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 System. 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 operational EMFs.

Definitions: Electromagnetic Spectrum and Electromagnetic Waves

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.

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; they occur naturally and they 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.

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

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 or the number of times the electromagnetic field changes direction in space 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. Electrical power systems 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 further are characterized by their frequency range. Extremely low frequency 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 extremely low frequency 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 cellular telephone towers; broadcast towers for radio and television; airport radar, navigation, and communication systems; high frequency and very high frequency communication systems used by police, fire, emergency medical technicians, utilities, and governments; and local wireless systems such as WiFi or cordless telephone.

The strength of magnetic fields often is measured in milligauss (mG), gauss (G), tesla (T), or microtesla (µT) (see the Unit Definitions and Conversions text box on the previous page). For comparison, the magnetic field ranges from 500 to 700 mG DC (0.5 to 0.7 G)[1] (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). 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-kilovolt (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 should meet the Federal Communications Commission (FCC) regulatory requirements for intentional emitters (*47 CFR Part 15 and FCC OET 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 Federal

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

- U.S. Department of Transportation, FRA, 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

[1] 1 milligauss (mG) = 0.001 Gauss

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.

3.5.2.2 State

- California High-Speed Rail Authority—Electromagnetic Compatibility Program Plan (EMCPP), September 2010 (Turner Engineering 2010). The EMCPP supports the 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 EMCPP 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 Utility Commission (CPUC) Decision D.93-11-013. The CPUC decision adopted a policy regarding EMF from regulated utilities.

3.5.2.3 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

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 includes 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 Merced to Fresno Section that might be susceptible to the EMFs produced by an 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 (2010). Selected measurement locations establish EMF levels representative of conditions along the Merced to Fresno Section. Using these targeted areas, the reconnaissance described above identified sensitive land uses. The *Merced to Fresno Section EMF and EMI Footprint Measurement Report* (Authority and FRA 2010) describes the measurement sites and discusses the existing levels of EMFs that could cause EMI at the measurement sites.

- Analysis included using a 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 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,[2] 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 *Merced to Fresno Section Electromagnetic Fields and Electromagnetic Interference Footprint Measurement Report* (Authority and FRA 2010) describes the measurement sites and discusses the existing levels of EMFs that could cause EMI at the measurement sites.

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, an impact is 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 on balance the impact has negligible intensity or even if the impact is 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 EMI/EMF are near or at background and are well below those which could result in a health hazard. 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 nearby pipelines or cables.

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

3.5.3.3 CEQA Significance Criteria

A significant impact on the environment would occur if the HST System exposes people to a documented EMF health risk or if HST operations interfere with implanted biomedical devices.

The Maximum permissible exposure (MPE) limit (International Commission on Non-Ionizing Radiation Protection [ICNIRP] Guidelines 1998; Tables 6 and 7) for 60-Hz magnetic fields for the instantaneous exposure of the general public is 0.833 G (83.3 µT), and the MPE for controlled environments where only employees work is 4.2 G (420 µT). The MPE limit (ICNIRP Guidelines 1998; Tables 6 and 7) for 60-Hz electric fields for the general public is 4,200 volts per meter (V/m) or 4.2 kilovolts per meter (kV/m). The MPE is 8.3 kV/m for controlled environments in which only employees work.

The Footprint Report (Authority 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 analysis, 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 2010).

3.5.3.4 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 for the UPRR/SR 99 Alternative includes the urban and developed areas in Merced, Chowchilla, Fairmead, Madera, and Fresno and in areas adjacent to the UPRR. The study area for the BNSF Alternative includes the urban and developed areas in Merced, Le Grand, Madera, and Fresno, as well those adjacent to the UPRR and BNSF railways. The study area for the Hybrid Alternative begins along the UPRR/SR 99 Alternative, then transitions along the Ave 24 Wye to follow the BNSF Alternative.
- 200 feet from the perimeter of the proposed 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 modeling shows that 200 feet is the distance where the EMF level has decayed to a low level below 2 mG. This is the level below which no associations have been seen between EMF exposure and human health effects.

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 proposed HMF sites.

Five-hundred feet is the distance at which the EMI will have similarly decayed to a low level. Beyond that distance, exposure to EMF/EMI from the HST should be of no concern.

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, cellular telephone towers, and television stations such as KMSG-LP Channel 39 in Fresno. The local sources identified in the measurements taken along the proposed corridor were police and fire department and FM radio transmitters. No local sources were identified within the EMI study area defined in Section 3.5.3.4.

The Castle Commerce Center HMF site is more developed than the other HMF sites. Sensitive receptors associated with the nonresidential buildings at the site include underground pipelines, underground cables, and fencing. As shown in Figure 3.5-1, two measurement sites were located adjacent to the Castle Commerce Center HMF site. They are at County Road 37/Santa Fe Dr. and Bellevue Road and at County Road 37/Santa Fe Dr. and F St.

