CALIFORNIA HIGH-SPEED TRAIN

Project Environmental Impact Report / Environmental Impact Statement

15% Design

Hydraulics and Floodplain Technical Report

Merced to Fresno Section Project EIR/EIS

August 2011

CALIFORNIA High-Speed Rail Authority

U.S. Department of Transportation Federal Railroad Administration

CALIFORNIA HIGH-SPEED TRAIN PROJECT-LEVEL EIR/EIS

15% Design
TECHNICAL REPORT

Merced to Fresno Section
Hydraulics and Floodplain

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August 2011

California High-Speed Rail Authority and Federal Railroad Administration. 2011. *Merced to Fresno Section Hydraulics and Floodplain Report, California High-Speed Train Draft Project EIR/EIS*. Sacramento, CA, and Washington, DC. Prepared by AECOM and CH2M HILL. August 2011.

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List of Abbreviated Terms

ASTM	American Society of Testing and Materials
Authority	California High-Speed Rail Authority
base flood	FEMA regulatory 100-year flood
Bay Area	San Francisco Bay Area
BFE	base flood elevation
Caltrans	California Department of Transportation
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CWA	Clean Water Act
CWC	California Water Code
CWD	Chowchilla Water District
DWR	California Department of Water Resources
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	flood insurance study
FRA	Federal Railroad Administration
GIS	geographic information system
H:V	horizontal:vertical
ID	identifier
HDPE	high-density polyethylene
HMF	heavy maintenance facility
HST	high-speed train
NFIP	National Flood Insurance Program
O&M	operations and maintenance

Draft Project EIR/EIS	*Merced to Fresno Section High-Speed Train Project EIR/EIS*
PVC	polyvinylchloride
SPFC	State Plan for Flood Control
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USGS	U.S. Geological Survey
WSE	water surface elevation

1.0 Introduction

The California High-Speed Train (HST) Project includes approximately 800 miles of new HST guideway and numerous related heavy maintenance and station facilities. The Merced to Fresno Section of the HST Project includes HST guideway, two HST stations, and, potentially, a heavy maintenance facility (HMF). This *Merced to Fresno Section Hydraulics and Floodplains Technical Report* provides important information related to the waterbody and floodplain crossings between the cities of Merced and Fresno that would result from the project. The term *waterbody* includes relatively stationary water features, such as ponds and reservoirs; and flowing water features, such as streams, irrigation canals, major drainage ditches, piped conduits, and defined features such as channels that are wet only periodically. A waterbody does not include broader habitat, such as wetlands and vernal pools. Waterbody is distinguished in this report from floodplains, which are areas generally characterized by infrequent shallow flooding.

Section 2 of this report describes the HST project between Merced and Fresno. The *Merced to Fresno Section High-Speed Train Project EIR/EIS* (Draft Project EIR/EIS) evaluates three HST alternatives. The HST alternatives are based on two primary north-south alignments and a hybrid combination of those alignments that extend between proposed HST stations in Merced and Fresno. The UPRR/SR 99 Alternative is generally adjacent to the existing transportation corridor defined by the UPRR railway and State Route (SR) 99. The BNSF Alternative is essentially the same as the UPRR/SR 99 Alternative at the northern and southern ends of the alignment, but veers to the east to follow the BNSF Railroad corridor in the middle. Each of these two major alignments includes two alternative wye configurations for guideways to and from the San Francisco Bay Area (Bay Area), as well as design options for alignment subalternatives. The Hybrid Alternative combines the UPRR/SR 99 Alternative alignment north of the City of Chowchilla and the BNSF Alternative alignment beginning north of Madera and extending farther south. The Hybrid Alternative also has two potential wye connection alternatives. Figure 1-1 shows these three primary HST alternative alignments (UPRR/SR 99, BNSF, and Hybrid), associated wyes, and design options. Figure 1-1 also shows an optional access guideway that extends north from the Downtown Merced Station to the Castle Commerce Center HMF site, should that site be selected.

The study area for this report includes the Merced to Fresno Section, the upstream drainage basins that contribute hydrologically; the various channel reaches and floodplains that may be affected hydraulically; existing hydraulic structures, such as bridges and levees that affect hydraulic conveyance; and downstream reaches that affect or are affected by hydraulic performance. The study area generally has low gradients of less than 1%. Because of these low gradients, the potential hydraulic impacts due to a project water crossing that constricts a river, stream, or canal could, in some cases, extend several thousand feet upstream and downstream. The study area includes the area approximately defined by the City of Merced to the north, the City of Fresno to the south, the lower San Joaquin River to the west, and the Sierra Nevada Mountain foothills and reservoirs to the east.

1.1 Report Objectives and Organization

This report has been prepared to develop information for inclusion in the Draft Project EIR/EIS and to provide engineering guidance for use in the preliminary design of the project. The report also identifies additional surveying, hydrologic assessments, and hydraulic modeling needed to complete permit applications related to waterbody and floodplain crossings.

Section 1 of this report provides an introduction. Section 2 is the project description for the Merced to Fresno Section of the California HST Project. Section 3 described applicable regulations, requirements, and design criteria. Section 4 describes analysis of floodplains in the study area, and Section 6 provides analysis of water bodies that cross the HST alignment. Section 6 describes additional hydraulic and hydrologic assessments required for permitting. Sections 7 and 8 list references cited in the document and describe the qualifications of the preparers, respectively.

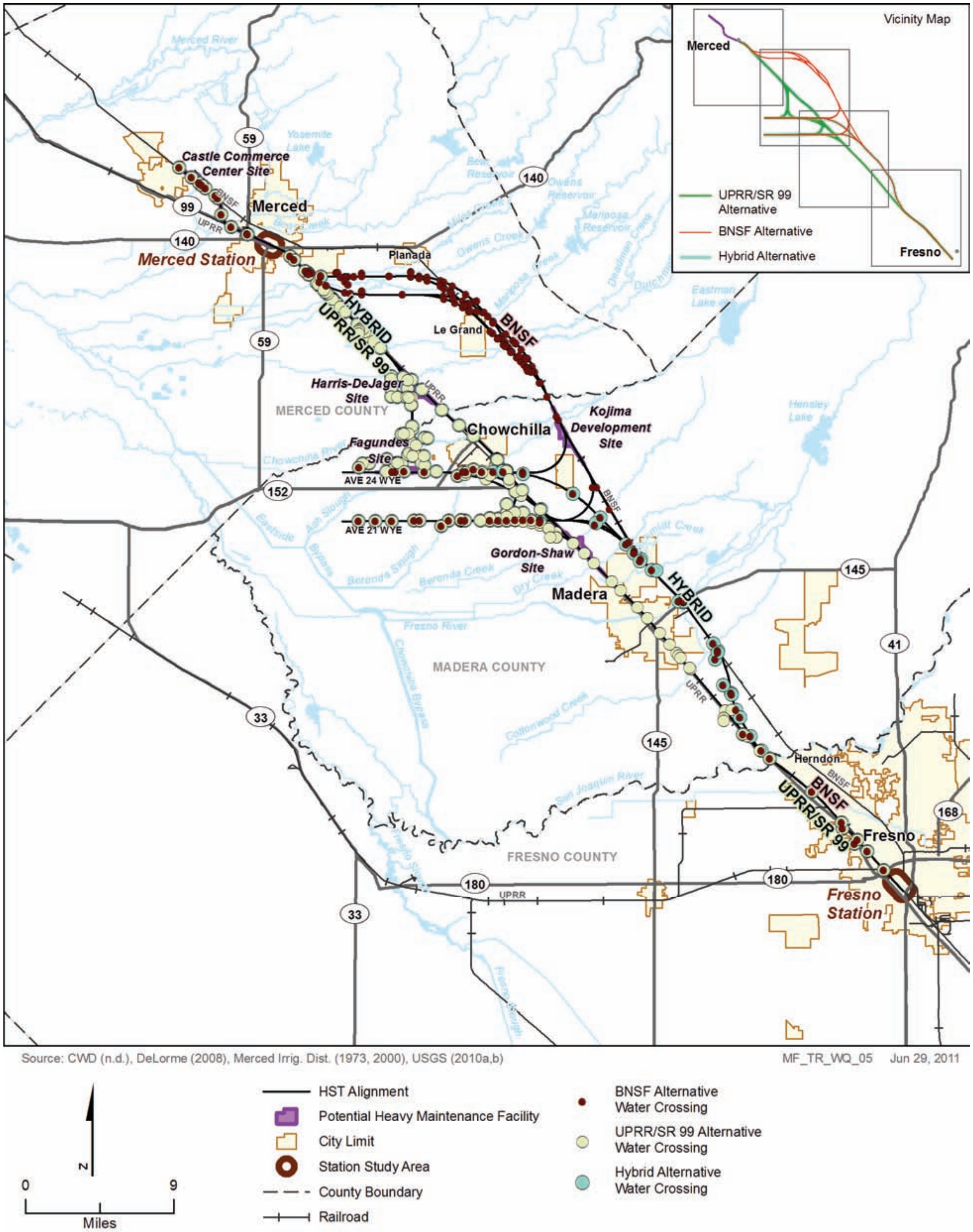


Figure 1-1
Merced to Fresno Section
HST Alternatives

1.2 Engineering Considerations and Constraints in the Routing of a High-Speed Train Alignment

The project would follow existing transportation corridors, where practical, to minimize impacts on existing land uses. The HST alignment must safely accommodate an HST speed of up to 220 miles per hour (mph). It is important to isolate the guideways from animals, pedestrians, and vehicles to avoid collisions. There must be a grade separation from intersecting roads, railroads, walkways, trails, and throughways. Elevated sections of the guideway would typically be 15 feet above the ground surface or higher. Curves in the horizontal and vertical alignments must be gradual to maintain the target speed and provide a comfortable ride. Because of the high design speed, the curve radii are much longer than for conventional railroad tracks or highways. Limitations on at-grade crossings and curve radii prevent the horizontal and vertical alignments from being constructed exactly parallel to existing transportation features at some locations. These constraints limit how and where floodplains and waterbodies are crossed.

It is generally impractical to reroute the alignment to reduce the skewing (degree of deviation from perpendicular) of crossings and avoid impacts on waterbodies and sensitive habitats adjacent to waterbodies, or to change whether guideway approaches to waterbodies are elevated or at grade for a single crossing. Because of requirements for grade separation at track crossings and the space required for the train embankment, at-grade portions of the track generally result in a larger permanent footprint for the HST project due to an increased number of overpasses, road modifications and right-of-way corridors.

Section 5.2.3 provides a summary of waterbody crossings.

2.0 Project Description

The purpose of the Merced to Fresno Section of the HST project is to implement the California HST System between Merced and Fresno, providing the public with electric-powered high-speed rail service that provides predictable and consistent travel times between major urban centers and connectivity to airports, mass transit systems, and the highway network in the south San Joaquin Valley, and to connect the northern and southern portions of the HST System. The approximately 65-mile-long corridor between Merced and Fresno is an essential part of the statewide HST System. The Merced to Fresno Section is the location where the HST would intersect and connect with the Bay Area and Sacramento branches of the HST System; it would provide a potential location for the heavy maintenance facility (HMF) where the HSTs would be assembled and maintained, as well as a test track for the trains; it would also provide Merced and Fresno access to a new transportation mode and would contribute to increased mobility throughout California.

2.1 No Project Alternative

The No Project Alternative refers to the projected growth planned for the region through the 2035 time horizon without the HST project and serves as a basis of comparison for environmental analysis of the HST build alternatives. The No Project Alternative includes planned improvements to the highway, aviation, conventional passenger rail, and freight rail systems in the Merced to Fresno project area. There are many environmental impacts that would result under the No Project Alternative.

2.2 High-Speed Train Alternatives

As shown in Figure 2-1, there are three HST alignment alternatives proposed for the Merced to Fresno Section of the HST System: the UPRR/SR 99 Alternative, which would primarily parallel the UPRR railway; the BNSF Alternative, which would parallel the BNSF railway for a portion of the distance between Merced and Fresno; and the Hybrid Alternative, which combines features of the UPRR/SR 99 and BNSF alternatives. In addition, there is an HST station proposed for both the City of Merced and the City of Fresno, there is a wye connection (see text box on page 2-3) west to the Bay Area, and there are five potential sites for a proposed HMF.

2.2.1 UPRR/SR 99 Alternative

This section describes the UPRR/SR 99 Alternative, including the Chowchilla design options, wyes, and HST stations.

2.2.1.1 North-South Alignment

The north-south alignment of the UPRR/SR 99 Alternative would begin at the HST station in Downtown Merced, located on the west side of the UPRR right-of-way. South of the station and leaving Downtown Merced, the alternative would be at-grade and cross under SR 99. Approaching the City of Chowchilla, the UPRR/SR 99 Alternative has two design options: the East Chowchilla design option, which would pass Chowchilla on the east side of town, and the West Chowchilla design option, which would pass Chowchilla 3 to 4 miles west of the city before turning back to rejoin the UPRR/SR 99 transportation corridor. These design options would take the following routes:

- **East Chowchilla design option:** This design option would transition from the west side of the UPRR/SR 99 corridor to an elevated structure as it crosses the UPRR railway and N Chowchilla Boulevard just north of Avenue 27, continuing on an elevated structure away from the UPRR corridor along the west side of and parallel to SR 99 to cross Berenda Slough. Toward the south side of Chowchilla, this design option would cross over SR 99 north of the SR 99/SR 152 interchange near Avenue 23½ south of Chowchilla. Continuing south on the east side of SR 99 and the UPRR corridor, this design option would remain elevated for 7.1 miles through the communities of

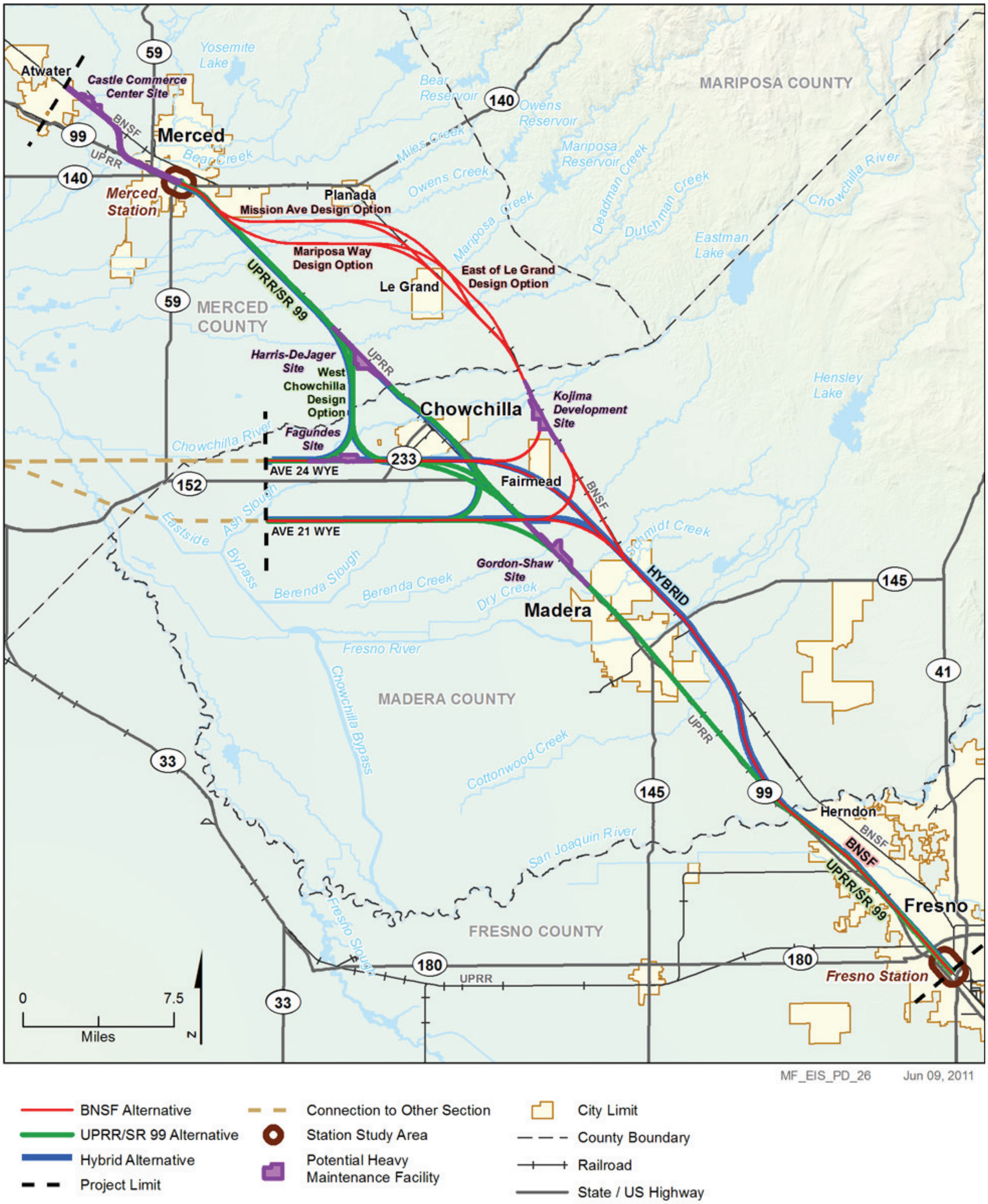


Figure 2-1
Merced to Fresno Section
HST Alternatives

Fairmead and Berenda until reaching the Dry Creek Crossing. The East Chowchilla design option connects to the HST sections to the west via either the Ave 24 or Ave 21 wyes (described below).

- **West Chowchilla design option:** This design option would travel due south from Sandy Mush Road north of Chowchilla, following the west side of Road 11¾. The alignment would turn southeast toward the UPRR/SR 99 corridor south of Chowchilla. The West Chowchilla design option would cross over the UPRR and SR 99 east of the Fairmead city limits to again parallel the UPRR/SR 99 corridor. The West Chowchilla design option would result in a net decrease of approximately 13 miles of track for the HST System compared to the East Chowchilla design option and would remain outside the limits of the City of Chowchilla. The West Chowchilla design option connects to the HST sections to the west via the Ave 24 Wye, but not the Ave 21 Wye.

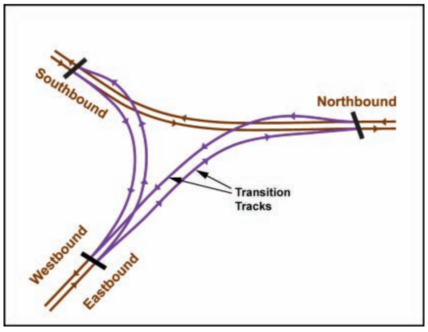
The UPRR/SR 99 Alternative would continue toward Madera along the east side of the UPRR south of Dry Creek and remain on an elevated profile for 8.9 miles through Madera. After crossing over Cottonwood Creek and Avenue 12, the HST alignment would transition to an at-grade profile and continue to be at-grade until north of the San Joaquin River. After the alternative crosses the San Joaquin River, it would rise over the UPRR railway on an elevated guideway, supported by straddle bents, before crossing over the existing Herndon Avenue and again descending into an at-grade profile and continuing west of and parallel to the UPRR right-of-way. After elevating to cross the UPRR railway on the southern bank of the San Joaquin River, south of Herndon Avenue, the alternative would transition from an elevated to an at-grade profile. Traveling south from Golden State Boulevard at-grade, the alternative would cross under the reconstructed Ashlan Avenue and Clinton Avenue overhead structures. Advancing south from Clinton Avenue between Clinton Avenue and Belmont Avenue, the HST guideway would run at-grade adjacent to the western boundary of the UPRR right-of-way and then enter the HST station in Downtown Fresno. The HST guideway would descend in a retained-cut to pass under the San Joaquin Valley Railroad spur line and SR 180, transition back to at-grade before Stanislaus Street, and continue to be at-grade into the station. As part of a station design option, Tulare Street would become either an overpass or undercrossing at the station.

2.2.1.2 Wye Design Options

The following text describes the wye connection from the San Jose to Merced Section to the Merced to Fresno Section. There are two variations of the Ave 24 Wye for the UPRR/SR 99 Alternative because of the West Chowchilla design option. The Ave 21 Wye does not connect to the West Chowchilla design option and therefore does not have a variation.

What is a "Wye"?

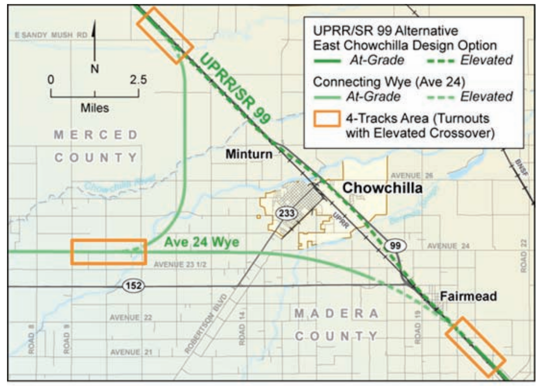
The word "wye" refers to the "Y"-like formation that is created where train tracks branch off the mainline to continue in different directions. The transition to a wye requires splitting two tracks into four tracks that cross over one another before the wye "legs" can diverge in opposite directions to allow bidirectional travel. For the Merced to Fresno Section of the HST System, the two tracks traveling east-west from the San Jose to Merced Section must become four tracks—a set of two tracks branching to the north and a set of two tracks branching to the south.



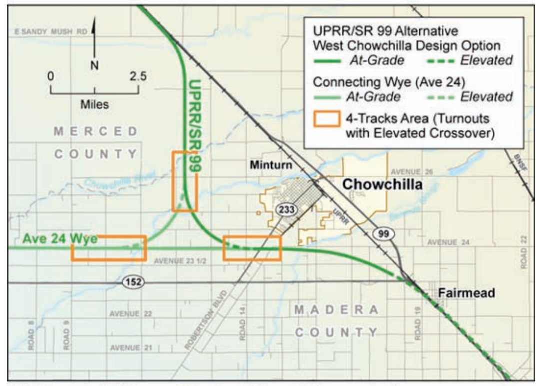
Ave 24 Wye

The Ave 24 Wye design option would travel along the south side of eastbound Avenue 24 toward the UPRR/SR 99 Alternative and would begin diverging onto two sets of tracks west of Road 11 and west of the City of Chowchilla. Under the East Chowchilla design option, the northbound set of tracks would travel northeast across Road 12, joining the UPRR/SR 99 north-south alignment on the west side of the UPRR right-of-way just north of Sandy Mush Road. Under the West Chowchilla design option, the northbound set of tracks would travel northeast across Road 12 and would join the UPRR/SR 99 north-south alignment just south of Avenue 26. The southbound HST guideway would continue east along Avenue 24, turning south near SR 233 southeast of Chowchilla, crossing SR 99 and the UPRR railway to connect to the UPRR/SR 99 Alternative north-south alignment on the east side of the UPRR near Avenue 21½. Under the West Chowchilla design option, the southbound tracks would turn south near Road 16 south of Chowchilla, crossing SR 99 and the UPRR to connect to the UPRR/SR 99 north-south alignment on the east side of the UPRR adjacent to the city limits of Fairmead.

Figure 2-2a shows the wye alignment for the East Chowchilla design option and Figure 2-2b shows the alignment for the West Chowchilla design option. Together, the figures illustrate the difference in the wye triangle formation for each design option connection. The north-south alignment of the West Chowchilla design option between Merced and Fresno diverges along Avenue 24 onto Road 12, on the north branch of the wye, allowing the HST alternative to avoid traveling through Chowchilla and to avoid constraining the city within the wye triangle.



(a) Ave 24 Wye with the East Chowchilla Design Option



(b) Ave 24 Wye with the West Chowchilla Design Option

Figure 2-2a and b
Ave 24 Wye and Chowchilla Design Options

Ave 21 Wye

The Ave 21 Wye would travel along the north side of Avenue 21. Just west of Road 16, the HST tracks would diverge north and south to connect to the UPRR/SR 99 Alternative, with the north leg of the wye joining the north-south alignment at Avenue 23½ and the south leg at Avenue 19½.

2.2.1.3 HST Stations

The Downtown Merced and Downtown Fresno station areas would each occupy several blocks, to include station plazas, drop-offs, a multimodal transit center, and parking structures. The areas would include the station platform and associated building and access structure, as well as lengths of platform tracks to accommodate local and express service at the stations. As currently proposed, both the Downtown Merced and Downtown Fresno stations would be at-grade, including all trackway and platforms, passenger services and concessions, and back-of-house functions.

Downtown Merced Station

The Downtown Merced Station would be between Martin Luther King Jr. Way to the northwest and G Street to the southeast. The station would be accessible from both sides of the UPRR, but the primary station house would front 16th Street. The major access points from SR 99 include V Street, R Street, Martin Luther King Jr. Way, and G Street. Primary access to the parking facility would be from West 15th Street and West 14th Street, just one block east of SR 99. The closest access to the parking facility from the SR 99 freeway would be R Street, which has a full interchange with the freeway. The site proposal includes a parking structure that would have the potential for up to 6 levels with a capacity of approximately 2,250 cars and an approximate height of 50 feet.

Downtown Fresno Station Alternatives

There are two station alternatives under consideration in Fresno: the Mariposa Street Station Alternative and the Kern Street Station Alternative.

Mariposa Street Station Alternative

The Mariposa Street Station Alternative is located in Downtown Fresno, less than 0.5 mile east of SR 99. The station would be centered on Mariposa Street and bordered by Fresno Street on the north, Tulare Street on the south, H Street on the east, and G Street on the west. The station building would be approximately 75,000 square feet, with a maximum height of approximately 60 feet. The two-level station would be at-grade, with passenger access provided both east and west of the HST guideway and the UPRR tracks, which would run parallel with one another adjacent to the station. Entrances would be located at both G and H Streets. The eastern entrance would be at the intersection of H Street and Mariposa Street, with platform access provided via the pedestrian overcrossing. The main western entrance would be located at G Street and Mariposa Street.

The majority of station facilities would be located east of the UPRR tracks. The station and associated facilities would occupy approximately 18.5 acres, including 13 acres dedicated to the station, bus transit center, surface parking lots, and kiss-and-ride accommodations. A new intermodal facility would be included in the station footprint on the parcel bordered by Fresno Street to the north, Mariposa Street to the south, Broadway Street to the east, and H Street to the west. The site proposal includes the potential for up to 3 parking structures occupying a total of 5.5 acres. Two of the three potential parking structures would each sit on 2 acres, and each would have a capacity of approximately 1,500 cars. The third parking structure would have a slightly smaller footprint (1.5 acres), with 5 levels and a capacity of approximately 1,100 cars. Surface parking lots would provide approximately 300 additional parking spaces.

Kern Street Station Alternative

The Kern Street Station Alternative for the HST station would also be in Downtown Fresno and would be centered on Kern Street between Tulare Street and Inyo Street. This station would include the same components and acreage as the Mariposa Street Station Alternative, but the station would not encroach on the historic Southern Pacific Railroad depot just north of Tulare Street and would not require relocation of existing Greyhound facilities. Two of the 3 potential parking structures would each sit on 2 acres and each would have a capacity of approximately 1,500 cars. The third structure would have a slightly smaller footprint (1.5 acres) and a capacity of approximately 1,100 cars. Like the Mariposa Street Station Alternative, the majority of station facilities under the Kern Street Station Alternative would be east of the HST tracks.

2.2.2 BNSF Alternative

This section describes the BNSF Alternative, including the Le Grand design options and wyes. It does not include a discussion of the HST stations, because the station descriptions are identical for each of the three HST alignment alternatives.

2.2.2.1 North-South Alignment

The north-south alignment of the BNSF Alternative would begin at the proposed Downtown Merced Station. This alternative would remain at-grade through Merced and would cross under SR 99 at the south end of the city. Just south of the interchange at SR 99 and E Childs Avenue, the BNSF Alternative would cross over SR 99 and UPRR as it begins to curve to the east, crossing over the E Mission Avenue interchange. It would then travel east to the vicinity of Le Grand, where it would turn south and travel adjacent to the BNSF tracks.

To minimize impacts on the natural environment and the community of Le Grand, the project design includes four design options:

- **Mission Ave design option:** This design option would turn east to travel along the north side of Mission Avenue at Le Grand and then would elevate through Le Grand adjacent to and along the west side of the BNSF corridor.
- **Mission Ave East of Le Grand design option:** This design option would vary from the Mission Ave design option by traveling approximately 1 mile farther east before turning southeast to cross

Santa Fe Avenue and the BNSF tracks south of Mission Avenue. The HST alignment would parallel the BNSF for a half-mile to the east, avoiding the urban limits of Le Grand. This design option would cross Santa Fe Avenue and the BNSF railroad again approximately one-half mile north of Marguerite Road and would continue adjacent to the west side of the BNSF corridor.

- **Mariposa Way design option:** This design option would travel 1 mile farther than the Mission Ave design option before crossing SR 99 near Vassar Road and turning east toward Le Grand along the south side of Mariposa Way. East of Simonson Road, the HST alignment would turn to the southeast. Just prior to Savana Road in Le Grand, the HST alignment would transition from at-grade to elevated to pass through Le Grand on a 1.7-mile-long guideway adjacent to and along the west side of the BNSF corridor.
- **Mariposa Way East of Le Grand design option:** This design option would vary from the Mariposa Way design option by traveling approximately 1 mile farther east before turning southeast to cross Santa Fe Avenue and the BNSF tracks less than one-half mile south of Mariposa Way. The HST alignment would parallel the BNSF to the east of the railway for a half-mile, avoiding the urban limits of Le Grand. This design option would cross Santa Fe Avenue and the BNSF again approximately a half-mile north of Marguerite Road and would continue adjacent to the west side of the BNSF corridor.

Continuing southeast along the west side of BNSF, the BNSF Alternative would begin to curve just before Plainsburg Road through a predominantly rural and agricultural area. One mile south of Le Grand, the HST alignment would cross Deadman and Dutchman creeks. The alignment would deviate from the BNSF corridor just southeast of S White Rock Road, where it would remain at-grade for another 7 miles, except at the bridge crossings, and would continue on the west side of the BNSF corridor through the community of Sharon. The HST alignment would continue at-grade through the community of Kismet until crossing at Dry Creek. The BNSF Alternative would then continue at-grade through agricultural areas along the west side of the BNSF corridor through the community of Madera Acres north of the City of Madera. South of Avenue 15 east of Madera, the alignment would transition toward the UPRR corridor, following the east side of the UPRR corridor near Avenue 9 south of Madera, then continuing along nearly the same route as the UPRR/SR 99 Alternative over the San Joaquin River to enter the community of Herndon. After crossing the San Joaquin River, the alignment would be the same as for the UPRR/SR 99 Alternative

2.2.2.2 Wye Design Options

The Ave 24 Wye and the Ave 21 Wye would be the same as described for the UPRR/SR 99 Alternative (East Chowchilla design option), except as noted below.

Ave 24 Wye

As with the UPRR/SR 99 Alternative, the Ave 24 Wye would follow along the south side of Avenue 24 and would begin diverging into two sets of tracks (i.e., four tracks) beginning west of Road 17. Two tracks would travel north near Road 20½, where they would join the north-south alignment of the BNSF Alternative on the west side of the BNSF corridor near Avenue 26½. The two southbound tracks would join the BNSF Alternative on the west side of the BNSF corridor south of Avenue 21.

Ave 21 Wye

As with the UPRR/SR 99 Alternative, the Ave 21 Wye would travel along the north side of Avenue 21. Two tracks would diverge, turning north and south to connect to the north-south alignment of the BNSF Alternative just west of Road 21. The north leg of the wye would join the north-south alignment just south of Avenue 24 and the south leg would join the north-south alignment just east of Frontage Road/Road 26 north of the community of Madera Acres.

2.2.3 Hybrid Alternative

This section describes the Hybrid Alternative, which generally follows the alignment of the UPRR/SR 99 Alternative in the north and the BNSF Alternative in the south. It does not include a discussion of the HST stations because the station descriptions are identical for each of the three HST alternatives.

2.2.3.1 North-South Alignment

From north to south, generally, the Hybrid Alternative would follow the UPRR/SR 99 alignment with either the West Chowchilla design option with the Ave 24 Wye or the East Chowchilla design option with the Ave 21 Wye. Approaching the Chowchilla city limits, the Hybrid Alternative would follow one of two options:

- In conjunction with the Ave 24 Wye, the HST alignment would veer due south from Sandy Mush Road along a curve and would continue at-grade for 4 miles parallel to and on the west side of Road 11¾. The Hybrid Alternative would then curve to a corridor on the south side of Avenue 24 and would travel parallel for the next 4.3 miles. Along this curve, the southbound HST track would become an elevated structure for approximately 9,000 feet to cross over the Ave 24 Wye connection tracks and Ash Slough, while the northbound HST track would remain at-grade. Continuing east on the south side of Avenue 24, the HST alignment would become identical to the Ave 24 Wye connection for the BNSF Alternative and would follow the alignment of the BNSF Alternative until Madera.
- In conjunction with the Ave 21 Wye connection, the HST alignment would transition from the west side of UPRR and SR 99 to an elevated structure as it crosses the UPRR and N Chowchilla Boulevard just north of Avenue 27, continuing on an elevated structure along the west side of and parallel to SR 99 away from the UPRR corridor while it crosses Berenda Slough. Toward the south side of Chowchilla, the alignment (with the Ave 21 Wye) would cross over SR 99 north of the SR 99/SR 152 interchange near Avenue 23½ south of Chowchilla. It would continue to follow along the east side of SR 99 until reaching Avenue 21, where it would curve east and run parallel to Avenue 21, briefly. The alignment would then follow a path similar to the Ave 21 Wye connection for the BNSF Alternative, but with a tighter 220 mph curve. The alternative would then follow the BNSF Alternative alignment until Madera.

Through Madera and until reaching the San Joaquin River, the Hybrid Alternative is the same as the BNSF Alternative. Once crossing the San Joaquin River, the alignment of the Hybrid Alternative becomes the same as for the UPRR/SR 99 Alternative.

2.2.3.2 Wye Design Options

The wye connections for the Hybrid Alternative follow Avenue 24 and Avenue 21, similar to those of the UPRR/SR 99 and BNSF alternatives.

Ave 24 Wye

The Ave 24 Wye is the same as the combination of the UPRR/SR 99 Alternative with the West Chowchilla design option, and the Ave 24 Wye for the BNSF Alternative.

Ave 21 Wye

The Ave 21 Wye is similar to the combination of the UPRR/SR 99 Alternative with the Ave 21 Wye on the northbound leg and the BNSF Alternative with the Ave 21 Wye on the southbound leg. However, the south leg under the Hybrid Alternative would follow a tighter, 220 mph curve than the BNSF Alternative, which follows a 250 mph curve.

2.2.4 Heavy Maintenance Facility Alternatives

The Authority is studying five HMF sites (see Figure 2-1) within the Merced to Fresno Section, one of which may be selected.

- **Castle Commerce Center HMF site** – A 370-acre site located 6 miles northwest of Merced, at the former Castle Air Force Base in northern unincorporated Merced County. It is adjacent to and on the east side of the BNSF mainline, 1.75 miles south of the UPRR mainline, off of Santa Fe Drive and Shuttle Road, 2.75 miles from the existing SR 99 interchange. The Castle Commerce Center HMF would be accessible by all HST alternatives.
- **Harris-DeJager HMF site** – A 401-acre site located north of Chowchilla adjacent to and on the west side of the UPRR corridor, along S Vista Road and near the SR 99 interchange under construction. The Harris-DeJager HMF would be accessible by the UPRR/SR 99 and Hybrid alternatives if coming from the Ave 21 Wye and the UPRR/SR 99 Alternative with the East Chowchilla design option and the Ave 24 Wye.
- **Fagundes HMF site** – A 231-acre site, located 3 miles southwest of Chowchilla on the north side of SR 152, between Road 11 and Road 12. This HMF would be accessible by all HST alternatives with the Ave 24 Wye.
- **Gordon-Shaw HMF site** – A 364-acre site adjacent to and on the east side of the UPRR corridor, extending from north of Berenda Boulevard to Avenue 19. The Gordon-Shaw HMF would be accessible from the UPRR/SR 99 Alternative.
- **Kojima Development HMF site** – A 392-acre site on the west side of the BNSF corridor east of Chowchilla, located along Santa Fe Drive and Robertson Boulevard (Avenue 26). The Kojima Development HMF would be accessible by the BNSF Alternative with the Ave 21 Wye.

2.2.5 Road Modifications and Other Permanent Footprint

In addition to the direct track infrastructure, there would be additional permanent facilities, some located inside of the fenced track right-of-way and some outside of that right of way. The permanent project footprint would include new and modified roads, roadway overpasses, relocated utility corridors, and supporting infrastructure such as power stations and stormwater facilities. These expand the number of waterbody crossings and extent of floodplain encroachments beyond those caused by the linear track features alone.

3.0 Applicable Regulations, Requirements and Design Criteria

This section provides an overview of federal, state, and local regulations that address the HST crossings of streams and other waterbodies and their associated floodplains. This section also presents the project design criteria applicable to waterbody crossings.

3.1 Applicable Regulations

A complex set of federal, state, and local regulations govern floodplain and waterbody crossings in the study area. This section discusses these regulations and associated project review processes. This technical report does not discuss stormwater, groundwater, water quality, or other broader water resource regulations governing the project. Stormwater regulations are addressed in the Stormwater Data Report (Authority and Federal Railroad Administration [FRA] 2011a) and the Stormwater Management Plan (Authority and FRA 2011b).

3.1.1 Federal Regulations

3.1.1.1 Rivers and Harbors Act

Protection of Improvements to Navigable Waters (Title 33 Section 10 of U.S.C Section 401)

Section 10 of the Rivers and Harbors Act (Title 33 United States Code [U.S.C] Section 401), which is administered by the U.S. Army Corps of Engineers (USACE), requires permits for all structures such as pilings, docks, or bridges that are constructed in navigable waters of the United States. Excavation or fill activities such as dredging and placement of fill or riprap in the waterways also require permits. Navigable waters include waters that are subject to the ebb and flow of the tide and rivers used as a means of interstate transport or foreign commerce. USACE grants or denies permits based on the impacts on navigation. Section 404 of the Clean Water Act (CWA) also covers most of these activities (see below).

Use of Harbor or River Improvements (Title 33 U.S.C. Section 408)

Modification of a federal flood control project requires permission by USACE through a Title 33 U.S.C. Section 408 permit. Section 408 specifies the technical and risk analyses that must be submitted to USACE by any non-federal sponsor of a project that may adversely affect the capacity or structural integrity of a federal flood control facility. The types of information required include detailed structural information, hydraulic data (e.g., water surface profiles), and geotechnical evaluations (e.g., levee seepage and stability). A memorandum, *Clarification Guidance on the Policy and Procedural Guidance for the Approval of Modifications and Alterations of Corps of Engineers Projects* (USACE 2008), provides detailed information.

Local Flood Protection Works (Title 33 CFR Section 208.10)

Title 33 of the Code of Federal Regulations (CFR) Section 208.10 defines the responsibilities of USACE for maintenance of flood channels, levees, and other flood protection features constructed by the federal government. Section 208.10.a.5 defines the responsibility for assuring that projects or other improvements are constructed in a manner that does not reduce the capacity or functionality of any federal flood control project.

USACE approval may be granted under Section 208.10 for alternations or improvements that have little or no impact on the authorized level of protection (capacity) and structural integrity of a federal flood protection project. The Central Valley Flood Protection Board (CVFPB), which is part of the California Department of Water Resources (DWR) (formerly the California Reclamation Board), administers Section 208.10 in the Central Valley. CVFPB administers permits for encroachments on state and state–federal flood control projects. USACE provides a concurrent review of the technical aspects of encroachment permit applications, and provides to CVFPB a list of technical requirements to satisfy USACE responsibilities under Section 208.10.

3.1.1.2 Clean Water Act

Section 404 Permit for Fill Material in Waters and Wetlands

The CWA Section 404 regulates the discharge of dredged and fill materials into waters of the United States, which include oceans, bays, rivers, streams, lakes, ponds, and wetlands. Emphasis is placed on protection of water quality and conservation of marine and aquatic habitat. Projects are encouraged to avoid impacts on waterbodies or to minimize impacts where a waterbody cannot be avoided. Projects mitigate for lost habitat, typically by providing replacement habitat at a different location. A 404 permit application must be submitted to USACE. Nationwide 404 permits exist for a large number of activities that have been determined to cause generally minor impacts. A single application typically covers the requirements of both Section 10 (Rivers and Harbors Act) and Section 404 (CWA).

Section 401 Clean Water Quality Certification

Under CWA Section 401, applicants for a federal license or permit to conduct activities that may result in the discharge of a pollutant into waters of the United States must obtain certification from the state in which the discharge would originate, or, if appropriate, from the interstate water pollution control agency with jurisdiction over affected waters at the point where the discharge would originate. Therefore, all projects that have a federal component and may affect the quality of state waters (including projects that require federal agency approval, such as issuance of a Section 404 permit) must also comply with CWA Section 401. Section 401 certification or waiver is under the jurisdiction of the applicable regional water quality control board.

3.1.1.3 Executive Order 11988 – Floodplain Management (U.S. Department of Transportation Order 5650.2)

Executive Order (EO) 11988 directs all federal agencies to (1) avoid to the extent practicable and feasible all short-term and long-term adverse impacts associated with floodplain modification and (2) avoid direct and indirect support of development within 100-year floodplains when there is a reasonable alternative. Additional specific information must support projects that encroach on 100-year floodplains. The U.S. Department of Transportation Order 5650.2, *Floodplain Management and Protection,* prescribes "policies and procedures for ensuring that proper consideration is given to the avoidance and mitigation of adverse floodplain impacts in agency actions, planning programs and budget requests." The order does not apply to Zone C (areas of minimal flooding) as shown on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs). Environmental review documents should indicate potential risks and impacts from proposed transportation facilities.

3.1.1.4 Flood Disaster Protection Act (Title 42 U.S.C. 4001 et seq.)

The purpose of the Flood Disaster Protection Act is to identify flood-prone areas and provide insurance. The act requires the purchase of insurance for buildings in special flood-hazard areas. The act is applicable to any federally assisted acquisition or construction project in an area identified as having special flood hazards. Projects should avoid construction in, or develop a design to be consistent with, FEMA-identified flood-hazard areas.

FEMA oversees the National Flood Insurance Program (NFIP). NFIP offers federally backed flood insurance to homeowners, renters, and business owners in communities that choose to participate in the program. Typically, each county has a flood insurance study (FIS). Within the study area, the latest FISs include Merced County (FEMA 2008a), Madera County (FEMA 2008b), and Fresno County (FEMA 2009).

FEMA and participating communities work together to develop FIRMs. The FIRMs divide communities into flood hazard zones. Flood hazard zones are areas inundated by the base flood, which has a 100-year recurrence interval (i.e., 1% chance of annual flooding and 26% chance of flooding over a 30-year period). Flood hazard zones are further classified by the hydraulic modeling approach and the level of detail used in delineating the base flood boundaries and elevation. Flood hazard zone classifications are defined in Table 3-1, and indicated for stream crossings, by alignment, in Section 6 (refer to Tables 6-3 through 6-5.

Table 3-1
Flood Hazard Zones

Zone	Description
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths or BFEs are shown within these zones.
AE	The base floodplain where BFEs are provided. AE zones are now used on new format FIRMs instead of A1–A30 zones.
A1 through A30	These are known as numbered A zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).
AH	Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. BFEs derived from detailed analyses are shown at selected intervals within these zones.
AO	River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.
AR	Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements apply, but rates do not exceed the rates for un-numbered A zones if the structure is built or restored in compliance with zone AR floodplain management regulations.
A99	Areas with a 1% annual chance of flooding that will be protected by a federal flood control system where construction has reached specified legal requirements. No depths or BFEs are shown within these zones.
BFE = base flood elevation	

In some reaches (zone AE), hydraulic modeling has been used to determine the inundation limits of the base flood on the FIRM, and the FIRM shows within these limits the boundaries of a floodway. The floodway is that portion of the 100-year floodplain in which, based on prior modeling, encroachment cannot be extended without causing more than a 1-foot water surface elevation rise at any location. Encroachments are excluded within the floodway unless modeling can demonstrate that the BFE will not rise.

To be eligible for federally backed flood insurance, a community must participate in the NFIP. Participating communities must adopt and enforce floodplain management ordinances (refer to Section 3.1.3) that meet or exceed FEMA requirements for reducing the risk of future flood damage. FEMA has set a minimum national standard, allowing no more than a 1-foot increase in BFEs (whether mapped or not mapped) because of the cumulative impact of local development. The participating FEMA communities in the study area are discussed later in this section. Each of those communities has adopted the FEMA 1-foot-maximum-rise criteria.

If a project will substantially alter the extent or depth of the base flood, the project owner must submit supporting documentation and modeling. If FEMA approves the development proposal, they issue a Conditional Letter of Map Revision. After construction is complete, as-built construction plans and modeling are submitted to FEMA, and they issue a Letter of Map Revision, which officially updates the FIRM.

3.1.2 State Regulations

3.1.2.1 Central Valley Flood Protection Board (California Code of Regulations Title 23, Division 1)

In cooperation with USACE, the CVFPB provides policy direction and coordination for the flood control efforts of state and local agencies along the Sacramento and San Joaquin Rivers and their tributaries. CVFPB cooperates with federal, state, and local government agencies in establishing, planning, constructing, operating, and maintaining flood control works. By issuing permits for encroachments, CVFPB also exercises regulatory authority to maintain the integrity of the existing flood control system and designated floodways.

CVFPB has mapped designated floodways along more than 60 streams and rivers in the Central Valley. CVFPB *designated floodways* are different from FEMA *floodways.* CVFPB-designated floodways are within the designated flood boundaries for the designated project flow rate and are similar in meaning to the FEMA base flood boundaries shown on FIRMs. In addition to designated floodways, Table 8.1 in Title 23 CCR lists several hundred stream reaches and waterways as regulated streams. Projects that would encroach on a designated floodway or regulated stream, or come within 10 feet of the toe of a state–federal flood control structure (e.g., a levee), require an application (with an associated environmental assessment questionnaire) for an encroachment permit.

CVFPB reviews applications for an encroachment permit for completeness and works with the applicant to ensure that all required application content is submitted (Taras 2010; Larson 2010). CVFPB provides a copy of the application to USACE for concurrent review. In general, USACE focuses on technical engineering requirements, such as hydraulic modeling, geotechnical studies, and performance requirements to fulfill its obligations under Section 408 and Section 208.10 (refer to Section 3.1.1.1); CVFPB focuses on environmental compliance and Title 23 standards to ensure compliance under the California Environmental Quality Act (CEQA) and Title 23. USACE develops a list of requirements and restrictions (e.g., maximum rise criteria demonstrated through hydraulic modeling), which append the permit. CVFPB may also develop a list of requirements and restrictions for the permit and either issue the permit with requirements and restrictions or deny the permit based on their collaborative review with USACE.

3.1.2.2 California Department of Fish and Game (California Code of Regulations Sections 1601–1603 – Streambed Alteration)

The California Department of Fish and Game (CDFG) is responsible for, among other things, preserving and protecting aquatic and marine habitats. Under Sections 1601–1603 of the California Fish and Game Code, agencies are required to notify CDFG prior to implementing a project that would substantially divert, obstruct, or change the natural flow of any river, stream, or lake. The project proponent must notify CDFG about any action that would substantially alter the channel or streambed or deposit material within the channel. The project proponent must submit a Notification of Lake or Streambed Alteration. If CDFG determines that the project may adversely affect an existing fish and wildlife resource, they will issue a Lake or Streambed Alteration Agreement that lists measures that adequately protect the resource.

3.1.2.3 Central Valley Flood Protection Act

DWR and CVFPB (which is part of DWR) are currently collaborating with local governments and planning agencies to prepare and adopt the Central Valley Flood Protection Plan (CVFPP) by mid-2012.
The objective of CVFPP is to create a system-wide approach to flood management and protection improvements in the Central Valley (Sacramento Valley and San Joaquin Valley).

The CVFPP is a requirement of the Central Valley Flood Protection Act of 2008, which establishes the 200-year flood event as the minimum level of flood protection in urban and urbanizing areas. Cities and counties must amend their general plans accordingly within 24 months of the CVFPP adoption; zoning ordinances must be amended within 36 months. Consequently, the 200-year flood event must be incorporated into city and county design standards by January 1, 2015 for new residential and nonresidential construction within flood hazard zones. By 2025, all urban areas protected by flood-control project levees must be protected from a 200-year flood event.

Under its FloodSAFE program, DWR is responsible for developing and making available maps for the 200-year floodplain (DWR 2008c). CVFPB collaborates with cities and counties to develop policies for implementing amended general plans.

3.1.3 Local Implementation of Federal and State Floodplain Programs

All of the cities and counties in the study area participate in the NFIP (refer to Section 3.1.1). Merced, Madera, and Fresno counties, and the cities of Merced and Fresno have adopted ordinances into their respective municipal codes that implement the community requirements for NFIP participation. In addition, Madera County flood-related ordinances address the cities of Madera and Chowchilla, and the Community of Le Grand. Table 3-2 summarizes local ordinances with minimum floor elevation, floodproofing, and floodway encroachment for new construction.

Table 3-2
Key Components of Local Flood Ordinances

City or County	Municipal Code Section	Minimum Elevation Residential	Minimum Elevation Nonresidential	Nonresidential Floodproofing	Encroachment into Floodways
Merced County	Chapter 18.34	Constructed above flood elevation	All construction below the flood elevation to be floodproofed	Allowed	Allowed only if no increase occurs in flood elevation
City of Merced	Chapter 17.48	Constructed above flood elevation	Constructed above flood elevation	Allowed	Allowed only if no increase occurs in flood elevation
Madera County	Title 14, Chapter IV	Constructed above flood elevation	Constructed above flood elevation	Allowed	Allowed only if no increase occurs in flood elevation
City of Madera	See Merced County				
Fresno County	Chapter 15.48	Constructed 12 inches above flood elevation	Constructed 6 inches above flood elevation	Allowed	Allowed only if no increase occurs in flood elevation
City of Fresno	Chapter 11.6	Constructed 6 inches above flood elevation	Constructed 6 inches above flood elevation	Allowed	Allowed only if no increase occurs in flood elevation

In general, the finished floor elevation for nonresidential structures must be at or above the BFE. However, the finished floor can be constructed below flood elevation if it is floodproofed. Floodproofing is generally achieved if the structure is watertight, with walls substantially impermeable to the passage of water. In addition, the structural components must be capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

As indicated in the previous section, DWR will require local ordinances to reflect a higher standard than required by FEMA, effectively requiring local implementation of floodplain regulations for the 200-year base flood rather than the 100-year base flood required by FEMA.

3.1.4 Location Hydraulic Studies

Chapter 804 of the *Highway Design Manual* (Caltrans 2009) addresses the topic of floodplains; Section 804.7.2.e states that the results of *location hydraulic studies* must be summarized in the environmental document prepared for the project. A location hydraulic study is the preliminary investigation of the degree of floodplain encroachment by a project (Caltrans 2009). The study must address the following:

- Flood risks associated with the project.
- Impacts on natural and beneficial floodplain values.
- Identification of probable incompatible floodplain development.
- Measures to minimize floodplain impacts.
- Measures to restore and preserve the natural and beneficial values affected by the project.
- Evaluation of the practicality of alternatives to significant floodplain encroachment.

A significant floodplain encroachment is determined by one or more of the following:

- A significant potential for interruption or termination of a transportation facility that is an emergency vehicle route or a community's only evacuation route.
- A significant risk to life or property.
- A significant adverse impact on the natural and beneficial floodplain values.

Section 804.7 of the *Highway Design Manual* states that the location hydraulic studies can be documented in a floodplain evaluation report attached to the project's environmental documentation. The timing of location hydraulic studies may depend in part on whether a state highway is being modified under Caltrans jurisdiction. Caltrans is not a direct reviewing agency for this project; however, the California High-Speed Rail Authority (Authority) has generally agreed to comply with Caltrans requirements and templates, when practical.

3.2 Hydraulic Basis of Design for Waterbody and Floodplain Crossings

3.2.1 General

The hydraulic basis of design can be broadly divided into the following categories; other regulations and categories may also apply:

- Design flow.
- Flood capacity.
- Flood control structures.
- Scour control.
- Borrow and excavation.
- Pipelines, conduits, and utility lines.
- Access.
- Seasonal construction restrictions.
- Other studies.

Various agencies have regulatory responsibility to check that the HST design adequately satisfies design requirements in these areas. Table 3-3 summarizes selected design requirements and Figure 3-1 illustrates the requirements. The following sections explain design requirements more fully.

