Electromagnetic Radiation Technical Memo

High Desert Corridor (HDC)
Palmdale to Apple Valley (State Route 14 to State Route 18)

May 2015

PARSONS
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Contract No.: 07A2912
Caltrans Project No.: 071200035 (EA: 2600U)

Electromagnetic Radiation Technical Memorandum

High Desert Corridor (HDC) Project

LOS ANGELES and SAN BERNARDINO COUNTIES, CALIFORNIA
District 07 – LOS ANGELES –PM 57.8 to PM 64.1
District 08 – SAN BERNARDINO –SR18 to PM 84.3
Caltrans Project No.: 071200035 (EA: 2600U)

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STATE OF CALIFORNIA
Department of Transportation

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The environmental review, certification, and any other action required in accordance with applicable federal laws for this Project is being, or has been, carried out by Caltrans under its assumption of responsibility pursuant to 23 U.S.C. 327.

EXECUTIVE SUMMARY

The objectives of the *Electromagnetic Radiation Technical Memorandum* (TM) are to describe existing sources and levels of electromagnetic radiation (EMR) in the Study Area, determine if potential project impacts on EMR-sensitive land uses would be adverse, based on preliminary project information, and to identify best management practices and feasible mitigation measures, if needed.

The counties of San Bernardino and Los Angeles; the cities of Adelanto, Victorville, Lancaster, and Palmdale; and the Town of Apple Valley have formed a Joint Powers Authority (JPA) to develop the High Desert Corridor (HDC) freeway/expressway from State Route (SR) 14 to Interstate (I) 15. The California Department of Transportation (Caltrans) and the Los Angeles Metropolitan Transportation Authority (Metro) have partnered with the JPA and other agencies to prepare environmental studies and preliminary engineering designs for the proposed HDC project. Caltrans is the lead agency for the project pursuant to the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA).

The project proposes to construct a new, approximately 63-mile long, east-west freeway/expressway linking SR-14 in Palmdale with SR-18 in Apple Valley. The HDC will follow an alignment within about 0.5-mile of and parallel to Avenue P-8 in Palmdale and to Air Expressway in Victorville. The HDC would be 500 feet wide from SR-14 to United States (U.S.) 395. East of U.S. 395, the HDC would transition to a 300-foot right-of-way. The HDC would be generally constructed as a new fill approximately 12 feet above existing terrain, with multiple bridges and structures spanning over drainages or over local roads.

Several project alternatives were considered and evaluated. A No-Build Alternative and four build alternatives were selected for detailed evaluation in the Draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS). The build alternatives are:

- Freeway/Expressway Alternative (Avenue P-8, I-15 and SR-18)
- Freeway/Tollway Alternative (Avenue P-8, I-15 and SR-18)
- Freeway/Expressway Alternative with High-Speed Rail (HSR) Feeder/Connector Service
- Freeway/Tollway Alternative with HSR Feeder/Connector Service

Only the two alternatives that include HSR, which raises a concern about electromagnetic fields (EMF), are evaluated in this TM. The other two alternatives are, in terms of EMR, indistinguishable from the No Build Alternative. Rail connection options common to both HSR build alternatives would include Rail Options 1 and 7 for the Palmdale rail connection and the Northern Alignment Option 1 and Variation E Alignment Option for the Victorville rail connection.

A significant impact would occur if health-based standards for human exposure to EMF were exceeded or if electromagnetic interference (EMI) from the project posed a substantial risk of interfering with or disrupting electronic communications or sensitive electronic devices.

The project would minimally increase the strength of EMF in portions of the Study Area along the HDC alignment. The project would have no substantial effect on human health or on sensitive facilities adjacent to the HDC.

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LIST OF ABBREVIATED TERMS

AC	Alternating Current
ACGIH	American Conference of Governmental Industrial Hygienists
AFP	Air Force Plant
AM	Amplitude Modulated
ANSI	American National Standards Institute
BMP	Best Management Practices
Caltrans	California Department of Transportation
CAT	Computed Axial Tomography
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CT	Computed Tomology
DC	Direct Current
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMF	Electromagnetic Field
EMI	Electromagnetic Interference
EMR	Electromagnetic Radiation
EMU	Electromagnetic Unit
FCC	Federal Communications Commission
FM	Frequency Modulated
G	Gauss
G	Giga
HDC	High Desert Corridor
HIRF	High-Intensity Radio Frequency
HSR	High-Speed Rail
Hz	Hertz
I	Interstate
IEEE	Institute of Electrical and Electronics Engineers
JPA	Joint Powers Authority
k	kilo
LA	Los Angeles
M	Mega
m	meter
m	milli
m^2	square meter
mG	milliGauss
MPE	Maximum Permissible Exposure
mph	miles per hour
MRI	Magnetic Resonance Imaging
NASA	National Aeronautic and Space Administration
NEPA	National Environmental Policy Act
NMI	Nuclear Magnetic Imaging
NMR	Nuclear Magnetic Resonance
OCS	Overhead Catenary System
RF	Radio-Frequency
SR	State Route
T	Tesla
TM	Technical Memo
U.S.	United States
V	Volts
W	Watts
WHO	World Health Organization
W/m^2	Watts per square meter