The EMF/EMI study areas for the Castle Commerce Center, Harris-DeJager, Gordon-Shaw, and Kojima Development HMF sites include existing rail lines. The Fagundes HMF site study area does not have an existing rail line.

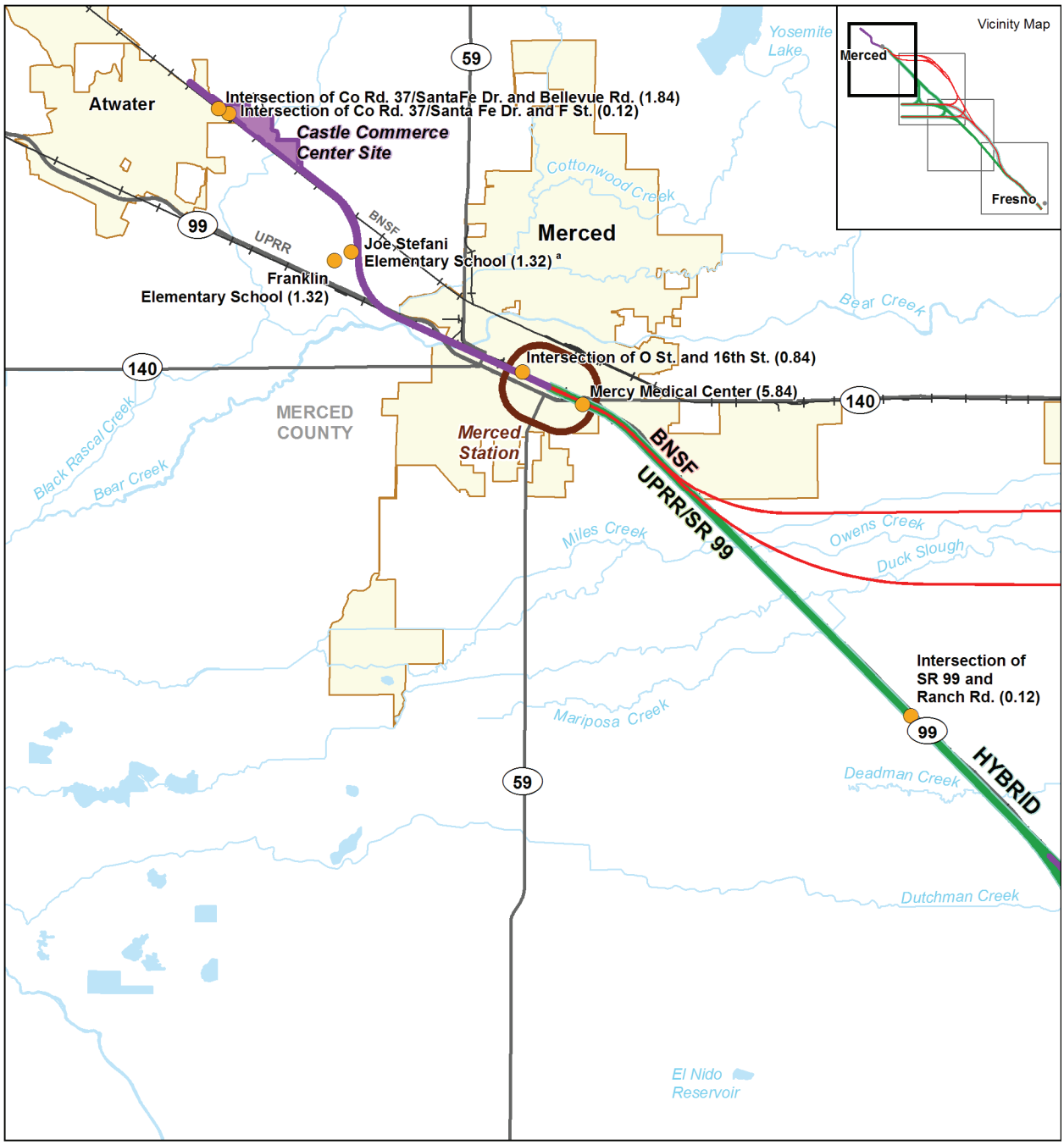
3.5.4.2 Local Conditions

Figures 3.5-1 through 3.5-4 show the measurement site locations. The measurement site locations along the UPRR/SR 99 Alternative are considered representative of the BNSF Alternative and Hybrid Alternative because no substantive change in rural or urban land use would be expected 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 areas include more residential housing subdivisions as well as underground pipelines, underground cables, and fencing associated with 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 levels, especially at the broadcast frequencies, occur in the Fresno and Merced urban areas.

