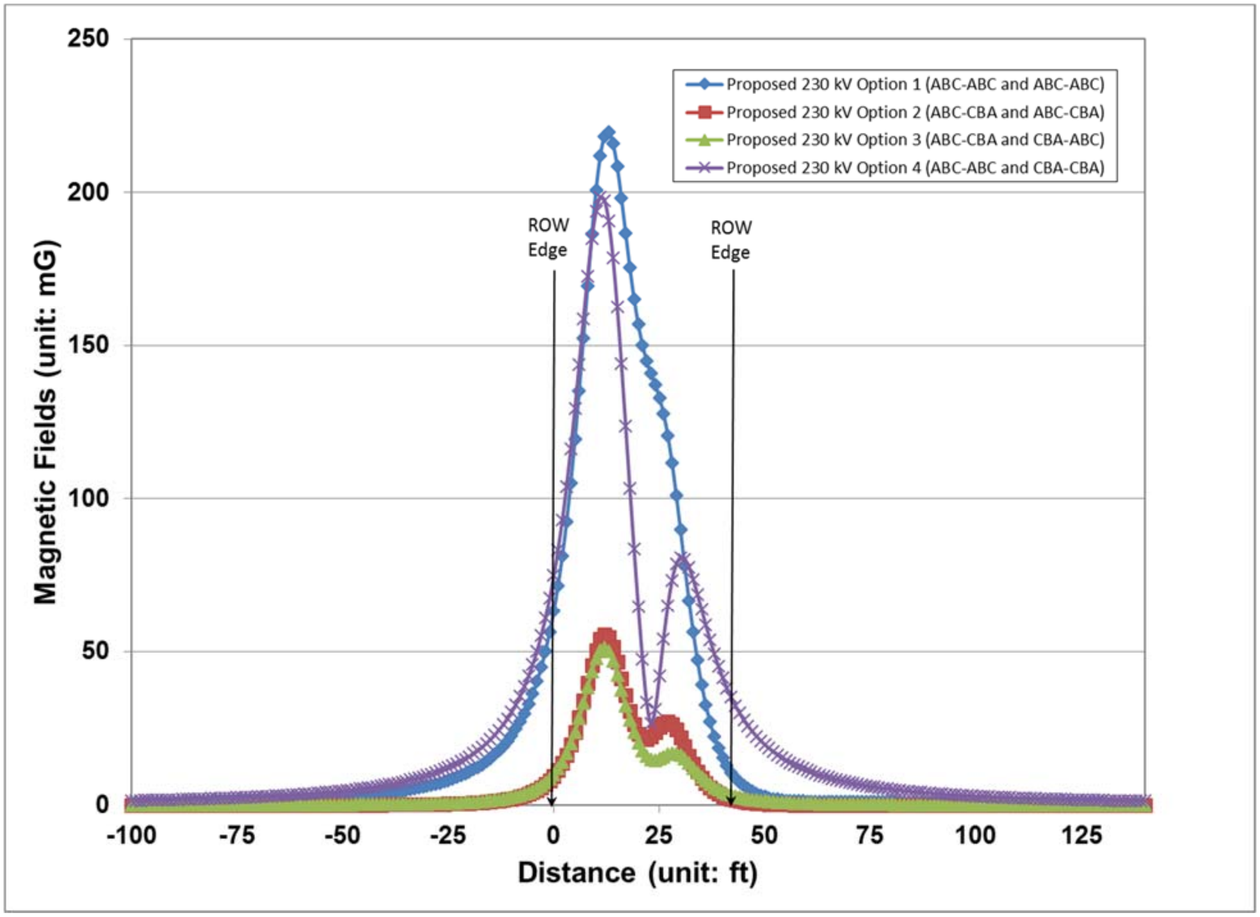
Vista-Wildlife 230 kV T/L



Mira Loma-Wildlife 230 kV T/L

*Note: S = Spare conduits

Calculated EMF:



Design Options	Left ROW (mG)	% Reduction	Right ROW (mG)	% Reduction
Proposed 230 kV Option 1 (ABC-ABC and ABC-ABC)	63.4		15.5	
Proposed 230 kV Option 2 (ABC-CBA and ABC-CBA)	9.5	85.0	3.0	80.6
Proposed 230 kV Option 3 (ABC-CBA and CBA-ABC)	10.1	Less than 15% Increase	4.4	Increase
Proposed 230 kV Option 4 (ABC-ABC and CBA-CBA)	74.9	Increase	41.5	Increase

Design Options	Peak Magnetic Field Values within ROW (mG)
Proposed 230 kV Option 1 (ABC-ABC and ABC-ABC)	220
Proposed 230 kV Option 2 (ABC-CBA and ABC-CBA)	56
Proposed 230 kV Option 3 (ABC-CBA and CBA-ABC)	51
Proposed 230 kV Option 4 (ABC-ABC and CBA-CBA)	198

Conclusion

Option 2 or 3 are the best possible phase cable arrangements with significant field reduction at edges of ROW. The no-cost or low-cost measure of arrange conductors to reduce magnetic field is recommended if it is deemed feasible to implement in the final engineering design phase.

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APPENDIX C

Electric and Magnetic Fields Supplemental Information

Electric an Magnetic Fields Supplemental Information

Electric and Magnetic Fields Analysis for the Underground

Segment Field Management Plan

Appendix B

RTRP FIELD MANAGEMENT PLAN

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List of Terms

CDHS	California Department of Health Services
CGC	Conductor Ground Clearance
CPCN	Certificate of Public Convenience and Necessity
CPUC	California Public Utilities Commission
EIR	Environmental Impact Report
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
FEIR	Final Environmental Impact Report
FMP	Field Management Plan
GO	General Order
Hz	hertz
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on non-Ionizing Radiation Protection
kV	kilovolt
LST	lattice steel tower
MFields	Magnetic Fields
mG	milligauss
μT	microTesla
MGC	Minimum Ground Clearance
N/A	Not Applicable
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NRPB	National Radiation Protection Board
PTC	Permit to Construct
RAPID	Research and Public Information Dissemination
ROW	Right-of-way
RPU	Riverside Public Utility
RTRP	Riverside Transmission Reliability Project
SCE	Southern California Edison
T/L	transmission line
TSP	tubular steel pole
WHO	World Health Organization

I. EXECUTIVE SUMMARY

This document is Southern California Edison Company's ("SCE") Field Management Plan ("FMP") for the proposed Riverside Transmission Reliability Project ("RTRP") ("Proposed Project"). The City of Riverside Public Utilities Department ("RPU") and SCE are proposing to construct and operate the Proposed Project in the Cities of Riverside, Norco, and Jurupa Valley and in unincorporated areas of Riverside County. The Proposed Project would involve the construction and operation of new double-circuit 230 kilovolt ("kV") transmission lines ("T/Ls") and new 69 kV subtransmission lines. It also would include a new SCE 230 kV electrical substation (Wildlife Substation) and a new RPU 230/69 kV electrical substation (Wilderness Substation) to be constructed adjacent to one another east of the Riverside Regional Water Quality Control Plant, as well as a number of 69 kV subtransmission circuits and other improvements. SCE would construct, maintain and operate the 230 kV T/Ls and the Wildlife Substation, while Riverside and RPU would construct, maintain and operate the Wilderness Substation and the 69 kV subtransmission lines. The Proposed Project would reduce RPU's dependence on the SCE's Vista Substation, which currently is the sole external source of electricity to RPU. The Proposed Project would provide for an increase in reliability and safety by providing another source path to RPU and sufficient electric capacity to meet future load growth and system demand in the City of Riverside.

SCE provides this FMP in order to inform the public, the California Public Utilities Commission ("CPUC"), and other interested parties of its evaluation of "no-cost and low-cost" magnetic field reduction design options for SCE's portions of the Proposed Project, and SCE's proposed plan to apply these design options where feasible from an engineering perspective and still within the cost parameters recommended by the CPUC. This FMP has been prepared in accordance with CPUC Decision No. 93-11-013 and Decision No. 06-01-042 relating to extremely low frequency ("ELF")[1] electric and magnetic fields ("EMF"). This FMP also provides background on the current status of scientific research related to possible health effects of EMF, and a description of the CPUC's EMF policy.

The "no-cost and low-cost" magnetic field reduction design options that are incorporated into the design of the Project are mainly as follows:

- Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction as a "no-cost" measure
- Arrange conductors of the proposed T/L for magnetic field reduction as a "no-cost" measure
- Raise the lowest conductor ground clearance (CGC) from the SCE design standard by 10 feet near populated areas as a "low-cost" option where final engineering deems feasible
- Place distribution underground cable duct banks greater than 12 feet from side of the Proposed Substation property line as a "no-cost" measure

[1] "Extremely low frequency" is defined as the frequency range from 3 Hz to 3,000 Hz.

The “no-cost and low-cost” magnetic field reduction design options that SCE considered for the Proposed Project are summarized in Table 1.