Table 3-3
Summary of Selected Hydraulic Design Requirements

No.	Design Consideration	USACE	CVFPB	Local Floodplain Ordinances (FEMA)	DWR Urban Areas	Irrigation Districts	Authority
1	Minimum design flow rate (basis)	Project	Project	100-year	200-year	Design	Design
2	Minimum residual freeboard	3.0	3.0	--	--	1.0 to 1.5	--
3	Minimum clearance above embankment	Not Settled, see Note 1.[1]	--	--	--	16+	--
4	Minimum setback from embankment toe	10 to 20 but see Note 2.	10+	--	--	Right-of-way	15
5	Minimum clearance above bottom of channel	--	--	--	--	8	--
6	Maximum flood water surface rise	0.1	0.1	1.0	1.0	--	--
7	Minimum crossing turnaround width	Not known	Not known	--	--	30	--
8	Detour distance requiring through access	Not known	Not known	--	--	2 miles	Not known
9	Flood season construction restrictions	--	Yes	--	--	Yes	--
10	Geotechnical studies	Maybe	Maybe	Maybe	--	Maybe	Maybe

Notes:

1. The USACE originally indicated that 18 feet of clearance would be required above federal project levees. More recently, they have suggested that zero clearance (to eliminate all maintenance needs) or around 6 feet of clearance (to allow human access during inspection and maintenance) may be adequate in some situations (USACE 2011). Final requirements remain unresolved, and subject to negotiation between USACE, the CVFPB, the local levee maintenance agency and design consultants.

2. However, the USACE and CVFPB recently suggested that it may be preferable to armor the crossed section of levee or replace it with a concrete abutment and completely fill in behind the levee to form a solid, armored levee abutment. This is not settled, and remains subject to negotiation and final determination (USACE 2011).

3. All elevations are in feet except where indicated.

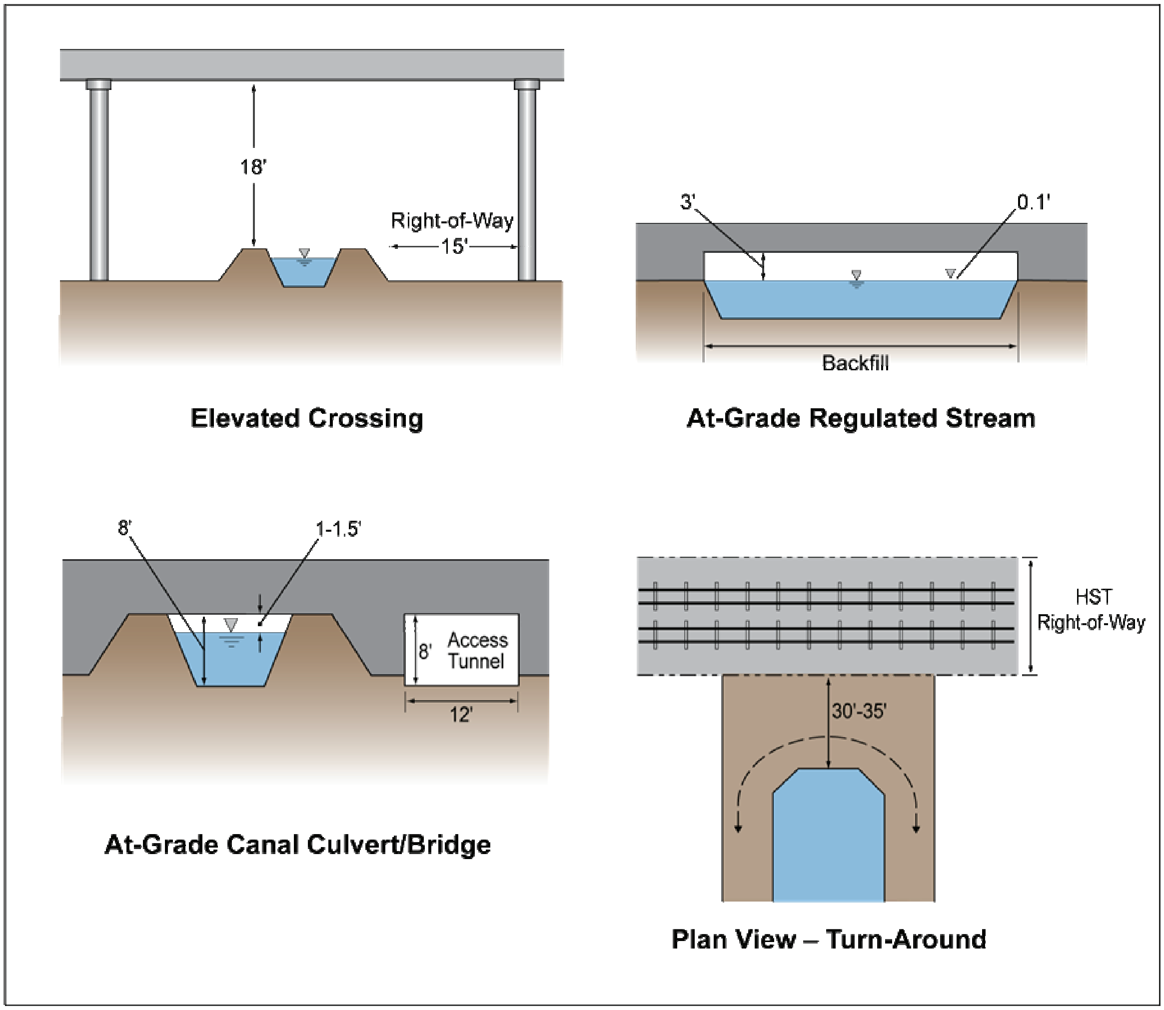


Figure 3-1
Representative Minimum Design Dimensions at Crossings
(Clearance Requirements at Elevated Crossings are Under Negotiation and May be Reduced.)

Title 23 (Waters), Volume 32 of the CCR provides CVFPB regulations and detailed lists of standards that must be met for an Encroachment Permit to build within the boundaries of an *adopted plan of flood control*. Title 23 defines an *adopted plan of flood control* as a flood control or reclamation strategy for a specific area that has been adopted by CVFPB or the California Legislature. The term typically applies to the area between adopted flood boundaries, such as a designated floodway, the channel and floodplain inundation area for a non-leveed state–federal flood control project, or the area between the outer boundaries of state–federal flood-control project levees. Title 23 includes a list of regulated waterbodies and regulatory requirements. Adopted plans of flood control are intended to comply with state–federal flood control project operation and maintenance (O&M) manuals, when relevant. USACE (at the district level) reviews Encroachment Permits to monitor conformance with 33 CFR Section 208.10.

It should be noted that CVFPB recently proposed a more comprehensive interpretation, in which the Title 23 list of regulated waterbodies should be viewed as incomplete, and that all named tributaries of the San Joaquin River should be treated as regulated and jurisdictional, thus requiring Encroachment Permits for encroachments/crossings (Taras, C. and Tice J., 2011). This inclusion of all named tributaries as jurisdictional crossings is based on the California Water Code Section 8710. This expanded list of jurisdictional crossings is a recent change to previous direction, and has not been fully formalized in writing by the CVFPB. At this time, the final interpretation of which crossings require an Encroachment Permit is not known, and is not fully incorporated in this version of the Technical Report.

This section provides a sample of Title 23 requirements. Title 23 should be reviewed for the full list of requirements. In some cases, variances to the design standards may be granted for good cause.

Floodplain design requirements are intended to prevent the following outcomes (Title 23, Section 15):

- Directly or indirectly jeopardize the physical integrity of levees or other works.
- Obstruct, divert, redirect, or raise the surface level of design floods or flows, or the lesser flows for which protection is provided.
- Cause significant adverse changes in water velocity or flow regime.
- Impair the inspection of floodways or project works.
- Interfere with the maintenance of floodways or project works.
- Interfere with the ability to engage in flood fighting, patrolling, or other flood emergency activities.
- Increase the damaging effects of flood flows.
- Be injurious to or interfere with the successful execution, functioning, or operation of adopted plans of flood control.

3.2.2 Design Flow

If an adopted plan of flood control includes a state–federal flood control project with a levee, USACE jurisdictional requirements will also apply (refer to Sections 3.1.1.1 and 3.1.2.1 for the overlapping jurisdictions and coordinated application of Section 408 permits, Section 208.10, and Title 23). The minimum required design flow depends on the type of crossing and the regulation under consideration. When more than one regulatory or project flow rate pertains, the largest design flow rate for the crossing should be used. Section 6, Tables 6-3 through 6-5 list applicable design flow rates for each crossing. The categories of flow rates that require consideration include the following:

- **State–federal flood control project authorized flow rate** – This flow rate is project specific and fixed by the original authorizing legislation. This authorized project flow rate can have any return period, although it is typically based on the calculated 100-year flow rate at the time the project is authorized. Alternative or updated calculations of the 100-year flow rate, such as those by FEMA, do not alter the state–federal flood control project authorized flow rate.
- However, recent communication by the CVFPB has suggested that, regardless of what the official project flow rate is, original hydrology should be developed to establish a new design flow rate consistent with current and projected future hydrologic conditions (Taras, C. 2011). In general, legislated project flow rates are 40 or more years old.
- **FEMA base flood** – The FEMA base flood is the peak 100-year flow rate. This 100-year flow rate can change over time as the watershed is developed, additional hydrologic information becomes available, and hydrologic models are updated. When available, the approved base flood flow rate is defined in the most recent FIS; however, on smaller or rural waterways, the base flood flow rate may not have been determined previously.
- **200-year base flood** – Beginning in 2015, DWR will require municipal floodplain ordinances for urban and urbanizing areas (refer to Sections 3.1.2 and 4.1.2) to manage to the 200-year base flood, rather than the current, standard FEMA base flood. Urban and urbanizing areas in the Merced to

Fresno Section that exceed a population of 10,000 include Atwater, Merced, Chowchilla, Madera, and Fresno in the Merced to Fresno Section.

- **Irrigation district design flows** – Irrigation canals and natural waterways between Merced and Fresno typically convey irrigation water and municipal stormwater pumped from detention basins. The natural waterways also transport watershed runoff and floodwater from upstream impoundments. Frequent diversions and interconnections complicate tracking of the source of these waters. In most cases, irrigation districts can refuse to accept stormwater in their system of canals and ditches after those features reach their design capacity. Therefore, the listed design flows for the irrigation channels are adequate for normal peak operations and flood conditions.

- **Authority project minimum design flood** – The Authority would select minimum design flood freeboard and return-period objectives for natural waterway crossings based on goals to protect the high-value HST facilities from flood-induced closures, delays or damage. *Hydraulics and Hydrology Design Guidelines* (Parsons Brinkerhoff 2010) summarizes current project design standards.

- **Design flow** – The highest applicable flow rate from this bullet list, determined on a case-by-case basis for each waterbody crossing.

3.2.3 Flood Capacity

The minimum flood capacity at waterbody crossings must accommodate the design flow while maintaining the required freeboard and not exceeding maximum rise criteria for the water surface elevation (WSE). The specific hydraulic criteria depend on the crossing classification and the regulation under consideration. Section 6, Tables 6-6, 6-7, and 6-8 list applicable waterway classifications for each crossing. When more than one set of regulatory criteria applies, the most stringent criteria should be used for design. Flood capacity classifications and criteria for design include the following:

- **State–federal flood control project** – When crossing any part of a state–federal flood control project or regulated stream, CVFPB, under Title 23 CCR, generally requires 3 feet of residual freeboard above the project design WSE to the low chord on the bridge. This clearance is intended to allow floating debris to pass without forming a debris dam. USACE requires that flow restrictions from the encroachment of piers, culverts, abutments or other project elements cause no more than a 0.1-foot rise in the project flood water-surface elevation at any location. Exceptions to these requirements would likely require a Section 408 permit (refer to Section 3.1.1.1).

- **Floodplain boundaries** – The floodplain is identified by mapping the inundation boundaries for the design flood flow. CVFPB, USACE, FEMA, DWR and other parties mapped the boundaries by using best-available information, which may or may not include mapped WSEs. Hydraulic modeling is generally required to determine WSEs and resulting areas of inundation.

- **Designated floodway versus regulated stream** – In the case of a CVFPB-designated floodway, the project flood elevation is determined by hydraulic modeling, and the inundation limits are defined on flood encroachment maps (refer to Figures 4-1 and 4-2). In the case of regulated streams without a designated floodway, there is no specific WSE established, and the project WSE is assumed to be at or below the top of the channel (no floodplain flow). Modeling is required to demonstrate an elevation lower than the top of the bank.

- **FEMA regulatory floodplain** – The FEMA regulatory floodplain is defined by the inundation limits of the base flood (100-year flood). It is similar in concept to the CVFPB-designated floodway, but it is based on FEMA's accepted estimate of the current 100-year flood, which may differ from the project floods legislated for CVFPB flood control projects. Section 4 provides the width of the FEMA regulatory floodplains for the UPRR/SR 99, BNSF, and Hybrid alignments, respectively (refer to Tables 4-1, 4-2, and 4-3); Figures 4-1 and 4-2 show each crossing.

- **FEMA base flood WSE** – FEMA requires restricting floodplain encroachments such that they do not cause more than a 1-foot rise in the BFE over existing conditions at any location. Counties and cities administer the FEMA floodplain management program through local floodplain ordinances. In some cases, a local floodplain ordinance to obtain a local building permit may be more restrictive than required by FEMA; however, for floodplains in the Merced to Fresno Section, local floodplain ordinances are consistent with the FEMA 1-foot-rise criteria.

- **FEMA base flood WSE determination** – At most locations in the study area, the elevation of the FEMA base flood has not been established and should be determined through hydraulic modeling. Hydraulic modeling is also required to demonstrate that the maximum 1-foot-rise criterion has been satisfied. Section 6 provides the status of the FEMA regulatory floodplain for each crossing (refer to Tables 6-3 through 6-5).

- **200-year floodplain** – As previously indicated, the 200-year floodplain will replace the FEMA 100-year floodplain as the regulatory standard by 2015 in urbanizing areas. The 200-year floodplain has been mapped under the direction of DWR and is shown on Figures 4-1 and 4-2. Section 4 provides the width of the 200-year floodplains (refer to Tables 4-1, 4-2, and 4-3).

- **FEMA floodway** – The FEMA floodway is different from a CVFPB designated floodway. As previously stated, the CVFPB floodway is the entire area inundated by the project flood. In contrast, the FEMA floodway is that portion of the FEMA regulatory floodplain that must generally remain free from encroachment to prevent exceedance of the 1-foot-rise criterion if the remaining portions of the floodplain are encroached on.[1] FEMA floodways are not delineated for most waterways, but when present, they provide a potential guide for allowable encroachment in the absence of modeling or more stringent restrictions. Appendix A includes the width of the FEMA floodway for locations that have been modeled for FEMA.

- **Irrigation canals and non-regulated streams** – Irrigation districts along the alignment require between 1 and 1.5 feet of freeboard for bridges or culverts above open channels. If baffles for a box culvert, piers for a bridge, or headworks for a pipe cause a rise in the canal WSE, a minimum of 1 foot of freeboard should be provided along the length of the canal. In addition, a minimum of 8 feet of vertical clearance is required from the bottom of the canal to allow for maintenance access. The section of canal that passes under the HST right-of-way should be concrete-lined to minimize maintenance requirements.

- **Piped conveyance** – Irrigation conveyance should be piped under the HST right-of-way for smaller design flows (typically less than 100 cubic feet per second [cfs]) and in a trapezoidal open canal when flows are larger. The exact design flow cutoff for piped conveyance should be discussed with the irrigation districts for each crossing. Based on preliminary discussions with the irrigation districts, they generally consider the minimum practical pipe size for inspection and maintenance to be 42 inches, and they generally prefer a minimum pipe size of 48 inches where a pipe would pass under the HST alignment and surface access for pipe replacement would be limited. Where surface access may be retained and irrigation ditches are relatively small (for example, where the permanent project footprint provides a new access road to a farmer's field and the new access road crosses a small irrigation ditch), culverts smaller than 42 inches may suffice. Also, a siphon pipe beneath the track could potentially be downsized if design velocities would result in excessive sediment deposition within the pipe.

- **Title 23 bridges** – Some sample regulations from Title 23 that pertain to bridges include the following:

[1] Note, however, that no rise in base flood elevation is permitted if a development encroaches within the floodway itself. This is to prevent the accumulated effect of multiple projects from eventually resulting in more than a 1-foot rise in the base flood.

  - Bridge piers and bents within the floodway must be constructed parallel to the direction of streamflow, and if widening a portion of an existing bridge, constructed in line with existing bents and piers.
  - Drainage from a bridge may not be discharged onto a levee section or streambank.
  - All construction facilities (such as temporary staging, cofferdams, and falsework) must be designed to prevent bank erosion during normal flows and to maintain maximum channel capacity during the flood season. If construction facilities remain in a floodway during flood season, plans must be submitted to CVFPB for approval prior to installation.
- The bottom members (soffit) of a proposed bridge must be at least 3 feet above the design flood WSE:
  - The required clearance may be reduced to 2 feet on minor streams at sites where significant amounts of stream debris are unlikely.
  - When an existing bridge is widened that does not meet the clearance requirement above the design flood WSE, the bottom structural members of the added section may be no lower than the bottom structural members of the existing bridge, except as may be caused by the extension of existing sloped structural members.
  - When the clearance requirement above the design flood WSE would result in bridge approach-ramp fill in the floodway, the clearance requirement may be reduced to the extent that reasonably balances clearance and fill that would obstruct flow, to maintain maximum channel capacity.
  - Replacement railroad bridges (i.e., existing UPRR and BNSF bridges) must have soffit members that are no lower than those of the replaced bridge, but are not required to have a specified amount of clearance above the design flood WSE.
  - Bridge replacements and new bridges shall be built at an elevation so that there is no depression in the crown of the levee.
- The standards for maintenance of bridges within an adopted plan of flood control are as follows:
  - The area in and around a bridge site must be kept clear to maintain the design flow capacity.
  - Trees, brush, sediment, and other debris must be kept cleared from the bridge site and be disposed of outside the limits of the floodway prior to the flood season.
  - Any accumulation of debris during high flows must be immediately removed from a bridge site and disposed of outside the floodway.
  - Access must be provided for these activities.

3.2.4 Flood Control Structures

When crossing an existing flood control structure, such as a levee, there are minimum requirements for vertical clearance, horizontal setback, and access. The specific requirements depend on whether the structure is part of a state–federal flood control project (i.e., a project levee) or part of a local or irrigation improvement, such as a canal embankment (i.e., a nonproject levee). Appendix A identifies crossings over project and nonproject levees. The only project levee crossed by the HST alternatives is the Owens Creek Diversion Canal (Waterbody Crossings #1126 and #1156 under the BNSF Alternative; refer to Figure 5-1). Clearance requirements for crossings at structures include the following:

- **State-federal flood control project structures** – If a bridge spans a state–federal flood control project structure, such as a levee, USACE originally stated that they require a minimum 18-foot clearance above the levee to provide access for emergency and maintenance equipment. After investigating further, and discussing challenges by the CVFPB, the USACE has determined that the 18-foot clearance requirement pertained to powerlines and that a lower clearance may be negotiated in some cases. Final requirements remain under discussion and subject to ongoing negotiations (USACE 2011). Piers or abutments must be set back a minimum of 10 feet from the outer levee toe and up to 20 feet in some cases (Title 23). A 15-foot setback is recommended in most cases so that clearance requirements are adequately satisfied. Recently, the USACE clarified that instead of a setback, the levee could be hardened or replaced to minimize maintenance concerns, and the area completely filled in behind the hardened levee section (USACE 2011). Exceptions to these requirements would likely require a Section 408 permit (refer to Section 3.1.1.1). The HST project design intends to minimize impacts on flood control projects and thereby allow permitting under Section 208.10 (i.e., CVFBP Encroachment Permit) without a Section 408 permit.

- **Nonproject levees** – CVFPB does not have a minimum clearance requirement above levees; therefore, the minimum clearance above nonproject levees is generally 3 feet above the design WSE, with the caveats that (1) the bridge soffit must be high enough to avoid depression of the levee crown (refer to Section 3.2.3) and (2) local levee maintenance agency requirements for maintenance access are satisfied. Clearance requirements at each crossing should be evaluated, with input from local levee maintenance agencies and adjacent landowners. Because a clearance requirement for operation o maintenance equipment is typically only practical where the HST guideway is elevated, there is an alternative at-grade approach (refer to the last bullet below).

- **Irrigation canals and nonregulated streams** – Irrigation districts along the alignment have variously indicated that they require between 1 and 1.5 feet of clearance for bridges or culverts above open channels. Where there are levee-like channel embankments at an open-channel crossing, the irrigation districts prefer that piers be set back to the legal right-of-way beyond the outer embankment toe. This distance varies by irrigation district and location. For elevated crossings, vertical clearance of the canal embankment generally should be treated as a nonproject levee and exceed 16 feet.

- **At-grade approach to nonproject levees and canals** – As an alternative to spanning the levee with full clearance, which is typically practical only if the HST is already elevated, a spanned section of a nonproject levee may be replaced with a low-maintenance, at-grade structure, such as a concrete box culvert or concrete bridge abutment. Integration of the existing levee embankment and engineered structural crossing should be properly designed to prevent levee failure or maintenance issues and satisfy requirements of the local levee maintenance agency. This is generally not an option for State-federal flood control project levees, which require a Section 408 permit.

The preliminary list of requirements is under consideration by the irrigation districts.

3.2.5 Scour Control

Erosion control may be required on the channel banks or levee slopes upstream and downstream from a proposed bridge to stabilize channel banks and bridge piers. Scour requirements defined in Title 23 include the following:

- Quarry stone, cobblestone, or their equivalent may be used for erosion control along rivers and streams if the materials meet the gradations specified in Table 3-4. Channel protection must include natural measures such as vegetation plantings.

- Bedding materials must be placed under the stone erosion control materials at locations where the underlying soils require stabilization because of streamflow velocity.

- Cobblestone protection must be placed on prepared slopes of 3 feet horizontal to 1 foot vertical (H:V) and may be used where streamflow velocities 10 feet from the bank do not exceed 8 feet per second.

- Quarry stone protection must be placed on prepared slopes steeper than 3H:1V and may be used where streamflow velocities 10 feet from the bank do not exceed 12 feet per second.

- Where streamflow velocities 10 feet from the bank exceed 12 feet per second, special cobble or quarry stone gradation is required. Flow-retarding structures, such as retards, wing dams, and rock groins may be permitted at these sites. CVFPB may permit the use of alternative bank protection materials. Possible alternatives include but are not limited to sacked concrete; broken concrete free of projecting steel, reinforced concrete, precast concrete jibbing, and stone-filled gabion baskets.

Broken concrete used for levee revetment may be no larger than 16 inches in its maximum dimension.

- Asphalt or other petroleum-based products may not be used for fill or erosion control on a levee section or within a floodway.
- Graded cobblestone and quarry stone must be placed in a way that avoids segregation.
- The minimum thickness of revetment is 18 inches perpendicular to the bank or levee slope below the usual water surface and 12 inches above the usual surface.

Table 3-4
Required Gradations of Cobblestones and Quarry Stones for Erosion Control

Cobblestone		Quarry Stone	
Stone Size (inches)	**Percent Passing**	**Stone Size (inches)**	**Percent Passing**
15	100	15	100
10	55 to 95	10	80 to 95
8	35 to 65	8	45 to 80
6	10 to 35	6	15 to 45
3	1 to 5	3	0 to 15

Stabilization of channel banks with stone alone may not be acceptable to CDFG and should be complimented with native riparian plantings or other natural stabilization alternatives that restore and maintain a more natural riparian corridor, where acceptable. However, as indicated in Section 3.2.3, Title 23 requires that “the area in and around a bridge site must be kept clear to maintain the design flow capacity. Trees, brush, sediment, and other debris must be kept cleared from the bridge site.” In addition, where project levees abut bridges, large woody vegetation (e.g., trees) is generally prohibited under USACE guidelines because it could be a potential levee failure mechanism and a hindrance to levee inspection and maintenance.

3.2.6 Borrow and Excavation

Regulations restricting borrow and excavation activities defined in Title 23 include the following:

- Storage of borrow material is not permitted on a levee section, within 10 feet of a levee toe, or within 30 feet of the top bank of a river.
- Excavation is not permitted within 100 feet of a levee toe or property line within the floodway, within 50 feet of the toe of any spur levee (a levee that protrudes into the floodway to direct the flow of floodwater), or within a leveed floodway where there is active erosion unless an engineering study demonstrates that the borrow will not exacerbate the erosion.
- The side slopes of a borrow area may not exceed 3H:1V.
- If connected to a low-water channel, a borrow area must transition smoothly at the upstream and downstream ends and drain smoothly toward the channel.
- The bottom elevation of any berm excavation may not be lower than the adjacent channel bottom without adequate setback from the channel (typically 500 feet).

- Any proposed borrow operation within 1 mile of a state highway bridge must be approved by Caltrans.
- A geotechnical investigation is required before initiating any borrow activity within a leveed floodway. The investigation must determine if the proposed borrow activity would increase seepage beneath levees, or expose soils susceptible to erosion.
- Any excavation within the levee section or near bridge supports within the floodway must be backfilled in 4- to 6-inch layers with approved material. Levee sections must be compacted to a relative compaction of not less than 90% in accordance with American Society of Testing and Materials (ASTM) D1557-91, dated 1991, and above optimum moisture content. Compaction within the floodway must be to the density of the adjacent undisturbed material. Compaction tests by a certified soils laboratory may be required to verify compaction.
- Waivers may be granted for borrow and excavation activities if supported by detailed studies that justify the waiver.

3.2.7 Pipelines, Conduits, and Utility Lines

Title 23 defines regulations governing linear conduit features, especially where they penetrate a project levee, and include the following:

3.2.7.1 General

- Appurtenant structures are generally not permitted within 10 feet of the levee toes to prevent interference with levee maintenance or flood fighting activities.
- Appropriate, visible markers acceptable to the local maintaining agency may be required to identify the location of buried pipelines, conduits, and utility lines.
- Buried high-voltage lines of greater than 24 volts are required to be protected with Schedule 40 PVC conduit or equivalent.
- Overhead electrical and communication lines must have a minimum vertical clearance above the levee crown and access ramps of 21 feet for lines carrying 750 volts or less, and 25 feet for lines carrying higher voltage.
- Low-voltage electrical or communication lines of 24 volts or less may be installed parallel to a levee and within 10 feet of the levee toe when it is demonstrated to be necessary and to not interfere with the integrity of levee, levee maintenance, inspection, or flood fighting activities.

3.2.7.2 Within the Floodway

- A minimum cover of 5 feet beneath the low-water channel and a minimum of 2 feet in the remaining area of the floodway are required. A thicker cover may be required, depending on channel hydraulics.
- Open-trench backfill using suitable material compacted to the density of adjacent undisturbed material is required. Compaction tests by a certified soils laboratory may be required.
- All debris that accumulates around utility poles and guy wires within the floodway must be completely removed after the flood season and immediately after major accumulations.

3.2.7.3 Through a Levee

- Pipelines, conduits, and utility lines must be installed through a levee as nearly at a right angle to the levee centerline as practical, and must have a location marker on the levee slope adjacent to either shoulder. Buried pipelines, conduits, and utility lines that do not surface near the levee toes must have location markers near both levee toes.

- The minimum cover for pipelines, conduits, and utility lines installed through the levee crown is 24 inches, or a concrete or other engineered cover is required. The minimum cover within the levee slope is 12 inches.
- When practical, pipelines, conduits, and utility lines installed within a levee section must be separated from parallel pipelines, conduits, and utility lines by a minimum of 12 inches, or the diameter of the largest pipeline, conduit, or utility line, whichever is larger, to a maximum of 36 inches.
- A siphon breaker with a protective housing may be required and must be installed off the levee crown roadway.
- Electrical and communication lines installed through a levee or within 10 feet of a levee toe must be encased in Schedule 40 polyvinylchloride (PVC) conduit or equivalent. Low-voltage lines (24 volts or less) and fiber optic cables may be allowed without conduit if properly labeled.
- A standard reinforced concrete U-wall for levee erosion protection is required at the outlet end of a pipeline or conduit discharging within 10 feet of a levee toe (Title 23 provides design figures).
- Excavations within the levee or within 10 feet of levee toes for the installation of a pipeline, conduit, or utility line must be backfilled in 4- to 6-inch layers with approved material and compacted to a relative compaction of not less than 90% in accordance with ASTM D1557-91, dated 1991, and above optimum moisture content; or 97% in accordance with ASTM D698-91, dated 1991. Compaction tests by a certified soils laboratory will be required to verify compaction of backfill within a levee.
- Boring a pipeline or conduit through a levee is permitted if certain conditions are met.
- Pipelines open to the waterway must be a minimum of 30 inches in diameter, and must have a readily accessible positive closure device installed on the waterward side.
- Seepage along pipelines, conduits, and utility lines must be prevented by encasement in reinforced concrete cast against firm undisturbed earth, or the conduit must have reinforced concrete battered walls at an inclination of 1H:4V or flatter.

3.2.7.4 Trenching

- The side slopes of trenches excavated for the installation of pipelines, conduit, or utility lines may be no steeper than 1H:1V; except vertical side slopes may be allowed for shallow (12-inch) installations above the floodplain and that portion of the trench above the design freeboard.
- The bottom width must be 2 feet wider than the diameter of the pipeline or conduit, or 2 times the pipe diameter, whichever is greater.
- When practical, pipelines, conduits, and utility lines must have a minimum vertical spacing of 6 inches when crossing other pipelines, conduits, or utility lines.

3.2.7.5 Jacking

Pipelines, conduits, and utility lines may be installed under a levee or stream channel by tunneling, jacking, or boring, if the following conditions are met:

- The pipeline, conduit, or utility line is at least 30 feet under the levee.
- The pipeline, conduit, or utility line is verified to have the required cover. A greater depth of cover may be required based on the feasibility of achieving the required cover or on local soil stability and channel hydraulics.

- The installation is more than 50 feet below the levee and the entire floodway and streambed; the CVFPB may waive the requirement for a permit if a letter of intent is filed with the CVFPB prior to commencement of the project.
- The portal and outlet of a tunnel, jacking, or boring must be a minimum of 10 feet beyond the projected levee slope without an approved stability and seepage analysis.
- Installation may occur during the flood season and when the WSE in the floodway is expected to be above the elevation of the landside levee toe if adequate containment cells are constructed at the portal and outlet.

3.2.7.6 Materials

The following pipe materials are allowed within a levee section when designed to resist all anticipated loading conditions and properly installed:

- Galvanized iron pipe is allowed if all joints are threaded. Galvanized iron pipe joints must be protected from corrosion by using PVC or polyethylene tape wrapped to a thickness of 30 mil or equivalent.
- Schedule 80 PVC pipe may be used if it is entirely buried, all joints are threaded, and the components have been continually protected from ultraviolet radiation damage or they are newly manufactured.
- Schedule 40 PVC or better may be used as a conduit for power or communication cables.
- High-density polyethylene (HDPE) pipe may be used for pipeline or conduit installations provided the following conditions are met:
  - HDPE pipe or conduit joints must be heat or electrofusion welded (ASTM Standards FI055-93, dated 1993, or D3261-93, dated 1993).
  - HDPE pipe and conduits must be designed to resist all anticipated loading conditions, and the design calculations must be submitted to CVFPB.
  - HDPE pipe and conduits must be protected from ultraviolet radiation.
- Cast-in-place reinforced concrete pipes and box culverts may be used above and below the design flood WSE if the concrete is at least 6 inches thick.
- Precast reinforced concrete pipes and box culverts and concrete cylinder pipes may be used above and below the design flood WSE if the following conditions are met:
  - Precast reinforced concrete pipe meets ASTM Specification C76-90, dated 1990.
  - Precast reinforced concrete pipe joints and precast box culvert joints are encased in reinforced concrete that is cast in place against firm undisturbed earth.
  - The cylinders of concrete cylinder pipes are welded and protected against corrosion internally and externally.
  - When installed below the design flood WSE, precast reinforced concrete pipe and concrete cylinder pipe must be encased below the springline in concrete cast against undisturbed earth.
- Steel pipe may be used for all types of pipeline or conduit installations through a levee above the design flood WSE if the pipe meets the following requirements:
  - The steel pipe is resilient and not materially reduced in quality because of weathering.
  - The steel pipe joints are butt-welded or threaded.
  - The steel pipe installations are corrosion-proofed externally with a coating of material such as coal-tar enamel, asphalt-dipped wrap, mortar, PVC tape, or polyethylene tape wrapped to a thickness of 30 mils, high-solids epoxy, or equivalent.

  - Steel pipe may convey only noncorrosive material unless it has a continuous internal lining of cement, mortar, or equivalent that is appropriate for the fluid to be conveyed. Water is considered corrosive.
  - Steel pipe installations must be designed to resist all anticipated loading conditions, and the design calculations must be submitted to CVFPB.
- Steel pipe meeting the following criteria may be used without submittal of design calculations to the CVFPB:
  - Ten-gauge steel pipe that is 12 inches in diameter or less.
  - Seven-gauge steel pipe that is between 12 to 30-inch-diameter.
  - Three-gauge steel pipe that is between 30 to 48 inches in diameter.

The following materials are not allowed for pipelines or conduits that carry fluids within a levee or within 10 feet of levee toes: aluminum pipe, cast iron pipe, pipe with flanges, flexible couplings, or other mechanical couplings or pre-stressed concrete.

3.2.8 Access

In general, natural waterways and irrigation channels are used for irrigation and flood conveyance. Access is required at every crossing to allow for maintenance, flood patrols, and convenient operations. The following sections discuss access requirements that should be considered in the design.

3.2.8.1 Levee and Channel Access

Vehicle access from the levee crown to the floodway and/or the landside levee toe beneath the bridge may be required. Ramps may slope upstream as necessary to provide the access. Title 23 provides guidelines for patrol roads and access ramps. Patrol roads provide vehicular access along levee crowns and flood channels for inspection, maintenance and flood fighting. Patrol roads must meet the following criteria:

- Patrol roads must be surfaced with a minimum of 4 inches of compacted, Class 2 aggregate base (Caltrans Spec. 26-I.02A, July 1992), or equivalent.
- Patrol road surface material must be compacted to a relative compaction of not less than 90% in accordance with ASTM 01557-91, dated 1991, with moisture content sufficient to achieve the required compaction.
- Compaction tests by a certified soils laboratory may be required to verify compaction.
- Ramps provide access to the levee crown from adjacent property and roads, either head-on or via a side approach:
  - Access ramps must be constructed of approved imported material.
  - Surfacing for access ramps must be the same as for patrol roads.
  - Excavations made in a levee section to key the ramp to the levee must be backfilled in 4- to 6-inch layers with approved material and compacted to a relative compaction of not less than 90% in accordance with ASTM 01557-91, and above optimum moisture content.
  - Compaction tests by a certified soils laboratory may be required to verify compaction.
  - All access ramps must direct surface drainage away from the levee section. Title 23 shows typical plans for each type of approach ramp, with restrictions and requirements.

3.2.8.2 Bi-directional Access

In general, access is required to both sides of the HST right-of-way and to both banks of waterways. Where the HST track abuts an adjacent linear right-of-way, such as the right-of-way for the UPRR and BNSF railways and SR 99, access need only be provided to the HST right-of-way without existing access.

3.2.8.3 Through Access

Where there is access on both sides of the HST right-of-way, USACE and the irrigation districts prefer access through the guideway embankment via a box culvert or similar tunnel. Preliminary minimum dimensions for the box culvert are 8 feet high and 12 feet wide to accommodate a standard large pickup truck used by ditch riders. The box culvert may be located at or beyond the landside levee toe if access ramps and right-of-way are provided. Through access may not be practical in all cases, but it is considered especially important where alternative access requires a detour of 2 miles or more.

3.2.8.4 TurnAround Access

In general, embankment crests provide insufficient room to turn around. Where there are raised embankments, narrow rights-of-way, or no through access on both sides of the waterway, the design should include cul-de-sacs on both sides of the waterbody crossing that extend approximately 30 to 35 feet beyond the HST right-of-way to allow the largest irrigation equipment to cross the waterway and return on the other side. Unless another waterway crossing is nearby and a properly sized cul-de-sac is provided for a dead-end turnaround, access across the waterway is required.

3.2.8.5 Maintenance Access

Table 3-3 and Figure 3-1 summarize the targets and requirements discussed in Section 3.2.4. The height of maintenance vehicles range from large backhoes that maintain a project levee during a flood to small bulldozers that clear debris from canals during the off-season.

3.2.9 Seasonal Construction Restrictions

CVFPB restricts construction within the floodplain of regulated streams during the flood season. The following list provides examples of restricted activities listed in Title 23:

- Excavation is not allowed within the floodplain or channel during the designated flood season without a waiver.
- Stockpiles of unsecured materials or equipment are not allowed within the floodway during the designated flood season.
- Pipelines, conduits, utility lines, utility poles, and appurtenant structures may not be installed within the levee section, within 10 feet of levee toes, or within the floodway during the flood season unless authorized by the general manager based on reservoir levels, stream levels, and forecasted weather conditions on a case-by-case basis.

There are two designated flood seasons: (1) November 1 to April 15 and (2) November 1 to July 15. Except for Mariposa Creek and the San Joaquin River, the flood season for regulated streams and designated floodways listed in Table 6-1 is from November 1 to April 15. The flood season for Mariposa Creek and the San Joaquin River is from November 1 to July 15.

Irrigation districts prohibit in-channel construction during the irrigation season, unless provision is made to maintain irrigation deliveries. The irrigation season varies with the weather and available storage, but generally begins in mid spring (April) and extends through mid fall (October).

Together, the flood season and the irrigation season span 12 months, and exceptions would be required. CVFPB accepts applications for exemptions to flood season construction restrictions. Irrigation districts determine exceptions to irrigation-related construction during non-work periods.

3.2.10 Other Studies

To issue encroachment permits, Section 408 permits, or building permits, agencies may require additional information, such as geotechnical explorations, soil testing, hydraulic or sediment transport studies, biological surveys, environmental surveys, and other analyses.

4.0 Floodplains

4.1 Flood Conditions in the Study Area

2012 Central Valley Flood Protection Plan – Regional Conditions Report (DWR 2010) provides a summary of the hydrologic system of the Central Valley. The FISs for Merced, Madera, and Fresno counties summarize flood problems. Anecdotal information from irrigation districts (Merced, Madera, Chowchilla, and Fresno Irrigation Districts) and cities also help identify local areas that are prone to flooding. The following subsections summarize flooding and major flood control features in the study area. Section 4.2 provides a summary of floodplains along the alternative alignments. Figures 4-1a through 4-1e show the floodplains crossed by the project. Figures 4-2a and 4-2b show floodplains near the Merced and Fresno HST station sites. Figures 4-3a through 4-3e show the floodplains near the potential sites for the HMF.

4.1.1 Major Streams in the Study Area

The study area is in the southern portion of the San Joaquin River basin. The basin extends from the Delta in the north to the northern boundary of the Tulare Lake Basin in the south, and from the crest of the Sierra Nevada Mountains in the east to the crest of the California Coastal Ranges in the west. The river basin encompasses about 13,500 square miles. The San Joaquin River basin includes large areas at high elevations along the western slope of the Sierra Nevada Mountains. As a result, significant snowmelt runoff feeds the river during late spring and early summer. Flood flows typically occur between April and June.

4.1.1.1 Merced County Stream Group

Streams in the Merced County Stream Group originate east and northeast of the City of Merced and includes Black Rascal Creek, Bear Creek, Cana Creek, Owens Creek and Mariposa Creek. A major flood control project authorized in the 1940s provided a diversion from Black Rascal Creek to Bear Creek, a diversion between Owens Creek and Mariposa Creek, and channel improvements and levees. Five small reservoirs east and northeast of Merced reduced flood risks to agricultural areas, the City of Merced, Le Grand, and other smaller communities.

4.1.1.2 Chowchilla River

The Chowchilla River originates in the Sierra Nevada Mountains and drains approximately 600 square miles. Because of the low elevation of the watershed, most of the flow in the Chowchilla River results from rainfall. Immediately east of the study area, the Chowchilla River forms three separate branches. From north to south, these branches are the Chowchilla River, Ash Slough, and Berenda Slough. The branches discharge into the San Joaquin River via the Eastside Bypass. The only regulating dam on the Chowchilla River is Buchanan Dam, which forms H.V. Eastman Lake 15 miles northeast of Chowchilla.

4.1.1.3 Fresno River

The Fresno River originates in the foothills of the Sierra Nevada Mountains and drains approximately 500 square miles. Similar to the Chowchilla River, most of the flow in the Fresno River results from rainfall. The Fresno River discharges into the Eastside Bypass. The only regulating dam on the Fresno River is Hidden Dam, which forms Hensley Lake about 15 miles northeast of Madera.

