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, 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 EMF.

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 naturally and are generated 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 is 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 catenary system (OCS) and power distribution system primarily would generate 60 Hz extremely low frequency fields and field harmonics (which may require filtering to prevent EMI.

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) = 1billion 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, the magnetic field ranges from 500 to 700 mG DC (0.5 to 0.7 G) (50 to 70 µT) at the surface of the earth. 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; Silva 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), 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 kilohertz 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

A. FEDERAL

The Authority has adopted the following standards for the HST project:

- 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. The FCC limits are based on the IEEE standards noted above.

B. STATE

- California High-Speed Rail Authority—Electromagnetic Compatibility Program (EMCP) Plan September 2010 (Authority 2010). The EMCP defines the High-Speed Transport Protocol Electromagnetic Compatibility (EMC) objective of the project, 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 EMCP Plan also will 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.

- 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.

C. LOCAL AND REGIONAL

EMF- and EMI-related issues are addressed in local and regional general plans and ordinances. 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

A. 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 conditions along the Fresno to Bakersfield Section (Authority and FRA 2010). Using these targeted areas, the reconnaissance described above identified sensitive land uses. The *Technical Study: Pre-Construction Electromagnetic Measurement Survey of 10 Locations along the Fresno to Bakersfield Section* (FB EMF Technical Study) describes the measurement sites and discusses the existing EMF levels that potentially could cause EMI at the measurement sites (see Appendix 3.5-A).

- Analysis included using a mathematical model of the HST traction electrical system 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 *EIR/EIS Assessment of CHST Alignment EMF Footprint Report* (Footprint Report (Authority and FRA 2011) 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 were predicted and compared to the ambient conditions that were measured. 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.

EMF/EMI measurements quantified existing levels at sensitive receptors and representative locations near the HST System alternative alignments. The FB EMF Technical Study describes the measurement sites and discusses the existing levels of EMFs that potentially could cause EMI at the measurement sites.

B. 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 consideration of context. Beneficial effects are

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

identified and described. When there is no measurable effect, impact is found not to occur. Intensity of adverse effects is summarized as the degree or magnitude of a potential adverse effect where the adverse effect is thus determined to be negligible, moderate, or substantial. It is possible that a significant adverse effect may still exist when on balance the impact is negligible or even beneficial. For EMF and EMI, the terms are defined as follows:

A negligible impact for EMI/EMF is defined as a slight measurable increase of EMI/EMF levels that are very close to the existing conditions. A moderate impact is defined as a measureable increase of EMI/EMF 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. A substantial impact is defined as an increase in EMI/EMF 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.

C. 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.

As previously noted, 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); and 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 kilovolts per meter (kV/m). The MPE is 20 kV/m for controlled environments in which only HST employees would work.

The report *Environmental Impact Report/Environmental Impact Statement Assessment of California High-Speed Train Alignment Electromagnetic Field Footprint* (Authority and FRA, 2011) 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 *EIR/EIS Assessment* 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 and FRA 2011).

D. STUDY AREA FOR ANALYSIS

The study area for EMFs 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.

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 alternative HMF sites.

3.5.4 Affected Environment

A. 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 the police and fire department and FM radio transmitters. Local sources and facilities that typically contain highly sensitive RF equipment were identified within the EMI study area defined in Section 3.5.3(D), Study Area for Analysis.