SCE’s plan for applying the above “no-cost and low-cost” magnetic field reduction design options for the Proposed Project is consistent with the CPUC’s EMF policy and with the direction of leading national and international health agencies. Furthermore, the plan complies with SCE’s EMF Design Guidelines[2], and with applicable national and state safety standards for new electrical facilities.

[2] EMF Design Guidelines, July 2006.

Table 1. Summary of "No-cost and Low-cost" Magnetic Field Reduction Design Options

Area No.	Location[3]	Adjacent Land Uses[4]	EMF Reduction Design Options Considered	Estimated Cost to Adopt	Design Option(s) Adopted? (Yes/No)	Reason(s) if not adopted
Model 1 – Lattice Steel Tower ("LST") Structures	At certain locations throughout the entire 230 kV T/L route	1,2,3,4,5,6	• Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction • Arrange conductors of the proposed T/L for magnetic field reduction • Raise the lowest conductor ground clearance	• "No-cost"[5] • "No-cost" • "Low-cost"	• Yes • Yes • Yes[6]	
Model 2 – Tubular Steel Pole ("TSP") Structures	Typical structures throughout the entire 230 kV T/L route	1,2,3,4,5,6	• Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction • Arrange conductors of the proposed T/L for magnetic field reduction • Raise the lowest conductor ground clearance	• "No-cost" • "No-cost" • "Low-cost"	• Yes • Yes • Yes[6]	
Model 3 – Near Elementary School on 68th Street	Section paralleling SCE's Mira Loma-Corona-Pedley 66 kV Subtransmission Line near the Louis Vandermolen Fundamental Elementary School on 68th Street	1,2,5,6	• Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction • Arrange conductors of the proposed T/L for magnetic field reduction • Raise the lowest conductor ground clearance	• "No-cost" • "No-cost" • "Low-cost"	• Yes • Yes • No	Less than 15% reduction

3 This column shows the major cross streets, existing transmission lines, or substation name(s) as reference points.

4 Land use codes are as follows: 1) schools, licensed day-cares, and hospitals, 2) residential, 3) commercial/industrial, 4) recreational, 5) agricultural, and 6) undeveloped land.

5 "No-cost" options were included in the preliminary design and continue to be included in the design of the Proposed Project.

6 The preliminary Engineering design suggests this may be a reasonable option. However, at final Engineering, this option will be determined for feasibility at the appropriate sections.

Area No.	**Location[7]**	**Adjacent Land Uses[8]**	**EMF Reduction Design Options Considered**	**Estimated Cost to Adopt**	**Design Option(s) Adopted? (Yes/No)**	**Reason(s) if not adopted**
Wildlife Substation	**Near the northeast corner of Wilderness Avenue and Ed Perkic Street**	**3,5,6**	• Place distribution underground cable duct banks greater than 12 feet from side of the Proposed Substation property line	• "No-cost"	• Yes	

7 This column shows the major cross streets, existing transmission lines, or substation name(s) as reference points.

8 Land use codes are as follows: 1) schools, licensed day-cares, and hospitals, 2) residential, 3) commercial/industrial, 4) recreational, 5) agricultural, and 6) undeveloped land.

II. BACKGROUND REGARDING EMF AND PUBLIC HEALTH RESEARCH ON EMF

There are many sources of power frequency[9] electric and magnetic fields, including internal household and building wiring, electrical appliances, and electric power transmission and distribution lines. There have been numerous scientific studies about the potential health effects of EMF. After many years of research, the scientific community has been unable to determine if exposures to EMF cause health hazards. State and federal public health regulatory agencies have determined that setting numeric exposure limits is not appropriate.[10]

Many of the questions about possible connections between EMF exposures and specific diseases have been successfully resolved due to an aggressive international research program. However, potentially important public health questions remain about whether there is a link between EMF exposures and certain diseases, including childhood leukemia and a variety of adult diseases (e.g., adult cancers and miscarriages). As a result, some health authorities have identified magnetic field exposures as a possible human carcinogen. As summarized in greater detail below, these conclusions are consistent with the following published reports: the National Institute of Environmental Health Sciences ("NIEHS") 1999[11], the National Radiation Protection Board ("NRPB") 2001[12], the International Commission on non-Ionizing Radiation Protection ("ICNIRP") 2001, the California Department of Health Services ("CDHS") 2002[13], the International Agency for Research on Cancer ("IARC") 2002[14] and the World Health Organization ("WHO") 2007[15] .

The federal government conducted EMF research as a part of a $45 million research program managed by the NIEHS. This program, known as the EMF RAPID (Research and Public Information Dissemination), submitted its final report to the U.S. Congress on June 15, 1999. The report concluded that:

- "The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak."[16]

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9 In U.S., it is 60 Hertz (Hz).

10 CPUC Decision 06-01-042, p. 6, footnote 10.

11 National Institute of Environmental Health Sciences' Report on Health Effects from Exposures to Power-Line frequency Electric and Magnetic Fields, NIH Publication No. 99-4493, June 1999.

12 National Radiological Protection Board, Electromagnetic Fields and the Risk of Cancer, Report of an Advisory Group on Non-ionizing Radiation, Chilton, U.K. 2001.

13 California Department of Health Services, An Evaluation of the Possible Risks from Electric and Magnetic Fields from Power Lines, Internal Wiring, Electrical Occupations, and Appliances, June 2002.

14 World Health Organization / International Agency for Research on Cancer, IARC Monographs on the evaluation of carcinogenic risks to humans (2002), Non-ionizing radiation, Part 1: Static and extremely low-frequency (ELF) electric and magnetic fields, IARCPress, Lyon, France: International Agency for Research on Cancer, Monograph, vol. 80, p. 338, 2002.

15 WHO, Environmental Health Criteria 238, EXTREMELY LOW FREQUENCY FIELDS, 2007.

16 National Institute of Environmental Health Sciences, NIEHS Report on Health Effects from Exposures to Power-Frequency Electric and Magnetic Fields, p. ii, NIH Publication No. 99-4493, 1999.

- "The NIEHS concludes that ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard."[17]
- "The NIEHS suggests that the level and strength of evidence supporting ELF-EMF exposure as a human health hazard are insufficient to warrant aggressive regulatory actions; thus, we do not recommend actions such as stringent standards on electric appliances and a national program to bury all transmission and distribution lines. Instead, the evidence suggests passive measures such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. NIEHS suggests that the power industry continue its current practice of siting power lines to reduce exposures and continue to explore ways to reduce the creation of magnetic fields around transmission and distribution lines without creating new hazards."[18]

In 2001, Britain's NRPB arrived at a similar conclusion:

> "After a wide-ranging and thorough review of scientific research, an independent Advisory Group to the Board of NRPB has concluded that the power frequency electromagnetic fields that exist in the vast majority of homes are not a cause of cancer in general. However, some epidemiological studies do indicate a possible small risk of childhood leukemia associated with exposures to unusually high levels of power frequency magnetic fields."[19]

In 2002, three scientists for CDHS concluded:

> "To one degree or another, all three of the [CDHS] 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 [CDHS] strongly believe that EMFs do not increase the risk of birth defects, or low birth weight.
>
> They [CDHS] 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 [CDHS] 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 a 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

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[17] *Ibid.*, p. iii.
[18] *Ibid.*, p. 37 – 38.
[19] NRPB, NRPB Advisory Group on Non-ionizing Radiation Power Frequency Electromagnetic Fields and the Risk of Cancer, NRPB Press Release March 2001.

> between believing or not believing' and one was 'prone to believe' that EMFs cause some degree of increased risk."[20]

Also in 2002, the World Health Organization's ("WHO") IARC concluded:

> "ELF magnetic fields are possibly carcinogenic to humans"[21], based on consistent statistical associations of high-level residential magnetic fields with a doubling of risk of childhood leukemia...Children who are exposed to residential ELF magnetic fields less than 0.4 microTesla (4.0 milliGauss "mG") have no increased risk for leukemia…. In contrast, "no consistent relationship has been seen in studies of childhood brain tumors or cancers at other sites and residential ELF electric and magnetic fields."[22]

In June of 2007, the WHO issued a report on their multi-year investigation of EMF and the possible health effects. After reviewing scientific data from numerous EMF and human health studies, they concluded:

> "Scientific evidence suggesting that everyday, chronic low-intensity (above 0.3-0.4 µT [3-4 mG]) power-frequency magnetic field exposure poses a health risk is based on epidemiological studies demonstrating a consistent pattern of increased risk for childhood leukemia."[23]

> "In addition, virtually all of the laboratory evidence and the mechanistic evidence fail to support a relationship between low-level ELF magnetic fields and changes in biological function or disease status. Thus, on balance, the evidence is not strong enough to be considered causal, but sufficiently strong to remain a concern."[24]

> "A number of other diseases have been investigated for possible association with ELF magnetic field exposure. These include cancers in both children and adults, depression, suicide, reproductive dysfunction, developmental disorders, immunological modifications and neurological disease. The scientific evidence supporting a linkage between ELF magnetic fields and any of these diseases is much weaker than for childhood leukemia and in some cases (for example, for cardiovascular disease or breast cancer) the evidence is sufficient to give confidence that magnetic fields do not cause the disease"[25]

> "Furthermore, given both the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukemia, and the limited impact on public

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[20] CDHS, An Evaluation of the Possible Risks From Electric and Magnetic Fields (EMFs) From Power Lines, Internal Wiring, Electrical Occupations and Appliances, p. 3, 2002.

