REDLANDS PASSENGER RAIL PROJECT

Preliminary Geotechnical Evaluation

San Bernardino, San Bernardino County, California

December 2011

Prepared for:

San Bernardino Associated Governments
1170 W. 3rd Street, 2nd Floor
San Bernardino, CA 92602

Prepared by:

HDR Engineering, Inc.
3230 El Camino Real, Suite 200
Irvine, California, 92602

December 15, 2011

San Bernardino Associated Governments
Attn: Mr. Mitch Alderman
1170 West 3rd Street, 2nd Floor
San Bernardino, California 92602

Subject: Preliminary Geotechnical Evaluation for SANBAG Redlands Passenger Rail Project, San Bernardino County, California

Dear Mr. Alderman:

In accordance with your request and authorization, HDR Engineering, Inc. (HDR) has performed a preliminary geotechnical evaluation for the Redlands Passenger Rail Project starting from the proposed E Street Station located at the southwest corner of E Street and Rialto Avenue to the University of Redlands, approximately nine miles. The purpose of this study was to assess the geologic, soils, and seismic conditions that could affect the proposed project.

This report summarizes our findings and conclusions and presents possible mitigation measures to reduce the potential impacts identified in this report. Our review has incorporated available published geologic and geotechnical information and data from projects in the site vicinity. During this study, we have not identified any geotechnical impacts within the proposed alignment that cannot be mitigated by proper planning, design, and sound construction practices. Future preliminary geotechnical exploration and analyses are planned to quantify the geotechnical impacts and develop the necessary mitigation measures.

We appreciate the opportunity to provide our services for this interesting project. If you have any questions, please contact this office at your convenience.

Respectfully submitted,

HDR ENGINEERING, INC.

Tae Kuk Kim, PE, GE 2919
Senior Geotechnical Engineer

Eric D. Chase, PG, CEG 1088
Senior Engineering Geologist

Reviewed by

Gary R. Goldman, PE, GE 2587
Geotechnical Section Manager

Distribution: (4) Addressee

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1.0 INTRODUCTION

1.1 SITE LOCATION AND PROPOSED PROJECT

The proposed project consists of the development of a passenger rail service operating between the proposed E Street Station, located at the southwest corner of E Street and Rialto Avenue, and the University of Redlands, over a distance of approximately nine miles. The location of the proposed alignment is shown on Figure 1, Vicinity Map.

This segment of the Redlands Branch of the San Bernardino Subdivision had previously been referred to as the “Back Nine.” This initial passenger rail service would have five stations to be located at the E Street, Tippecanoe Avenue, New York Street, Downtown Redlands, and the University of Redlands. The proposed project also includes the replacement of four bridges and the replacement of the existing track structure (jointed rail, wood ties, and ballast) with new continuously welded rail on concrete ties and a new ballast and sub-ballast section.

1.2 PURPOSE AND SCOPE OF WORK

The purpose of this study was to assess the geologic, soils, and seismic conditions that could affect the proposed project. The scope of work consisted of the following tasks:

- Review of available published documents and geologic maps, including Caltrans as-built Log of Test Borings (LOTBs), covering geotechnical conditions in the site vicinity and analyzing the collected data with respect to the proposed project. A list of references used in preparation of this report is presented in Section 4.0.
- Seismic analysis for the major active and potentially active faults in the region and a site-specific evaluation of ground motion.
- Preparation of this report presenting the site geotechnical conditions and potential hazards.

2.0 GEOTECHNICAL CONDITIONS

2.1 GEOLOGIC SETTING

The project area is located within Peninsular Ranges Geomorphic Province of Southern California within the central portion of the San Bernardino Valley. The subject alignment begins west of the former Norton Air Force Base (San Bernardino Airport) and north of the Santa Ana River and extends southeast to the University of Redlands. The alignment crosses Interstate 10 (I-10), the Santa Ana River, and several perennial streams emanating from the nearby San Bernardino Mountains, including Warm Creek, the Mission-Zanja Channel, and Mill Creek Zanja. This area is characterized as being a relatively flat-lying, alluvium-filled valley overlying crystalline basement rock.

In general, the alignment is underlain by young alluvium valley deposits (designated Qya1, Qya3, Qya4, and Qya5, CGS, 2003). At the Santa Ana River and several creek crossings, the alignment is underlain by very young alluvial wash deposits (designated Qw, CGS, 2003). The alluvial soils are composed primarily of sand and gravel with some local finer and coarser deposits. A geologic map of the area is presented on Figure 2.

2.2 REGIONAL FAULTING AND SEISMICITY

Southern California is one of the most seismically active regions in the world. As such, the alignment is subject to seismic hazards from numerous sources in the area. The severity of the potential seismic hazards is related to the topography and geology of the project area, the distance to the seismic source, and the magnitude of the earthquake generated by the seismic source. The primary seismic hazard for most areas is the potential for strong seismic shaking. Secondary hazards include local surface fault rupture hazards and damage that may result from strong, seismically induced shaking, such as seismically induced settlement, liquefaction, lurching, and seismically induced landslides.

2.2.1 Faults

A review of available in-house literature indicates that there are no known active or potentially active faults that have been mapped along the alignment, and the alignment is not located within an Alquist-Priolo Earthquake Fault Zone (Bryant and Hart, 2007, see Figure 3). The principal seismic hazard that could affect the proposed alignment is ground shaking resulting from an earthquake occurring along one of several major active or potentially active faults in Southern California. Based on a review of the Caltrans ARS Website, Alquist-Priolo Special Studies Zone Map and Preliminary Fault Map for the San Bernardino 30’ by 60’ Quadrangle (California Geological Survey, 2003), the closest active faults that could affect the alignment are the Loma Linda fault, the Redlands fault, the San Jacinto fault (San Bernardino Valley Sections), the Rialto-Colton fault, and the San Andreas fault. The locations of these faults with respect to the alignment are shown on Figures 3 and 4. The distances from these faults to the project alignment are discussed below.

San Jacinto Fault

The San Jacinto fault (San Bernardino Valley section) is the closest active fault, located at a minimum distance of approximately 1.1 miles (1.7 kilometers (km)) to the southwest of the alignment. This fault is believed to be capable of generating a maximum considered earthquake (MCE) of magnitude 7.5 (Caltrans 2011) and for this project is considered to be the controlling fault with respect to the hazard of seismic shaking.

San Andreas Fault Zone

The San Andreas Fault zone is located approximately 3.9 miles (6.2 km) east of the eastern end of the alignment. This fault is believed to be capable of generating a MCE of magnitude 7.8 (Caltrans 2011).

Loma Linda Fault

The Loma Linda fault is a concealed fault located at a closest distance of approximately 0.3 miles (0.5 km) to the southwest of the alignment. CHJ (2011) indicated that the Loma Linda fault was formerly included in an Alquist-Priolo Zone; however, subsequent trenching studies showed no evidence of Holocene rupture of the fault. The Loma Linda fault is not considered to represent a significant seismic hazard.

Redlands Fault

The Redlands fault is located at a distance of approximately 0.75 miles (1.2 km) east of the eastern end of the alignment.

Rialto-Colton Fault

The Rialto-Colton fault is a concealed fault located at a closest distance of approximately 2.4 miles (3.8 km) west of the west end of the alignment.

2.2.2 Fault-Induced Ground Rupture

The fault classification criteria adopted by the California Geological Survey for active or potentially active faults are used in this report (Bryant and Hart, 2007). Thus, an active fault is one that has exhibited earthquake activity during Holocene time (the last 11,400 years). A fault that has ruptured during the last 1.6 million years (Quaternary time), but is not proven by direct evidence to have moved within the Holocene is considered to be potentially active. Any fault older than Pleistocene (1.6 million years) is considered inactive. The potentially active fault designation by the State essentially includes those faults that have not been studied in sufficient detail to be classified as either active or inactive.

Surface ground rupture is generally considered most likely to occur along pre-existing active faults. The proposed alignment is not located within an Alquist-Priolo Earthquake Fault Zone (Bryant and Hart, 2007).

2.2.3 Seismic Ground Shaking

The probability that the proposed alignment will be subject to strong seismic shaking is considered to be high, due to the proximity of known active faults and the nature of the materials underlying the project area. The maximum peak ground accelerations at three proposed bridge locations along the alignment are estimated using the USGS deaggregation hazard online program (USGS, 2008). The estimated peak ground accelerations for different seismic levels per the American Railway Engineering and Maintenance-of-Way Association (AREMA, 2010) are summarized in Table 1.

2–1. Peak Horizontal Ground Accelerations

Seismic Event Level	Return Period (years)	Peak Horizontal Accelerations, g		
		Warm Creek Crossing (MP 1.1)	Santa Ana River Crossing (MP 3.4)	Mill Creek Zanja Crossing (MP 9.4)
I	108	0.37	0.37	0.35
II	475	0.66	0.66	0.62
III	2,475	1.05	1.05	0.96

2.3 GROUNDWATER

A review of available groundwater data obtained from the Department of Water Resources (California Department of Water Resources) indicated that several wells are located adjacent to the proposed alignment. Records for these wells provided groundwater data dating from 1915 to 2008. The data indicate that the shallowest water levels recorded at the adjacent wells along the alignment between the western end of the alignment and the I-10 crossing near Mountain View Avenue ranged from approximately 10 to 50 feet below ground surface between 1915 and 2000. However, review of groundwater data recorded between 2005 and 2008 indicated that groundwater levels ranged from approximately 45 feet to 80 feet below ground surface. The shallowest water levels recorded along the alignment between the I-10 crossing near Mountain View Avenue and the eastern end of the alignment ranged from approximately 42 feet to deeper than 70 feet below existing ground. Surface water is present at times in the Santa Ana River and in Warm and Mill Creeks Zanja.