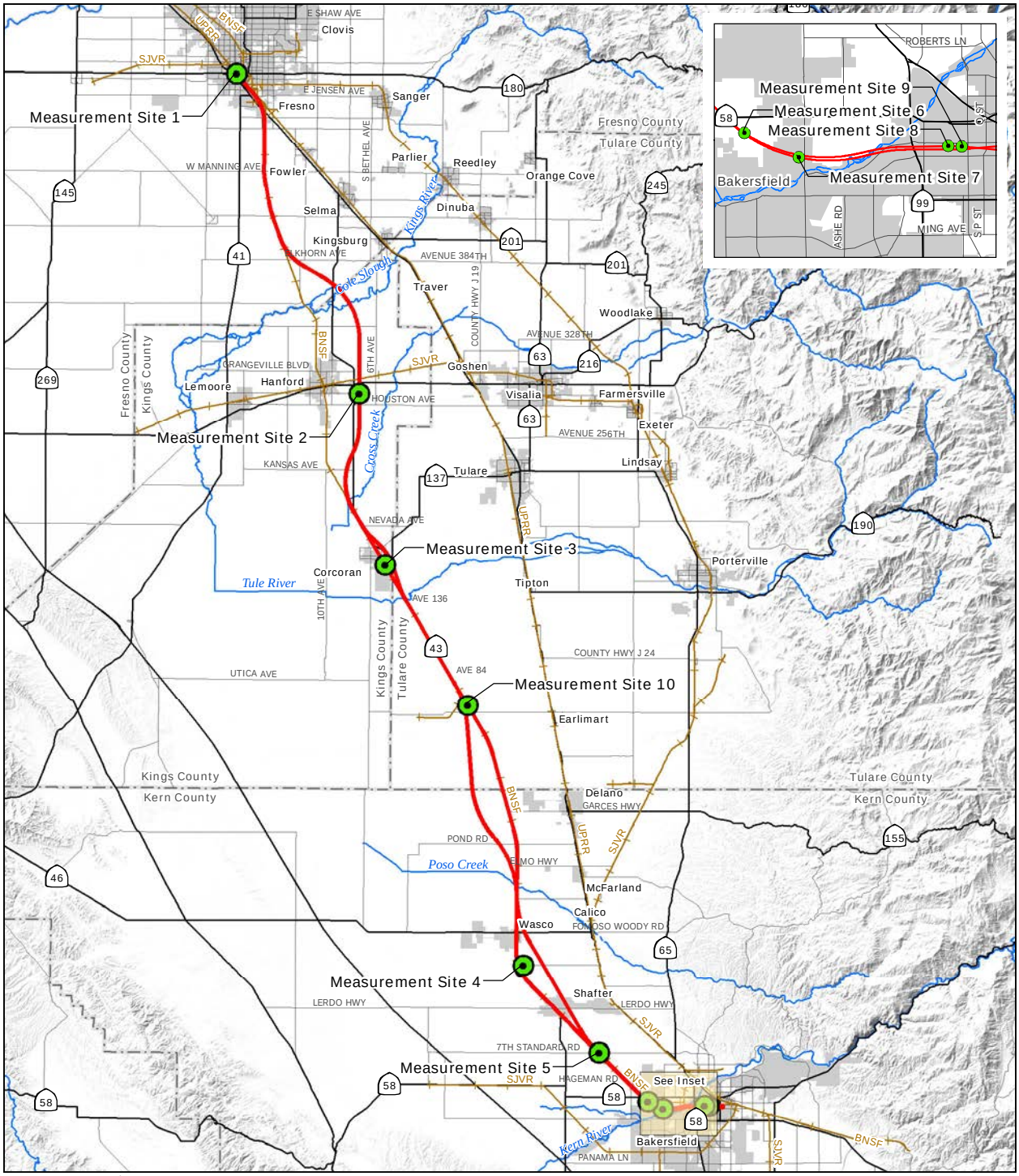
Measurements for EMF and RF signal strength were taken within 1.5 miles of each alternative HMF site, except for the Fresno HMF, where they were taken within 4 miles. All of the alternative HMF sites are in less-developed agricultural and rural areas. Sensitive receptors associated with these locations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

B. LOCAL CONDITIONS

Figure 3.5-1 shows the field measurement site locations. The measurement site locations along the BNSF Alternative are considered representative of each HST bypass alternative under consideration since 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 that 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.



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HST ALIGNMENT IS NOT DETERMINED

March 23, 2011

Source: Vibro-Acoustic Consultants, Inc. 2010.

Alternative alignments

Existing rail line

EMF/EMI measurement site

Community/Urban area

County boundary

N

0 5 10
Miles

0 10 20
Kilometers

Figure 3.5-1
EMF/EMI measurement site locations

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. 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.

Table 3.5-1 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 and are presented in detail in the Footprint Report (Authority and FRA 2011). 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 catenary.

Table 3.5-1
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 Hwy 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
Assumed Fenceline	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 *EIR/EIS Assessment Of CHST Alignment EMF Footprint (Authority and FRA, May 2011)*.
* Potentially sensitive receptors.