1 INTRODUCTION

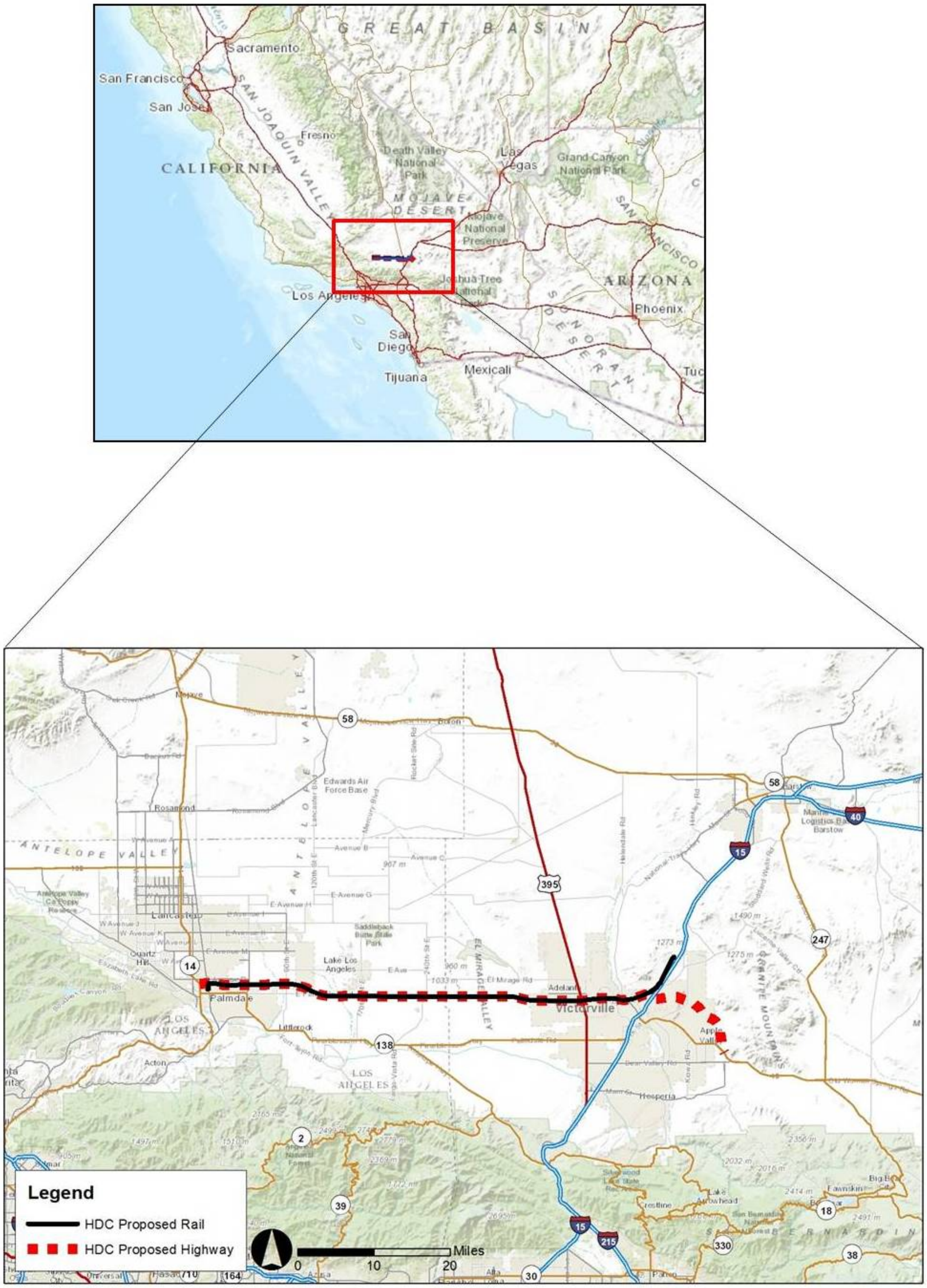
1.1 Purpose of this Technical Memorandum

The purpose of this Technical Memo (TM) is to fulfill the requirements of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). This TM includes a discussion of the project, its physical setting, and the regulatory framework with respect to electromagnetic radiation (EMR) and electromagnetic interference (EMI) from electromagnetic fields (EMF). The report also identifies potential impacts of the proposed project, and recommends avoidance or minimization measures for potentially adverse impacts.

1.2 Project Description

The California Department of Transportation (Caltrans), in cooperation with the Los Angeles County Metropolitan Transportation Authority (Metro), proposes to construct the High Desert Corridor (HDC) as a new transportation facility in the High Desert region of Los Angeles and San Bernardino Counties. The proposed 63-mile-long, west-east facility would provide route continuity and relieve traffic congestion between State Route (SR) 18 and United States (U.S.) Highway 395 (U.S. 395) in San Bernardino County with SR-14 in Los Angeles County. The project would be comprised of one or more of the following major components: highway, high-speed rail (HSR) transit, and bikeway, along with recommendation for green energy facilities. Figures 1-1 and 1-2 are maps of the project vicinity and location, respectively.

Figure 1-1 Project Vicinity Map



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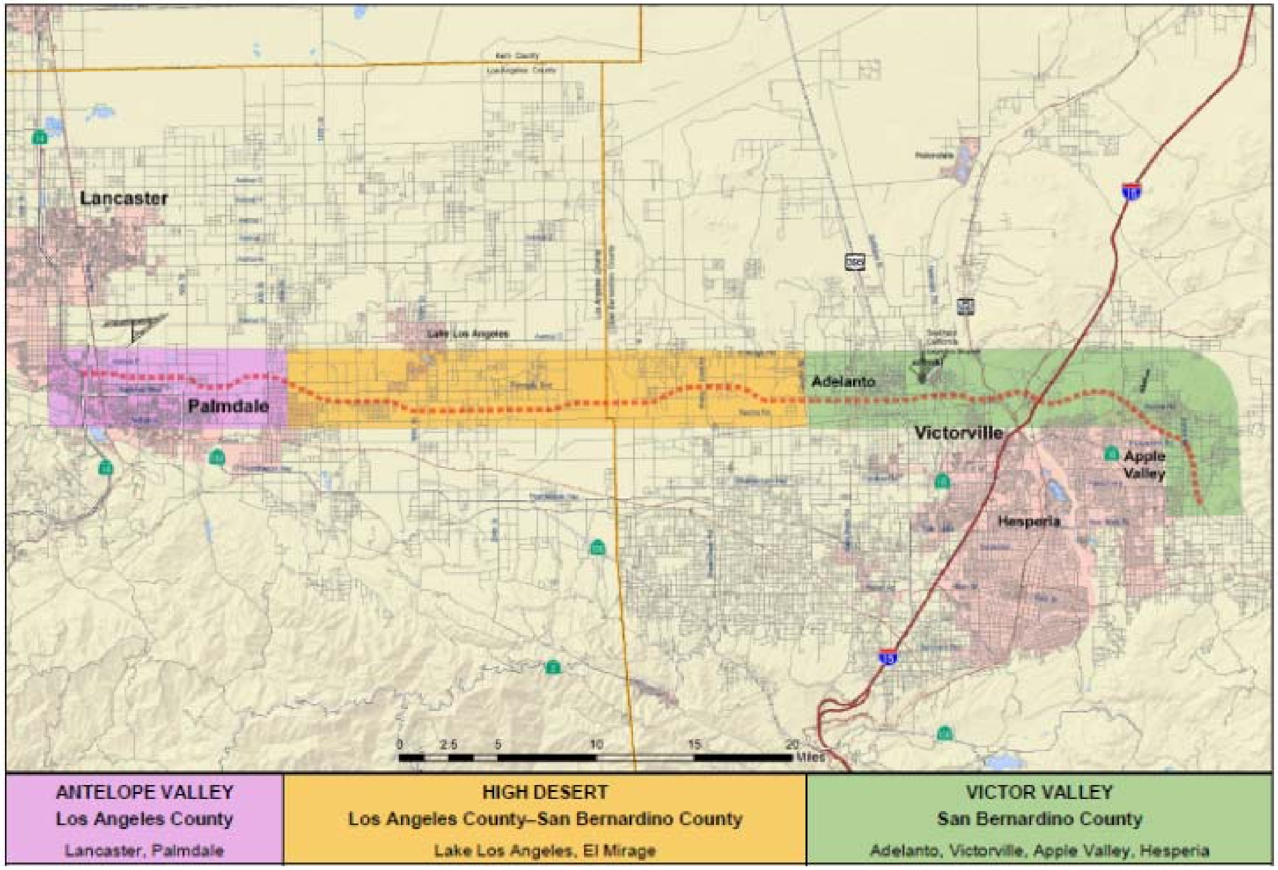

