3.5 Electromagnetic Fields and Electromagnetic Interference

3.5.1 Introduction

This section provides information about electromagnetic fields (EMFs)—what they are, how they are measured, and what governmental and industry standards have been developed to regulate these fields. For this EIR/EIS, the Authority undertook a measurement program to identify existing electromagnetic levels in each section of the HST project. This EIR/EIS section describes the measured levels, as well as the potential for electromagnetic interference (EMI) from operation of the HST. This section focuses on land uses that are particularly sensitive to EMF, such as businesses and institutions that use equipment that may be highly susceptible to EMI, or that engage in medical research activities that might be affected by HST-operation EMFs.

Other sections provide additional information about issues related to EMF/EMI, such as the presence and growth of populations and locations of sensitive receptors. These sections include 3.12, Socioeconomics, Communities, and Environmental Justice; 3.13, Station Planning, Land Use, and Development; and 3.18, Regional Growth.

EMFs are electric and magnetic fields. Electric fields describe forces that electric charges exert on other electric charges. Magnetic fields describe forces that a magnetic object or moving electric charge exerts on other magnetic materials and electric charges. EMFs occur throughout the electromagnetic spectrum, are found in nature, and are generated both naturally and by human activity. Naturally occurring EMFs include the Earth's magnetic field, static electricity, and lightning. EMFs also are created by the generation, transmission, and distribution of electricity; the use of everyday household electric appliances and communication systems; industrial processes; and scientific research.

Definitions: Electromagnetic Spectrum and Wave

The **electromagnetic spectrum** is the range of waves of electromagnetic energy. It includes static fields such as the earth's magnetic field, radio waves, microwaves, x-rays, and light.

An **electromagnetic wave** has a frequency and wavelength that are directly related to each other—the higher the frequency, the shorter the wavelength.

EMI occurs when the EMFs produced by a source adversely affect operation of an electrical, magnetic, or electromagnetic device. EMI may be caused by a source that intentionally radiates EMFs (such as a television broadcast station), or one that does so incidentally (such as an electric motor).

EMFs are described in terms of their frequency, which is the number of times the electromagnetic field increases and decreases its intensity each second. In the United States, the commercial electric power system operates at a frequency of 60 Hertz (Hz) or cycles per second, meaning that the field increases and decreases its intensity 60 times per second. Electric power system components are typical sources of electric and magnetic fields. These components include generating stations and power plants, substations, high-voltage transmission lines, and electric distribution lines. Even in areas not adjacent to transmission lines, 60-Hz EMFs are present from electric power systems and common building wiring, electrical equipment, and appliances.

Natural and human-generated EMFs cover a broad-frequency spectrum. EMFs that are nearly constant in time are called "DC" (direct-current) EMFs. EMFs that vary in time are called "AC" (alternating-current) EMFs. AC EMFs are further characterized by their frequency range. Extremely low frequency (ELF) magnetic fields typically are defined as having a lower limit of 3 to 30 Hz and an upper limit of 30 to 3,000 Hz. The HST overhead contact system (OCS) and power distribution system primarily would generate ELF fields at 60 Hz and at harmonics (multiples) of 60 Hz.

Radio and other communications operate at much higher frequencies, often in the range of 500,000 Hz (500 kilohertz [kHz]) to 3 billion Hz (3 gigahertz [GHz]). Typical radio frequency (RF) sources of EMF include antennas associated with cellular telephone towers; broadcast towers for radio and television; airport radar, navigation, and communication systems; high frequency (HF) and very high frequency (VHF) communication systems used by police, fire, emergency medical technicians, utilities, and governments; and local wireless systems such as wireless fidelity (WiFi) or cordless telephone.

Unit Definitions and Conversions

Hertz (Hz) – Unit of frequency equal to one cycle per second

1 kilohertz (kHz) = 1,000 Hz

1 gigahertz (GHz) = 1 billion Hz

Gauss (G) – Unit of magnetic flux density (intensity) (English units)

1 G = 1,000 milligauss (mG)

Tesla (T) – Unit of magnetic flux density (intensity) (International units)

1 T = 1 million microtesla (µT)

1 G = 100 µT

1 mG = 0.1 µT

The strength of magnetic fields often is measured in milligauss (mG), gauss (G), tesla (T), or microtesla (µT). For comparison, earth's ambient magnetic field ranges from 500 to 700 mG DC (0.5 to 0.7 G) (50 to 70 µT) at its surface. Average AC magnetic field levels within homes are approximately 1 mG (0.001 G) (0.1 µT), and measured AC values range from 9 to 20 mG (0.009 to 0.020 G) (0.9 to 2 µT) near appliances (Severson et al. 1988). The strength of an EMF rapidly decreases with distance away from its source; thus, EMFs higher than background levels are usually found close to EMF sources.

The information presented in this section primarily concerns EMFs at the 60-Hz power frequency, and at radio frequencies produced intentionally by communications or unintentionally by electric discharges. EMFs from the HST operation would consist of the following:

- Power-frequency electric and magnetic fields from the traction power system, traction power substations (TPSSs), emergency generators that provide backup power to the stations in case of a power outage, and utility feeder lines: 60-Hz electric fields would be produced by the 25-kV operating voltage of the HST traction system, and 60-Hz magnetic fields would be produced by the flow of currents providing power to the HST vehicles. Along the tracks, the magnetic fields would be produced by the flow of propulsion currents to the trains in the OCS and rails.

- Harmonic magnetic fields from vehicles: Depending on the design of power equipment in the HST trains, power electronics would produce currents with frequency content in the kHz range. Potential sources include power conversion units, switching power supplies, motor drives, and auxiliary power systems. Unlike the traction power system, these sources are highly localized in the trains, and move along the track as the trains move.

- RF fields: The HST system would use a variety of communications, data transmission, and monitoring systems—both on and off vehicles—that operate at radio frequencies. These wireless systems would meet the Federal Communications Commission (FCC) regulatory requirements for intentional emitters (47 CFR Part 15 and FCC DET Bulletin No. 65, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields)*.

Of these EMFs, the dominant effect is expected to be the 60-Hz AC magnetic fields from the propulsion currents flowing in the traction power system; that is, the OCS and rails.

3.5.2 Laws, Regulations, and Orders

3.5.2.1 Introduction

Several organizations have developed guidelines for EMF exposure, including individual states, the Federal Communications Commission (FCC), Occupational Safety and Health Administration (OSHA), the Institute of Electrical and Electronics Engineers (IEEE), American National Standards Institute (ANSI), and the American Conference of Governmental Industrial Hygienists (ACGIH). Neither the California government nor the United States government has regulations limiting EMF exposure to residences.

EMF exposure guidelines and standards have also been adopted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in the ELF and RF frequency bands applicable to HST emissions. The ICNIRP and the IEEE standards both address EMF exposure by the general public and for workers in an occupational setting. While the ICNRIP guidelines are widely used within the United States and abroad, and have been formally adopted by the European Union, the IEEE standards have been identified in the Statewide Program EIS/EIR to assess the potential for health and compatibility effects from anticipated HST emissions. For occupational exposure, ICNIRP reference values are 1,000 µT for magnetic fields and 8.333 kilovolt/meter (kV/m) for electric fields.

The IEEE Standard C95.6, IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz, which is often referenced in the United States and has been formally adopted by ANSI, specifies maximum permissible exposure (MPE) levels for the general public and for occupational exposure to extremely low-frequency EMFs, which have frequencies of 0 to 3 kHz. The HST electrification and traction systems would generate extremely low-frequency EMFs with frequencies of 60 Hz, which is in the range covered by this standard. The IEEE Standard C95.6 exposure levels are presented in Tables 3.5-1 and 3.5-2 below (IEEE 2002). Note that the IEEE exposure levels are recommendations only, not regulations.