[21] IARC, Monographs, Part I, Vol. 80, p. 338.

[22] *Ibid.*, p. 332 – 334.

[23] WHO, Environmental Health Criteria 238, EXTREMELY LOW FREQUENCY FIELDS, p. 11 - 13, 2007.

[24] *Ibid.*, p. 12.

[25] *Ibid.*, p. 12.

health if there is a link, the benefits of exposure reduction on health are unclear. Thus the costs of precautionary measures should be very low."[26]

III. APPLICATION OF THE CPUC'S "NO-COST AND LOW-COST" EMF POLICY TO THE PROPOSED PROJECT

Recognizing the scientific uncertainty over the connection between EMF exposures and health effects, the CPUC adopted a policy that addresses public concern over EMF with a combination of education, information, and precaution-based approaches. Specifically, Decision 93-11-013 established a precautionary based "no-cost and low-cost" EMF policy for California's regulated electric utilities based on recognition that scientific research had not demonstrated that exposures to EMF cause health hazards and that it was inappropriate to set numeric standards that would limit exposure.

In 2006, the CPUC completed its review and update of its EMF Policy in Decision 06-01-042. This decision reaffirmed the finding that state and federal public health regulatory agencies have not established a direct link between exposure to EMF and human health effects,[27] and the policy direction that (1) use of numeric exposure limits was not appropriate in setting utility design guidelines to address EMF,[28] and (2) existing "no-cost and low-cost" precautionary-based EMF policy should be continued for proposed electrical facilities. The decision also reaffirmed that EMF concerns brought up during Certificate of Public Convenience and Necessity ("CPCN") and Permit to Construct ("PTC") proceedings for electric and transmission and substation facilities should be limited to the utility's compliance with the CPUC's "no-cost and low-cost" policies.[29]

The decision directed regulated utilities to hold a workshop to develop standard approaches for EMF Design Guidelines and such a workshop was held on February 21, 2006. Consistent design guidelines have been developed that describe the routine magnetic field reduction measures that regulated California electric utilities consider for new and upgraded T/Land transmission substation projects. SCE filed its revised EMF Design Guidelines with the CPUC on July 26, 2006.

"No-cost and low-cost" measures to reduce magnetic fields would be implemented for this Project in accordance with SCE's EMF Design Guidelines. In summary, the process of evaluating "no-cost and low-cost" magnetic field reduction measures and prioritizing within and between land usage classes considers the following:

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[26] *Ibid*., p. 13.

[27] CPUC Decision 06-01-042, Findings of Fact No. 5, mimeo. p. 19 ("As discussed in the rulemaking, a direct link between exposure to EMF and human health effects has yet to be proven despite numerous studies including a study ordered by this Commission and conducted by DHS.").

[28] CPUC Decision 06-01-042, mimeo. p. 17 - 18 ("Furthermore, we do not request that utilities include non-routine mitigation measures, or other mitigation measures that are based on numeric values of EMF exposure, in revised design guidelines or apply mitigation measures to reconfigurations or relocations of less than 2,000 feet, the distance under which exemptions apply under GO 131-D. Non-routine mitigation measures should only be considered under unique circumstances.").

[29] CPUC Decision 06-01-042, Conclusion of Law No. 2, mimeo.p. 21, ("EMF concerns in future CPCN and PTC proceedings for electric and transmission and substation facilities should be limited to the utility's compliance with the Commission's low-cost/no-cost policies.").

1. SCE's priority in the design of any electrical facility is public and employee safety. Without exception, design and construction of an electric power system must comply with all applicable federal, state, and local regulations, applicable safety codes, and each electric utility's construction standards. Furthermore, transmission and subtransmission lines and substations must be constructed so that they can operate reliably at their design capacity. Their design must be compatible with other facilities in the area and the cost to operate and maintain the facilities must be reasonable.

2. As a supplement to Step 1, SCE follows the CPUC's direction to undertake "no-cost and low-cost" magnetic field reduction measures for new and upgraded electrical facilities. Any proposed "no-cost and low-cost" magnetic field measures, must, however, meet the requirements described in Step 1 above. The CPUC defines "no-cost and low-cost" measures as follows:

   - "No-cost" measures, in aggregate, should:
     - Have already been incorporated into the preliminary engineering design due to SCE design standards that have EMF reduction measures built-in.
     - Incur no additional cost to implement the recommended measures.
   - "Low-cost" measures, in aggregate, should:
     - Cost in the range of 4 percent of the total project cost.
     - Result in magnetic field reductions of "15% or greater at the utility R-O-W [right-of-way]…"[30]

   The CPUC Decision stated,

   > "We direct the utilities to use 4 percent as a benchmark in developing their EMF mitigation guidelines. We will not establish 4 percent as an absolute cap at this time because we do not want to arbitrarily eliminate a potential measure that might be available but costs more than the 4 percent figure. Conversely, the utilities are encouraged to use effective measures that cost less than 4 percent."[31]

3. The CPUC provided further policy direction in Decision 06-01-042, stating that, "[a]lthough equal mitigation for an entire class is a desirable goal, we will not limit the spending of EMF mitigation to zero on the basis that not all class members can benefit."[32] While Decision 06-01-042 directs the utilities to favor schools, day-care facilities and hospitals over residential areas when applying "low-cost" magnetic field reduction measures, prioritization within a class can be difficult on a project case-by-case basis because schools, day-care facilities, and hospitals are often integrated into residential areas, and many licensed day-care facilities are housed in private homes, and can be easily moved from one location to another.

[30] CPUC Decision 06-01-042, p. 10.
[31] CPUC Decision 93-11-013, § 3.3.2, p.10.
[32] CPUC Decision 06-01-042, p. 10.

> Therefore, it may be practical for public schools, licensed day-care centers, hospitals, and residential land uses to be grouped together to receive highest prioritization for "low-cost" magnetic field reduction measures. Commercial and industrial areas may be grouped as a second priority group, followed by recreational and agricultural areas as the third group. "Low-cost" magnetic field reduction measures will not be considered for undeveloped land, such as open space, state and national parks, and Bureau of Land Management and U.S. Forest Service lands. When spending for "low-cost" measures would otherwise disallow equitable magnetic field reduction for all areas within a single land-use class, prioritization can be achieved by considering location and/or density of permanently occupied structures on lands adjacent to the projects, as appropriate.

This FMP contains descriptions of various magnetic field models and the calculated results of magnetic field levels based on those models. These calculated results are provided only for purposes of identifying the relative differences in magnetic field levels among various transmission or subtransmission line design alternatives under a specific set of modeling assumptions and determining whether particular design alternatives can achieve magnetic field level reductions of 15 percent or more. The calculated results are not intended to be predictors of the actual magnetic field levels at any given time or at any specific location if and when the Project is constructed. This is because magnetic field levels depend upon a variety of variables, including load growth, customer electricity usage, and other factors beyond SCE's control. The CPUC affirmed this in D. 06-01-042 stating:

> "Our [CPUC] review of the modeling methodology provided in the utility [EMF] design guidelines indicates that it accomplishes its purpose, which is to measure the relative differences between alternative mitigation measures. Thus, the modeling indicates relative differences in magnetic field reductions between different T/L construction methods, but does not measure actual environmental magnetic fields."[33]

[33] CPUC Decision 06-01-042, p. 11.

IV. PROJECT DESCRIPTION

This document is Southern California Edison Company's ("SCE") Field Management Plan ("FMP") for the proposed Riverside Transmission Reliability Project ("RTRP") ("Proposed Project"). The City of Riverside Public Utilities Department ("RPU") and SCE are proposing to construct and operate the Proposed Project in the Cities of Riverside, Norco, and Jurupa Valley and in unincorporated areas of Riverside County. The Proposed Project would involve the construction and operation of new double-circuit 230 kilovolt ("kV") transmission lines ("T/Ls") and new 69 kV subtransmission lines. It also would include a new SCE 230 kV electrical substation (Wildlife Substation) and a new RPU 230/69 kV electrical substation (Wilderness Substation) to be constructed adjacent to one another east of the Riverside Regional Water Quality Control Plant, as well as a number of 69 kV subtransmission circuits and other improvements. SCE would construct, maintain and operate the 230 kV T/Ls and the Wildlife Substation, while Riverside and RPU would construct, maintain and operate the Wilderness Substation and the 69 kV subtransmission lines. The Proposed Project would reduce RPU's dependence on the SCE's Vista Substation, which currently is the sole external source of electricity to RPU. The Proposed Project would provide for an increase in reliability and safety by providing another source path to RPU and sufficient electric capacity to meet future load growth and system demand in the City of Riverside.