Fluctuations in the groundwater level, localized zones of perched water, and an increase in soil moisture should be anticipated during and following the rainy seasons or periods of locally intense rainfall or storm water runoff, the impacts of which, however, are not expected to be significant.

3.0 POTENTIAL GEOTECHNICAL HAZARDS AND POSSIBLE MITIGATION MEASURES

This section summarizes the principal geological and geotechnical conditions in the study area. The findings presented in this report are preliminary, and are based on the subsurface soil conditions documented in the as-built LOTBs at two I-10 crossings along the alignment and are also based on information gained from review of published documents. Field exploration and laboratory testing will be conducted during future phase(s) of the project to confirm these findings.

3.1 EARTHQUAKE DAMAGE

3.1.1 Fault Displacement/Ground Rupture

Surface slip along a fault plane can damage structures that cross the fault trace by surface rupture and offset. No active or potentially active faults are known to cross the proposed alignment. The proposed alignment is not located within an Alquist-Priolo Earthquake Fault Zone (Bryant and Hart, 2007). The nearest active or potentially active faults are the Loma Linda fault, the Redlands fault, and the San Jacinto fault located approximately 0.3 miles (0.5 km), 0.75 miles (1.2 km), and 1.1 miles (1.7 km), respectively, from the alignment. The geotechnical hazard posed by ground surface rupture from direct fault offset is considered to be low. Therefore, this impact is less than significant.

Mitigation Measure No 1: None are required.

3.1.2 Seismic Ground Shaking

The alignment is expected to experience ground shaking resulting from an earthquake occurring along several major active or potentially active faults in Southern California. The intensity of ground shaking at a given location depends on several factors, but primarily on the earthquake magnitude, the distance from the epicenter to the site of interest, and the response characteristics of the soils or bedrock units underlying the site. As shown in Table 1, the maximum peak horizontal ground accelerations along the alignment are estimated to be on the order of 0.37g, 0.66g, and 1.05g for earthquake events with a return period of 108, 475, and 2,475 years, respectively. Therefore, within the site area, the hazard posed by seismic shaking is considered to be high due to the proximity of known active faults and the nature of the materials underlying the alignment. This is a significant impact. There is no realistic way in which the seismic shaking hazard can be avoided; however, design and construction of the project in accordance with current regulations and codes are expected to mitigate the effects of ground shaking to the degree feasible. This is expected to reduce the effects of ground shaking to less than significant with mitigation.

Mitigation Measure No 2: None are required.

3.1.3 Secondary Effects of Seismic Shaking

Secondary effects generally associated with strong seismic shaking include liquefaction, seismically induced settlement, lateral spreading, seismically induced landslides, ground lurching, seismically induced inundation, tsunamis, and seiches. Each of these phenomena is discussed below.

Liquefaction

Liquefaction is a seismic phenomenon in which loose, saturated, fine-grained granular soils behave similarly to a fluid when subjected to high-intensity ground shaking. Liquefaction occurs when three general conditions exist: (1) shallow groundwater; (2) low density, fine, clean sandy soils; and (3) high-intensity ground motion. Studies indicate that saturated, loose and medium dense, cohesionless soils exhibit the highest liquefaction potential, while dry, dense, cohesionless soils and cohesive soils exhibit low to negligible liquefaction potential. Effects of liquefaction on level ground can include sand boils, settlement, and bearing capacity failures below structural foundations. Effects of liquefaction on deep pile foundations include reduction in the resistance of piles to lateral loads and downdrag or negative friction due to settlement of liquefied strata and the strata above it.

Based on the *San Bernardino County General Plan – Geology Hazard Overlays* (San Bernardino, 2009, see Figure 5), an approximate western half of the alignment up to the west side of Mountain View Avenue is located within an area designated as low to high susceptibility to liquefaction; (1) High susceptibility from E Street to approximately 2,500 feet west of Tippecanoe Avenue, (2) Medium susceptibility from approximately 2,500 feet west of Tippecanoe Avenue to approximately 1,500 feet east of Tippecanoe Avenue, and (3) Low susceptibility from approximately 1,500 feet east of Tippecanoe Avenue to the west side of Mountain View Avenue. The potential for surface manifestation of liquefaction in the form of sand boils and ground cracking may be anticipated. The remaining stretch of the alignment is not considered susceptible to liquefaction.

Mitigation Measure No 3: Future geotechnical exploration will need to be performed to evaluate the liquefaction potential, and the proposed structures constructed in areas susceptible to liquefaction should be supported on piles embedded below the liquefaction zones or on a mat foundation, if feasible. Alternatively, the liquefaction potential can be mitigated by ground improvements, such as stone columns or compaction grouting.

Lateral Spreading

Lateral spreading is a phenomenon where large blocks of soil translate laterally along or through a layer of liquefied soil. The mass moves downslope toward an unconfined area, such as a descending slope or river, and is known to move on slope gradients as gentle as one degree. For lateral spreading to occur, the layer of liquefied soil needs to be continuous. Mission Creek is an incision in the topography that could provide an unconfined area for lateral spreading to occur.

Mitigation Measure No 4: Lateral spreading is a regional phenomenon that cannot be efficiently mitigated locally. Future geotechnical exploration will need to be performed to evaluate the continuity of the liquefiable layers and quantify the effects of lateral spreading.

Conclusions: Depending on the expected severity of the lateral spreading, structures may be designed to account for additional lateral loads caused by lateral flow of soils, or ground improvement may be performed to reduce the impact to less than significant with mitigation.

Seismically Induced Settlements

These settlements, consisting of dynamic settlement (above groundwater) and liquefaction settlement (below groundwater), occur primarily in loose sandy soils due to reduction in volume during or after an earthquake event. These settlements are caused by strong ground shaking that allows the sediment particles to become more tightly packed, thereby reducing pore space. Poorly compacted artificial fills and poorly consolidated alluvium are especially susceptible to this phenomenon.

Mitigation Measure No 5: Removal and recompaction of low-density, near-surface soils should reduce this potential hazard. Additionally, structures will need to be designed to account for the potential settlements.

Conclusions: Implementation of mitigation measures is expected to reduce the effects of seismically-induced settlement to less than significant.

Seismically Induced Landslides

Marginally stable slopes, including existing landslides, may be subject to landsliding caused by seismic shaking. In most cases, this is limited to relatively shallow soil failures on steep slopes, especially where the soil is relatively thick and loose. The project area in general is not located in an area shown to be susceptible to seismically induced landslides by San Bernardino County (see Figure 5).

Mitigation Measure No 6: Future geotechnical exploration will need to be performed to evaluate the potential for seismically induced landsliding along Mission–Zanja Creek. Depending on the expected stability of the slopes in question, proper slope protection may be provided to reduce the impact of seismically induced landsliding. This is expected to reduce the effects of seismically-induced landslides to less than significant with mitigation.

Ground Lurching

Seismically induced ground lurching occurs when soil or rock masses move at right angles to a cliff or steep slope in response to seismic waves. Structures built on these masses can experience significant lateral and vertical deformations if ground lurching occurs. The proposed project will be built on relatively flat terrain, and the impact of ground lurching is expected to be negligible.

Mitigation Measure No 7: None are required.

Seismically Induced Inundation

Strong seismic ground motion can cause dams and levees to fail, resulting in damage to structures and properties located downstream. Based on the *San Bernardino County General Plan – Hazard Overlays* (San Bernardino, 2009, see Figure 6), the area along the alignment between Central Avenue (approximately Milepost 2.0) and east of the Santa Ana River (approximately Milepost 6.0) is located within an area designated as having a dam inundation hazard. The reservoirs retained at Big Bear Lake and Seven Oaks Dam are tributary to the Santa Ana River. If the Big Bear Lake Dam and/or the Seven Oaks Dam fails due to a strong earthquake, the above-named portion of the alignment is expected to experience significant flooding. The potential for seismically induced inundation due to failure of the Big Bear Lake Dam or the Seven Oaks Dam cannot be mitigated locally.

Mitigation Measure No 8: None are required.

Tsunamis and Seisches

Tsunamis are tidal waves generated in large bodies of water by fault displacement or major ground movement. Tsunamis affect coastal areas with large waves, some of which can crest at heights of more than 100 feet and strike with devastating force. Considering the inland location of the proposed alignment, the potential for a tsunami to affect the proposed alignment is considered low. Seiches are large waves generated in enclosed bodies of water in response to ground shaking. We are not aware of any enclosed bodies of water that can experience seiches during an earthquake in the vicinity of the proposed alignment.

Mitigation Measure No 9: None are required.

3.2 GROUND SUBSIDENCE

3.2.1 Extraction

Ground subsidence is generally caused by the extraction of subsurface fluids such as petroleum or groundwater. A secondary cause of subsidence is the oxidation of organic material such as peat.

No oil fields or peat deposits are known to exist in the area of the proposed alignment. Therefore, this potential hazard is considered low.

Mitigation Measure No 10: None are required.

3.2.2 Hydroconsolidation

Hydroconsolidation is caused by the addition of water to loose, dry soils in a semi-arid climate. The earth materials most susceptible to hydroconsolidation are silty sands, sandy silts, and fine sands with relatively low moisture content. The soils along the proposed alignment are known to have the potential for hydroconsolidation. The hazard for hydroconsolidation along the proposed alignment, therefore, is considered moderate to high.

Mitigation Measure No 11: Removal and recompaction of subsurface soils susceptible to hydroconsolidation should reduce this potential hazard to less than significant with mitigation. Future geotechnical exploration will need to be performed to evaluate the potential for hydroconsolidation, and remedial measures, if necessary, shall be provided.

3.3 SLOPE/FOUNDATION STABILITY

3.3.1 Unstable Fill Slopes

Fill slopes at I-10 Freeway crossings were constructed by Caltrans for the freeway embankments and associated on- and off-ramps. These slopes are expected to be stable.