The survey also quantified typical power-frequency magnetic field levels along the section. Two AC EMF measurements exceeded 2 mG. The AC EMF measured at the Mercy Medical Center in the City of Merced was 5.84 mG. This measurement was greater than 2 mG because there are power utilities in the vicinity. The AC EMF was 16.8 mG, measured directly underneath a 345-kV transmission line where it crosses SR 99 near the San Joaquin River north of Fresno. This measurement was greater than 2 mG because of EMF generated by electricity flowing through the 345-kV transmission line. The remaining AC measurements were less than 2 mG, with several measurements at 0.08 mG. The *Merced to Fresno Section EMF and EMI Footprint Measurement Report* (Authority and FRA 2010) presents the measurements at the measurement locations.



Source: CH2M HILL (2010).

MF_EIS_EM_01-04_a Jun 15, 2011

N

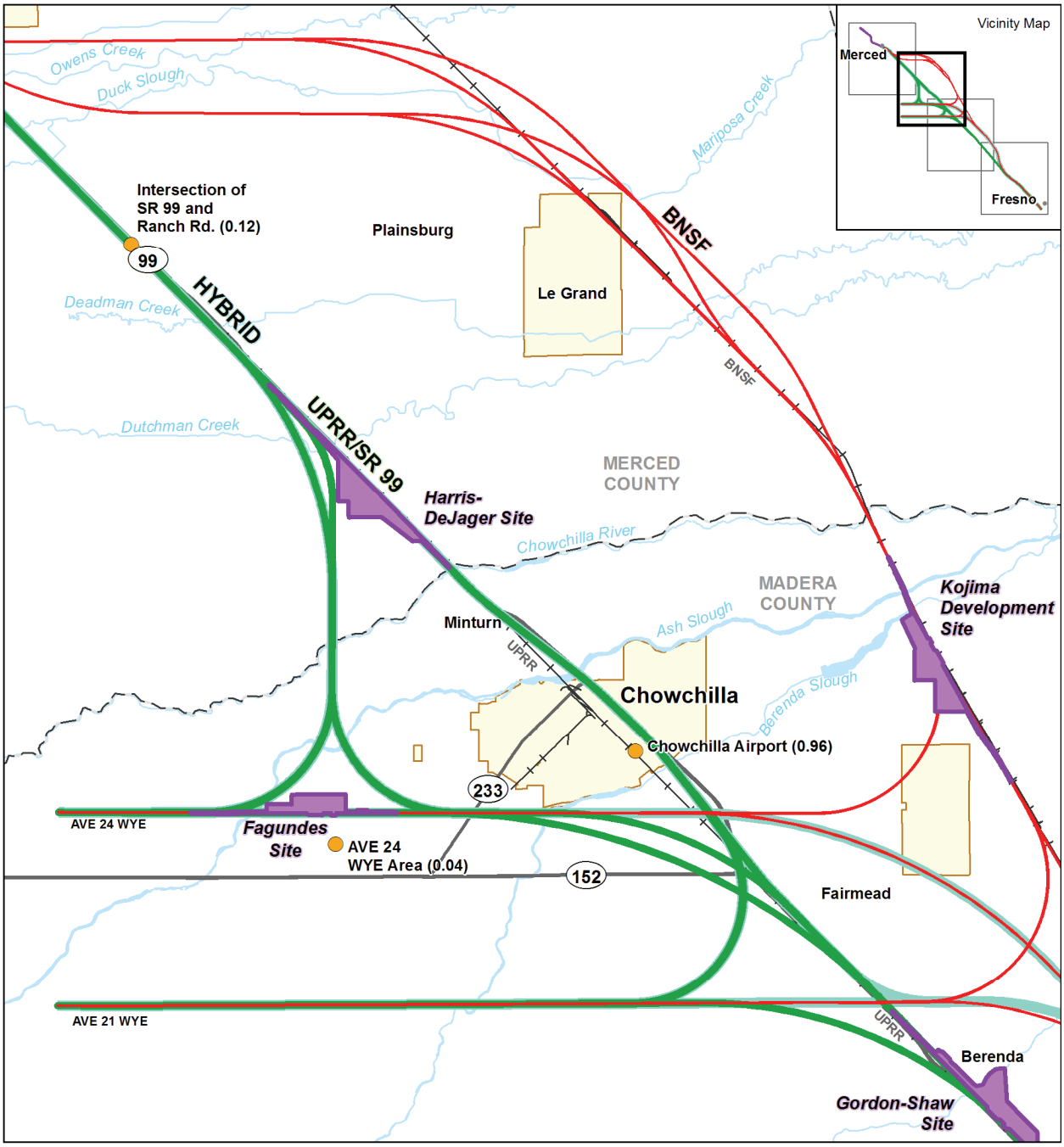
0 2.5
Miles

UPRR/SR 99 Alternative
BNSF Alternative
Hybrid Alternative
Potential Heavy Maintenance Facility
Station Study Area
City Limit
County Boundary
Railroad

EMF/EMI Measurement Site Location (EMF Baseline Measurement [mG])

[a] Value is representative based on measurements taken at Franklin Elementary School.

Figure 3.5-1
EMF/EMI Measurement Locations in the Merced Project Vicinity



Source: CH2M HILL (2010).