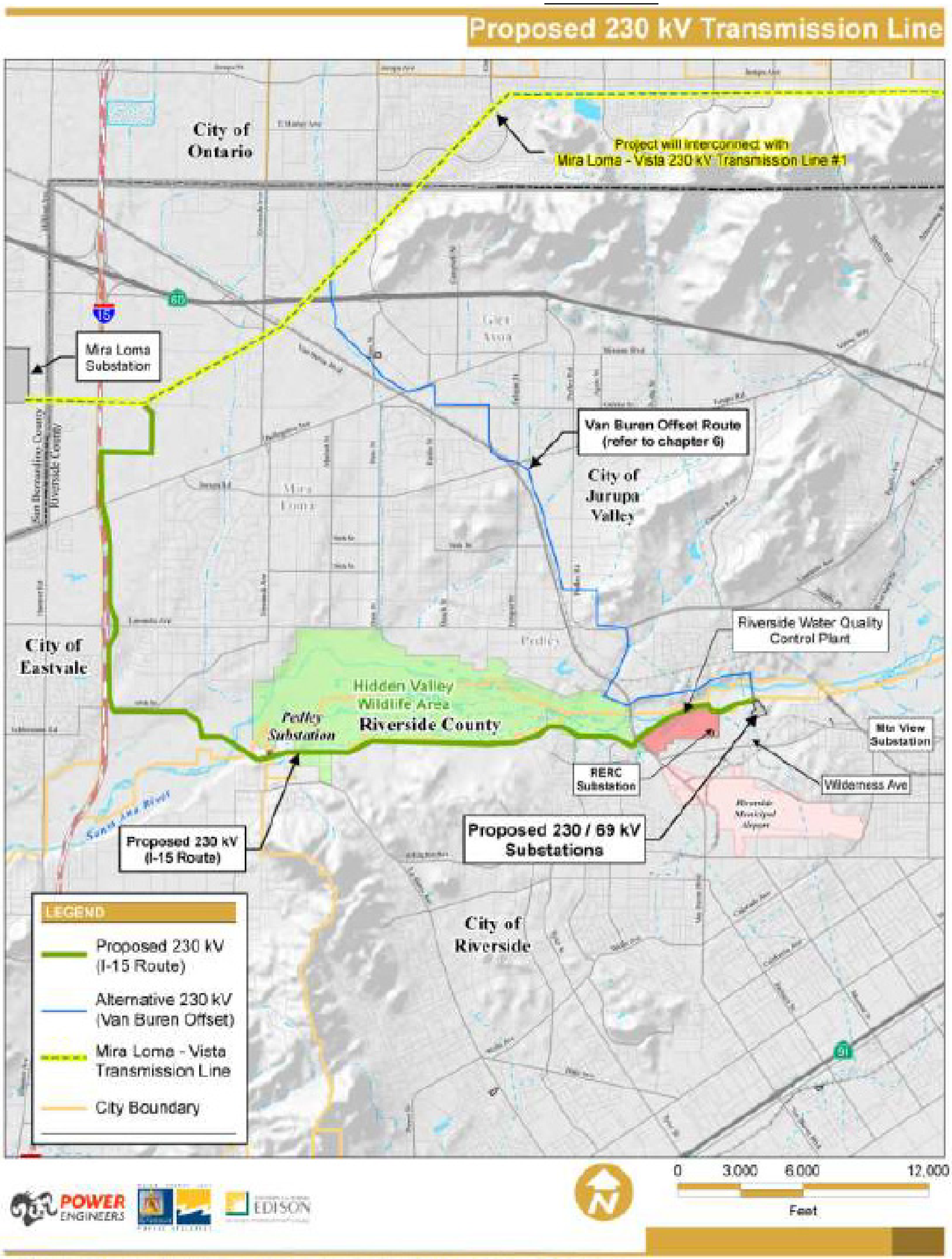
For the purpose of EMF analysis, this FMP focuses only on major electrical components of the SCE work scope of the Proposed Project, which involves design and construction of the Wildlife Substation and interconnecting it to the SCE Mira Loma-Vista #1 230 kV T/L, thereby forming the Mira Loma-Wildlife 230 kV T/L, and the Vista-Wildlife 230 kV T/L. Substation apparatus upgrades, distribution system modifications, telecommunication lines, construction details, the proposed Wilderness Substation and the 69 kV portion of that the Proposed Project (for which RPU is responsible) are not evaluated in this FMP.

230 kV Transmission Lines

The Proposed Project would add a new source of transmission for bulk power supply to RPU by "looping" SCE's Mira Loma-Vista #1 230 kV T/L in to a new 230 kV Wildlife Substation which would be located near the northeast corner of Wilderness Avenue and Ed Perkic Street within the City of Riverside. Under the Proposed Project, approximately ten miles of new double-circuit 230 kV T/L would be constructed that would "loop" the existing Mira Loma-Vista #1 230 kV T/L into the proposed Wildlife Substation. The "loop" would be created by connecting each of the new circuits into the existing Mira Loma-Vista #1 230 kV T/L. The interconnection would occur at approximately the point where the Mira Loma-Vista #1 230 kV T/L crosses Wineville Avenue, east of Interstate 15 ("I-15"). From here, the new double-circuit lines would run south along Wineville Avenue and then west to follow Landon Drive towards the I-15. Here the line would turn to roughly follow I-15 south just to the east of the I-15 Caltrans right-of-way ("ROW"), crossing Bellegrave Avenue, Limonite Avenue (west of the Vernola Marketplace), and 68th Street before turning east on the south side of 68th Street and proceeding toward the Goose Creek Golf Club. At the Goose Creek Golf Club, the line would cross the course to a larger river-crossing structure that would be located within a lawned area east of the teeing ground for the golf course's fourth hole. From here, an approximate 2,025-foot span would completely cross the Santa Ana River and riparian corridor, ending on a hill to the southwest of SCE's Pedley Substation. The line would then continue east along bluffs parallel to the Santa Ana River, mostly within the City of Riverside. In some locations here, the line would cross into the Hidden Valley Wildlife Area. Eventually the line would cross over Van Buren Boulevard, and then enter the property of the City of Riverside Water Quality Control Plant, following the northern perimeter of the plant before reaching the proposed Wildlife Substation on the south side of the Santa Ana River, east of Wilderness Avenue, as shown in Figure 1.

The project description is based on planning level assumptions. Exact details would be determined following completion of final engineering, identification of field conditions, availability of labor, material, equipment, and compliance with applicable environmental and permitting requirements.

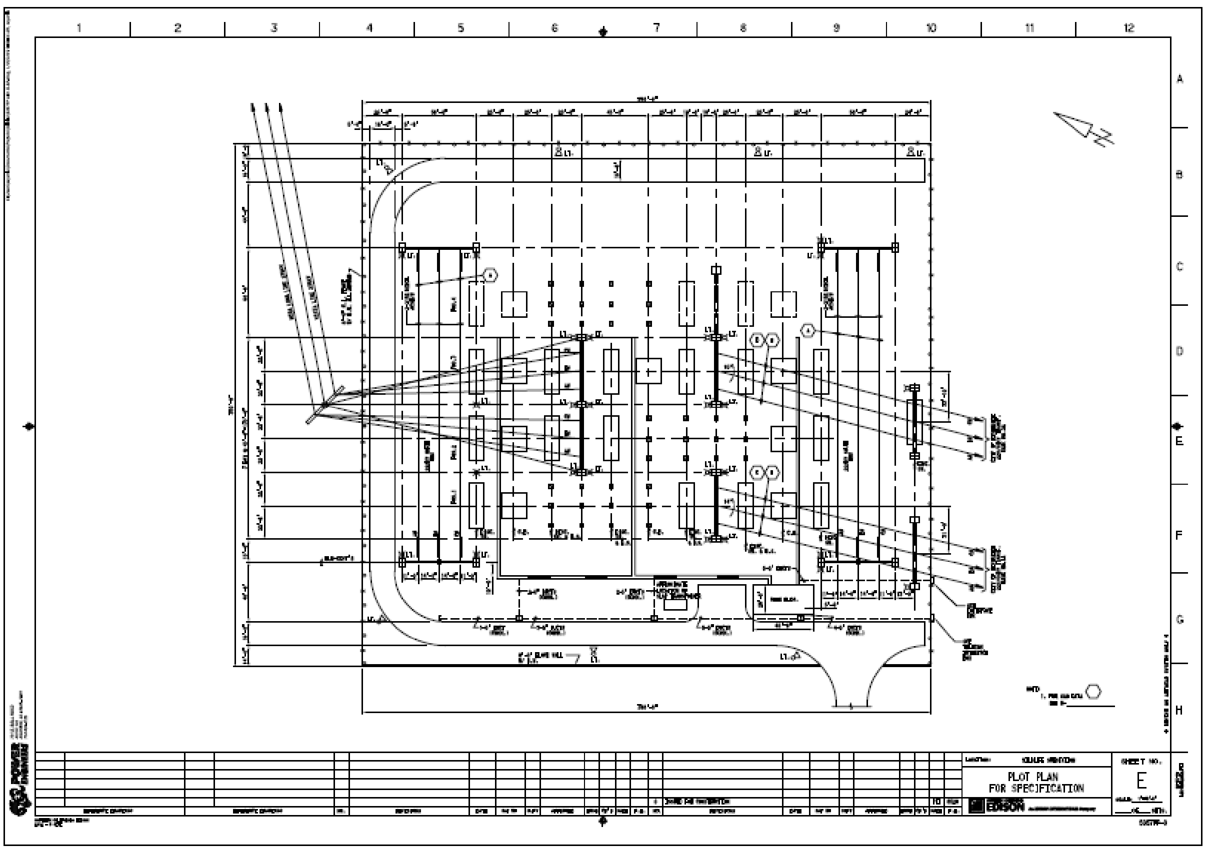
Figure 1. RTRP 230 kV Transmission Line Route