Mitigation Measure No 12: None are required. If fill slopes are proposed, the fill slopes shall be designed to have an adequate factor of safety against instability and shall be constructed in accordance with applicable regulations and codes.

3.3.2 Landslides and Mudflows

There are no known or mapped landslides at or near the alignment. Due to the relatively flat topography of the proposed alignment, the potential for landslides or mudflows is considered low.

Mitigation Measure No 13: Future geotechnical exploration will need to be performed to evaluate the potential for landslide and mudflows along Mission–Zanja Creek.

Conclusions: Depending on the expected stability of the slopes in question, proper slope protection may be provided to reduce the impact of landslides and mudflow.

3.3.3 Compressible/Collapsible Soils

When a load, such as a fill or a structure, is placed on alluvial soils, the underlying soil layers can undergo a certain amount of compression. This compression is due to the deformation of the soil structure, the redistribution of soil particles, the expulsion of water or air from the void spaces, and other factors. Some of this settlement occurs immediately after a load is applied, while some of the settlement occurs over a period of time after placement of the load. For engineering applications, it is important to estimate the total amount of settlement that will occur upon placement of a given load and the rate of consolidation.

The near-surface soils along the alignment may be potentially collapsible, especially within the upper 5 feet.

Mitigation Measure No 14: Future geotechnical exploration will need to be performed to evaluate the collapse potential of the subsurface soils. To reduce the potential for settlement of the railroad embankment and other structures, the upper collapsible layers, if any, should be densified or removed and replaced with compacted fill. This is normally achieved by excavation and recompaction during grading operations.

Conclusions: With the implementation of appropriate mitigation measures, this impact can be reduced to a less than significant level.

3.3.4 Expansive Soils

Expansive soils are generally clay-rich soils that can cause damage by changes in their volume due to wetting (expansion) and drying (shrinkage). Since clay-rich materials are not anticipated along the alignment, this impact is considered to be low.

Mitigation Measure No 15: None are required.

3.4 Erosion and Drainages

3.4.1 Erosion of Graded Areas

Erosion can be caused by running water or by wind. Erosion by running water is likely to occur during periods of prolonged rainfall (most common during the winter rainy season) or high-intensity and short-duration storms (such as summer thunderstorms). Strong winds can cause downwind movement of silt and fine to medium sand particles, depending on the wind velocity. This process is most likely to occur in areas where the surface has been disturbed or the vegetation has been removed. Therefore, erosion from wind or running water along the alignment is considered a potential impact.

Mitigation Measure No 16: Erosion will be mitigated through the implementation of Storm Water Pollution Protection in compliance with the general construction practices.

Conclusions: Implementation of these mitigation measures will make this impact less than significant.

3.4.2 Runoff, Drainages and Impervious Surfaces

No major drainages will be altered during or after the construction of this project. Local drainage occurs as sheet flow or in storm drains and would not be significantly altered by the project.

Based on the *San Bernardino County General Plan – Hazard Overlays* (San Bernardino, 2009, see Figure 6), the areas along the alignment between Twin Creek (also called Lower Warm Creek) and west of California Street and between the east side of New York Street and the eastern end of the alignment are located within an area designated as a 100-year flood plain. The potential for flooding at these locations is considered high.

The construction of the project will not leave any current drainage ways unprotected nor will it create any new drainage ways that would be left unprotected. The potential for this hazard is considered low. The potential of flood cannot be mitigated locally.

Mitigation Measure No 17: None required.

3.4.3 Scour

Scour occurs as a result of the erosive power of water during periods of flood that erodes and transports sediments, causing downward erosion of a stream bed. Scour frequently affects man-made structures such as bridges and levees. The depth of scour is a function of the type of sediments in the stream bed and the velocity of the stream flow. Scour may be a design issue for the bridge crossing the Santa Ana River and for the bridge crossing Mill Creek Zanja, as well as for the railroad embankment along the Mission-Zanja Channel.

Mitigation Measure No 18: The depth of scour within the active drainage areas of the Santa Ana River, Mill Creek Zanja, and the Mission-Zanja Channel should be evaluated to assess potential impacts on the bridge reconstruction and railroad embankment designs in these areas. Foundation design and embankments for the bridge crossing the Santa Ana River and Mill Creek Zanja and railroad embankment along Mission-Zanja Creek shall take the potential scour into consideration. .

3.5 Earthwork Impacts

3.5.1 Import Material

The proposed project may require minor fill placement. The fill will require moisture conditioning and adequate compaction to provide proper support for the proposed improvements. Transportation of the import material may affect traffic in the vicinity. This impact is considered potentially significant.

Mitigation Measure No 19: Sources for the import material should be identified prior to construction, sampled, and tested to verify that the material is suitable for the intended use at the project site. Routes and schedules for importing should be established to minimize disruption to traffic. This will reduce the impact to less than significant.

3.6 Loss of Mineral Resources

3.6.1 Loss of Access

No existing mineral extraction areas are known along the proposed alignment. The materials present along the alignment are widespread and abundant in adjacent areas. Therefore, the loss of access to mineral resources is considered **less than significant.**

Mitigation Measure No 20: None are required.

3.6.2 Deposits Covered by Changed Land-Use Conditions

No mineral extraction areas are known along the proposed alignment. The materials present along the alignment are widespread and abundant in adjacent areas. Therefore, the loss of potential mineral resources is considered less than significant.

Mitigation Measure No. 21: None are required.

3.7 Waste Disposal Problems

3.7.1 Change in Groundwater Level

Based on the available groundwater well data and As-built LOTBs, groundwater is estimated to be at least 10 feet below ground surface to deeper than 50 feet below ground surface along the proposed alignment. Surface water is present at times in the Santa Ana River, the Mission-Zanja Channel, Warm Creek, and Mill Creek Zanja. The reconstruction of the existing railroad bridges is not expected to affect surface flow in the Santa Ana River or groundwater levels along the project alignment. This impact is considered low**.**

Mitigation Measure No 22: None are required.

3.8 Volcanic Hazards

No volcanoes have been mapped or are known to exist near the proposed alignment. The potential for any lava flow or ash fall is negligible. Therefore, the potential for these hazards is low.

Mitigation Measure No 23: None are required.

4.0 REFERENCES

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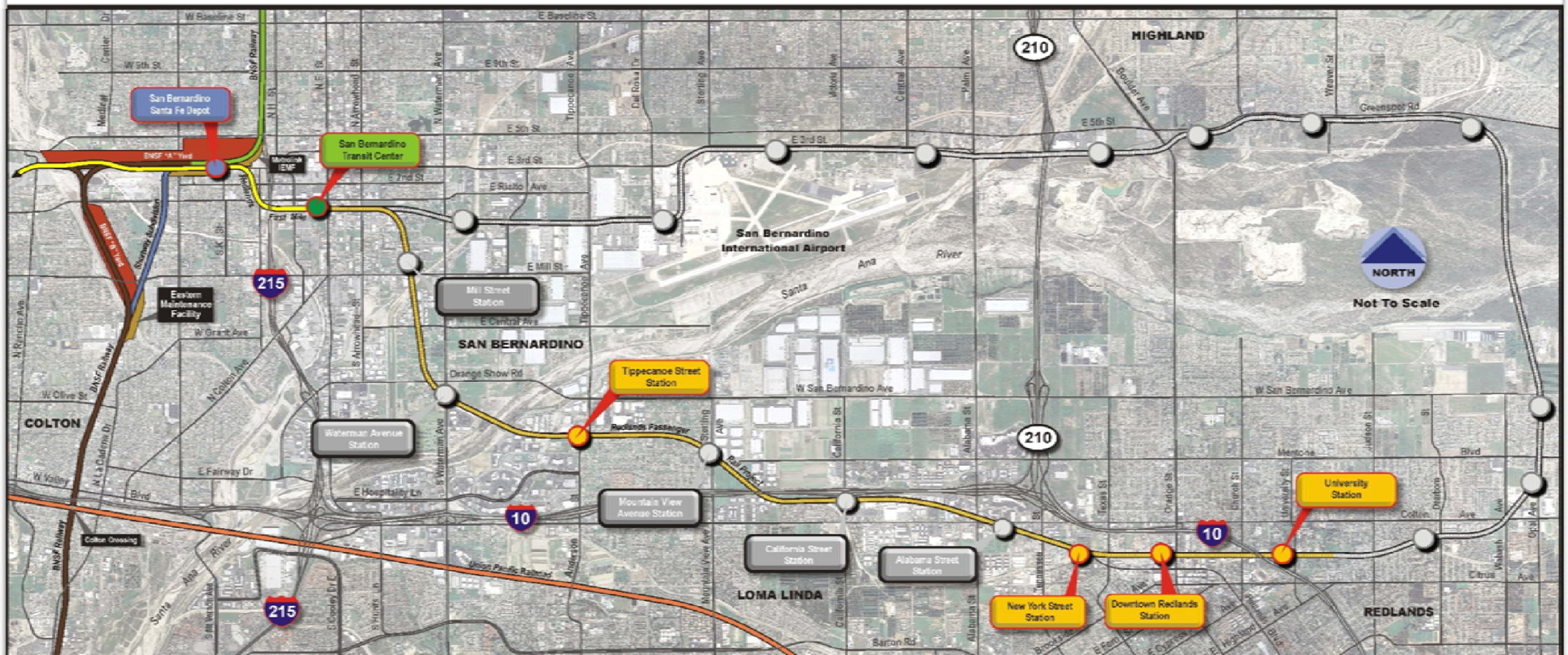
Figures

REDLANDS PASSENGER RAIL PROJECT

Strategic Plan: PHASE 1



LEGEND

Rail Lines	Passenger Stations
- Downtown San Bernardino Passenger Rail Project	- Metrolink/Amtrak
- Redlands Passenger Rail Project - Phase 1 & 2	- Potential Phase 1 Stations