Figure 1-2. Project Location Map

1.3 Purpose and Need

The purpose of the proposed action is to improve west-east mobility through the High Desert region of southern California by addressing present and future travel demand and mobility needs within Antelope and Victor Valleys. The proposed action is intended to:

- Increase the capacity of west-east transportation facilities to accommodate existing and future transportation demand;
- Improve travel safety and reliability within the High Desert region;
- Improve the regional goods movement network;
- Provide improved access and connectivity to regional transportation facilities, including airports and existing and future passenger rail systems, which include the proposed California High Speed Train system and the proposed XpressWest HSR system; and
- Contribute to state greenhouse gas reduction goals through the use of green energy features.

The specific needs to be addressed by the proposed action include:

- Recent and future planned population growth within the High Desert region,
- Limited and unreliable west-east connectivity within the High Desert region,
- Regional demands for goods movement to support the growth of the regional economy, and
- Future demands for the use of green energy, including sustainability and green energy provisions in state law and policy.

1.4 Project Alternatives

Several project alternatives and design variations have been considered and evaluated. A No Build Alternative and four build alternatives were selected for detailed evaluation. These alternatives are described in the following section, along with relevant variations and options.

1.4.1 No Build Alternative

Under the No Build alternative, no new transportation infrastructure would be built within the project area to connect Los Angeles and San Bernardino Counties, aside from existing SR-138 safety corridor improvements in Los Angeles County and SR-18 corridor improvements in San Bernardino County. Traffic circulation and congestion currently experienced on Palmdale Boulevard, Air Expressway, and Happy Trails Highway (existing SR-18) would remain. The no action alternative functions as a baseline to compare with the proposed build alternatives.

1.4.2 Freeway/Expressway Alternative (Avenue P-8, I-15 and SR-18)

This alternative would be a combination of a controlled-access freeway and an expressway. It generally would follow Avenue P-8 in Los Angeles County and would run just south of El Mirage Road in San Bernardino County. This alternative would extend east to Air Expressway Road near I-15 and curve south, terminating at Bear Valley Road. The incorporation of green energy technologies and a bike path along segments of the alternative would also be considered.

Two physical alignment variations are being considered, including:

- Variation B (south): East of the county line, the freeway/expressway would flare out slightly south of the main alignment between Oasis Road and Coughlin Road. Variation B1 would be at the same location, but it would flare out a little less and pass through the Krey airfield.
- Variation D: Near the community of Lake Los Angeles, the freeway/expressway would dip slightly south of the main alignment, just south of Avenue R approximately between 180th St. East and 230th Street East.

1.4.3 Freeway/Tollway Alternative (Avenue P-8, I-15 and SR-18)

This alternative would follow the same physical alignment as the Freeway/Expressway Alternative (including Variations B and D), but the section between 100th Street East and U.S. 395 would operate as a tollway. Details of this operating feature are being evaluated as part of an ongoing P3 analysis. The incorporation of green energy technologies and a bike path would also be considered.

1.4.4 Freeway/Expressway Alternative with High-Speed Rail (HSR) Feeder/Connector Service

This alternative would be the same as the Freeway/Expressway Alternative, except that it would also include an HSR Feeder/Connector Service between the cities of Palmdale and Victorville. The HSR Feeder/Connector Service would use proven steel wheel-on-steel track technology, and would have a design speed of 180 miles per hour (mph) with an optimal operating speed of 125 mph. The incorporation of green energy technologies and a bike path would also be considered.

1.4.5 Freeway/Tollway Alternative with High-Speed Rail Feeder/Connector Service

This alternative would be the same as the Freeway/Tollway Alternative, except that it would also include an HSR Feeder/Connector Service between Palmdale and Victorville. The incorporation of green energy technologies and a bike path would also be considered.

1.5 High Speed Rail Features Common to the Build Alternatives

1.5.1 Rail Connection Options

At the western end of the HDC, the HSR component would be designed to connect with the Palmdale Transportation Center. At the eastern end of the HDC, the HSR component would be designed to connect with the XpressWest Victorville Station.

PALMDALE RAIL CONNECTION

Two rail alignment options are under consideration for the western terminus of the HSR, Rail Option 1 and Rail Option 7.

Rail Option 1

Rail Option 1 would shift the existing Palmdale Transportation Center 800 feet south, and would require a cut-and-cover box and mined tunnels. This option would encroach upon the Air Force Plant 42 parking lot associated with the Palmdale Airport. The alignment would also pass under commercial development at Rancho Vista Boulevard and 15th Street East. This option would diverge from the HDC median, and would require two rail tracks to pass under the HDC westbound lanes.

Rail Option 7

Rail Option 7 would require a mixture of aerial structures and tunneling, and would allow the Palmdale Transportation Center to remain at its current location. This option would encroach upon a small residential area near 10th Street East. It would require a four-track section within the HDC median and a larger HDC right-of-way in this area.