Table 3.5-1
IEEE C95.6 Magnetic Field MPE Levels for the General Public

Body Part	Frequency Range (Hz)	B-Field (mG)
Head and Torso	20 – 759	9.04 x 103
	759 – 3,000	6.87 x 106/f
	60	9.04 x 103
Arms or Legs	< 10.7	3.53 x 106
	10.7 – 3,000	3.79 x 107/f
	60	632,000

Notes:
/f = divide by the frequency
Hz = hertz
IEEE = Institute of Electrical and Electronics Engineers
mG = milligauss
MPE = maximum permissible exposure

Table 3.5-2
IEEE C95.6 Electric Field MPE Levels for the General Public

Body Part	Frequency Range (Hz)	E Field (v/m)
Whole Body	1 – 368	5,000
	368 - 3,000	1.84 x 106/f
	60	5,000

Notes:
/f = divide by the frequency
Hz = hertz
IEEE = Institute of Electrical and Electronics Engineers
MPE = maximum permissible exposure
v/m = volts per meter

In 2006, the ANSI adopted IEEE Standard C95.1 as its standard for safe human exposure to non-ionizing electromagnetic radiation (ANSI/IEEE 2006). The HST train control and communications systems would use radio signals within the range covered by this standard. The C95.1 Standard specifies MPE levels for whole and partial body exposure to electromagnetic energy. MPE exposure levels are lower at 100 to 300 megahertz (MHz) because the human body absorbs the greatest percentage of incident energy at these frequencies. The MPE standards become progressively higher at frequencies above 400 MHz because the human body absorbs less energy at these higher frequencies. The IEEE C95.1 Standard MPEs are based on RF levels averaged over a 30-minute exposure time for the general public. For occupational exposure, the averaging time varies with frequency from 6 minutes at 450 MHz to 3.46 minutes at 5,000 MHz.

Both the IEEE C95.6 and C95.1 standards specify safety levels for occupational and general-public exposure. For each, the exposure levels are frequency dependent. The general-public exposure safety levels are stricter because workers are assumed to have knowledge of occupational risks and are better equipped to protect themselves (e.g., through use of personal safety equipment). The general-public safety levels are intended to protect all members of the public (including pregnant women, infants, the unborn, and the infirm) from short-term and long-term exposure to electromagnetic fields. The safety levels are also set at 10 to 50 times below the levels at which scientific research has shown harmful effects may occur, thus incorporating a large safety factor (ANSI/IEEE 2006).

The OSHA safety standards for occupational exposure to RF emissions are found at 29 CFR 1910.97. The OSHA safety levels do not vary with frequency and are less stringent than the equivalent ANSI/IEEE and FCC MPEs, except for occupational exposure to fields with frequencies above 5,000 MHz where the OSHA MPE is equal to the C95.1 MPE and is two times higher than the FCC MPE. The OSHA MPEs are based on a 6-minute averaging time.

The ACGIH provides that occupational exposures should not exceed 10 G (10,000 mG or 1 mT). ACGIH additionally recommends that workers with pacemakers should not exceed 1 G (1,000 mG or 0.1 mT). The ACGIH 10 G guideline level is intended to prevent effects such as induced currents in cells or nerve stimulation. However, the ACGIH guidelines are for occupational exposure, not general-public exposure.

3.5.2.2 Federal

- U.S. Department of Transportation, Federal Railroad Administration, 49 CFR Parts 236.8, 238.225, and 236 Appendix C. These regulations provide rules, standards, and instructions regarding operating characteristics of electromagnetic, electronic, or electrical apparatus, and regarding safety standards for passenger equipment.
- U.S. Department of Commerce, FCC, 47 CFR Part 15. Part 15 provides rules and regulations regarding licensed and unlicensed RF transmissions. Most telecommunications devices sold in the United States, whether they radiate intentionally or unintentionally, must comply with Part 15. However, Part 15 does not govern any device used exclusively in a vehicle, including on HST trains.
- U.S. Department of Commerce, FCC, Office of Engineering and Technology (OET) 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 (FCC 1997).
- FCC Regulations at Title 47 CFR 1.1310 are based on the 1992 version of the ANSI/IEEE C95.1 safety standard. Table 3.5-3 shows MPEs contained in the ANSI/IEEE C95.1 and FCC standards at frequencies of 450, 900, and 5,000 MHz, which covers the range of frequencies that may be used by HST radio systems. FCC MPEs are based on an averaging time of 30 minutes for exposure of the general public and 30 minutes for occupational exposure. As shown in Table 3.5-3, the differences between the ANSI/IEEE C95.1 and FCC MPEs are minor.

Table 3.5-3
RF Emissions Safety Levels Expressed as MPEs

	ANSI/IEEE C95.1 MPE (mW/cm^2)		FCC MPE (mW/cm^2)		OSHA MPE (mW/cm^2)
Frequency	**Occupational**	**General Public**	**Occupational**	**General Public**	**Occupational**
450 MHz	1.5	0.225	1.5	0.3	10
900 MHz	3.0	0.45	3.0	0.6	10
5,000 MHz	10	1.0	5.0	1.0	10

Acronyms and Abbreviations:
ANSI/IEEE = American National Standards Institute/Institute of Electrical and Electronics Engineers
cm = centimeter
FCC = Federal Communications Commission
MHz = megahertz
MPE = maximum permissible exposure
mW = megawatt
OSHA = Occupational Safety and Health Administration
RF = radio frequency

3.5.2.3 State

- California High-Speed Rail Authority—Electromagnetic Compatibility Program Plan (EMCPP). The EMCPP defines the project's High-Speed Transport Protocol Electromagnetic Compatibility (EMC) objective, which will provide for electromagnetic compatibility of HST equipment and facilities with themselves, with equipment and facilities of the HST's neighbors, and with passengers, workers, and neighbors of the HST. The EMCPP will also guide and coordinate the EMC design, analysis, test, documentation, and certification activities among HST project management, systems, and sections through the project phases; conform with the EMC-related HST system requirements; and comply with applicable regulatory requirements, including EMC requirements in 49 CFR 200-299 for the HST systems and sections (Authority 2010a).

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

- California Public Utilities Commission (CPUC) Decision D.93-11-013. The CPUC decision adopted a policy regarding EMF from regulated utilities'.

3.5.2.4 Regional and Local

EMF- and EMI-related topics are discussed in some local and regional general plans and ordinances, typically as guidance or policy. The EMI and EMF guidance in these plans and ordinances generally is derived from the federal and state regulations listed above.

3.5.3 Methods for Evaluating Impacts

3.5.3.1 Electromagnetic Fields and Electromagnetic Interference Data Collection and Analysis

The following steps were performed to identify representative land uses that could be affected by the EMFs resulting from HST operations, and to predict HST EMF levels for those land uses. The assessment included sites that would not be expected to be affected by HST operations, which serve as "control" sites.

- Maps, surveys, photographs, and database searches to identify land uses in the Fresno to Bakersfield Section that might be susceptible to the EMFs produced by a HST. Such uses include universities, medical institutions, high-tech businesses, and governmental facilities that use equipment that could be affected by new sources of EMFs. Baseline measurements of EMFs were made in accordance with technical guidance developed by the Authority and FRA at selected measurement locations to establish EMF levels representative of existing conditions along the Fresno to Bakersfield Section (Authority and FRA 2010). Using these targeted areas, the reconnaissance described above identified sensitive land uses. Appendix 3.5-A, Technical Study: Pre-Construction Electromagnetic Measurement Survey of 10 Locations along the Fresno to Bakersfield Section, describes the measurement sites and discusses the existing EMF levels that potentially could cause EMI at the measurement sites.