Proposed Wildlife 230 kV Substation

The proposed SCE 230 kV Wildlife Substation would be constructed on three acres of land currently owned by RPU and located near the northeast corner of Wilderness Avenue and Ed Perkic Street. This area is within the Riverside City limits. If the Proposed Project is approved, SCE would purchase property from RPU to accommodate the new Wildlife Substation. The proposed substation would connect to the SCE system via the proposed double-circuit 230 kV T/Ls described above, and would also connect into RPU's proposed adjacent proposed Wilderness 230/69 kV Substation. Figure 2 shows the preliminary layout of the proposed Wildlife Substation.

Figure 2. Preliminary Layout of the Proposed Wildlife 230 kV Substation



V. EVALUATION OF "NO-COST AND LOW-COST" MAGNETIC FIELD REDUCTION DESIGN OPTIONS

Please note that the following magnetic field models and the calculated results of magnetic field levels are intended only for purposes of identifying the relative differences in magnetic field levels among various T/L and subtransmission line design alternatives under a specific set of modeling assumptions (see §VII-Appendix A for more detailed information about the calculation assumptions and loading conditions) and determining whether particular design alternatives can achieve magnetic field level reductions of 15 percent or more. The calculated results are not intended to be predictors of the actual magnetic field levels at any given time or at any specific location when the Proposed Project is constructed.

For the purpose of evaluating "no-cost and low-cost" magnetic field reduction design options, the evaluation of magnetic fields associated with SCE's portion of work of the Proposed Project is divided into two parts:

- Part 1: Proposed 230 kV Transmission Lines

- Part 2: Proposed 230 kV Substation

Part 1: Proposed 230 kV Transmission Lines

The following magnetic field reduction methods are applicable for overhead 230 kV T/L designs:

- Selecting 230 kV T/L routes that would have the least impact to populated areas
- Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction
- Arrange conductors of the proposed T/Ls for magnetic field reduction ("Phasing")
- Raising Conductor Ground Clearance ("CGC") to increase distance from populated areas

There are mainly two types of structures for the proposed 230 kV T/Ls: LST and TSP. There is only one section which the proposed T/Ls would run parallel to another circuit, which is SCE's Mira Loma-Corona-Pedley 66 kV Subtransmission Line. Three EMF computer models are used to compare various design options.

Model 1 – Lattice Steel Tower

The proposed LST structures in the Proposed Project are dead-end structures as shown in Figure 3. For EMF analysis, calculated magnetic field levels were evaluated at the edges of the approximately 100-foot wide ROW or easement.

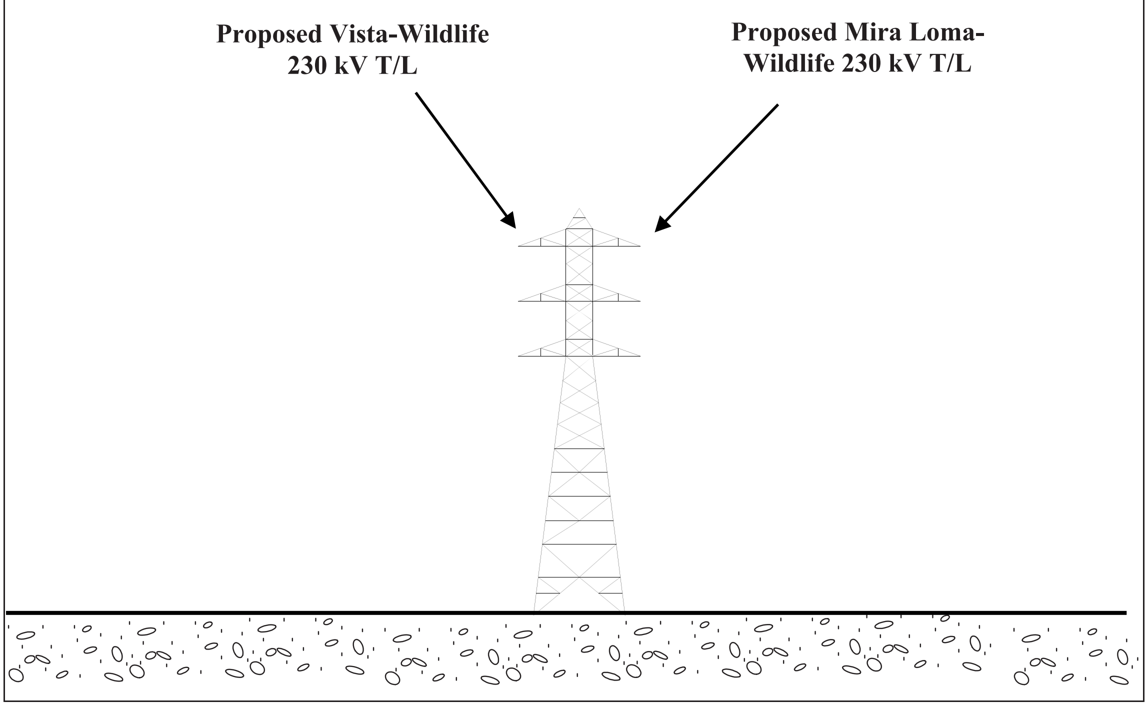
"No-Cost" Field Reduction Measures: The proposed design includes the following "no-cost" field reduction measures:

1. Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction
2. Arrange conductors of T/Ls for magnetic field reduction ("Phasing")

"Low-Cost" Field Reduction Option:

1. The preliminary engineering analysis was based on minimum structure heights of 113 feet above ground, with a minimum ground clearance of the lowest conductor at 32 feet above ground. The "low-cost" option of raising the CGC by an additional 10 feet from the preliminary design is considered for locations adjacent to populated areas.

Figure 3. Proposed 230 kV LST Structures Design - Model 1[34]



Magnetic Field Calculations: Figure 4 and Table 2 show the calculated magnetic field levels for the proposed design with and without field reduction measures.

[34] Figure is not to scale.

Figure 4. Calculated Magnetic Field Levels[35] for Model 1
Proposed 230 kV T/L Portion with LST Structures[36]