VICTORVILLE RAIL CONNECTION

Two rail alignment options are under consideration for the eastern terminus of the HSR, the Northern Alignment Option 1 and the Variation E Alignment Option.

Northern Alignment Option 1

Northern Alignment Option 1 would cross the Mojave River and Quarry Road, and would gradually curve northeast. This option would diverge from the HDC median in a trench, and would require two rail tracks to pass under the HDC westbound travel lanes, HDC on-ramp, and Mojave Railroad, where the tracks would connect to the southernmost limit of the XpressWest tracks.

Variation E Alignment Option

The Variation E Alignment Option would diverge from the HDC alignment at East El Evado Road in a northeasterly direction and cross the Mojave River. This option would require two rail tracks to pass under the HDC westbound and eastbound lanes, and connect with the southernmost limit of the XpressWest tracks.

1.5.2 Power and Communications Features

The HSR components of the project would include the train cars themselves, each of which would have an electric motor and would function as an electric multiple unit (EMU), the overhead catenary system (OCS) that would supply power to the train motors and the steel rails that would provide a return circuit for that power, the traction power substations and distribution lines that would support the OCS, and the power lines providing electric power to the traction power substations. These systems would operate at a frequency of 60 Hertz (Hz) and voltages up to 25 kilovolts. The communications system would include a radio tower that would maintain communications with trains traveling along the HDC, transponders on the trains, and radios to send and receive voice communications, signals, and data. Voice communications likely would operate at frequencies of 160 Megahertz (MHz) and 450 MHz, while data communications likely would operate at frequencies between 2.4 and 5.9 Gigahertz. Radio towers necessary for HSR communications would be approximately 100 feet tall and would be spaced approximately 2 miles apart along the entire HSR alignment.

2 ELECTROMAGNETIC FIELDS

2.1 Introduction

Electromagnetic (EM) fields (EMF) consisting of both an electric field and a magnetic field are generated by natural sources such as the sun, lightning, biological processes, and currents within the earth's molten metallic core. Human-made EMF are intentionally generated by electrical devices, such as television and radio broadcasting towers, hand-held radios, X-ray machines, microwave links, and cellular phones. EMF are also unintentionally generated by such devices as electric power transmission and distribution lines, televisions, computers, appliances, ignition systems, and electrical wiring and switches.

Both direct current (DC) and alternating current (AC) electrical devices generate EMF; however, the magnetic flux density[1] is much higher for DC than for AC current. The strength of the electric field generated is proportional to the strength of the electric charge, while the strength of the magnetic field generated is proportional to the motion of the charge (current); when no current is flowing in an electrical circuit, only the electrical field is present. The power of an electric field (i.e., the rate at which energy is transferred) is measured in Watts (W), and the power density (power distributed over a given cross-sectional area perpendicular to the direction of its flow) of the electric field's flux is measured in Watts per square meter (W/m^2).

Electrical devices generate both near-field and far-field EMF. Non-radiative near-field behaviors of EMF dominate close to the device (e.g., within 1 to 2 wavelengths of their source) while far-field behaviors dominate at greater distances. Near-field EM strength decreases in proportion to increasing distance from the source, while far-field EM strength decreases in proportion to the square of increasing distance from the source (the so-called inverse-square law). Far-field EMF are completely independent of their sources, and constitute what is typically referred to as electromagnetic radiation (EMR).

EMR consists of waves characterized by variations in electric fields (measured in volts [V] per meter [m], or V/m) and magnetic fields (measured in Tesla [T] or Gauss [G]). These periodic waves move through a medium, such as air, transferring energy from place to place as they go. The waves move at the speed of light, and have dimensions of height, or amplitude; wavelength, or the distance between two adjacent peaks of the wave; and number of cycles per second (Hertz [Hz]), or frequency. Table 2-1 shows wavelengths for a range of different frequencies. Table 2-2 shows the magnetic field strengths of electrical devices and facilities commonly found in urban areas.

[1] Magnetic Flux Density is a measure of the strength of a magnetic field at a given point, expressed by the force per unit length on a conductor carrying unit current at that point (also called magnetic induction)

Table 2-1: Relationship between Typical Frequencies and Their Wavelengths

FREQUENCY	WAVELENGTH
1 Hz	186,280 miles
60 Hz	3,105 miles
10 kHz	186 miles
10 MHz	98.4 feet
100 MHz	9.8 feet
NOTES: Hz – Hertz, kHz – kilohertz, MHz – MegaHertz.	
Source: Occupational Safety and Health Administration 1990	

Table 2-2: Typical Magnetic Field Strengths

ELECTRICAL SOURCE	MAGNETIC FIELD STRENGTH AT 1 FOOT (mG)
Dishwasher	30
Hair Dryer	70
Electric Shaver	100
Vacuum Cleaner	200
High-Voltage Power Transmission Line (115kV-500kV)	30 – 87
Power Distribution Line (4kV-24kV)	10-70
NOTES: mG – milliGauss; kV – kilovolts.	
Source: Peninsula Corridor Joint Powers Board 2014	

The EM spectrum consists of two types of radiation, ionizing and non-ionizing radiation. A wave's position on the EM spectrum depends upon its wavelength. Ionizing radiation – capable of removing electrons from atoms and of thus damaging biological tissues – consists of "short wave" or "high-frequency" radiation, including ultraviolet, x-ray, and gamma ray radiation. Non-ionizing radiation consists of "long-wave" radiation, including radio waves, microwaves, and infrared radiation. Visible light is that portion of the EM spectrum that lies between the infrared (non-ionizing) and ultraviolet (ionizing) portions of the EM spectrum. Radar and many communications systems, such as cell phone towers, radio and television broadcast towers, airport radar and navigation systems, and police, fire, and emergency communications, operate in the range of 500 kilohertx (kHz) to 3 Gigahertz (GHz). Extremely low frequency (ELF) EMR consists of EMR from approximately 3 to 3,000 Hz.

This Technical Memo (TM) addresses the potential electromagnetic interference effects of non-ionizing long-wave EMR at wavelengths below those of visible light on human health and on sensitive electric and electronic equipment and facilities along the project alignment.