- A mathematical model of the HST traction electrical system was used to calculate the anticipated maximum 60-Hz magnetic fields that a single HST train would produce. The model incorporates conservative assumptions for the potential EMF impacts of the HST. For example, the projected maximum magnetic fields would exist only for a short time and only in certain locations as the train moves along the track or changes its speed and acceleration.

The magnetic field levels decline rapidly as lateral distance from the tracks increases. For most locations and most times, "exposure" to EMFs would not be as great as predicted by the model, which gives peak levels. The EMF model uses a 220-mph speed assumption. The worst-case conditions for magnetic fields would be short term, because train current is not always at a peak level, depending on train speed and acceleration, and because currents split between two tracks, between contact wire and negative feeder, and between front and rear power stations as the train travels down the line. The model identifies how the projected maximum EMF levels vary with lateral distance from the centerline of the tracks. The *Draft Environmental Impact Report/Environmental Impact Statement Assessment of California High-Speed Train Alignment Electromagnetic Field Footprint* (Footprint Report) (Authority 2010b) describes the modeling methodology and discusses the modeling results for a single-train HST.

- For the identified sensitive land uses from the field reconnaissance, maximum EMF levels emitted by the HST system were predicted and compared to the measured, existing ambient conditions. Because magnetic fields are expected to be the dominant EMF effect from HST operation,[1] these calculation results serve as the basis for the EMF impact analysis. Impacts were identified based on the difference between the predicted EMF levels and the existing conditions. Where the predicted magnetic fields are comparable to or lower than the typical levels, no adverse impact would occur, and these locations were screened out. Where the predicted magnetic fields are higher than typical levels for exposure, then the potential for EMI is used to evaluate whether adverse impacts could be expected.

3.5.3.2 Methods for Evaluating effects under NEPA

Pursuant to NEPA regulations (40 CFR 1500-1508), project effects are evaluated based on the criteria of context and intensity. Context means the affected environment in which a proposed project occurs. Intensity refers to the severity of the effect, which is examined in terms of the type, quality, and sensitivity of the resource involved, location and extent of the effect, duration of the effect (short- or long-term), and other considerations. Beneficial effects are identified and described. When there is no measurable effect, impacts are found not to occur. The intensity of adverse effects is the degree or magnitude of a potential adverse effect, described as negligible, moderate, or substantial. Context and intensity are considered together when determining whether an impact is significant under NEPA. Thus, it is possible that a significant adverse effect may still exist when the intensity of the impact is determined to be negligible or even beneficial.

For EMF and EMI, an impact with *negligible* intensity is defined as a slight, measurable increase of EMF/EMI levels that are very close to the existing conditions or a slight increase in corrosion of nearby metal objects. These low levels of EMF/EMI are near or at background, well below those which could result in a health hazard, and comply with FCC regulations at 47 CFR Part 15 and Federal Railroad Administration, 49 CFR Parts 236.8, 238.225, and 236 Appendix C regarding compatibility with other systems and equipment. An impact with *moderate* intensity is defined as a measureable increase of EMF/EMI levels that is well above existing conditions but not at levels that would expose people to a documented EMF health risk (including interference with implanted biomedical devices) or adversely affect operation of an electrical, magnetic, or electromagnetic device. This could also result in a moderate increase in the corrosion of nearby metal objects, such as pipelines or electrical cables. An impact with *substantial* intensity is defined as an increase in EMF/EMI at levels that would expose people to a documented EMF health risk (including interference with implanted biomedical devices) or adversely affect operation of an electrical, magnetic, or electromagnetic device or result in severe corrosion of

[1] The HST OCS and distribution systems primarily would have 60-Hz magnetic fields.

nearby pipelines or cables. The IEEE standards discussed in Section 2.5.2 above, and identified in the Statewide Program EIS/EIR, are used to assess the potential for substantial health and compatibility effects from anticipated HST emissions.

3.5.3.3 CEQA Significance Criteria

A significant impact on the environment would occur if the HST project exposes people to a documented EMF health risk, or if HST operations interfere with implanted biomedical devices and unshielded sensitive equipment.

Human Exposure: As shown in Table 3.5-1, the MPE limit (IEEE Standard C95.6, Table 2) for 60-Hz magnetic fields for the instantaneous exposure of the general public is 9.04 G (904 µT); the MPE for controlled environments where only employees work is 27.12 G (2,712 µT). The MPE limit (IEEE Standard C95.6, Table 4) for 60-Hz electric fields for the general public is 5,000 volts per meter (V/m), or 5 kV/m (Table 3.5-2). The MPE is 20 kV/m for controlled environments in which only HST employees would work.

Interference: The Footprint Report provides the typical interference levels for common types of sensitive equipment. These reported levels are used as the significance criteria for this impact analysis. From the Footprint Report, 2 mG is used as a screening level for potential disturbance to unshielded sensitive equipment. In addition, 2 mG is a typical EMF level from early epidemiological studies, which showed that it is the lowest level of chronic, long-term magnetic field exposure with no statistical association with a disease outcome (Savitz et al. 1988; Severson et al. 1988). The value of 2 mG also is a typical EMF level emitted from household appliances (Authority 2010b).

3.5.3.4 Study Area for Analysis

The study area for EMFs is limited to either side of the planned track, as described in Section 6.3.2 of the *Draft Environmental Impact Report/Environmental Impact Statement Assessment of California High-Speed Train Alignment Electromagnetic Field Footprint* prepared by Turner Engineering in July 2010 (Authority 2010b). The study area is as follows:

- 200 feet on both sides of the proposed HST right-of-way centerline (a 400-foot-wide strip centered on the proposed HST alignment) for each HST Alternative. The study area includes urban and developed areas in Fresno, Hanford, Corcoran, Wasco, Shafter, and Bakersfield.
- 200 feet from the perimeter of the alternative heavy maintenance facility (HMF) sites.
- 200 feet on both sides of the proposed HST right-of-way centerline (a 400-foot-wide strip) from the transmission lines supplying TPSS for each HST Alternative.

Computer modeling shows that the EMF level will decay to a level below 2 mG at 200 feet from either side of the HST right-of-way centerline.

The study area for radio-frequency interference (RFI) includes the following:

- 500 feet on both sides of the proposed HST right-of-way centerline (a 1,000-foot-wide strip centered on the proposed HST alignment) for each HST alternative.
- 500 feet from the perimeter of the HMF site alternatives.

The potential for EMI would no longer exist for equipment beyond 500 feet from the HST right-of-way centerline.

3.5.4 Affected Environment

3.5.4.1 Sources of EMF, EMI, and RFI

EMI can come from regional and local sources. Regional sources, such as television and radio transmissions, are present over a broad region and are captured in measurements taken at various measurement sites. Local sources are present only in measurements at the site nearest the source.

The measured regional sources along the proposed HST corridor were stronger telecommunication transmitters that broadcast over a large area. These sources include AM and FM radio stations, time signal transmitters, maritime and land mobile radio transmitters, air-to-ground transceivers, cellular telephone antennas, and television station transmission antennas. These local sources were visually identified as near or in the line-of-sight of the measurement locations photographed (see Appendix 3.5-A). Photographs of antennae taken at measurement locations at or near the proposed corridor show the presence of police and fire department and FM radio transmitters. Local sources and facilities that typically contain highly sensitive RF equipment were identified in the EMI study area defined in Section 3.5.3.4, Study Area for Analysis.

Measurements for EMF and RF signal strength were taken within 1.5 miles of each alternative HMF site, except for the Fresno HMF, where they were taken within 4 miles. All of the alternative HMF sites are in less-developed agricultural and rural areas. Sensitive receptors associated with these locations do not include RF-transmission equipment; they are primarily underground pipelines, underground cables, and metal fencing.