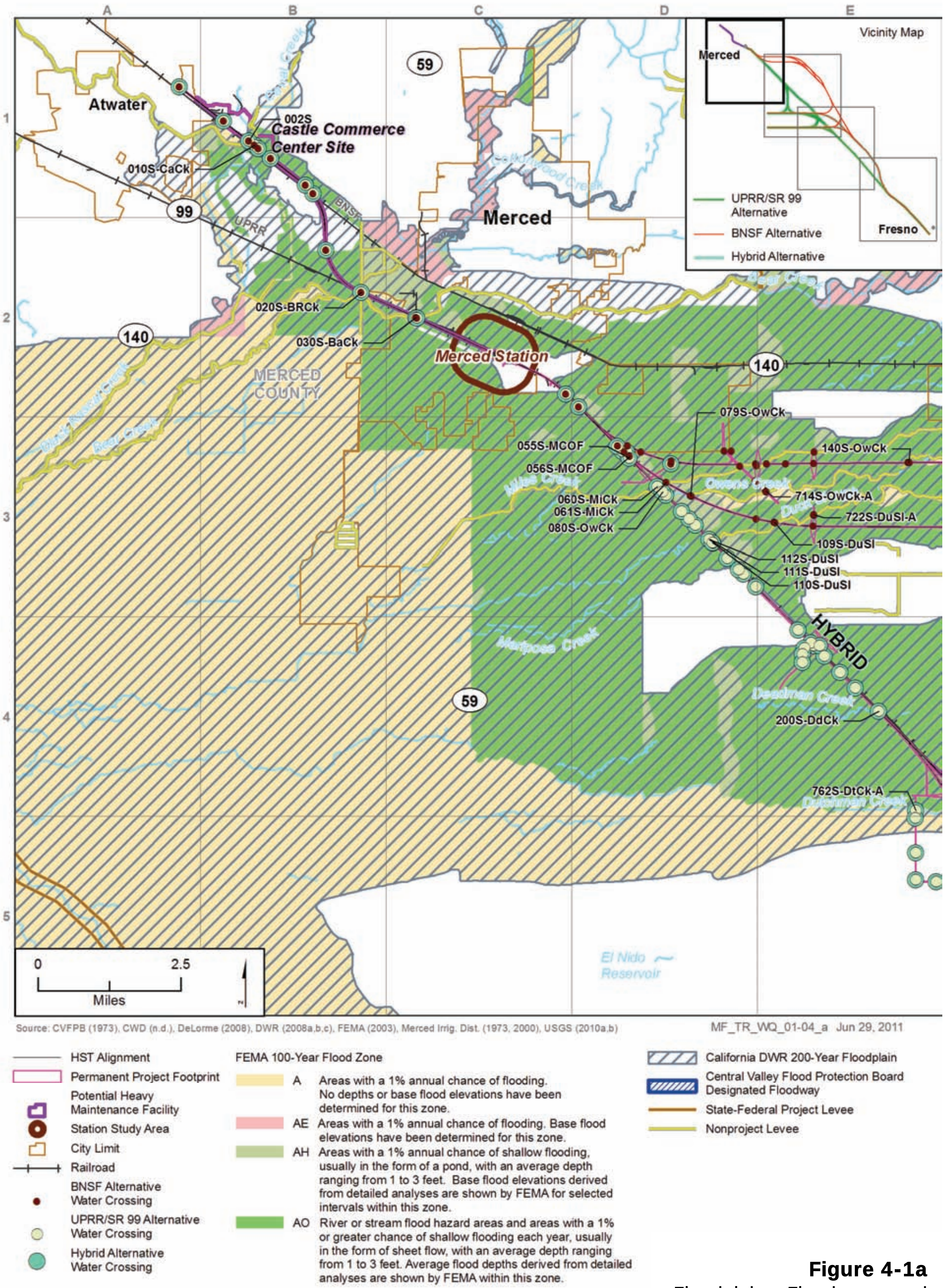


Figure 4-1a
Floodplains, Floodways, and Levees

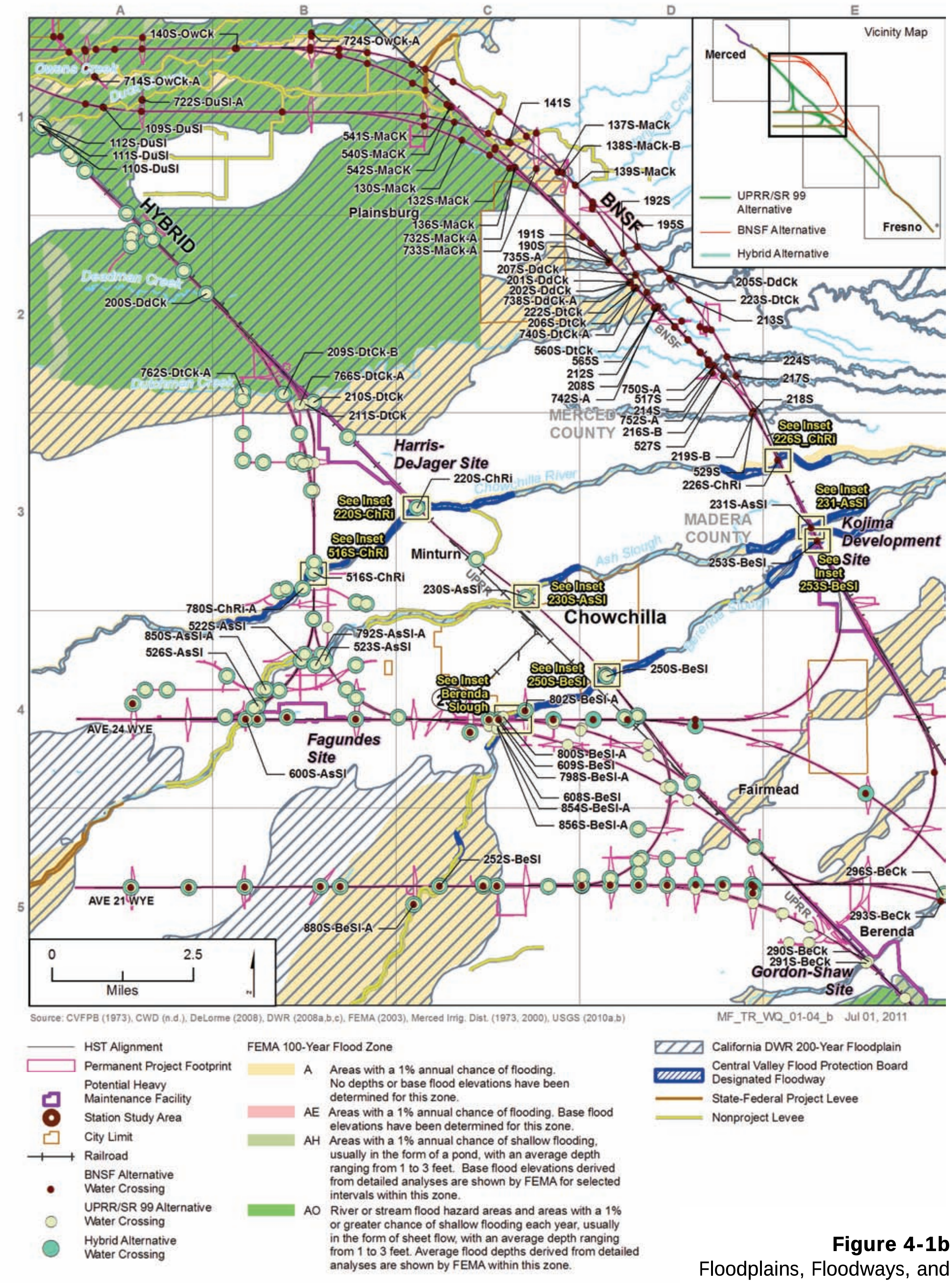


Figure 4-1b
Floodplains, Floodways, and Levees

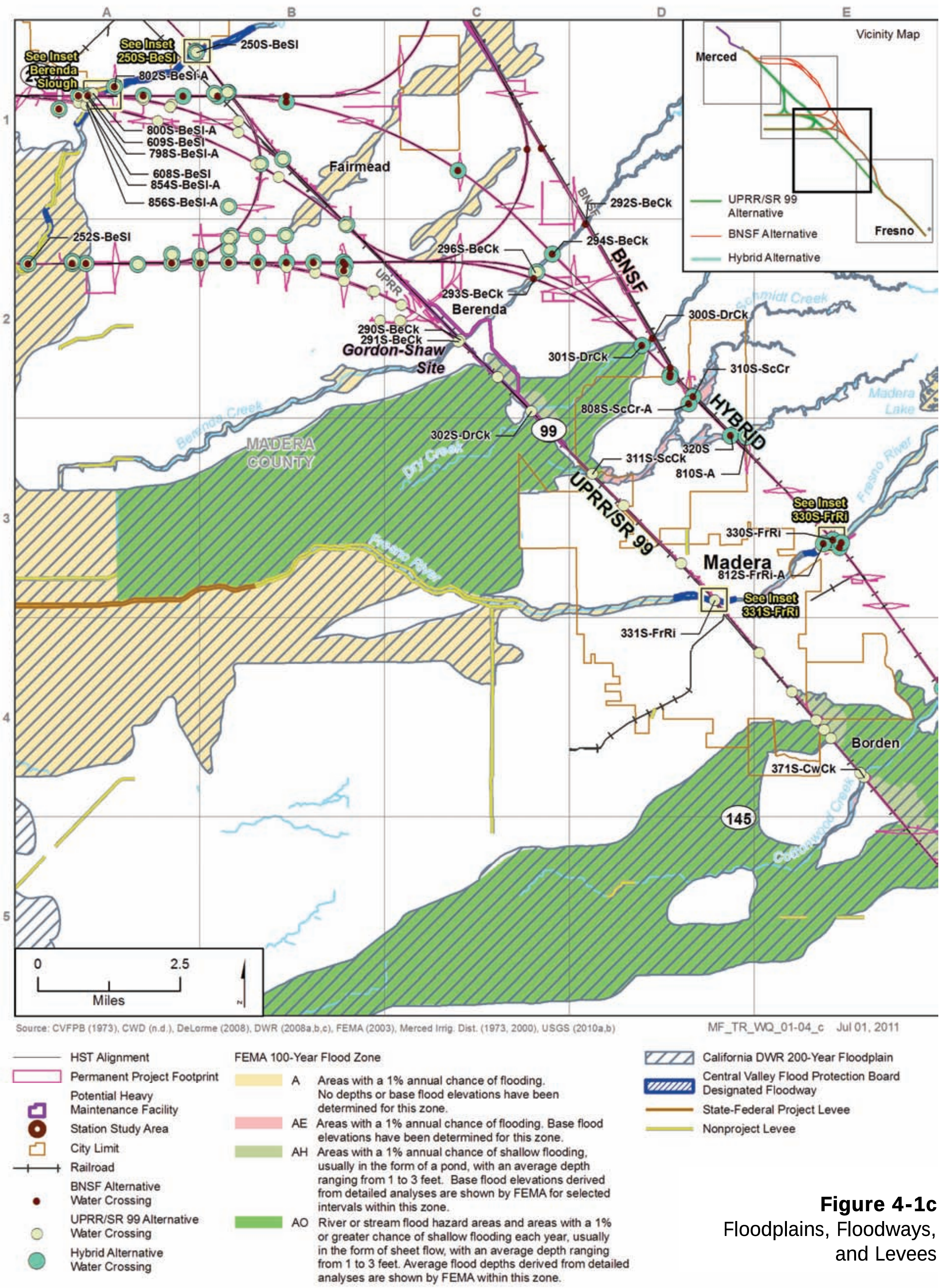


Figure 4-1c
Floodplains, Floodways, and Levees

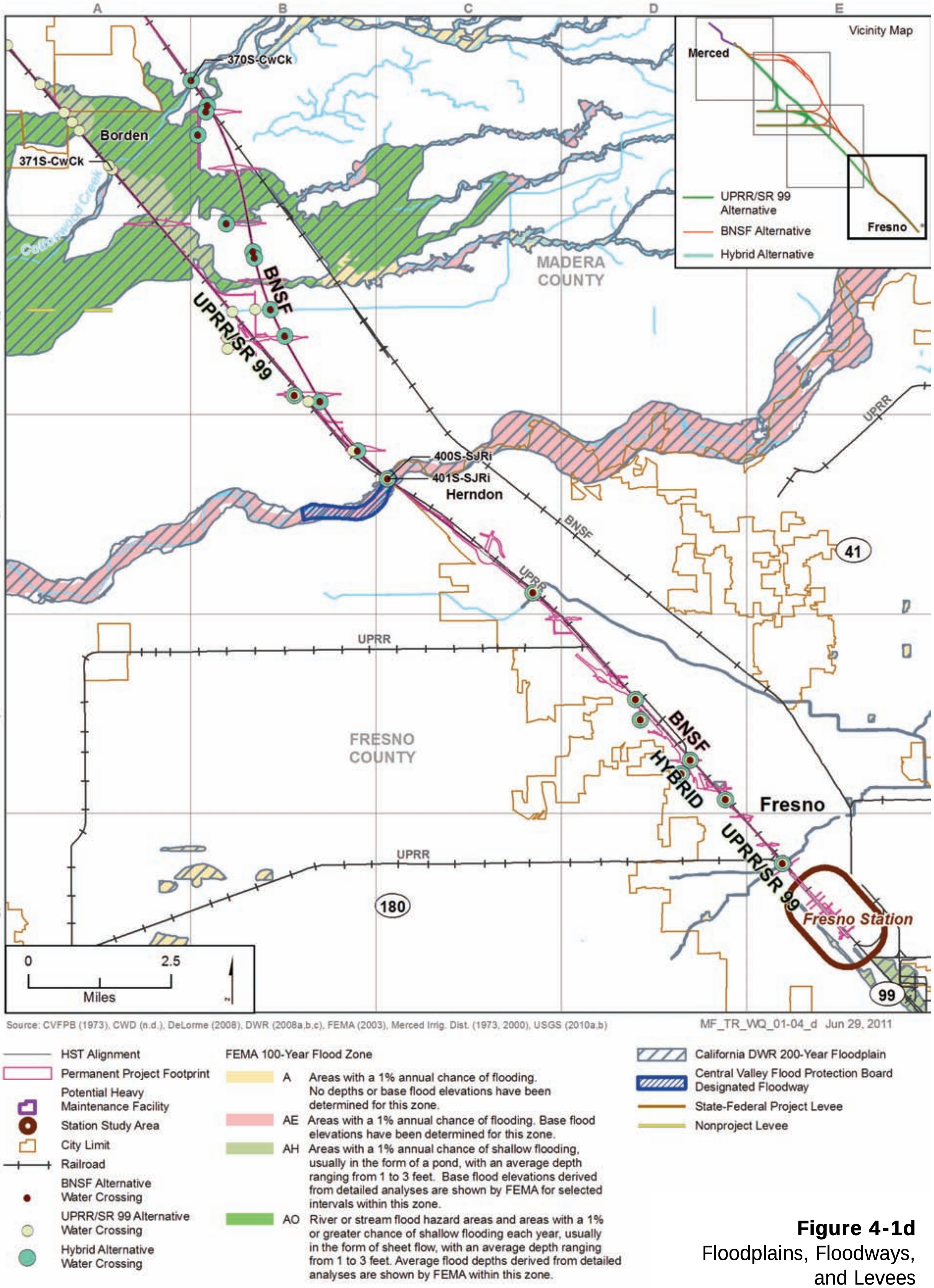


Figure 4-1d
Floodplains, Floodways, and Levees

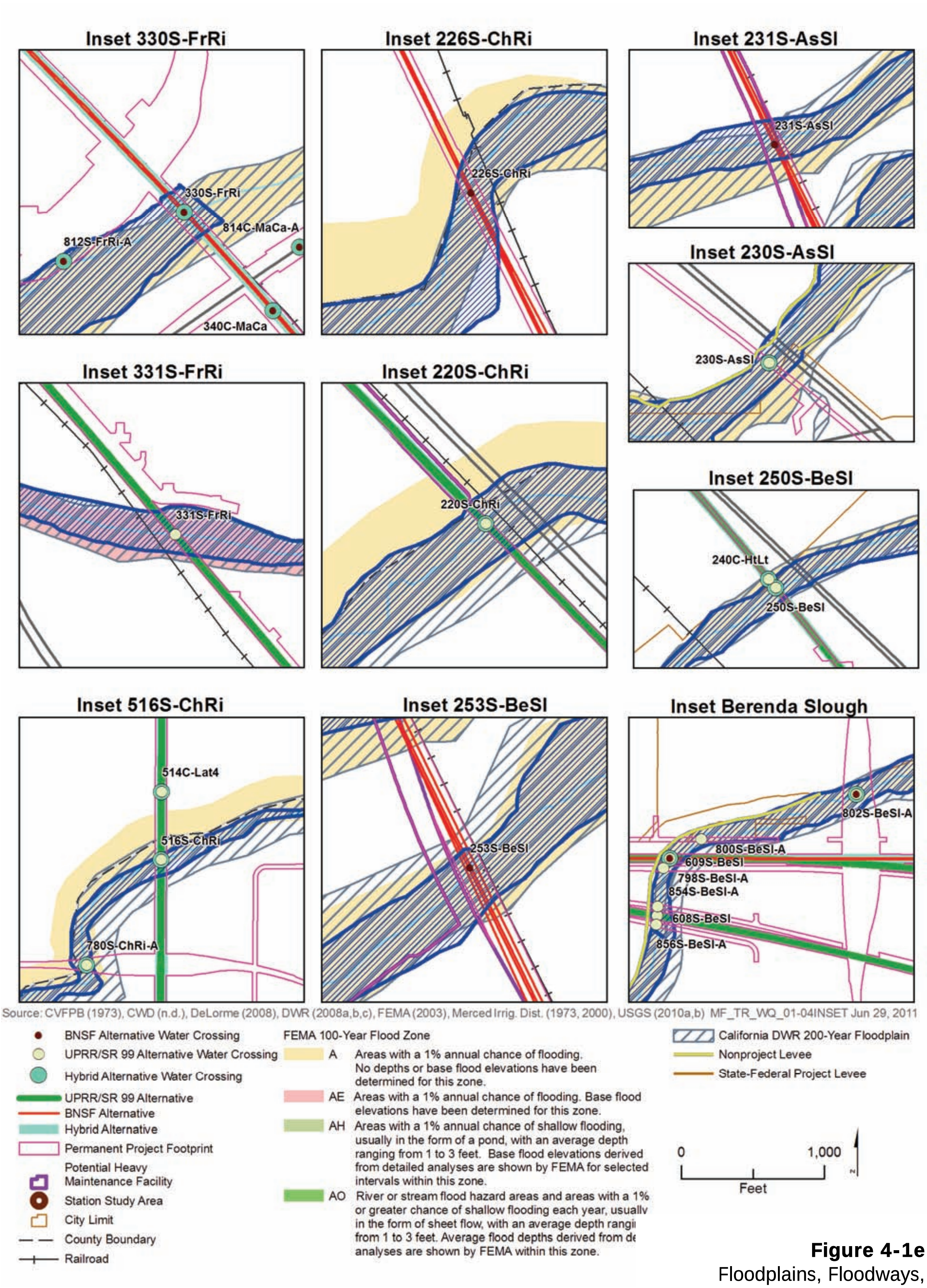
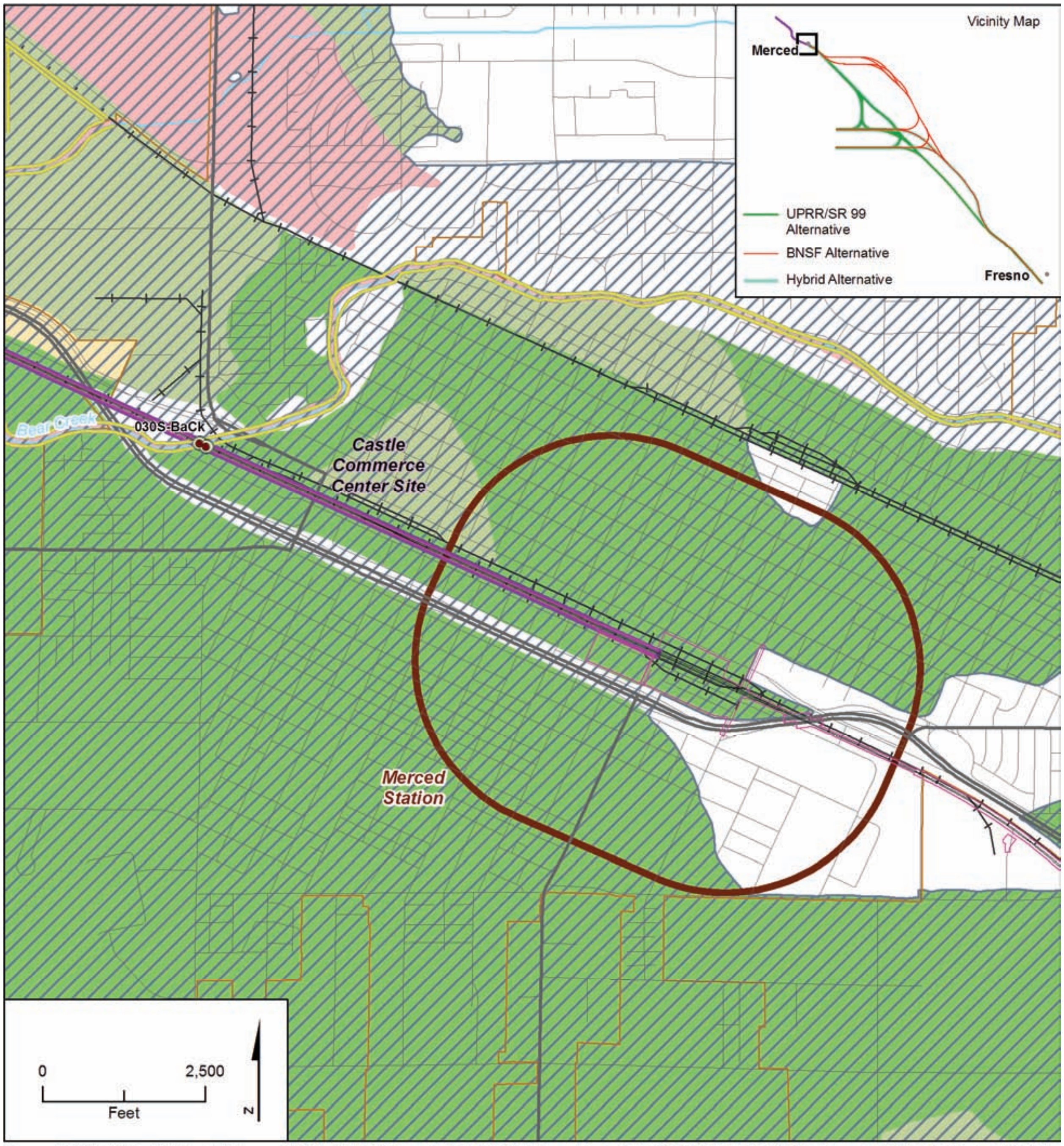


Figure 4-1e
Floodplains, Floodways, and Levees



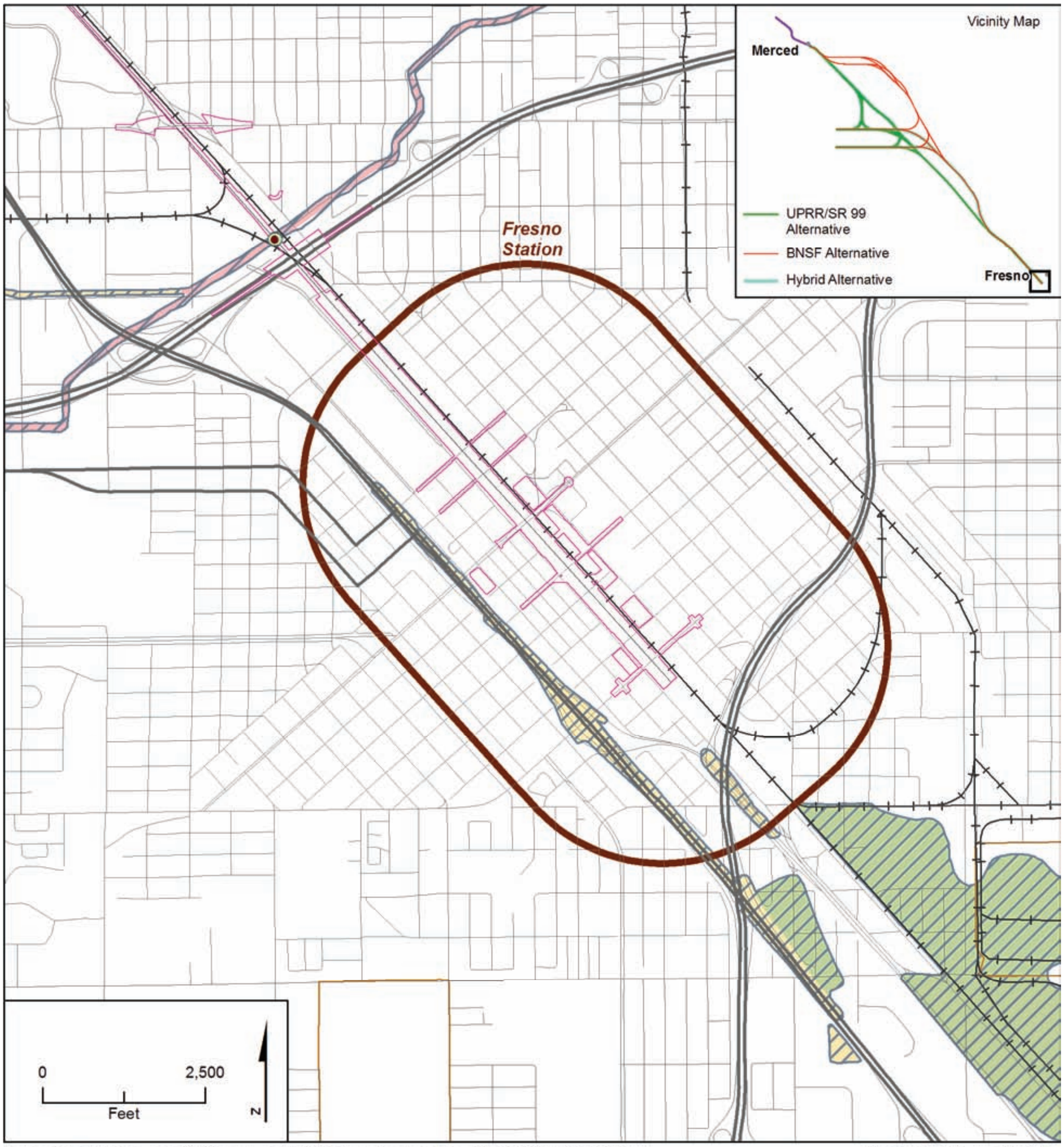
Source: CVFPB (1973), CWD (n.d.), DeLorme (2008), DWR (2008a,b,c), FEMA (2008b), Merced Irrig. Dist. (1973, 2000), USGS (2010a,b) MF_TR_WQ_08 Jun 29, 2011

- HST Alignment
- Permanent Project Footprint
- Potential Heavy Maintenance Facility
- Station Study Area
- City Limit
- County Boundary
- Railroad
- BNSF Alternative Water Crossing
- UPRR/SR 99 Alternative Water Crossing
- Hybrid Alternative Water Crossing

- A — Areas with a 1% annual chance of flooding. No depths or base flood elevations have been determined for this zone.
- AE — Areas with a 1% annual chance of flooding. Base flood elevations have been determined for this zone.
- AH — Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. Base flood elevations derived from detailed analyses are shown by FEMA for selected intervals within this zone.
- AO — River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. Average flood depths derived from detailed analyses are shown by FEMA within this zone.

- California DWR 200-Year Floodplain
- Central Valley Flood Protection Board Designated Floodway
- State-Federal Project Levee
- Nonproject Levee

Figure 4-2a
HST Station Floodplains
Downtown Merced Station



Source: CVFPB (1973), DWR (2008a,b,c), FEMA (2008b), Merced Irrig. Dist. (1973, 2000), USGS (2010a,b)

MF_TR_WQ_16 Jun 30, 2011

HST Alignment
Permanent Project Footprint
Potential Heavy Maintenance Facility
Station Study Area
City Limit
County Boundary
Railroad
BNSF Alternative Water Crossing
UPRR/SR 99 Alternative Water Crossing
Hybrid Alternative Water Crossing

A Areas with a 1% annual chance of flooding. No depths or base flood elevations have been determined for this zone.
AE Areas with a 1% annual chance of flooding. Base flood elevations have been determined for this zone.
AH Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. Base flood elevations derived from detailed analyses are shown by FEMA for selected intervals within this zone.
AO River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. Average flood depths derived from detailed analyses are shown by FEMA within this zone.

California DWR 200-Year Floodplain
Central Valley Flood Protection Board Designated Floodway
State-Federal Project Levee
Nonproject Levee

Figure 4-2b
HST Station Floodplains
Downtown Fresno Station

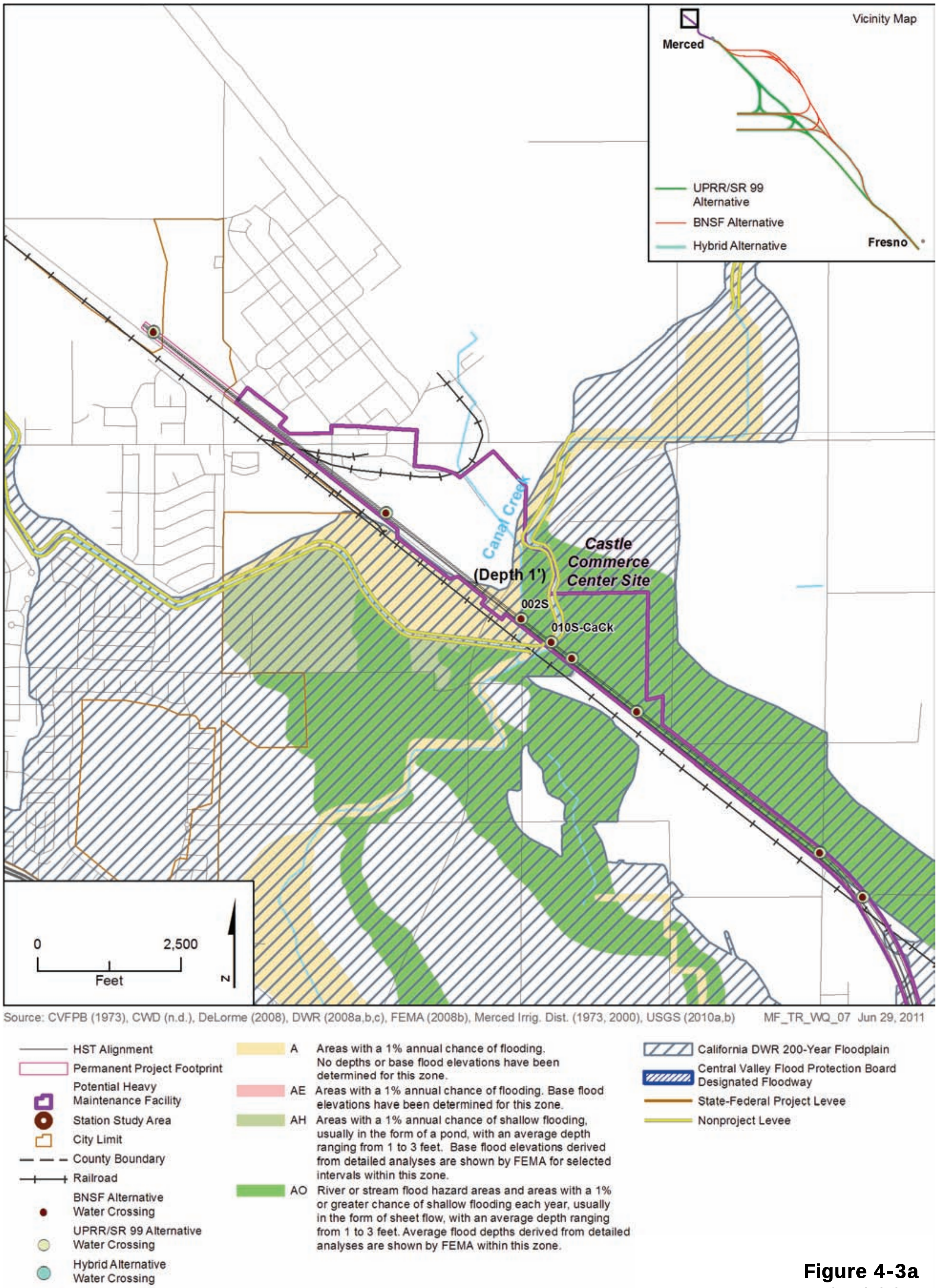


Figure 4-3a
HMF Floodplains
Castle Commerce Center Site

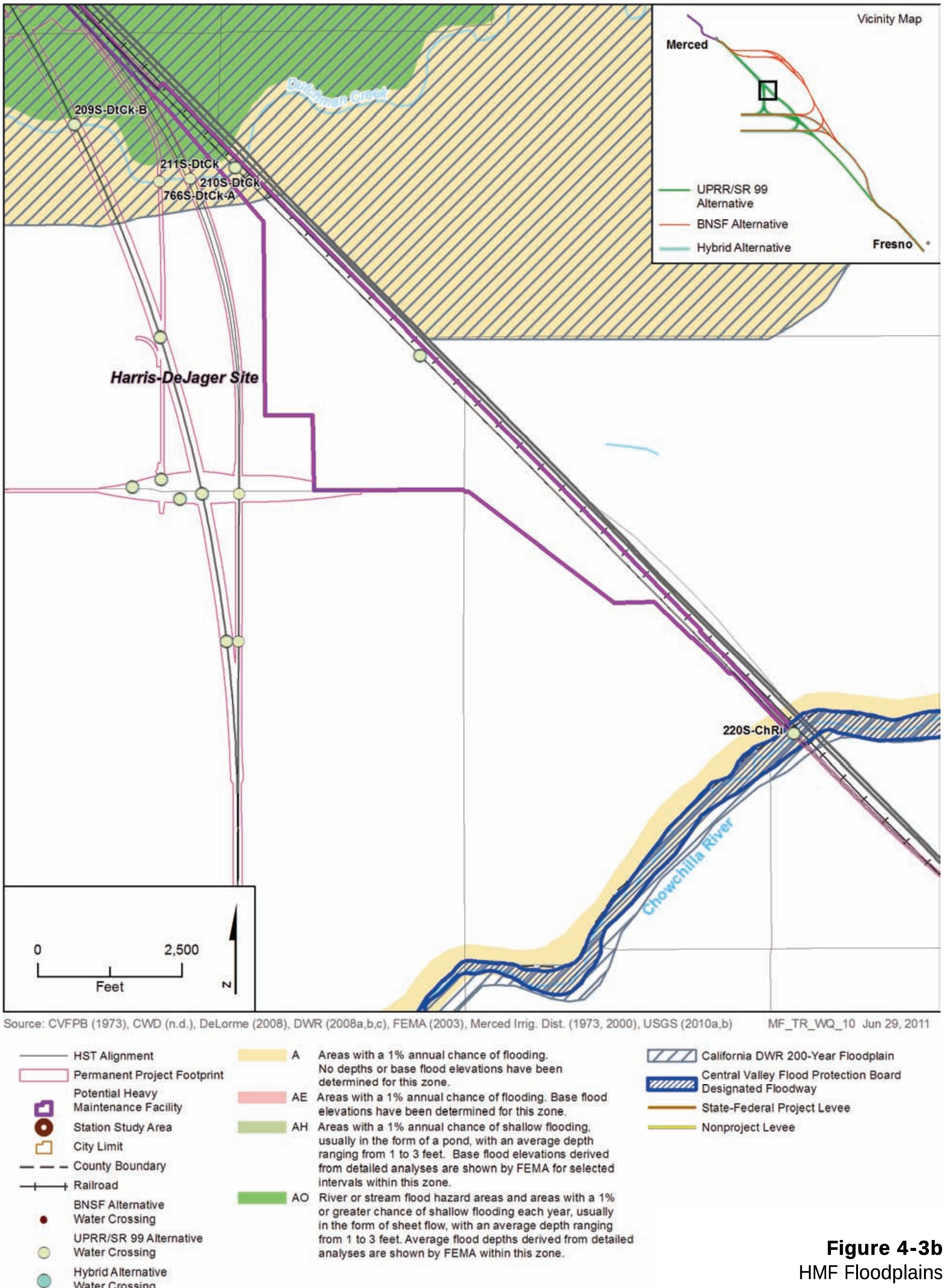


Figure 4-3b
HMF Floodplains
Harris-DeJager Site

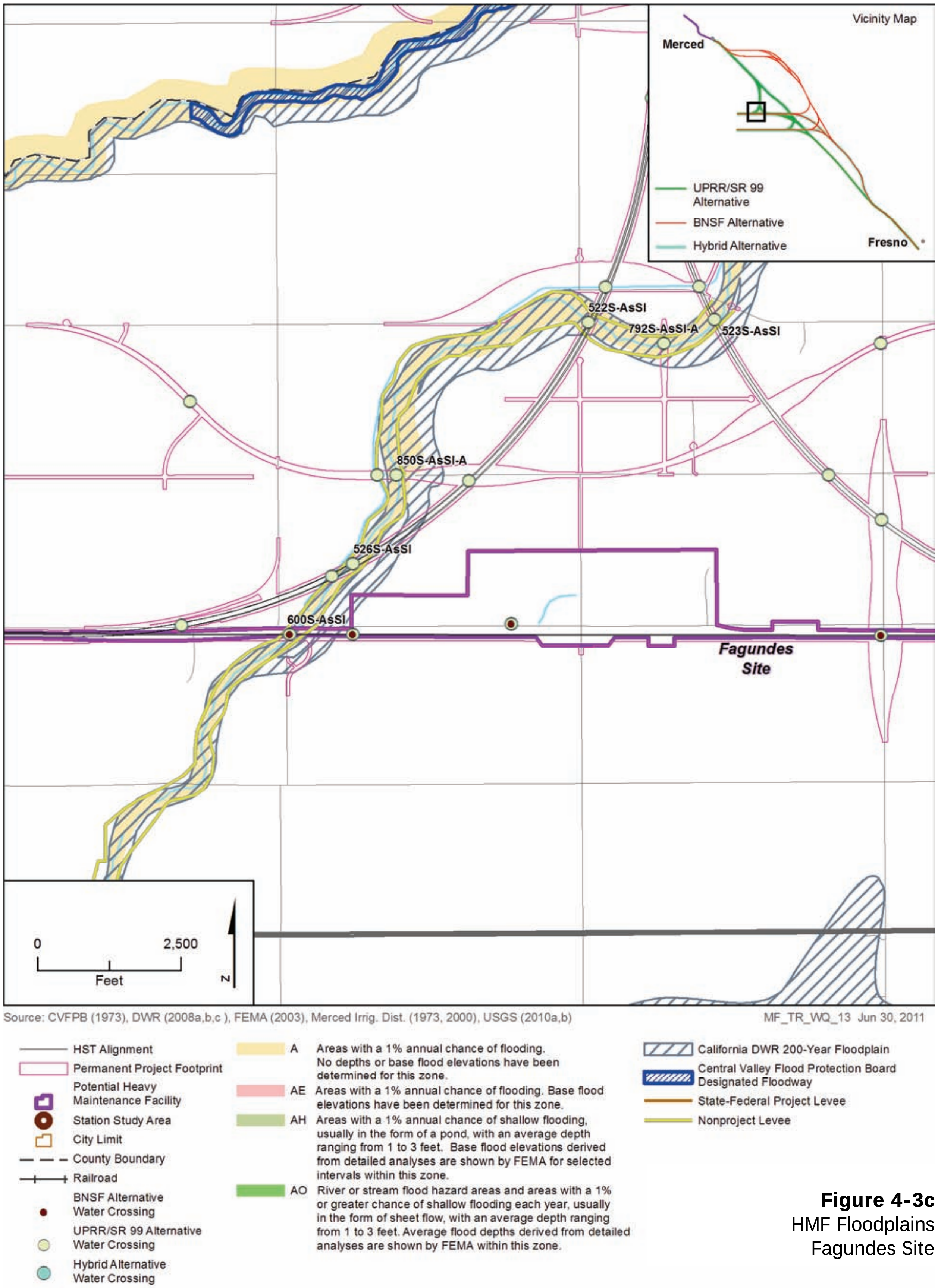


Figure 4-3c
HMF Floodplains
Fagundes Site

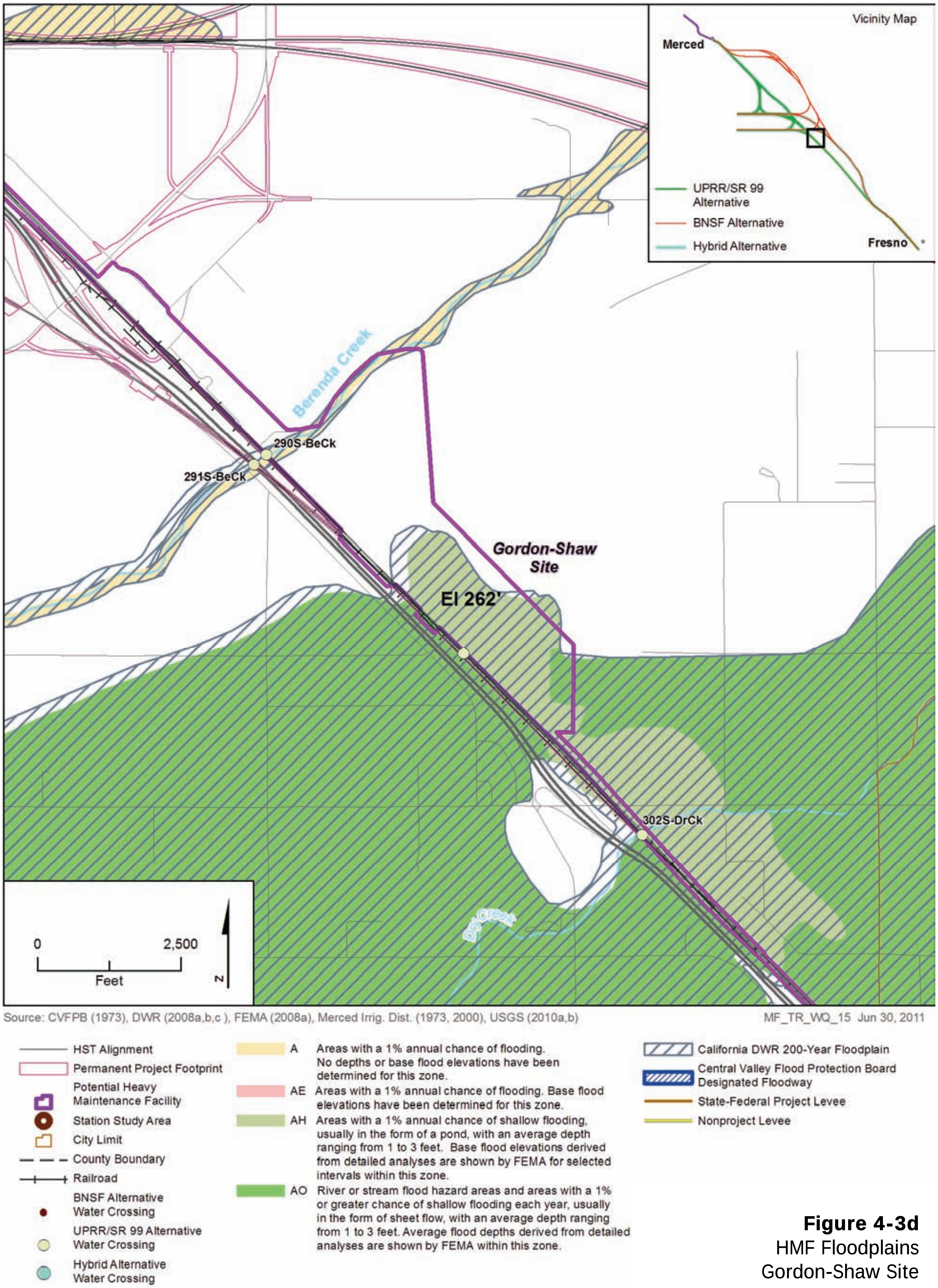


Figure 4-3d
HMF Floodplains
Gordon-Shaw Site

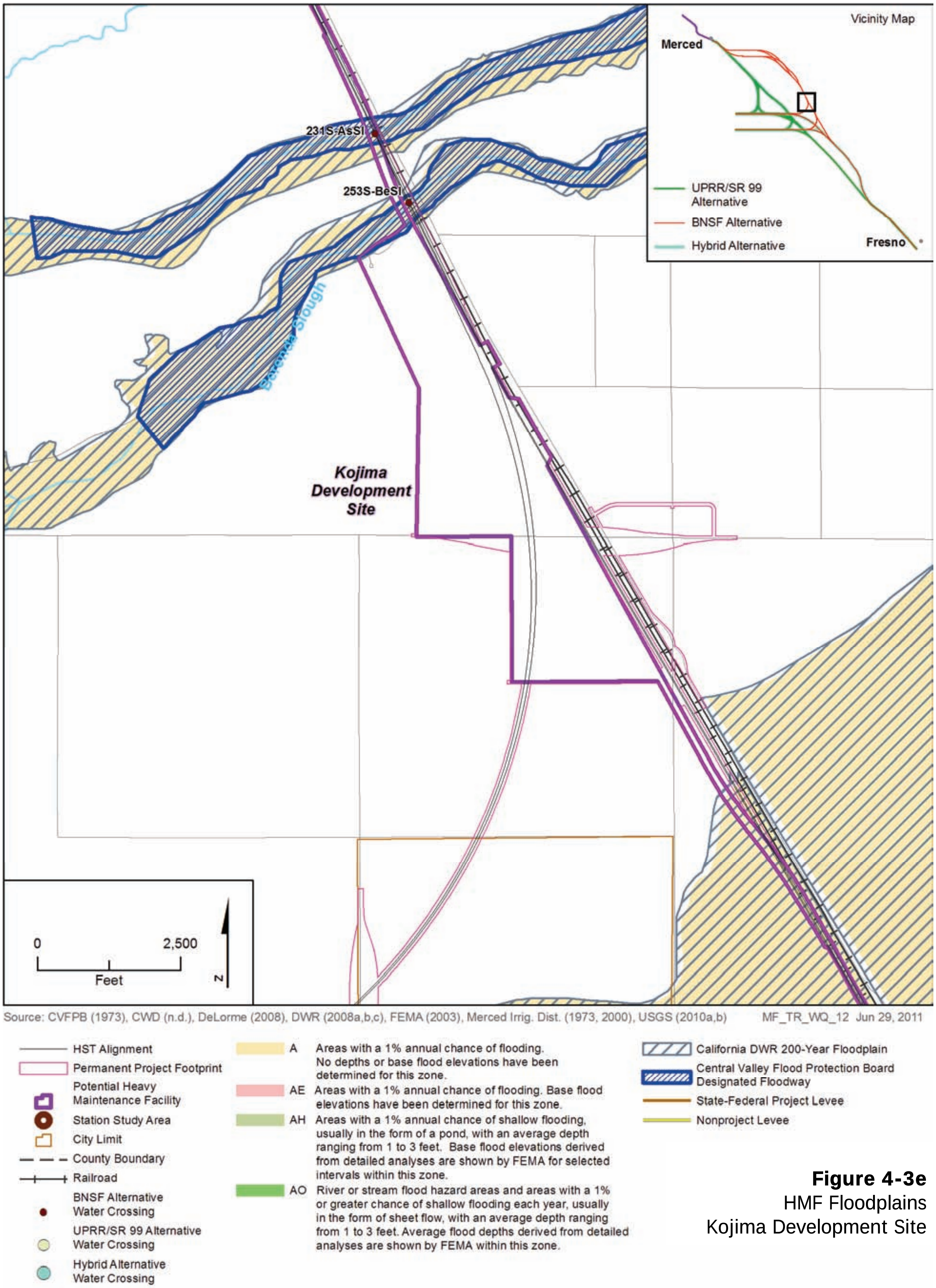


Figure 4-3e
HMF Floodplains
Kojima Development Site

4.1.1.4 San Joaquin River

Within the study area, the San Joaquin River receives flows from the Fresno and Chowchilla rivers, Bear and Owens creeks, and Ash and Berenda sloughs. These streams flow through the study area in a generally southwest direction and discharge into the Chowchilla and Eastside bypass canals that parallel the river along its eastern side (refer to Figures 4-1a to 4-1e). These bypass canals ultimately discharge into the San Joaquin River downstream from the study area.

The remaining streams in the study area have basins that lie primarily at lower elevations. In contrast to the San Joaquin River, flooding in these streams results from intense rainfall events between November and April. Although flooding caused by snowmelt is longer in duration and generates larger volumes of runoff, floods that result from rainfall produce the highest peak flows.

Friant Dam controls base flows and floodwater in the San Joaquin River. Historical diversions left the lower portion of the river dry; however, a base flow to the ocean is being restored to support the reintroduction of anadromous salmonids.

4.1.2 Flood Control in the Study Area

A variety of structures provide flood control in the study area. Some of these flood control structures were constructed as part of state–federal flood control projects. *Project flood control facilities* are those flood control facilities that were funded by either the state of California or the federal government. When funded by the federal government, the state assumed responsibility for O&M after completion and exempted the federal government from any related claims for damages. Statewide, project flood control facilities consist of 1,569 miles of levees, hundreds of miles of improved flood channels, and 56 major flood control works (California Department of Water Resources 2010). CVFPB has responsibility for O&M of project flood control facilities in the Central Valley. In many cases, CVFPB has turned over O&M to local flood and levee districts under its jurisdiction.

DWR is currently preparing the Central Valley Flood Management Planning Program, which will identify improvements to the project flood control facilities and 1,200 miles of designated floodways collectively called the State Plan for Flood Control (SPFC). The program will also identify flood hazard areas in urban or urbanizing areas of the Central Valley and recommend levees or other means for protecting these areas. An urban area is any contiguous area in which more than 10,000 residents are protected by project levees (Public Resources Code 5096.805). The mandate is to provide flood protection by the year 2025 for urban and urbanizing areas from a 200-year flood event. DWR is currently defining and mapping 200-year flood hazard areas.

This Central Valley Flood Management Planning Program is scheduled for adoption by CVFPB in mid 2012. Local entities are required to update their general plans and zoning ordinances to control development in flood hazard areas identified by the program by mid-2015.

Within the study area, the SPFC facilities include levees along the lower portions of Ash Slough, Berenda Slough, Bear Creek, Fresno River, and levee sections along San Joaquin River. Although the levees for these five waterbodies are downstream from the Merced to Fresno Section, the upstream portions of the rivers in the corridor are regulated and managed as part of the overall flood control project.

Chowchilla Canal Bypass and the Eastside Bypass, which parallel the San Joaquin River along its eastern side, are critical to flood management. The Chowchilla Canal Bypass diverts excess San Joaquin River flow and sends it to the Eastside Bypass. In addition to the Chowchilla Canal Bypass flow, the Eastside Bypass intercepts flows from minor tributaries before rejoining the San Joaquin River downstream from the study area. Two additional diversion canals (from Black Rascal Creek and Owens Creek) are located between Merced and Le Grand.

The alignments, design options, and wyes of the three proposed alternatives cross two project flood control structures, the levees on each side of the Owens Creek Diversion Canal. Two design options cross this canal 3 miles northwest of Le Grand. Section 5 discusses these crossings, which are uniquely labeled 1126C and 1156C in this report.

Nonproject flood control facilities include levees and related facilities constructed by local agencies along rivers, creeks, and streams in the Central Valley. Many of these facilities are operated and maintained similar to project facilities, and some connect to project facilities. By definition, they are not part of the SPFC; however, the nonproject levees affect the performance of the SPFC as part of the flood protection system.

Designated floodways preserve flood capacity under the primary nonstructural flood management program in California. The program started in 1968 to control encroachments and preserve the flow regimes of floodways to protect public improvements, lives, and land-use values (California Water Code [CWC] Section 8609). Designated floodways are defined as follows: (1) the channel of the stream and that portion of the adjoining floodplain reasonably required to provide for the passage of a design flood, as indicated by floodway encroachment lines on an adopted map, or (2) the floodway between existing levees, as adopted by CVFPB or the California Legislature. Floodways are designated by CVFPB and serve a critical function in protecting life and property from flood risks. Statewide, designated floodway system includes more than 60 designated floodways and more than 1,300 miles of stream. Within the Merced to Fresno Section, five streams have CVFPB-designated, mapped floodways: San Joaquin River, Chowchilla River, Ash Slough, Berenda Slough, and Fresno River. As previously discussed, these five waterbodies have SPFC levees downstream from the Merced to Fresno Section.

4.1.3 Overview of Study Area Flooding

Stream and river channels tend to be well entrenched and confined when flowing through the foothills east of the study area. After entering the relatively flat San Joaquin Valley, the channels often become much shallower and can easily overflow during periods of high runoff. Overflow tends to spread out as shallow, slow-moving water across large areas. During major storms, much of this water ponds behind canal, road, and railroad embankments. In the study area, large flood-prone areas exist west of SR 99, especially near the San Joaquin River. From Merced to Chowchilla, extensive areas on both sides of SR 99 are subject to flooding. South of Chowchilla, widespread flooding generally does not occur east of SR 99. The City of Merced experiences flooding from several creeks including Black Bear Creek, which flows west through the city. Upstream from Merced, excess flows overflow the creek banks and flow overland. The BNSF railway embankment is a barrier to these flows and directs floodwater into the city. This flow crosses the railroad tracks and SR 99, eventually reaching the Eastside Canal 1 mile to the west (FEMA 2008a). Flood flows in Little Rascal Creek divert to Bear Creek; the former thus causes only localized flooding. Merced Irrigation District indicated that within their boundaries, Bear Creek is especially flood prone, and flooding has historically been a concern along Mariposa Creek, Duck Slough and Black Rascal Creek. As an example outside of the study area, overflows from Fehrens Creek can cause widespread flooding in the northwest portion of the City of Merced.

The Fresno River flows through the City of Madera. Since Hidden Dam went into operation in 1976, severe flooding has not occurred in the city (FEMA 2008b). Cottonwood, Dry, and Schmidt Creeks in Madera County typically have no flow from May through October. However, they have shallow, poorly defined channels that can readily overtop during high flows and inundate large areas. Ash Slough flows through the Community of Chowchilla. According to FEMA 100-year flood maps, Ash Slough remains within its levees during a 100-year flood event. However, Madera Irrigation District indicated that Ash Slough, Berenda Slough, and the Chowchilla River have historically had flooding issues. According to the district, Berenda Slough levees were recently decertified and efforts are underway to recertify them.

Several irrigation canals cross the east–west path of streams east of Clovis and Fresno. During periods of high flow, these canals convey floodwater from these streams through the Clovis–Fresno area to farmland west of Fresno, with minimal flooding in the cities (FEMA 2009a). Only isolated portions of Fresno are within a 100-year floodplain.

4.2 Floodplain Crossings for the Merced to Fresno Section Alternatives

This section discusses the parts of the HST alignments that cross floodplains. This section also reviews the floodplain status of the HST stations and potential HMF sites within the Merced to Fresno Section.

4.2.1 UPRR/SR 99 Alternative

Table 4-1 summarizes the lengths of sections of the UPRR/SR 99 Alternative alignment that cross FEMA 100-year floodplains, as shown on Figures 4-1a through 4-1e. Between 15.7 and 18.5 miles of the UPRR/SR 99 Alternative alignment lies within FEMA 100-year floodplains, depending on the combination of Chowchilla design options and wyes evaluated. This range is relatively small, which suggests that there are only small differences among the three combinations of design options and wyes. The access guideway to the Castle Commerce Center HMF site would cross another 3.2 miles of 100-year floodplain.

Table 4-1
UPRR/SR 99 Alternative Alignment Floodplain Crossings

UPRR/SR 99	East Chowchilla Design Option and Ave 24 Wye (miles)	East Chowchilla Design Option and Ave 21 Wye (miles)	West Chowchilla Design Option and Ave 24 Wye (miles)	Access Guideway to Castle Commerce Center HMF (miles)
Zone A	1.5	3.5	0.8	0.2
Zone AE	0.4	0.4	0.4	0.0
Zone AH	1.7	1.7	1.7	0.0
Zone AO	13.3	12.8	12.8	3.0
Total 100-Year Floodplain	16.9	18.5	15.7	3.2
Additional 200-Year Floodplain	3.3	4.5	3.3	1.2
Total Guideway Length in Floodplain	20.2	23.0	19.0	4.4
Total Guideway Length	76.8	75.4	67.4	7.0

The northern 9 miles of the north-south alignment lie almost entirely within floodplain areas. Farther south and north of Madera, the alignment crosses a 3-mile-wide floodplain associated with Dry Creek and Schmidt Creek. South of Madera, the alignment also crosses a 4-mile-wide floodplain associated with Cottonwood Creek. Most of the floodplains crossed by the UPRR/SR 99 Alternative involve shallow floodwaters.

The UPRR/SR 99 Alternative traverses an additional 3.3 to 4.5 miles of 200-year floodplain that extends beyond the limits of the FEMA 100-year floodplain (refer to Table 4-1). The access guideway to the Castle Commerce Center HMF site would add another 1.2 miles of 200-year floodplain near Atwater. From 26% to 31% of the guideway length under the UPRR/SR 99 Alternative and 63% of the access guideway to the Castle Commerce Center HMF site lie within a floodplain.

Apart from crossing FEMA floodplains, the UPPR/SR 99 Alternative alignment also crosses the five designated floodways in the study area: San Joaquin River, Chowchilla River, Ash Slough, Berenda Slough, and Fresno River. The designated floodways are similar, but not identical, to the FEMA 100-year floodplains at these crossings.

4.2.2 BNSF Alternative

Table 4-2 summarizes the lengths of sections of the BNSF Alternative alignment that cross FEMA 100-year floodplains, as shown on Figures 4-1a through 4-1e. Between 16.6 and 21.9 miles of the BNSF Alternative alignment lies within FEMA-designated 100-year floodplains, depending on the Le Grand design option and wye evaluated. This range of lengths is somewhat broader than for the UPRR/SR 99 Alternative, but is relatively narrow for each of the wye options (16.6 to 19.0 miles using Ave 24 Wye and 19.5 to 21.9 miles using Ave 21 Wye).

Nearly all of the northern 17 miles of the alignment between the Merced Station and Le Grand lies within floodplains. Most of this area is classified as Zone AO – shallow flowing water, 1 to 3 feet deep. Most of the remaining floodplain area is Zone A. Although specific flood depths for the latter have not been calculated, the majority of the flooding would also be shallow. Most of the remaining floodplains along the BNSF Alternative alignment are relatively narrow and are associated with individual stream crossings. An exception is a 2-mile length of floodplain crossed by the alignment south of Madera. The BNSF Alternative alignment crosses the same five designated floodways that the UPRR/SR 99 Alternative alignment crosses.

The BNSF Alternative traverses an additional 0.6 to 2.3 miles of 200-year floodplain that extends beyond the limits of the FEMA 100-year floodplain (refer to Table 4-2). From 26% to 32% of the total guideway length under the BNSF Alternative lies within a floodplain.

Apart from crossing FEMA floodplains, the BNSF Alternative alignment also crosses designated floodways along the same waterbodies as the UPRR/SR 99 Alternative alignment: San Joaquin River, Chowchilla River, Ash Slough, Berenda Slough, and Fresno River. The designated floodways are similar, but not identical, to the FEMA 100-year floodplains at these locations.

Section 4.2.2 discusses the floodplain associated with the access guideway for the Castle Commerce Center HMF site under the UPRR/SR 99 Alternative.

4.2.3 Hybrid Alternative

Table 4-3 summarizes the lengths of sections of the Hybrid Alternative alignment that cross FEMA 100-year floodplains, as shown on Figures 4-1a through 4-1e. Depending on the wye design option selected, between 13.0 and 15.5 miles of the Hybrid Alternative alignment lie within FEMA designated 100-year floodplains. This length is less than the length under the other two HST alternatives because the UPRR/SR 99 alignment has shorter floodplain crossings on the northern end, and the BNSF alignment has shorter floodplain crossings on the southern end.

Table 4-2
BNSF Alternative Alignment Floodplain Crossings

BNSF	Ave 24 Wye				Ave 21 Wye				Access Guideway to Castle Commerce Center HMF (miles)
	Mission Ave Design Option (miles)	Mission Ave East of Le Grand Design Option (miles)	Mariposa Way Design Option (miles)	Mariposa Way East of Le Grand Design Option (miles)	Mission Ave Design Option (miles)	Mission Ave East of Le Grand Design Option (miles)	Mariposa Way Design Option (miles)	Mariposa Way East of Le Grand Design Option (miles)	
Zone A	4.6	6.1	3.0	3.2	7.5	9.0	5.9	6.1	0.2
Zone AE	0.5	0.5	0.5	0.5	0.4	0.5	0.4	0.5	0.0
Zone AH	0.2	0.1	1.2	1.3	0.2	0.1	1.2	1.3	0.0
Zone AO	13.7	9.9	14.2	12.7	13.7	9.9	14.3	12.7	3.0
Total 100-Year Floodplain	19.0	16.6	18.9	17.7	21.9	19.5	21.8	20.6	3.2
Additional 200 Year Floodplain	0.6	0.7	0.7	1.0	1.8	2.0	2.0	2.3	1.2
Total Guideway Length in Floodplain	19.6	17.3	19.6	18.7	23.7	21.5	23.8	22.9	4.4
Total Guideway Length	84.9	85.2	83.8	85.1	81.9	82.2	80.9	82.1	7.0

Table 4-3
Hybrid Alternative Alignment Floodplain Crossings

Hybrid	Total Hybrid (Ave 24 Wye) (miles)	Total Hybrid (Ave 21 Wye) (miles)	Access Guideway to Castle Commerce Center HMF (miles)
Zone A	1.1	3.8	0.2
Zone AE	0.4	0.4	0.0
Zone AH	0.0	0.0	0.0
Zone AO	11.5	11.3	3.0
Total 100-year Floodplain	13.0	15.5	3.2
Additional 200-year Floodplain	0.6	1.8	1.2
Total Rail Length in Floodplain	13.6	17.3	4.4
Total Rail Length	68.8	70.1	7.0

The northern 9 miles of the north-south alignment under the Hybrid Alternative lie almost entirely within floodplain areas. The floodplains encountered by the UPRR/SR 99 Alternative farther south are largely avoided because the alignment transitions to the BNSF Alternative alignment at Chowchilla. Like the other two alternatives, most of the floodplains crossed by the Hybrid Alternative involve shallow floodwaters.

The Hybrid Alternative traverses an additional 0.6 to 1.8 miles of 200-year floodplain that extends beyond the limits of the FEMA 100-year floodplain (refer to Table 4-3). About 20% of the total guideway length under the Hybrid Alternative lies within a floodplain.

Apart from crossing FEMA floodplains, the Hybrid Alternative also crosses the five designated floodways in the study area: San Joaquin River, Chowchilla River, Ash Slough, Berenda Slough, and Fresno River. The designated floodways are similar, but not identical, to the FEMA 100-year floodplains at these locations.

Section 4.2.2 discusses the floodplain associated with the access guideway for the Castle Commerce HMF under the UPRR/SR 99 Alternative.

4.2.4 High-Speed Train Stations and Heavy Maintenance Facilities

4.2.4.1 High-Speed Train Stations

There are two proposed HST stations within the study area, one in Downtown Merced and one in Downtown Fresno. The following sections discuss the stations at these locations.

As shown on Figure 4.2a, the Downtown Merced Station area lies mostly within the 100-Year Flood Hazard Zone AO (shallow flooding). The flood insurance rate map for Downtown Merced (FIRM #06047C0440G – December 2, 2008) indicates flood depths of 1 to 2 feet. Only the southeastern portion of the HST station area and SR 99 lie outside the floodplain.

In contrast to the Downtown Merced Station area, the Downtown Fresno Station area has two isolated locations of 100-year floodplain (refer to Figure 4-2b). One is a small area at the southern end of the HST station area, and the other is a narrow stretch of floodplain along a 2-mile length of SR 99, 1,500 feet west of the proposed HST alternative routes. Both areas are classified as 100-Year Flood Hazard Zone A.

4.2.4.2 Heavy Maintenance Facility

Five sites between Merced and Fresno are being considered as possible sites for the HMF. They are all located in the northern portion of the study area, as shown on Figures 4-3a through 4-3e. These figures also illustrate floodplains and nearby streams at each potential HMF site. The following sections briefly discuss floodplains at the potential sites for the HMF.

Castle Commerce Center HMF Site

The east side of this site is within the floodplain of Canal Creek. Canal Creek bisects the southeastern portion of the site.

Harris-DeJager HMF Site

A small portion of the northwest side of the site lies within the Dutchman Creek floodplain.

Fagundes HMF Site

Small portions of the northwest side of the site are within the Chowchilla River floodplain.

Gordon-Shaw HMF Site

The southern portion of this site lies within the 100-Year Floodplain Hazard Zone AH (ponding), with a flood elevation of 262 feet (FIRM #06039C0900E – September 26, 2008). Berenda Creek borders the northwest side of the site.

Kojima Development HMF Site

This is the only potential HMF site along the BNSF Alternative alignment. Berenda Slough borders a small portion of the northwest side of the site.