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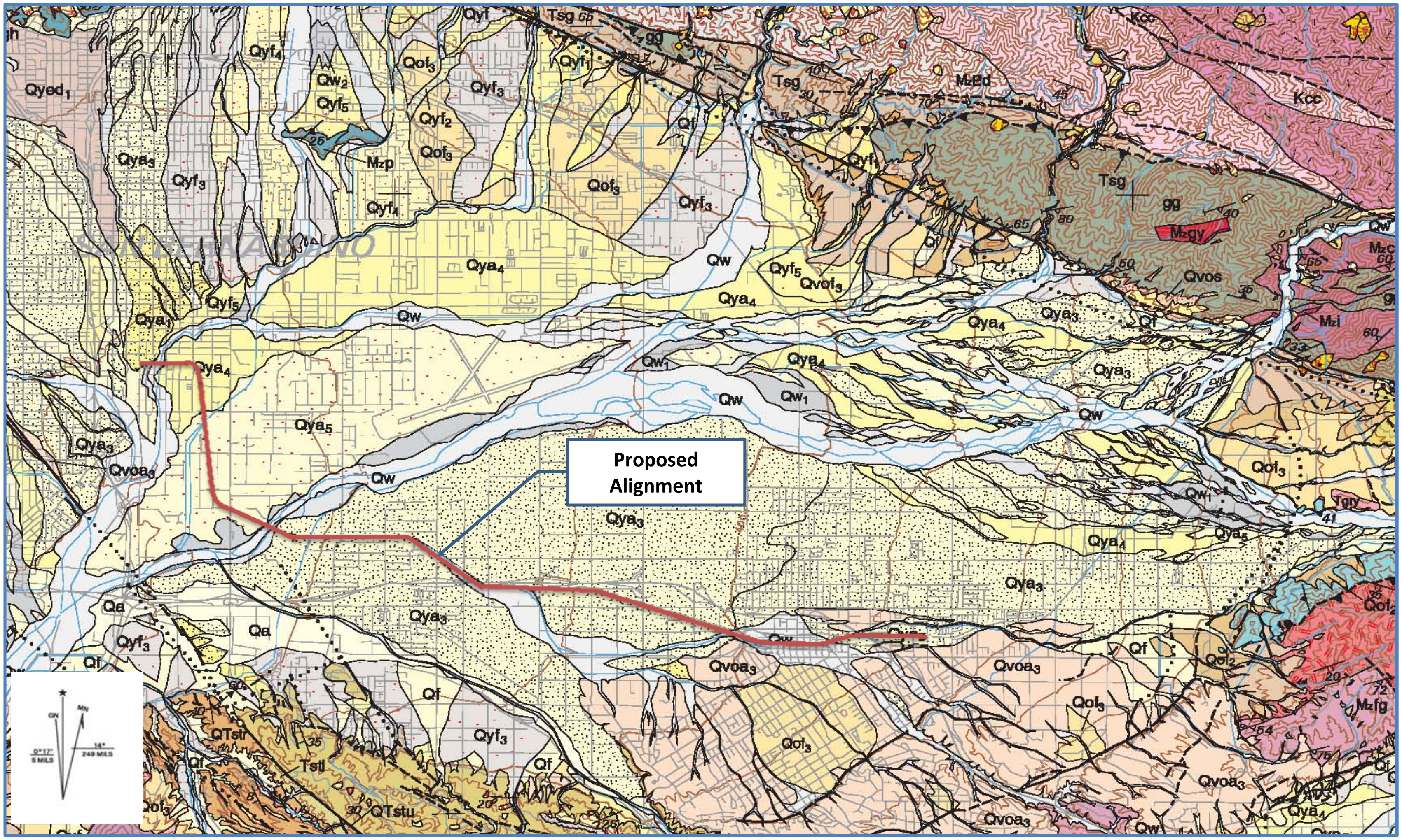
VICINITY MAP
REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : Redlands Passenger Rail Project
PROJECT NUMBER : 043-170063
DESIGNED/CHECKED BY: TK/GG

HDR

Figure 1



Legend:

Qya5	Young alluvial-valley deposits, Unit 5 (late Holocene)
Qya4	Young alluvial-valley deposits, Unit 4 (late Holocene)
Qya3	Young alluvial-valley deposits, Unit 3 (middle Holocene)
Qya1	Young alluvial-valley deposits, Unit 1 (middle Holocene)
Qw	Very young wash deposits (late Holocene)

Reference: Douglas M. Morton, et al, 2003, Preliminary Geology Map of the San Bernardino 30' by 60' Quadrangle, California

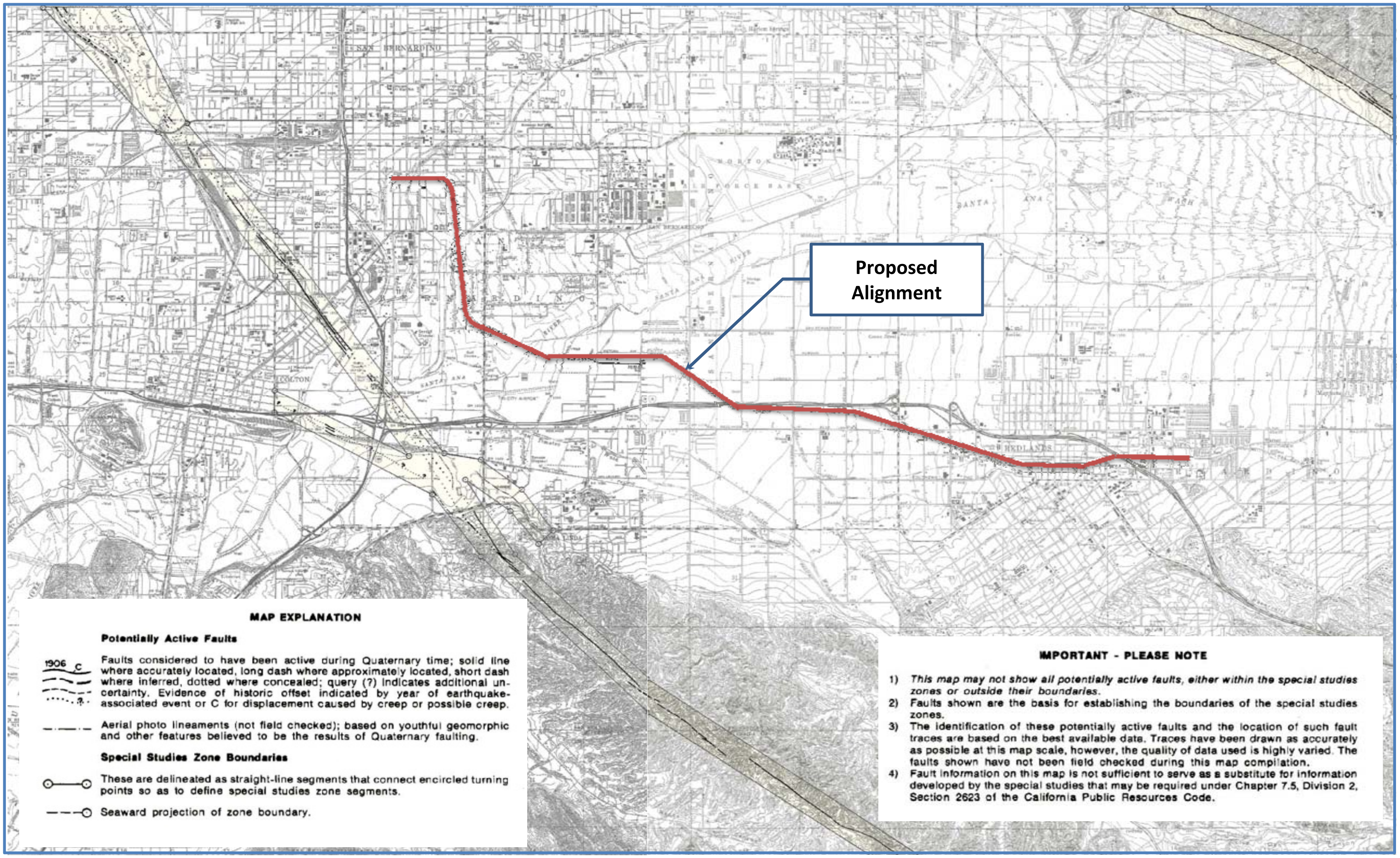
GEOLOGIC MAP

REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : Redlands Passenger Rail Project
PROJECT NUMBER : 043-170063
DESIGNED/CHECKED BY: TK/GG

HDR

Figure 2



Reference: Alquist-Priolo Fault Map - San Bernardino South and Redlands Quadrangles, January 1, 1997