3.5.4.2 Local Conditions

Figure 3.5-1 shows the field measurement site locations. Magnetic fields were measured only from 0 Hz to 800 Hz DC. The measurement site locations along the BNSF Alternative are considered representative of each HST alternative under consideration, because no substantive change in rural or urban land use occurs between alternatives in the vicinity of the measurement sites. Rural and urban EMF and EMI study areas have the following differences:

- The rural EMF/EMI study areas have only a few residences, which are sparsely distributed. These areas may have underground pipelines, underground cables, and fencing associated with agricultural operations, including irrigation systems.
- The urban EMF/EMI study areas include more dense residential housing, high-voltage overhead power lines, industrial parks that include laboratories that operate sensitive medical devices, and associated urban infrastructure.

The field survey involved measurements of radiated electric field strengths (RF levels) from 10 kHz to 6 GHz. This frequency range encompasses many different applications, including broadcast radio and digital television signals, communications, cellular telephones, and radar and navigation systems. In general, the highest RF electric field levels, especially at the broadcast frequencies, occur in the Fresno and Bakersfield urban areas. The survey also quantified typical power-frequency magnetic field levels along the section to characterize typical DC and ELF (up to 3 kHz) sources such as high-voltage transmission lines, electrical distribution lines, and electrical substations or generating equipment. The maximum or peak 60-Hz magnetic fields recorded in the survey ranged from 0.46 mG to 10.94 mG, depending on the measurement locations relative to local distribution and transmission power lines.

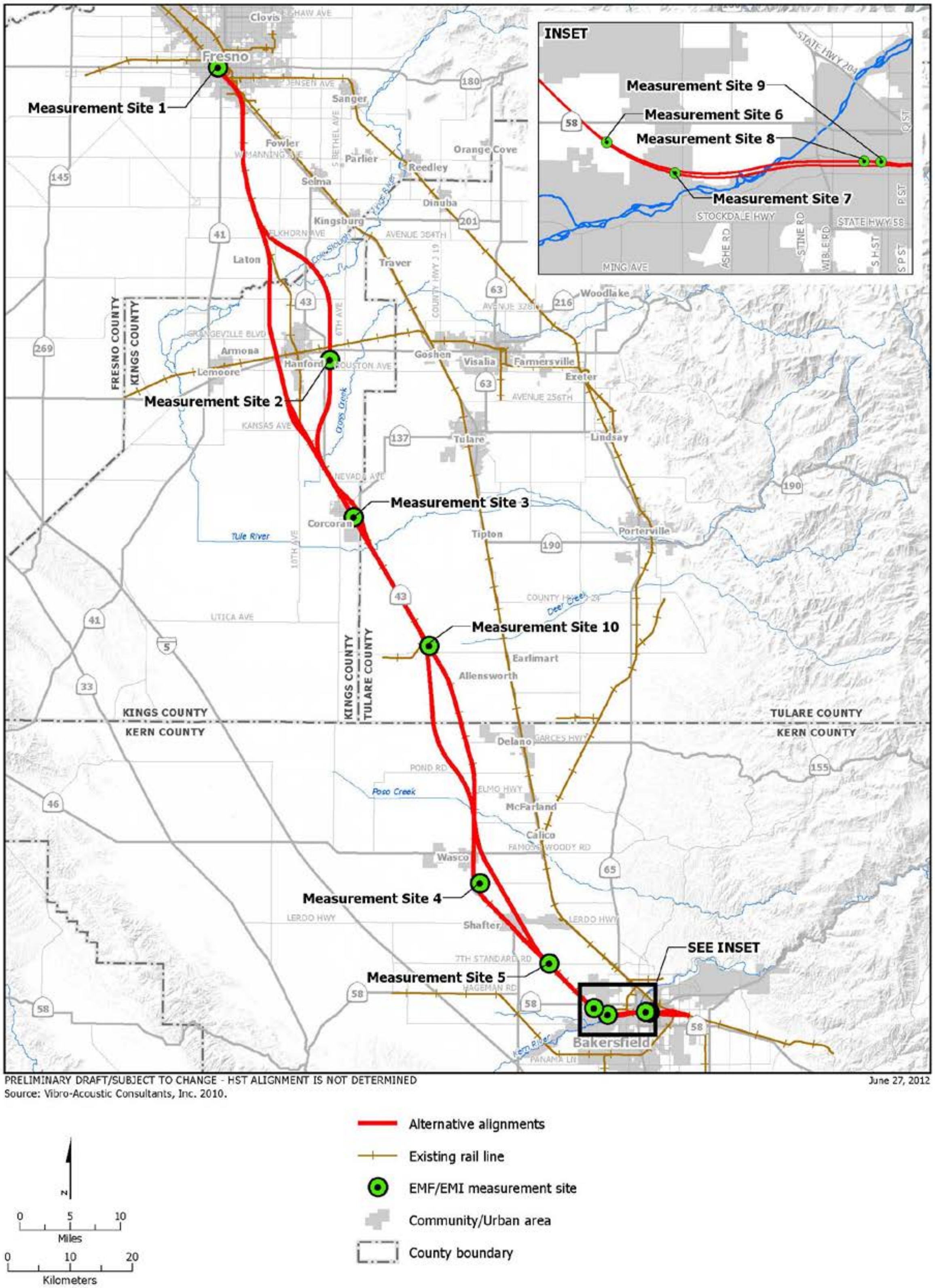

Figure 3.5-1
EMF/EMI measurement site locations

Table 3.5-4 provides a comparison by listing the measured and calculated magnetic fields at the distances of each of the nine sites from the centerline of the proposed HST right-of-way. The calculated magnetic fields include those for the single-train HST modeled in the Footprint Report (Authority 2010b). The calculated fields take into consideration the magnetic fields from the return currents flowing in the running rails, and the negative feeder partially cancelling the magnetic fields from the supply current flowing in the messenger wire and the contact.

Table 3.5-4
Summary Comparison of Measured and Calculated 60-Hz Magnetic Fields

Measurement Location	Distance from Centerline of Right-of-Way (feet)[a]	Measured AC Magnetic Field Levels[b] (mG)	Calculated 60-Hz Fields at Distance from HST Right-of-Way Centerline (Single Train) (mG)[c,d]
1. Intersection of Tuolumne & H Streets	295	0.46	0.8
2. 7500 Hanford-Armona Road	215	7.83	1.4
3. Intersection of Oregon & Santa Fe Avenues	205	3.14	1.5
4. Kimberlina Road, east of SR 43	2100	0.37	<0.05
5. Intersection of 7th Standard Road and Nord Avenue	250	1.42	1.1
6. Intersection of Verdugo Lane & Glenn Street	135	1.14	3
7. Transmission lines crossing Brimhall Road	75	10.94	11
8. Mercy Hospital*, 16th Street	505	3.91	0.3
9. Intersection of H & 16th Streets	415	1.54	0.4
10. SR 43 north of Allensworth	85	no data	9
11. Assumed fence line	30	no data	45

[a] Approximate maximum distance of measurement location from centerline of right-of-way.
[b] Maximum measured AC magnetic field for spatial profile measured at each site (see Appendix 3.5A).
[c] It is assumed that the calculated magnetic fields for single-train HST (Footprint Report) are for a single train passing closest to the measurement location.
[d] Source: Estimated from Figure E-1b of *Draft Environmental Impact Report/Environmental Impact Statement Assessment of California High-Speed Train Alignment Electromagnetic Field Footprint* (Authority 2010b).
* Potentially sensitive receptors.