4.3 Floodplain Impacts and Mitigation

4.3.1 Impacts

As discussed in Section 4.2, the three HST alternatives cross many miles of floodplains, as summarized in Tables 4-1 to 4-3. The majority of the floodplains have shallow flow or ponding 1 to 3 feet deep that spreads out over areas that are thousands of feet or miles wide. This shallow flooding is primarily due to overflow of stream channels when high flows exceed the capacity of the channels. The resulting shallow flooding tends to be slow moving.

The general gradient of the land in the study area slopes to the west or southwest. The shallow, overland flooding tends to pond against canal berms, levees, and road embankments that are perpendicular to the land gradient. If these features lack adequate culverts or other means of cross-drainage, the overland flows are sometimes diverted long distances before finally overflowing the linear obstacles and continuing their flow west. An example of this occurs southeast of Merced. Overflow from Bear Creek, east of Merced, naturally moves in a southwesterly direction. However, a portion of this shallow flow diverts northwest into Merced along the existing BNSF railway (FEMA 2008a).

Adequate culverts and bridge openings for cross-drainage will be important to prevent the at-grade guideway berms from excessively diverting shallow flood flows in a similar manner at locations where embankments do not already exist. The potential for worsening flood concerns is limited where the HST guideways are adjacent to existing embankments that already create a flood barrier. Potential new impacts are most likely to require mitigation where the HST guideway does not parallel existing railroad or highway embankments. One such segment crosses the Cottonwood Creek floodplain along the north-south alignment of the BNSF Alternative. The Mission Ave and Mariposa Way design options of the BNSF Alternative could also divert shallow floodwaters from Bear, Owens and Mariposa creeks.

Where guideways are elevated, there is little potential to exacerbate flooding; however, floodplain mitigation measures should generally allow adequate flood management without elevating the guideway solely for flood control purposes.

Apart from the wide, flat, low-gradient floodplains, the project would also cross several stream channels that have a higher hydraulic capacity. The higher flows in the stream and river channels are fundamentally different from the shallow, relatively slow-moving floodwater. Floodwater flows within channels involve deeper, faster-flowing water that can potentially erode stream banks and channel bottoms. If not properly designed, HST bridge piers and abutments have the potential to restrict flow in the channels and increase flood depths in adjacent reaches and at nearby structures. Bridge abutments and piers must be constructed at depths adequate to prevent their compromise and failure because of channel scouring during flood events.

Five of the streams crossed have designated floodways mapped by CVFPB. From north to south, they are the Chowchilla River, Ash Slough, Berenda Slough, Fresno River, and San Joaquin River. The cities of Chowchilla, Madera, and Fresno are situated along the banks of Ash Slough, Fresno River, and San Joaquin River, respectively. These communities have populations greater than 10,000. Structures within or spanning these channels should be designed to accommodate the 200-year flood to meet emerging state requirements in the Central Valley Flood Protection Act (refer to Section 3.1.2) for urban and urbanizing areas. Table 4-4 shows the longest length of alternative alignments that cross the 200-year floodplains associated with these streams. In some cases, the alternative may cross a stream in more than one location. The crossing lengths vary from 470 to 22,500 feet, with the longest length associated with the Ave 21 Wye, which may or may not pertain to each alternative. Bridges spanning these streams generally require piers in the channels or floodplains, or both. The piers should be designed to prevent excessive hydraulic restrictions (refer to criteria in Section 3.2) as confirmed by hydraulic modeling.

Table 4-4

Longest Length of 200-Year Floodplain Crossings at Major Streams and Rivers (in feet)

Stream	UPRR/SR 99 Alternative	BNSF Alternative	Hybrid Alternative
Chowchilla River	780	470	780
Ash Slough	990	570	990
Berenda Slough	22,500	22,500[a]	22,500
Fresno River	500	720	720
San Joaquin River	1,100	1,100	1,100

Mitigation in Channels

Section 5 includes more information regarding stream crossing impacts. Implementing the design guidelines presented in Section 3.2 could potentially avoid or reduce adverse hydraulic impacts at bridge crossings. Hydraulically significant design criteria include the following:

- Bridge piers should be oriented parallel to the expected high-water flow where practical and should generally line up with piers at adjacent bridges.
- Provide a minimum of 3 feet of freeboard between the design high WSE and the bridge soffit to prevent formation of debris dams.
- Locate abutments where they minimize impacts from channel constrictions.

- Design for proper scour depth.

4.3.2 Mitigation in Shallow Floodplains

The project should include culverts with sufficient capacity and at a sufficient spacing to prevent substantial ponding against the upslope side of the guideway embankment and project roadway embankments that could result in deeper ponded conditions and/or lateral diversion of shallow flooding. However, the location, spacing, and size of existing culverts through adjacent railroad and highway embankments limits the effectiveness of culverts in reducing local flooding. Where there are opportunities to improve the combined culvert performance, stormwater hydromodifications and objectives should be evaluated. Separate reports address stormwater considerations and requirements for Caltrans and the project as a whole. These are, respectively, the Stormwater Data Report (Authority and Federal Railroad Administration [FRA] 2011a) and the Stormwater Management Report (Authority and FRA 2011b).

Most of the length of each of the HST alternative alignments is adjacent to one or more existing railroad embankments. The specific locations and spacing of the HST guideway embankment culverts that would be developed during the detailed design must account for local topography and shallow flooding conditions. At a minimum, culverts should match those through the adjacent railroad embankment. However, additional culverts may be required to avoid known ponding or flow diversion problems, such as the diversion of floodwaters toward Merced along the BNSF. Where the HST guideway embankment would be constructed downgradient from an existing railroad berm, simple matching of the culvert locations and capacities would probably be adequate to allow floodwater to flow downgradient from the project under existing conditions. However, to accommodate potential future flood improvements, the project could install additional culverts where it is determined that the existing upgradient embankment has inadequate flood passage facilities. This would allow hydraulic constrictions to be corrected in the future when the existing, upgradient railroad tracks are upgraded or abandoned.

A 4-mile length of the BNSF and Hybrid alternatives crosses shallow floodplains southeast of Madera where there are no significant railroad or highway embankments that restrict floodwater flows. Culvert placement along this portion of the guideway would be particularly important to assure adequate floodwater flows across the project without excessively raising the floodplain WSE. Farther north, the BNSF Alternative East of Le Grand design options are offset from the BNSF railway embankment and similarly merit special attention because the existing embankment culvert capacity is not necessarily a limiting factor in local flood passage capacity. Where the four Mission Ave and Mariposa Way design options generally parallel their respective roads and the BNSF or UPRR railway embankments, the considerations in the previous paragraph would apply. Close coordination among the city and county public works agencies, irrigation districts, and levee districts is necessary.

Inlets and outlets should be protected at crossings. Wing walls, riprap, or similar protection should be placed to protect the guideway embankment and outlet channel from possible erosion. Culverts would also be needed where new project road embankments or other elevated project facilities impede floodplain flows.

4.3.3 Mitigation for Rail Stations and Heavy Maintenance Facilities

4.3.3.1 High-Speed Train Stations

The Downtown Fresno Station (refer to Figure 4-2b) would not be located in a floodplain. However, the Merced HST station would likely be located in a floodplain because most of the downtown area lies within a 100-year Flood Hazard Zone AO (shallow flooding) (refer to Figure 4-2a). The 100-year flood depths near the Merced HST station are 1 to 2 feet. After 2015, the City of Merced and other urbanizing areas would be required to plan for protection for the 200-year flood event.

4.3.3.2 Heavy Maintenance Facility

As shown on Figures 4-3a to 4-3e, five sites are being considered for an HMF between Merced and Fresno. The Castle Commerce Center HMF and the associated 7 miles of track would cross four streams: an unnamed tributary to Canal Creek, Canal Creek, Black Rascal Creek, and Bear Creek. Of these, only Canal Creek and its unnamed tributary would be crossed by a portion of the site beyond than the 7 miles of access track. The northwest access guideway of the Harris-DeJager site would cross Dutchman Creek and the associated floodplain. The Gordon-Shaw HMF site and associated access guideway would cross Berenda Creek and Dry Creek. The access guideway for the Kojima HMF site would cross Berenda Slough and Ash Slough. At these sites, an appropriate riparian buffer distance from the stream bank should be maintained. Access guideway stream crossings are adjacent to crossings of the main track and are counted as part of the same crossing location in the tables in Section 5 of this technical report.

Approximately one-half of the Castle Commerce Center site lies within floodplains (the eastern side of the site and approximately 5 miles of the associated track). Of 370 acres, approximately 172 acres are within the 100-year floodplain and 208 acres are within the 200-year floodplain. To the extent practical, the floodplain at the Castle Commerce Center HMF site should not be developed; however, much of the floodplain area at the site may be required for HMF facilities, making encroachment unavoidable. Where an encroachment is needed, several feet of fill would be required to raise those portions of the site above the BFE. A hydraulic study should be performed to assure that fill placement does not affect other properties in this heavily developed area. Specific site boundaries and conceptual HMF layouts may continue to evolve during early design concept development.

A small portion of the western corner of the Fagundes HMF site lies within the Ash Slough floodplain (1.1 acres within the 100-year floodplain and 3.2 acres within the 200-year floodplain). The floodplain is relatively narrow at this location (refer to Figure 4-3c), but the 200-year floodplain splits into two parallel, separated inundation areas. The first inundation area extends about 160 feet from the southern edge of the channel, and the second extends up to about 600 feet from the edge of the channel. Adherence to an appropriate riparian buffer (e.g., 100 feet) would reduce but not necessarily eliminate floodplain impacts at this site. Overall, however, the majority of the 226-acre site should be available for development without floodplain encroachment.

Approximately 40% of the Gordon-Shaw HMF site lies within a floodplain. The floodplain is in the southern portion of the site. Of 364 acres, 144 acres lie within the 100-year floodplain and 156 acres lie within the 200-year floodplain. The area is classified as Flood Hazard Zone AH (shallow ponding), with a FEMA base flood WSE of 262 feet (refer to Figure 4-3d) (FEMA 2008a). Where practical, the project would avoid development of the floodplains within the site; however, if this site is selected, much of the floodplains within the site may be required for HMF facilities, making encroachment unavoidable. Where encroachment is unavoidable, the site would need to be raised from approximately 1 foot to 5 feet to meet the Madera County Code for constructing nonresidential development above the 100-year and future 200-year design flood elevation. The northwest side of the site would cross Berenda Creek, and the southwest access guideway would cross Dry Creek. Construction on the northwest side of the site should be offset back from the stream bank to provide a riparian buffer (about 100 feet). Facilities within the floodplain, which extends about 250 feet from the edge of the channel within the HMF site, would need to comply with FEMA and Madera County codes. A hydraulic study should be performed so that the placement of fill does not violate floodwater elevation criteria (maximum 1-foot incremental rise).

The access guideway on the north side of the Kojima Development HMF site would cross Berenda Slough and Ash Slough adjacent to existing mainline track crossings. These crossings should be treated in the same way as those along the main track section. An access guideway on the south side of the site lies within a floodplain. A portion of the northwest side of the site would border Berenda Slough, and there should be an appropriate riparian buffer (e.g., 100 feet).

An access guideway entering the north side of the Harris-DeJager HMF site would lie within a floodplain and would cross Dutchman Creek. Sections 4.3.2 and 4.3.3 discuss mitigation measures for channels and shallow floodplains, respectively.

5.0 Waterbody Crossings

The three HST alternative alignments cross existing natural and constructed waterbodies including rivers, streams, and irrigation canals. This section provides an inventory of the waterbody crossings, discusses potential design concepts for waterbody crossings, and summarizes preliminary water crossing design concepts for selected crossings. In addition, this section also discusses waterbody crossings that require further consideration during the preliminary design.

Waterbodies are crossed by both the track alignment and the associate permanent project footprint, including new roads, relocated utility corridors and other associated project features. Culverts would be needed where new project road embankments or other elevated project facilities impede floodplain flows or cross small drainages and irrigation features such as private ditches and small canals. In some cases, roads are envisioned to provide access to land parcels where current access would be blocked by project features, and these new access roads must cross existing waterbodies. Many concepts for culverts developed during 15% design are likely to be modified as private farmers decide to reroute or relocate their ditches to adapt to modified parcel configurations and access roads. Some smaller ditches may also be temporary, constructed and filled seasonally or depending on crop rotations, to facilitate relocation .

There are also locations were either the track right-of-way or portions of the permanent project footprint overlap longitudinal sections of natural and irrigation channels that parallel the project or are crossed by both the track and adjacent roads modifications over a single, continuous reach. At some locations, the permanent project footprint overlaps several hundred feet of channel. In some cases, the overlap may be eliminated during final design by refining the project footprint to avoid the waterbodies. At other locations, especially irrigation channels, it may be more practical to relocate the channel outside of the project footprint. In order to ensure track isolation safety, no active irrigation channels can remain within the fenced portion of the HST right-of-way.

5.1 Inventory of Waterbody Crossings

The inventory of waterbody crossings was developed by using data and information listed in Table 5-1.

Table 5-1
Information Sources for Waterbody Crossing Inventory

Data Source	Detail
National Hydrography Dataset High Resolution	Primary source
Irrigation District Maps	Merced Irrigation District (1973) Madera Irrigation District (2000) Chowchilla Water District (No date)
Input from Irrigation District Personnel	Personal communication (Markups of spreadsheet lists and maps)
Aerial Imagery	Mapcon Mapping, Ltd. (2007)
Field Reconnaissance	In some cases, waterbodies were added, removed or named based on information recorded by team members performing site visits.

The names of waterbodies crossed by the alignments were determined by using the best available information from the sources listed in Table 5-1, topographic maps (U.S. Geological Survey [USGS] 1987), and the California Atlas and Gazetteer (DeLorme 2008). The names of some waterbody crossings are different in different sources. Appendix A provides a record of name conflicts in the "Name and Field Notes" field.

Each crossing was assigned a unique 3-digit identification (ID) number. After the first three digits, the ID contains alphanumeric information. The letter immediately following the three digits indicates the crossing type: streams and rivers (S), constructed irrigation canals (C), existing irrigation pipes (P), or minor drainage ditches and swales (D). If the name of the waterbody is known, an additional four-letter designation developed from the waterbody name follows the ID. For example, the Crossing ID 400S-SJRi indicates that the crossing is at the San Joaquin River (appended - SJRi). This location (uniquely identified as 400) is a natural stream or river (the letter after four digits = S).

In some cases, canals are named with a number, so a number follows after a dash (for example, ID 321C-242L is named MID 24.2 Lateral).

This report lists waterbodies that would be crossed by the HST track and crossings associated with project roads and the overall permanent project footprint. Road crossings end in "–A", for example, Fresno River crossing 812S-FrRi-A. Where a crossing is widened in an upstream-downstream direction because it is crossed contiguously by both the HST track and the adjacent permanent project footprint without a significant gap, the ID ends in "–B" for "both" (for example, the Ash Main Canal crossing ID is 521C-AMCa-B). Thus, an ID ending in "-B" indicates a single crossing that extends over a longer reach than would be crossed by the track alignment alone.

Table 5-2 lists the number of waterbody crossings under each combination of HST alternative, design option, and wye. The crossings are quantified separately for natural and irrigation channels, and for the number of locations crossed by the track as a subset and all crossings crossed by the entire permanent project footprint. The final two columns provide total crossings when natural waterbodies are combined with canals and ditches. Depending on the configuration, the number of waterbody crossings would range from 98 to 113, 88 to 109, and 113 under the UPRR/SR 99, BNSF, and Hybrid alternatives, respectively. This inventory may not be all-inclusive, because smaller drainage ditches and culverts may not have been identified. Figures 5-1a through 5-1m show the location of these crossings. Tables 5-3, 5-5, and 5-7 provide additional information regarding these crossings for the UPRR/SR 99, BNSF, and Hybrid alternatives, respectively. Appendix A contains a comprehensive inventory of waterbody crossings.

Table 5-2
Waterbody Crossings by Alternative

Alternative, Design Option, and Wye Combination	Natural Waterbodies		Canals, Ditches and Pipes		Total	
	Main Track Only	All	Main Track Only	All	Main Track Only	All
UPRR/SR 99 Alternative						
North-South Alignment, Design Options, and Wye Combinations						
East Chowchilla with Ave 24 Wye	23	27	53	71	76	98
West Chowchilla with Ave 24 Wye[a]	20	27	53	86	73	113
East Chowchilla with Ave 21 Wye	19	20	61	85	80	105
Total UPRR/SR 99 Alternative Waterbody Crossings	19-23	20-27	53-61	71-86	73-80	98-113

Alternative, Design Option, and Wye Combination	Natural Waterbodies		Canals, Ditches and Pipes		Total	
	Main Track Only	All	Main Track Only	All	Main Track Only	All
BNSF Alternative						
North-South Alignment and Wye Combinations[b]						
BNSF with Ave 24 Wye	14	17	26	38	40	55
BNSF with Ave 21 Wye	13	16	32	44	45	60
Le Grand Design Options						
Mission Ave	11	19	21	30	32	49
Mission Ave East of Le Grand	10	14	22	32	32	46
Mariposa Way	13	20	14	17	27	37
Mariposa Way East of Le Grand	14	16	13	17	27	33
North and South Design Options Combined						
BNSF Alternative with Ave 24 Wye	24-28	31-37	39-48	55-70	67-72	88-104
BNSF Alternative with Ave 21 Wye	23-27	30-36	45-54	61-76	72-77	93-109
Total BNSF Alternative Waterbody Crossings	23-28	30-37	39-54	55-76	67-77	88-109
Hybrid Alternative with Wye Combinations						
North-South Alignment with Ave 24 Wye	21	29	50	84	71	113
Hybrid Alternative with Ave 21 Wye	19	23	55	78	74	101
Total Hybrid Alternative Waterbody Crossings	19-21	23-29	50-55	78-84	71-74	101-113
Heavy Maintenance Facility Alternatives						
Castle Commerce Center	4	4	8	8	12	12
Harris-DeJager	0	0	0	0	0	0
Fagundes	0	0	1	1	1	1
Gordon-Shaw	0	0	0	0	0	0
Kojima Development	0	0	0	0	0	0

[a] Does not include Le Grand design options.

5.1.1 UPRR/SR 99 Alternative

Table 5-3 lists all waterbody crossings for the UPRR/SR 99 Alternative under headings for the north-south alignment along the East Chowchilla design option, Ave 24 Wye and Ave 21 Wye, and the West Chowchilla design option where it differs from the Ave 24 Wye (refer to Table 5-3 notes). At a few locations, crossings may pertain to more than one heading and be repeated. Appendix B contains fact sheets for the UPRR/SR 99 Alternative natural waterbody crossings that are named. Waterbody locations crossed by the UPRR/SR 99 Alternative where the alignment matches a portion of the BNSF or Hybrid alternatives are discussed here and repeated in the subsequent subsections for those alternatives.

Table 5-3 provides information about the waterbody name, type, vertical alignment at completion of conceptual (15%) design, the waterbody length if it is displaced longitudinally, ownership to distinguish private irrigation ditches from canals owned by irrigation districts and publically owned natural streams used to convey irrigation flows, the conceptual (15% design) approach and details, and a map reference to help locate the crossing on Figures 5-1a to 5-1m. Where the conceptual design approach and details were left blank, a conceptual approach to the crossing was not provided by the design team and will be addressed instead during 30% design.

It should be noted that the conceptual (15%) design crossings and footprint are preliminary, based on current design considerations and limited information. During 30% design, the concepts will be refined and potentially changed or eliminated based on new information (such as improved survey data, communication with waterbody owners, and feedback during 15% design review) and general design progression and advancement. The tabulated approaches should be considered as a whole as representative preliminary concepts rather than a firm commitment or limitation at any specific crossing location.

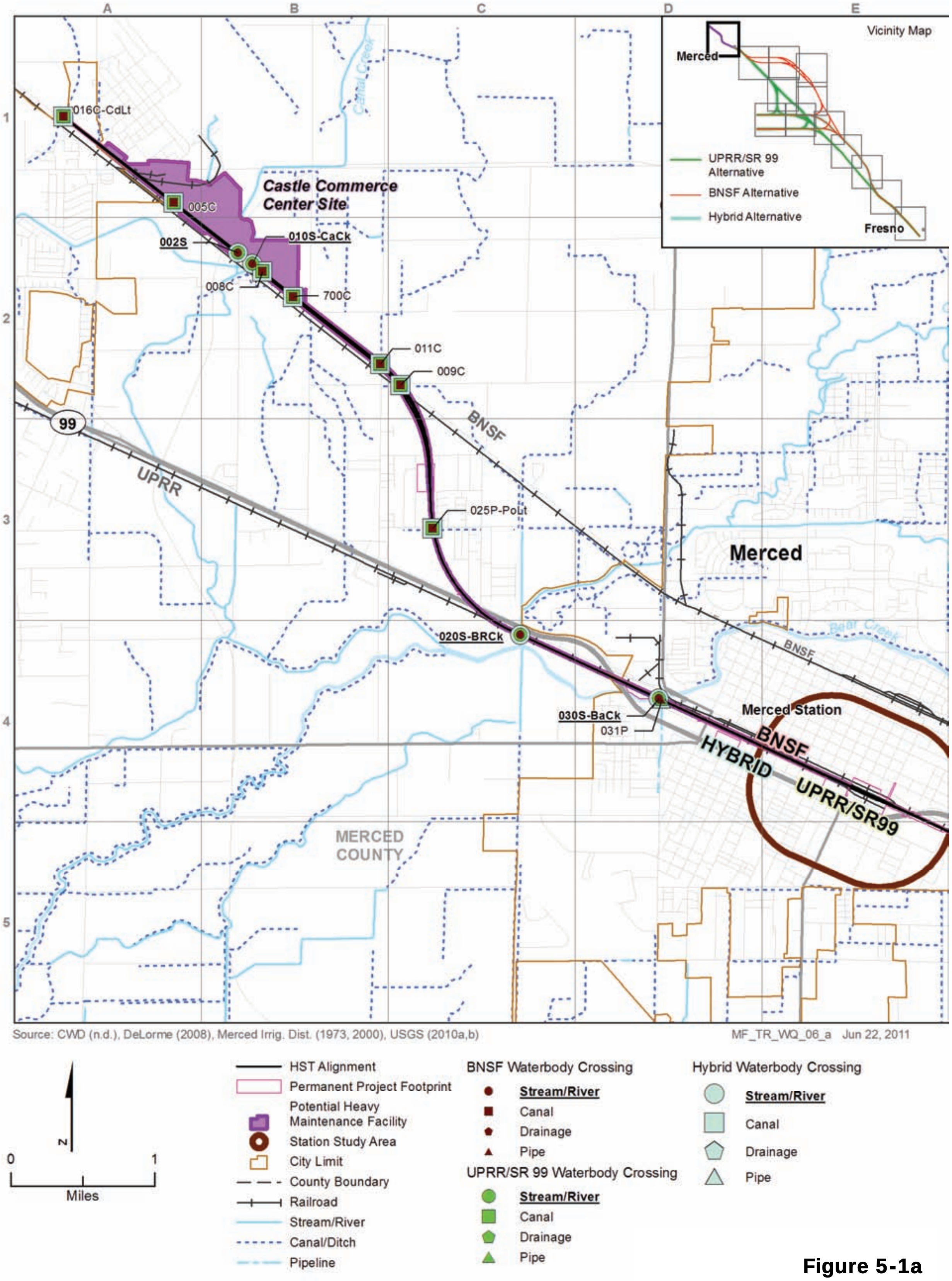


Figure 5-1a
Waterbody Crossings

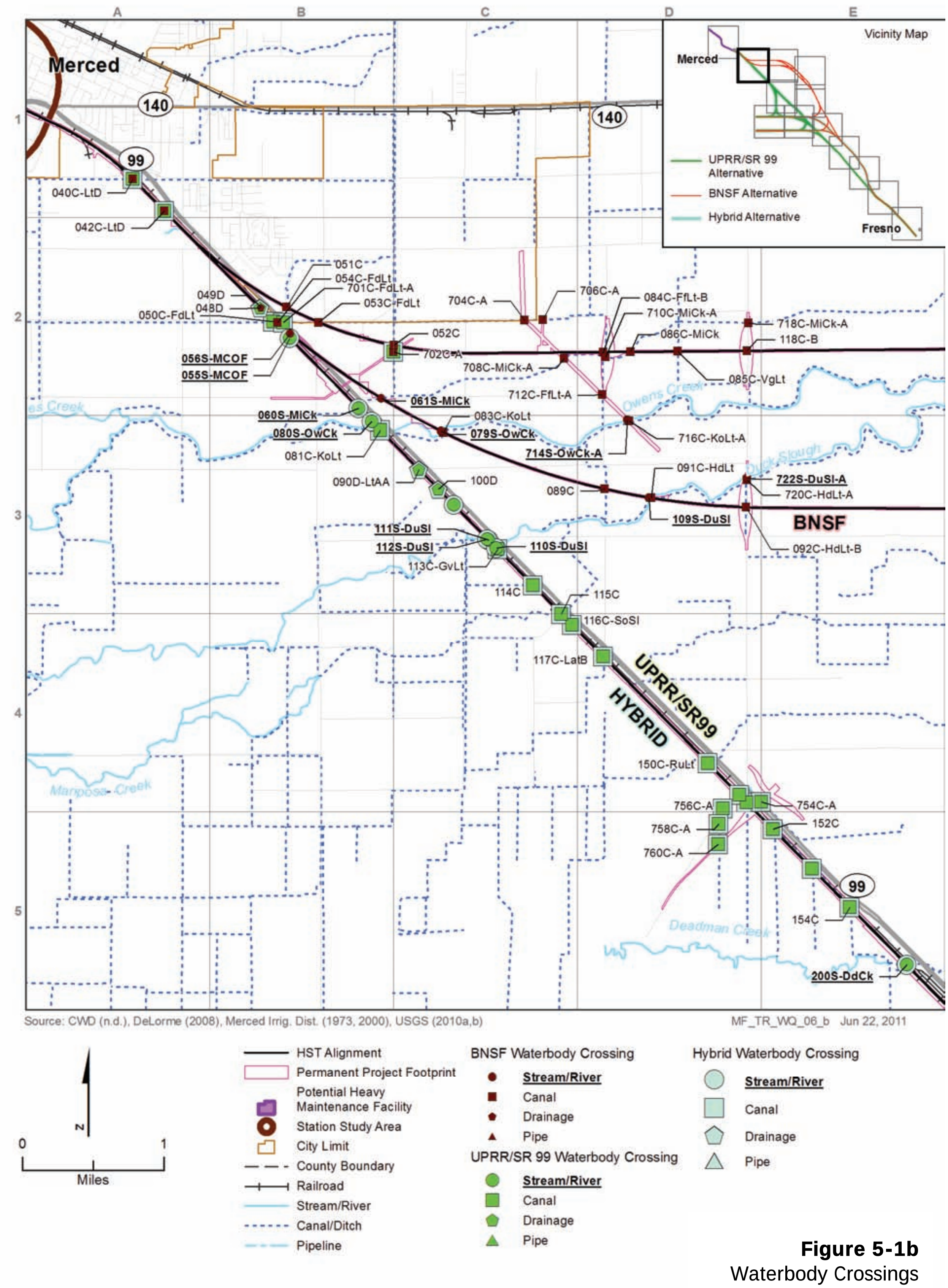


Figure 5-1b
Waterbody Crossings

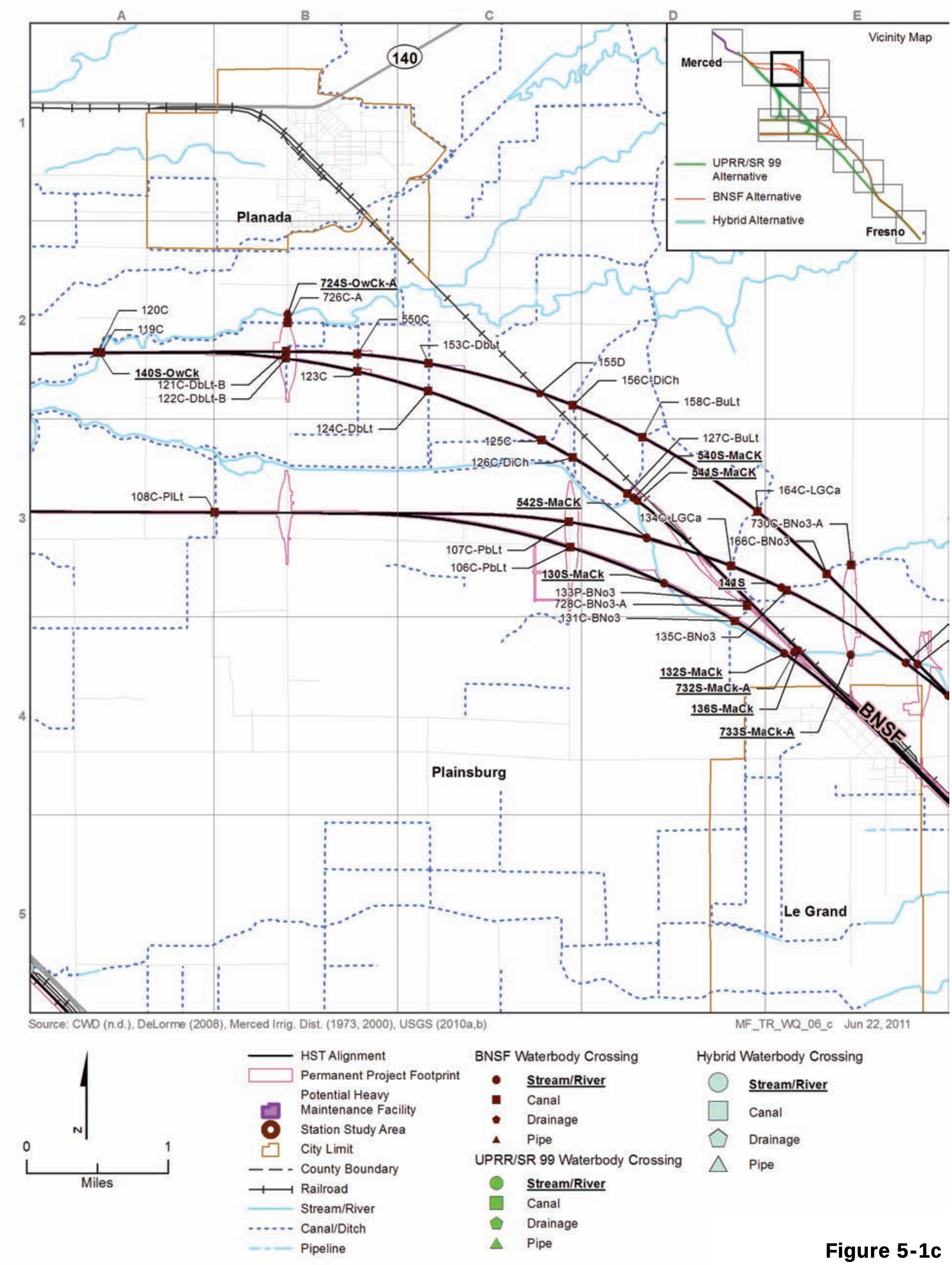


Figure 5-1c
Waterbody Crossings

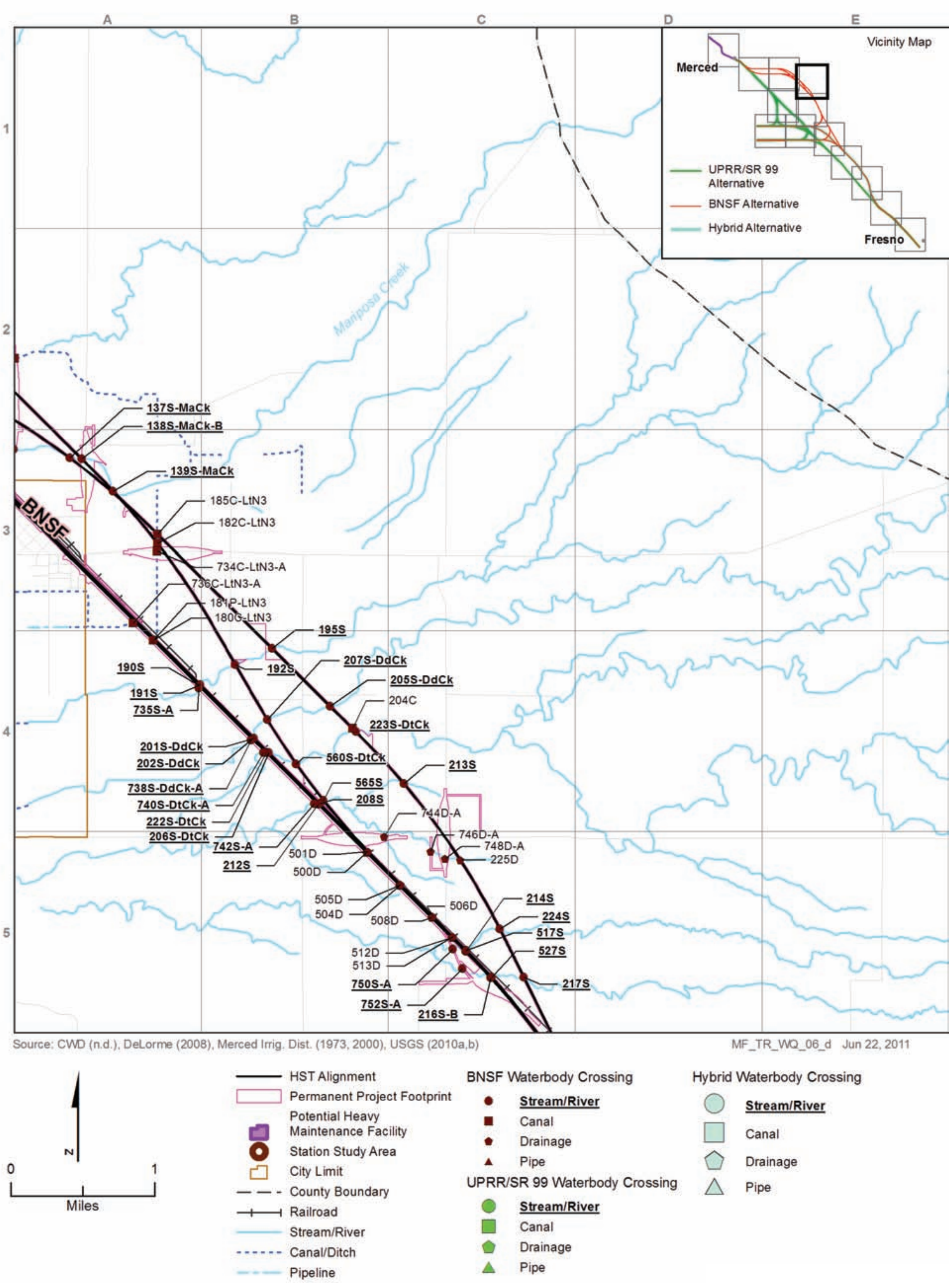


Figure 5-1d
Waterbody Crossings

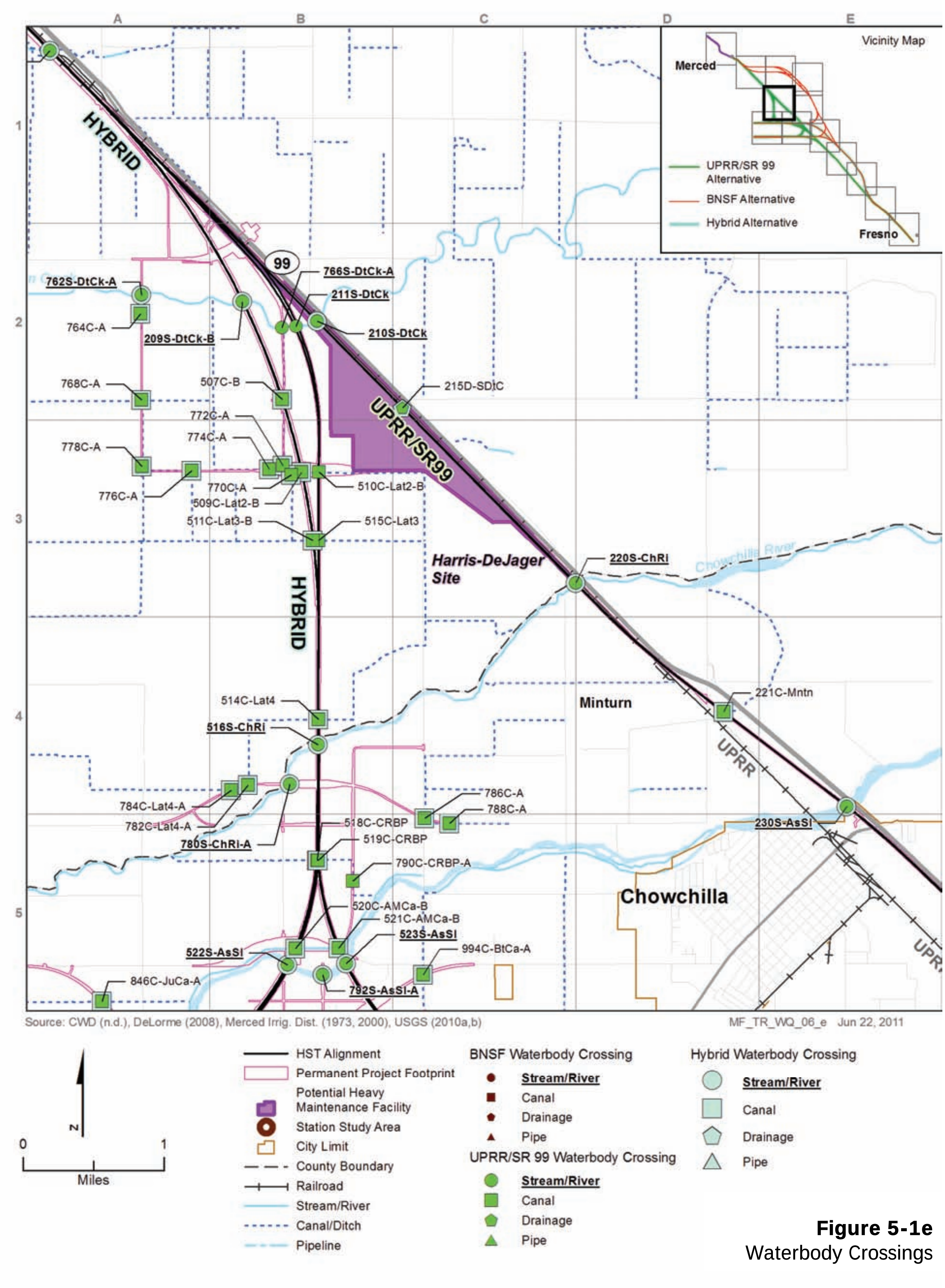


Figure 5-1e
Waterbody Crossings

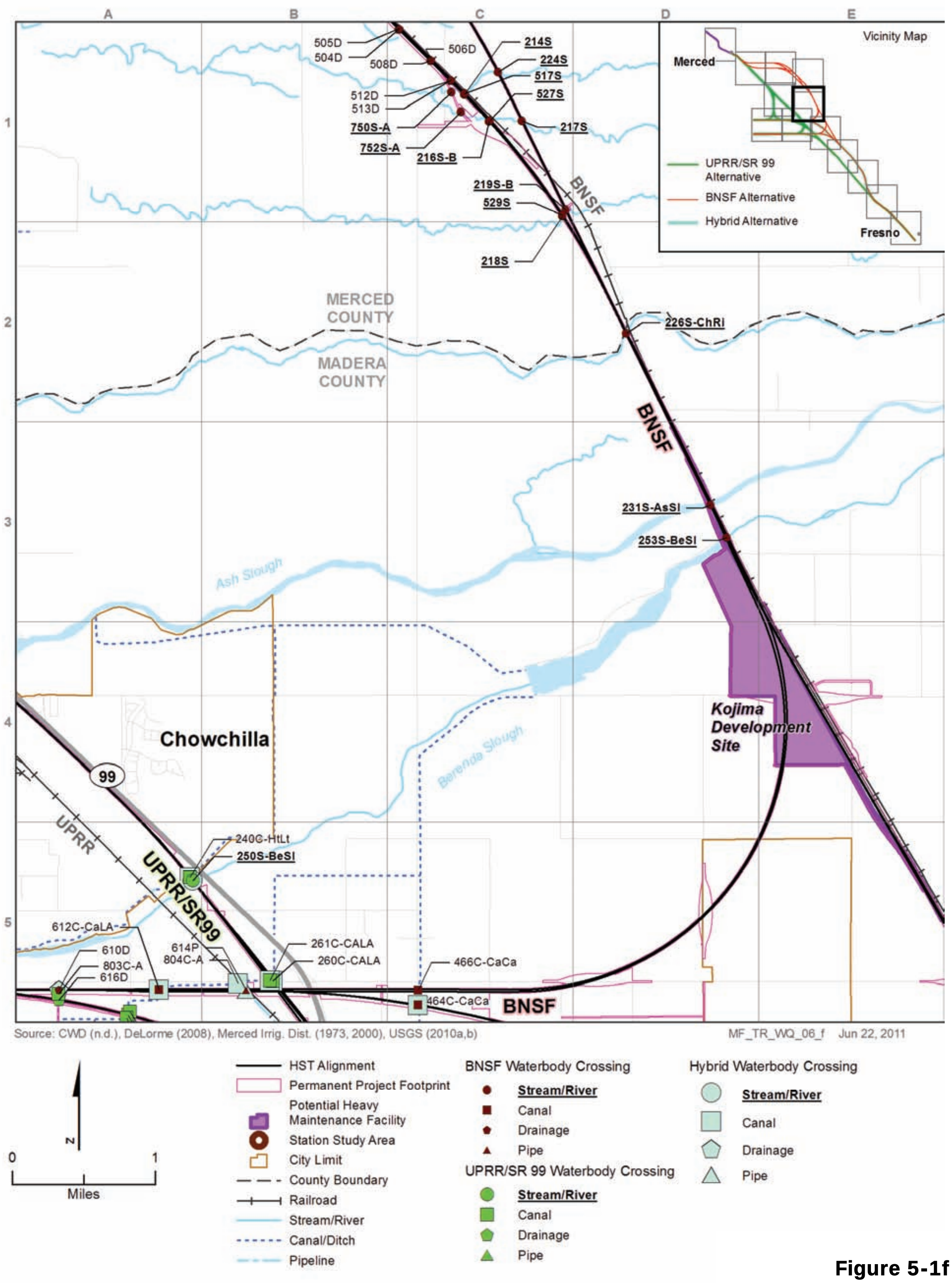


Figure 5-1f
Waterbody Crossings

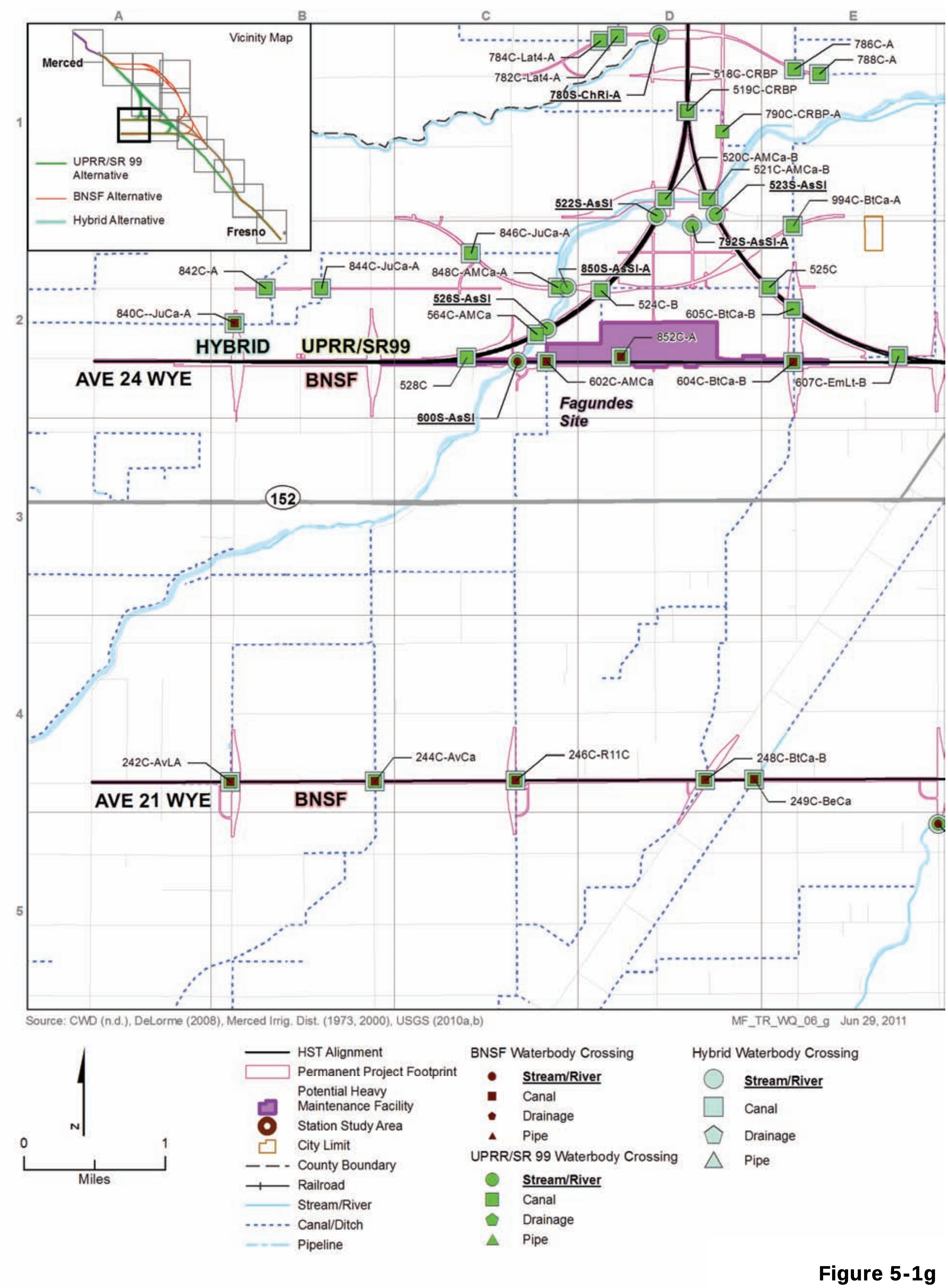


Figure 5-1g
Waterbody Crossings

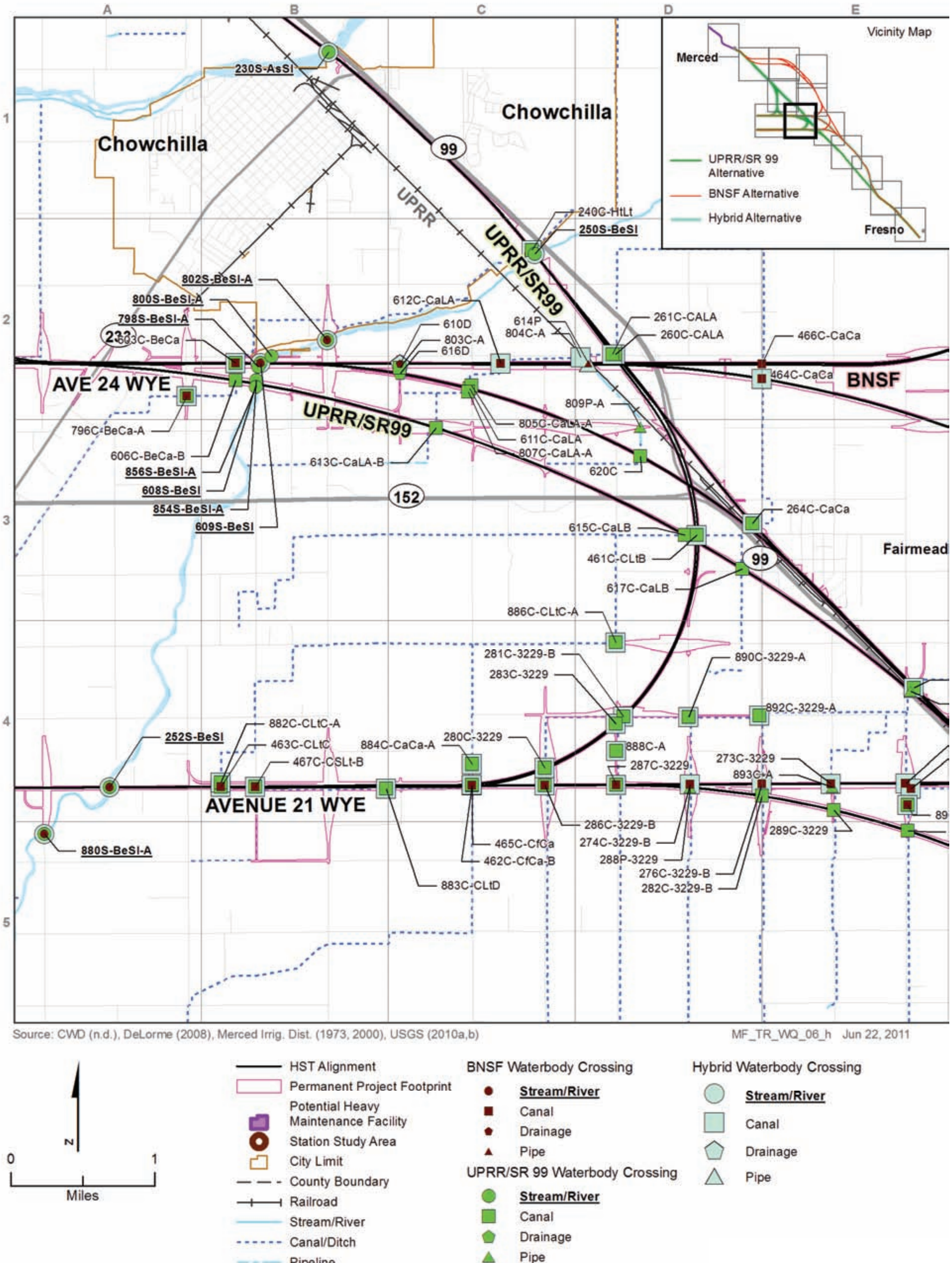


Figure 5-1h
Waterbody Crossings

CALIFORNIA High-Speed Rail Authority
U.S. Department of Transportation Federal Railroad Administration