C. 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 3.5-2 summarizes the expected worst-case 60-Hz magnetic fields based on the closest distances from the centerline of the HST right-of-way (for two alignments: the BNSF Alternative Alignment and the Bakersfield South Alternative Alignment) 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 3.5-2
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)	BNSF Alternative Alignment (mG)	Bakersfield South Alternative Alignment (mG)
Mercy Hospital[b]	630	180	0.2	1.8
Truxtun Radiology Medical Group[c]	390	790	0.4	0.1
Sierra Radiology Medical Group[d]	260	620	0.9	0.2

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

HST = high-speed train
Hz = hertz
mG = milligauss

D. RAILROAD/TRANSPORTATION EQUIPMENT SUSCEPTIBLE TO EMF/EMI/RFI EFFECTS FROM AIRPORTS, MILITARY, OR OTHER COMMERCIAL TRANSMITTERS ALONG THE RIGHT-OF-WAY

Corrosion of underground pipelines, cables, and adjoining rails parallel to the California HST track alignment or interference with existing railroad signaling systems can occur due to HST-generated EMF/EMI emissions, Along the BNSF Alternative, trains use the existing rail line 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. To a lesser extent, the other alignment alternatives also parallel existing railroad tracks.

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. This section also discusses measures to reduce impacts.

A. OVERVIEW

EMF/EMI effects that would occur during construction are negligible under NEPA and less than significant under CEQA, because only a slight measurable increase of EMI/EMF levels that are very close to the existing conditions would occur. When the California HST project is complete, the predicted HST-generated EMF/EMI levels to which the general public is 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 would be exposed would be lower than the applicable HST project MPE standards for human exposure in controlled environments. Negligible effects would result from corrosion of underground pipelines, cables, and adjoining rails, because installation of standard corrosion protection will eliminate risk of substantial corrosion.

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 negligible effects on sensitive receptors, provided that typical magnetic shielding is installed.

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.

B. 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 facilities would continue in the area.

C. 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.

Construction Period Impacts

There would be negligible EMF or EMI impacts under NEPA and less than significant impacts under CEQA during construction of the HST alternatives 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.

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, effects on adjacent existing rail signal systems. The following sections discuss different types of potential EMI/EMF effects.

Human Exposure

Operation of the HST would generate 60-Hz electric and magnetic fields on and adjacent to trains, including in passenger station areas. Table 3.5-3 presents the HST project model results that apply to the alignment alternatives.

Table 3.5-3
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	73	Less than 1

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

Source: Authority and FRA 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 listed in Table 3.5-3 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 negligible effects under NEPA from EMF exposure to people. Under CEQA, the impacts are considered to be less than significant.

It is expected that the effects to the general public also would be less than significant for people with implanted medical devices, as it has been determined that sensitivity ranges from 1.5 kV/m upward. 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.

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, businesses, colleges, and residences would be expected to 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 are not expected to be reached. These effects would be negligible under NEPA since the HST will increase magnetic field exposure slightly but not to the level of the IEEE Standard. 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 no higher than on an active rail line, the effect of EMFs on employees at the HMF would be negligible under NEPA. Under CEQA, the impact would be less than significant.

Employees with Implanted Medical Devices

EMF levels above the recommended limits for employees with implanted medical devices could exist inside traction power facilities. Traction power facilities sites would be unmanned and workers would enter them only periodically, for example, to perform routine maintenance. Any exposure to EMF levels above those recommended for implanted medical devices could result in health effects, including death. For this reason, effects on the health of workers with implanted medical devices could be substantial under NEPA. Under CEQA, impacts could be significant.

Sensitive Equipment

As indicated in Table 3.5-2 above, three potentially sensitive receptors were identified within the 500-foot study area. All three receptors are along the Bakersfield South Alternative and 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, which would result in a substantial effect under NEPA and a significant impact under CEQA.

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

Nuisance Shocks

The voltage 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, since 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. In the project vicinity, most people live in the urban areas of the cities of Fresno, Hanford, Corcoran, Wasco, Shafter, and Bakersfield.

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 be negligible under NEPA and impacts would be less than significant under CEQA.