Acronyms and Abbreviations:
AC = alternating current
HST = high-speed train
Hz = hertz
mG = milligauss
SR = state route

3.5.4.3 Receivers Susceptible to EMF/EMI/RFI Effects

The alternative alignments include urban and developed areas, particularly in the cities of Bakersfield and Fresno. Sensitive human receptors, such as hospitals, medical centers, schools and colleges are concentrated in the urban areas. In some cases, these locations may be associated with the use, assembly, calibration, or testing of sensitive and unshielded RF equipment. For unshielded equipment that is sensitive to magnetic fields in the range of 1 to 3 mG (such as magnetic resonance imaging [MRI] systems), interference is possible at distances of up to approximately 200 feet from the centerline of the HST right-of-way. For the most-sensitive electron-beam microscopes, which are sensitive to magnetic fields in the range of 0.1 to 0.3 mG, interference would be possible to approximately 700 feet from the centerline of the HST right-of-way. From a practical standpoint, local 60-Hz magnetic field sources would be dominant well before this distance, as evidenced by the median magnetic field levels measured along the spatial profiles during the baseline survey (these field levels ranged from 0.12 to 4.77 mG).

A review of land uses along the alternative alignments identified three potentially sensitive receptors (i.e., medical imaging) within the 200-foot study area. All three receptors, Mercy Hospital, Truxtun Radiology Medical Group, and Sierra Radiology Medical Group, are situated in Bakersfield and are sites that use medical imaging equipment. As such, the susceptibility levels, if they use unshielded equipment, would typically be in the 1 to 3 mG range. Table 3.5-5 summarizes the expected worst-case 60-Hz magnetic fields based on the closest distances from the centerline of the HST right-of-way (for three alignments: the BNSF Alternative, Bakersfield South Alternative, and Bakersfield Hybrid Alternative) to each facility. At the time of the baseline survey, one of the sensitive receptors, the Sierra Radiology Medical Group facility, was no longer occupied or operating.

Table 3.5-5
Expected Worst-Case 60-Hz Magnetic Fields based on Closest Distances to Sensitive Receptors from the Centerline for Two HST Alternative Alignments

Sensitive Receptor	Distance from Centerline of HST Right-of-Way			Calculated HST Worst-Case Magnetic Fields[a]		
	BNSF Alternative Alignment (feet)	Bakersfield South Alternative Alignment (feet)	Bakersfield Hybrid Alternative Alignment (feet)	BNSF Alternative Alignment (mG)	Bakersfield South Alternative Alignment (mG)	Bakersfield Hybrid Alternative Alignment (mG)
Mercy Hospital[b]	630	180	180	0.2	1.8	1.8
Truxtun Radiology Medical Group [c]	790	390	450	0.1	0.4	0.3
Sierra Radiology Medical Group[d]	620	260	460	0.2	0.6	0.3

[a] Calculated HST worst-case magnetic field at comparable distances relative to centerline of right-of-way
[b] Mercy Hospital, 2215 Truxtun Avenue, Bakersfield, California
[c] Truxtun Radiology Medical Group, 1817 Truxtun Avenue, Bakersfield, California
[d] Sierra Radiology Medical Group, 1601 H Street, Bakersfield, California (possibly closed)

Acronyms and Abbreviations:
HST = high-speed train
Hz = hertz
mG = milligauss

3.5.4.4 Railroad/Transportation Equipment Susceptible to EMF/EMI/RFI Effects from Airports, Military, or Other Commercial Transmitters along the Right-of-Way

Parallel to the HST right of way, there are adjacent and nearby railroad tracks, underground pipelines, and cables susceptible to corrosion due to EMF/EMI emissions.

Along the BNSF Alternative, trains use the existing rail line and portions of the San Joaquin Valley Railroad to haul freight and transport passengers (e.g., Amtrak's San Joaquin service). Most of this alignment alternative is adjacent and parallel to the existing BNSF Railway track, except near Hanford, and to metal pipelines and cables for shorter distances. To a lesser extent, the other alignment alternatives also parallel existing railroad tracks, metal pipelines, and cables.

The various alternative track alignments pass within 1,000 feet of eight schools and one college. The closest would be 127 ft from Bethel Christian School. In addition, six schools would be located within ½ mile (1,640 ft) of HST stations and HMFs. The closest school to a station or HMF would be Our Lady of Guadalupe School, located 487 feet from the alignment proposed within the city of Bakersfield. Radio communications systems (e.g. wireless local area networks and internet connections) are expected to be in use at these schools and college. FCC spectrum frequency allocations allow WiFi systems to operate in their frequency blocks at 2.4, 3.6 and 4.9/5.0 GHz, each divided into channels to allow multiple systems to operate without interfering with one another. Wireless networks used by schools and colleges operate at relatively low power levels and have limited range of 100 to 300 feet (FCC 2012), therefore EMI with distant uses is generally not a concern.

3.5.5 Environmental Consequences

This section describes the environmental consequences of EMF/EMI for the proposed alternatives. This section lists the magnetic field levels used to evaluate whether an impact would be significant, and discusses measures to reduce impacts.

3.5.5.1 Overview

EMF/EMI effects that would occur during construction would have negligible intensity under NEPA and would be less than significant under CEQA, because only a slight measurable increase of EMF/EMI levels would occur and within a very limited geographical area.

When the HST System is complete, the predicted HST-generated EMF/EMI levels to which members of the general public are expected to be exposed will be lower than the applicable HST project MPE standards for humans in uncontrolled (open) environments.

The predicted HST-generated EMF/EMI levels to which the employees working in traction power facilities and emergency back-up generator room would be exposed would be lower than the applicable HST project MPE standards for human exposure in controlled environments. Impacts of negligible intensity would result from corrosion of underground pipelines, cables, and adjoining rails, because installation of standard corrosion protection will eliminate risk of substantial corrosion. These impacts would be less than significant under CEQA.

Operation of the alignment alternatives and the HMF could result in EMI with medical imaging equipment exposed to the range of 1 to 3 mG. These EMFs would have impacts of substantial intensity on sensitive receptors, in the absence of magnetic shielding installed in accordance with the EMCPP. These impacts would be significant under CEQA.

Standard HST project design features would preclude other potentially significant effects, such as nuisance shocks when touching ungrounded metal fences and ungrounded metal irrigation systems, and interference with the signal systems of adjoining rail lines. These design features would include grounding of fences and coordination with adjoining railroads to implement suitable track signal equipment on adjoining railroad tracks.

3.5.5.2 No Project Alternative

As discussed in Chapter 1.0, Project Purpose, Need, and Objectives of the Project, and Section 3.18, Regional Growth, the population in the San Joaquin Valley is growing, and is projected to continue growing. Section 3.19, Cumulative Impacts, provides foreseeable future projects, which include shopping centers, industrial parks, transportation projects, and residential developments. These development and transportation infrastructure projects are planned or approved to accommodate the growth projections in the area. The use of electricity and RF communication equipment, including high-voltage power lines and directional and non-directional (cellular and broadcast) antennas that result in EMFs and EMI, currently occurs and would continue to occur along the Fresno to Bakersfield Section. Under the No Project Alternative, future conditions would be likely to result in additional use of electricity and RF communications, consistent with that found in the urban and rural environments in the study area today. It is reasonable to assume that by 2035, the use of electricity and RF communications would increase because of increased development, increased use of electrical devices, and technological advances in wireless transmission (such as wireless data communication). As a result, generation of EMFs and EMI that might affect people and sensitive receptors would continue in the area.

3.5.5.3 High-Speed Train Alternatives

The populations and facilities close to the HST that could be affected by exposure to HST-related EMFs and EMI include medical laboratories, research and technology parks, dense housing developments, schools and colleges, employees, underground pipelines and cables, fences, and existing railroads.