2.2 Existing Electric Train Systems and Studies

A substantial body of literature is available on EMR from operating light and heavy rail systems in the United States and Europe. These systems include AMTRAK's Northeastern Corridor line (a 25-kilovolt [kV], 60-Hz system) and the Los Angeles (LA) Metro Rail's light rail lines. Post-electrification studies were conducted on the Northeastern Corridor in

2006. The potential for electromagnetic interference (EMI) from the Central Corridor Light Rail Transit (LRT) line in Minneapolis to interfere with sensitive equipment was studied by University of Michigan staff in 2009, based on an existing light rail operation (Hiawatha LRT). The potential for radio-frequency EMI from LA Metro's Crenshaw / LAX light rail line to interfere with commercial aircraft operations was studied by LA Metro in 2013. These studies provide a broad understanding of the potential EMI effects of EMR from electric rail operations.

2.3 EMF Exposure and Health Effects

EMF can cause EMI, which can disrupt sensitive equipment, possibly triggering a malfunction (e.g., pacemakers). At sufficiently high exposure levels, EMF could also directly affect human health. Extensive research on EMF has led the majority of scientists and health officials to conclude, however, that at typical exposure levels, low-frequency EMF has no adverse health effects. Objective scientific reviews of animal studies, from which some human health risks have been extrapolated, have also concluded that existing data are inadequate to indicate a potential risk of cancer, which is the primary human health concern associated with EMF exposure (World Health Organization 2007, International Agency for Research on Cancer 2002). However, EMF remains a human health concern. Health-related EMR effects will not be further addressed in this TM.

2.4 Electromagnetic Interference

2.4.1 General Considerations

EMI is a disturbance that interrupts or degrades the performance of an electrical device, circuit, or signal due to EMR from an outside source. Ambient EMI occurs when EMR intentionally or unintentionally jams, or blocks, another EM signal in free space. Hardware EMI occurs when EMR induces an unintended current in an electrical circuit.

Commercial and military standards have been developed for electromagnetic compatibility (EMC), both to limit EMI generated by electrical devices and to reduce susceptibility of electrical devices to external EMI. For example, the Federal Aviation Administration's interim EMC commercial standards require aircraft systems to withstand EMR fields of up to 200 V/m. The Department of Defense also has established EMC requirements for military aircraft that generally operate in a more harsh EMR environment.

2.4.2 Electromagnetic Interference and Radio Communications

Intentional radio signals exist in a sea of unwanted radio-frequency "noise," so radio communications systems and devices are designed to operate in this environment. General frequency ranges are assigned for various types of signals, and specific radio frequencies and power output levels are assigned to individual users to minimize the potential for disruptions. Radio equipment is designed to separate the frequency of interest from background noise and to reject transient or unfocussed signals. To interfere with a radio or microwave signal, the

EMI must be at or near its frequency, and at a relatively high power level. Radio and other communications typically operate in the range of 500 kHz to 3 GHz.

2.4.3 Electromagnetic Interference and Aircraft

Modern aircraft rely upon sophisticated electronic systems, especially navigation, surveillance, and communications systems, for safe flight. Metallic aircraft fuselages provide relatively good shielding for internal electronic systems; however, windows provide pathways into the interior of the aircraft and externally mounted antennas and equipment provide pathways for EMI to penetrate the fuselage (National Aeronautic and Space Administration [NASA] 1994). As aircraft manufacturers shift from metallic to composite materials, as electronic systems expand and operate at lower voltages, as hydraulic and mechanical control systems are replaced with electrical systems, and as analog systems are replaced with digital systems, aircraft are becoming more vulnerable to EMI from external sources.

It is well-established that external EMI can affect aircraft in flight. Lightning, radar, amplitude modulated (AM) and frequency modulated (FM) radio transmitters – all high-intensity sources - have all been documented as affecting aircraft (NASA 1994). The effects included triggering warning lights, moving control surfaces, and disrupting communications. A survey of pilots found that high-intensity radio-frequency (HIRF) EMI had an incidence rate of 2.6 to 7.9 events per 1,000 flights. However, all of these effects were associated with high-intensity sources of EMI (NASA 1994). Field simulations and other testing of aircraft communications systems exposed to low-intensity radio-frequency EMR from a light rail transit system indicated that there was no interference (Los Angeles Metro Rail 2013).

2.4.4 Electromagnetic Interference and Sensitive Equipment

Research equipment is generally designed to operate within the earth’s natural magnetic field, and to compensate for fluctuations in that field of up to 10 milliGauss (mG) (University of Michigan 2009). Sensitive electrical equipment is usually well-shielded to protect it against magnetic fields from nearby utility power lines. Industries associated with the use, assembly, calibration, or testing of sensitive or unshielded radio-frequency (RF) equipment, however, are still sensitive to EMI. In particular, fluctuations in the magnetic field can interfere with nuclear magnetic resonance (NMR), nuclear magnetic imaging (NMI), and other imaging equipment, such as electron microscopes. Computed tomology (CT) and computed axial tomology (CAT) scanning devices also are sensitive to EMI, as are some semi-conductor, nano-technology, and bio-technology operations. NMR spectrometers are sensitive to time-varying DC magnetic fields of under 2 mG (University of Michigan 2009). For unshielded equipment that is sensitive to magnetic fields in the range of 1 to 3 mG, such as magnetic resonance imaging (MRI) systems, electromagnetic interference is possible from sources up to 200 feet from the MRI. An installation guide for NMR equipment recommends a separation distance of 100 m from electric trains.

3 AFFECTED ENVIRONMENT

3.1 Introduction

The high-speed rail (HSR) alternatives for the High Desert Corridor (HDC) encompass urban areas (Palmdale and Victorville) at each end, and traverses an undeveloped area between the two cities. The electromagnetic field (EMF) environment is thus expected to vary substantially, with a relatively noisy EMF environment in the urban areas and a relatively quiet EMF environment in undeveloped areas. This section of the Technical Memo describes the HDC Study Area in terms of existing and proposed sources of EMF and in terms of current and anticipated future EMF field densities.

3.2 Regulatory Setting

3.2.1 Health and Safety

FEDERAL

The United States (U.S.) Department of Commerce, Federal Communications Commission (FCC), has rules and regulations (47 Code of Federal Regulations [CFR] Part 15) on licensed and unlicensed radio-frequency (RF) transmissions. Most telecommunications devices sold in the United States, whether they radiate intentionally or unintentionally, must comply with 47 CFR Part 15. FCC maximum permissible exposure (MPE) levels are compared to American National Standards Institute (ANSI)/ Institute of Electrical and Electronics Engineers (IEEE) safety standards in Table 3-1.