Effects on Adjacent Existing Rail Lines

Signal systems control the movement of trains on the existing BNSF tracks that one HST 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, i.e., 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 A 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 the no freight train present when in fact one is there, 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 catenary 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 3.5-4 shows the BNSF Alternative Alignment alone would be adjacent to 84 miles of existing railroad tracks, with shorter 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 3.5-5). 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 3.5-4
Length of High-Speed Train Alternative Alignments Adjacent to Existing Rail Lines

Alternative Alignment	Distance Adjacent to Existing Tracks (BNSF Alternative with Use of Indicated Alternative)
BNSF Alternative Alignment (only)	84 miles
Corcoran Elevated	4 miles
Corcoran Bypass Alternative Alignment	72 miles
Allensworth Bypass Alternative Alignment	62 miles
Wasco-Shafter Bypass Alternative Alignment	63 miles
Bakersfield South Alternative Alignment	83 miles

Table 3.5-5
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 West	2.5 miles	2.5 miles
Shafter East	2.3 miles	2.3 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. 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 be negligible under NEPA. Under CEQA, potential impacts would be less than significant.

3.5.6 Mitigation Measures

The HST project would comply with applicable federal and state laws and regulations. Similarly, project design will follow the EMCPP to avoid EMI/EMC conflicts and to ensure the HST operational safety. 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 to human health:

EMF/EMI-MM#1: Protect workers with implanted medical devices. Implement a safety program that includes disclosure of health risks to employees who have implanted medical devices. To protect their health and safety, the safety program precludes workers with implanted medical devices from entering any facility with electrical equipment that could endanger them. This program will include posting warnings as need in high EMF areas such as parts of the HMF and at TPSS to discourage access by employees or visitors who have implanted medical devices.

EMF/EMI-MM#2: Protect sensitive equipment. The Authority will coordinate with affected sensitive medical or research equipment users regarding the potential impacts of HST–related EMF or RF interference on imaging equipment, and make suitable design provisions to prevent interference. The design provisions may include establishing magnetic field shielding walls around sensitive equipment or installing RF filters into sensitive equipment.

3.5.7 NEPA Impacts Summary

The following list summarizes the impacts identified in Section 3.5.5, Environmental Consequences:

- Negligible effects would occur during construction.
- Human exposure to EMF affecting people at station platforms, on the trains, and in the HMFs would be negligible.
- Impacts on sensitive receptors along the alignment or near the HMF site would be negligible.
- With implementation of the HST safety program (MM#1) at HST traction power facilities, exposure of HST workers who have implanted medical devices would be avoided and not result in adverse effects on their health. The impact after mitigation would be negligible.

- During operation, under the Bakersfield South 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. Hence, EMI may occur to medical imaging equipment in the study area if the equipment is unshielded. In the absence of effective mitigation measures, these effects could be substantial.

- Grounding systems and/or installation of insulating joints or couplings would prevent corrosion of underground pipelines and cables along the alternatives and the HMF site. With appropriate prevention measures, these effects would be negligible.

- Grounding fences and irrigation systems would prevent nuisance shocks to people touching ungrounded metal fences and ungrounded metal irrigation systems that could result in health effects. The Vermeer-type metal irrigation systems are on metal wheels; therefore, they would be grounded through the wheels. Any surface pipe would be grounded through ground surface contact, so the only issue would be a center pivot system with rubber tires. With appropriate grounding, these effects would be negligible.

3.5.8 CEQA Significance Conclusion

The project would comply with applicable federal and state regulations and implement design strategies as outlined in the Final Statewide Program EIR/EIS (Authority and FRA 2005). Table 3.5-6 summarizes the remaining significant EMF/EMI impacts.

Table 3.5-6
Summary of Potentially Significant EMI/EMF Impacts and Mitigation Measures

Impact	Level of Significance before Mitigation	Mitigation Measure	Level of Significance after Mitigation
Construction Period Impacts			
No significant impacts would occur during construction.			
Project Impacts			
EMF/EMI Impact #1. Effects on workers with implanted medical devices. Under all alternatives, workers with implanted medical devices could be affected by work at electrical facilities.	Significant	EMF/EMI-MM#1	Less than significant
EMF/EMI Impact #2: Sensitive equipment. Under the Bakersfield South 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. Hence, EMI may occur to sensitive medical devices or imaging equipment potentially in the study area if the equipment is unshielded.	Significant	EMF/EMI-MM#2	Less than significant

EMF = electromagnetic field
EMI = electromagnetic interference
mG = milligauss

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