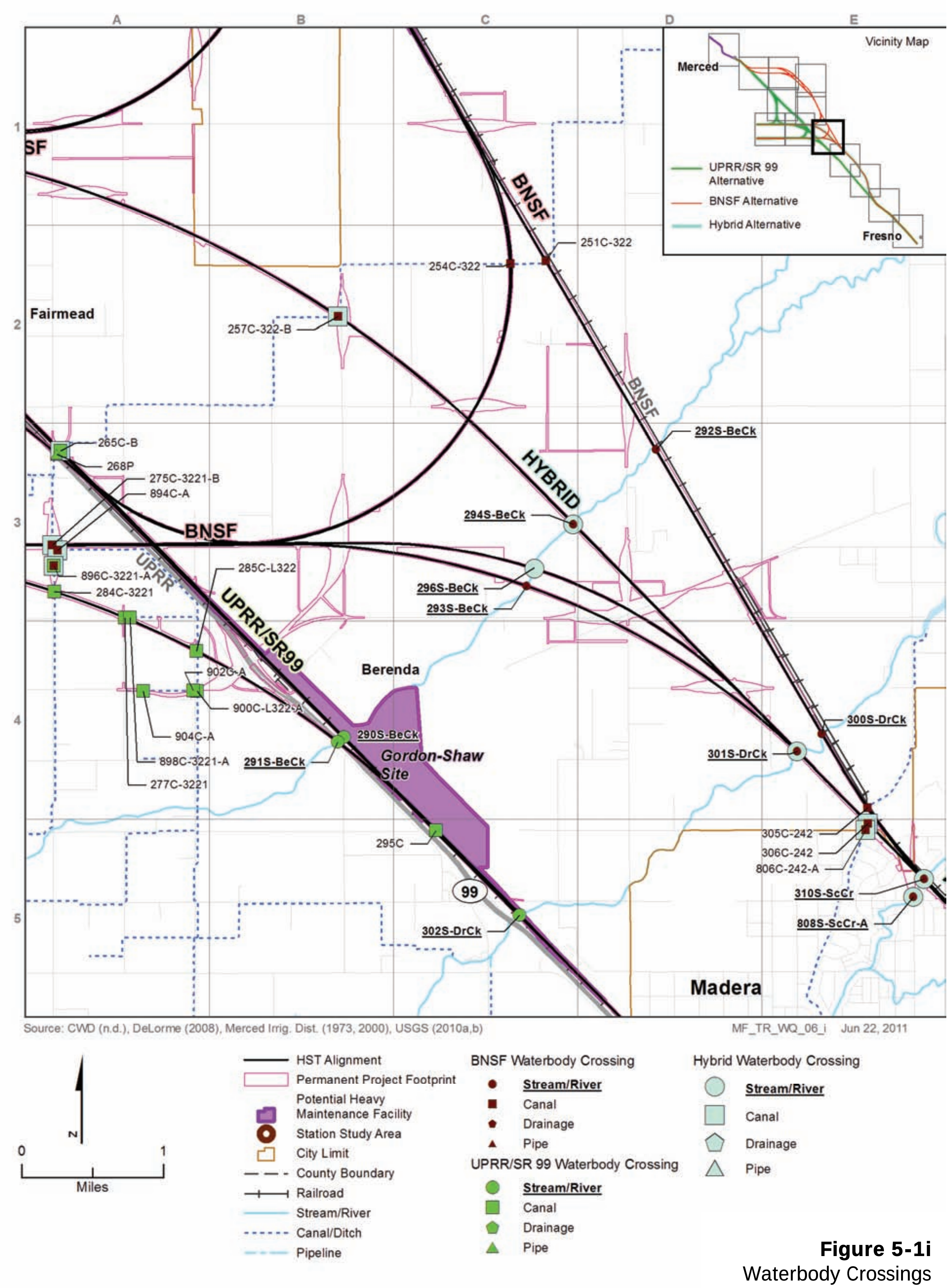


Figure 5-1i
Waterbody Crossings

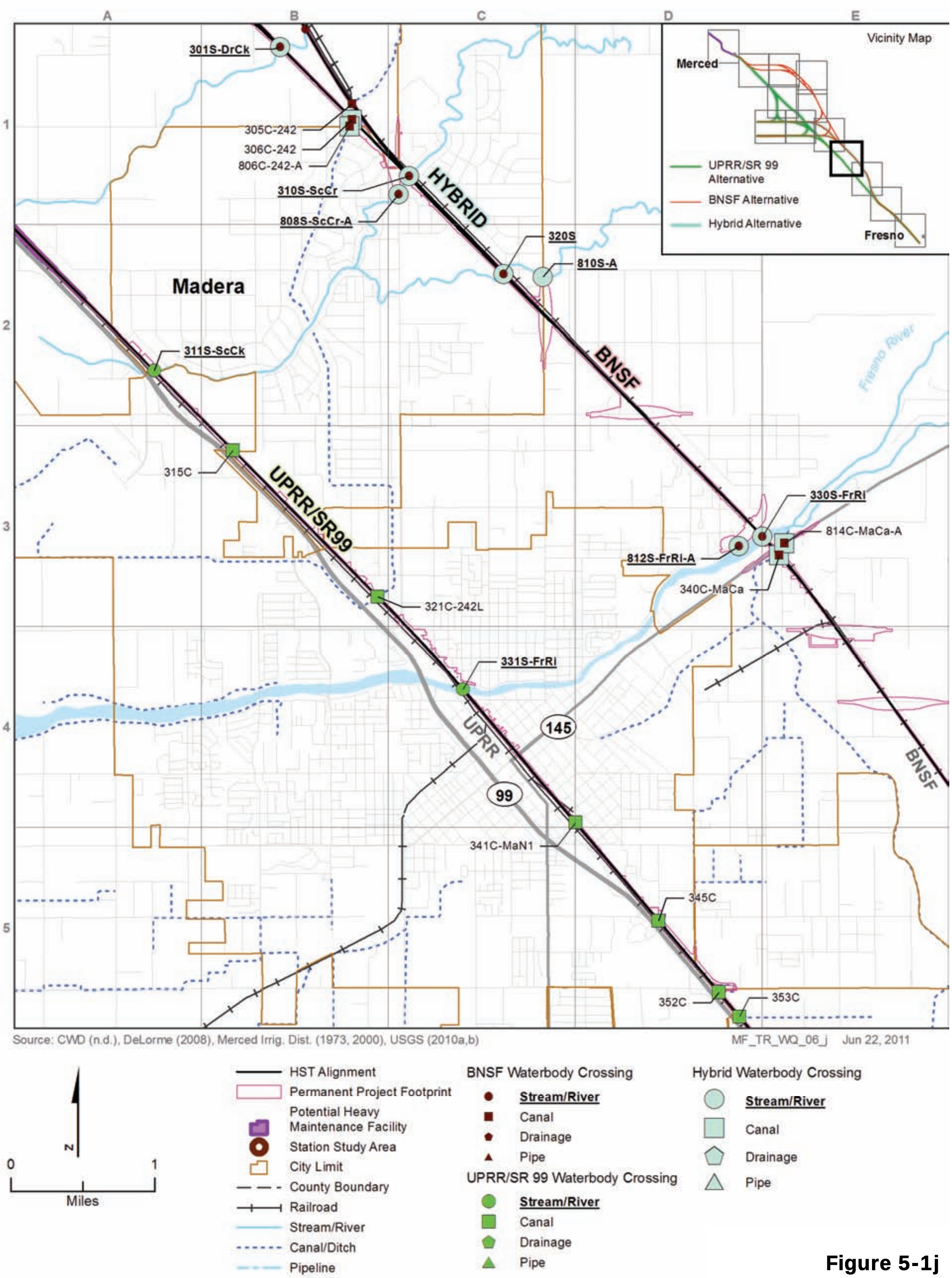


Figure 5-1j
Waterbody Crossings

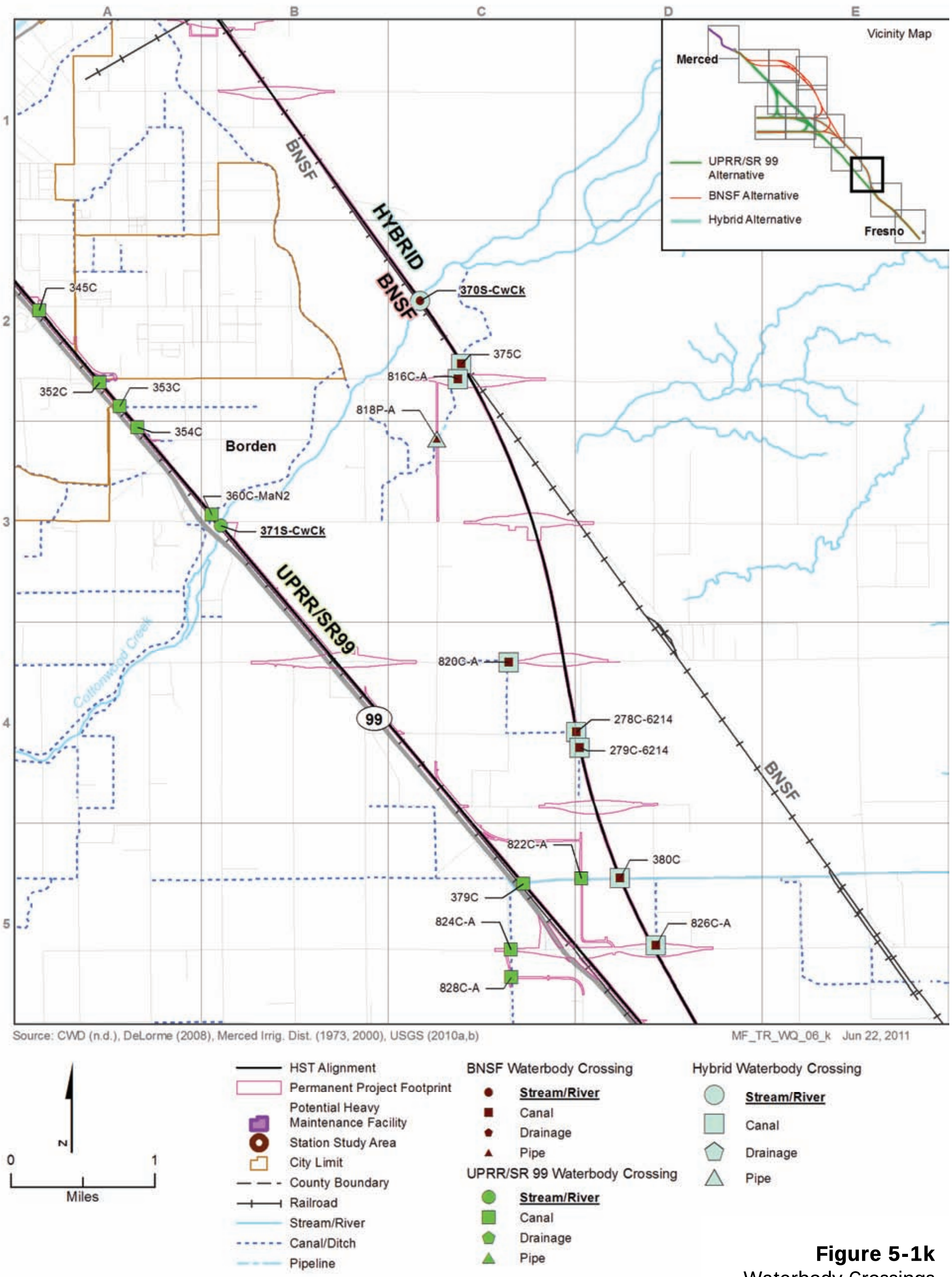


Figure 5-1k
Waterbody Crossings

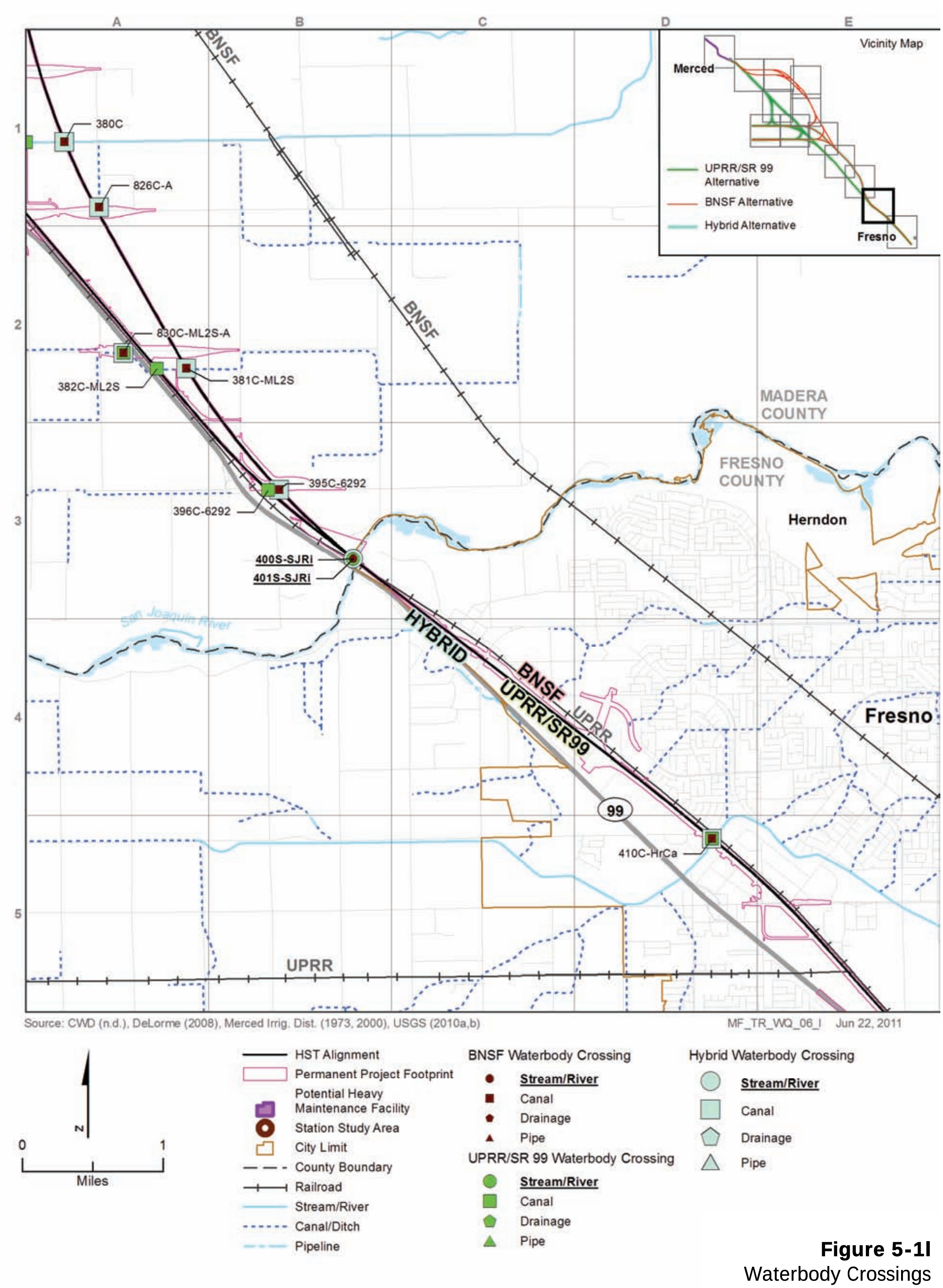


Figure 5-1l
Waterbody Crossings

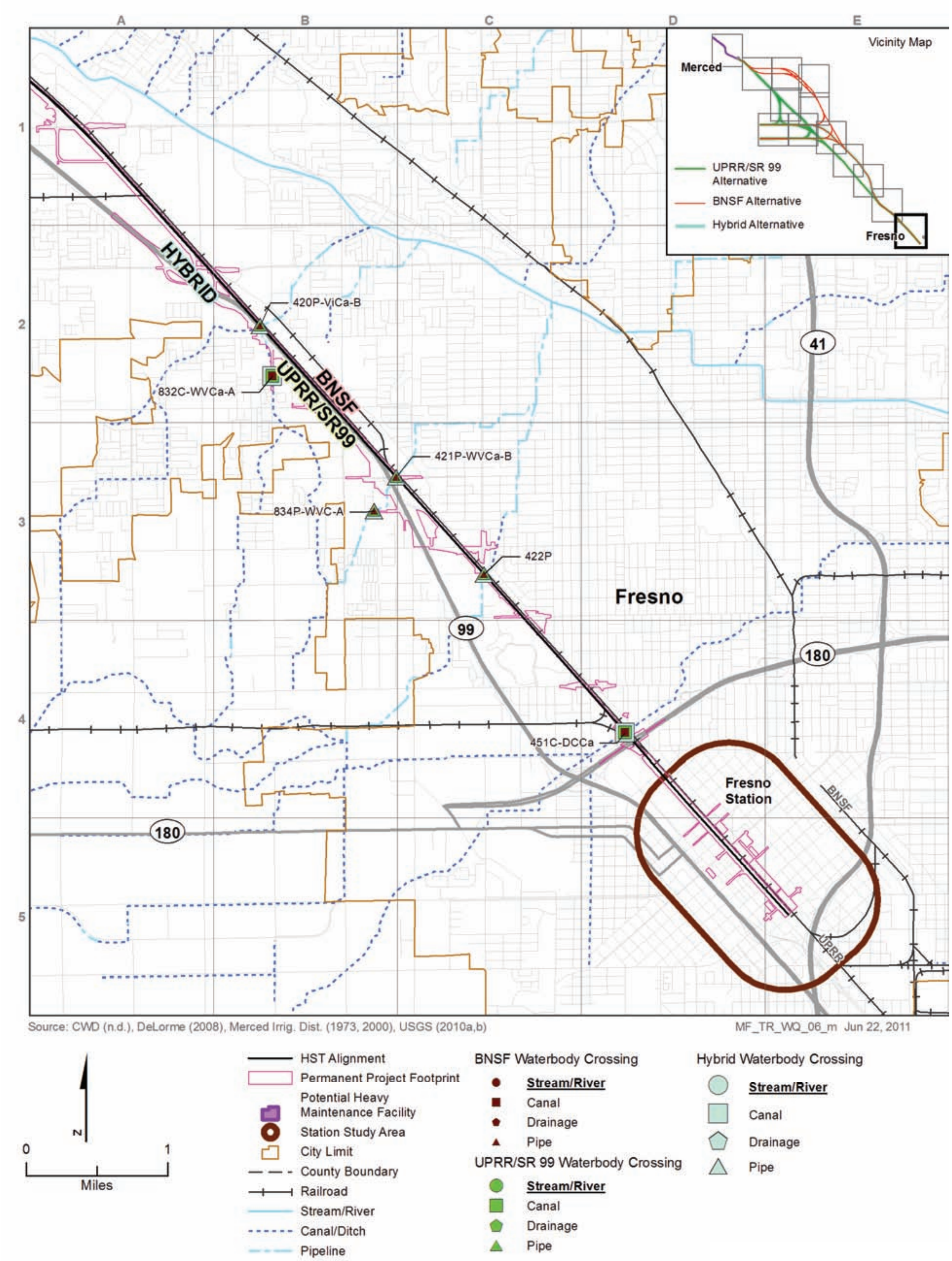


Figure 5-1m
Waterbody Crossings

Table 5-3
Inventory of Waterbody Crossings – UPRR/SR 99 Alternative

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
UPRR/SR 99 North-South Alignment (58 crossings for all wye and design options, generally listed north to south)								
040C-LtD	Lateral D	Canal	At-Grade	N/A	MerID	culvert	Note B	5-1b, A-1
042C-LtD	Lateral D	Canal	At-Grade	N/A	MerID	culvert	Note B	5-1b, A-1
702C-A		Canal	At-Grade	N/A	MerID	Relocate	20' beyond ROW	5-1b, C-2
048D		Ditch	At-Grade	N/A	Private	no data		5-1b, B-2
050C-FdLt	Farmdale Lateral	Canal	At-Grade	N/A	MerID	culvert	Note B	5-1b, B-2
701C-FdLt-A	Farmdale Lateral	Canal		N/A	MerID			5-1b, B-2
055S-MCOF	Miles Creek Overflow No. 1	Stream	At-Grade	N/A	Public[2]	culvert	Note B	5-1b, B-2
060S-MiCk	Miles Creek	Stream	At-Grade	N/A	Public[2]	multispan	PC/PS Box; 2-50' span	5-1b, B-2
080S-OwCk	Owens Creek	Stream	At-Grade	580	Public[2]	relocate/multispan	PC/PS Box; 2-50' span	5-1b, B-3
081C-KoLt	Koff Lateral	Canal	At-Grade	870	MerID	relocated/culvert	Note C	5-1b, B-3
090D-LtAA	Lateral A-A	Ditch	At-Grade	N/A	MerID			5-1b, C-3
100D		Ditch	At-Grade	N/A	MerID			5-1b, C-3
112S-DuSl	Duck Slough	Stream	At-Grade	N/A	Public[2]	realign/multispan	Note D	5-1b, C-3
111S-DuSl	Duck Slough	Stream	At-Grade	N/A	Public[2]	realign/multispan	Note D	5-1b, C-3
110S-DuSl	Duck Slough	Stream	At-Grade	N/A	Public[2]	realign/multispan	Note D	5-1b, C-3

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
113C-GvLt	Givens Lateral	Canal	At-Grade	N/A	MerID	relocated/culvert	Note D	5-1b, C-3
114C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1b, C-3
115C		Canal	At-Grade	N/A	MerID	culvert	Note B	5-1b, C-4
116C-SoSl	South Slough / Lingard Lateral	Canal	At-Grade	N/A	MerID	multispan	100' span, 2	5-1b, C-4
117C-LatB	Lateral B	Canal	At-Grade	N/A	MerID	Culvert	12' box culvert, 2	5-1b, D-4
150C-RuLt	South Slough / Russell Lateral	Canal	At-Grade	N/A	MerID	multispan	100' span, 2	5-1b, D-4
756C-A		Canal		550	Private	culvert		5-1b, D-4
758C-A		Canal		N/A	Private	culvert	12' box culvert, 2	5-1b, D-5
760C-A		Canal		N/A	Private	culvert		5-1b, D-5
754C-A		Canal		N/A	Private	culvert		5-1b, D-4
152C		Canal	At-Grade	N/A	Private[6]	Culvert	12' box culvert, 2	5-1b, E-5
154C		Canal	At-Grade	N/A	Private[6]	Culvert	12' box culvert, 2	5-1b, E-5
200S-DdCk (Ave 24 Wye, East Chowchilla and West Chowchilla Design Options split here)	Deadman Creek	Stream	At-Grade	N/A	Public	single span	PC/PS Box; 1-40' span	5-1e, A-1; 5-1b, E-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
265C-B (Ave 24 Wye, East Chowchilla and West Chowchilla Design Options join here)		Canal	Elevated	100	MadID	culvert	14' box culvert, 3	5-1i, A-3; 5-1h, E-4
290S-BeCk	Berenda Creek	Stream	Elevated	2760	Public[3]	Multispan	Note A	5-1i, B-4
295C		Canal	Elevated	N/A	Private	elevated		5-1i, C-5
302S-DrCk	Dry Creek	Stream	Elevated	N/A	Public[4]	Multispan	Note A	5-1i, C-5
311S-ScCk	Schmidt Creek	Stream	Elevated	N/A	Public[4]	Multispan	Note A	5-1j, A-2
315C		Canal	Elevated	N/A	Private	elevated		5-1j, B-3
321C-242L	MID 24.2 Lateral	Canal	Elevated	N/A	MadID	elevated		5-1j, B-3
331S-FrRi	Fresno River	Stream	Elevated	N/A	Public[4]	Multispan	Note A	5-1j, C-4
341C-MaN1	Main No. 1	Canal	Elevated	N/A	MadID	elevated		5-1j, C-4
345C		Canal	Elevated	N/A	Private	elevated		5-1k, A-2; 5-1j, D-5
352C		Canal	Elevated	N/A	Private	elevated		5-1k, A-2; 5-1j, D-5
353C		Canal	Elevated	N/A	Private	elevated		5-1k, A-2; 5-1j, D-5
354C		Canal	Elevated	N/A	Private	elevated		5-1k, A-3
360C-MaN2	Main No. 1	Canal	Elevated	N/A	MadID	elevated		5-1k, B-3

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
371S-CwCk	Cottonwood Creek	Stream	Elevated	N/A	Public[4]	Multispan	Note A	5-1k, B-3
379C		Canal	At-Grade	N/A	MadID	culvert	Note B	5-1k, C-5
822C-A		Canal		N/A	MadID	culvert	12' box culvert, 2	5-1k, D-5
824C-A		Canal		N/A	MadID	culvert		5-1k, C-5
828C-A		Canal		N/A	MadID	culvert	12' box culvert, 2	5-1k, C-5
382C-ML2S	Mid Lateral 6.2-9.25	Canal	At-Grade	N/A	MadID	culvert	Note B	5-1l, A-2
396C-6292	6.2-9.2-5.05	Canal	At-Grade	N/A	MadID	culvert	Note B	5-1l, B-3
401S-SJRi	San Joaquin River	Stream	Elevated	N/A	Public	Multispan	Note A	5-1l, B-3
410C-HrCa	Herndon Canal	Canal	Elevated	N/A	FID	elevated		5-1l, D-5
420P-ViCa-B	Victoria Canal	Pipe	At-Grade	1220	FID			5-1m, B-2
832C-WVCa-A	West Branch Victoria Canal	Canal		1140	FID	culvert		5-1m, B-2
421P-WVCa-B	West Branch Victoria Canal	Pipe	At-Grade	850	FID			5-1m, B-3
834P-WVC-A	West Branch Victoria Canal	Pipe		80	FID			5-1m, B-3
422P		Pipe	At-Grade	N/A	FID			5-1m, C-3
451C-DCCa	Dry Creek Canal	Canal	Retained Fill	N/A	FID	culvert	Note B	5-1m, D-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
830C-ML2S-A	Mid Lateral 6.2-9.25	Canal	Retained Fill (Roadway Embankment)	2030	MadID	Relocated/culvert	12' box culvert, 2, 175' box culvert	5-1l, A-2
UPRR/SR 99 East Chowchilla Design Option (9 crossings, generally listed north to south; wye crossings listed separately)								
210S-DtCk	Dutchman Creek	Stream	Elevated	380	Public[3]	Single Span	150' span	5-1e, B-2
215D-SDtC	South Dutchman Creek	Ditch	Elevated	N/A	Public[3]			5-1e, C-2
220S-ChRi	Chowchilla River	Stream	Elevated	N/A	Public[3]			5-1e, C-3
221C-Mntn	Minturn	Canal	Elevated	N/A	CWD	elevated		5-1e, D-4
230S-AsSl	Ash Slough	Stream	Elevated	N/A	Public[3]	Multispan	Note A	5-1h, B-1; 5-1e, E-4
240C-HtLt	Hartley Lateral	Canal	Elevated	N/A	CWD	elevated		5-1h, C-2; 5-1f, A-5
250S-BeSl	Berenda Slough	Stream	Elevated	N/A	Public[3]	Multispan	Note A	5-1h, C-2; 5-1f, A-5
260C-CALA	California Lateral A	Canal	Elevated	N/A	CWD	elevated		5-1h, D-2; 5-1f, B-5
264C-CaCa	Califa Canal	Canal	Elevated	N/A	CWD	elevated		5-1h, D-3
UPRR/SR 99 West Chowchilla Design Option(44 crossings, generally listed north to south; wye crossings listed separately)								
209S-DtCk-B	Dutchman Creek	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-40' span	5-1e, B-2
762S-DtCk-A	Dutchman Creek	Stream	At-Grade	N/A	Public[6]	multispan	PC/PS Box; 3-60' span	5-1e, A-2
764C-A		Canal	At-Grade	1280	Private	Relocate	20' beyond ROW	5-1e, A-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
507C-B		Canal	At-Grade	N/A	CWD	culvert	Note B	5-1e, B-2
768C-A		Canal	At-Grade	N/A	Private	culvert	12' box culvert, 2	5-1e, A-2
778C-A		Canal	At-Grade	250	Private	culvert	12' box culvert, 2	5-1e, A-3
776C-A		Canal	At-Grade	N/A	Private	culvert	12' box culvert, 2	5-1e, A-3
774C-A		Canal	Roadway Embankment	920	Private	culvert	12' box culvert, 3	5-1e, B-3
772C-A		Canal	Roadway Embankment	1230	Private	culvert	12' box culvert, 3	5-1e, B-3
770C-A		Canal		130	Private	No Impact		5-1e, B-3
509C-Lat2-B	Lat. 2	Canal	At-Grade	N/A	CWD	No Impact		5-1e, B-3
511C-Lat3-B	Lat. 3	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1e, B-3
514C-Lat4	Lat. 4	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1e, B-4
516S-ChRi	Chowchilla River	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 7-50' span	5-1e, B-4
784C-Lat4-A	Lat. 4	Canal	At-Grade	N/A	CWD	culvert	14' box culvert, 2	5-1g, D-1; 5-1e, B-4
782C-Lat4-A	Lat. 4	Canal	At-Grade	N/A	CWD	culvert	14' box culvert, 3	5-1g, D-1; 5-1e, B-4
780S-ChRi-A	Chowchilla River	Stream	Roadway Embankment	N/A	Public[3]	Multispan	100' span, 4	5-1g, D-1; 5-1e, B-4
786C-A		Canal	At-Grade	N/A	Private	culvert	12' box culvert, 3	5-1g, E-1; 5-1e, C-5
788C-A		Canal		540	Private	No Impact		5-1g, E-1; 5-1e, C-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
519C-CRBP	Chowchilla River By-Pass	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, D-1; 5-1e, B-5
521C-AMCa-B	Ash Main Canal	Canal	At-Grade	1640	CWD	culvert	14' box culvert, 3	5-1g, D-1; 5-1e, B-5
523S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 5-50' span	5-1g, D-1; 5-1e, B-5
792S-AsSl-A	Ash Slough	Stream		N/A	Public[3]			5-1g, D-2; 5-1e, B-5
994C-BtCa-A	Bethel Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1g, E-2; 5-1e, C-5
846C-JuCa-A	Justin Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1g, C-2; 5-1e, A-5
842C-A		Canal	At-Grade	N/A	CWD	Relocate	20' beyond ROW	5-1g, B-2
844C-JuCa-A	Justin Canal	Canal	at-Grade	N/A	CWD	Relocate	20' beyond ROW	5-1g, B-2
848C-AMCa-A	Ash Main Canal	Canal	Roadway Embankment	N/A	CWD	see 850S-AsSl-A	see 850S-AsSl-A	5-1g, C-2
850S-AsSl-A	Ash Slough	Stream	Roadway Embankment	N/A	Public[3]	Multispan	100' span, 6	5-1g, C-2
525C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1g, E-2
605C-BtCa-B	Bethel Canal	Canal	At-Grade	2660	CWD	culvert	Note B	5-1g, E-2
607C-EmLt-B	Eastman Lateral	Canal	At-Grade	4240	CWD	culvert	Note B	5-1g, E-2
796C-BeCa-A	Berenda Canal	Canal	Roadway Embankment	N/A	CWD	culvert	12' box culvert, 2	5-1h, A-2
603C-BeCa	Berenda Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, B-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
798S-BeSl-A	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 6-50' span	5-1h, B-2
609S-BeSl	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
800S-BeSl-A	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 8-80' span	5-1h, B-2
802S-BeSl-A	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
616D		Ditch	At-Grade	N/A	Private	culvert	12' box culvert, 3	5-1h, C-2; 5-1f, A-5
611C-CaLA	Califa Lateral A	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, C-2
807C-CaLA-A	Califa Lateral A	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1h, C-2
805C-CaLA-A	Califa Lateral A	Canal		N/A	CWD	culvert		5-1h, C-2; 5-1f, A-5
809P-A		Pipe	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1h, D-3
620C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1h, D-3
UPRR/SR 99 Ave 24 Wye for the West Chowchilla Design Option (11 crossings, generally listed west to east and then north to south; these crossings are also listed in the Ave 24 Wye for the East Chowchilla Design Option)								
840C--JuCa-A	Justin Canal	Canal		N/A	CWD	culvert		5-1g, B-2
528C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1g, C-2
600S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 10-60' span	5-1g, C-2
564C-AMCa	Ash Main Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, C-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
526S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 15-50' span	5-1g, C-2
602C-AMCa	Ash Main Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1g, C-2
524C-B		Canal	At-Grade	2820	Private	culvert	Note B	5-1g, D-2
522S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 5-50' span	5-1g, D-1; 5-1e, B-5
520C-AMCa-B	Ash Main Canal	Canal	At-Grade	2320	CWD	culvert	Note B	5-1g, D-1; 5-1e, B-5
518C-CRBP	Chowchilla River By-Pass	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, D-1; 5-1e, B-5
604C-BtCa-B	Bethel Canal	Canal	At-Grade	3040	CWD	culvert	12' box culvert, 2	5-1g, E-2
UPRR/SR 99 Ave 24 Wye for the East Chowchilla Design Option (31 crossings, generally listed north to south and then west to east)								
211S-DtCk	Dutchman Creek	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-40' span	5-1e, B-2
766S-DtCk-A	Dutchman Creek	Stream	At-Grade	N/A	Public[6]	multispan	PC/PS Box; 3-60' span	5-1e, B-2
510C-Lat2-B	Lat. 2	Canal	At-Grade	2060	CWD	No Impact		5-1e, B-3
774C-A		Canal	Roadway Embankment	920	Private	culvert	12' box culvert, 3	5-1e, B-3
772C-A		Canal	Roadway Embankment	1230	Private	culvert	12' box culvert, 3	5-1e, B-3
770C-A		Canal		130	Private	No Impact		5-1e, B-3
515C-Lat3	Lat. 3	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1e, B-3
514C-Lat4	Lat. 4	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1e, B-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
516S-ChRi	Chowchilla River	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 7-50' span	5-1e, B-4
790C-CRBP-A	Chowchilla River By-Pass	Canal	At-Grade	1360	CWD	culvert	12' box culvert, 2	5-1g, D-1; 5-1e, B-5
840C--JuCa-A	Justin Canal	Canal		N/A	CWD	culvert		5-1g, B-2
528C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1g, C-2
600S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 10-60' span	5-1g, C-2
564C-AMCa	Ash Main Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, C-2
526S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 15-50' span	5-1g, C-2
602C-AMCa	Ash Main Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1g, C-2
524C-B		Canal	At-Grade	2820	Private	culvert	Note B	5-1g, D-2
522S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 5-50' span	5-1g, D-1; 5-1e, B-5
520C-AMCa-B	Ash Main Canal	Canal	At-Grade	2320	CWD	culvert	Note B	5-1g, D-1; 5-1e, B-5
518C-CRBP	Chowchilla River By-Pass	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, D-1; 5-1e, B-5
792S-AsSl-A	Ash Slough	Stream		N/A	Public[3]			5-1g, D-2; 5-1e, B-5
604C-BtCa-B	Bethel Canal	Canal	At-Grade	3040	CWD	culvert	12' box culvert, 2	5-1g, E-2
606C-BeCa-B	Berenda Canal	Canal	At-Grade	240	CWD	culvert	12' box culvert, 2	5-1h, B-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
608S-BeSl	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
854S-BeSl-A	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
856S-BeSl-A	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
803C-A		Canal		1230	Private	culvert		5-1h, C-2; 5-1f, A-5
613C-CaLA-B	Califa Lateral A	Canal	At-Grade	830	CWD	culvert	12' box culvert, 3	5-1h, C-3
615C-CaLB	Califa Lateral B	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, D-3
617C-CaLB	Califa Lateral B	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, D-3
268P		Pipe	At-Grade	N/A	Private[8]			5-1i, A-3; 5-1h, E-4
UPRR/SR 99 Ave 21 Wye (38 crossings, generally listed west to east and then north to south; only applies to the East Chowchilla Design Option)								
242C-AvLA	Ashview Lateral A	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, B-4
244C-AvCa	Ashview Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, B-4
246C-R11C	Road 11 Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, C-4
248C-BtCa-B	Bethel Canal	Canal	At-Grade	2150	CWD	culvert	Note B	5-1g, D-4
249C-BeCa	Berenda Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, D-4
880S-BeSl-A	Berenda Slough	Stream		N/A	Public[3]			5-1h, A-5
252S-BeSl	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, A-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
463C-CLtC	Califa Lateral C	Canal	At-Grade	N/A	CWD	See 883C-CLtD		5-1h, B-4
882C-CLtC-A	Califa Lateral C	Canal		N/A	CWD	culvert		5-1h, B-4
467C-CSLt-B	Canal Spill Lateral	Canal	At-Grade	N/A	CWD	See 883C-CLtD		5-1h, B-4
883C-CLtD	Califa Lateral D	Canal	At-Grade	N/A	CWD	relocated (b/n Road 17 & Rd 15 1/2)	20' beyond ROW	5-1h, B-4
884C-CaCa-A	Califa Canal	Canal		260	CWD	See 465C-CfCa	See 465C-CfCa	5-1h, C-4
465C-CfCa	Califa Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 3	5-1h, C-4
462C-CfCa-B	Califa Canal	Canal	At-Grade	300	CWD	See 465C-CfCa	See 465C-CfCa	5-1h, C-4
280C-3229	32.2 9.9-2.0	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, C-4
286C-3229-B	32.2 9.9-2.0	Canal	At-Grade	4280	CWD	culvert	12' box culvert, 3	5-1h, C-4
886C-CLtC-A	Califa Lateral C	Canal		N/A	CWD	culvert		5-1h, D-4
283C-3229		Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, D-4
888C-A		Canal		1640	CWD	culvert/relocate	12' box culvert, 3	5-1h, D-4
287C-3229	32.2-9.9	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, D-4
281C-3229-B	32.2-9.9	Canal	At-Grade	3750	CWD	culvert	Note B	5-1h, D-4
461C-CLtB	Califa Lateral B	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, D-3
890C-3229-A	32.2-9.9	Canal		N/A	CWD	No Impact		5-1h, D-4
288P-3229	32.2-9.9-1.5	Pipe	At-Grade	N/A	CWD	culvert	12' box culvert, 3	5-1h, D-4
892C-3229-A	32.2-9.9	Canal		N/A	CWD	No Impact		5-1h, D-4
282C-3229-B	32.2-9.9-1.0	Canal	At-Grade	1830	CWD	culvert	12' box culvert, 3	5-1h, D-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
261C-CALA	California Lateral A	Canal	Elevated	N/A	CWD	elevated		5-1h, D-2; 5-1f, B-5
893P-A		Pipe		N/A				5-1h, E-4
289C-3229	32.2-9.9-0.1	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 3	5-1h, E-4
284C-3221	32.2-10.2	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 3	5-1i, A-3; 5-1h, E-5
896C-3221-A	32.2-10.2	Canal	Retained Fill (Roadway Embankment)	1850	CWD	relocated	1000', prop toe of slope	5-1i, A-3; 5-1h, E-4
277C-3221	32.2-11.7	Canal	Elevated	N/A	CWD	culvert	12' box culvert, 2	5-1i, A-3
898C-3221-A	32.2-11.7	Canal		N/A	CWD	culvert		5-1i, A-3
285C-L322	LAT 32.2	Canal	Elevated	N/A	CWD	No Impact		5-1i, A-4
904C-A		Canal		820	CWD	culvert	12' box culvert, 3	5-1i, A-4
902C-A		Canal		200	CWD	culvert	12' box culvert, 3	5-1i, A-4
900C-L322-A	LAT 32.2	Canal		60	CWD	culvert		5-1i, A-4
291S-BeCk	Berenda Creek	Stream	Elevated	N/A	Public[3]	Multispan	Note A	5-1i, B-4
Access Guideway for the Castle Commerce Center HMF (12 crossings, generally listed north to south)								
016C-CdLt	Casad Lateral	Canal	At-Grade	N/A	MerID	outside limits		5-1a, A-1
005C		Canal	At-Grade	6430	Private			5-1a, A-1
002S		Stream	At-Grade	2990	Private[7]			5-1a, B-2
010S-CaCk	Canal Creek	Stream	At-Grade	1040	Public[2]	outside limits		5-1a, B-2
008C		Canal	At-Grade	1670	Private			5-1a, B-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
700C		Canal	At-Grade	N/A	MerID	culvert	Note B	5-1a, B-2
011C		Canal	Elevated	N/A	MerID	outside limits		5-1a, B-2
009C		Canal	Elevated	N/A	MerID			5-1a, C-2
025P-PoLt	Pohlie Lateral	Canal	At-Grade	N/A	MerID	outside limits		5-1a, C-3
020S-BRCk	Black Rascal Creek	Stream	Elevated	N/A	Public	outside limits		5-1a, C-4
030S-BaCk	Bear Creek	Stream	Retained Fill	N/A	Public[2]	outside limits		5-1a, D-4
031P		Pipe	Retained Fill	N/A	Private	outside limits		5-1a, D-4
Fagundes HMF (1 crossing)								
852C-A		Canal		3380	CWD	No Impact		5-1g, D-2

[1] Many of the "natural" waterways designated "public" are an integral part of the local irrigation or water district distribution system for conveyance of irrigation water. The footnotes indicate the local district that utilizes the waterway and may have some operational and maintenance authority with respect to the waterway.

[2] MerID = Merced Irrigation District

[3] CWD = Chowchilla Water District

[4] MadID = Madera Irrigation District

[5] FID = Fresno Irrigation District

[6] LGAWD = Le Grand-Athlone Water District

[7] City of Atwater storm water channel

[8] Cal Trans drainage facility

[9] Drainage swale between County road and railroad

[10] County road drainage facility

A Where track is supported on elevated guideway the spans are anticipated to be between 100-120 ft between supports. Supports would be adjusted to avoid conflicts with the water feature

B All canals crossing the HST R/W within either at-grade or retained fill sections of the alignments are assumed to be conveyed within concrete box culverts for larger canals, pipe culverts for open-channel ditch crossings at new roads, and pipes where the canal is placed in a siphon. Sizes, lengths and approach will be determined during 30% design."

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location

C Relocation of Owens Creek [900' +/-] and Koff Lateral [1000' +/-] to the west of the HST at-grade section is required. Will require one multispan bridge for the natural waterway and one culvert for the lateral.

D Realign Duck Slough [550' +/-] and Givens Lateral [750' +/-] to the west of the HST at-grade section is required. Will require one multispan bridge for the natural waterway and one culvert for the lateral.

E Realign Mariposa Creek [800' +/-] to shift the channel to the east of the HST at-grade section would eliminate the structure required.

F Realign Mariposa Creek [600' +/-] to shift the channel to the southwest of the HST at-grade section would eliminate the structure required. May be possible to move the beginning of the elevated section to the east, but the foundations would end up in the meander of the creek.

The UPRR/SR 99 Alternative crosses 15 natural channels (i.e., streams, slough, or rivers). The Castle Commerce Center track crosses an additional 3 named and 1 unnamed natural channels. Table 5-4 lists the crossings from north to south. Including multiple waterbody crossings, there are 27, 20, and 27 natural waterbody crossings along the configurations respectively named East Chowchilla design option with Ave 24 Wye, East Chowchilla design option with Ave 21 Wye, and West Chowchilla design option with Ave 24 Wye . These alignment configurations cross 71, 85, and 86 constructed (i.e., canal or pipeline) waterbodies, respectively.

Table 5-4
Natural Waterbodies Crossed by the UPRR/SR 99 Alternative

Natural Waterbody	East Chowchilla Design Option with Ave 24 Wye	East Chowchilla Design Option with Ave 21 Wye	West Chowchilla Design Option with Ave 24 Wye
Access Track to Castle Commerce Center HMF			
Unnamed Creek	002S	002S	002S
Canal Creek	010S-CaCk	010S-CaCk	010S-CaCk
Black Rascal Creek	020S-BRCk	020S-BRCk	020S-BRCk
Bear Creek	030S-BaCk	030S-BaCk	030S-BaCk
Total Natural Waterbodies	4	4	4
Constructed Waterbodies[a]	8	8	8
Total Waterbodies[a]	12	12	12
UPRR/SR 99 Alignment			
Miles Creek Overflow No. 1	055S-MCOF	055S-MCOF	055S-MCOF
Miles Creek	060S-MiCk	060S-MiCk	060S-MiCk
Owens Creek	080S-OwCk	080S-OwCk	080S-OwCk
Duck Slough	112S-DuSl	112S-DuSl	112S-DuSl
	111S-DuSl	111S-DuSl	111S-DuSl
	110S-DuSl	110S-DuSl	110S-DuSl
Deadman Creek	200S-DdCk	200S-DdCk	200S-DdCk
Dutchman Creek	210S-DtCk	210S-DtCk	
	--	--	209S-DtCk-B
	--	--	762S-DtCk-A
	211S-DtCk	--	--
	766S-DtCk-A	--	--
Chowchilla River	220S-ChRi	220S-ChRi	
	--	--	780S-ChRi-A
	516S-ChRi	--	516S-ChRi

Natural Waterbody	East Chowchilla Design Option with Ave 24 Wye	East Chowchilla Design Option with Ave 21 Wye	West Chowchilla Design Option with Ave 24 Wye
Ash Slough	230S-AsSl	230S-AsSl	
	--	--	523S-AsSl
	--	--	850S-AsSl-A
	600S-AsSl	--	600S-AsSl
	526S-AsSl	--	526S-AsSl
	522S-AsSl	--	522S-AsSl
	792S-AsSl-A	--	792S-AsSl-A
Berenda Slough	250S-BeSl	250S-BeSl	
	--	--	798S-BeSl-A
	--	--	800S-BeSl-A
	--	--	609S-BeSl
	--	--	802S-BeSl-A
	608S-BeSl	--	--
	854S-BeSl-A	--	--
	856S-BeSl-A	--	--
	--	880S-BeSl-A	--
	--	252S-BeSl	--
Berenda Creek	290S-BeCk	290S-BeCk	290S-BeCk
		291S-BeCk	
Dry Creek	302S-DrCk	302S-DrCk	302S-DrCk
Schmidt Creek	311S-ScCk	311S-ScCk	311S-ScCk
Fresno River	331S-FrRi	331S-FrRi	331S-FrRi
Cottonwood Creek	371S-CwCk	371S-CwCk	371S-CwCk
San Joaquin River	401S-SJRi	401S-SJRi	401S-SJRi
Natural Waterbodies	27	20	27
Constructed Waterbodies[a]	71	85	86
Total Waterbodies[a]	98	105	113

[a] These values include waterbodies enclosed in pipes, and are greater than values presented for canals and ditches only.

5.1.2 BNSF Alternative

Table 5-5 lists all waterbody crossings under the BNSF Alternative for the north-south alignment, Ave 24 Wye and Ave 21 Wye, and four design options (Mission Ave, Mission Ave East of Le Grand, Mariposa Way, and Mariposa Way East of Le Grand). At a few locations, crossings may pertain to more than one heading and be repeated. Design options in Fresno are sufficiently similar that they are not differentiated. Appendix B contains fact sheets for the BNSF Alternative natural waterbody crossings that are named. Table 5-5 provides the same types of information as Table 5-3.

The BNSF Alternative crosses 16 named natural channels and 7 unnamed tributaries. Table 5-6 lists these natural channels from north to south. The number of natural, constructed, and total waterbodies are listed at the bottom of the table for each BNSF Alternative configuration.

5.1.3 Hybrid Alternative

Table 5-7 lists all waterbody crossings for the Hybrid Alternative. Design options in Fresno are sufficiently similar that they are not differentiated. Appendix B contains fact sheets for the Hybrid Alternative natural waterbody crossings that are named. These can be cross-referenced to Table 5-7.

The Hybrid Alternative crosses 16 natural channels (streams, rivers, and sloughs); 15 of the channels are named and 1 is unnamed. Table 5-8 lists the channels from north to south. The Hybrid Alternative alignment crosses 29 natural and 84 constructed waterbodies.

5.1.4 Heavy Maintenance Facility

Figure 5-1 shows the general location of the potential sites for an HMF. Figures 4-3a through 4-3e show the sites in greater detail. All five sites are potentially affected by waterbody crossings or floodplains. The following are potential sites for the HMF and the waterbodies adjacent to those sites

- Castle Commerce Center HMF Site – bisected by Canal Creek.
- Harris-DeJager HMF Site – bordered on the north side by Dutchman Creek and bordered by the Chowchilla River at the southwestern end of the site.
- Fagundes HMF Site –bordered by Ash Slough on the northwest side of the site.
- Gordon-Shaw HMF Site –bordered by Berenda Creek at the northwestern end of the site.
- Kojima Development HMF Site –bordered by Berenda Slough at the northwest end of the site.

As design evolves and more information becomes available, care should be taken to identify if waterbodies are crossed or within the footprint of site facilities to evaluate the permit requirements that may pertain.