ALQUIST-PRIOLO FAULT MAP

REDLANDS PASSENGER RAIL PROJECT

COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : Redlands Passenger Rail Project
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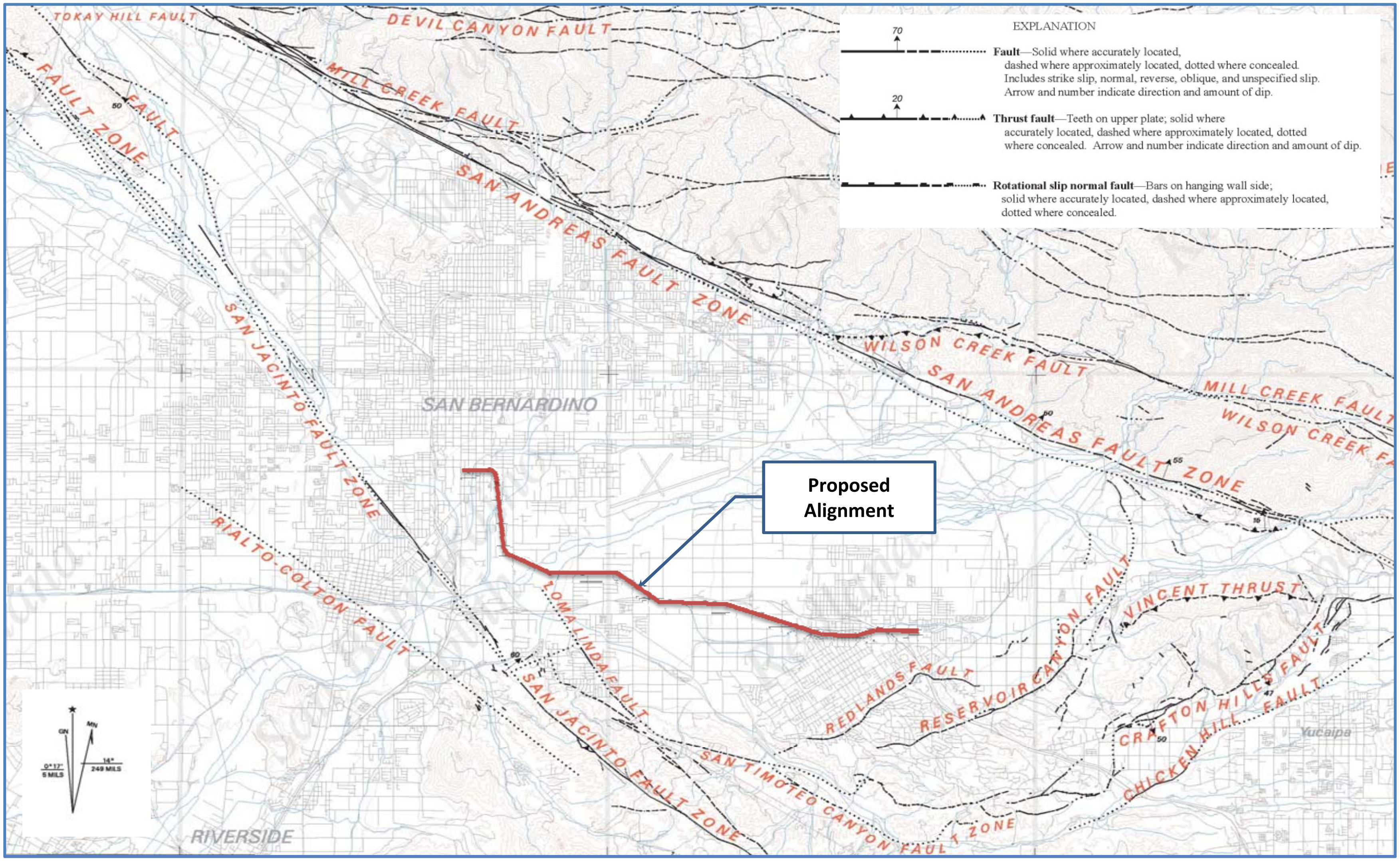
Figure 3



Reference: Douglas M. Morton, et al, 2003, Preliminary Geology Map of the San Bernardino 30' by 60' Quadrangle - Faults, California

FAULT MAP

REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : Redlands Passenger Rail Project
PROJECT NUMBER : 043-170063
DESIGNED/CHECKED BY: TK/GG

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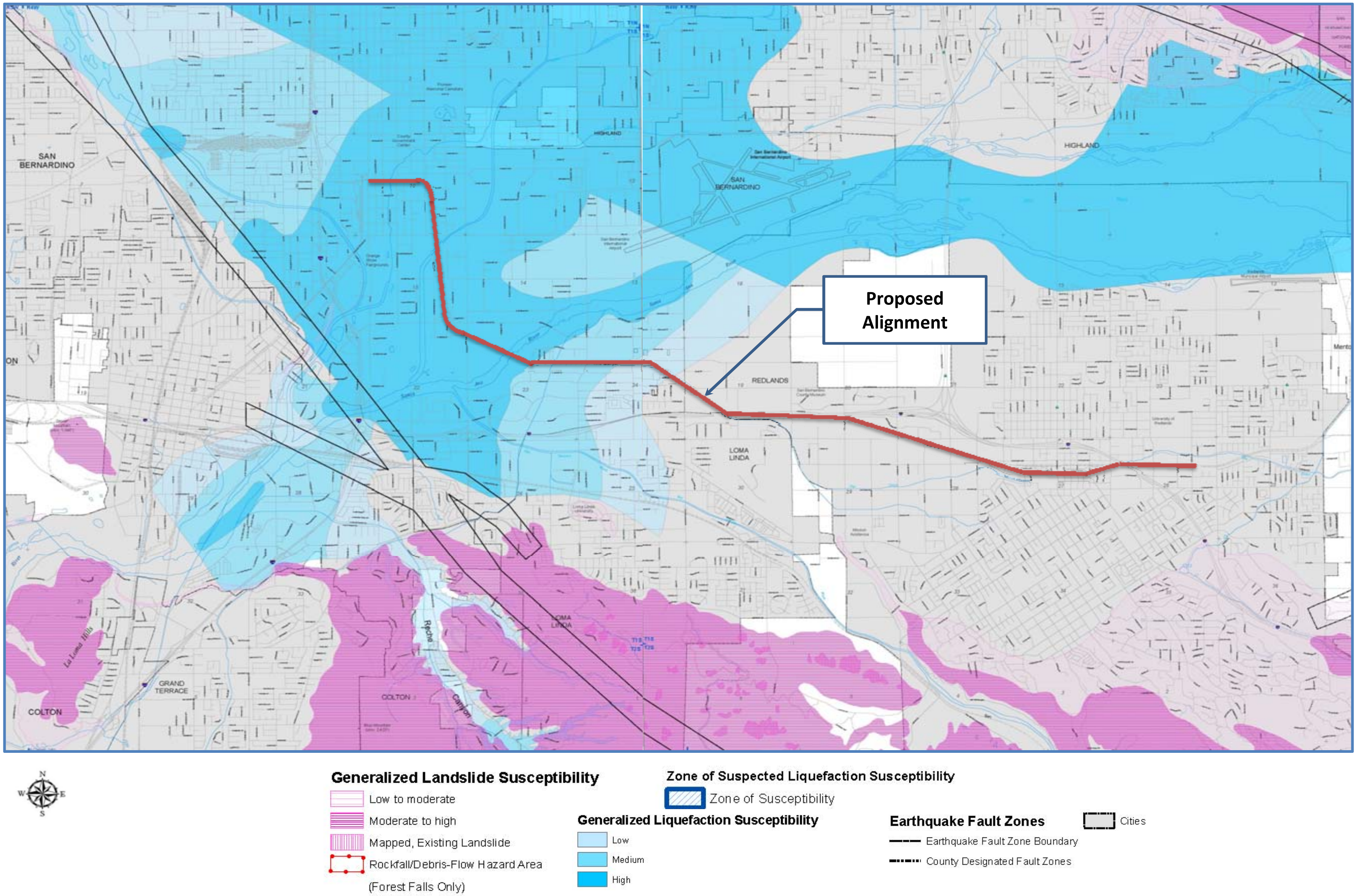
Figure 4



References: San Bernardino County Land Use Plan, 2009, General Plan, Geology Hazard Overlays, FH30C and FH31C