MF_EIS_EM_01-04_b Jun 15, 2011

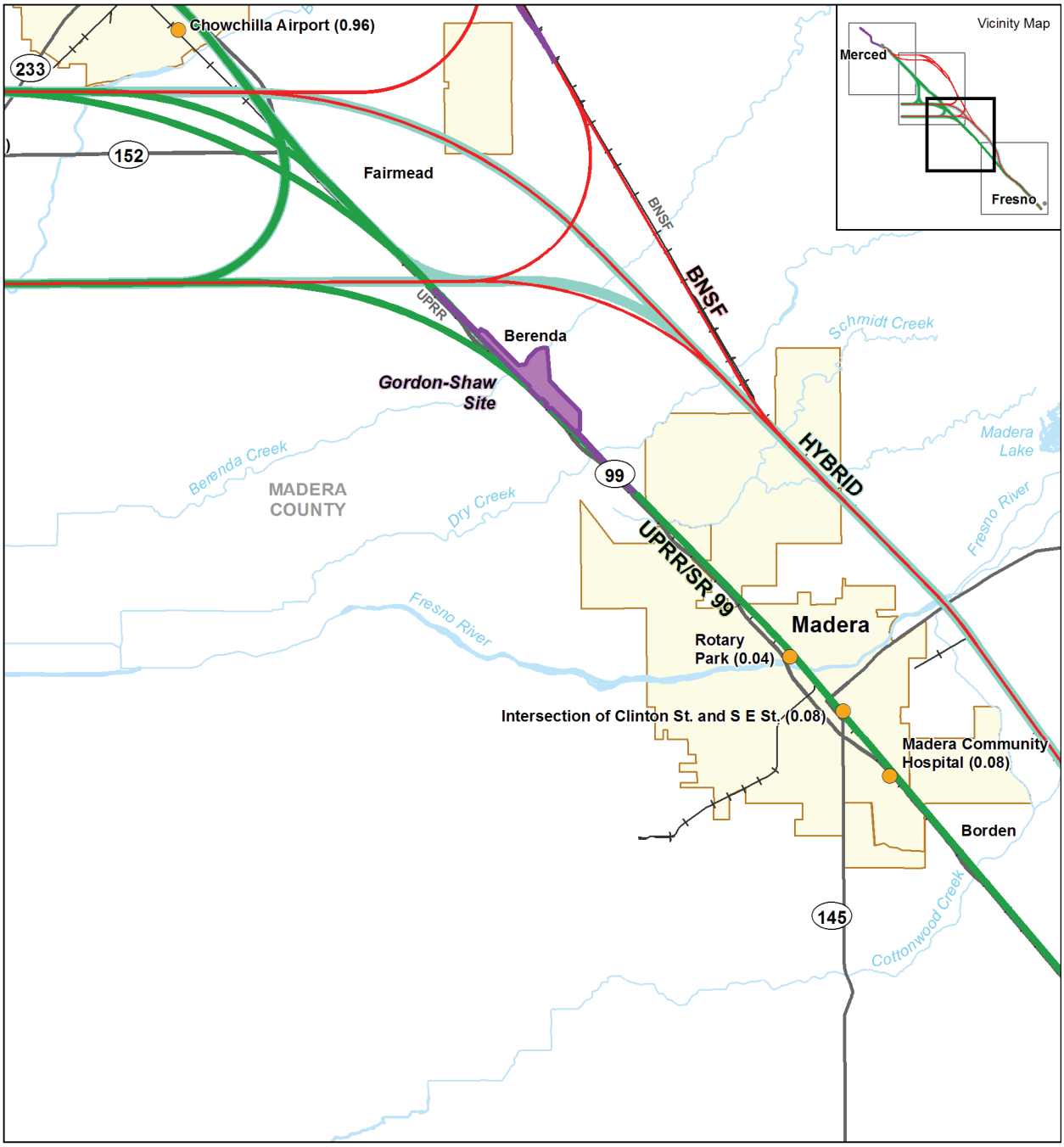
N

0 2.5
Miles

UPRR/SR 99 Alternative
BNSF Alternative
Hybrid Alternative
Potential Heavy Maintenance Facility
Station Study Area
City Limit
County Boundary
Railroad

EMF/EMI Measurement Site Location
(EMF Baseline Measurement [mG])
[a] Value is representative based on measurements taken at Franklin Elementary School.

Figure 3.5-2
EMF/EMI Measurement Locations in the Chowchilla Project Vicinity



Source: CH2M HILL (2010).