Table 5-5
Inventory of Waterbody Crossings – BNSF Alternative

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
BNSF Alternative North-South Alignment, Excluding Design Options (38 crossings, generally listed north to south)								
040C-LtD	Lateral D	Canal	At-grade	N/A	MerID	culvert	Note B	5-1b, A-1
042C-LtD	Lateral D	Canal	At-grade	N/A	MerID	culvert	Note B	5-1b, A-1
702C-A		Canal	At-grade	N/A	MerID	Relocate	20' beyond ROW	5-1b, C-2
Water crossings within the design option alignments fall sequentially here and are listed in separate sections below.								
226S-ChRi	Chowchilla River	Stream	At-grade	N/A	Private			5-1f, D-2
231S-AsSl	Ash Slough	Stream	At-grade	220	Private			5-1f, D-3
253S-BeSl	Berenda Slough	Stream	At-grade	360	Private			5-1f, D-3
251C-322	LAT 32.2	Canal	At-grade	N/A	CWD	culvert	Note B	5-1i, C-2
292S-BeCk	Berenda Creek	Stream	At-grade	N/A	MerID	elevated		5-1i, D-3
300S-DrCk	Dry Creek	Stream	At-grade	N/A	Private	culvert		5-1i, E-4
305C-242	24.2	Canal	At-grade	N/A	MadID	culvert	Note B	5-1j, B-1; 5-1i, E-4
806C-242-A	24.2	Canal		N/A	CWD	culvert		5-1j, B-1; 5-1i, E-5
310S-ScCr	Schmidt Creek	Stream	At-grade	N/A	Public[4]	culvert		5-1j, C-1; 5-1i, E-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
808S-ScCr-A	Schmidt Creek	Stream		N/A	Public[4]			5-1j, C-1; 5-1i, E-5
320S		Stream	At-grade	N/A	Public[2]	multispan	PC/PS Box; 2-50' span	5-1j, C-2
330S-FrRi	Fresno River	Stream	At-grade	N/A	Public[4]	multispan	PC/PS Box; 9-50' span	5-1j, D-3
812S-FrRi-A	Fresno River	Stream	N/A	400	Public[4]	N/A	N/A	5-1j, D-3
814C-MaCa-A	Main Canal	Canal	At-grade (Roadway)	N/A	MadID	culvert	100' box culvert	5-1j, E-3
340C-MaCa	Main Canal	Canal	At-grade	N/A	MadID	culvert	Note B	5-1j, E-3
370S-CwCk	Cottonwood Creek	Stream	At-grade	N/A	Public[4]	multispan	PC/PS Box; 5-50' span	5-1k, C-2
375C		Canal	At-grade	N/A	Private	culvert	Note B	5-1k, C-2
816C-A		Canal	N/A	540	MadID	N/A	N/A	5-1k, C-2
818P-A		Pipe		N/A	MadID			5-1k, C-3
820C-A		Canal	At-grade (Roadway)	N/A	MadID	culvert	60' box culvert	5-1k, C-4
278C-6214	6.2-14.0-W	Canal	At-grade	N/A	MadID	culvert	Note B	5-1k, D-4
279C-6214	6.2-14.0-W	Canal	At-grade	N/A	Public[2]	multispan	PC/PS Box; 5-80' span	5-1k, D-4
380C		Canal	At-grade	N/A	MadID	culvert	Note B	5-1l, A-1; 5-1k, D-5
826C-A		Canal	N/A	N/A	MadID	N/A	N/A	5-1l, A-1; 5-1k, D-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
381C-ML2S	Mid Lateral 6.2-9.25	Canal	At-grade	N/A	MadID	culvert	Note B	5-1l, A-2
395C-6292	6.2-9.2-5.05	Canal	At-grade	N/A	MadID	culvert	Note B	5-1l, B-3
400S-SJRi	San Joaquin River	Stream	Elevated	N/A	Public	Multispan	Note A	5-1l, B-3
410C-HrCa	Herndon Canal	Canal	Elevated	N/A	FID	elevated		5-1l, D-5
420P-ViCa-B	Victoria Canal	Pipe	At-grade	1220	FID			5-1m, B-2
832C-WVCa-A	West Branch Victoria Canal	Canal		1140	FID	culvert		5-1m, B-2
421P-WVCa-B	West Branch Victoria Canal	Pipe	At-grade	850	FID			5-1m, B-3
834P-WVC-A	West Branch Victoria Canal	Pipe		80	FID			5-1m, B-3
422P		Pipe	At-grade	N/A	FID			5-1m, C-3
451C-DCCa	Dry Creek Canal	Canal	Retained Fill	N/A	FID	culvert	Note B	5-1m, D-4
830C-ML2S-A	Mid Lateral 6.2-9.25	Canal	Retained Fill (Roadway Embankment)	2030	MadID	Relocated/culvert	12' box culvert, 2, 175' box culvert	5-1l, A-2
Design Option: Mission Ave (49 crossings, generally listed north to south)								
051C		Canal	Elevated	N/A	Private[8]	no data		5-1b, B-2
053C-FdLt	Farmdale Lateral	Canal	Elevated	N/A	MerID	elevated		5-1b, B-2
052C		Canal	Elevated	N/A	MerID	no data		5-1b, C-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
704C-A		Canal		N/A	MerID			5-1b, C-2
706C-A		Canal		N/A	MerID			5-1b, C-2
708C-MiCk-A	Miles Creek	Canal		N/A	Public[2]			5-1b, C-2
084C-FfLt-B	Fairfield Lateral	Canal	At-grade	2330	Public[3]	multispan	PC/PS Box; 3-30' span	5-1b, D-2
710C-MiCk-A	Miles Creek	Canal	Elevated (Roadway)	N/A	Public[2]	multispan	100' spans, 4	5-1b, D-2
712C-FfLt-A	Fairfield Lateral	Canal		N/A	MerID			5-1b, D-2
086C-MiCk	Miles Creek	Canal	At-grade	N/A	MerID			5-1b, D-2
714S-OwCk-A	Owens Creek	Stream		N/A	Public[2]			5-1b, D-3
716C-KoLt-A	Koff Lateral	Canal		N/A	MerID			5-1b, D-3
085C-VgLt	Vaughn Lat.	Canal	At-grade	N/A	MerID	culvert	Note B	5-1b, D-2
118C-B		Canal	At-grade	2130	MerID	culvert	Note B	5-1b, D-2
718C-MiCk-A	Miles Creek	Canal	At-grade (Roadway)	N/A	Public[2]	single span	70' span	5-1b, D-2
120C		Canal	At-grade	N/A	Public[6]			5-1c, A-2
140S-OwCk	Owens Creek	Stream	At-grade	N/A	Public[3]	multispan	PC/PS Box; 5-50' span	5-1c, A-2
119C		Canal	At-grade	N/A	MerID	culvert	Note B	5-1c, A-2
122C-DbLt-B	Dibblee Lateral	Canal	At-grade	1460	Private			5-1c, B-2
123C		Canal	At-grade	N/A	Private	relocate pond		5-1c, B-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
124C-DbLt	Dibblee Lateral	Canal	At-grade	N/A	Private	no data		5-1c, C-2
125C		Canal	Elevated	N/A	CWD	culvert	Note B	5-1c, C-3
126C-DiCh	Diversion Channel (U.S.E.D)	Canal	Elevated	N/A	Private			5-1c, C-3
127C-BuLt	Burchell Lat	Canal	Elevated	N/A	Public[2]			5-1c, D-3
540S-MaCK	Mariposa Creek	Stream	At-grade	N/A	Public[2]	multispan	PC/PS Box; 3-30' span	5-1c, D-3
541S-MaCK	Mariposa Creek	Stream	At-grade	N/A	CWD	culvert	Note B	5-1c, D-3
133P-BNo3	Booster No. 3	Pipe	At-grade	N/A	Private	elevated		5-1c, D-3
728C-BNo3-A	Booster No. 3	Canal		N/A	MerID	culvert		5-1c, D-3
136S-MaCk	Mariposa Creek	Stream	At-grade	N/A	MerID	culvert	Note B	5-1c, E-4
732S-MaCk-A	Mariposa Creek	Stream		N/A	Public[2]			5-1c, E-4
736C-LtN3-A	No. 3 LAT	Canal	At-grade (Roadway)	N/A	MerID	culvert	70' box culvert	5-1d, A-3
181P-LtN3	No. 3 LAT	Pipe	At-grade	N/A	MerID			5-1d, A-4
191S		Stream	At-grade	N/A	Private	multispan	PC/PS Box; 3-30' span	5-1d, A-4
735S-A		Stream	At-grade (Roadway)	N/A	Private	single span	70' span	5-1d, A-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
201S-DdCk	Deadman Creek	Stream	At-grade	N/A	Public[6]	multispan	PC/PS Box; 3-30' span	5-1d, B-4
738S-DdCk-A	Deadman Creek	Stream	At-grade (Roadway)	N/A	Public[6]	single span	100' span	5-1d, B-4
740S-DtCk-A	Dutchman Creek	Stream	At-grade (Roadway)	N/A	Public[6]	single span	100' span	5-1d, B-4
206S-DtCk	Dutchman Creek	Stream	At-grade	N/A	Public[6]	multispan	PC/PS Box; 3-40' span	5-1d, B-4
742S-A		Stream	At-grade (Roadway)	N/A	Private	culvert	circular pipe	5-1d, B-4
208S		Stream	At-grade	N/A	Public[9]	no data		5-1d, B-4
501D		Ditch	At-grade	N/A	Private[10]			5-1d, B-5
505D		Ditch	At-grade	N/A	Private[10]			5-1d, C-5
506D		Ditch	At-grade	N/A	Private[10]			5-1f, C-1; 5-1d, C-5
513D		Ditch	At-grade	N/A	Private[10]			5-1f, C-1; 5-1d, C-5
750S-A		Stream	At-grade (Roadway)	N/A	Public[6]	culvert	circular pipe	5-1f, C-1; 5-1d, C-5
517S		Stream	At-grade	N/A	Private[10]	culvert		5-1f, C-1; 5-1d, C-5
752S-A		Stream	At-grade (Roadway)	N/A	Private	culvert	circular pipe	5-1f, C-1; 5-1d, C-5
527S		Stream	At-grade	N/A	Public[9]	culvert		5-1f, C-1; 5-1d, C-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
529S		Stream	At-grade	N/A	Private	culvert		5-1f, C-1
Design Option: Mission Ave East of Le Grand (46 crossings, generally listed north to south)								
051C		Canal	Elevated	N/A	Private[8]	no data		5-1b, B-2
053C-FdLt	Farmdale Lateral	Canal	Elevated	N/A	MerID	elevated		5-1b, B-2
052C		Canal	Elevated	N/A	MerID	no data		5-1b, C-2
704C-A		Canal		N/A	MerID			5-1b, C-2
706C-A		Canal		N/A	MerID			5-1b, C-2
708C-MiCk-A	Miles Creek	Canal		N/A	Public[2]			5-1b, C-2
084C-FfLt-B	Fairfield Lateral	Canal	At-grade	2330	Public[3]	multispan	PC/PS Box; 3-30' span	5-1b, D-2
710C-MiCk-A	Miles Creek	Canal	Elevated (Roadway)	N/A	Public[2]	multispan	100' spans, 4	5-1b, D-2
712C-FfLt-A	Fairfield Lateral	Canal		N/A	MerID			5-1b, D-2
086C-MiCk	Miles Creek	Canal	At-grade	N/A	MerID			5-1b, D-2
714S-OwCk-A	Owens Creek	Stream		N/A	Public[2]			5-1b, D-3
716C-KoLt-A	Koff Lateral	Canal		N/A	MerID			5-1b, D-3
085C-VgLt	Vaughn Lat.	Canal	At-grade	N/A	MerID	culvert	Note B	5-1b, D-2
118C-B		Canal	At-grade	2130	MerID	culvert	Note B	5-1b, D-2
718C-MiCk-A	Miles Creek	Canal	At-grade (Roadway)	N/A	Public[2]	single span	70' span	5-1b, D-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
120C		Canal	At-grade	N/A	Public[6]			5-1c, A-2
140S-OwCk	Owens Creek	Stream	At-grade	N/A	Public[3]	multispan	PC/PS Box; 5-50' span	5-1c, A-2
119C		Canal	At-grade	N/A	MerID	culvert	Note B	5-1c, A-2
121C-DbLt-B	Dibblee Lateral	Canal	At-grade	610	Private	culvert	Note B	5-1c, B-2
726C-A		Canal	At-grade (Roadway)	N/A	MerID	culvert	130' box culvert	5-1c, B-2
724S-OwCk-A	Owens Creek	Stream	At-grade (Roadway)	N/A	Public[2]	culvert	70' box culvert	5-1c, B-2
550C		Canal	At-grade	N/A	Public[2]	no structure	Note E	5-1c, B-2
153C-DbLt	Dibblee Lateral	Canal	At-grade	N/A	Public[2]	multispan	PC/PS Box; 5-80' span	5-1c, C-2
155D		Ditch	Elevated	N/A	Private	culvert		5-1c, C-2
156C-DiCh	Diversion Channel (U.S.E.D)	Canal	Elevated	N/A	MerID	culvert	Note B	5-1c, C-2
158C-BuLt	Burchell Lat	Canal	At-grade	N/A	MerID	culvert	Note B	5-1c, D-3
164C-LGCa	Le Grand Canal	Canal	At-grade	N/A	Private[10]			5-1c, D-3
166C-BNo3	Booster No. 3	Canal	At-grade	N/A	Private	culvert	Note B	5-1c, E-3
730C-BNo3-A	Booster No. 3	Canal		N/A	MerID	culvert		5-1c, E-3
138S-MaCk-B	Mariposa Creek	Stream	At-grade	450	MadID	culvert	Note B	5-1d, A-3; 5-1c, E-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
139S-MaCk	Mariposa Creek	Stream	At-grade	360	Public[4]	multispan	PC/PS Box; 3-30' span	5-1d, A-3
182C-LtN3	No. 3 LAT	Canal	At-grade	N/A	MerID	culvert	Note B	5-1d, A-3
734C-LtN3-A	No. 3 LAT	Canal	Retained Fill (Roadway Embankment)	450	MerID	culvert	180' box culvert	5-1d, A-3
192S		Stream	Elevated	N/A	Private			5-1d, B-4
207S-DdCk	Deadman Creek	Stream	Elevated	N/A	Public[6]			5-1d, B-4
560S-DtCk	Dutchman Creek	Stream	Elevated	N/A	Public[6]	Multispan	Note A	5-1d, B-4
565S		Stream	Elevated	N/A	Private	Multispan	Note A	5-1d, B-4
501D		Ditch	At-grade	N/A	Private[10]			5-1d, B-5
505D		Ditch	At-grade	N/A	Private[10]			5-1d, C-5
506D		Ditch	At-grade	N/A	Private[10]			5-1f, C-1; 5-1d, C-5
513D		Ditch	At-grade	N/A	Private[10]			5-1f, C-1; 5-1d, C-5
750S-A		Stream	At-grade (Roadway)	N/A	Public[6]	culvert	circular pipe	5-1f, C-1; 5-1d, C-5
517S		Stream	At-grade	N/A	Private[10]	culvert		5-1f, C-1; 5-1d, C-5
752S-A		Stream	At-grade (Roadway)	N/A	Private	culvert	circular pipe	5-1f, C-1; 5-1d, C-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
527S		Stream	At-grade	N/A	Public[9]	culvert		5-1f, C-1; 5-1d, C-5
529S		Stream	At-grade	N/A	Private	culvert		5-1f, C-1
Design Option: Mariposa Way (37 crossings, generally listed north to south)								
049D		Ditch	Elevated	N/A	MerID	culvert	Note B	5-1b, B-2
054C-FdLt	Farmdale Lateral	Canal	Elevated	N/A	MerID	elevated		5-1b, B-2
056S-MCOF	Miles Creek Overflow No. 1	Stream	Elevated	N/A	MerID	culvert	Note B	5-1b, B-2
061S-MiCk	Miles Creek	Stream	At-grade	N/A	MerID	elevated		5-1b, B-2
079S-OwCk	Owens Creek	Stream	At-grade	N/A	MerID	culvert	Note B	5-1b, C-3
083C-KoLt	Koff Lateral	Canal	At-grade	N/A	MerID	elevated		5-1b, C-3
089C		Canal	At-grade	N/A	Private	culvert	Note B	5-1b, D-3
109S-DuSl	Duck Slough	Stream	At-grade	N/A	MerID	culvert	Note B	5-1b, D-3
091C-HdLt	Hadley Lat	Canal	At-grade	N/A	MerID	culvert	Note B	5-1b, D-3
092C-HdLt-B	Hadley Lat	Canal	At-grade	2190	MerID	culvert	Note B	5-1b, D-3
720C-HdLt-A	Hadley Lat	Canal	At-grade (Roadway)	N/A	MerID	culvert	130' box culvert	5-1b, D-3
722S-DuSl-A	Duck Slough	Stream	At-grade (Roadway)	N/A	Public[2]	single span	100' span	5-1b, D-3
108C-PlLt	Planada Lat	Canal	At-grade	N/A	Public[6]			5-1c, B-3
106C-PbLt	Plainsburg Lat	Canal	At-grade	N/A	MerID	elevated		5-1c, C-3

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
130S-MaCk	Mariposa Creek	Stream	At-grade	N/A	MerID	culvert	Note B	5-1c, D-3
131C-BNo3	Booster No. 3	Canal	At-grade	N/A	CWD	elevated		5-1c, D-4
132S-MaCk	Mariposa Creek	Stream	At-grade	N/A	MerID	culvert	Note B	5-1c, E-4
736C-LtN3-A	No. 3 LAT	Canal	At-grade (Roadway)	N/A	MerID	culvert	70' box culvert	5-1d, A-3
180C-LtN3	No. 3 LAT	Canal	Elevated	1110	Public[3]	multispan	PC/PS Box; 3-50' span	5-1d, A-4
190S		Stream	Elevated	N/A	MadID	culvert	Note B	5-1d, A-4
735S-A		Stream	At-grade (Roadway)	N/A	Private	single span	70' span	5-1d, A-4
202S-DdCk	Deadman Creek	Stream	Elevated	N/A	CWD	culvert	Note B	5-1d, B-4
738S-DdCk-A	Deadman Creek	Stream	At-grade (Roadway)	N/A	Public[6]	single span	100' span	5-1d, B-4
740S-DtCk-A	Dutchman Creek	Stream	At-grade (Roadway)	N/A	Public[6]	single span	100' span	5-1d, B-4
222S-DtCk	Dutchman Creek	Stream	Elevated	N/A	Public[6]	culvert		5-1d, B-4
742S-A		Stream	At-grade (Roadway)	N/A	Private	culvert	circular pipe	5-1d, B-4
212S		Stream	Elevated	N/A	MerID	Culvert	12' box culvert, 2	5-1d, B-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
744D-A		Ditch	At-grade (Roadway)	N/A	Private	culvert	circular pipe	5-1d, B-5
500D		Ditch	Elevated	N/A	Private			5-1d, B-5
504D		Ditch	Elevated	N/A	Public[2]	multispan	PC/PS Box; 3-50' span	5-1d, C-5
508D		Ditch	Elevated	N/A	Private[10]			5-1f, C-1; 5-1d, C-5
512D		Ditch	At-grade	N/A	Private[10]			5-1f, C-1; 5-1d, C-5
750S-A		Stream	At-grade (Roadway)	N/A	Public[6]	culvert	circular pipe	5-1f, C-1; 5-1d, C-5
214S		Stream	At-grade	N/A	Public[4]	multispan	PC/PS Box; 3-50' span	5-1f, C-1; 5-1d, C-5
752S-A		Stream	At-grade (Roadway)	N/A	Private	culvert	circular pipe	5-1f, C-1; 5-1d, C-5
216S-B		Stream	At-grade	1020	Private			5-1f, C-1; 5-1d, C-5
218S		Stream	At-grade	N/A	Private	culvert		5-1f, C-1
Design Option: Mariposa Way East of Le Grand (33 crossings, generally listed north to south)								
049D		Ditch	Elevated	N/A	MerID	culvert	Note B	5-1b, B-2
054C-FdLt	Farmdale Lateral	Canal	Elevated	N/A	MerID	elevated		5-1b, B-2
056S-MCOF	Miles Creek Overflow No. 1	Stream	Elevated	N/A	MerID	culvert	Note B	5-1b, B-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
061S-MiCk	Miles Creek	Stream	At-grade	N/A	MerID	elevated		5-1b, B-2
079S-OwCk	Owens Creek	Stream	At-grade	N/A	MerID	culvert	Note B	5-1b, C-3
083C-KoLt	Koff Lateral	Canal	At-grade	N/A	MerID	elevated		5-1b, C-3
089C		Canal	At-grade	N/A	Private	culvert	Note B	5-1b, D-3
109S-DuSl	Duck Slough	Stream	At-grade	N/A	MerID	culvert	Note B	5-1b, D-3
091C-HdLt	Hadley Lat	Canal	At-grade	N/A	MerID	culvert	Note B	5-1b, D-3
092C-HdLt-B	Hadley Lat	Canal	At-grade	2190	MerID	culvert	Note B	5-1b, D-3
720C-HdLt-A	Hadley Lat	Canal	At-grade (Roadway)	N/A	MerID	culvert	130' box culvert	5-1b, D-3
722S-DuSl-A	Duck Slough	Stream	At-grade (Roadway)	N/A	Public[2]	single span	100' span	5-1b, D-3
108C-PlLt	Planada Lat	Canal	At-grade	N/A	Public[6]			5-1c, B-3
107C-PbLt	Plainsburg Lat	Canal	At-grade	N/A	Private[10]	culvert		5-1c, C-3
542S-MaCK	Mariposa Creek	Stream	Elevated	N/A	Private			5-1c, D-3
134C-LGCa	Le Grand Canal	Canal	Elevated	N/A	MerID		no data to size feature	5-1c, D-3
141S		Stream	At-grade	190	Public[6]	single span	PC/PS Box; 1-60' span	5-1c, E-3
135C-BNo3	Booster No. 3	Canal	At-grade	N/A	Public[2]	multispan	PC/PS Box; 5-80' span	5-1c, E-3
733S-MaCk-A	Mariposa Creek	Stream	At-grade (Roadway)	N/A	Public[2]	single span	130' span	5-1c, E-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
137S-MaCk	Mariposa Creek	Stream	At-grade	500	Public[2]	multispan	PC/PS Box; 3-50' span	5-1d, A-3; 5-1c, E-4
185C-LtN3	No. 3 LAT	Canal	At-grade	N/A	Private[10]			5-1d, A-3
734C-LtN3-A	No. 3 LAT	Canal	Retained Fill (Roadway Embankment)	450	MerID	culvert	180' box culvert	5-1d, A-3
195S		Stream	At-grade	N/A	Public[2]	multispan	PC/PS Box; 5-80' span	5-1d, B-4
205S-DdCk	Deadman Creek	Stream	At-grade	N/A	Public[2]	realign/multispan	Note F	5-1d, B-4
204C		Canal	At-grade	N/A	Private	single span	PC/PS Box; 1-40' span	5-1d, B-4
223S-DtCk	Dutchman Creek	Stream	At-grade	N/A	MerID	culvert	Note B	5-1d, B-4
213S		Stream	At-grade	N/A	Public[2]	multispan	PC/PS Box; 3-30' span	5-1d, C-4
746D-A		Ditch	Retained Fill (Roadway Embankment)	N/A	Private	culvert	170' box culvert	5-1d, C-5
748D-A		Ditch	Retained Fill (Roadway Embankment)	450	Private	culvert	circular pipe	5-1d, C-5
225D		Ditch	At-grade	N/A	Public[2]	multispan	PC/PS Box; 2-50' span	5-1d, C-5
224S		Stream	Elevated	N/A	MerID	culvert	Note B	5-1f, C-1; 5-1d, C-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
217S		Stream	Elevated	N/A	MerID	culvert	Note B	5-1f, C-1; 5-1d, C-5
219S-B		Stream	Elevated	230	MerID	culvert	Note B	5-1f, C-1
BNSF Alternative Ave 24 Wye (17 crossings, generally listed west to east and then north to south)								
840C--JuCa-A	Justin Canal	Canal		N/A	CWD	culvert		5-1g, B-2
600S-AsSl	Ash Slough	Stream	At-grade	N/A	Public[3]	multispan	PC/PS Box; 10-60' span	5-1g, C-2
602C-AMCa	Ash Main Canal	Canal	At-grade	N/A	CWD	culvert	12' box culvert, 2	5-1g, C-2
604C-BtCa-B	Bethel Canal	Canal	At-grade	3040	CWD	culvert	12' box culvert, 2	5-1g, E-2
796C-BeCa-A	Berenda Canal	Canal	Roadway Embankment	N/A	CWD	culvert	12' box culvert, 2	5-1h, A-2
603C-BeCa	Berenda Canal	Canal	At-grade	N/A	CWD	culvert	Note B	5-1h, B-2
609S-BeSl	Berenda Slough	Stream	At-grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
802S-BeSl-A	Berenda Slough	Stream	At-grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
610D		Ditch	At-grade	N/A	MerID	culvert	Note B	5-1h, C-2; 5-1f, A-5
612C-CaLA	Califa Lateral A	Canal	At-grade	N/A	Public[3]	multispan	PC/PS Box; 7-50' span	5-1h, C-2; 5-1f, A-5
614P		Pipe	Elevated	N/A	Public[3]	multispan	PC/PS Box; 8-50' span	5-1h, D-2; 5-1f, B-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
466C-CaCa	Califa Canal	Canal	Elevated	N/A	Public[2]	culvert	Note B	5-1h, D-2; 5-1f, C-5
464C-CaCa	Califa Canal	Canal	At-grade	N/A	?	elevated		5-1h, D-2; 5-1f, C-5
257C-322-B	LAT 32.2	Canal	At-grade	1730	MerID	culvert	Note B	5-1i, B-2
294S-BeCk	Berenda Creek	Stream	At-grade	N/A	Private	culvert		5-1i, C-3
301S-DrCk	Dry Creek	Stream	At-grade	N/A	MerID	culvert	Note B	5-1j, B-1; 5-1i, E-4
306C-242	24.2	Canal	At-grade	N/A	Public[2]	Multispan	Note A	5-1j, B-1; 5-1i, E-5
BNSF Alternative Ave 21 Wye (22 crossings, generally listed west to east and then north to south)								
242C-AvLA	Ashview Lateral A	Canal	At-grade	N/A	CWD	culvert	Note B	5-1g, B-4
244C-AvCa	Ashview Canal	Canal	At-grade	N/A	CWD	culvert	Note B	5-1g, B-4
246C-R11C	Road 11 Canal	Canal	At-grade	N/A	CWD	culvert	Note B	5-1g, C-4
248C-BtCa-B	Bethel Canal	Canal	At-grade	2150	CWD	culvert	Note B	5-1g, D-4
249C-BeCa	Berenda Canal	Canal	At-grade	N/A	CWD	culvert	Note B	5-1g, D-4
880S-BeSl-A	Berenda Slough	Stream		N/A	Public[3]			5-1h, A-5
252S-BeSl	Berenda Slough	Stream	At-grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, A-4
463C-CLtC	Califa Lateral C	Canal	At-grade	N/A	CWD	See 883C-CLtD		5-1h, B-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
467C-CSLt-B	Canal Spill Lateral	Canal	At-grade	N/A	CWD	See 883C-CLtD		5-1h, B-4
462C-CfCa-B	Califa Canal	Canal	At-grade	300	CWD	See 465C-CfCa	See 465C-CfCa	5-1h, C-4
286C-3229-B	32.2 9.9-2.0	Canal	At-grade	4280	CWD	culvert	12' box culvert, 3	5-1h, C-4
287C-3229	32.2-9.9	Canal	At-grade	N/A	CWD	culvert	Note B	5-1h, D-4
896C-3221-A	32.2-10.2	Canal	Retained Fill (Roadway Embankment)	1850	CWD	relocated	1000', prop toe of slope	5-1i, A-3; 5-1h, E-4
274C-3229-B	32.2-9.9-1.5	Canal	At-grade	2570	CWD	culvert	12' box culvert, 3	5-1h, D-4
276C-3229-B	32.2-9.9-1.0	Canal	At-grade	1430	CWD	culvert	Note B	5-1h, D-4
273C-3229	32.2-9.9-0.1	Canal	At-grade	N/A	CWD	culvert	Note B	5-1h, E-4
275C-3221-B	32.2-10.2?	Canal	At-grade	1640	CWD	culvert	Note B	5-1i, A-3; 5-1h, E-4
894C-A			Elevated (Roadway)	230	CWD	multispan	100' spans, 4	5-1i, A-3; 5-1h, E-4
254C-322	LAT 32.2	Canal	At-grade	N/A	CWD	culvert	Note B	5-1i, C-2
293S-BeCk	Berenda Creek	Stream	At-grade	N/A	Public[3]	multispan	PC/PS Box; 3-50' span	5-1i, C-3
301S-DrCk	Dry Creek	Stream	At-grade	N/A	MerID	culvert	Note B	5-1j, B-1; 5-1i, E-4
306C-242	24.2	Canal	At-grade	N/A	Public[2]	Multispan	Note A	5-1j, B-1; 5-1i, E-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
Access Guideway for the Castle Commerce Center HMF (12 crossings, generally listed north to south)								
016C-CdLt	Casad Lateral	Canal	At-grade	N/A	MerID	outside limits		5-1a, A-1
005C		Canal	At-grade	6430	Private			5-1a, A-1
002S		Stream	At-grade	2990	Private[7]			5-1a, B-2
010S-CaCk	Canal Creek	Stream	At-grade	1040	Public[2]	outside limits		5-1a, B-2
008C		Canal	At-grade	1670	Private			5-1a, B-2
700C		Canal	At-grade	N/A	MerID	culvert	Note B	5-1a, B-2
011C		Canal	Elevated	N/A	MerID	outside limits		5-1a, B-2
009C		Canal	Elevated	N/A	MerID			5-1a, C-2
025P-PoLt	Pohlie Lateral	Canal	At-grade	N/A	MerID	outside limits		5-1a, C-3
020S-BRCk	Black Rascal Creek	Stream	Elevated	N/A	Public	outside limits		5-1a, C-4
030S-BaCk	Bear Creek	Stream	Retained Fill	N/A	Public[2]	outside limits		5-1a, D-4
031P		Pipe	Retained Fill	N/A	Private	outside limits		5-1a, D-4
Fagundes HMF (1 crossing)								
852C-A	852C-A	852C-A	852C-A	852C-A	852C-A	852C-A	852C-A	852C-A

[1] Many of the "natural" waterways designated "public" are an integral part of the local irrigation or water district distribution system for conveyance of irrigation water. The footnotes indicate the local district that utilizes the waterway and may have some operational and maintenance authority with respect to the waterway.

[2] MerID = Merced Irrigation District

[3] CWD = Chowchilla Water District

[4] MadID = Madera Irrigation District

[5] FID = Fresno Irrigation District

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location

[6] LGAWD = Le Grand-Athlone Water District

[7] City of Atwater storm water channel

[8] Cal Trans drainage facility

[9] Drainage swale between County road and railroad

[10] County road drainage facility

General Notes:

A Where track is supported on elevated guideway the spans are anticipated to be between 100-120 ft between supports. Supports would be adjusted to avoid conflicts with the water feature

B All canals crossing the HST R/W within either at-grade or retained fill sections of the alignments are assumed to be conveyed within concrete box culverts for larger canals, pipe culverts for open-channel ditch crossings at new roads, and pipes where the canal is placed in a siphon. Sizes, lengths and approach will be determined during 30% design.

C Relocation of Owens Creek [900' +/-] and Koff Lateral [1000' +/-] to the west of the HST at-grade section is required. Would require one multispan bridge for the natural waterway and one culvert for the lateral.

D Realign Duck Slough [550' +/-] and Givens Lateral [750' +/-] to the west of the HST at-grade section is required. Would require one multispan bridge for the natural waterway and one culvert for the lateral.

E Realign Mariposa Creek [800' +/-] to shift the channel to the east of the HST at-grade section would eliminate the structure required.

F Realign Mariposa Creek [600' +/-] to shift the channel to the southwest of the HST at-grade section would eliminate the structure required. May be possible to move the beginning of the elevated section to the east, but the foundations would end up in the meander of the creek.

Table 5-6
Natural Waterbodies Crossed by the BNSF Alternative

Natural Waterbody	Ave 24 Wye				Ave 21 Wye			
	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option
Access Track to Castle Commerce Center HMF								
Unnamed Creek	002S	002S	002S	002S	002S	002S	002S	002S
Canal Creek	010S-CaCk	010S-CaCk	010S-CaCk	010S-CaCk	010S-CaCk	010S-CaCk	010S-CaCk	010S-CaCk
Black Rascal Creek	020S-BRCk	020S-BRCk	020S-BRCk	020S-BRCk	020S-BRCk	020S-BRCk	020S-BRCk	020S-BRCk
Bear Creek	030S-BaCk	030S-BaCk	030S-BaCk	030S-BaCk	030S-BaCk	030S-BaCk	030S-BaCk	030S-BaCk
Natural Waterbodies	4	4	4	4	4	4	4	4
Constructed Waterbodies[a]	8	8	8	8	8	8	8	8
Total Waterbodies[a]	12	12	12	12	12	12	12	12
BNSF Alignment								
Miles Creek Overflow	--	--	056S-MCOF	056S-MCOF	--	--	056S-MCOF	056S-MCOF
Miles Creek	--	--	061S-MiCk	061S-MiCk	--	--	061S-MiCk	061S-MiCk

Natural Waterbody	Ave 24 Wye				Ave 21 Wye			
	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option
Owens Creek	714S-OwCk-A	714S-OwCk-A	--	--	714S-OwCk-A	714S-OwCk-A	--	--
	140S-OwCk	140S-OwCk	--	--	140S-OwCk	140S-OwCk	--	--
	--	724S-OwCk-A	--	--	--	724S-OwCk-A	--	--
	--	--	079S-OwCk	079S-OwCk	--	--	079S-OwCk	079S-OwCk
Duck Slough	--	--	109S-DuSl	109S-DuSl	--	--	109S-DuSl	109S-DuSl
	--	--	722S-DuSl-A	722S-DuSl-A	--	--	722S-DuSl-A	722S-DuSl-A
Unnamed Creek	--	--	--	141S	--	--	--	141S
Mariposa Creek	540S-MaCK	--	--	--	540S-MaCK	--	--	--
	541S-MaCK	--	--	--	541S-MaCK	--	--	--
	136S-MaCk	--	--	--	136S-MaCk	--	--	--
	732S-MaCk-A	--	--	--	732S-MaCk-A	--	--	--
	--	138S-MaCk-B	--	--	--	138S-MaCk-B	--	--
	--	139S-MaCk	--	--	--	139S-MaCk	--	--
	--	--	130S-MaCk	--	--	--	130S-MaCk	--
	--	--	132S-MaCk	--	--	--	132S-MaCk	--
	--	--	--	542S-MaCK	--	--	--	542S-MaCK
	--	--	--	733S-MaCk-A	--	--	--	733S-MaCk-A
	--	--	--	137S-MaCk	--	--	--	137S-MaCk

Natural Waterbody	Ave 24 Wye				Ave 21 Wye			
	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option
Unnamed Creek	191S	--	--	--	191S	--	--	--
	--	192S	--	--	--	192S	--	--
	--	--	190S	--	--	--	190S	--
	--	--	--	195S	--	--	--	195S
	735S-A	--	735S-A	--	735S-A	--	735S-A	--
Deadman Creek	201S-DdCk	--	--	--	201S-DdCk	--	--	--
	738S-DdCk-A	--	738S-DdCk-A	--	738S-DdCk-A	--	738S-DdCk-A	--
	--	207S-DdCk	--	--	--	207S-DdCk	--	--
	--	--	202S-DdCk	--	--	--	202S-DdCk	--
	--	--	--	205S-DdCk	--	--	--	205S-DdCk
Dutchman Creek	740S-DtCk-A	--	740S-DtCk-A	--	740S-DtCk-A	--	740S-DtCk-A	--
	206S-DtCk	--	--	--	206S-DtCk	--	--	--
	--	560S-DtCk	--	--	--	560S-DtCk	--	--
	--	--	222S-DtCk	--	--	--	222S-DtCk	--
	--	--	--	223S-DtCk	--	--	--	223S-DtCk

Natural Waterbody	Ave 24 Wye				Ave 21 Wye			
	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option
Unnamed Creek	208S	--	--	--	208S	--	--	--
	--	565S	--	--	--	565S	--	--
	--	--	212S	--	--	--	212S	--
	--	--	--	213S	--	--	--	213S
	742S-A	--	742S-A	--	742S-A	--	742S-A	--
Unnamed Creek	517S	517S	--	--	517S	517S	--	--
	--	--	214S	--	--	--	214S	--
	--	--	--	224S	--	--	--	224S
	750S-A	750S-A	750S-A	--	750S-A	750S-A	750S-A	--
Unnamed Creek	527S	527S	--	--	527S	527S	--	--
	--	--	216S-B	--	--	--	216S-B	--
	--	--	--	217S	--	--	--	217S
	752S-A	752S-A	752S-A	--	752S-A	752S-A	752S-A	--
Unnamed Creek	--	--	218S	--	--	--	218S	--
	--	--	--	219S-B	--	--	--	219S-B
	529S	529S	--	--	529S	529S	--	--
Chowchilla River	226S-ChRi	226S-ChRi	226S-ChRi	226S-ChRi	226S-ChRi	226S-ChRi	226S-ChRi	226S-ChRi
Unnamed Creek	320S	320S	320S	320S	320S	320S	320S	320S

Natural Waterbody	Ave 24 Wye				Ave 21 Wye			
	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option
Ash Slough	231S-AsSl	231S-AsSl	231S-AsSl	231S-AsSl	231S-AsSl	231S-AsSl	231S-AsSl	231S-AsSl
	600S-AsSl	600S-AsSl	600S-AsSl	600S-AsSl	--	--	--	--
Berenda Slough	253S-BeSl	253S-BeSl	253S-BeSl	253S-BeSl	253S-BeSl	253S-BeSl	253S-BeSl	253S-BeSl
	609S-BeSl	609S-BeSl	609S-BeSl	609S-BeSl	--	--	--	--
	802S-BeSl-A	802S-BeSl-A	802S-BeSl-A	802S-BeSl-A	--	--	--	--
	--	--	--	--	880S-BeSl-A	880S-BeSl-A	880S-BeSl-A	880S-BeSl-A
	--	--	--	--	252S-BeSl	252S-BeSl	252S-BeSl	252S-BeSl
Berenda Creek	292S-BeCk	292S-BeCk	292S-BeCk	292S-BeCk	292S-BeCk	292S-BeCk	292S-BeCk	292S-BeCk
	294S-BeCk	294S-BeCk	294S-BeCk	294S-BeCk				
	--	--	--	--	293S-BeCk	293S-BeCk	293S-BeCk	293S-BeCk
Dry Creek	300S-DrCk	300S-DrCk	300S-DrCk	300S-DrCk	300S-DrCk	300S-DrCk	300S-DrCk	300S-DrCk
	301S-DrCk	301S-DrCk	301S-DrCk	301S-DrCk	301S-DrCk	301S-DrCk	301S-DrCk	301S-DrCk
Schmidt Creek	310S-ScCr	310S-ScCr	310S-ScCr	310S-ScCr	310S-ScCr	310S-ScCr	310S-ScCr	310S-ScCr
	808S-ScCr-A	808S-ScCr-A	808S-ScCr-A	808S-ScCr-A	808S-ScCr-A	808S-ScCr-A	808S-ScCr-A	808S-ScCr-A
Fresno River	330S-FrRi	330S-FrRi	330S-FrRi	330S-FrRi	330S-FrRi	330S-FrRi	330S-FrRi	330S-FrRi
	812S-FrRi-A	812S-FrRi-A	812S-FrRi-A	812S-FrRi-A	812S-FrRi-A	812S-FrRi-A	812S-FrRi-A	812S-FrRi-A
Cottonwood Creek	370S-CwCk	370S-CwCk	370S-CwCk	370S-CwCk	370S-CwCk	370S-CwCk	370S-CwCk	370S-CwCk
San Joaquin River	400S-SJRi	400S-SJRi	400S-SJRi	400S-SJRi	400S-SJRi	400S-SJRi	400S-SJRi	400S-SJRi
Natural	36	31	37	33	35	30	36	32

Natural Waterbody	Ave 24 Wye				Ave 21 Wye			
	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option	Mission Ave Design Option	Mission Ave East of Le Grand Design Option	Mariposa Way Design Option	Mariposa Way East of Le Grand Design Option
Waterbodies								
Constructed Waterbodies[a]	68	70	55	55	74	76	61	61
Total Waterbodies[a]	104	101	92	88	109	106	97	93

[a] These values include waterbodies enclosed in pipes, and are greater than values presented for canals and ditches only.

Table 5-7
Inventory of Waterbody Crossings – Hybrid Alternative

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
Hybrid North-South Alignment (59 crossings where consistent for both wye design options, generally listed north to south)								
040C-LtD	Lateral D	Canal	At-Grade	N/A	MerID	culvert	Note B	5-1b, A-1
042C-LtD	Lateral D	Canal	At-Grade	N/A	MerID	culvert	Note B	5-1b, A-1
048D		Ditch	At-Grade	N/A	Private	no data		5-1b, B-2
050C-FdLt	Farmdale Lateral	Canal	At-Grade	N/A	MerID	culvert	Note B	5-1b, B-2
701C-FdLt-A	Farmdale Lateral	Canal		N/A	MerID			5-1b, B-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
055S-MCOF	Miles Creek Overflow No. 1	Stream	At-Grade	N/A	Public[2]	culvert	Note B	5-1b, B-2
702C-A		Canal	At-Grade	N/A	MerID	Relocate	20' beyond ROW	5-1b, C-2
060S-MiCk	Miles Creek	Stream	At-Grade	N/A	Public[2]	multispan	PC/PS Box; 2-50' span	5-1b, B-2
080S-OwCk	Owens Creek	Stream	At-Grade	580	Public[2]	relocate/multispan	PC/PS Box; 2-50' span	5-1b, B-3
081C-KoLt	Koff Lateral	Canal	At-Grade	870	MerID	relocated/culvert	Note C	5-1b, B-3
090D-LtAA	Lateral A-A	Ditch	At-Grade	N/A	MerID			5-1b, C-3
100D		Ditch	At-Grade	N/A	MerID			5-1b, C-3
112S-DuSl	Duck Slough	Stream	At-Grade	N/A	Public[2]	realign/multispan	Note D	5-1b, C-3
111S-DuSl	Duck Slough	Stream	At-Grade	N/A	Public[2]	realign/multispan	Note D	5-1b, C-3
110S-DuSl	Duck Slough	Stream	At-Grade	N/A	Public[2]	realign/multispan	Note D	5-1b, C-3
113C-GvLt	Givens Lateral	Canal	At-Grade	N/A	MerID	relocated/culvert	Note D	5-1b, C-3
114C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1b, C-3
115C		Canal	At-Grade	N/A	MerID	culvert	Note B	5-1b, C-4
116C-SoSl	South Slough/Lingard Lateral	Canal	At-Grade	N/A	MerID	multispan	100' span, 2	5-1b, C-4
117C-LatB	Lateral B	Canal	At-Grade	N/A	MerID	Culvert	12' box culvert, 2	5-1b, D-4
150C-RuLt	South Slough/ Russell Lateral	Canal	At-Grade	N/A	MerID	multispan	100' span, 2	5-1b, D-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
756C-A		Canal		550	Private	culvert		5-1b, D-4
758C-A		Canal		N/A	Private	culvert	12' box culvert, 2	5-1b, D-5
760C-A		Canal		N/A	Private	culvert		5-1b, D-5
754C-A		Canal		N/A	Private	culvert		5-1b, D-4
152C		Canal	At-Grade	N/A	Private[6]	Culvert	12' box culvert, 2	5-1b, E-5
154C		Canal	At-Grade	N/A	Private[6]	Culvert	12' box culvert, 2	5-1b, E-5
200S-DdCk (Wye Options split here)	Deadman Creek	Stream	At-Grade	N/A	Public	single span	PC/PS Box; 1-40' span	5-1e, A-1; 5-1b, E-5
301S-DrCk (Wye Options join here)	Dry Creek	Stream	At-Grade	N/A	MerID	culvert	Note B	5-1j, B-1; 5-1i, E-4
306C-242	24.2	Canal	At-Grade	N/A	Public[2]	Multispan	Note A	5-1j, B-1; 5-1i, E-5
806C-242-A	24.2	Canal		N/A	CWD	culvert		5-1j, B-1; 5-1i, E-5
310S-ScCr	Schmidt Creek	Stream	At-Grade	N/A	Public[4]	culvert		5-1j, C-1; 5-1i, E-5
808S-ScCr-A	Schmidt Creek	Stream		N/A	Public[4]			5-1j, C-1; 5-1i, E-5
320S		Stream	At-Grade	N/A	Public[2]	multispan	PC/PS Box; 2-50' span	5-1j, C-2
810S-A		Stream	N/A	N/A	Private[10]	N/A	N/A	5-1j, C-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
330S-FrRi	Fresno River	Stream	At-Grade	N/A	Public[4]	multispan	PC/PS Box; 9-50' span	5-1j, D-3
812S-FrRi-A	Fresno River	Stream	N/A	400	Public[4]	N/A	N/A	5-1j, D-3
814C-MaCa-A	Main Canal	Canal	At-Grade (Roadway)	N/A	MadID	culvert	100' box culvert	5-1j, E-3
340C-MaCa	Main Canal	Canal	At-Grade	N/A	MadID	culvert	Note B	5-1j, E-3
370S-CwCk	Cottonwood Creek	Stream	At-Grade	N/A	Public[4]	multispan	PC/PS Box; 5-50' span	5-1k, C-2
375C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1k, C-2
816C-A		Canal	N/A	540	MadID	N/A	N/A	5-1k, C-2
818P-A		Pipe		N/A	MadID			5-1k, C-3
820C-A		Canal	At-Grade (Roadway)	N/A	MadID	culvert	60' box culvert	5-1k, C-4
278C-6214	6.2-14.0-W	Canal	At-Grade	N/A	MadID	culvert	Note B	5-1k, D-4
279C-6214	6.2-14.0-W	Canal	At-Grade	N/A	Public[2]	multispan	PC/PS Box; 5-80' span	5-1k, D-4
380C		Canal	At-Grade	N/A	MadID	culvert	Note B	5-1l, A-1; 5-1k, D-5
826C-A		Canal	N/A	N/A	MadID	N/A	N/A	5-1l, A-1; 5-1k, D-5
830C-ML2S-A	Mid Lateral 6.2-9.25	Canal	Retained Fill (Roadway Embankment)	2030	MadID	Relocated/culvert	12' box culvert, 2, 175' box culvert	5-1l, A-2
381C-ML2S	Mid Lateral 6.2-9.25	Canal	At-Grade	N/A	MadID	culvert	Note B	5-1l, A-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
395C-6292	6.2-9.2-5.05	Canal	At-Grade	N/A	MadID	culvert	Note B	5-1l, B-3
400S-SJRi	San Joaquin River	Stream	Elevated	N/A	Public	Multispan	Note A	5-1l, B-3
410C-HrCa	Herndon Canal	Canal	Elevated	N/A	FID	elevated		5-1l, D-5
420P-ViCa-B	Victoria Canal	Pipe	At-Grade	1220	FID			5-1m, B-2
832C-WVCa-A	West Branch Victoria Canal	Canal		1140	FID	culvert		5-1m, B-2
421P-WVCa-B	West Branch Victoria Canal	Pipe	At-Grade	850	FID			5-1m, B-3
834P-WVC-A	West Branch Victoria Canal	Pipe		80	FID			5-1m, B-3
422P		Pipe	At-Grade	N/A	FID			5-1m, C-3
451C-DCCa	Dry Creek Canal	Canal	Retained Fill	N/A	FID	culvert	Note B	5-1m, D-4
Hybrid Alignment with Ave 24 Wye(43 crossings generally listed north to south, west to east; north-south alignment west of Chowchilla; Ave 24 Wye crossings listed separately below)								
209S-DtCk-B	Dutchman Creek	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-40' span	5-1e, B-2
762S-DtCk-A	Dutchman Creek	Stream	At-Grade	N/A	Public[6]	multispan	PC/PS Box; 3-60' span	5-1e, A-2
764C-A		Canal	At-Grade	1280	Private	Relocate	20' beyond ROW	5-1e, A-2
507C-B		Canal	At-Grade	N/A	CWD	culvert	Note B	5-1e, B-2
768C-A		Canal	At-Grade	N/A	Private	culvert	12' box culvert, 2	5-1e, A-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
778C-A		Canal	At-Grade	250	Private	culvert	12' box culvert, 2	5-1e, A-3
776C-A		Canal	At-Grade	N/A	Private	culvert	12' box culvert, 2	5-1e, A-3
774C-A		Canal	Roadway Embankment	920	Private	culvert	12' box culvert, 3	5-1e, B-3
772C-A		Canal	Roadway Embankment	1230	Private	culvert	12' box culvert, 3	5-1e, B-3
770C-A		Canal		130	Private	No Impact		5-1e, B-3
509C-Lat2-B	Lat. 2	Canal	At-Grade	N/A	CWD	No Impact		5-1e, B-3
511C-Lat3-B	Lat. 3	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1e, B-3
514C-Lat4	Lat. 4	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1e, B-4
516S-ChRi	Chowchilla River	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 7-50' span	5-1e, B-4
784C-Lat4-A	Lat. 4	Canal	At-Grade	N/A	CWD	culvert	14' box culvert, 2	5-1g, D-1; 5-1e, B-4
782C-Lat4-A	Lat. 4	Canal	At-Grade	N/A	CWD	culvert	14' box culvert, 3	5-1g, D-1; 5-1e, B-4
780S-ChRi-A	Chowchilla River	Stream	Roadway Embankment	N/A	Public[3]	Multispan	100' span, 4	5-1g, D-1; 5-1e, B-4
786C-A		Canal	At-Grade	N/A	Private	culvert	12' box culvert, 3	5-1g, E-1; 5-1e, C-5
788C-A		Canal		540	Private	No Impact		5-1g, E-1; 5-1e, C-5

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
519C-CRBP (near north wye connection)	Chowchilla River By-Pass	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, D-1; 5-1e, B-5
521C-AMCa-B	Ash Main Canal	Canal	At-Grade	1640	CWD	culvert	14' box culvert, 3	5-1g, D-1; 5-1e, B-5
523S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 5-50' span	5-1g, D-1; 5-1e, B-5
792S-AsSl-A	Ash Slough	Stream		N/A	Public[3]			5-1g, D-2; 5-1e, B-5
994C-BtCa-A	Bethel Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1g, E-2; 5-1e, C-5
842C-A		Canal	At-Grade	N/A	CWD	Relocate	20' beyond ROW	5-1g, B-2
844C-JuCa-A	Justin Canal	Canal	at-Grade	N/A	CWD	Relocate	20' beyond ROW	5-1g, B-2
846C-JuCa-A	Justin Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1g, C-2; 5-1e, A-5
848C-AMCa-A	Ash Main Canal	Canal	Roadway Embankment	N/A	CWD	see 850S-AsSl-A	see 850S-AsSl-A	5-1g, C-2
850S-AsSl-A	Ash Slough	Stream	Roadway Embankment	N/A	Public[3]	Multispan	100' span, 6	5-1g, C-2
525C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1g, E-2
605C-BtCa-B	Bethel Canal	Canal	At-Grade	2660	CWD	culvert	Note B	5-1g, E-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
607C-EmLt-B (near south wye connection)	Eastman Lateral	Canal	At-Grade	4240	CWD	culvert	Note B	5-1g, E-2
796C-BeCa-A	Berenda Canal	Canal	Roadway Embankment	N/A	CWD	culvert	12' box culvert, 2	5-1h, A-2
603C-BeCa	Berenda Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, B-2
609S-BeSl	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
802S-BeSl-A	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, B-2
610D		Ditch	At-Grade	N/A	MerID	culvert	Note B	5-1h, C-2; 5-1f, A-5
612C-CaLA	Califa Lateral A	Canal	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 7-50' span	5-1h, C-2; 5-1f, A-5
804C-A		Canal		170	CWD	culvert		5-1h, D-2; 5-1f, B-5
614P		Pipe	Elevated	N/A	Public[3]	multispan	PC/PS Box; 8-50' span	5-1h, D-2; 5-1f, B-5
464C-CaCa	Califa Canal	Canal	At-Grade	N/A	?	elevated		5-1h, D-2; 5-1f, C-5
257C-322-B	LAT 32.2	Canal	At-Grade	1730	MerID	culvert	Note B	5-1i, B-2
294S-BeCk	Berenda Creek	Stream	At-Grade	N/A	Private	culvert		5-1i, C-3
Hybrid Ave 24 Wye (11 crossings generally listed west to east, north to south; wye only)								
840C-JuCa-A	Justin Canal	Canal		N/A	CWD	culvert		5-1g, B-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
528C		Canal	At-Grade	N/A	Private	culvert	Note B	5-1g, C-2
600S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 10-60' span	5-1g, C-2
602C-AMCa	Ash Main Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 2	5-1g, C-2
524C-B		Canal	At-Grade	2820	Private	culvert	Note B	5-1g, D-2
522S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 5-50' span	5-1g, D-1; 5-1e, B-5
520C-AMCa-B	Ash Main Canal	Canal	At-Grade	2320	CWD	culvert	Note B	5-1g, D-1; 5-1e, B-5
518C-CRBP (near north wye connection)	Chowchilla River By-Pass	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, D-1; 5-1e, B-5
526S-AsSl	Ash Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 15-50' span	5-1g, C-2
564C-AMCa	Ash Main Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, C-2
604C-BtCa-B	Bethel Canal	Canal	At-Grade	3040	CWD	culvert	12' box culvert, 2	5-1g, E-2
Hybrid Alignment with Ave 21 Wye (11 crossings generally listed north to south, west to east; north-south alignment through Chowchilla; Ave 21 Wye crossings listed separately below)								
210S-DtCk	Dutchman Creek	Stream	Elevated	380	Public[3]	Single Span	150' span	5-1e, B-2

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
215D-SDtC	South Dutchman Creek	Ditch	Elevated	N/A	Public[3]			5-1e, C-2
220S-ChRi	Chowchilla River	Stream	Elevated	N/A	Public[3]			5-1e, C-3
221C-Mntn	Minturn	Canal	Elevated	N/A	CWD	elevated		5-1e, D-4
230S-AsSl	Ash Slough	Stream	Elevated	N/A	Public[3]	Multispan	Note A	5-1h, B-1; 5-1e, E-4
240C-HtLt	Hartley Lateral	Canal	Elevated	N/A	CWD	elevated		5-1h, C-2; 5-1f, A-5
250S-BeSl	Berenda Slough	Stream	Elevated	N/A	Public[3]	Multispan	Note A	5-1h, C-2; 5-1f, A-5
260C-CALA (near north wye connection)	California Lateral A	Canal	Elevated	N/A	CWD	elevated		5-1h, D-2; 5-1f, B-5
264C-CaCa	Califa Canal	Canal	Elevated	N/A	CWD	elevated		5-1h, D-3
265C-B (near south wye connection)		Canal	Elevated	100	MadID	culvert	14' box culvert, 3	5-1i, A-3; 5-1h, E-4
296S-BeCk	Berenda Creek	Stream	At-grade	N/A	Public[3]	multispan	PC/PS Box; 3-50' span	5-1i, C-3
Hybrid Ave 21 Wye (31 crossings generally listed west to east, north to south; wye only)								
242C-AvLA	Ashview Lateral A	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, B-4
244C-AvCa	Ashview Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, B-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
246C-R11C	Road 11 Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, C-4
248C-BtCa-B	Bethel Canal	Canal	At-Grade	2150	CWD	culvert	Note B	5-1g, D-4
249C-BeCa	Berenda Canal	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1g, D-4
880S-BeSl-A	Berenda Slough	Stream		N/A	Public[3]			5-1h, A-5
252S-BeSl	Berenda Slough	Stream	At-Grade	N/A	Public[3]	multispan	PC/PS Box; 3-60' span	5-1h, A-4
463C-CLtC	Califa Lateral C	Canal	At-Grade	N/A	CWD	See 883C-CLtD		5-1h, B-4
882C-CLtC-A	Califa Lateral C	Canal		N/A	CWD	culvert		5-1h, B-4
467C-CSLt-B	Canal Spill Lateral	Canal	At-Grade	N/A	CWD	See 883C-CLtD		5-1h, B-4
883C-CLtD	Califa Lateral D	Canal	At-Grade	N/A	CWD	relocated (b/n Road 17 & Rd 15 1/2)	20' beyond ROW	5-1h, B-4
884C-CaCa-A	Califa Canal	Canal		260	CWD	See 465C-CfCa	See 465C-CfCa	5-1h, C-4
465C-CfCa	Califa Canal	Canal	At-Grade	N/A	CWD	culvert	12' box culvert, 3	5-1h, C-4
462C-CfCa-B	Califa Canal	Canal	At-Grade	300	CWD	See 465C-CfCa	See 465C-CfCa	5-1h, C-4
280C-3229	32.2 9.9-2.0	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, C-4
888C-A		Canal		1640	CWD	culvert/relocate	12' box culvert, 3	5-1h, D-4
283C-3229		Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, D-4
892C-3229-A	32.2-9.9	Canal		N/A	CWD	No Impact		5-1h, D-4

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
890C-3229-A	32.2-9.9	Canal		N/A	CWD	No Impact		5-1h, D-4
281C-3229-B	32.2-9.9	Canal	At-Grade	3750	CWD	culvert	Note B	5-1h, D-4
886C-CLtC-A	Califa Lateral C	Canal		N/A	CWD	culvert		5-1h, D-4
461C-CLtB	Califa Lateral B	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, D-3
261C-CALA (near north wye connection)	California Lateral A	Canal	Elevated	N/A	CWD	elevated		5-1h, D-2; 5-1f, B-5
286C-3229-B (on south wye)	32.2 9.9-2.0	Canal	At-Grade	4280	CWD	culvert	12' box culvert, 3	5-1h, C-4
287C-3229	32.2-9.9	Canal	At-Grade	N/A	CWD	culvert	Note B	5-1h, D-4
274C-3229-B	32.2-9.9-1.5	Canal	At-grade	2570	CWD	culvert	12' box culvert, 3	5-1h, D-4
276C-3229-B	32.2-9.9-1.0	Canal	At-grade	1430	CWD	culvert	Note B	5-1h, D-4
273C-3229	32.2-9.9-0.1	Canal	At-grade	N/A	CWD	culvert	Note B	5-1h, E-4
275C-3221-B	32.2-10.2?	Canal	At-grade	1640	CWD	culvert	Note B	5-1i, A-3; 5-1h, E-4
894C-A			Elevated (Roadway)	230	CWD	multispan	100' spans, 4	5-1i, A-3; 5-1h, E-4
896C-3221-A	32.2-10.2	Canal	Retained Fill (Roadway Embankment)	1850	CWD	relocated	1000', prop toe of slope	5-1i, A-3; 5-1h, E-4
Access Guideway for the Castle Commerce Center HMF (12 crossings, north to south)								
016C-CdLt	Casad Lateral	Canal	At-Grade	N/A	MerID	outside limits		5-1a, A-1

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location
005C		Canal	At-Grade	6430	Private			5-1a, A-1
002S		Stream	At-Grade	2990	Private[7]			5-1a, B-2
010S-CaCk	Canal Creek	Stream	At-Grade	1040	Public[2]	outside limits		5-1a, B-2
008C		Canal	At-Grade	1670	Private			5-1a, B-2
700C		Canal	At-Grade	N/A	MerID	culvert	Note B	5-1a, B-2
011C		Canal	Elevated	N/A	MerID	outside limits		5-1a, B-2
009C		Canal	Elevated	N/A	MerID			5-1a, C-2
025P-PoLt	Pohlie Lateral	Canal	At-Grade	N/A	MerID	outside limits		5-1a, C-3
020S-BRCk	Black Rascal Creek	Stream	Elevated	N/A	Public	outside limits		5-1a, C-4
030S-BaCk	Bear Creek	Stream	Retained Fill	N/A	Public[2]	outside limits		5-1a, D-4
031P		Pipe	Retained Fill	N/A	Private	outside limits		5-1a, D-4
Fagundes HMF (1 crossing)								
852C-A		Canal	At-Grade			Culvert		5-1g, D-2

[1] Many of the "natural" waterways designated "public" are an integral part of the local irrigation or water district distribution system for conveyance of irrigation water. The footnotes indicate the local district that utilizes the waterway and may have some operational and maintenance authority with respect to the waterway.