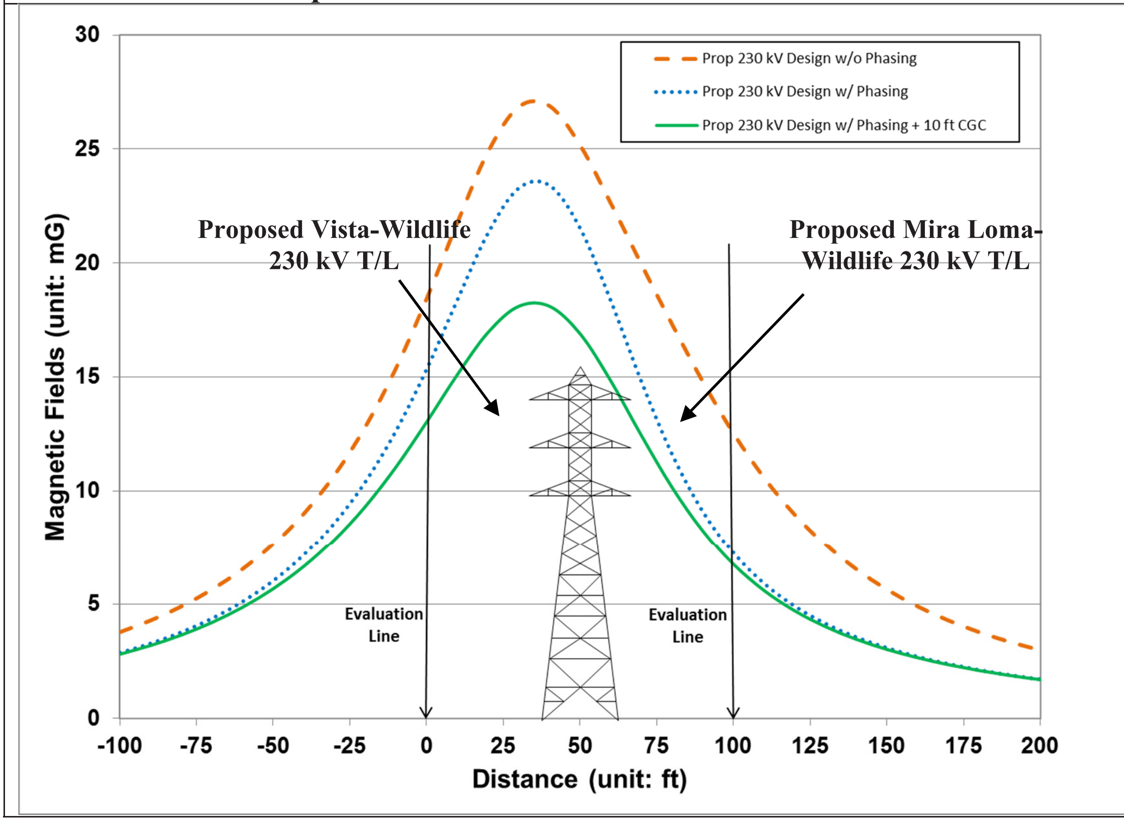


Table 2. Calculated Magnetic Field Levels[37] for Model 1

Design Options	Vista-Wildlife Side of ROW (mG)	% Reduction[38]	ML-Wildlife Side of ROW (mG)	% Reduction
Proposed w/o Phasing	18.6	-	12.6	-
Proposed w/ Phasing	15.5	16.7	7.3	42.1
Proposed w/ Phasing and +10 ft CGC	13.0	16.1	6.7	8.2

[35] This figure shows calculated magnetic field levels for design comparison only and is not meant to predict actual magnetic field levels.
[36] Structure is not to scale
[37] This table lists calculated magnetic field levels for design comparison only and is not meant to predict actual magnetic field levels.
[38] "% Reduction" represents the percentage of reduction achieved with the implementation of the referenced "no-cost and/or low-cost" magnetic field reduction measures as compared to the proposed design in the previous row in this table.

“Low-Cost” recommendations for Model 1: *The “low-cost” measure of raising the CGC is recommended near populated areas since it would achieve at least 15% of magnetic field reduction on one side of the T/L route.*

Model 2 – Tubular Steel Pole

The proposed TSP structures in the Proposed Project are tangent structures as shown in Figure 5. For EMF analysis, calculated magnetic field levels were evaluated at the edges of the approximately 100-foot wide ROW or easement.

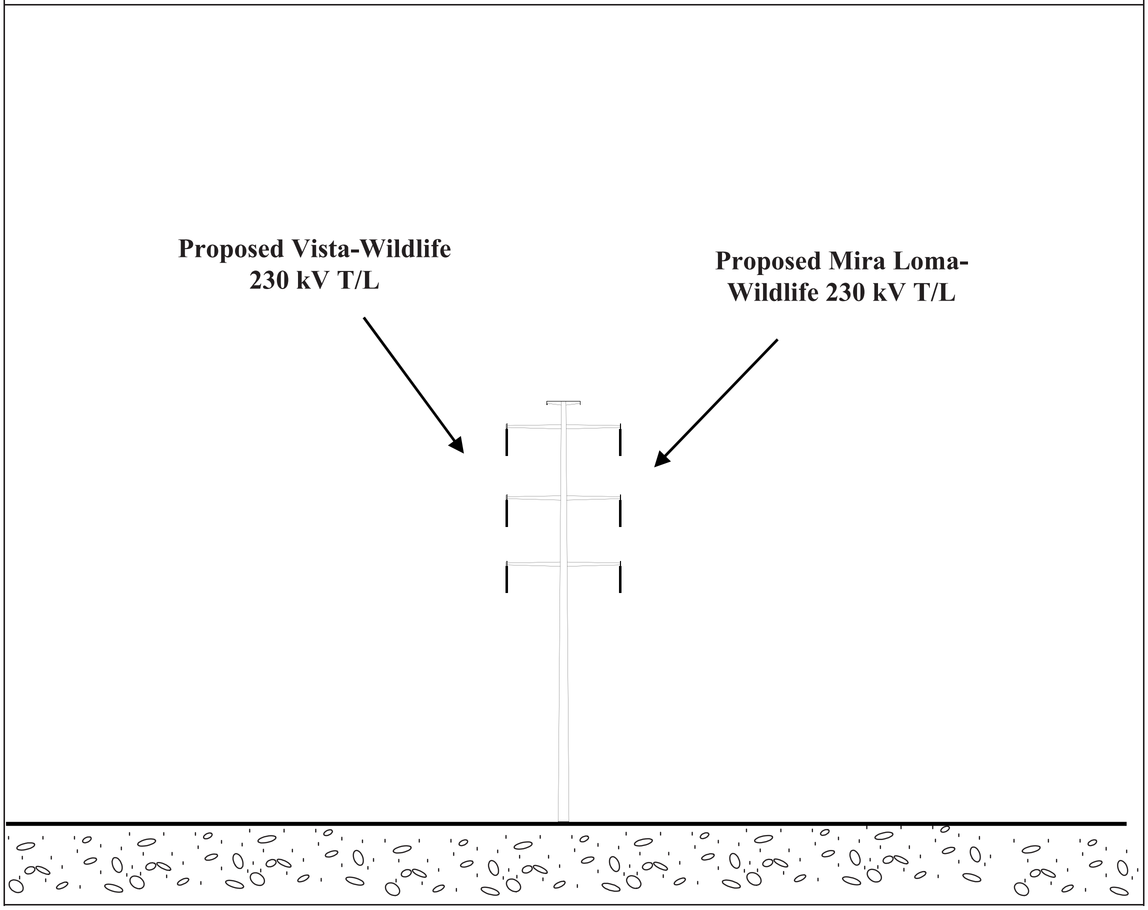
“No-Cost” Field Reduction Measures: The proposed design includes the following “no-cost” field reduction measure:

1. Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction
2. Arrange conductors of T/Ls for magnetic field reduction (“Phasing”)

“Low-Cost” Field Reduction Options:

1. The preliminary engineering analysis was based on minimum structure heights of 105 feet above ground with a minimum ground clearance of the lowest conductor at 32 feet above ground. The “low-cost” option of raising the CGC by an additional 10 feet from the preliminary design is considered for locations adjacent to populated areas.

Figure 5. Proposed 230 kV TSP Structures Design - Model 2[39]



Magnetic Field Calculations: Figure 6 and Table 3 show the calculated magnetic field levels for the proposed design with and without field reduction measures.

39 Figure is not to scale.

Figure 6. Calculated Magnetic Field Levels[40] for Model 2 Proposed 230 kV T/L Portion with TSP Structures[41]

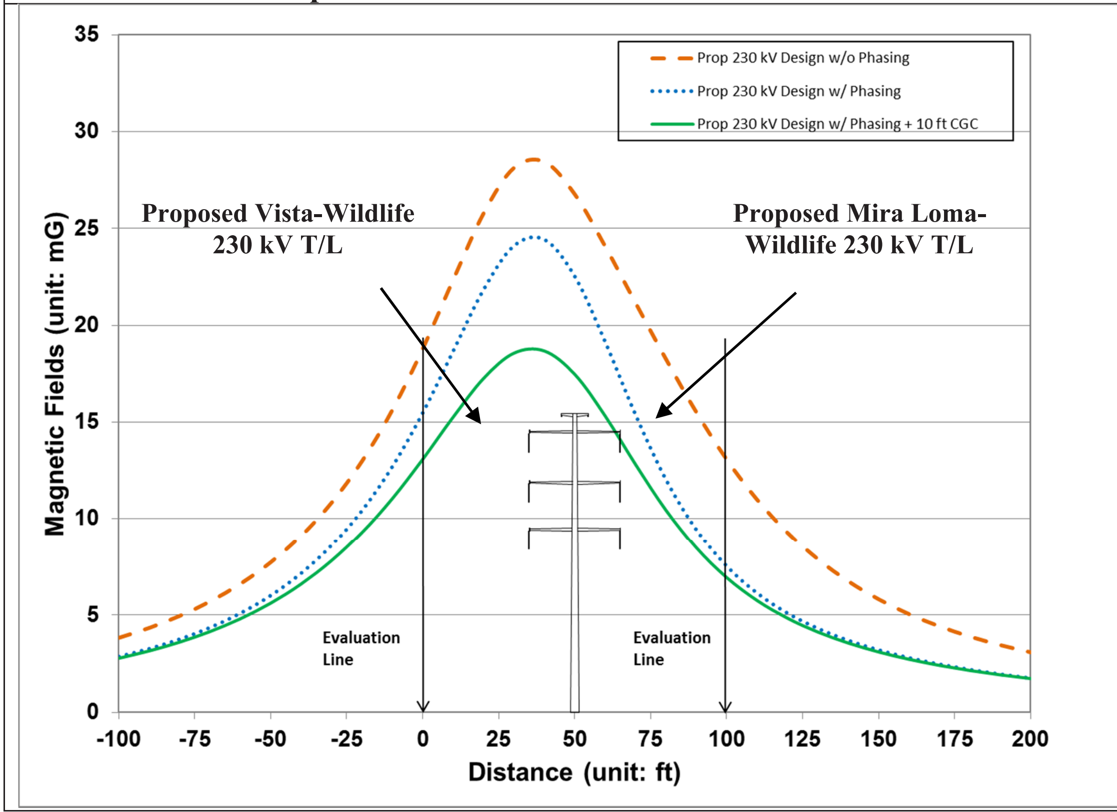


Table 3. Calculated Magnetic Field Levels[42] for Model 2

Design Options	Vista-Wildlife Side of ROW (mG)	% Reduction[43]	ML-Wildlife Side of ROW (mG)	% Reduction
Proposed w/o Phasing	18.8	-	13.0	-
Proposed w/ Phasing	15.5	17.6	7.5	42.3
Proposed w/ Phasing and +10 ft CGC	13.1	15.5	6.9	8.0