MF_EIS_EM_01-04_c Jun 15, 2011

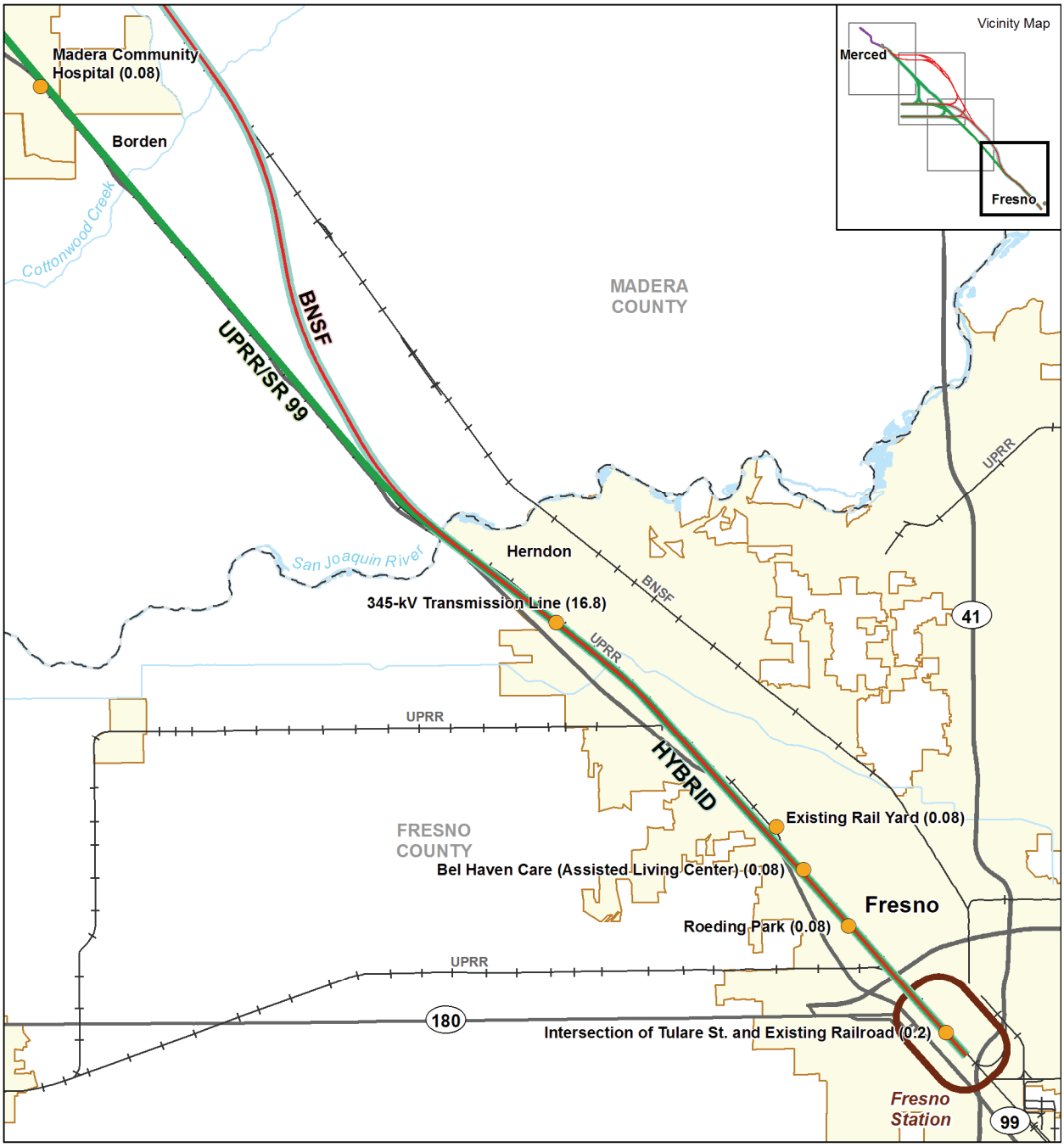
N

0 2.5
Miles

UPRR/SR 99 Alternative
BNSF Alternative
Hybrid Alternative
Potential Heavy Maintenance Facility
Station Study Area
City Limit
County Boundary
Railroad

EMF/EMI Measurement Site Location (EMF Baseline Measurement [mG])
[a] Value is representative based on measurements taken at Franklin Elementary School.

Figure 3.5-3
EMF/EMI Measurement Locations in the Madera Project Vicinity



Source: CH2M HILL (2010).

MF_EIS_EM_01-04_d Jun 15, 2011

N

0 2.5
Miles

UPRR/SR 99 Alternative
BNSF Alternative
Hybrid Alternative
Potential Heavy Maintenance Facility
Station Study Area
City Limit
County Boundary
Railroad

EMF/EMI Measurement Site Location (EMF Baseline Measurement [mG])
[a] Value is representative based on measurements taken at Franklin Elementary School.

Figure 3.5-4
EMF/EMI Measurement Locations in the Fresno Project Vicinity

Table 3.5-1 provides a comparison of the calculated magnetic fields for each of the 17 measurement locations and the measured magnetic fields for each site. The calculated magnetic fields include those for the single-train HST modeled in the Footprint Report (Authority 2011). The calculated magnetic fields are presented in detail. 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. The calculated magnetic fields for the minimum fence line position relative to the centerline of the right-of-way (30 feet) are 177 mG for the single-train HST (Authority 2011).