[2] MerID = Merced Irrigation District

[3] CWD = Chowchilla Water District

[4] MadID = Madera Irrigation District

[5] FID = Fresno Irrigation District

[6] LGAWD = Le Grand-Athlone Water District

[7] City of Atwater storm water channel

[8] Cal Trans drainage facility

[9] Drainage swale between County road and railroad

[10] County road drainage facility

Crossing ID	Waterbody Name	Waterbody Type (canal, pipe, drainage, natural)	15% Design Vertical Alignment (elevated, retained fill, at-grade)	Waterbody Length Parallel to Track (feet)	Owner (Public, Water/ Irrigation District, Private)[1]	15% Design Approach (pipe, culvert, single span, multispan, relocated)	15% Design Details (dimension-type, #)	Figure 5-1 Map and Grid Location

A Where track is supported on elevated guideway the spans are anticipated to be between 100-120 ft between supports. Supports would be adjusted to avoid conflicts with the water feature

B All canals crossing the HST R/W within either at-grade or retained fill sections of the alignments are assumed to be conveyed within concrete box culverts for larger canals, pipe culverts for open-channel ditch crossings at new roads, and pipes where the canal is placed in a siphon. Sizes, lengths and approach will be determined during 30% design.

C Relocation of Owens Creek [900' +/-] and Koff Lateral [1000' +/-] to the west of the HST at-grade section is required. Would require one multispan bridge for the natural waterway and one culvert for the lateral.

D Realign Duck Slough [550' +/-] and Givens Lateral [750' +/-] to the west of the HST at-grade section is required. Would require one multispan bridge for the natural waterway and one culvert for the lateral.

E Realign Mariposa Creek [800' +/-] to shift the channel to the east of the HST at-grade section would eliminate the structure required.

F Realign Mariposa Creek [600' +/-] to shift the channel to the southwest of the HST at-grade section would eliminate the structure required. May be possible to move the beginning of the elevated section to the east, but the foundations would end up in the meander of the creek.

Table 5-8
Natural Waterbodies Crossed by the Hybrid Alternative

Waterbody	Hybrid Alternative with Ave 24 Wye	Hybrid Alternative with Ave 21 Wye
Access Guideway to Castle Commerce Center HMF		
Unnamed Creek	002S	002S
Canal Creek	010S-CaCk	010S-CaCk
Black Rascal Creek	020S-BrCk	020S-BrCk
Bear Creek	030S-BaCk	030S-BaCk
Total Natural Waterbodies	4	4
Constructed Waterbodies[a]	8	8
Total Waterbodies[a]	12	12
Hybrid Alignment		
Miles Creek Overflow No. 1	055S-MCOF	055S-MCOF
Miles Creek	060S-MiCk	060S-MiCk
Owens Creek	080S-OwCk	080S-OwCk
Duck Slough	112S-DuSl	112S-DuSl
	111S-DuSl	111S-DuSl
	110S-DuSl	110S-DuSl
Deadman Creek	200S-DdCk	200S-DdCk
Dutchman Creek	209S-DtCk-B	--
	--	210S-DtCk
	762S-DtCk-A	--
Chowchilla River	516S-ChRi	--
	--	220S-ChRi
	780S-ChRi-A	--
Ash Slough	--	230S-AsSl
	523S-AsSl	--
	792S-AsSl-A	--
	522S-AsSl	--
	850S-AsSl-A	--
	526S-AsSl	--
	600S-AsSl	--

Waterbody	Hybrid Alternative with Ave 24 Wye	Hybrid Alternative with Ave 21 Wye
Berenda Slough	609S-BeSl	--
	--	250S-BeSl
	802S-BeSl-A	--
	--	880S-BeSl-A
	--	252S-BeSl
Berenda Creek	294S-BeCk	--
	--	296S-BeCk
Dry Creek	301S-DrCk	301S-DrCk
Schmidt Creek	310S-ScCr	310S-ScCr
	808S-ScCr-A	808S-ScCr-A
Unnamed Creek	320S	320S
	810S-A320S	810S-A320S
Fresno River	330S-FrRi	330S-FrRi
	812S-FrRi-A	812S-FrRi-A
Cottonwood Creek	370S-CwCk	370S-CwCk
San Joaquin River	400S-SJRi	400S-SJRi
Total Natural Waterbodies	29	23
Constructed Waterbodies[a]	85	78
Total Waterbodies[a]	113	101

[a] These values include waterbodies enclosed in pipes, and are greater than values presented for canals and ditches only.

5.2 Preliminary Waterbody Crossing Design Concepts

5.2.1 Typical Design Concepts

This section discusses potential design concepts for waterbody crossings by the HST guideways. HST waterbody crossing designs can be broadly classified as culverts (circular conduits or concrete boxes), bridges (typified by an at-grade profile at the abutments and piers or large box culverts in the channel), or elevated (approaches at the abutments are elevated on piers). Section 3.2 provides specific design requirements for each design concept.

5.2.1.1 Culvert

Culverts range in size from relatively small-diameter pipe (typically 12 inches to several feet in diameter) to large precast concrete-box structures (typically 3- to 8-foot-high openings and opening widths of 5 to 24 feet). Culverts can be configured as a single conduit or as multiple parallel conduits. Culverts can be sized for a wide range of flows typical of small- to medium-size drainages or irrigation channels, with flow capacities ranging from less than 1 cfs to several hundred cfs depending on the culvert configuration, channel dimensions, channel slope, and downstream hydraulic constrictions. Each culvert or set of culverts must be sized individually based on hydrologic (runoff) and hydraulic (capacity) modeling.

In the context of irrigation canals, culverts include pressurized pipes or inverted siphons used to pass water from an open canal headwork under the HST embankment and adjacent embankments. Where possible, a straight culvert is preferred rather than a U-shaped siphon. A straight culvert can flush out sediment and debris more easily.

The culvert design must meet hydraulic conveyance requirements, provide for collection of trash via a trash rack or adequate capacity to pass the anticipated debris, and have adequate room for inspection and maintenance when dry. When irrigation flows or runoff cannot be conveyed by a culvert pipe, open box culverts or a bridge is typically required.

5.2.1.2 Bridge

When a series of closely spaced culvert openings or a single span exceeds 20 feet, including intermediate supports, Federal Highway Administration National Bridge Inspection Standards 23 CFR 650.305 define the structure as a bridge. On a practical basis, a typical bridge with abutments, a bridge deck, and possibly piers becomes a practical alternative to parallel precast box culverts when the required flow depth or channel depth exceeds economical box culvert dimensions, or the span length requires more than three or four box culvert widths. This could result in a cost savings by using cast-in-place abutments and piers with larger heights and spans. This is true for most natural streams, rivers, sloughs, and larger irrigation canals. In the few possible instances where selection of a bridge instead of culverts is not obvious, site-specific design considerations would be evaluated to select an economical design.

Bridges are useful in spanning ravines, providing a habitat corridor and conveying debris-laden floodwater. Hydraulic and environmental impacts typically are minimized when the bridge fully spans the waterbody; however, economics and practical limitations in span length typically require supporting piers or columns. Environmental or hydraulic considerations could influence the specific placement of bridge supports in the primary channel.

5.2.1.3 Elevated Guideway

In locations where the HST guideway is elevated, the structure crosses over the waterbody similar to a bridge, except without at-grade abutments. Elevated guideways are hydraulically beneficial in wide floodplains and where adequate freeboard is a concern. Elevated guideways also provide corridors for habitat. Environmental or hydraulic considerations could influence the specific placement of column supports in the primary channel.

5.2.2 Preliminary Design Concepts by Water Crossing

The project design team has developed preliminary waterbody crossing design concepts as part of the 15% design submittal for the Draft Project EIR/EIS. The 15% design concept includes the project's preliminary (15% design) vertical alignment (i.e., elevated, retained fill, retained cut, or at-grade) and the preliminary recommended design approach (e.g., pipe or box culvert; single span or multispan box culvert, bridge or elevated guideway; or relocation of the waterbody to reduce or eliminate the length of the crossing) based on the following considerations:

- Vertical alignment (elevated, at-grade, or in transition; elevation of the top of guideway in relation to local topography).
- Existing nearby crossing (culvert or bridge).
- Qualitative waterbody hydraulics (e.g., width and depth of channel at crossing, width of riparian area, length of longitudinal crossing and ease of relocation, and design flow rate).

Tables 5-3, 5-5, and 5-7 show the preliminary vertical alignment and the preliminary recommended design approach and details for each waterbody crossing of the UPRR/SR 99, BNSF, and Hybrid alternatives, respectively. A final design approach has not been determined for HST waterbody crossings; rather, these three tables indicate a preliminary design concept that may mitigate or prevent hydraulic impacts.

5.2.3 Selected Crossings for Further Review

The design team selected preliminary horizontal and vertical alignments based on several potentially competing or conflicting considerations. The following selected waterbody crossings require additional review during iterative design because of potential hydraulic or environmental impacts. Modifications to the HST alignment or relocation of the waterbody may reduce or eliminate hydraulic impacts. Such changes might include a full-span crossing of the waterbody, a slight shift in permanent project footprint to avoid a longitudinal channel displacement, careful placement of bridge supports, or realignment of the channel. In addition to the list below, every longitudinal crossing (i.e., crossings with a length listed under the heading "Waterbody Length Parallel to Track") in Tables 5-3, 5-5 and 5-7 should be reviewed for opportunities to reduce impacts.

5.2.3.1 UPRR/SR 99 Alternative

Owens Creek and Koff Lateral (Watercrossing IDs: 080S-OwCk and 081C-KoLt, UPRR/SR 99 Alternative north-south alignment)

These waterbody crossings are in unincorporated Merced County along the UPRR/SR 99 Alternative north-south alignment. Owens Creek and nearby Koff Lateral (Watercrossing ID: 2081C-KoLt) parallel the existing SR 99 and UPRR infrastructure and follows the perimeter of existing agricultural fields; the HST alignment nearly parallels these waterbodies for several hundred feet. The HST alignment is elevated or in transition at this location. Placing columns requires special care. Consider realignment of Koff Lateral and a full span crossing over Owens Creek to minimize impacts.

Duck Slough (Watercrossing IDs: 110S-DuSl, 111S-DuSl, and 112S-DuSl, UPRR/SR 99 north-south alignment)

Because of meanders in Duck Slough, the UPRR/SR 99 Alternative alignment would cross the slough at two locations about 400 feet apart. The guideway is at-grade in this location. The length of the crossings over Duck Slough is approximately 500 feet. The alignment closely parallels the existing UPRR railway, making its relocation infeasible. Relocating the slough bend 100 to 200 feet to the southeast could avoid the northern crossings (111S-DuSl and 112S-DuSl). However, relocation would eliminate the slough bend, reducing the natural sinuosity and the length of the stream locally. Relocation may also exacerbate impacts to an extensive forested wetland adjacent to the slough. Permits from CDFG and USACE would likely be required. Also, an existing canal that parallels this slough may have to be relocated. Because of these complications, further analysis is recommended to better define the environmental impacts resulting from relocation of the slough. Alternatively, the HST alignment could span the Duck Slough complex in two parts (250 feet each span) with careful placement of the supports.

San Joaquin River (Watercrossing ID: 401S-SjRi, UPRR/SR 99 Alternative and BNSF alternative north-south alignments)

The San Joaquin River low-flow channel makes a sharp bend and approximately parallels the HST alignment for 400 feet before making another sharp bend to continue downstream at an approximately 90-degree angle to the HST alignment. The HST alignments overlie this transverse-flowing portion of the river, resulting in a waterbody crossing at least 400 feet long. Although it is infeasible to change the HST alignment at this location, careful placement of bridge supports could mitigate hydraulic and environmental impacts. Relocating the San Joaquin River channel to reduce or eliminate this meander may be difficult from a permitting standpoint.

5.2.3.2 BNSF Alternative

Owens Creek Diversion (Watercrossing IDs: 126C-DiCh, 156C-DiCh; BNSF Alternative with Mission Ave and Mission Ave East of Le Grand design options)

The Mission Ave design option and the Mission Ave East of Le Grand design option cross over a federal levee project east of the City of Merced. The federal levee project is part of the Merced County Streams Group Flood Control Project and is a diversion between Owens and Mariposa Creeks. Without sufficient vertical and horizontal clearance, crossing a federal project with the HST guideway would require a Section 408 Permit from USACE. To avoid the need for a Section 408 permit at this location, the HST would be elevated through this area with an 18-foot clearance above the levees and a 15-foot horizontal clearance between guideway piers and the toe of the levee (awaiting final confirmation from USACE on exact vertical and horizontal clearance requirements). Note that the USACE staff have indicated that the clearance and setback requirements listed above may be relaxed for this project (refer to Section 3.2.4). An Encroachment Permit from CVFPB (which fulfills Section 208.10 for USACE) would be required.

Mariposa Creek (Watercrossing ID: 131S_MaCk, BNSF alternative with Mission Ave East of Le Grand and Mariposa Ave East of Le Grand design options)

BNSF Alternative with Mission Ave East of Le Grand and Mariposa Ave East of Le Grand design options

The Le Grand design option closely parallels the west bank of Mariposa Creek for 1 mile north of Le Grand, near Banks Road. A 600-foot length of the corridor appears to be within the riparian portion of the creek. The alignment would be at-grade in this location. The BNSF Alternative alignment in this area passes through agricultural land. Riparian impacts could be avoided or reduced if the BNSF Alternative alignment is moved about 100 feet farther west.

Owens Creek (Watercrossing ID: 140S-OwCk, BNSF Alternative with Mission Ave and Mission Ave East of Le Grand design options)

The Mission Ave design option traverses Owens Creek for 700 feet. The alignment is at-grade at this location. The guideway would need to be moved several hundred feet to the north to avoid Owens Creek and its associated riparian area.

San Joaquin River (Watercrossing ID: 400S-SjRi, UPRR/SR 99 and BNSF alternative north-south alignments, [see previous discussion])

The San Joaquin River crossing is discussed under the UPRR/SR 99 Alternative.

5.2.3.3 Hybrid Alternative

There are no additional selected crossings for further review that are unique to the Hybrid Alternative.

5.2.3.4 Access Guideway to Castle Commerce Center HMF Site

Canal Creek (Watercrossing ID: 010S-CaCk, UPRR/SR 99 and BNSF alternative north-south alignments)

This waterbody crossing is within the City of Merced near the northern end of the Merced to Fresno Section alignment. Near Canal Creek, the access guideway would parallel the west side of the existing BNSF railway and Santa Fe Ave. The vertical alignment is unknown. Several canals pass through the area, including Canal Creek. There are also one or more small ponds and at least one irrigation canal control structure. Combined, these features cover at least 400 feet of the guideway corridor. Relocation of the access guideway corridor to avoid these waterbodies is likely not feasible. If the alignment is at-grade in this location, the irrigation features would need to be reconstructed or relocated. Alternatively, an elevated guideway through this area could minimize impacts.

6.0 Additional Hydraulic and Hydrologic Assessments Required for Permitting

6.1 Overview

Hydrologic and hydraulic information and modeling are required for permitting, endorsement by local maintenance agencies, and design (refer to Section 3.1). Permits potentially requiring hydraulic modeling include the following:

- Encroachment permits for waterways within an adopted plan of flood control, administered by CVFPB under Title 23 (refer to Section 3.2.1) and state–federal flood control project maintenance O&M manuals; and supported by USACE at the district level under 33 CFR 208.10.
- Local development permits that require conformance with local floodplain ordinances intended to support the FEMA National Flood Insurance Program and future DWR requirements pertaining to a 200-year base flood in developed and developing areas.
- Location hydraulic studies.
- Borrow permit administered by CVFPB under Title 23.

The three HST alternative alignments cross waterbodies that have an adopted plan of flood control and FEMA floodplains; therefore, encroachment permits, local development permits, Caltrans location hydraulic studies, and, potentially, borrow permits are required. The guideways would be designed to limit hydraulic impacts at waterbody crossings and floodplains to satisfy regulatory requirements. Hydraulic modeling is required to evaluate hydraulic impacts, conform to Title 23 design regulations, and demonstrate to USACE that a Section 408 permit is not required.

This section includes an inventory of the available hydrologic and hydraulic information acquired through a combination of research, interviews with state and local agencies, FISs, and local hydraulic studies. It also outlines recommended approaches for obtaining missing hydrologic and hydraulic information and conducting hydraulic modeling where necessary.

6.2 Encroachment Permits

6.2.1 Encroachment Permit Overview

CVFPB is responsible for reviewing and approving all encroachment permits under Title 23 and California Water Code Section 8710. Preliminary direction by the CVFPB was that encroachments permits are required for three types of waterbodies associated with designated flood projects: leveed streams, designated floodways, and regulated streams. Each of these is associated with a stage in the development of the CVFPB:

- **Leveed streams:** The predecessor agency of CVFPB (the California Reclamation Board) was originally established to provide assurance that federal flood control projects constructed by USACE are operated and maintained (usually by a local levee maintenance agency) in accordance with the USACE O&M manuals prepared for the individual rivers.
- **Designated floodways:** Under the Designated Floodway Program, CVFPB can establish and delineate floodplains that it regulates, even when not originally part of a USACE flood control project. The Designated Floodway Program is CVFPB's primary nonstructural floodplain management program, with the purpose of controlling encroachments and unwise development within the floodplains of unleveed streams in the Central Valley. CVFPB issues permits for encroachments in designated floodways through its Encroachment Permit Program outlined in Title 23.

- **Regulated streams:** In addition to regulating development in designated floodways, CVFPB also requires encroachment permits for development along regulated streams identified in Title 23. Regulated streams are distinguished from designated floodways in that there is no established floodway in regulated streams. The goal is to maintain existing flood capacity within stream channels. The objective is to regulate the streams to manage encroachments and obstructions that would hinder flood passage.

- In February, the CVFPB made it clear that Encroachment Permits should be obtained by the HST Project consultants and not left to the design-build team (Taras 2011). In April, the CVFPB provided direction that the CVFPB jurisdiction was not limited to regulated streams as listed in Title 23; rather, than their jurisdiction pertains to all tributaries of the San Joaquin River and the Sacramento River under California Water Law Section 8710, and that encroachment permit applications should be submitted for "every named slough" that the HST Project crosses (and that application would not be required for "unnamed trickle creeks" and irrigation canals) (Taras and Tice 2011). Furthermore, the permit application would include topographical and hydraulic data.

6.2.2 Required Encroachment Permits

CVFPB's jurisdiction includes all the tributaries and distributaries of the Sacramento and San Joaquin River basins. Each waterbody crossing under the UPRR/SR 99, BNSF, and Hybrid alternatives are within the San Joaquin River basin. All three alignments cross five designated floodways and eight regulated streams. The Owens Creek Diversion is constrained by federal flood-control levees, and there are additional named tributaries to the San Joaquin River that are crossed (see Table 6-1). These crossings require encroachment permits. Where the BNSF Alternative crosses a Merced County Stream Group Flood Control Project levee on the Owens Creek Diversion Channel, it would be designed for minimal impacts to the levee and flood-control capacity to qualify for an encroachment permit from the CVFPB.

Table 6-1
Waterbodies Requiring Encroachment Permits

Designated Floodways	Regulated Stream	Flood Control Project	Other Streams
Chowchilla River	Canal Creek	Owens Creek Diversion	Miles Creek Overflow No. 1
Ash Slough	Black Rascal Creek		Deadman Creek
Berenda Slough	Bear Creek		Dutchman Creek
Fresno River	Miles Creek		Berenda Creek
San Joaquin River	Owens Creek		Schmidt Creek
	Duck Slough		Cottonwood Creek
	Mariposa Creek		
	Ash Slough[a]		
	Dry Creek		

[a] Portions of Ash Slough west of SR 99 do not have designated floodways

Tables 5-4, 5-6, and 5-8 indicate that the HST alternatives cross several natural waterbodies multiple times. In some cases (e.g., Ash Slough, Berenda Slough, Chowchilla River, Owens Diversion Channel, Owens Creek, Mariposa Creek, Miles Creek, and Dry Creeks), a separate permit is required for each individual crossing because the crossings are separated. However, where the alignment crosses a cluster of points in a waterway because of a meander, such as the three Duck Slough crossings under the UPRR/SR 99 Alternative, only one permit application is required (Taras 2010). The number of encroachment permits required depends on the alternative alignment selected, the design options and wye chosen within that alternative, and negotiations with CVFPB over exactly which crossings would require a permit. The number of permits required would likely be similar to the number of named natural stream crossings in Tables 5-4, 5-6 and 5-8. The number of crossings identified for possible permit applications would diminish as the design alternatives for the alignments are defined.

6.2.3 Approach for Obtaining Encroachment Permits

It has yet to be decided whether encroachment permit applications will be submitted during the preliminary engineering phase (before 30% design) or by the design-build contractor; however, CVFPB has made it clear that they expect submittal in conjunction with 30% design. Caltrans requires location-specific hydraulic studies in support of environmental permitting, and the studies need to be completed early in the process. Early completion of the hydraulic assessments also supports 30% design efforts. This section addresses an approach to permitting that assumes submittal of encroachment permits in conjunction with 30% design.

Applications must be completed by using the encroachment permit application form at the end of Title 23. Recommendations for completing each field on the form include the following:

1. **Description of the proposed work:** A concise, boilerplate description of the project on a program level. This should be used for each application from, followed by a description of the specific crossing (e.g., elevated or at-grade; bridge or culvert; size; and details).

2. **Location:** Use geographic information system (GIS) data to provide the location of the specific crossing including county, section, township, range, base, and meridian.

3. **Applicants' contact information:** Assume that CH2M HILL represents the Authority, and provide a point-of-contact for permit coordination and ownership.

4. **Endorsement signatures or letters of endorsement:** Appendix A lists local maintenance agencies (primarily irrigation districts). Each district would have the option of drafting a single letter of endorsement for all crossings within their jurisdiction, or separately signing each application that pertains to their irrigation system. Districts were advised of the eventual need for endorsement during face-to-face meetings on May 26 and 27, 2010, and asked to provide supporting information including the following:

- Confirmation that the system of waterways and levees is properly identified and labeled in the HST database.
- Channel and levee dimensions.
- Design flows.
- Hydrologic and hydraulic models.
- Design high-water elevations.
- Key design considerations and requirements.
- Environmental considerations.

5. **List of names and addresses of all adjacent property owners:** Obtain this information from the GIS database of property owners along the HST alignment.

6. **CEQA determination and lead contacts:** For CEQA documents, applications should be submitted after publication of the ROD. Check the "YES" box.

7. **Timing of construction:** Provide the latest construction schedule.

8. **Exhibits:** Include maps of proposed work; plan drawings, elevations, sections, and details including profiles of existing and proposed features and color photographs of the proposed HST alignment. This information would be compiled during a future phase of this project.

9. **Contact information for the owner:** Provide information for the Program Management Team lead for the Authority.

10. **Completed environmental assessment questionnaire:** The permitting team would coordinate with CH2M HILL to provide site-specific and global environmental summaries.

11. **Additional information, as needed:** Primarily, USACE will determine additional information needs. This would likely include hydraulic modeling for each crossing. In some cases, it may include survey data, geotechnical investigations, supporting design packages, and information on nonproject levees and irrigation district contacts.

CVFPB requires a separate permit application for each stream crossing, except where crossings are clustered as a set (e.g., crossing a stream meander or where a guideway begins to separate).

6.2.3.1 Letters of Endorsement

The local agencies responsible for the maintenance of levees within the area of the proposed work must endorse encroachment permit applications before submitting the applications to CVFPB. This includes irrigation districts and local levee maintenance agencies. A formal letter of endorsement is not required; instead, the application form can be signed to indicate endorsement or withholding of endorsement. Additional information can be included in a letter and submitted with the application.

If the application is not endorsed or is unreasonably delayed, it can be submitted without the endorsement with a satisfactory explanation. CVFPB may still consider the application for approval.

6.2.3.2 High-Level Workplan

In general, complete the following sequential steps:

1. Summarize available and anticipated hydrology and hydraulic models and data in the report. Decide on the approach to fill in inadequate existing hydrologic data to define the design flow rate.

2. Continue to acquire existing data that are available but not received.

3. Identify and review existing survey data. Develop a survey plan to obtain missing data for hydraulic models required for selected crossings. Include surveys of irrigation canals, as needed.

4. Develop hydrologic models for crossings that are missing design flow information. Review with CVFPB the approach for developing hydrologic models, and the adequacy of existing design flows. This section identifies the need for additional hydrology.

5. Develop hydraulic models, as needed, for each crossing (existing and proposed conditions). Demonstrate that rise criteria are met, and provide the design WSE.

6. Develop permit applications in an assembly line approach, with designated participants filling in the same sections on multiple applications.

7. Develop scope, budget, and schedule at two key junctures: (1) to complete acquisition of identified, available data and (2) to perform surveying and hydraulic modeling and complete draft permit applications.

6.3 Local Implementation of Federal and State Floodplain Programs through Development Permits

6.3.1 100-Year Base Flood

The Cities of Merced, Atwater, Chowchilla, Madera, and Fresno and Merced, Madera, and Fresno counties regulate development within flood hazard areas through floodplain ordinances. These cities and counties are part of the NFIP and have defined flood hazard areas through a local FIS (refer to Section 3.1.3). For each jurisdiction, the regulated flood hazard area is the floodplain for the FEMA base flood, with a 100-year return period. All new development within flood hazard areas must meet the lowest floor elevation or flood-proofing requirements outlined in Section 3.1.

In some cases, a defined floodway is located within areas of special flood hazard (the FEMA 100-year floodplain). As indicated in Section 3.2.3, these floodways are different from CVFPB designated floodways and are defined by FEMA as the area including channel and adjacent land that must be reserved to discharge the base flood without causing a cumulative WSE rise greater than 1 foot. New developments that encroach on floodways are prohibited, unless a registered civil engineer certifies that the encroachments would not cause an increase in BFE during a base flood discharge.

6.3.2 200-Year Base Flood

As indicated in Sections 3 and 4, California has adopted a new standard for base flood events in the Central Valley for urban and urbanizing areas. As part of the Central Valley Flood Protection Plan and California flood legislation in 2008, the 200-year flood discharge and 200-year floodplain would be the new standard for planning and floodplain ordinances by January 1, 2015, for urban and urbanizing areas. DWR is still in the process of redefining the new 200-year discharge and floodplain under its FloodSAFE program (DWR 2008c; Taras 2011). CVFPB has provided direction that original hydrology should be developed by the HST Project consultants without waiting on the DWR (Taras 2011).

6.3.3 Required Development Permits

Local development permits for base floor elevations, floodproofing, and floodway encroachments. The Merced, Madera, or Fresno FISs reference the streams that flood in these jurisdictions and San Joaquin River where FEMA has defined floodways require particular attention. Table 6-2 includes streams that should be analyzed for local development permits.

Table 6-2
Waterbodies Pertinent to Local Floodplain Ordinance Development Permits

Merced County	Madera County	Fresno County
Canal Creek[a]	Chowchilla River[a]	San Joaquin River
Black Rascal Creek	Ash Slough[a]	
Bear Creek	Berenda Slough[a]	
Miles Creek	Fresno River	
Owens Creek[a]	Dry Creek	
Duck Slough[a]	Schmidt Creek	

Merced County	Madera County	Fresno County
Mariposa Creek[a]		

[a] No modeling information is available for these waterways in the county FIS reports. However, they have an important role in floodplain management for Merced and Madera counties. For the purpose of this report, these waterways should be included in analysis for development permit applications.

6.3.4 Approach for Development Permits

Applications for development permits must be obtained before any construction or development within any special flood hazard zone can begin. To apply for a development permit, all other required state and federal permits must be obtained prior to the permit review. This includes all appropriate encroachment permits. However, encroachment and local development permit applications and the associated hydrologic and hydraulic analysis could be completed in parallel. Encroachment permits require endorsement of the conceptual design by local endorsement agencies, including cities and levee and irrigation districts, prior to review by CVFPB.

Development permit applications are obtained through the appropriate municipalities. Typical permits require the following information (Fresno County Ordinances, Chapter 15.48.060, Flood Hazard Areas Administration):

1. Plans in duplicate, drawn to scale, showing the following:
    a. Location, dimensions, and elevation for the area in question, existing or proposed structures, storage of materials and equipment, and their location.
    b. Proposed locations of water supply, sanitary sewer, and other utilities.
    c. Grading information showing existing and proposed contours, proposed fill, and drainage facilities.
    d. Location of the regulatory floodway when applicable.
    e. BFE obtained from the appropriate local FIS. Where not available, the BFE must be estimated by using local studies or in accordance with *Managing Floodplain Development in Approximate Zone A Areas: A Guide for Obtaining and Developing Base (100-Year) Flood Elevations* (FEMA 1995).
    f. Proposed elevation, in relation to mean sea level, of the lowest floor (including basement) of all proposed structures.
    g. Proposed elevation in relation to mean sea level to which a proposed nonresidential structure would be floodproofed according to the local floodplain ordinance.
2. Certification by a registered civil engineer or architect that the proposed nonresidential floodproofed building meets the local flood proofing criteria.
3. Description of the extent to which any watercourse would be altered or relocated as result of proposed development.

To establish minimum elevations and grading requirements, the FEMA flood hazard area zones must be determined for the alignment by using the appropriate local FIRMs. Additionally, BFEs for each flood hazard area must be obtained by using the appropriate FIRMs, FISs, local hydraulic studies where available, or through modeling where needed. To ensure that BFEs within regulated floodways do not increase, the extent of the Fresno River and San Joaquin River regulated floodways at the HST crossings and the BFEs at those locations must be acquired or developed through hydraulic modeling before applying for local development permits.

6.4 Location Hydraulic Studies

As discussed in Section 3.1.4, location hydraulic studies must be performed for each of the major stream crossings. For permitting purposes, it is assumed these are the same waterbodies identified for development permits. The level of detail for these studies is comparable to the analysis required for development permits and should be summarized in a floodplain evaluation report appended to the final EIR/EIS for the Merced to Fresno Section. The following should be determined and developed for all waterbodies identified in Table 6-2:

- WSE based on the 100-year design flow (or 200-year design flow).
- Map illustrating the FEMA 100-year flood limits (or DWR 200-year floodplain limits) and portions of the project and existing buildings situated within the floodplain.
- Completion of Forms 804.7A (Technical Information for Location Hydraulic Study) and 804.7B (Floodplain Evaluation Report Summary) for projects identified to have minor floodplain impacts (Section 804 of the *Highway Design Manual* [Caltrans 2009]).

6.5 Hydrologic Information

Preliminary research and interviews were conducted to determine what hydrologic information is currently available and to assess the quality of that information. The base or design flow is the most important hydrologic information needed to perform the appropriate hydraulic analyses to support permitting efforts. Where possible, it is preferred to use existing design floods and peak-discharge flow rates rather than developing new hydrologic models. The following were inventoried for hydrologic information:

- USACE O&M manuals for state–federal flood control projects.
- CVFPB Designated Floodway Program documents.
- Local FISs.
- DWR Best Available Maps.
- Caltrans hydrologic records.
- Irrigation district design flows.
- USACE Comprehensive Study (USACE 2002) and ongoing FloodSAFE Program.
- Local county and municipal records.

Tables 6-3, 6-4, and 6-5 summarize the results for the UPRR/SR 99, BNSF and Hybrid alternatives, respectively. The references section includes the sources used for this inventory.

6.5.1 Hydrologic Information for Encroachment Permits

USACE levee O&M manuals design capacities and CVFPB designated project design flows are the most pertinent hydrologic values for encroachment permits. USACE provided the O&M manuals for three state-federal flood control projects (Larson 2010):

- Merced County Stream Group: *Operation and Maintenance Manual for Channels and Levees of the Merced County Stream Group* (USACE 1962).
- Buchanan Dam and H.V. Eastman Lake: *Operation and Maintenance Manual for Channels and Levees of the Hidden Buchanan Dam and H.V. Eastman Lake* (USACE 1960).
- Hidden Dam and Hensely Lake projects: *Operation and Maintenance Manual for Channels and Levees of the Hidden Dam and Hensely Lake* (USACE 1959).

Figures 6-1, 6-2, and 6-3 illustrate the stream reaches included in these projects and the location of some project levees. The design flows provided in the USACE O&M manuals are based on 100-year flood event information from studies performed in the 1960s and are fixed by the original authorizing legislation. The three O&M manuals provide channel capacities for all CVFPB-designated floodways and regulated streams requiring encroachment permits, except for Canal Creek, Owens Creek, and Dry Creek. Design flows in the San Joaquin River that are related to the Lower San Joaquin River Flood Control Project, are 8,000 cfs, which is valid from the Friant Dam upstream to the Chowchilla Canal Bypass Upstream (DWR 1964). In this case, the design flow is much smaller than the results of more recent modeling (e.g., the FEMA base flood flow rate is 74,300 cfs [FEMA 2009b]), which takes precedence for project designers.

Table 6-3
Inventory of Hydrologic Information – UPRR/SR 99 Alternative

Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
				Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
010S-CaCk ****	Canal Creek	Regulated stream/ irrigation canal	Encroachment & Merced County Development	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002	200-year	TBD
020S-BrCk ****	Black Rascal Creek	Regulated stream	Encroachment & City of Merced Development	3,900	Merced County Stream Group	1962	N/A	N/A	5,720	1995	14,700	1995	Merced County FIS	AE	Requested	USACE Comprehensive Study, 2002	100-year	5,720
030S-BaCk ****	Bear Creek	Regulated stream	Encroachment & City of Merced Development	7,000	Merced County Stream Group	1962	N/A	N/A	6,150	1995	11,100	1995	Merced County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
055S-MCOF	Miles Creek Overflow No. 1	Named stream	Encroachment & City of Merced Development	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002		
060S-MiCk	Miles Creek	Regulated stream	Encroachment & Merced County Development	1,000	Merced County Stream Group	1962	N/A	N/A	3,400	1995	Unavailable	Unavailable	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002	200-year	TBD
080S-OwCk	Owens Creek	Regulated stream	Encroachment & Merced County Development	Does not exist**	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	100-year	TBD
110S-DuSl; 111S-DuSl; 112S-DuSl	Duck Slough	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	200-year	TBD
200S-DdCk	Deadman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002		
209S-DtCk-B	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002		
210S-DtCk	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002		
211S-DtCk	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002		
762S-DtCk-A	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002		

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
766S-DtCk-A	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002		
220S-ChRi	Chowchilla River	Designated floodway	Encroachment & Madera County Development	1,000[1]	Buchanan Dam and H.V. Eastman Lake [2]	1960	1,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	200-year	TBD
516S-ChRi	Chowchilla River	Designated floodway	Encroachment & Madera County Development	500[1]	Buchanan Dam and H.V. Eastman Lake	1960	500	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	500
780S-ChRi-A	Chowchilla River	Designated floodway	Encroachment & Madera County Development	500[1]	Buchanan Dam and H.V. Eastman Lake	1960	500	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	500
230S-AsSl	Ash Slough	Designated floodway	Encroachment & City of Chowchilla Development	6,000	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	6,000
523S-AsSl	Ash Slough	Regulated stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
792S-AsSl-A	Ash Slough	Regulated stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
850S-AsSl-A	Ash Slough	Regulated stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
250S-BeSl	Berenda Slough	Designated floodway	Encroachment	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
609S-BeSl	Berenda Slough	Regulated stream	Encroachment & City of Chowchilla Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
798S-BeSl-A	Berenda Slough	Regulated stream	Encroachment & City of Chowchilla Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
800S-BeSl-A	Berenda Slough	Regulated stream	Encroachment & City of Chowchilla Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
802S-BeSl-A	Berenda Slough	Regulated stream	Encroachment & City of Chowchilla Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
880S-BeSl-A	Berenda Slough	Regulated stream	Encroachment	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000/A	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
290S-BeCk	Berenda Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002		
291S-BeCk	Berenda Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002		
302S-DrCk	Dry Creek	Nonregulated segment of regulated stream	Encroachment & Madera County Development	N/A	N/A	N/A	N/A	N/A	2,830	1985	3,950	1985	Madera County FIS	AH	Requested	USACE Comprehensive Study, 2002	100-year	2,830
311S-ScCk	Schmidt Creek	Stream	Madera County Development	N/A	N/A	N/A	N/A	N/A	1,270	1985	1,760	1985	Madera County FIS	AO	Requested	USACE Comprehensive Study, 2002	200-year	TBD
331S-FrRi	Fresno River	Designated floodway	Encroachment & City of Madera Development	5,000 [3]	Hidden Dam and Hensley Lake [4]	1959	5,000	1970	5,800	1985	12,500	1985	Madera County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
370S-CwCk	Cottonwood Creek	Stream	Madera County Development	N/A	N/A	N/A	N/A	N/A	4,810	1985	6,670	1985	Madera County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
401S-SjRi	San Joaquin River [5]	Designated floodway	Encroachment & City of Fresno Development	Unavailable	Unavailable	Unavailable	18,000-20,000	1977	74,300	1998 [6]	151,100	1998	Fresno County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
522S-AsSl	Ash Slough	Regulated stream	Encroachment & City of Chowchilla Development	Does not exist***	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
526S-AsSl	Ash Slough	Regulated stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
600S-AsSl	Ash Slough	Regulated stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
608S-BeSl	Berenda Slough	Regulated stream	Encroachment & City of Chowchilla Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
854S-BeSI-A	Berenda Slough	Regulated stream	Encroachment & City of Chowchilla Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
856S-BeSI-A	Berenda Slough	Regulated stream	Encroachment & City of Chowchilla Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
252S-BeSI	Berenda Slough	Regulated stream	Encroachment	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000/A	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000

** Owens Creek is part of the Merced County Stream Group Flood Control Project. However, no flow capacity is indicated for Owens Creek at the location of this crossing.

*** Ash Slough is part of the Buchanan Dam and H.V. Eastman Lake Flood Control Project. However, no flow capacity is indicated for Ash Slough at the location of this crossing.

**** These sites are included only on the access track to the Castle Commerce Center HMF.

***** CVFPB adopted design flows for regulated streams that contain designated floodways. Both alignments that cross portions of Ash Slough and Berenda Slough that are considered designated floodways and that are not considered designated floodways. Design flow information is available for both. However, the program does not provide design flows for regulated streams that do not contain a designated floodway along any portion of it (e.g., Black Rascal Creek).

[1] Design flow changes from 1,000 cfs to 500 cfs approximately 1 mile downstream of Hwy 99.

[2] All Merced to Fresno Section alignments cross the Chowchilla River, Ash Slough, and Berenda Slough downstream from the federal project at "unimproved portions of the channel."

[3] Design flow changes from 8,000 cfs immediately upstream from crossing.

[4] All Merced to Fresno Section alignments cross the Fresno River upstream from the federal project at "unimproved portions of the channel."

[5] Efforts to restore the San Joaquin River involve restudying the hydrology and hydraulics. Information gathered regarding San Joaquin River is subject to change.

[6] Since 1981, there have been three re-studies and revisions for the San Joaquin River (1996, 1998, and 2000).

Does Not Exist = Detailed analysis of this stream was not performed as a part of the county FIS.

N/A = not applicable

TBD = to be determined

Table 6-4
Inventory of Hydrologic Information – BNSF Alternative

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
010S-CaCk ****	Canal Creek	Regulated stream/ irrigation canal	Encroachment & Merced County Development	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD
020S-BrCk ****	Black Rascal Creek	Regulated stream	Encroachment & City of Merced Development	3,900	Merced County Stream Group	1962	N/A	N/A	5,720	1995	14,700	1995	Merced County FIS	AE	Pending from USACE	USACE Comprehensive Study, 2002	100-year	5,720
030S-BaCk ****	Bear Creek	Regulated stream	Encroachment & City of Merced Development	7,000	Merced County Stream Group	1962	N/A	N/A	6,150	1995	11,100	1995	Merced County FIS	AE	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD
056S-MCOF	Miles Creek Overflow No. 1	Named stream	Encroachment & City of Merced Development	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002		
061S-MiCk	Miles Creek	Regulated stream	Encroachment & Merced County Development	1,000	Merced County Stream Group	1962	N/A+	N/A	3,400	1995	Unavailable	Unavailable	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	100-year	3,400
079S-OwCk	Owens Creek	Regulated stream	Encroachment & Merced County Development	Does not exist	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD
140S-OwCk	Owens Creek	Regulated stream	Encroachment & Merced County Development	Not available	Not available	Not available	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	100-year	TBD
714S-OwCk-A	Owens Creek	Regulated stream	Encroachment & Merced County Development	N/A	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD
724S-OwCk-A	Owens Creek	Regulated stream	Encroachment & Merced County Development	N/A	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD
110S-DuSl	Duck Slough	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
722S-DuSl-A	Duck Slough	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD
126C-DiCh	Owens Creek Diversion Channel	Flood control project diversion channel	408, Encroachment & Merced County Development	400	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AH	Pending from USACE	USACE Comprehensive Study, 2002	100-year	400
156C-DiCh	Owens Creek Diversion Channel	Flood control project diversion channel	408, Encroachment & Merced County Development	400	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	400
540S-MaCK	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	100-year	1,250
541S-MaCK	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	100-year	1,250
542S-MaCK	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	100-year	1,250
130S-MaCk	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	100-year	1,250
132S-MaCk	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	100-year	1,250
732S-MaCk-A	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Pending from USACE	USACE Comprehensive Study, 2002	100-year	1,250
136S-MaCk	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Pending from USACE	USACE Comprehensive Study, 2002	100-year	1,250

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
733S-MaCk-A	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Pending from USACE	USACE Comprehensive Study, 2002	100-year	1,250
137S-MaCk	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Pending from USACE	USACE Comprehensive Study, 2002	100-year	1,250
138S-MaCk-B	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Pending from USACE	USACE Comprehensive Study, 2002	100-year	1,250
139S-MaCk	Mariposa Creek	Regulated stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS		Requested	USACE Comprehensive Study, 2002	100-year	1,250
201S-DdCk	Deadman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002		
738S-DdCk-A	Deadman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2003		
207S-DdCk	Deadman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2004		
202S-DdCk	Deadman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2005		
205S-DdCk	Deadman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS		Requested	USACE Comprehensive Study, 2006		
740S-DtCk-A	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2007		
206S-DtCk	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2008		
560S-DtCk	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2009		

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
222S-DtCk	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2010		
223S-DtCk	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS		Requested	USACE Comprehensive Study, 2011		
226S-ChRi	Chowchilla River	Designated floodway	Encroachment & Madera County Development	1,000 [1]	Buchanan Dam and H.V. Eastman Lake [2]	1960	1,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	1,000
231S-AsSl	Ash Slough	Designated floodway	Encroachment & City of Chowchilla Development	10,000	Buchanan Dam and H.V. Eastman Lake	1960	10,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	10,000
253S-BeSl	Berenda Slough	Designated floodway	Encroachment & City of Chowchilla Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
292S-BeCk	Berenda Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2011		
300S-DrCk	Dry Creek	Nonregulated segment of regulated stream	Encroachment & Madera County Development	N/A	N/A	N/A	N/A	N/A	2,830	1985	3,950	1985	Madera County FIS	AO	Requested	USACE Comprehensive Study, 2002	100-year	2,830
301S-DrCk	Dry Creek	Nonregulated segment of regulated stream	Encroachment & Madera County Development	N/A	N/A	N/A	N/A	N/A	2,830	1985	3,950	1985	Madera County FIS	AO	Requested	USACE Comprehensive Study, 2002	100-year	2,830
310S-ScCr	Schmidt Creek	Stream	Madera County Development	N/A	N/A	N/A	N/A	N/A	1,270	1985	1,760	1985	Madera County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
808S-ScCr-A	Schmidt Creek	Stream	Madera County Development	N/A	N/A	N/A	N/A	N/A	1,270	1985	1,760	1985	Madera County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
330S-FrRi	Fresno River	Designated floodway	Encroachment & City of Madera Development	8,000 [3]	Hidden Dam and Hensley Lake [4]	1959	8,000	1970	5,800	1985 [5]	29,000	1985	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	200-year	TBD

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
812S-FrRi-A	Fresno River	Designated floodway	Encroachment & City of Madera Development	8,000 [3]	Hidden Dam and Hensley Lake [4]	1959	8,000	1970	5,800	1985 [5]	29,000	1985	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	200-year	TBD
370S-CwCk	Cottonwood Creek	Stream	Madera County Development	N/A	N/A	N/A	N/A	N/A	4,810	1985	6,670	1985	Madera County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
400S-SjRi	San Joaquin River [6]	Designated floodway	Encroachment & City of Fresno Development	Not available	Not available	Not available	18,000–20,000	1977	74,300	1986	151,100	1998 [7]	Fresno County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
600S-AsSl	Ash Slough	Regulated stream	Encroachment & City of Chowchilla Development	Does not exist***	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
252S-BeSl	Berenda Slough	Regulated stream	Encroachment & Madera County Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
880S-BeSl-A	Berenda Slough	Regulated stream	Encroachment & Madera County Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
294S-BeCk	Berenda Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2011		
609S-BeSl	Berenda Slough	Regulated stream	Encroachment & Madera County Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
802S-BeSl-A	Berenda Slough	Regulated stream	Encroachment & Madera County Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000
293S-BeCk	Berenda Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2011		

**Owens Creek is part of the Merced County Stream Group Flood Control Project. However, no flow capacity is indicated for Owens Creek at the location of this crossing.

*** Ash Slough is part of the Buchanan Dam and H.V. Eastman Lake Flood Control Project. However, no flow capacity is indicated for Ash Slough at the location of this crossing.

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)

**** These sites are included only on the access track to the Castle Commerce Center HMF.

***** CVFPB adopted design flows for regulated streams that contain designated floodways. Both alignments cross portions of Ash Slough and Berenda Slough that are considered designated floodways and that are not considered designated floodways. Design flow information is available for both. However, the program does not provide design flows for regulated streams that do not contain a designated floodway along any portion of it (e.g., Black Rascal Creek).

1 Design flow changes from 1,000 cfs to 500 cfs approximately 1 mile downstream of Hwy 99.

2 All Merced to Fresno Section alignments cross the Chowchilla River, Ash Slough, and Berenda Slough downstream from the federal project at "unimproved portions of the channel."

3 Design flow changes from 10,000 cfs immediately upstream from crossing.

4 All Merced to Fresno Section alignments cross the Fresno River upstream from the federal project at "unimproved portions of the channel."

5 A re-study and revision have been performed for Fresno River since 1985. However, the FIS does not include the date of this revision.

6 Efforts to restore the San Joaquin River involve re-studying the hydrology and hydraulics. Information gathered regarding San Joaquin River is subject to change.

7 Since 1981, there have been three re-studies and revisions for the San Joaquin River (1996, 1998, and 2000).

Does Not Exist = Detailed analysis of this stream was not performed as a part of the county FIS.

N/A = not applicable

TBD = to be determined

Table 6-5
Inventory of Hydrologic Information – HYBRID Alternative

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
010S-CaCk ***	Canal Creek	Regulated Stream/ Irrigation Canal	Encroachment & Merced County Development	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD
020S-BrCk ***	Black Rascal Creek	Regulated Stream	Encroachment & City of Merced Development	3,900	Merced County Stream Group	1962	N/A	N/A	5,720	1995	14,700	1995	Merced County FIS	AE	Pending from USACE	USACE Comprehensive Study, 2002	100-year	5,720
030S-BaCk ***	Bear Creek	Regulated Stream	Encroachment & City of Merced Development	7,000	Merced County Stream Group	1962	N/A	N/A	6,150	1995	11,100	1995	Merced County FIS	AE	Pending from USACE	USACE Comprehensive Study, 2002	200-year	TBD
055S-MCOF	Miles Creek Overflow No. 1	Named stream	Encroachment & City of Merced Development	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002		
060S-MiCk	Miles Creek	Regulated Stream	Encroachment & Merced County Development	1,000	Merced County Stream Group	1962	N/A	N/A	3,400	1995	Unavailable	Unavailable	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	200-year	TBD
080S-OwCk	Owens Creek	Regulated Stream	Encroachment & Merced County Development	Does Not Exist**	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	100-year	TBD
110S-DuSl; 111S-DuSl; 112S-DuSl	Duck Slough	Regulated Stream	Encroachment & Merced County Development	1,250	Merced County Stream Group	1962	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	200-year	TBD
200S-DdCk	Deadman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	AO	Requested	USACE Comprehensive Study, 2002	0	0
209S-DtCk-B	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002	0	0
210S-DtCk	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002	0	0

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
762S-DtCk-A	Dutchman Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Merced County FIS	A	Requested	USACE Comprehensive Study, 2002	0	0
516S-ChRi	Chowchilla River	Designated Floodway	Encroachment & Madera County Development	500 [1]	Buchanan Dam and H.V. Eastman Lake [2]	1960	1,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	1,000
220S-ChRi	Chowchilla River	Designated floodway	Encroachment & Madera County Development	1,000 [1]	Buchanan Dam and H.V. Eastman Lake [2]	1960	1000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	200-year	TBD
780S-ChRi-A	Chowchilla River	Designated Floodway	Encroachment & Madera County Development	500 [1]	Buchanan Dam and H.V. Eastman Lake [2]	1960	1,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	1,000
230S-AsSl	Ash Slough	Designated floodway	Encroachment & City of Chowchilla Development	6000	Buchanan Dam and H.V. Eastman Lake	1960	5000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	6000
523S-AsSl	Ash Slough	Regulated Stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
792S-AsSl-A	Ash Slough	Regulated Stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
850S-AsSl-A	Ash Slough	Regulated Stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
609S-BeSl	Berenda Slough	Regulated Stream	Encroachment & Madera County Development	2,000	Buchanan Dam and H.V. Eastman Lake	1960	2,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2,000

Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
				Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
250S-BeSl	Berenda Slough	Designated floodway	Encroachment	2000	Buchanan Dam and H.V. Eastman Lake	1960	2000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2000
802S-BeSl-A	Berenda Slough	Regulated stream	Encroachment & City of Chowchilla Development	2000	Buchanan Dam and H.V. Eastman Lake	1960	2000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2000
880S-BeSl-A	Berenda Slough	Regulated stream	Encroachment	2000	Buchanan Dam and H.V. Eastman Lake	1960	2,000/A	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2000
252S-BeSl	Berenda Slough	Regulated stream	Encroachment	2000	Buchanan Dam and H.V. Eastman Lake	1960	2,000/A	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	2000
294S-BeCk	Berenda Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2011		
296S-BeCk	Berenda Creek	Named stream	Encroachment	N/A	N/A	N/A	N/A	N/A	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2011		
301S-DrCk	Dry Creek	Nonregulated Segment of Regulated Stream	Encroachment & Madera County Development	N/A	N/A	N/A	N/A	N/A	2,830	1985	3,950	1985	Madera County FIS	AO	Requested	USACE Comprehensive Study, 2002	200-year	TBD
310S-ScCr	Schmidt Creek	Stream	Madera County Development	N/A	N/A	N/A	N/A	N/A	1,270	1985	1,760	1985	Madera County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
808S-ScCr-A	Schmidt Creek	Stream	Madera County Development	N/A	N/A	N/A	N/A	N/A	1,270	1985	1,760	1985	Madera County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
330S-FrRi	Fresno River	Designated Floodway	Encroachment & City of Madera Development	8,000 [3]	Hidden Dam and Hensley Lake [4]	1959	8,000	1970	5,800	1985 [5]	29,000	1985	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	200-year	TBD

				USACE Levee O&M Manuals			CVFPB- Designated Floodway Program		FIS						DWR		Authority Design Flow	
Crossing ID	Waterbody Name	Regulatory Status	Some Required Hydraulic Permits	Design Capacity (cfs)	Flood Control Project	Year of Authori-zation	Design Flow ***** (cfs)	Year Adopted	100-year Peak Flow Rate (cfs)	Study Year	500-year Peak Flow Rate (cfs)	Study Year	Source	100-year Flood Hazard Zone	200-year Peak Flow Rate (cfs)	Study Year	Design Frequency (%)	Design Flow (cfs)
812S-FrRi-A	Fresno River	Designated Floodway	Encroachment & City of Madera Development	8,000 [3]	Hidden Dam and Hensley Lake [4]	1959	8,000	1970	5,800	1985 [5]	29,000	1985	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	200-year	TBD
370S-CwCk	Cottonwood Creek	Stream	Madera County Development	N/A	N/A	N/A	N/A	N/A	4,810	1985	6,670	1985	Madera County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
400S-SjRi	San Joaquin River [6]	Designated Floodway	Encroachment & City of Fresno Development	Not Available	Not Available	Not Available	18,000-20,000	1977	74,300	1986	151,100	1998 [7]	Fresno County FIS	AE	Requested	USACE Comprehensive Study, 2002	200-year	TBD
522S-AsSl	Ash Slough	Regulated Stream	Encroachment & City of Chowchilla Development	Does not exist***	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
600S-AsSl	Ash Slough	Regulated Stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000
526S-AsSl	Ash Slough	Regulated Stream	Encroachment & City of Chowchilla Development	Does not exist	Buchanan Dam and H.V. Eastman Lake	1960	5,000	1972	Does not exist	Does not exist	Does not exist	Does not exist	Madera County FIS	A	Requested	USACE Comprehensive Study, 2002	100-year	5,000

** Ash Slough is part of the Buchanan Dam and H.V. Eastman Lake Flood Control Project. However, no flow capacity is indicated for Ash Slough at the location of this crossing.