<u>Construction Period Impacts</u>

Impact EMF/EMI #1 – Impacts During Construction

Construction of the HST rails, stations, and TPSSs would require use of heavy equipment, trucks, and light vehicles which, like all motor vehicles, generate EMFs. Additionally, many types of construction equipment contain electric motors that also generate EMFs. Communication equipment used by construction crews would include mobile telephones and radios that would generate RF fields. Communications equipment would include off-the-shelf products that comply with FCC regulations designed to prevent EMI with other equipment or hazards to persons. The EMFs generated during project construction would be similar in strength to the EMFs produced at non-project construction sites and would be unlikely to cause EMI with nearby land uses or hazards to workers.

The EMF or EMI effect of project construction would have negligible intensity under NEPA and the impact would be less than significant under CEQA because construction equipment generates low EMF and EMI levels. The only EMI that might be generated during construction would be occasional licensed radio transmissions between construction vehicles. This is not considerably different from the number of radio transmissions that occur under existing conditions.

Project Impacts

Common EMF/EMI Impacts

The operation of any of the project alternatives would result in human exposure to electric and magnetic fields. Standard HST design provisions would avoid the potential for corrosion of underground pipelines and cables, nuisance shocks, and effects on adjacent existing rail signal systems. The following section discusses different types of potential EMF/EMI effects associated with project operations.

Impact EMF/EMI #2 – General Human Exposure to EMF

Operation of the HST would generate 60-Hz electric and magnetic fields on and adjacent to trains, including in passenger station areas. Table 3.5-6 presents the HST project model results that apply to the alignment alternatives.

Table 3.5-6
Summary of HST EMF Modeling Results

EMF Analysis	Platform – 16 feet from HST Alignment Centerline	Fence Line – 30 feet from HST Alignment Centerline	Study Area – 350 feet from HST Alignment Centerline
Magnetic Field (mG) Single-Train HST	720	177	Less than 1

Acronyms and Abbreviations:
EMF = electromagnetic field
HST = high-speed train
kV/m = kilovolts per meter
mG = milligauss

Source: Authority 2011.

Magnetic field measurements have been made in the passenger compartment onboard other HST systems such as the Acela Express (119 mG) and French TGV A (165 mG) and in the operator's cab of the Acela Express (58 mG) and French TGV A (367 mG) (FRA 2006). Because the modeled levels of EMF exposure are very near to measured values listed in Table 3.5-4 and measurements on other existing HSTs are below the MPE limits of 5 kV/m and 9,040 mG for the public, the HST alternatives would have impacts with negligible intensity under NEPA relative to EMF exposure to people. Under CEQA, the impacts would be less than significant.

The HST EMF analyses indicate that the EMFs generated by an HMF would be less than significant for the main line because HST trains would operate at much lower speeds and would have much lower acceleration rates at the HMF, whether entering or exiting the site, or during maintenance and testing. When the trains operate at low speeds and have low acceleration rates, they draw much less current through the OCS, and thus produce lower magnetic fields.

EMF impacts on people in nearby schools, hospitals, businesses, colleges, and residences would be below the IEEE Standard 95.6 MPE limit of 9,040 mG for the public because even within the mainline right-of-way, these levels would not be reached. Because the modeled levels of EMF exposure are very near to measured values listed in Table 3.5-4, these effects would have negligible intensity under NEPA. Under CEQA, the impact would be less than significant.

The IEEE Standard C95.6 MPE for controlled environments in which employees work is 27,120 mG (27.12 G). Because the EMF levels at the HMF are expected to be very near to existing conditions, and no higher than on an active rail line, the effect of EMFs on employees at the HMF would have negligible intensity under NEPA. Under CEQA, the impact would be less than significant.

Impact EMF/EMI #3 – People with Implanted Medical Devices and Exposure to EMF

Magnetic fields of 1,000 to 12,000 mG (1 to 12 G) may interfere with implanted medical devices (EPRI 2004). The American Conference of Governmental Industrial Hygienists has recommended magnetic and electric field exposure limits of 1,000 mG and 1 kV/m, respectively, for people with pacemakers (ACGIH 1996). These levels would occur only inside traction power facilities, which are unmanned and inaccessible to the general public. Therefore, effects on people with implanted medical devices would have negligible intensity under NEPA and would be less than significant under CEQA.

For the Fresno to Bakersfield Section, emergency standby generators would be located at passenger stations, at the HMF and at the TPSS facilities. EMF would occur due to electrical devices, such as transformers and distribution bus lines common to an electrical substation. EMF would occur primarily to the immediate, secure work area, except where power lines enter and exit the facility, and rapidly decrease with distance from the source located within the study area.

EMF levels above the recommended limits for employees with implanted medical devices could exist inside traction power facilities and emergency power generator rooms. Traction power facilities and emergency power generator room sites would be unmanned, and workers would enter them only periodically (e.g., to perform routine maintenance). An exposure to an EMF level above those recommended for implanted medical devices could result in health effects. With implementation of the EMCPP as defined for this project, persons with an implanted medical device would not be permitted near the traction power facilities. Therefore, these effects would be avoided.

Impact EMF/EMI #4 – Livestock and Poultry Exposure

In regard to dairy production, McGill University conducted a study with cows in pens exposed to controlled EMF levels of 330 mG and 10 kV/m, the projected magnetic and electric fields that occur at ground level under a 735 kV line at full load. The researchers measured the following: melatonin levels, prolactin levels, milk production, milk fat content, dry matter intake by cows, and reproductive outcomes. While a few statistically significant changes in these factors were found, none of the changes was outside the normal range for cows (McGill University 2008). The study concluded that the EMF exposure did not harm the cows or reduce milk productivity. Various studies cited by other researchers regarding EMF and wildlife suggest a range of effects similar to livestock from non-existent to relatively small to positive. One study suggests a beneficial application for ELF-EMF in broiler chickens to fight a common parasitic infection called Coccidiosis (Golder Associates 2009). For these reasons, EMF effects on livestock and poultry would have negligible intensity under NEPA and the impact would be less than significant under CEQA.

Impact EMF/EMI #5 – Effects to Sensitive Equipment from EMI

As indicated in Table 3.5-5 above, three potentially sensitive receptors were identified in the 500-foot study area. All three receptors are along the Bakersfield South and Bakersfield Hybrid alternatives, and they are sites that use medical imaging. As such, the typical susceptibility levels would be in the range of 1 to 3 mG. At the time of the baseline survey, one of the sensitive receptors, the Sierra Radiology Group, was no longer occupied or operating. Due to the proximity of sensitive imaging equipment and other medical devices, the potential exists for EMI to occur. This EMI effect would have substantial intensity under NEPA, and a significant impact under CEQA.

Impact EMF/EMI #6 – EMI Effects to Schools

The HST System would use radio systems for automatic train control, data transfer, and communications, raising the concern that HST operations would result in EMI with the radio systems at use at nearby schools and a college. HST radio systems would transmit radio signals from antennas located at stations and HMFs, along the track alignment, and on locomotives and train cars. HST plans to acquire two dedicated frequency blocks, each with a width of 4 MHz, for use by automatic train control systems. These blocks would be at frequencies below 925 MHz because frequencies higher than 925 MHz will not function on trains moving at the speed of an HST. These blocks would be dedicated for HST use and EMI with other users would not be expected. Communications systems at stations may operate at WiFi frequencies to connect to stationary trains; channels would be selected to avoid EMI with other users, including WiFi systems at use at nearby schools (Authority, TM 300.3, 2011 and TM 300.04, 2011).