"Low-Cost" recommendations for Model 2: *The "low-cost" measure of raising the CGC is recommended near populated areas.*

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40 This figure shows calculated magnetic field levels for design comparison only and is not meant to predict actual magnetic field levels.

41 Structure is not to scale

42 This table lists calculated magnetic field levels for design comparison only and is not meant to predict actual magnetic field levels.

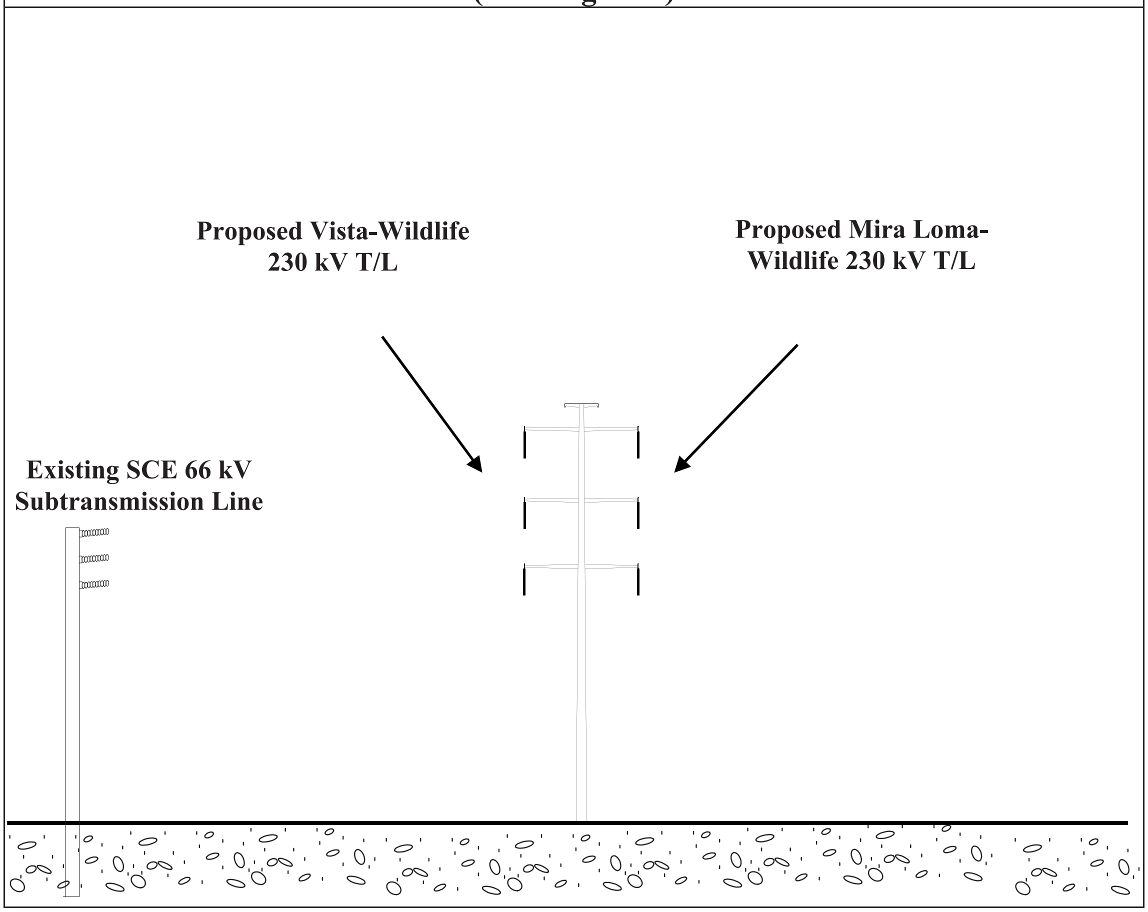
43 "% Reduction" represents the percentage of reduction achieved with the implementation of the referenced "no-cost and/or low-cost" magnetic field reduction measures as compared to the proposed design in the previous row in this table.

Model 3 – Section Near the Louis Vandermolen Fundamental Elementary School

There is a section in the 230 kV T/L route that would parallel an existing SCE 66 kV subtransmission line along 68th Street. The proposed TSP structures in this section are mostly tangent structures located on the south side of the 66 kV subtransmission line as shown in Figure 7 (the existing 66 kV line is on the north side of the street). The Louis Vandermolen Fundamental Elementary School, as well as residential homes, are on the north side of the 66 kV subtransmission line. For EMF analysis, calculated magnetic field levels were evaluated at the edges of the approximately 100-foot wide ROW or easement. An assessment of the calculated magnetic field level on the north side of the 66 kV subtransmission line was also performed.

Figure 7. Proposed 230 kV T/L Near Louis Vandermolen Fundamental Elementary School - Model 3[44]

(Looking East)



44 Figure is not to scale.

"No-Cost" Field Reduction Measure: The proposed design includes the following "no-cost" field reduction measure:

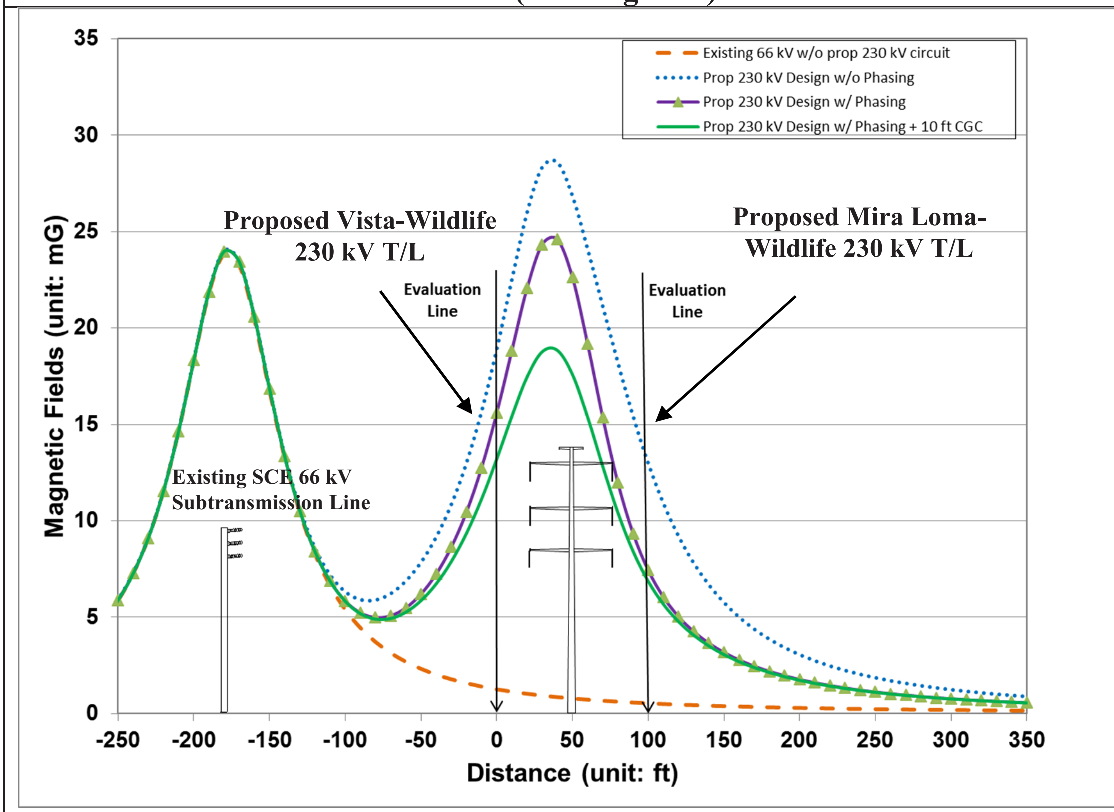
1. Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction
2. Arrange conductors of T/Ls for magnetic field reduction ("Phasing")

"Low-Cost" Field Reduction Options:

1. The initial analysis was based on minimum structure heights of 105 feet above ground with a minimum ground clearance of the lowest conductor at 32 feet above ground. The "low-cost" option of raising the CGC by an additional 10 feet from the preliminary design is considered for this section.