LANDSLIDE AND LIQUEFACTION HAZARD MAP

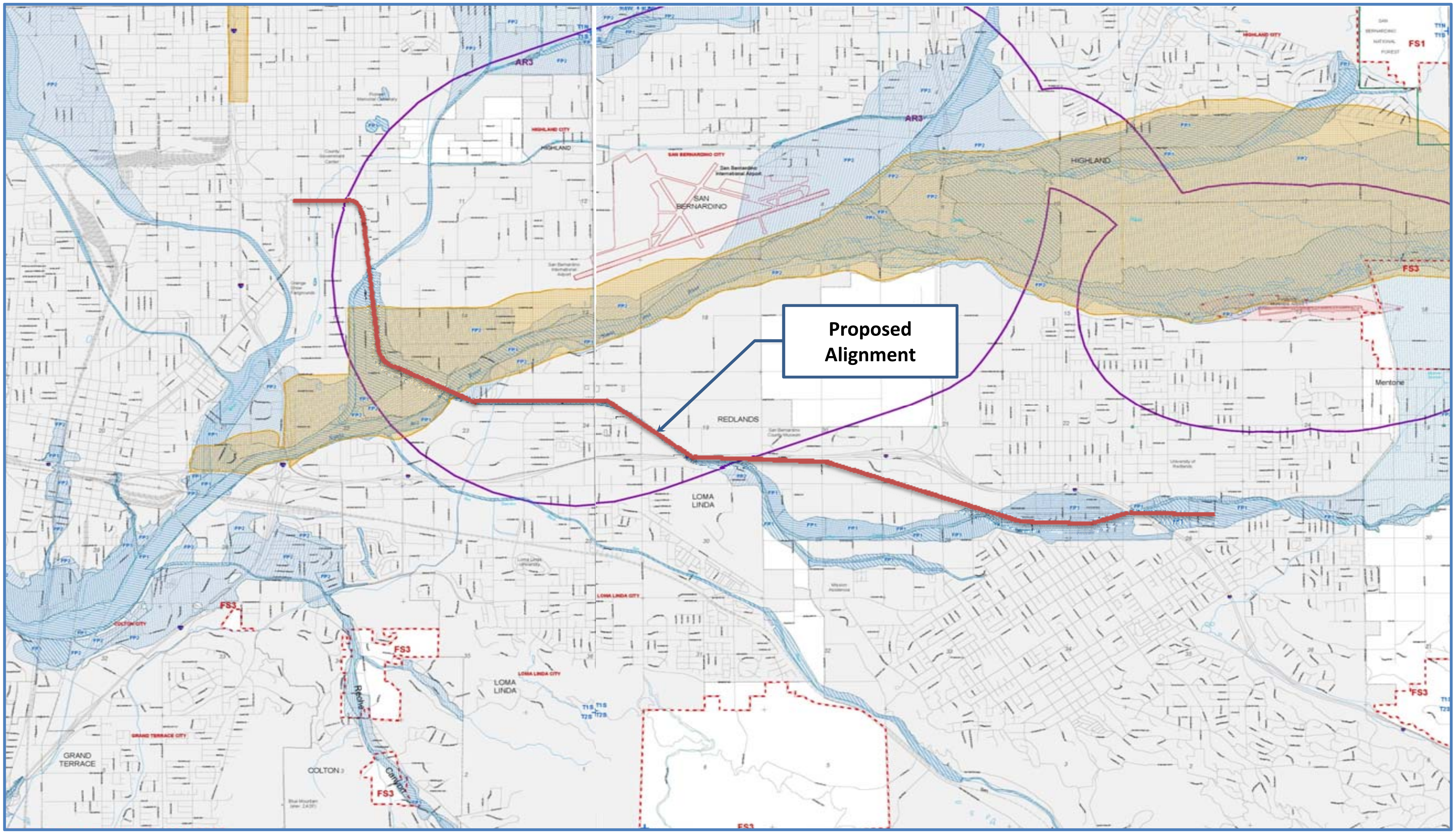
REDLANDS PASSENGER RAIL PROJECT

COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : Redlands Passenger Rail Project
PROJECT NUMBER : 043-170063
DESIGNED/CHECKED BY: TK/GG

HDR

Figure 5



Dam Inundation

- Area of Inundation
- Limit of Inundation
- Dam
- Limit of Study

Flood Plain Safety (FP) Overlay District

- FP1 (Zone A - Inside 100 Year Flood Plain)
- FP2 (Zone X - Inside 500 Year Flood Plain)
- FP3 (Local Flood Data)

Noise Hazard (NH) Overlay District

- Noise Contour in LDN
- Runway Location

Fire Safety (FS) Overlay District

- Fire Safety Boundary
- FS1 Fire Safety Area 1
- FS2 Fire Safety Area 2

Airport Safety Review

- AR3 (Airport Safety Review Area 3)
- AR4 (Airport Safety Review Area 4)

References: San Bernardino County Land Use Plan, 2009, General Plan, Hazard Overlays, FH30B and FH31B

FLOOD HAZARD MAP

REDLANDS PASSENGER RAIL PROJECT

COUNTY OF SAN BERNARDINO, CALIFORNIA

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Figure 6

REDLANDS PASSENGER RAIL PROJECT

Slope Analysis and Photodocumentation

San Bernardino, San Bernardino County, California

July 2012

Table 1. Summary of Existing Conditions of Embankment along Railroad Track

Station Nos	Photo Nos.	Existing Conditions
236+00 to 263+00	1 and 2	Slope face covered with trees, bushes and occasionally rocks
263+00 to 263+70	2 and 3	Concrete drop structure, approximately 11 feet in height
263+70 to 267+00	4	Rocks and boulders on slope face
267+00 to 269+00	5 and 6	Approximately 3 to 4 feet high of retaining structure at bottom of slope with rocks and boulders at bottom of Creek. Minor localized surficial/erosion failure or loss of soils behind retaining structure.
269+00 to 269+80	5 and 6	Tippecanoe Avenue Crossing
269+80 to 281+00	7	Unprotected slope face with gravel and cobbles and occasional rocks and boulders
281+00 to 290+40	8 and 9	Several localized surficial/erosion failures observed during site visit in March, 2011. Exposed slope face included garbage mixed with soils. New fills were already placed over localized failure areas during site visit in October 2011.
290+40 to 291+40	10	Retaining structure at bottom of slope with rocks and boulder at bottom of Creek. Encountered refusal on the south side of existing track at shallow depth due to possibly rocks and boulders.
291+40 to 292+00	10 and 11	Richardson Street Crossing
292+00 to 320+20	12, 13 and 14	Unprotected slope face with occasional rocks, boulders, asphalt concrete and concrete debris. Several localized surficial/erosion failures were observed during site visits New fills were already placed over localized failure areas during site visit in October 2011. Rocks and boulders were observed at bottom of Creek at several locations.
317+00 to 320+20	15 and 16	Loose concrete debris observed on slope face and exposed steel pipe on slope face. Indication of loose surficial soils
320+20 to 321+00	14	Mountain View Avenue Crossing
321+00 to 323+00	17 and 18	Two concrete panels, possibly part of wing wall for adjacent bridge, were placed on slope face.
323+00 to 343+20	19, 20, 21 and 22	Unprotected slope face with occasional rocks, boulders and concrete debris. Observed signs of new fills placed on access road and slope face along existing railroad track. Several local surficial failure observed
326+00	19	Narrow access road, possibly loose soils due to the drainage outlet to Creek. Local surficial failure observed
343+20 to 347+40	23 and 24	I-10 overcrossing with slope face covered with rock and cement grouting
347+40 to 364+00	25 and 26	Unprotected slope face with occasional rocks and boulders. Observed signs of new fills placed on access road and slope face along existing railroad track.

Table 2. Summary of Slope Stability Analyses

Location	Station No.	Avg. Slope Angle	Approximate Height of Slope (feet)	Calculated Factor of Safety			
				Infinite Slope	Static	Pseudo -Static	Rapid Drawdown
Cross Section A-A’	236+20	2.05H:1V	25	1.3	2.242	1.656	1.217
Cross Section B-B’	252+00	1.45H:1V	20	4.7(3)	2.503	2.304	2.348
Cross Section C-C’	271+00	1.70H:1V	10	**0.51**	2.637	2.877	3.939
Cross Section D-D’	290+00	1.51H:1V	15	**8.3(4)**	2.447	2.075	2.472
Cross Section E-E’(1)&(2)	319+14	1.28H:1V	17	**0.83**	**1.412**	1.311	**1.055**
Cross Section F-F’(2)	343+14	1.18H:1V	16	**0.96**	1.604	1.279	**1.050**
Cross Section G-G’	355+00	1.42H:1V	10	**1.04**	1.922	1.725	1.170
Cross Section H-H’	369+00	1.85H:1V	16	**0.72**	1.558	1.244	1.180

(1): need mitigation to increase safety factor to the code required for Static condition

(2): need mitigation to increase safety factor to the code required for Rapid Drawn Down condition

(3): subsurface soils for upper 5 feet consisted of silt and slope face within this area was covered with vegetations during our site visits.

(4): **subsurface soils for upper 5 feet consisted of silt. Slope face was unprotected in general at this location during our site visits. Soil type at the slope face may be sandy soils and a factor of safety could be less than 1.0 if sandy soils are saturated.**

Preliminary Recommendations

Based on the field observations of the existing embankment and slope stability analyses, existing slope areas between Station Nos approximately 305+00 and 349+00 should be mitigated to provide factor of safety greater than code required. The mitigation measures may be include, but not limited to, flattened existing slopes, slope protection, and/or retaining walls including mechanically stabilized earth walls and soil nail walls.

Also the existing slopes between Station Nos approximately 261+00 and 369+00 should be mitigated to minimize surficial/erosion failures. The artificial debris (garbage mixed with soils) observed within areas between Station Nos approximately 281+00 and 290+40 should be completely removed and replaced with compacted fill. An additional field exploration should be performed to verify our preliminary findings and recommendations within the above-named portion of the alignment.

PHOTO 1

Approx. Station 241, looking east
October 2011

PHOTO 2

Approx. Station 254, looking west
October 2011

PHOTOS 1 AND 2
MISSION ZANJA CREEK
REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : RPRP
PROJECT NUMBER : 043-170063
DESIGNED/CHECKED BY: TM/TK