The Authority will implement an EMCPP during project planning and implementation to ensure EMC with radio systems operated by neighboring uses, including schools and colleges. During the planning stage through system design, the Authority will perform EMC/EMI safety analyses, which will include identification of existing nearby radio systems, design of systems to prevent EMI with identified neighboring uses, and incorporation of these design requirements into bid specifications used to procure radio systems. The implementation stage will include monitoring and evaluation of system performance. Most radio systems procured for HST use are expected to be commercial off-the-shelf systems (COTS) conforming to FCC regulations at Title 47 Code of Federal Regulations, Part 15, which contain emissions requirements designed to ensure EMC among users and systems. The Authority will require all non-COTS systems procured for HST use to be certified in conformity with FCC regulations for Part 15, Sub-part B, Class A devices. HST radio systems will also meet emissions and immunity requirements designed to ensure EMC with other radio users that are contained in the European Committee for Electrotechnical Standardization (CENELEC) EN 50121-4 Standard for railway signaling and telecommunications operations (CENELEC, 2006).

Because the HST radio system would use dedicated frequency blocks and all HST equipment will meet FCC regulations (47 CFR Part 15) for EMI, the effect of the HST System on school communication systems would have negligible intensity under NEPA and the impact would be less than significant under CEQA.

Impact EMF/EMI #7 – Potential for Corrosion of Underground Pipelines and Cables and Adjoining Rail

TPSSs located every 30 miles would deliver AC current to the HSTs through the OCS, with return current flowing from the trains back to the TPSSs through the steel rails and static wires. At paralleling stations, which would be positioned approximately every 5 miles along the right-of way, and at regularly spaced bonding locations, some of the return current to the TPSS would be transferred from the rails to the static wires. Most return current would be carried by the HST rails and the static wire back to the TPSS, but some return current would find a path through rail connections to the ground and through leakage into the ground from the rails via the track ballast.

Soils in the project vicinity tend to be sandy and dry (except where irrigated), so they have higher electrical resistivity and lower ability to carry electrical current than soils with more clay and moisture content (see Section 3.9, Geology, Soils, and Seismicity). Nevertheless, other linear metallic objects such as buried pipelines or cables, or adjoining rails, could carry AC ground current. AC ground currents have a much lower propensity to cause corrosion in parallel conductors than the DC used by rail transit lines such as Bay Area Rapid Transit or the Los Angeles County Metropolitan Transportation Authority. Nonetheless, the stray AC currents might cause corrosion by galvanic action. If adjacent pipelines and other linear metallic structures are not sufficiently grounded through the direct contact with earth, the project would include additional grounding of pipelines and other linear metallic objects in coordination with the affected owner or utility, as part of the construction of the HST System. Alternatively, insulating joints or couplings may be installed in continuous metallic pipes to prevent current flow.

The potential for corrosion from ground currents would be avoided by installing supplemental grounding or by insulating sections in continuous metallic objects in accordance with standard HST designs. Because the potential for corrosion is slight and would be avoided by standard design provisions, the effect would have negligible intensity under NEPA. Under CEQA, the impact would be less than significant.

Impact EMF/EMI #8 – Potential for Nuisance Shocks

The voltage on and currents running through the OCS have the potential to induce voltage and current in nearby conductors such as ungrounded metal fences and ungrounded metal irrigation systems alongside the HST alignment. This effect would be more likely where long (1 mile or more), ungrounded fences or irrigation systems are parallel to the HST, and electrically continuous throughout that distance. Such voltages potentially could cause a nuisance shock to anyone who touches such a fence or irrigation system. An example of an ungrounded metal irrigation system would be a center pivot system on rubber tires. By contrast, the Vermeer-type metal irrigation system is grounded by its metal wheels and therefore offers less shock hazard, because any surface pipe metal irrigation system is grounded through its contact with the ground. Long, ungrounded fences and metal irrigation systems are more common in rural areas than urban areas because they are used to divide or irrigate agricultural fields.

To avoid possible shock hazards, the project design includes grounding of HST fences and the grounding of non-HST parallel metal fences and parallel metal irrigation systems within a to-be-determined specified lateral distance of the HST alignment. In addition, insulating sections could be installed in fences to prevent the possibility of current flow. For cases where such fences are purposely electrified to inhibit livestock or wildlife from traversing the barrier, specific insulation design measures would be implemented. Therefore, effects would have negligible intensity under NEPA, and impacts would be less than significant under CEQA.

Impact EMF/EMI #9 – Effects on Adjacent Existing Rail Lines

Signal systems control the movement of trains on the existing BNSF tracks that the BNSF Alternative would parallel. These signal systems serve three general purposes:

- To warn drivers of street vehicles that a train is approaching. The rail signal system turns on flashing lights and warning bells; some crossings lower barricades to stop traffic.
- To warn train engineers of other train activity on the same track a short distance ahead, and advise the engineer that the train should either slow or stop. This is done by using changing, colored (green, yellow, or red) trackside signals.

- To show railroad dispatchers in a central control center where trains are located on the railway so that train movements can be controlled centrally for safety and efficiency.

Railroad signal systems operate in several ways, but generally, they are based on the principle that the railcar metal wheels and axles electrically connect the two running rails. An AC or DC voltage applied between the rails by a signal system will be shorted out; that is, reduced to a low voltage, by the rail-to-rail connection of the metal wheel-axle sets of a train. The low-voltage condition is detected and interpreted by the signal system to indicate the presence of a train on that portion of track.

The HST OCS would carry 60-Hz AC electric currents of up to 750 amps per HST. Interference between the HST 60-Hz currents and a nearby freight railroad signal system could occur under the following conditions:

- The high electrical currents flowing in the OCS and the return currents in the overhead negative feeder, HST rails, and ground could induce 60-Hz voltages and currents in existing parallel railroad tracks. If an adjoining freight railroad track parallels the HST tracks for a long-enough distance (i.e., several miles), the induced voltage and current in the adjoining freight railroad tracks could interfere with the normal operation of the signal system, so that it indicates there is no freight train present when in fact one is; or so that it indicates the presence of a freight train when in fact none is there.
- Higher-frequency EMI from several HST sources (electrical noise from the contact on the pantograph sliding along the contact conductor, from electrical equipment onboard the HST, or from the cab radio communication system) could cause electrical interaction with the adjoining freight railroad signal or communication systems.

There are standard design and operational practices that a nonelectric railroad must use to avoid EMI effects on the signal and communication system when electric power lines or an electric railroad are installed adjacent to its tracks. These standard design and operational practices prevent the possible effects that HST operation might otherwise cause: disruption of the safe and dependable operation of the adjacent railroad signal system, resulting in train delays or hazards, or disruption of the road-crossing signals, stopping road traffic from crossing the tracks when no train is there (EPRI 2006).

Table 3.5-7 shows that the BNSF Alternative located at-grade would be adjacent to 60 miles of existing railroad tracks, with slightly shorter and longer lengths for each of the bypass alternatives. Operation of the HST System could affect the signaling systems along these existing track lengths.

Existing railroad tracks (i.e., the adjacent freight and passenger railroad tracks) in the study areas for the five alternative HMF sites would be affected by two alternative alignments (the approximate distances affected are shown in Table 3.5-8). These distances would be relatively small compared to the overall section length, regardless of which alternative HMF site is selected. At these sites, HMF operations could affect rail signaling systems.