Potentially sensitive receptors are shown in Table 3.5-1 with an asterisk (*); these are Mercy Medical Center, Madera Community Hospital, and Bel Haven Care (Assisted Living Center). The magnetic fields for the potentially sensitive receptor locations are calculated from the Footprint Report (Authority 2011) and the measured magnetic fields for the potentially sensitive receptor sites are from the *Merced to Fresno Section EMF and EMI Footprint Measurement Report* (Authority and FRA 2010). The sensitive receptors are the Mercy Medical Center, Madera Community Hospital, and Bel Haven Care (Assisted Living Center).

Table 3.5-1
Summary Comparison of Measured and Calculated 60-Hz Magnetic Fields

Measurement Location	Distance from Centerline of Right-of-Way[a]	Measured AC Magnetic Field Levels[b] (mG)	Calculated Fields at HST Right-of-Way Distance[c] (Single Train) (mG)[d]
Intersection of Co Rd 37/Santa Fe Dr and Bellevue Rd	232	1.84	1.7
Intersection of Co Rd 37/Santa Fe Dr and F St	14	0.12	1,200
Franklin Elementary School	1912	1.32	<0.1
Joe Stefani Elementary School[e]	In construction footprint	1.32	<0.1
Intersection of O St and 16th St	165	0.84	4.0
Mercy Medical Center*	158	5.84	5.0
Intersection of SR 99 and Ranch Rd	39	0.12	170
Ave 24 Wye Area	2554	0.04	<0.1
Chowchilla Airport	1445	0.96	<0.1
Rotary Park	276	0.04	1.3
Intersection of Clinton St and S E St	155	0.08	6.0
Madera Community Hospital*	360	0.08	0.70
345-kV Transmission Line	32	16.8	300

Measurement Location	Distance from Centerline of Right-of-Way[a]	Measured AC Magnetic Field Levels[b] (mG)	Calculated Fields at HST Right-of-Way Distance[c] (Single Train) (mG)[d]
Existing Rail Yard (Intersection of N Weber Ave and W Shields Ave)	897	0.08	0.11
Bel Haven Care (Assisted Living Center)*	227	0.08	1.8
Roeding Park	109	0.08	11
Intersection of Tulare St and Existing Railroad	37	0.20	200

[a] Approximate maximum distance of spatial profile from centerline of right-of-way.
[b] Summary statistics of magnetic field for spatial profile measured at each site. Source: Authority and FRA (2010).
[c] Calculated magnetic fields from Authority and FRA (2010).
[d] It is assumed that the calculated magnetic fields for single-train HST (Authority and FRA 2010) are also for a single train passing closest to the measurement location.
[e] Value is representative based on measurements taken at Franklin Elementary School.
* Potentially sensitive receptors.
Source: Footprint Report (Authority 2011).

3.5.4.3 Receivers Susceptible to EMF/EMI/RFI Effects

The alternatives include urban and developed areas in the cities of Merced, Chowchilla, Madera, and Fresno. In addition, the UPRR/SR 99 Alternative and the Hybrid Alternative are adjacent to the community of Fairmead. Sensitive human receptors, such as residences, schools, and colleges, are concentrated in the urban areas. In the rural areas, effects on aboveground utilities, including ungrounded metal irrigation systems and ungrounded metal fences, could occur near at-grade sections of the HST track. No sensitive telecommunication or research facilities are in the study area.

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

Along the UPRR/SR 99 Alternative, trains use the UPRR rail line to haul freight. Along the BNSF Alternative, trains use the BNSF rail line to haul freight and to transport passengers (for example, on Amtrak's San Joaquin). The Castle Commerce Center, Harris-DeJager, and Gordon-Shaw HMF sites are along the UPRR rail line. The Kojima Development HMF site is along the BNSF rail line. The Fagundes HMF site is not near an existing rail line.

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.

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. When the California HST project is complete, the predicted HST-generated EMF/EMI levels to which the general public is expected to be exposed would 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 and emergency backup generator facilities would be exposed would be lower than the applicable HST project MPE standards for human exposure in controlled environments. No corrosion or negligible corrosion would affect underground pipelines, cables, and adjoining rails because installation of standard corrosion protection will eliminate risk of substantial corrosion.

Standard HST project design features would preclude other 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 equipment on adjoining railroad tracks. There are no sensitive telecommunication or research facilities or airports in the EMF/EMI study area.

3.5.5.2 No Project Alternative

As discussed in Chapter 1.0, 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, large residential developments, quarries, and expansion of SR 99 between Merced and Fresno by 2020. These development and transportation infrastructure projects are planned or approved to accommodate the growth projections in the area. The use of electricity and RF communications, including broadcast services and cell phones, that result in EMFs and EMI currently occurs and would continue to occur along the Merced to Fresno 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.

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 residences, schools and colleges, employees, underground pipelines and cables, fences, and existing railroads.