HDR

PHOTOS 3 AND 4

MISSION ZANJA CREEK

REDLANDS PASSENGER RAIL PROJECT

COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : RPRP

PROJECT NUMBER : 043-170063

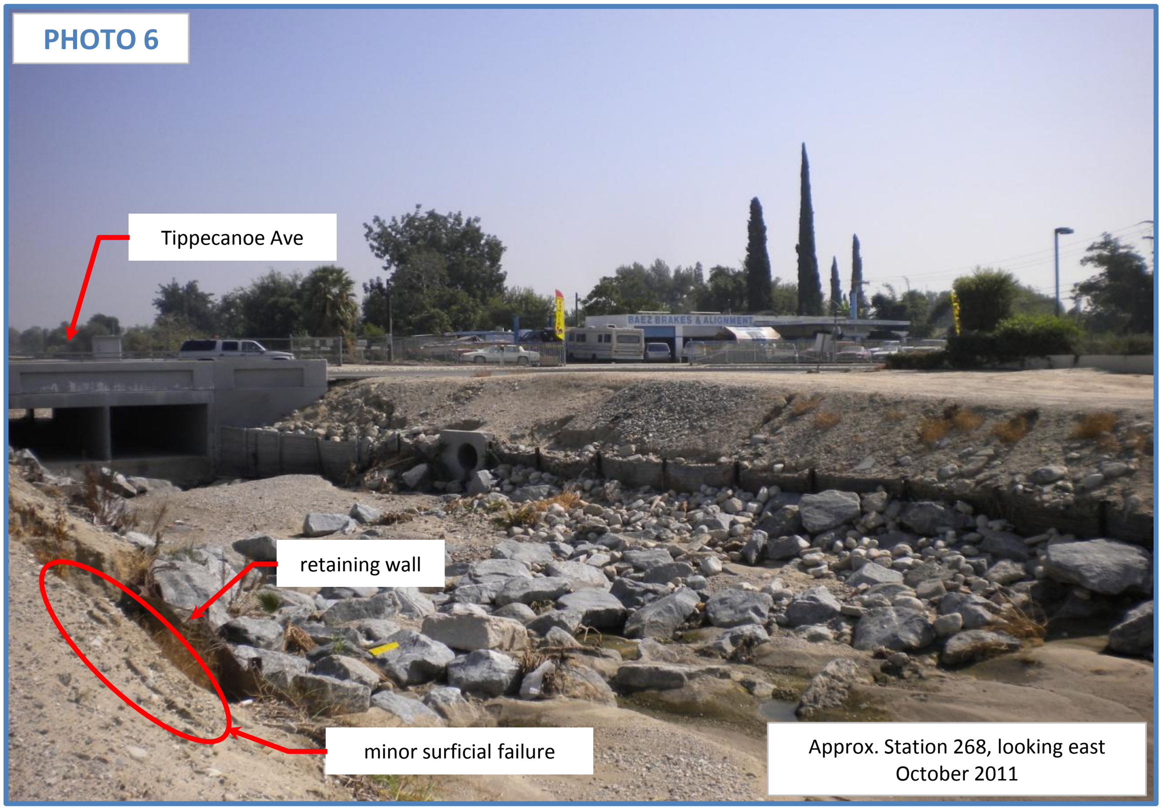
DESIGNED/CHECKED BY: TM/TK

HDR

PHOTO 5

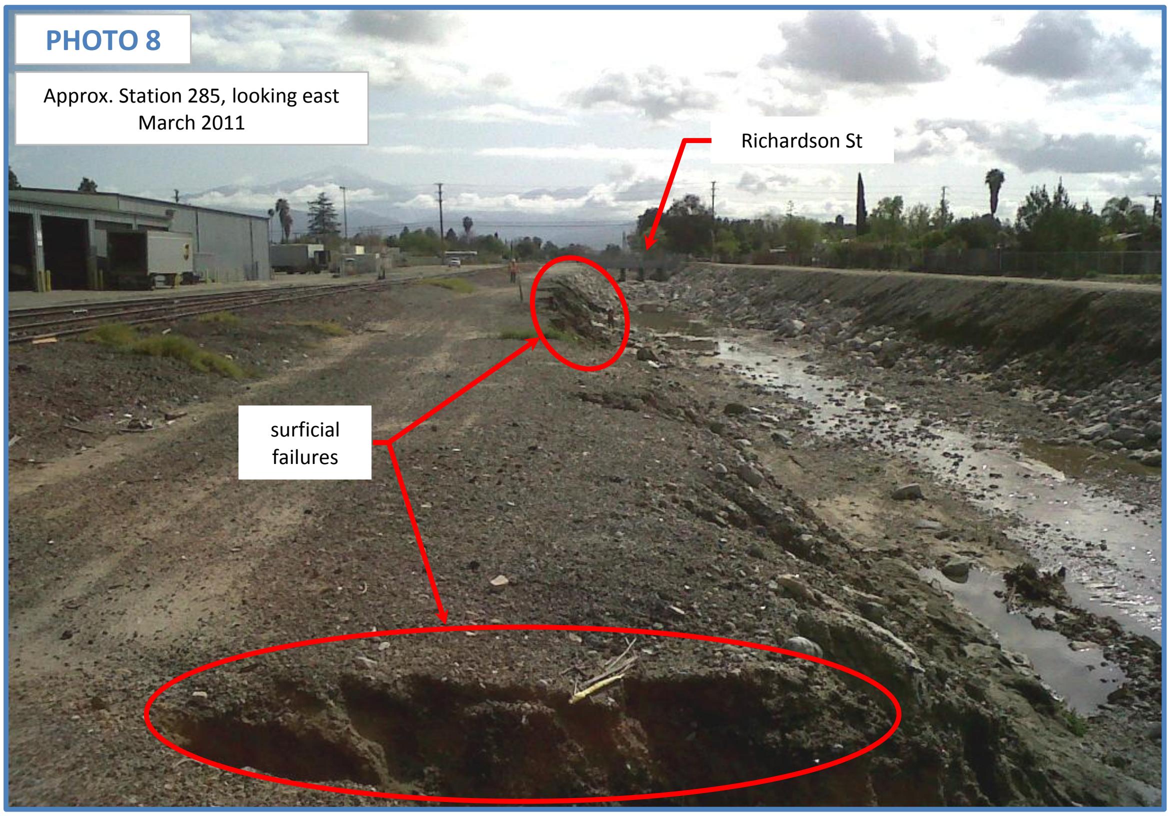
Approx. Station 267, looking east
March 2011

PHOTO 6



Approx. Station 268, looking east
October 2011

PHOTOS 5 AND 6 MISSION ZANJA CREEK REDLANDS PASSENGER RAIL PROJECT COUNTY OF SAN BERNARDINO, CALIFORNIA	PROJECT NAME : RPRP PROJECT NUMBER : 043-170063 DESIGNED/CHECKED BY: TM/TK	HDR



PHOTOS 7 AND 8
MISSION ZANJA CREEK
REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : RPRP
PROJECT NUMBER : 043-170063
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HDR

PHOTOS 9 AND 10

MISSION ZANJA CREEK
REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : RPRP
PROJECT NUMBER : 043-170063
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PHOTOS 11 AND 12
MISSION ZANJA CREEK
REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : RPRP
PROJECT NUMBER : 043-170063
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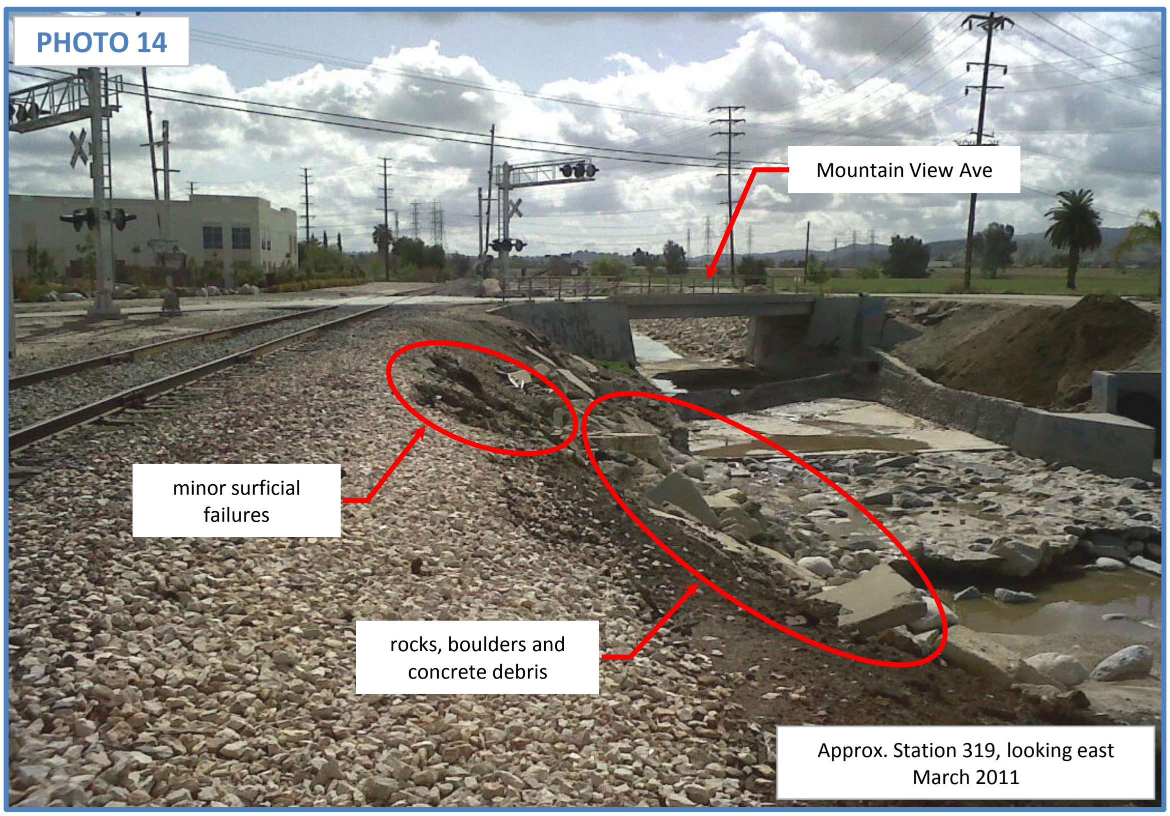
HDR



PHOTOS 13 AND 14 MISSION ZANJA CREEK REDLANDS PASSENGER RAIL PROJECT COUNTY OF SAN BERNARDINO, CALIFORNIA	PROJECT NAME : RPRP PROJECT NUMBER : 043-170063 DESIGNED/CHECKED BY: TM/TK	HDR

PHOTOS 15 AND 16 MISSION ZANJA CREEK REDLANDS PASSENGER RAIL PROJECT COUNTY OF SAN BERNARDINO, CALIFORNIA	PROJECT NAME : RPRP PROJECT NUMBER : 043-170063 DESIGNED/CHECKED BY: TM/TK	HDR

PHOTO 17

PHOTO 18

PHOTOS 17 AND 18

MISSION ZANJA CREEK
REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

PROJECT NAME : RPRP
PROJECT NUMBER : 043-170063
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PHOTOS 19 AND 20
MISSION ZANJA CREEK
REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