Table 3-1: Maximum Permissible Exposure Levels for the General Public

Frequency (MHz)	General Public Maximum Permissible Exposure (mW/cm^2)	
	FCC Standards	ANSI/IEEE Standards
450	0.3	0.225
900	0.6	0.45
5,000	1.0	1.0
NOTES: ANSI – American National Standards Institute, IEEE – Institute of Electrical and Electronics Engineers, FCC – Federal Communications Commission, mW/cm^2 – milliWatts per square centimeter, MHz – megahertz.		
Source: California High Speed Rail Authority and United States Department of Transportation Federal Rail Administration 2012.		

U.S. Department of Commerce, FCC, Office of Engineering and Technology Bulletin 65, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields* (OET 65) provides assistance in evaluating whether proposed or existing transmitting facilities, operations, or devices comply with limits for human exposure to RF fields adopted by the FCC.

STATE

The California Department of Education has established minimum distances for siting school facilities from the edge of power line easements (California Code of Regulations, Title 5, Section 14010) at: 100 feet for 50- to 133-kilovolt (kV) lines; 150 feet for 220- to 230-kV lines; and 350 feet for 500- to 550-kV lines.

The California Energy Commission (CEC) recommends designing electric power transmission lines so that electric fields at the edge of the utility's right-of-way do not exceed 1.6 kV per meter (kV/m); the CEC made no recommendation on the strength of magnetic fields.

OTHER ORGANIZATIONS

Several organizations have developed guidelines for electromagnetic radiation (EMR) exposure, including the International Commission on Non-Ionizing Radiation Protection, the IEEE, ANSI, and the American Conference of Governmental Industrial Hygienists (ACGIH). EMR standards suggested by these organizations address low-frequency (e.g., 60-Hertz [Hz]) EMR exposure to the general public. A 1982 ANSI-recommended standard is 1 milliWatt per square centimeter (mW/cm^2).

The IEEE Standard, C95.6, *IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz*, is commonly used in the United States and was formally adopted by ANSI. This standard specifies maximum permissible exposure (MPE) levels for the general public to extremely low frequency (ELF; e.g., 0-3 kiloHertz [kHz]) EMFs. IEEE standards for the general public are frequency-dependent, and are based on RF levels averaged over 30 minutes. The MPEs are intended to protect all members of the public, including pregnant women, infants, and the infirm. The IEEE standards for 60-Hz fields for the general public are shown in Table 3-2.

Table 3-2: Magnetic and Electric Field Levels for the General Public

Body Part	Frequency (Hz)	Field Strength
Magnetic Field Level		
Head and Torso	60	9.04×10^3 mG
Arms or Legs	60	632,000 mG
Electric Field Level		
Whole Body	60	5 kV/m
Notes: k – kilo, Hz – Hertz, mG – milliGauss, V – volts, m – meter.		
Source: California High Speed Rail Authority and United States Department of Transportation Federal Rail Administration 2012..		

3.2.2 Electromagnetic Interference

The U.S. Department of Transportation, Federal Railroad Administration has regulations (49 CFR Parts 236.8, 238.225, and 236 Appendix C) that provide rules, standards, and instructions about operating characteristics of electromagnetic, electronic, and electrical apparatus, and standards for passenger equipment. The FCC regulations discussed above, although health-based, serve to limit electromagnetic interference (EMI) from telecommunications devices. No other federal, state, or local governmental agency specifically regulates EMF for purposes of avoiding EMI.

3.3 General Setting

3.3.1 Land Use

Lands along the project alignment are mostly undeveloped. Some of the undeveloped land is used for rangeland or agriculture. Other common land uses along the proposed HDC route are residential and office development. Air Force Plant 42 (AFP-42) / Palmdale Regional Airport abuts the project alignment near its western terminus in Palmdale. Land uses in the general vicinity of the proposed HDC include several other airports (e.g., Southern California Logistics Airport) and airfields; several schools; and at least three medical centers.

Sensitive receptors of EMR for health effects concerns include homes, offices, and other occupied structures near the project alignment, especially high-density land uses or land uses where individuals are present for long periods. Sensitive receptors for potential EMI along the proposed HDC include businesses engaged in nano-technology or bio-technology research or other high-technology industries with sensitive electrical equipment, hospitals and other health facilities that use magnetic resonance imaging (MRI) or computerized axial tomology (CAT) technology, airports and other aircraft facilities, and businesses with radio or microwave communications.

3.3.2 Existing Sources of EMR

Substantial sources of EMR in the vicinity of the HDC alignment include several amplitude modulated (AM) and frequency modulated (FM) radio stations. Two cell phone towers are located near the alignment, one to the southwest of Palmdale and one to the east. A third cell phone tower is located at Quartzite Mountain to the north of Victorville. Several electric power transmission lines rated at 100 kV to 500 kV and owned by Los Angeles Department of Water and Power or Southern California Edison cross the eastern portion of the HDC alignment, including one 500-kV, direct current (DC) power line with a capacity of 2,400 megawatts (MW). In addition, several low-power electric power distribution lines cross the project alignment at various points. All of these facilities generate EMR of different frequencies and intensities.

3.3.3 Existing EMR Levels

The earth’s natural magnetic field ranges from about 300-600 milliGauss (mG), DC. EMR from human-made sources is common, and is generally increasing in urban areas as new technologies are introduced and proliferate. People living in urban areas are exposed daily to a complex EMF of varying frequencies and strengths from a variety of electrical sources, both from external sources and from appliances, televisions and computers, and even the wiring in their homes. The average home in North America has a background alternating current (AC) magnetic field level indoors of about 1 mG (World Health Organization 2007).

EMF in the HDC Study Area has not been measured. EMF levels along the CalTrain corridor on the San Francisco peninsula have been measured, however, and are assumed to be reasonably representative of urban and rural EMF levels in California. Along that alignment, DC magnetic fields ranged from about 357 mG to 640 mG, and AC magnetic fields ranged from about 1.8 to 18.4 mG. EMF in the kHz to Megahertz (MHz) range also were detected along the alignment, but were not quantified.