Construction Period Impacts

There would be EMF or EMI impacts with negligible intensity under NEPA and less than significant impacts under CEQA during construction of the HST alternatives because construction equipment generates low levels of EMFs and EMI. 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 three 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 sections discuss different types of potential EMF/EMI 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 3.5-2 presents the HST project model results that apply to the alignment alternatives.

Table 3.5-2
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
Source: Footprint Report (Authority 2011).			

Magnetic field measurements have been made in the passenger compartments onboard other HST systems such as the Acela Express (119 mG) and French TGV A (165 mG) and in the operator's cabs of the Acela Express (58 mG) and French TGV A (367 mG) (FRA 2006). Because the modeled levels of EMF exposure listed in Table 3.5-2 and measurements on these 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 from EMF exposure to people. Under CEQA, the impacts would be considered to be less than significant.

The HST EMF analyses indicate that the EMF generated by an HMF would be less than for the main line because HST trains would operate at much lower speeds and would have much lower acceleration rates at HMF sites, whether entering or exiting facilities 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 hospitals, schools, businesses, colleges, and residences would be expected to be below the ICNIRP 1998 Guideline of 833 mG for the public because, even within the mainline right-of-way, these levels are not expected to be reached. As shown in Table 3.5-1, the calculated field levels are low due to the large distance from the HST right-of-way to potentially sensitive receptors at the Mercy Medical Center, Madera Community Hospital, and Bel Haven Care (Assisted Living Center). Accordingly, there would be no EMF effect from the HST on these facilities. EMF impacts on sensitive receptors would have negligible intensity under NEPA because the HST would increase magnetic field exposure slightly but not to the level of the ICNIRP guideline. Under CEQA, the impact would be less than significant. The ICNIRP Guideline MPE for controlled environments in which employees work is 4,200 mG (4.2 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 have negligible intensity under NEPA. Under CEQA, the impact would be less than significant.

Implanted Medical Devices

It is expected that the effects also would have negligible intensity under NEPA and would be less than significant under CEQA on people with implanted medical devices, because it has been determined that electric field sensitivity ranges from 1.5 kV/m upward. Magnetic fields of 1,000 to 12,000 mG (1 to 12 G) may produce interference (EPRI 2001). The American Conference of Governmental Industrial Hygienists (ACGIH) 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.

In addition, backup and emergency power supply sources would be provided through use of an emergency standby generator, an uninterruptable power supply, and/or a DC battery system. For the Merced to Fresno Section, permanent emergency standby generators are anticipated to be located at passenger stations and at the HMF and terminal layup/storage and maintenance facilities. EMF would come in the form of electrical devices, such as transformers and buss lines common to an electrical substation. Regardless of the location of these sources, EMF would be confined primarily to the

immediate, fenced area surrounding the facility or source except where power lines enter and exit the facility. In the case of the emergency standby generator, EMF would be negligible. 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. These emergency power facilities are all located within the study area and the EMI/EMF impact from them was considered in this analysis.

EMF levels above the recommended limits for employees with implanted medical devices could exist inside traction power facilities and emergency power generators. Traction power facilities and emergency power generation sites would be unmanned, and workers would enter them only periodically, for example, 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 or emergency power facilities. Therefore, these effects would be avoided.

Livestock and Poultry Exposure

Table 3.5-2 provides the modeled levels of EMF exposure that would be produced by the HST outside of the fenced right-of-way. At these levels of exposure there would be no significant impact from EMF to livestock and poultry along the right-of-way. Previous studies (Amstutz and Miller 1980) have shown that even at EMF levels much higher than those from the HST, there is no effect on herds of beef or dairy cattle or swine. There are no known poultry facilities located along the proposed construction footprint, but even if there were, no studies have shown that exposure to these low levels of EMF would be detrimental to poultry flocks.

Sensitive Equipment

The businesses in the EMF study area generally consist of commercial and light industry, such as lumber yards. These businesses are not medical or scientific. No businesses had names or descriptions indicating that they housed sensitive scientific or medical equipment. Therefore, this EIR/EIS assumes that there is no magnetic resonance imaging equipment or specialized scientific equipment, such as nuclear magnetic resonance, scanning electron microscopes, or transmission electron microscopes within the EMF study area. Because there is no magnetic resonance imaging equipment or specialized scientific equipment in the EMF study area, operation of the HST alternatives would result in no impact on these types of equipment (LTK Engineering Services 2006).

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. Although much of the return current would be carried by the HST rails and the static wire back to the TPSS, some return current would find another 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 not sufficiently grounded through the direct contact with earth, the project would separately ground pipelines and other linear metallic objects in coordination with the appropriate 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 by standard design provisions, the effect would have negligible intensity under NEPA. Under CEQA, the impact would be less than significant.

Nuisance Shocks

The voltages 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 ungrounded fences or irrigation systems are parallel to the HST, are long (1 mile or more), and are electrically continuous throughout that distance. Such voltages 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 agricultural fields and vineyards. In the project vicinity, however, most people are located in the urban areas of the cities of Merced, Madera, and Fresno.