Table 3.5-7
Length of High-Speed Train Alternative Alignments At-Grade and Adjacent to Existing Rail Lines

Alternative Alignment	Distance At-Grade and Adjacent to Existing Tracks (miles)
BNSF Alternative	60
Hanford West Bypass 1 Alternative	64
Hanford West Bypass 2 Alternative	66
Corcoran Elevated Alternative	57
Corcoran Bypass Alternative	55
Allensworth Bypass Alternative	44
Wasco-Shafter Bypass Alternative	48
Bakersfield South Alternative	60
Bakersfield Hybrid Alternative	60

Table 3.5-8
Length of Tracks Associated with Alternative HMF Sites Adjacent to Existing Rail Lines

Alternative HMF Site	BNSF Alternative Alignment	Wasco-Shafter Bypass Alternative Alignment
Fresno	3.5 miles	3.5 miles
Kings County–Hanford	2.0 miles	2.0 miles
Kern Council of Governments–Wasco	1.5 miles	1.2 miles
Shafter East	2.3 miles	2.3 miles
Shafter West	2.5 miles	2.5 miles
HMF = heavy maintenance facility		

The potential for interference caused by HMF operations is similar to but less than the interference along the HST tracks. The coupling between freight signal equipment and the HST track would increase as the length of the parallel portions of freight tracks and HST track increases. The distance to the HMF would be relatively short compared with the distances of up to 84 miles of parallel sections of HST track, and most HMF tracks would be farther from the freight tracks than the parallel sections of HST and freight tracks. Accordingly, the coupling between HMF tracks and adjoining freight tracks would be less than for a long parallel section of freight and HST tracks.

Interference from HST currents could result in a nuisance or reduction in operational efficiency by interrupting road and rail traffic. To preclude this possibility, the project design includes working with the engineering department of freight railroads that parallel the HST line to apply the standard design practices that a nonelectric railroad must use when electric power lines or an electric railroad are installed adjacent to its tracks. This would be documented in the EMCPP. These standard design practices include assessment of the specific track signal and communication equipment in use on nearby sections of existing rail lines, evaluation of potential impacts of HST EMFs and RFI on adjoining railroad equipment, and the application of suitable design provisions on the adjoining rail lines to prevent interference.

Design provisions often include replacement of specific track circuit types on the adjoining rail lines with other types developed for operation on or near electric railways or adjacent to parallel utility power lines, providing filters for sensitive communication equipment, and potentially relocating or reorienting radio antennas. These design provisions would be put in place and determined to be adequately effective prior to the activation of potentially interfering systems of the HST. With regard to the impacts of the alternative HMF sites on underground infrastructure, none of the HMF sites have existing underground pipelines, cables, or other conduits. Therefore, the possibility of effects on the adjacent railroad would have negligible intensity under NEPA. Under CEQA, potential impacts would be less than significant.

3.5.6 Project Design Features

The HST project would adhere to international guidelines and comply with applicable federal and state laws and regulations. Similarly, project design will follow the EMCPP to avoid EMI and to ensure HST operational safety. Some features of the EMCPP include:

- During the planning stage through system design, the Authority will perform EMC/EMI safety analyses, which will include identification of existing nearby radio systems, design of systems to prevent EMI with identified neighboring uses, and incorporation of these design requirements into bid specifications used to procure radio systems.
- Pipelines and other linear metallic objects that are not sufficiently grounded through the direct contact with earth would be separately grounded in coordination with the affected owner or utility to avoid possible shock hazards. For cases where metallic fences are purposely electrified to inhibit livestock or wildlife from traversing the barrier, specific insulation design measures would be implemented.
- HST standard corrosion protection measures would be implemented to eliminate risk of substantial corrosion of nearby metal objects.
- The Authority will work with the engineering departments of BNSF Railway, UPRR, and SJVR where these railways parallel the HST to apply the standard design practices to prevent interference with the electronic equipment operated by these railroads. Design provisions to prevent interference would be put in place and determined to be adequately effective prior to the activation of potentially interfering systems of the HST.

Applicable design standards for EMI/EMF that would be used for the project are provided in Appendix 2-D.

3.5.7 Mitigation Measures

The *Final Program EIR/EIS for the Proposed California HST System* (Authority and FRA 2005) mitigation strategies have been refined and adapted for this project EIR/EIS. During project design and construction, the following mitigation measures (MM) would be implemented to reduce the potential for impacts on human health:

EMF/EMI-MM #1: Protect sensitive equipment. The Authority will contact Mercy Hospital regarding the potential impacts of HST–related EMF or RF interference on imaging equipment prior to completion of final design. Where necessary to avoid interference, the final design will include suitable design provisions to prevent interference. These design provisions may include establishing magnetic field shielding walls around sensitive equipment, or installing RF filters into sensitive equipment.

3.5.8 NEPA Impacts Summary

Measurements of EMF along representative portions of the HST alignments for the Fresno to Bakersfield Segment indicate that background levels for both magnetic and electric fields are well below accepted thresholds applied for the California HST System relative to human health and interference with other equipment and systems. In the context of this anticipated baseline condition and based on the intensity of effects described above, the following list summarizes the impacts identified in Section 3.5.5, Environmental Consequences:

- Construction equipment generates low levels of EMFs and EMI; therefore, electromagnetic effects would have low intensity. Facilities such as underground pipelines and cables and metal fencing as well as people and livestock would be exposed to EMFs and EMI for a short time period. The thresholds for human exposure to EMI/EMF would not be exceeded. For these reasons, construction-related EMI/EMF effects would not be significant under NEPA.

- The EMFs at station platforms, on trains, and in the HMFs would have impacts with negligible intensity under NEPA. The thresholds for human exposure to EMI/EMF would not be exceeded. Therefore, the EMI/EMF effect would not be significant under NEPA.

- HST workers with implanted medical devices exposed to EMFs from HST traction power facilities could have substantial health effects. Under the EMCPP, workers with implanted medical devices would not be permitted to work at these facilities. Therefore, the EMF impact on workers would not be significant under NEPA.

- During operation, the EMF from an HST on the Bakersfield South and Bakersfield Hybrid alignment alternatives would be 1.8 mG at the edge of Mercy Hospital closest to the centerline of the HST right-of-way. The EMI effect from the HST could have substantial intensity to unshielded medical imaging equipment at the hospital. Where necessary to avoid interference, the final project design will include suitable provisions, such as shielding or RF filters, to prevent interference with medical equipment at the hospital. Therefore, this EMI effect would not be significant under NEPA.

- The intensity of EMF exposure from HST operations to underground pipelines and cables would be substantial. As a standard engineering practice, appropriate grounding systems and/or installation of insulating joints or couplings would be included in project design to prevent corrosion of underground infrastructure. Therefore, this EMF effect would not be significant under NEPA.

- The intensity of EMF exposure from HST operations could be substantial enough to cause nuisance shocks to people and animals touching ungrounded metal fences and above-ground metal irrigation systems adjacent to the HST right-of-way. Grounding fences and irrigation systems would be a standard design requirement for the project. Therefore, this EMF effect would not be significant under NEPA.

3.5.9 CEQA Significance Conclusion

The project would comply with applicable federal and state regulations and would implement the design strategies outlined in the *Final Statewide Program EIR/EIS* (Authority and FRA 2005). Table 3.5-9 summarizes the remaining significant EMF/EMI impacts.

Table 3.5-9
Summary of Potentially Significant EMF/EMI Impacts and Mitigation Measures

Impact	Level of Significance before Mitigation	Mitigation Measure	Level of Significance after Mitigation
Construction			
No significant impacts would occur during construction.			
Project			
EMF/EMI Impact #5: Impacts to Sensitive Equipment from EMI. Under the Bakersfield South Alternative Alignment and the Bakersfield Hybrid Alternative Alignment, the worst-case EMFs are 1.8 mG at the edge of Mercy Hospital closest to the centerline of the HST right-of-way. Therefore, EMI may occur to sensitive medical devices or imaging equipment in the study area if the equipment is unshielded.	Significant	**EMF/EMI-MM#1: Protect sensitive equipment**.	Less than significant
Acronyms and Abbreviations: EMF = electromagnetic field EMI = electromagnetic interference HST = high-speed train mG = milligauss MM = Mitigation Measure			

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