Ambient EMF levels also were measured for the Merced to Fresno portion of the California High Speed Train project alignment. Measurements of the AC magnetic field at nine locations along the proposed alignment resulted in a range of levels from 0.46 mG to 10.94 mG; the high measurement was detected where a transmission line crossed the alignment. Combining the two sets of field measurements for other proposed HSR alignments in California yields a range of values for AC magnetic fields of about 0.5 mG to about 18 mG. This range of EMF levels is assumed to be similar to the range of EMF levels along the HDC alignment.

4 ENVIRONMENTAL CONSEQUENCES

4.1 Introduction

This discussion examines whether electromagnetic radiation (EMR) from the project would adversely affect high-technology facilities or equipment along the project alignment. Construction of the High Desert Corridor (HDC) would not use any unusual powered construction equipment, and thus would not affect EMR-sensitive land uses along the project alignment. Should one of the high-speed rail (HSR) alternatives be selected, however, operation of the HDC could affect such uses. Best management practices (BMPs) would be evaluated and implemented to address potential impacts during the operational phases. A discussion regarding the potential EMR impacts, along with project design features, is provided in the following sections.

4.2 Determination of Significance

An impact would occur if project-generated electromagnetic interference (EMI) disrupted sensitive electrical, electronic, or magnetic equipment in nearby facilities. Based on the standards, observations, and recommendations discussed in Section 2, a useful screening level for such disruptions would be a change in the alternating current (AC) magnetic field at the receptor site of 2 milliGauss (mG) or more, assuming that electric fields generated by project operations would not be a substantial factor. Further evaluation would then be necessary to determine the exact level of effect on the facility. An impact on a single device or facility, however, would not constitute a “public” impact unless the disruption of that facility, in turn, resulted in a substantial public effect. A disruption that affects a substantial portion of the community over a substantial period, or that reoccurs frequently, would qualify as a significant impact under the California Environmental Quality Act (CEQA) or the National Environmental Policy Act (NEPA).

4.3 Impact Analysis

4.3.1 Construction Impacts

Equipment used to construct the project could generate electromagnetic fields (EMF) and EMI, primarily from powered construction equipment and on-site communications (e.g., cell phones). The EMR levels would be typical for a construction site, and would have no substantial effect on adjacent land uses. EMF/EMI effects during construction would have a negligible intensity under NEPA and would be less than significant under CEQA because the increase in EMR would be minor and geographically limited.

4.3.2 Operational Impacts

NO BUILD ALTERNATIVE

The HSR would not be constructed under the No Build Alternative. No new EMFs would be created within the HDC, although continuing development of the Study Area could include new sources of EMF.

FREEWAY/EXPRESSWAY AND FREEWAY/TOLLWAY ALTERNATIVES

The HSR would not be constructed under the freeway/expressway and freeway/tollway alternatives. No new EMFs would be created within the HDC, although continuing development of the Study Area could include new sources of EMF.

FREEWAY/EXPRESSWAY ALTERNATIVE WITH HIGH-SPEED RAIL FEEDER/CONNECTOR SERVICE

The HSR portion of the HDC project would incrementally increase the electric and magnetic fields near the alignment. The HSR system would create new sources of EMI and would expose humans to slightly higher EMF levels. EMR generated by the low-voltage electric power distribution lines, traction power substations, switching equipment, overhead catenary system, communications and control systems, train motors (electric multiple units, or EMUs), and train movements would consist of power-frequency electric and magnetic fields, harmonic magnetic fields from vehicles, radio-frequency fields, and minor perturbations of the earth’s background magnetic field. Among these sources, traction power substations would generate the most substantial EMR, along with the AC magnetic fields from the propulsion currents flowing in the traction power system – the overhead catenary system (OCS) and rails. EMF fields from electric HSR service on the HDC right-of-way would be highest during periods of peak train operations.

Power Supply System

Power-frequency electric and magnetic fields would be produced by the traction power system, traction power substations, and utility feeder lines. Commercial power in the United States operates at a frequency of 60 Hertz (Hz), so the dominant EMF would be 25 kilovolts (kV) at 60 Hz, AC. A 60-Hz electric field would be produced by the 25-kV operating voltage of the traction system, and a 60-Hz magnetic field would be produced by the flow of currents providing power to the HSR vehicles. Along the tracks, magnetic fields would be produced by the flow of propulsion currents to the trains in the OCS and rails. The OCS and power distribution system would generate Extremely Low Frequency (ELF) EMR at 60 Hz and at harmonics (multiples) of 60 Hz. Magnetic fields from low-voltage lines would drop to background levels within a few hundred feet (e.g., a 115-kV power line generates an electric field of about 0.07 volts per meter [V/m] and a magnetic field of about 1.7 milliGauss [mG] at 100 feet [Hafemeister 1996]). So, depending upon the placement of these facilities, EMF levels at the edge of the right-of-way are expected to be at or below background levels, and below the screening level of 2 mG.

The main source of transient EMI disturbances from the HSR would be switching currents produced by switching loads, relays, power controllers, and switch mode power supplies associated with the OCS and the traction power facilities. High-current electronic switches and controls can produce transient signals that can be transmitted along the power supply network to other electronic systems. Magnetic fields also can be generated by switching stations and traction power substations. The specific frequencies and power levels of these EMR emissions would depend upon the design of the system but, based upon studies of similar light rail and high-speed rail systems, EMI beyond the edge of the project alignment would not be substantial, and would not adversely affect sensitive facilities.

The OCS would also generate EMF from the frequent loss of continuity and arcing between the power supply line and the pantograph.[2] Studies have shown that EMF emissions from the detaching of the power supply line and from re-establishing contact with it differ. Generally, however, these OCS discontinuities produce a large, strongly damped oscillation at 0.5 to 1.0 Megahertz (MHz) and a smaller, less damped oscillation at about 20 MHz (Gianetti et al 2001). Other researchers have determined that the OCS discontinuities produce broadband EMI in the 20 MHz to 40 MHz range. However, most of the EMF generated by the OCS comes from the main circuit conducting power to the trains rather than from the OCS arcs.

Electromagnetic Fields from Vehicles

Power electronics would produce currents with frequencies in the kilohertz (kHz) range. Potential sources include power conversion units, switching power supplies, motor drives, and auxiliary power systems. These sources are highly localized in the trains and would move along the track with the trains. When departing from a station, HSR trains would operate at lower speeds but would have high acceleration rates, thus drawing much more current and producing stronger magnetic fields. Conversely, when approaching a station, HSR trains would be decelerating and would draw much less current.