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 (EPRI 2005). Because the project design would avoid possible shock hazards and prevent the possibility of current flow, impacts would have negligible intensity under NEPA and would be less than significant under CEQA.

Effects on Adjacent Existing Rail Lines

Signal systems control the movement of trains on the existing UPRR or BNSF tracks that the HST 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 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 930 amperes 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, thereby indicating that there is no freight train

present when, in fact, a train is present, or thereby indicating that a train is present when, in fact, no train is present.

- 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 3.5-3 shows that the HST alternatives are adjacent to existing railroad tracks where the HST operation could affect signal systems.

Existing railroad tracks within the study areas for the Castle Commerce Center, Harris-DeJager, Gordon-Shaw, and Kojima Development HMF sites include adjacent freight railroad tracks, and at these sites, HMF operations could affect rail signal systems, shown in Table 3.5-4. The Fagundes HMF site study area does not include existing railroad tracks.

Table 3.5-3
Length Adjacent to Existing Rail Lines – HST Alternatives

Alternative	Distance Adjacent to[a]	
	UPPR	BNSF
UPRR/SR 99 Alternative	51 miles	0 mile
BNSF Alternative	16 miles	27 miles
Hybrid Alternative	37 miles	7 miles

[a] Miles rounded to nearest whole number.
Source: Mapcon Mapping Ltd. (2007).

Table 3.5-4
Length Adjacent to Existing Rail Lines – HMF Alternatives

HMF Site	Length Adjacent to Existing Rail Lines[a]		
	UPPR/SR 99 Alternative	BNSF Alternative	Hybrid Alternative
Castle Commerce Center	2 miles	3 miles	2 miles – UPRR 3 miles – BNSF
Harris-DeJager	4 miles	0 mile	4 miles
Fagundes	0 mile	0 mile	0 mile
Gordon-Shaw	4 miles	0 mile	0 mile
Kojima Development	0 mile	4 miles	4 miles

[a] Miles rounded to nearest whole number.
Source: Mapcon Mapping Ltd. (2007).

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 HMF would be relatively short compared to up to 51 miles of parallel section 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 in the EMCPP 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 provisions would be put in place prior to the activation of potentially interfering systems of the HST so that the possibility of impact on the adjacent railroad would have negligible intensity under NEPA. Under CEQA, impacts would be less than significant.

3.5.6 Project Design Features

Existing standards and regulations address many of the impacts identified in this analysis. The 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. Appendix 3.5-A, Applicability of Laws, Regulations, and Design Standards for EMI/EMF, in Volume II, provides a matrix that indicates relevant standards and regulations for the impacts discussed in Section 3.5.5, Environmental Consequences.

3.5.7 Mitigation Measures

The mitigation strategies presented in the California HST System Program EIR/EIS documents have been refined and adapted for this project EIR/EIS and incorporated into the EMCPP. During project design and construction, the EMCPP will be followed to avoid and minimize potential for impacts on human health. Because there would be no significant impacts, there are no additional mitigation measures identified.

3.5.8 NEPA Impacts Summary

This section summarizes impacts identified in Section 3.5.5, Environmental Consequences, and evaluates whether they are significant according to NEPA. Under NEPA, project effects are evaluated based on the criteria of context and intensity. Context means the affected environment in which a proposed project occurs, while intensity 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. The following NEPA impacts were identified under the No Project Alternative and the HST Project alternatives.

- Effects with negligible intensity would occur during construction because construction equipment generates low levels of EMF and EMI, consistent with background levels of EMF and EMI.
- Human exposure to EMF, affecting people at station platforms, on the trains, and in the HMFs, would have negligible intensity because the thresholds for human exposure to EMI/EMF would not be exceeded.

- Impacts on sensitive receptors along the alignment or near the HMF site would have negligible intensity because the thresholds for human exposure to EMI/EMF would not be exceeded.
- Effects on the health of workers with implanted medical devices would be avoided by following the EMCPP, because workers with implanted medical devices would not be permitted to enter the traction power facilities.
- Because there is no magnetic resonance imaging equipment or specialized scientific equipment in the EMF study area, operation of the HST alternatives would result in no impact on sensitive equipment.
- Grounding systems and/or installation of insulating joints or couplings would prevent corrosion of underground pipelines and cables along the alternatives and HMF site. With appropriate prevention measures, these effects would have negligible intensity.
- 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 have negligible intensity.

Given the negligible intensity of EMF/EMI impacts that would be encountered during construction and operation of the HST, and human exposure to low levels of EMF/EMI within the project vicinity, the impact would not be significant under NEPA.

3.5.9 CEQA Significance Conclusions

The project would comply with applicable federal and state regulations and implement design features from the Program EIR/EIS documents, as incorporated into the EMCPP. No significant impacts would occur during construction or operation of the HST Alternatives or HMFs.