Magnetic Field Calculations: Figure 8 and Table 4 show the calculated magnetic field levels for the proposed design comparing existing and proposed design with and without field reduction measures.

Figure 8. Calculated Magnetic Field Levels[45] for Model 3 Near Louis Vandermolen Fundamental Elementary School on 68th Street[46] (Looking East)



[45] This figure shows calculated magnetic field levels for design comparison only and is not meant to predict actual magnetic field levels.

[46] Structures are not to scale

Table 4. Calculated Magnetic Field Levels[47] for Model 3				
Design Options	Vista-Wildlife Side of ROW (mG)	% Reduction[48]	ML-Wildlife Side of ROW (mG)	% Reduction
Existing 66 kV w/o Proposed Project	1.3		0.5	
Proposed w/o Phasing	18.9	Increase	13.0	Increase
Proposed w/ Phasing	15.6	17.5	7.4	43.1
Proposed w/ Phasing and +10 ft CGC	13.2	15.4	6.9	6.8

"Low-Cost" recommendations for Model 3: *Although increasing the CGC would result in more than 15% of field reduction on the north side of the proposed T/L, it would have a minimal effect on the north side of the 66 kV subtransmission line where the school and homes are. Therefore, the "low-cost" measure of raising the CGC is* ***NOT*** *recommended for this section.*

Part 2: Proposed 230 kV Substation

Generally, magnetic field values along the substation perimeter are low compared to the substation interior because of the distance from the perimeter to the energized equipment. Normally, the highest magnetic field values around the perimeter of a substation result from overhead power lines and underground duct banks entering and leaving the substation, and are not caused by substation equipment. Therefore, the magnetic field reduction measures generally applicable to a substation project are as follows:

- Site selection for a new substation;
- Setback of substation structures and major substation equipment (such as bus, transformers, and underground cable duct banks, etc.) from perimeter;
- Lines entering and exiting the substation.

The Substation Checklist, as shown on Table 5, is used for evaluating the "no-cost and low-cost" measures considered for the proposed Wildlife Substation, the measures adopted, and reasons that certain measures were not adopted.

47 This table lists calculated magnetic field levels for design comparison only and is not meant to predict actual magnetic field levels.

48 "% Reduction" represents the percentage of reduction achieved with the implementation of the referenced "no-cost and/or low-cost" magnetic field reduction measures as compared to the proposed design in the previous row in this table.

Table 5. Substation Checklist for Examining "No-Cost and Low-Cost" Magnetic Field Reduction Measures			
No.	**"No-Cost and Low-Cost" Magnetic Field Reduction Measures Evaluated for a Substation Project**	**Measures Adopted? (Yes/No)**	**Reason(s) if not Adopted**
1	Are transformers and air-core reactors > 50 feet from the substation property line?	N/A[49]	
2	Are switch-racks, capacitor banks & bus > 40 feet from substation property line?	No	Not adjacent to populated area[50]
3	Are distribution underground cable duct banks greater than 12 feet from side of the substation property line?	Yes	

This document includes only "no-cost and low-cost" magnetic field reduction measures for the Proposed T/L route and Wildlife Substation based on preliminary engineering design. The City of Riverside's Final Environmental Impact Report (FEIR) contains various alternative T/L routes. The proposed "no-cost and low-cost" magnetic field reduction measures for the Proposed Project can be similarly applied to the alternative line routes. If the alternative route is chosen for this project, a supplemental FMP would be prepared based on the final engineering design.

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[49] "N/A" means "Not Applicable." There are no transformers or reactors in the proposed Wildlife Substation.

[50] North and South sides of the Proposed Substation will not be adjacent to populated areas

VI. FINAL RECOMMENDATIONS FOR IMPLEMENTING "NO-COST AND LOW-COST" MAGNETIC FIELD REDUCTION DESIGN OPTIONS

In accordance with the EMF Design Guidelines filed with the CPUC in compliance with CPUC Decisions 93-11-013 and 06-01-042, SCE would implement the following "no-cost and low-cost" magnetic field reduction design options for the Proposed Project.

Part 1: Proposed 230 kV Transmission Line Work

<u>Model 1 – Lattice Steel Tower</u>

- Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction as a "no-cost" measure

- Arrange conductors of the proposed T/Ls for magnetic field reduction as a "no-cost" measure
    - Vista-Wildlife 230 kV: **B-A-C**: top-to-bottom
    - Mira Loma-Wildlife 230 kV: **C-A-B**: top-to-bottom; **or equivalent opposite phasing combination**

- Raise the lowest conductor ground clearance from the SCE design standard by 10 feet near residential, commercial/industrial, or recreational areas as a "low-cost" option where final engineering deems feasible

<u>Model 2 – Tubular Steel Pole</u>

- Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction as a "no-cost" measure

- Arrange conductors of the proposed T/Ls for magnetic field reduction as a "no-cost" measure
    - Vista-Wildlife 230 kV: **B-A-C**: top-to-bottom
    - Mira Loma-Wildlife 230 kV: **C-A-B**: top-to-bottom; **or equivalent opposite phasing combination**

- Raise the lowest conductor ground clearance from the SCE design standard by 10 feet near residential, commercial/industrial, or recreational areas as a "low-cost" option where final engineering deems feasible

<u>Model 3 – Section Near the Louis Vandermolen Fundamental Elementary School</u>

- Utilize double-circuit construction that reduces spacing between circuits as compared with single-circuit construction as a "no-cost" measure

- Arrange conductors of the proposed T/Ls for magnetic field reduction as a "no-cost" measure
  - Vista-Wildlife 230 kV: **B-A-C**: top-to-bottom
  - Mira Loma-Wildlife 230 kV: **C-A-B**: top-to-bottom; **or equivalent opposite phasing combination**

- The "low-cost" field reduction measure of raising the CGC is **Not** recommended due to minimal effect near populated areas in this section

Part 2: Proposed 230 kV Substation

- Place major substation electric equipment away from the substation property lines, as shown on Table 5.

SCE's plan for applying the above "no-cost and low-cost" magnetic field reduction design options uniformly for the Proposed Project is consistent with the CPUC's EMF Decisions No. 93-11-013 and No. 06-01-042. Furthermore, the recommendations above meet the CPUC approved EMF Design Guidelines, as well as all applicable national and state safety standards for new electrical facilities. If necessary, a supplemental FMP would be prepared based on the final engineering design.

VII. APPENDIX A: TWO-DIMENSIONAL MODEL ASSUMPTIONS AND YEAR 2020 FORECASTED LOADING CONDITIONS

Magnetic Field Model Assumptions:

SCE uses a computer program titled "MFields"[51] to model the magnetic field characteristics of various transmission designs options. All magnetic field models and the calculated results of magnetic field levels presented in this document are intended only for purposes of identifying the relative differences in magnetic field levels among various T/Ls and subtransmission line design alternatives under a specific set of modeling assumptions and determining whether particular design alternatives can achieve magnetic field level reductions of 15 percent or more. The calculated results are not intended to be predictors of the actual magnetic field levels at any given time or at any specific location if and when the Proposed Project is constructed.

Typical two-dimensional magnetic field modeling assumptions include:

- All transmission and subtransmission lines were modeled using forecasted peak loads (see Tables 6 and 7).
- All conductors were assumed to be straight and infinitely long.
- Average conductor heights account for line sag used in the calculation for the transmission and subtransmission line designs.
- Magnetic field strength was calculated at a height of three feet above ground.
- Resultant magnetic fields values were presented in this FMP.
- All line currents within the same circuit were assumed to be balanced. (i.e. neutral or ground currents are not considered)
- Terrain was assumed to be flat.
- Project dominant power flow directions in the year of operational date of the Proposed Project were used.

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51 SCE, MFields for Excel, Version 2.0, 2007.

Table 6. Year 2020 Forecasted Peak Loading Conditions[1] for the Proposed Project (After Project Completion)		
Line Name	**Current (Amps)**	**Power Flow Direction**
Vista-Wildlife 230 kV T/L	347	Vista to Wildlife
Mira Loma-Wildlife 230 kV T/L	68	Mira Loma to Wildlife
Mira Loma-Corona-Pedley 66 kV Subtransmission Line	731	Mira Loma to Corona and Pedley

Table 7. Year 2020 Forecasted Peak Loading Conditions[1] without the Proposed Project		
Line Name	**Current (Amps)**	**Power Flow Direction**
Mira Loma-Vista #1 230 kV T/L	65	Vista to Mira Loma

Notes:

1. Forecasted loading data is based upon scenarios representing peak load forecasts for 2020 under normal conditions. The forecasting data is subject to change depending upon availability of generation, load increases, changes in load demand, and by many other factors.