*** These sites are included only on the access guideway to the Castle Commerce Center HMF.

***** The CVFPB adopted design flows for regulated streams that contain designated floodways. Both alignments cross portions of Ash Slough and Berenda Slough that are considered designated floodways and that are not considered designated floodways. Design flow information is available for both. However, the program does not provide design flows for regulated streams that do not contain a designated floodway along any portion of it (e.g., Black Rascal Creek).

[1] Design flow changes from 1,000 cfs to 500 cfs approximately 1 mile downstream of Hwy 99.

[2] All Merced to Fresno Section alignments cross the Chowchilla River, Ash Slough, and Berenda Slough downstream from the federal project at "unimproved portions of the channel."

[3] Design flow changes from 8,000 cfs immediately upstream from crossing.

[4] All Merced to Fresno Section alignments cross the Fresno River upstream from the federal project at "unimproved portions of the channel."

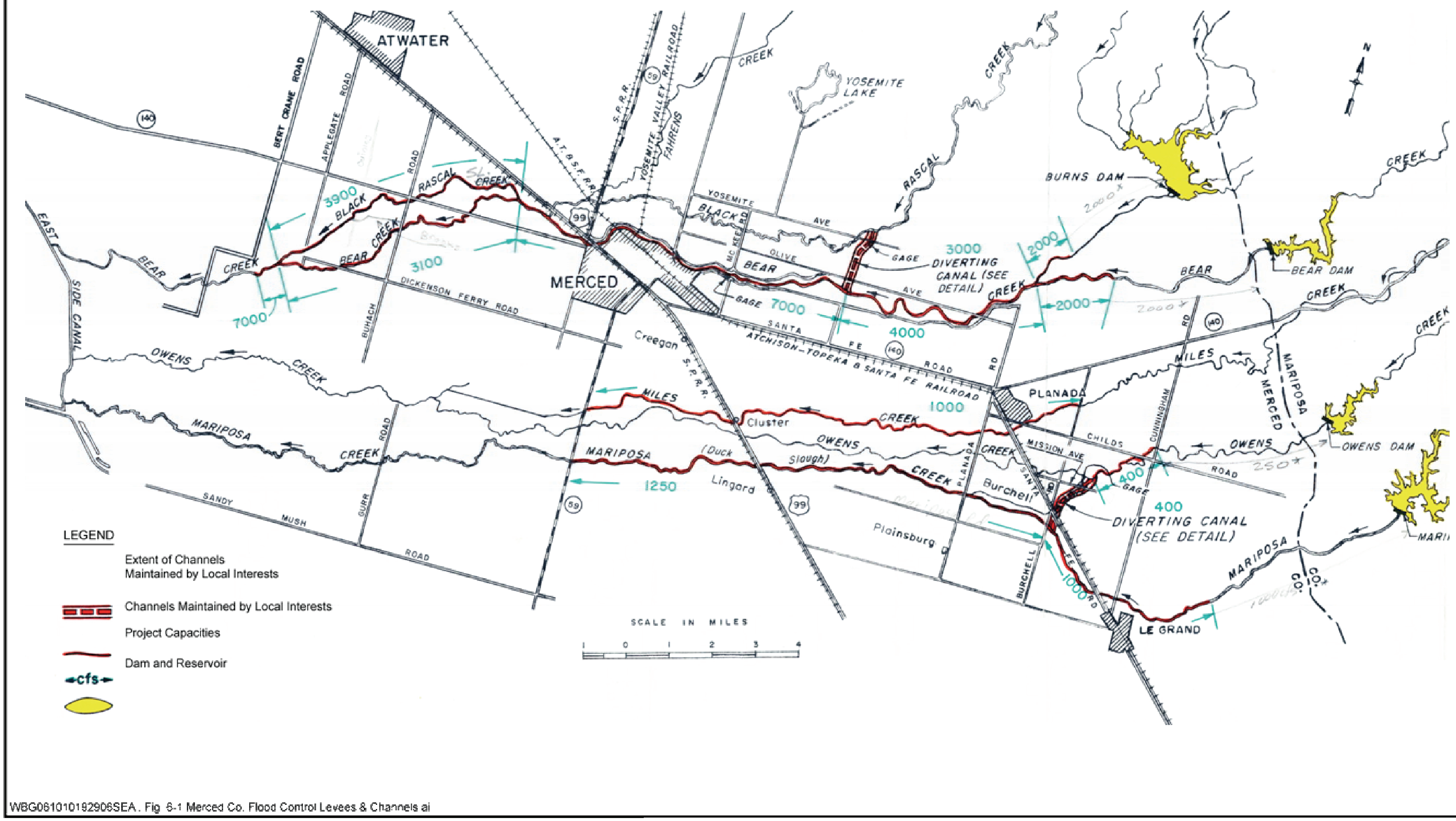
[5] Efforts to restore the San Joaquin River involve re-studying the hydrology and hydraulics. Information gathered regarding San Joaquin River is subject to change.

[6] Since 1981, there have been three re-studies and revisions for the San Joaquin River (1996, 1998, and 2000).

Does Not Exist = Detailed analysis of this stream was not performed as a part of the county FIS.

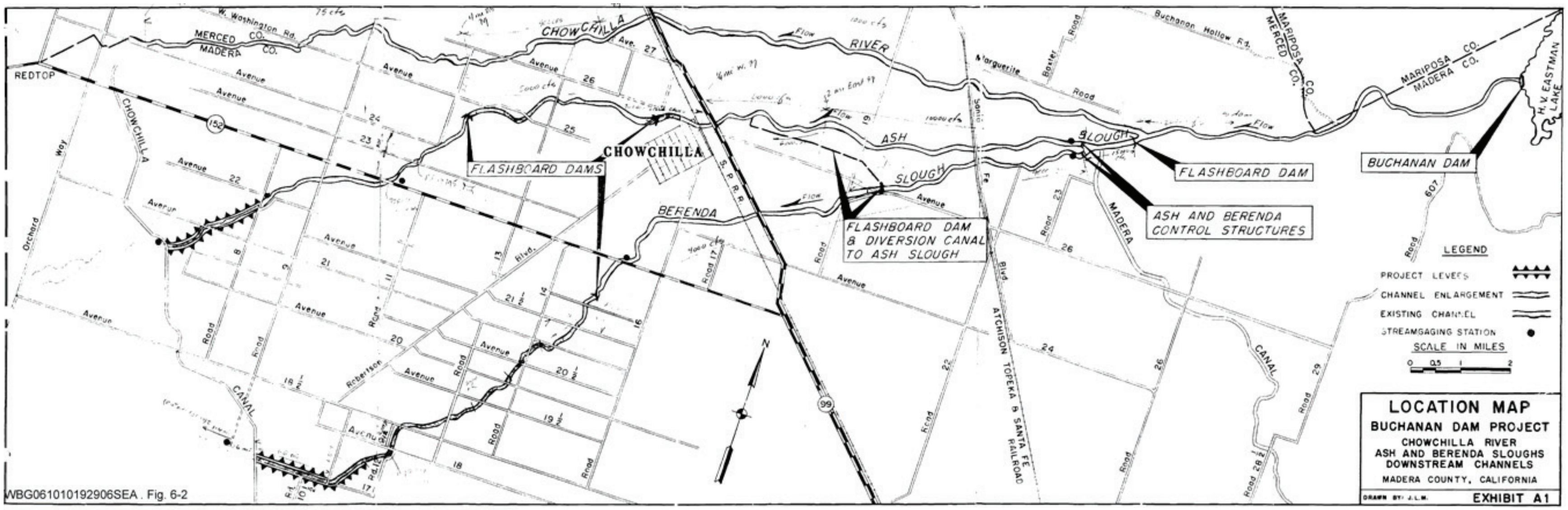
N/A = not applicable

TBD = to be determined



Source: USACE (1962).

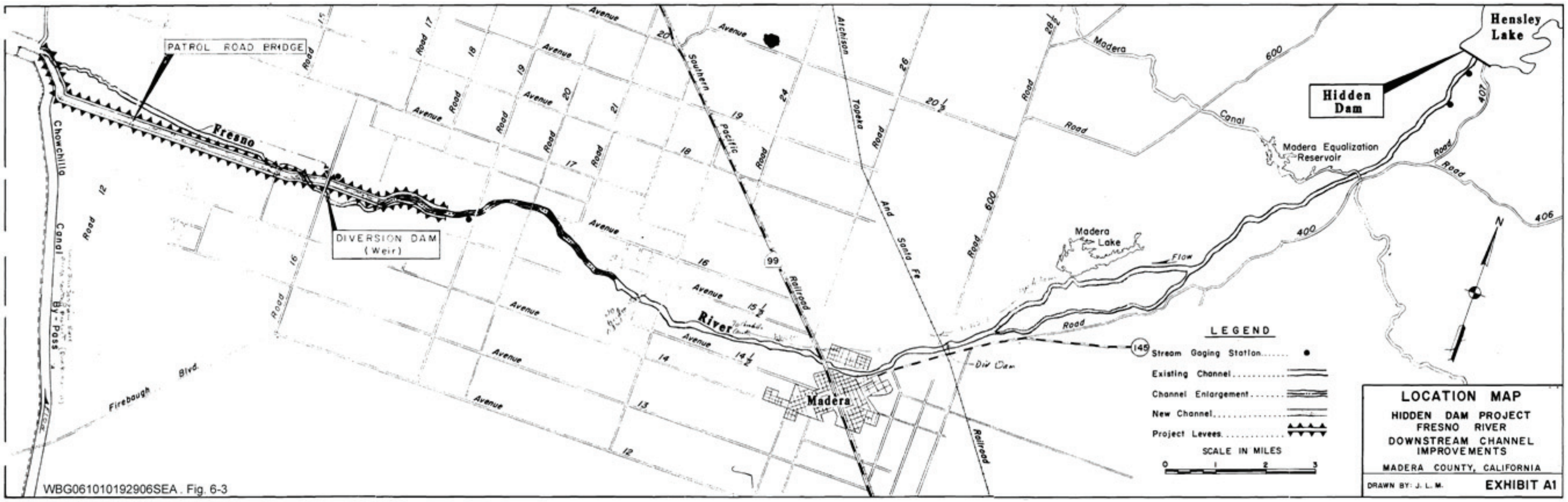
Figure 6-1
Merced County Stream Group Flood Control Project Levees and Channels Map



WBG061010192906SEA . Fig. 6-2

Source: USACE (1960).

Figure 6-2
Buchanan Dam and H.V. Eastman Lake Flood Control Project Levees and Channels Map



Source: USACE (1959).

Figure 6-3
Hidden Dam and Hensely Lake Flood Control Project Levees and Channels Map

Design capacities for the Merced County Stream Group (Bear Creek, Black Rascal Creek, Miles Creek, Mariposa Creek, and Duck Slough) match the design capacities currently used by the Merced County Public Works Engineering Department (Jacobs 2010). Additionally, the Chowchilla Water District (CWD) confirmed the design flows for the Chowchilla River, Ash Slough, and Berenda Slough. Portions of these three waterbodies are within CWD jurisdiction; therefore, those design capacities are still relevant and can be used for subsequent hydraulic analysis; hydrologic modeling would likely not be required for the Merced County Stream Group. However, the levees on Ash and Berenda sloughs have been decertified by the state, and both sloughs experience a significant reduction in carrying capacity because of vegetation growth (Welch 2010). This would affect future hydraulic analyses and is further addressed in the following sections.

CVFPB supplied the 100-year peak discharges for the five designated floodway crossings: San Joaquin River, Fresno River, Chowchilla River, and Ash Slough, and Berenda Slough (CVFPB Designated Floodway Program Table, September 1990). These design flows match the capacities provided in the USACE O&M manuals.

6.5.2 Hydrologic Information for Local Development Permits

The most relevant hydrologic information needed to complete local development permits are flood hazard zones, BFEs, and 200-year (0.5% frequency interval) design flows (refer to Section 3.1.2). This information would be used to ensure that the project meets the minimum elevation requirement in accordance with local floodplain ordinances (refer to Section 3.1.3). Tables 6-3, 6-4, and 6-5 summarize information compiled from FISs and FIRMs for the UPRR/SR 99, BNSF and Hybrid alternatives, respectively. Crossings within Zone A (see Table 3-1) lack BFEs and consequently may require hydraulic modeling to establish the BFE.

DWR is currently working on updating floodplain maps with the new 200-year base flood standard set for adoption in local floodplain ordinances by 2015. DWR has released the shapefiles used to create the Best Available Maps depicting estimated boundaries for the new 200-year floodplain based on a preliminary study (DWR 2008d). The design flows used for defining those boundaries have been requested from DWR and is still pending. These data are critical if the HST Project adopts the 200-year flood as a criterion for project design.

6.5.3 Additional Work for Hydrology

Some hydrologic information is available for many of the natural waterbodies (see Tables 6-3 to 6-5); however, this data is typically several decades old. Curt Taras of CVFPB has indicated that new, original hydrology should be developed for all of the natural waterbody crossings, and that the available hydrologic information, including older FEMA flow rates and flood control project designated design flow rates, are generally not adequate for either design or encroachment permits (Taras, C. 2011). Further discussion may be appropriate on a case-by-case basis for specific crossings.

6.6 Hydraulic Information

Encroachment and local development permit applications require evaluation of the project hydraulic impacts to WSE, freeboard, and scour potential. To determine the levels of hydraulic analysis and potential modeling necessary to complete permit applications, available hydraulic information was gathered, compiled, and assessed. Hydraulic information was acquired from several sources, including a cursory field survey; Merced County FIS, Madera County FIS, and Fresno County FIS; Caltrans as-built and hydraulic studies; irrigation districts in Merced, Madera, and Fresno counties; hydraulic studies conducted for local municipalities; and personal communications. Tables 6-6 through 6-8 summarize available hydraulic information for the UPRR/SR 99, BNSF, and Hybrid alternatives, respectively.

6.6.1 Hydraulic Information for Encroachment Permits

Encroachment permit applications require demonstrating a minimal WSE rise (0.1 foot) (refer to Section 3.2). This typically requires hydraulic modeling. Working under this assumption, hydraulic information was collected that would help facilitate the development and calibration of a hydraulic model for each waterway crossing that requires an encroachment permit. Three main categories of information have been compiled: (1) available survey data and existing bridge geometries, (2) existing hydraulic model cross sections, and (3) historical flooding information for model calibration.

6.6.1.1 Geometry AND Existing Conditions

To evaluate the incremental rise, it is necessary to establish a base WSE profile to assess existing conditions at each crossing. The base model must be based on surveyed geometry for the channel and existing structures.

In some cases, existing topographic data may have sufficient resolution to develop cross sections. Figure 6-4 illustrates a typical cross section based on readily available USGS 10m-DEM elevation data. However, USGS 10m-DEM elevation data are probably not accurate enough for detailed hydraulic analyses.

Higher-resolution data, such as aerial light detection and ranging (LiDAR) data, would be preferable for general development of cross sections to that based upon available topographic mapping. DWR has developed and processed LiDAR survey data within most of the Merced to Fresno Section as part of its FloodSAFE Program. According to a grid of surveyed areas provided by DWR, it appears LiDAR survey data should be available for most or all of the encroachment and development permit waterbody crossings, and most of the HST alternative alignments between the cities of Merced and Fresno. DWR has indicated that bathymetric surveys have been or would be obtained for some waterbodies. The status of existing bathymetry has not been established.

Preliminary field observations were made at most crossings that require encroachment and local development permits (see Appendix B for fact sheets regarding waterbody crossings). Tables 6-6, 6-7, and 6-8 summarize key hydraulic characteristics including the type of crossing, evidence of sedimentation or erosion, and high water marks.

Additionally, field survey data from 1998 were used to update the FIS for the San Joaquin River. That information may be useful for developing channel geometry and cross sections for a future hydraulic analysis.

Caltrans bridge crossing as-built drawings for SR 99, which is generally parallel to the UPRR/SR 99 Alternative alignment, may be useful in modeling the geometries of the existing bridges. The drawings are currently being examined and inventoried.

6.6.1.2 Existing Models

Most existing hydraulic models for streams within the HST alignment are more than two decades old and were developed for FIRMs, designated floodways, or state–federal flood control projects. In many cases, the models may no longer be available. An inventory of existing hydraulic models for HST crossings has been created to identify models that are recent enough for immediate use as a base model or that may provide useful model inputs, such as the geometric configuration of existing bridges. Designated floodways are the most strictly regulated type of waterway and are the most likely to require up-to-date hydraulic modeling.

Table 6-6
Inventory of Hydraulic Information – UPRR/SR 99 Alternative

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
010S-CaCk	Canal Creek	Regulated stream/irrigation canal	Culvert; nonproject levee	USGS DEM-10m	Structures, bathymetry	No	Unavailable	Unavailable	AFD	Modeling	At-Grade
020S-BrCk	Black Rascal Creek	Regulated stream	Bridge with piers; nonproject levee	USGS DEM-10m	Structures, bathymetry	No	1969, 1997, 1998, 2006	Pending confirmation with Merced County	BFE	Modeling	Elevated
030S-BaCk	Bear Creek	Regulated stream	Bridge with piers; concrete abutments; nonproject levee	USGS DEM-10m	Structures, bathymetry	No	1969, 1997, 1998, 2006	Pending confirmation with Merced County	BFE	Modeling	Retained Fill
055S-MCOF	Miles Creek Overflow No. 1	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	AFD	Modeling	At-Grade
060S-MiCk	Miles Creek	Regulated stream	Bridge with piers; Nonproject levee downstream	USGS DEM-10m	Structures, bathymetry	No	1969, 1997, 1998, 2006	Pending confirmation with Merced County	AFD	Modeling	At-Grade
080S-OwCk	Owens Creek	Regulated stream	Bridge with piers; nonproject levee	USGS DEM-10m	Structures, bathymetry	No	1969, 1997, 1998, 2006	Pending confirmation with Merced County	AFD	Modeling	At-Grade
110S-DuSl; 111S-DuSl; 112S-DuSl	Duck Slough	Regulated stream	Bridge with piers; concrete abutments	USGS DEM-10m	Structures, bathymetry	No	1969, 1997, 1998, 2006	Pending confirmation with Merced County	AFD	Modeling	At-Grade
200S-DdCk	Deadman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	AFD	Modeling	At-Grade
209S-DtCk-B	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
210S-DtCk	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
211S-DtCk	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
762S-DtCk-A	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
766S-DtCk-A	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
220S-ChRi	Chowchilla River	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956 and 1992)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	Elevated
516S-ChRi	Chowchilla River	Designated floodway	Unavailable	USGS DEM-10m; bridge (as-built, 1956 and 1992)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
780S-ChRi-A	Chowchilla River	Designated floodway	Unavailable	USGS DEM-10m; bridge (as-built, 1956 and 1992)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	Roadway Embankment
230S-AsSl	Ash Slough	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	High water marks on piers; pending survey confirmation	None	Modeling	Elevated

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
523S-AsSl	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
792S-AsSl-A	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	
850S-AsSl-A	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	Roadway Embankment
250S-BeSl	Berenda Slough	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	--	None	Modeling	Elevated
609S-BeSl	Berenda Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
798S-BeSl-A	Berenda Slough	Regulated Stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
800S-BeSl-A	Berenda Slough	Regulated Stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
802S-BeSl-A	Berenda Slough	Regulated Stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
880S-BeSl-A	Berenda Slough	Regulated stream	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	No	Modeling	
290S-BeCk	Berenda Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	Elevated
291S-BeCk	Berenda Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	Elevated
302S-DrCk	Dry Creek	Regulated stream	Nonproject levee	USGS DEM-10m; bridge (as-built, 1947)	Bathymetry	No	Unavailable	2 feet[3]	BFE	Modeling	Elevated
311S-ScCk	Schmidt Creek	Stream	Bridge with culverts; concrete abutments	USGS DEM-10m; bridge (as-built, 1973)	Bathymetry	No	Unavailable	Unavailable	AFD	Modeling	Elevated
331S-FrRi	Fresno River	Designated floodway	Bridge with piers; nonproject levee	USGS DEM-10m; bridge (as-built, 1957)	Bathymetry	HEC-2 (Madera County FIS); HEC-RAS, 2006 (Westberry Drive Bridge Hydraulic Study, Madera County)[4]	1955, 1969 [5]	Unavailable	BFE	Validation or modeling	Elevated
370S-CwCk	Cottonwood Creek	Stream	Bridge with culverts	USGS DEM-10m; bridge (as-built, 1967)	Bathymetry	HEC-2, 1983 (Madera County FIS); HEC-RAS, 2010 (Southeast Madera Development Project, City of Madera)[6]	Unavailable	Unavailable	B FE	Validation or modeling	At-Grade

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
401S-SjRi	San Joaquin River	Designated floodway	Truss bridges with piers	USGS DEM-10m;1998 Digital topographic map (Fresno County FIS); bridge (as-built, 1958 and 2006)	Bathymetry	HEC-RAS, 1999 (Fresno County FIS)	1997 (record flood), 1983, 2006	Available from DWR for 1997 flood	BFE	Validation or modeling	Elevated
522S-AsSl	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
526S-AsSl	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
600S-AsSl	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
608S-BeSl	Berenda Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
854S-BeSl-A	Berenda Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
856S-BeSl-A	Berenda Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
252S-BeSl	Berenda Slough	Regulated stream	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	No	Modeling	At-Grade

* These crossings are included only on the access guideway to the Castle Commerce Center HMF site.

[1] Includes survey data collected within the past 20 years.

[2] Only includes hydraulic studies and models performed within the past 20 years.

[3] High water marks observed from field survey in March and April 2010 by CH2M HILL.

[4] Keith Helmuth, City Engineer, City of Madera, provided the Westberry Drive Bridge Design Hydraulic Study (Avila & Associates 2006). The hydraulic analysis is for a segment of Fresno River relevant to the HST alignments. The study has not been approved and is only a draft.

[5] Fresno River flooded the City of Madera in December 1955 and February 1969. However, the river has not flooded since construction of Hidden Dam in September 1976.

[6] Keith Helmuth, City Engineer, City of Madera, provided the *Environmental Impact Report for the Southeast Madera Development Project* (City of Madera 2010). The study includes a hydraulic analysis (Valley Planning 2010) of a relevant segment of Cottonwood Creek. The analysis is a draft and has not been approved.

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Table 6-7
Inventory of Hydraulic Information – BNSF Alternative

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
010S-CaCk *	Canal Creek	Regulated stream/ irrigation canal	Culvert; NPL	USGS DEM-10m;	Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
020S-BrCk *	Black Rascal Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Confirm 2006 flood levels with Merced County	BFE	Modeling	Elevated
030S-BaCk *	Bear Creek	Regulated stream	Bridge with piers; concrete abutments; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Confirm 2006 flood levels with Merced County	BFE	Modeling	Retained Fill
056S-MCOF	Miles Creek Overflow No. 1	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	AFD	Modeling	Elevated
061S-MiCk	Miles Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Confirm 2006 flood levels with Merced County	AFD	Modeling	At-Grade
079S-OwCk	Owens Creek	Regulated stream	Unavailable	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Confirm 2006 flood levels with Merced County	AFD	Modeling	At-Grade
140S-OwCk	Owens Creek	Regulated stream	Unavailable	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2008	Pending confirmation with Merced County	AFD	Modeling	At-Grade
714S-OwCk-A	Owens Creek	Regulated stream	Unavailable	USGS DEM-10m;	Structures, bathymetry	No	Unavailable	Unavailable	AFD	Modeling	
724S-OwCk-A	Owens Creek	Regulated stream	Unavailable	USGS DEM-10m;	Structures, bathymetry	No	Unavailable	Unavailable	AFD	Modeling	At-Grade (Roadway)
110S-DuSl	Duck Slough	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Confirm 2006 flood levels with Merced County	AFD	Modeling	At-Grade
722S-DuSl-A	Duck Slough	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2007	Confirm 2006 flood levels with Merced County	AFD	Modeling	At-Grade (Roadway)
126C-DiCh	Owens Creek Diversion Channel	Flood control project diversion channel	High berms; well maintained levees	USGS DEM-10m;	Structures, bathymetry	No	Unavailable	Unavailable	BFE	Modeling	Elevated
156C-DiCh	Owens Creek Diversion Channel	Flood control project diversion channel	High BERMS; well maintained levees	USGS DEM-10m;	Structures, bathymetry	No	Unavailable	Unavailable	BFE	Modeling	Elevated
540S-MaCK	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2007	Pending Confirmation with Merced County	AFD	Modeling	At-Grade
541S-MaCK	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2007	Pending Confirmation with Merced County	AFD	Modeling	At-Grade
542S-MaCK	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2007	Pending confirmation with Merced County	AFD	Modeling	Elevated
130S-MaCk	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2007	Pending confirmation with Merced County	AFD	Modeling	At-Grade
132S-MaCk	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2008	Pending confirmation with Merced County	AFD	Modeling	At-Grade

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
732S-MaCk-A	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2008	Pending confirmation with Merced County	AFD	Modeling	
136S-MaCk	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2009	Pending confirmation with Merced County	None	Modeling	At-Grade
733S-MaCk-A	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2008	Pending confirmation with Merced County	None	Modeling	At-Grade (Roadway)
137S-MaCk	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2010	Pending confirmation with Merced County	None	Modeling	At-Grade
138S-MaCk-B	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2011	Pending confirmation with Merced County	None	Modeling	At-Grade
139S-MaCk	Mariposa Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2012	Pending confirmation with Merced County	N/A	Modeling	At-Grade
201S-DdCk	Deadman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
738S-DdCk-A	Deadman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade (Roadway)
207S-DdCk	Deadman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	Elevated
202S-DdCk	Deadman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	Elevated
205S-DdCk	Deadman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
740S-DtCk-A	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade (Roadway)
206S-DtCk	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
560S-DtCk	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	Elevated
222S-DtCk	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	Elevated
223S-DtCk	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
226S-ChRi	Chowchilla River	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956&1992)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
231S-AsSl	Ash Slough	Designated floodway	Bridge with piers; NPL	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
253S-BeSl	Berenda Slough	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
292S-BeCk	Berenda Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
300S-DrCk	Dry Creek	Nonregulated segment of regulated stream	Bridge; NPL	USGS DEM-10m; bridge (as-built, 1947)	Bathymetry	No	Unavailable	Unavailable	AFD	Modeling	At-Grade
301S-DrCk	Dry Creek	Nonregulated segment of regulated stream	Bridge; NPL	USGS DEM-10m; bridge (as-built, 1947)	Bathymetry	No	Unavailable	Unavailable	AFD	Modeling	At-Grade
310S-ScCr	Schmidt Creek	Stream	Bridge with culverts; concrete abutments	USGS DEM-10m; bridge (as-built, 1973)	Bathymetry	No	Unavailable	Unavailable	BFE	Modeling	At-Grade
808S-ScCr-A	Schmidt Creek	Stream	Bridge with culverts; concrete abutments	USGS DEM-10m; bridge (as-built, 1973)	Bathymetry	No	Unavailable	Unavailable	BFE	Modeling	
330S-FrRi	Fresno River	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1957)	Bathymetry	HEC-2 (Madera County FIS) ; HEC-RAS, 2006 (Westberry Drive Bridge Hydraulic Study, Madera County) [2]	1955, 1969 [3]	Unavailable	None	Validation or modeling	At-Grade
812S-FrRi-A	Fresno River	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1957)	Bathymetry	HEC-2 (Madera County FIS) ; HEC-RAS, 2006 (Westberry Drive Bridge Hydraulic Study, Madera County) [3]	1955, 1969 [4]	Unavailable	None	Validation or modeling	N/A
370S-CwCk	Cottonwood Creek	Stream	No bridge or span	USGS DEM-10m; bridge (as-built, 1967)	Bathymetry	HEC-2, 1983 (Madera County FIS); HEC-RAS, 2010 (Southeast Madera Development Project, City of Madera)[4]	Unavailable	Unavailable	BFE	Validation or modeling	At-Grade
400S-SjRi	San Joaquin River	Designated floodway	Truss bridges with piers	USGS DEM-10m;1998 Digital Topo Map (Fresno County FIS); bridge (as-built, 1958&2006)	Bathymetry	HEC-RAS, 1999 (Fresno County FIS)	1997, 1983, 2006	Pending Confirmation with DWR	BFE	Validation or modeling	Elevated
600S-AsSl	Ash Slough	Regulated stream	Bridge with piers; NPL	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
252S-BeSl	Berenda Slough	Regulated stream	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
880S-BeSl-A	Berenda Slough	Regulated stream	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	No	Modeling	
294S-BeCk	Berenda Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
609S-BeSl	Berenda Slough	Regulated stream	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Berenda Slough	None	Modeling	At-Grade

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
802S-BeSl-A	Berenda Slough	Regulated Stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
293S-BeCk	Berenda Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade

[*] These sites are included only on the access guideway to the Castle Commerce Center HMF.

[1] Available survey information only includes survey data collected within the past 20 years.

[2] Available hydraulic information only includes hydraulic studies and models performed within the past 20 years.

[3] Keith Helmuth, City Engineer, City of Madera, provided the Westberry Drive Bridge Design Hydraulic Study (Avila & Associates 2006). The hydraulic analysis is for a segment of Fresno River relevant to the HST alignment. The study has not been approved and is only a draft.

[4] The Fresno River flooded the City of Madera in December 1955 and February 1969. However, the river has not flooded since the construction of Hidden Dam in September 1976.

[5] Keith Helmuth, City Engineer, City of Madera, provided the *Environmental Impact Report for the Southeast Madera Development Project* (City of Madera 2010). The study includes a hydraulic analysis (Valley Planning Consultants 2010) of a relevant segment of Cottonwood Creek. The study has not been approved and is only a draft.

NPL: nonproject levee.

Table 6-8
Inventory of Hydraulic Information – Hybrid Alternative

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
010S-CaCk *	Canal Creek	Regulated stream/ irrigation canal	Culvert; NPL	USGS DEM-10m;	Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
020S-BrCk *	Black Rascal Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Confirm 2006 flood levels with Merced County	BFE	Modeling	At-grade
030S-BaCk *	Bear Creek	Regulated stream	Bridge with piers; concrete abutments; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Confirm 2006 flood levels with Merced County	BFE	Modeling	Elevated spans
055S-MCOF	Miles Creek Overflow No. 1	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	AFD	Modeling	At-Grade
060S-MiCk	Miles Creek	Regulated stream	Bridge with piers; NPL downstream	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Pending confirmation with Merced County	AFD	Modeling	Transition
080S-OwCk	Owens Creek	Regulated stream	Bridge with piers; NPL	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Pending confirmation with Merced County	AFD	Modeling	Transition
110S-DuSl; 111S-DuSl; 112S-DuSl	Duck Slough	Regulated stream	Bridge with piers; concrete abutments	USGS DEM-10m;	Structures, bathymetry	No	1969, 1997, 1998, 2006	Pending confirmation with Merced County	AFD	Modeling	At-grade
200S-DdCk	Deadman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	AFD	Modeling	At-Grade
209S-DtCk-B	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
210S-DtCk	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
762S-DtCk-A	Dutchman Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
516S-ChRi	Chowchilla River	Designated floodway	Unavailable	USGS DEM-10m; Bridge (as-built, 1956&1992)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-grade
220S-ChRi	Chowchilla River	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956 and 1992)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	Elevated
780S-ChRi-A	Chowchilla River	Designated floodway	Unavailable	USGS DEM-10m; bridge (as-built, 1956 and 1992)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	Roadway Embankment
230S-AsSl	Ash Slough	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	High water marks on piers; pending survey confirmation	None	Modeling	Elevated
523S-AsSl	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; Bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-grade
792S-AsSl-A	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
850S-AsSl-A	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	Roadway Embankment
609S-BeSl	Berenda Slough	Regulated stream	Bridge with piers	USGS DEM-10m; Bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-grade
250S-BeSl	Berenda Slough	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	--	None	Modeling	Elevated
802S-BeSl-A	Berenda Slough	Regulated Stream	Unavailable	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
880S-BeSl-A	Berenda Slough	Regulated stream	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	No	Modeling	
252S-BeSl	Berenda Slough	Regulated stream	Bridge with piers	USGS DEM-10m; bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	No	Modeling	At-Grade
294S-BeCk	Berenda Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
296S-BeCk	Berenda Creek	Named Stream			Structures, bathymetry	No	Unavailable	Unavailable	None	Modeling	At-Grade
301S-DrCk	Dry Creek	Nonregulated segment of regulated stream	Bridge; NPL	USGS DEM-10m; Bridge (as-built, 1947)	Bathymetry	No	Unavailable	Unavailable	AFD	Modeling	Transition
310S-ScCr	Schmidt Creek	Stream	Bridge with culverts; concrete abutments	USGS DEM-10m; Bridge (as-built, 1973)	Bathymetry	No	Unavailable	Unavailable	BFE	Modeling	At-grade
808S-ScCr-A	Schmidt Creek	Stream	Bridge with culverts; concrete abutments	USGS DEM-10m; bridge (as-built, 1973)	Bathymetry	No	Unavailable	Unavailable	BFE	Modeling	
330S-FrRi	Fresno River	Designated floodway	Bridge with piers	USGS DEM-10m; Bridge (as-built, 1957)	Bathymetry	HEC-2 (Madera County FIS) ; HEC-RAS, 2006 (Westberry Drive Bridge Hydraulic Study, Madera County) [2]	1955, 1969 [3]	Unavailable	None	Validation or modeling	At-grade
812S-FrRi-A	Fresno River	Designated floodway	Bridge with piers	USGS DEM-10m; bridge (as-built, 1957)	Bathymetry	HEC-2 (Madera County FIS) ; HEC-RAS, 2006 (Westberry Drive Bridge Hydraulic Study, Madera County) 3	1955, 1969 4	Unavailable	None	Validation or modeling	N/A
370S-CwCk	Cottonwood Creek	Stream	No bridge or span	USGS DEM-10m; Bridge (as-built, 1967)	Bathymetry	HEC-2, 1983 (Madera County FIS); HEC-RAS, 2010 (Southeast Madera Development Project, City of Madera)[4]	Unavailable	Unavailable	BFE	Validation or modeling	At-grade
400S-SjRi	#N/A	Designated floodway	Truss bridges with piers	USGS DEM-10m;1998 Digital Topo Map (Fresno County FIS); Bridge (as-built, 1958&2006)	Bathymetry	HEC-RAS, 1999 (Fresno County FIS)	1997, 1983, 2006	Pending confirmation with DWR	BFE	Validation or modeling	Elevated spans

Crossing ID	Waterbody Name	Classification	Existing Crossing Conditions	Available Survey Information[1] (structures, cross sections, bathymetry)	Additional Surveying Needs	Readily Available Hydraulic Information[2]	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs	Preliminary Design Concept
522S-AsSl	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; Bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-grade
600S-AsSl	Ash Slough	Regulated stream	Bridge with piers; NPL	USGS DEM-10m; Bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-grade
526S-AsSl	Ash Slough	Regulated stream	Unavailable	USGS DEM-10m; Bridge (as-built, 1956)	Bathymetry	No	Unavailable	Unavailable	None	Modeling	At-grade

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NPL: nonproject levee.

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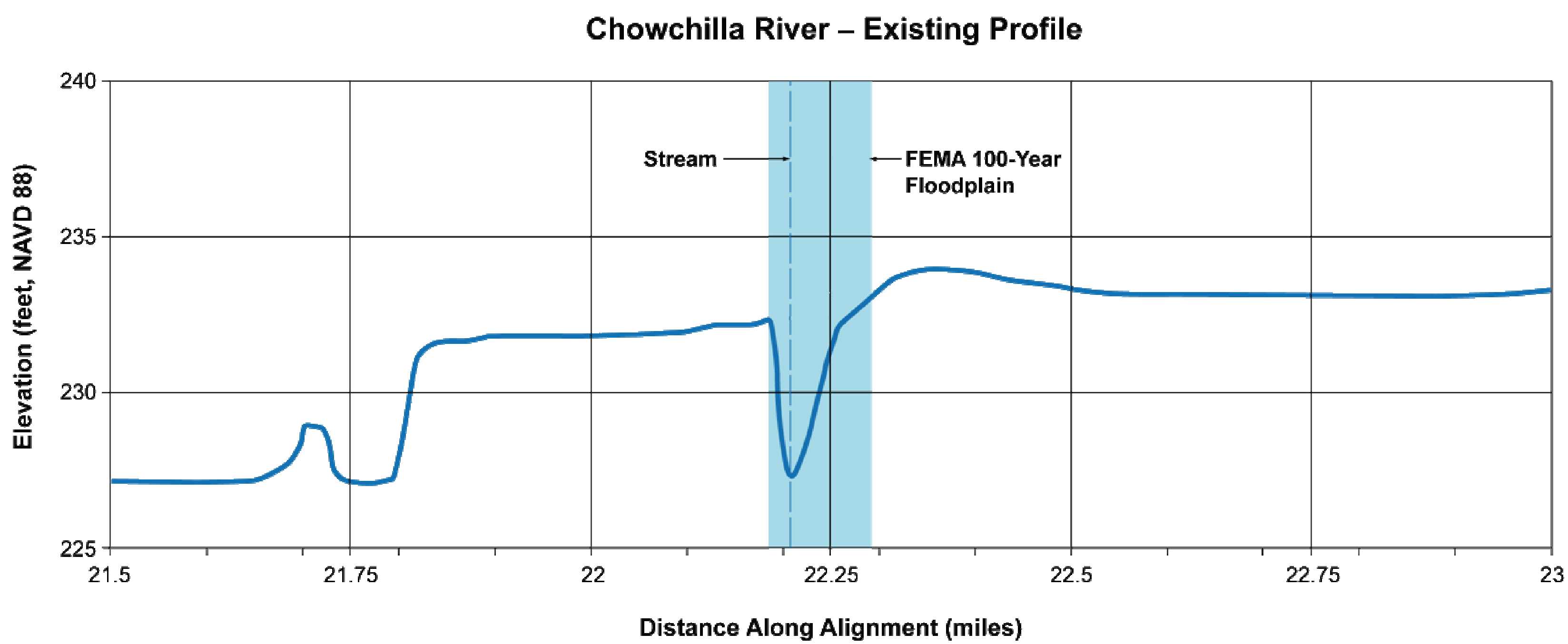

WBG061010192906SEA Fig. 6-4 Typical Cross-Section Profile.ai

Figure 6-4
Typical Cross Section Profile

Two of the CVFPB-designated floodways that the HST alignment crosses, Fresno River and San Joaquin River, have HEC-RAS models that were developed in 2006 and 1999, respectively. The Fresno River HEC-RAS model was developed as part of a design hydraulic study (Avila & Associates 2006) conducted for the Westberry Bridge where it crosses the Fresno River. Madera County has not approved the study. However, the study may be useful in developing a model for the Fresno River. The San Joaquin River HEC-RAS model was completed as a part of a re-study for the Fresno County FIS in 1999.

There are no known hydraulic models for three CVFPB-designated floodways: Chowchilla River, Ash Slough, and Berenda Slough. Because of local funding issues, the state has decommissioned state–federal project levees for Ash Slough and Berenda Slough. Additionally, CWD reported that the carrying capacity of the sloughs is greatly reduced because of channel constrictions and vegetation growth. Berenda Slough has a design capacity of 2,000 cfs but can only carry 500 cfs before overtopping the banks (Welch 2010). There are known significant flooding issues and the lack of readily available models suggests that new base models would likely need for Chowchilla River, Ash Slough, and Berenda Slough.

Existing models were inventoried for regulatory streams. HEC-2 models were developed between 1983 and 1986 for Bear Creek, Black Rascal Creek, Miles Creek, Owens Creek, Mariposa Creek, Duck Slough, Dry Creek, and Fresno River. These models are used in the most current versions of the FISs for Merced, Madera, and Fresno counties. These models are likely available through FEMA and may be sufficient for model development and calibration purposes. However, updated cross-section data would likely be required so that current channel conditions are adequately addressed (refer to Section 6.2.2.4).

No existing model information was found for Canal Creek, which is a regulated stream. In addition, there is no hydrologic information for Canal Creek; therefore, Canal Creek would likely require original hydrologic and hydraulic modeling efforts.

6.6.1.3 Historical Flood Information

The FISs provide information regarding historical flooding within the Merced to Fresno Section study area. Tables 6-6, 6-7, and 6-8 report the dates of historical floods for the UPRR/SR 99, BNSF, and Hybrid alternative crossings, respectively. No high water marks are available to use for calibration purposes.

Additional information from interviews with local municipalities provides insight into flooding issues for Merced County. Merced County experienced historical flooding in 1998 and 2006. In 2006, El Capitan Canal broke, resulting in a flood depth of 3 feet immediately southwest of Bear Creek in the City of Merced. This is southwest of where the three HST alternative alignments would cross Bear Creek. Merced County also tends to experience shallow flooding and ponding near the existing UPRR tracks (Jacobs 2010). Section 4 provides additional information on flood-prone areas.

6.6.2 Hydraulic Information for Local Development Permits

Cursory hydraulic analyses are required for local development permit applications. This includes examining development impacts on the carrying capacity of FEMA-regulated floodways at Fresno River and San Joaquin River crossings, as well as determining BFEs for flood hazard areas classified as Zone A. BFEs must be determined for the following waterways:

- Canal Creek (UPRR/SR 99 and BNSF alternatives)
- Black Rascal Creek (UPRR/SR 99 and BNSF alternatives)
- Chowchilla River (UPRR/SR 99 and BNSF alternatives)
- Ash Slough (UPRR/SR 99 and BNSF alternatives)
- Berenda Slough (UPRR/SR 99 and BNSF alternatives)
- Dry Creek (UPRR/SR 99 and BNSF alternatives)
- Cottonwood (UPRR/SR 99 and BNSF alternatives)
- Fresno River (UPRR/SR 99 and BNSF alternatives)
- Schmidt Creek (UPRR/SR 99 and BNSF alternatives)

Existing HEC-2 models listed in Table 6-6 can possibly be used to determine BFEs in Black Rascal Creek, Dry Creek, and Fresno River; however, the relatively old dates of the models make their acceptance uncertain. Similarly, information on BFEs for Cottonwood Creek and Schmidt Creek may be determined by using the HEC-2 models from the most recent Madera County FIS. However, it is unknown at this time if the HEC-2 models would contain that information. Additionally, a HEC-RAS model developed for Cottonwood Creek as part of the *Environmental Impact Report for the Southeast Madera Development Project* (City of Madera 2010) may be useful in developing BFEs. However, this model has not been approved by the City of Madera and should only be used for validation purposes.

Widening of SR 99 at Mission Interchange (Caltrans 2002) provides useful information regarding design flows, WSE, and scour analysis for Owens Creek and Miles Creek. A hydraulic analysis was likely performed that might be useful in hydraulic analyses for Merced County Stream Group crossings (Jacobs 2010). Hydraulic information and models are currently lacking for Canal Creek, Chowchilla River, Ash Slough, and Berenda Slough. Determining BFEs for those waterways may require original modeling.

6.6.3 Additional Work for Hydraulics

6.6.3.1 Additional Available Information

Additional information and hydraulic studies may be available from USACE and local irrigation districts. Follow-up interviews are necessary to determine if the following agencies and projects can provide useful hydraulic information:

- According to the City of Merced, Merced Irrigation District may have HEC-RAS models of portions of its irrigation system; however, Merced Irrigation District has not confirmed the existence of the models. If HEC-RAS models are available, they could potentially be useful in hydraulic analyses for Merced County Stream Group crossings, particularly Canal Creek (Jacobs 2010).
- USACE updated the Merced County floodplain in 2008 (in whole or in part) as part of the FIRM updates, but it has not released the models or methodology to Merced County. This information could be useful for hydraulic analyses for the Merced County Stream Group crossings (Jacobs 2010).
- The *Fresno County Multi-Hazard Mitigation District Plan* (Fresno County 2009) may provide helpful information about historical flooding within Fresno County (Guzman 2010).
- Merced Irrigation District indicated that within the last 2 years the City of Merced and the Merced Irrigation District completed new aerial surveys, which they combined into a single file. Merced Irrigation District has not yet confirmed if the survey data are available for use by the project.

6.6.3.2 Recommended Project Hydraulic Modeling Efforts

Updated HEC-RAS models are recommended for CVFPB encroachment permits for the five designated floodways. Adequate models for Fresno River and San Joaquin River appear to exist and can likely be used for the project hydraulic analyses to satisfy permitting requirements. The input data files from the most recent hydraulic model run for the San Joaquin River has been obtained from FEMA. However, hydraulic models have not been identified for Chowchilla River, Ash Slough, or Berenda Slough.

Many of the remaining crossings requiring encroachment permits are part of the Merced County Stream Group (Bear Creek, Black Rascal Creek, Miles Creek, Owens Creek, Mariposa Creek, and Duck Slough). At one time, HEC-2 models from 1986 were developed for these waterbodies. Converting the available HEC-2 models to HEC-RAS models and calibrating with updated information from MID models and historical flooding may be adequate for encroachment permits for these streams.

Available information for Canal Creek requires further investigation. Canal Creek is a regulated stream and an irrigation canal. Therefore, Merced Irrigation District may have information regarding design capacity and WSEs. However, if there are no more available data, Canal Creek would require substantial modeling efforts to complete an encroachment permit application.

6.6.3.3 Scour Analysis

Channel modification and scour analysis are important additional considerations for the hydraulic analysis. If the project design proposes a significant modification or relocation of a channel bed, that would require modeling as part of the permitting. The modeling most likely would use HEC-RAS. Additionally, evidence of channel scouring near the proposed crossings would also require modeling as part of the permit requirements. Scour analysis may also be required in support design of bridge abutments and column foundations within channels.

6.6.3.4 Surveying needs

Surveying needs for hydraulic modeling depend on the timing and quality of the LiDAR data and potential bathymetry provided by DWR and the quality and availability of aerial survey data from Merced Irrigation District and the City of Merced. According to preliminary information provided by DWR, LiDAR data exist for each of the waterbody crossings that require permitting. Assuming that the LiDAR data were obtained and analyzed in a timely manner and that the data for the area within the stream channels and channel banks are adequately accurate, these data could be used in conjunction with GIS data to generate cross sections for base model development. If this is the case, additional surveying needs would be significantly reduced and could focus on obtaining or confirming the geometry of existing structures, high water marks, and channel profiles. However, if the LiDAR data are inadequate for cross sections, field surveys are recommended. In general, five cross sections are required for each structure at each waterbody crossing: two upstream, two downstream, and one along the structure to define the road high points and bridge or culvert openings. Surveying should characterize and define the following (refer to Figure 6-5):

- Define bridge openings and piers (pier centerlines, shape, dimensions, and number of rows). Rows should be defined separately if piers do not line up when looking downstream.
- Define road/railroad surface elevations and geometry longitudinally along the apparent linear high feature (track, curb, crown, or superelevated margin).
- Describe hydraulic barriers that may catch debris (e.g., fences and railings).
- Define upstream and downstream channel transitions near bridges.
- One cross section upstream and one downstream where the ground surface is representative near the bridge (typically within about 3 to 10 feet).
- One cross section upstream and one downstream where the channel completes a transition to its representative dimensions.

Cross sections should clearly define the edges of the channel bottom, top of low water bank, top of ravine, and all significant changes in side slope. They should also extend laterally beyond the top of ravine to tie in to existing topography for the broad floodplain. Typical extension beyond visible level ground on each end might be 10% to 20% of the ravine width.

A typical UPRR/SR 99 waterbody crossing has existing twin SR-99 bridges that may be treated as a single bridge. Typically, there is also a UPRR bridge and a third bridge (e.g., frontage or other road) nearby upstream or downstream. According to Figure 6-5, channel hydraulics can be defined for three bridges and the associated channel with approximately 19 cross sections, including bridge decks (9 for the UPRR/SR 99 complex; 5 for an upstream or downstream bridge; and 5 to define upstream, downstream, and intervening channels). Where there are no upstream or downstream bridges, 14 cross sections should suffice (9 for the UPRR/SR 99 complex and 5 to define extended upstream and downstream channels). Where the guideway is elevated, a simpler model may suffice—one that does not define the WSE, but only tests sensitivity of water surface rise. The response of CVFPB and USACE to this approach is not known. If this approach is accepted, perhaps six cross sections would suffice at elevated crossings to define the nearest bridge and channel slope. Ultimately, the number of survey cross sections required depends on the quality and detail of the survey data obtained.

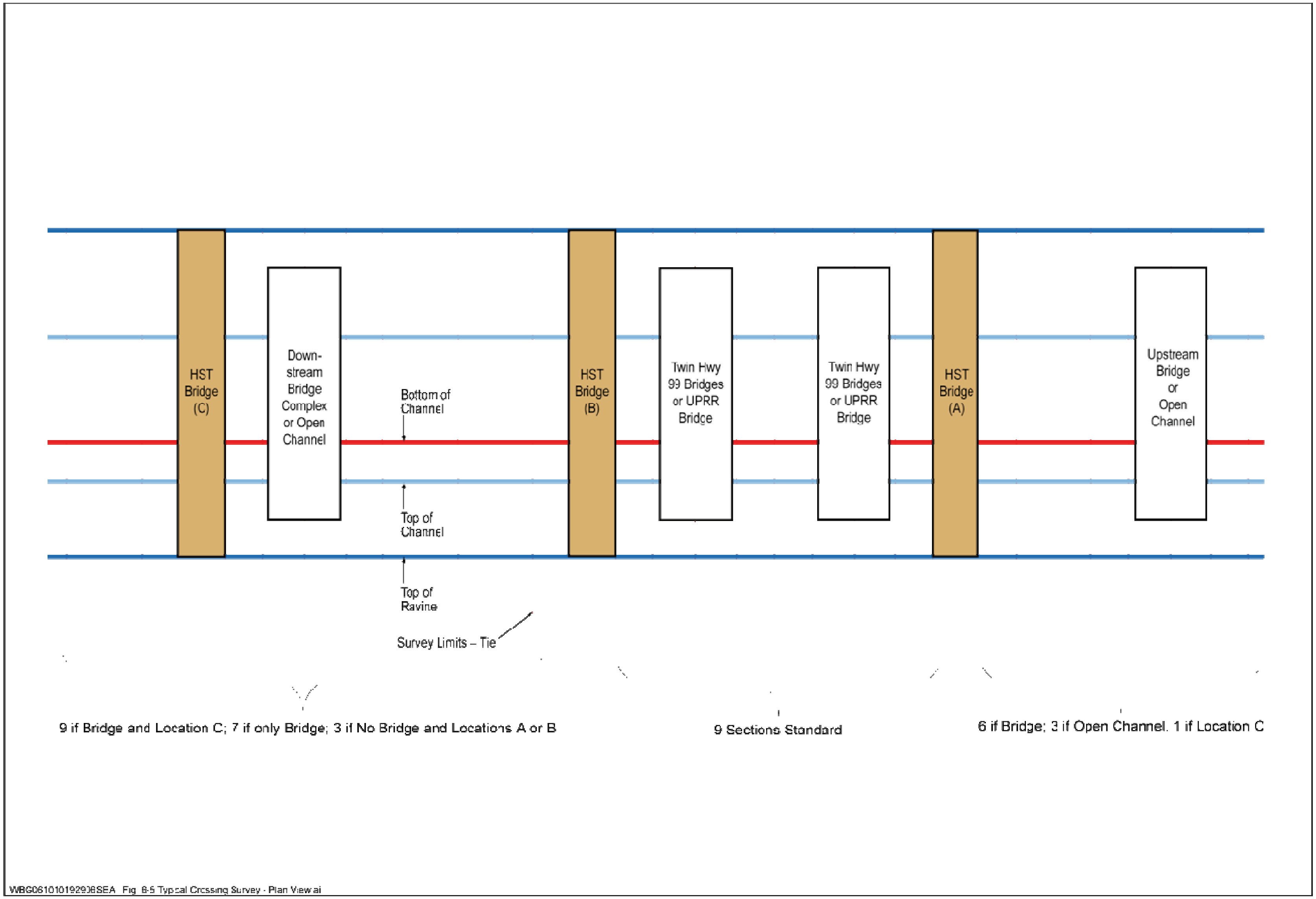

Figure 6-5
Typical Crossing Survey

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8.0 Preparer Qualifications

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