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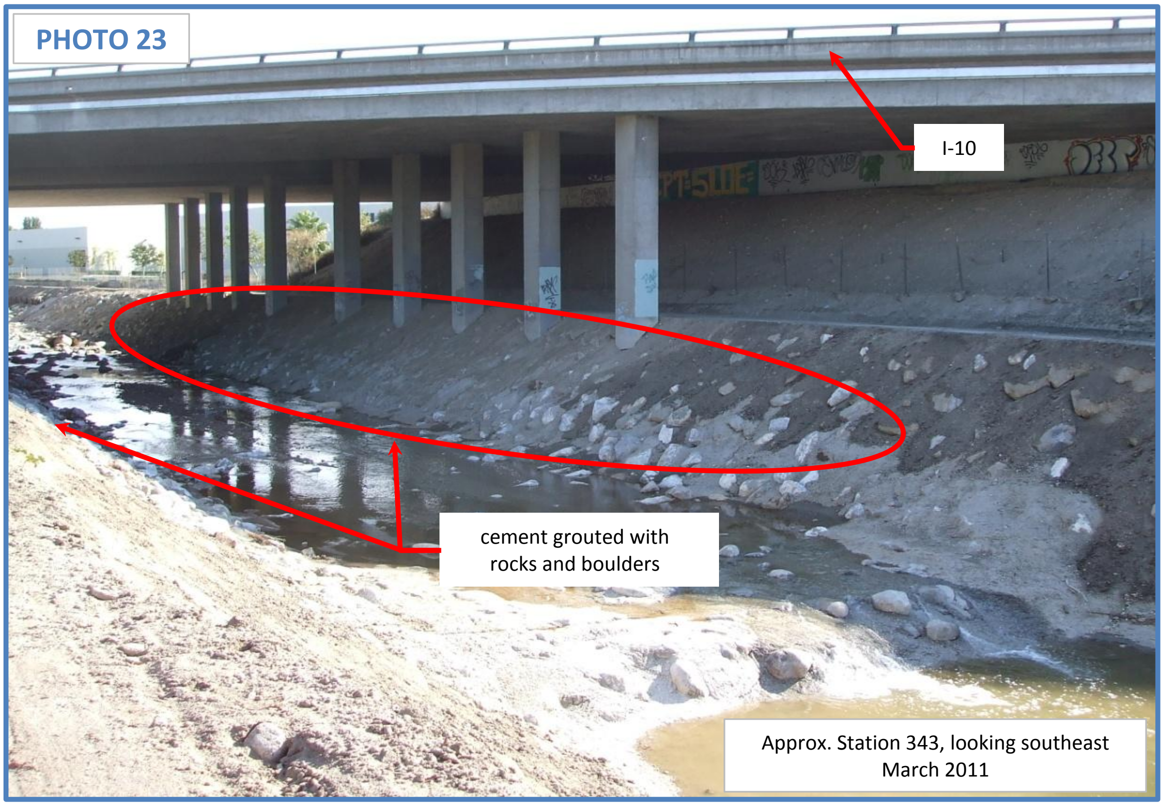
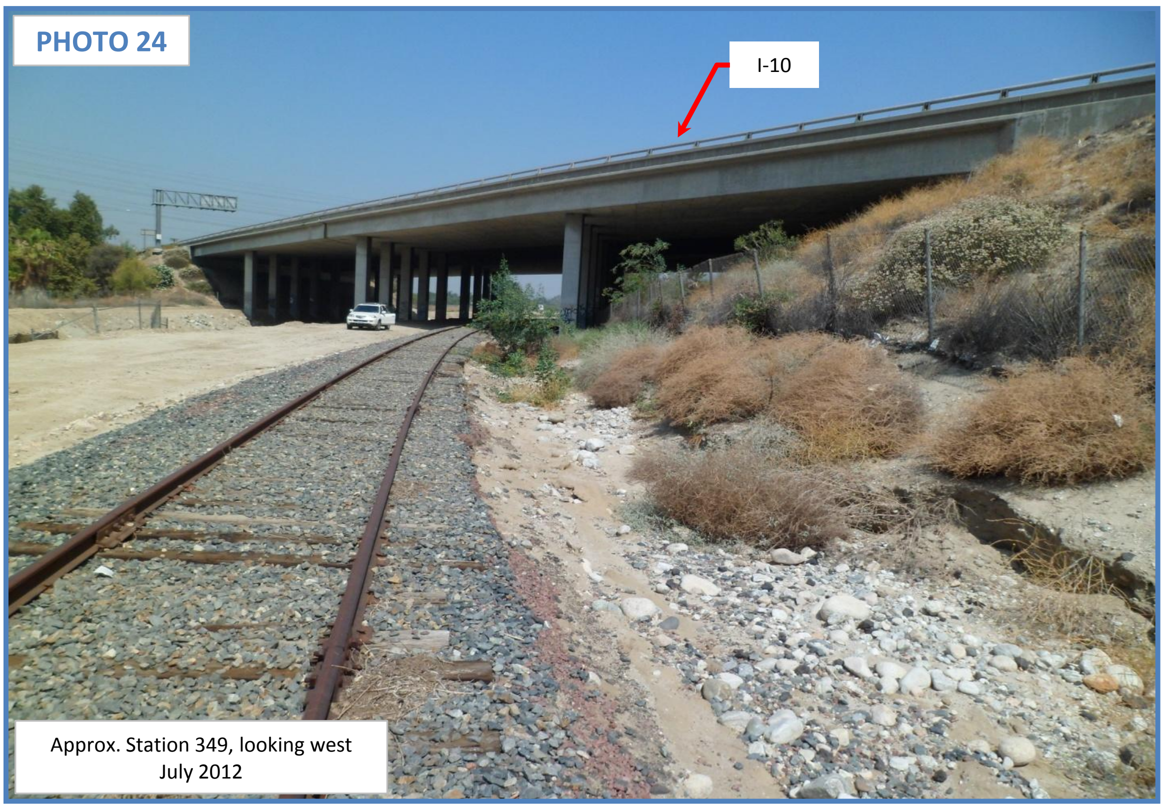
PHOTOS 21 AND 22 MISSION ZANJA CREEK REDLANDS PASSENGER RAIL PROJECT COUNTY OF SAN BERNARDINO, CALIFORNIA	PROJECT NAME : RPRP PROJECT NUMBER : 043-170063 DESIGNED/CHECKED BY: TM/TK	HDR

PHOTO 23



Approx. Station 343, looking southeast
March 2011

PHOTO 24



Approx. Station 349, looking west
July 2012

PHOTOS 23 AND 24
MISSION ZANJA CREEK
REDLANDS PASSENGER RAIL PROJECT
COUNTY OF SAN BERNARDINO, CALIFORNIA

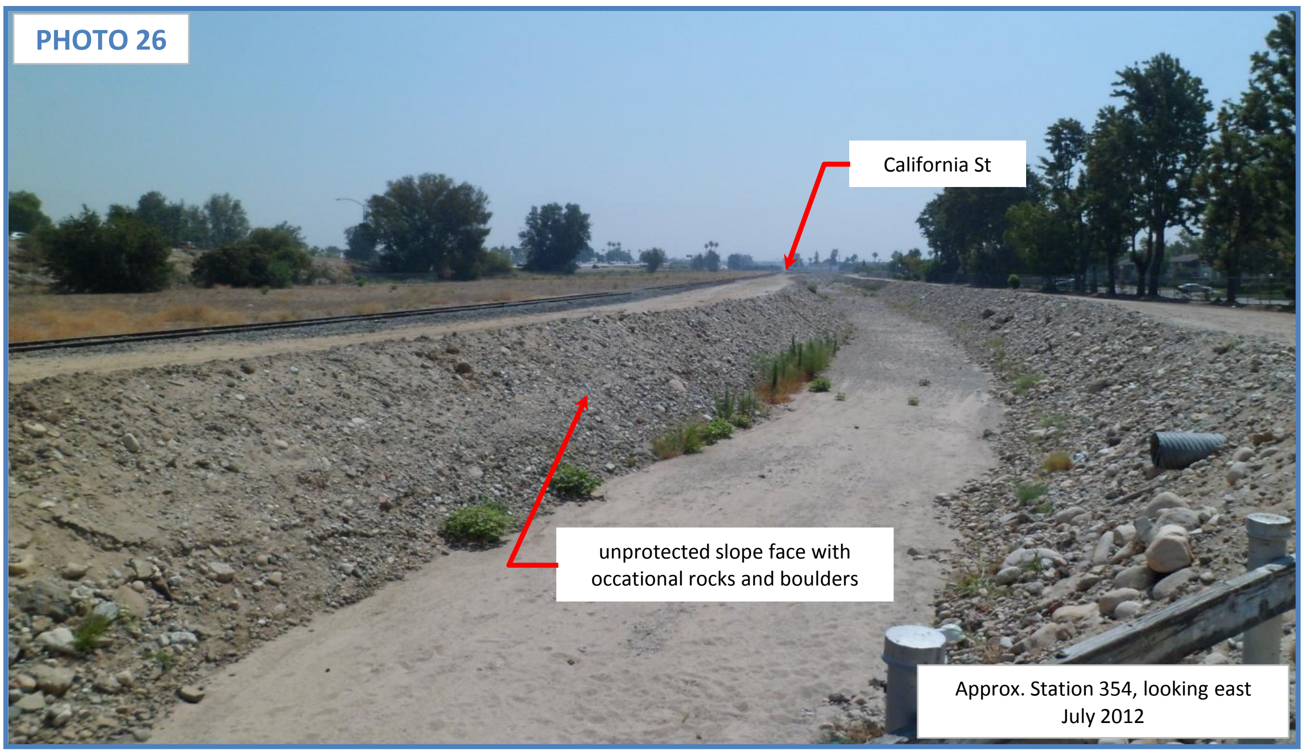
PROJECT NAME : RPRP
PROJECT NUMBER : 043-170063
DESIGNED/CHECKED BY: TM/TK

HDR

PHOTO 25

Approx. Station 354, looking east
October 2011

PHOTO 26



Approx. Station 354, looking east
July 2012

PHOTOS 25 AND 26 MISSION ZANJA CREEK REDLANDS PASSENGER RAIL PROJECT COUNTY OF SAN BERNARDINO, CALIFORNIA	PROJECT NAME : RPRP PROJECT NUMBER : 043-170063 DESIGNED/CHECKED BY: TM/TK	HDR