The specific frequencies and power levels of these EMR emissions would depend upon the design of the system, as noted above for wayside facilities but, based upon studies of similar light rail and high-speed rail systems, EMF beyond the edge of the project alignment would be at or below background levels. A study of an operating light rail system found that the maximum EMI from the propulsion system was only 2 mG at 30 feet from the train (University of Michigan 2009). The propulsion systems are point sources of EMF, and the field strength would decrease with the square of the distance from the source (e.g., field strength at the edge of the HDC corridor would be only about 0.2% to 0.4% of the field strength in the vicinity of the source). Thus, EMR from individual trains is not expected to adversely affect sensitive equipment or interfere with communications systems.

Radio-Frequency Fields

The HSR system would use a variety of radio-frequency communications, data transmission, and monitoring systems, both on the vehicles and along the corridor. These communications

[2] Pantograph - a device usually consisting of twoparallel, hinged, double-diamond frames, for transferring current from an overhead wire to a vehicle, as a trolley car or electric locomotive.

systems would operate in the same frequency ranges as existing communications systems in the Study Area, but would be assigned specific frequencies that would not conflict with other communications systems in the area. HSR radio systems would transmit radio signals from antennas located at stations, along the track alignment, and on train cars; radio communications would be facilitated by 100-foot-high radio towers located approximately every two miles along the alignment. These radio systems would likely operate at frequencies below 925 MHz because frequencies higher than 925 MHz will not function on trains traveling at high speeds. Radio systems procured for HDC use are expected to be commercial off-the-shelf systems. These wireless systems would meet the Federal Communications Commission's (FCC's) regulatory requirements for intentional emitters (47 Code of Federal Regulations Part 51 and FCC DET Bulletin #65), which include emissions requirements intended to ensure electromagnetic compatibility with other radio users.

Train Movement

The movement of large metallic objects within the earth's natural magnetic field causes fluctuations in that field. Thus, high-speed trains would cause short-term fluctuations in the background magnetic field as they move along the HDC alignment. These shifts in the earth's direct current (DC) magnetic field measure about 1 mG at a distance of 80 feet from a train (University of Michigan 2009), and would not adversely affect nearby sensitive land uses.

Estimated Overall EMR Strength from High-Speed Rail Operations

As shown in Table 4-1, estimated field strengths beyond the HDC right-of-way for HSR operations are generally well below recommended thresholds, with the exception of electric fields at traction power substations. The electric field at the traction power substation, however, would be mostly contained within the structure.

Table 4-1: Estimated EMR Strength for High-Speed Rail Operations Within the High Desert Corridor

Location	Electric Field (kV/m)	Magnetic Field (mG)	
		Average / Off-Peak	Maximum
Within 15 feet of outside rail	0.35	1.9-4.5	11.4
Within 58 feet of alignment centerline	0.48	4-11	35-41
Traction Power Substation	0-22.2	15	110
Notes: Values are for a frequency range of 0-3,000 Hz. Calculations were made from the centerline of the track. The current distributions assumed for the analysis represent "worst-case" conditions and are therefore conservative.			
Source: Peninsula Corridor Joint Powers Board 2014			

Magnetic fields generated by the project beyond the HSR right-of-way would be minor in comparison to background levels and threshold levels. The intensity of these magnetic fields generated by the project would decrease rapidly with distance and would be substantially lower at nearby sensitive receptors where sensitive equipment may be located. EMF levels at nearby schools, hospitals, businesses, and residences would be below the screening threshold for magnetic fields. EMR from the project would not create EMI with existing communications systems or sensitive equipment. Thus, these effects would have negligible intensity under NEPA and, under CEQA, would be less than significant.

Rail Option #1

Under this HSR option, the nearest approach of the HSR alignment to Air Force Plant (AFP)-42 would be about 900 feet. At this distance, the EMF would be about 10% of its strength at the edge of the 500-foot-wide corridor.

Rail Option #7

Under this HSR option, the nearest approach of the HSR alignment to AFP-42 would be about 700 feet. At this distance, the EMF would be about 5% of its strength at the edge of the 500-foot-wide corridor.

FREEWAY/TOLLWAY ALTERNATIVE WITH HIGH-SPEED RAIL FEEDER/CONNECTOR SERVICE

The impacts on the environment from EMF generated by the HSR component of this alternative would be the same as described for the freeway/expressway alternative with HSR. No significant impacts on sensitive facilities or land uses would result from EMF generated by the HSR component of the HDC project.

4.4 Cumulative Impacts

Cumulative impacts are impacts that result from past, present, and reasonably foreseeable future actions, combined with the potential impacts of this project. A cumulative effect assessment looks at the aggregate impacts resulting from two or more individual land use plans or projects. Cumulative impacts can result from individually minor, but collectively substantial, impacts.

Cumulative EMR impacts in the Study Area would result from commercial or industrial development that included new sources of EMR. Foremost among potential new sources of EMR in the community would be the California HSR and Xpress HSR projects. While their alignments would not overlap with that of the HDC HSR, these projects would increase EMR levels to the north of the western end of the HDC and east of the eastern end of the HDC alignment. Expanded operations at Palmdale Regional Airport or at Southern California Logistics Airport, with their associated new aircraft navigation and communications activity, would incrementally increase radio-frequency EMR in the vicinities of these facilities. No other substantial new sources of EMR in the Study Area have been identified.

5 BEST MANAGEMENT PRACTICES

The potential for electromagnetic interference (EMI) shall be minimized by ensuring that all electronic equipment is operated with a good electrical ground and that proper shielding is provided for electronic system cords, cables, and peripherals. The design of the system will consider and incorporate, where practicable, the latest standards relevant to minimizing the effects of EMI on other systems.

During final design, detailed analyses shall be undertaken to determine the specific levels of voltages that could be induced onto paralleling longitudinal conductors and, if significant voltages are identified, mitigation measures shall be developed in accordance with the relevant industry-accepted Institute of Electrical and Electronics Engineers or military standards. The final design shall use proven technologies for overhead catenary system components, and the technical specifications shall be written to assure that damage to the conductors and hardware during construction will be minimized.

6 LIST OF PREPARERS

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