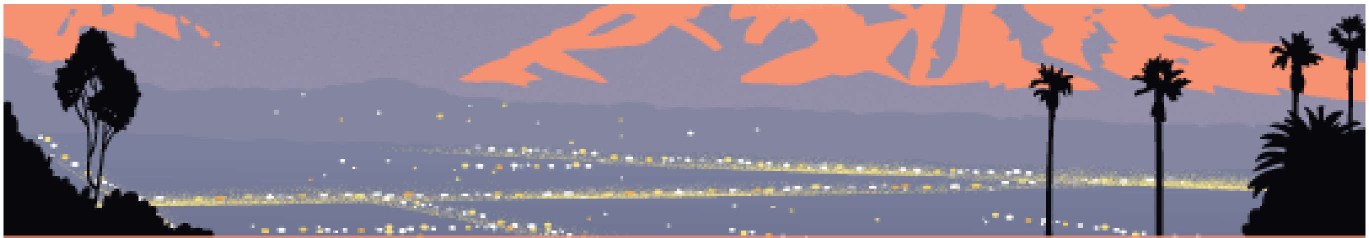

SR-710 Study

Alternatives Analysis Report

# Appendix T

## Geotechnical Study Technical Memorandum

Metro


TECHNICAL MEMORANDUM

# Geotechnical Study Technical Memorandum

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|---|---|
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| | Study Team |
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| DATE: | December 18, 2012 |
| PROJECT NUMBER: | 428908 |

The purpose of this technical memorandum is to identify the geological/geotechnical aspects that impact the design/construction of the proposed alternatives for the State Route (SR) 710 Study in Los Angeles County, California. The rating system developed to rank the proposed alternatives based on the geological/geotechnical conditions encountered within each alternative is outlined. In addition, the measurement scale and overall geotechnical rating for each alternative is also included in this memorandum.

## Methodology

As part of the Level II screening evaluation of the 12 proposed alternatives and 3 design variations (No Build, Transportation System Management/Traffic Demand Management [TSM/TDM], Bus Rapid Transit-1 [BRT-1], Bus Rapid Transit-6A [BRT-6A], Bus Rapid Transit-6 [BRT-6], Light Rail Transit-4A [LRT-4A], Light Rail Transit-4B [LRT-4B], Light Rapid Transit-4D [LRT-4D], Light Rapid Transit-6 [LRT-6], Freeway-2 [F-2], Freeway-5 [F-5], Freeway-6 [F-6], Freeway-7 [F-7], Highway/Arterial Improvements-2 [H-2], and Highway/Arterial Improvements-6 [H-6]), a rating system was developed to rank the alternatives based on the geological/geotechnical conditions encountered within each alignment. Four “Evaluation Criteria” were established to rate the alignments based on the geological/geotechnical conditions. Each of the evaluation criteria are defined by “Performance Measures,” which are generally based on the percentage of an alternative impacted by the condition defined in the evaluation criteria. The only exception is that for faults, the number of faults crossing each alternative is considered. Table 1 summarizes the evaluation criteria and performance measures.

TABLE 1
**Summary of Level II Evaluation Geotechnical Criteria and Performance Measures**
*SR 710 Study Alternative Analyses*

| Evaluation Criteria | Performance Measure |
|---|---|
| Liquefaction | Approximate percentage of alternative alignment within potentially liquefiable zone(s) that could impact proposed improvements |
| Fault | Number of active and potentially active faults crossing within the alternative alignment that could impact proposed improvements |
| Variance in Subsurface Materials | Approximate percentage of subsurface material variability that could impact the proposed improvements within the alternative alignment |
| Natural Gas Exposure | Approximate percentage of alternative alignment constructed within formational materials known to contain natural gas |

Each of the alternatives was rated against the performance measures in the evaluation criteria and assigned an overall rating on a scale of 1 to 7. A rating of 1 would indicate that the alternative is subject to one or more of the geotechnical conditions that increase the difficulty/complexity of the design/construction of the alternative to the highest extent. On the other end of the scale, a rating of 7 would indicate that there are minimal or no geological/geotechnical conditions, as identified in the performance measures, that impact the design/ construction of the alternative. All other conditions will rate between these two end scales. The ratings of performance measures are provided in Table 2.

TABLE 2
**Rating of Performance Measures**
***SR 710 Study Alternative Analyses***

| Screening Level II: Performance Measure | Worst/Low Likely Outcome | | | Moderate/ Medium Likely Outcome | | | Best/High Likely Outcome |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| Approximate percentage of alternative alignment within potential liquefiable zone(s) that could impact proposed improvements | 50% to 60% | 40% to 50% | 30% to 40% | 20% to 30% | 10% to 20% | 5% to 10% | 0% to 5% |
| Number of active and potentially active faults crossing within the alternative alignment that could impact proposed improvements | 3 | - | 2 | - | 1 | - | 0 |
| Approximate percentage of subsurface material variability that could impact the proposed improvements within the alternative alignment | 60% to 70% | 50% to 60% | 40% to 50% | 30% to 40% | 20% to 30% | 10% to 20% | 0% to 10% |
| Approximate percentage of alternative alignment constructed within formational materials known for natural gas potential | 60% to 70% | 50% to 60% | 40% to 50% | 30% to 40% | 20% to 30% | 10% to 20% | 0% to 10% |

# Regional Geologic Setting

## Physiography

The SR 710 study area primarily consists of the western San Gabriel Valley, the southern San Rafael Hills, the eastern portion of the Elysian Hills, and the Repetto Hills areas of Los Angeles-Pasadena. These areas are within the transition zone between the northwest-southeast-trending Peninsular Ranges physiographic/geologic province on the south, and the east-west-trending Transverse Ranges province on the north. The San Gabriel Valley floor gently descends southerly from elevations of 700 to 1,000 feet along the northern margin to approximately 300 to 400 feet in the south. The gradual descent is interrupted locally by a 10- to 150-foot escarpment trending from east-west to northeast-southwest and extending from the Monrovia area to the South Pasadena area and westerly into the hills of Glendale and Los Angeles. Associated with this escarpment are closed depressions, springs, reverse-tilted fan surfaces, and small ridges. All of these features are due to fault displacement by the Raymond fault.

## Stratigraphy

Regional geologic maps indicate that geologic deposits within the SR 710 Study area are marine and nonmarine Quaternary-age (approximately less than 2 million years old) sediments, deposited atop marine sedimentary rocks of Tertiary-age (approximately 2 to 16 million years old), which overlie a crystalline basement complex of Cretaceous and Pre-Cretaceous (120 to 160+ million years old) igneous and metamorphic rocks.

Young and Old Quaternary alluvial materials are encountered within the study area. The alluvial materials consist of interbedded lenses and/or discontinuous layers of fine-grained soil (clay and silt) and coarse-grained materials (sand and gravel) that generally increase in strength with depth.

The Pliocene-age Fernando Formation is present within the southern portion of the study area. This formation consists primarily of low-strength, dark gray to black, massive (unbedded), marine claystone and siltstone. The lower portion grades upward into white-to-brick-red, conglomeratic sandstones, conglomerates, and interbedded sandstones, all of which are believed to have been deposited in near-shore marine conditions as a deep marine basin was filled.

The deep-water marine rocks of the late Miocene Puente Formation (variously named Puente, Monterey, Modelo, and Unnamed Shale) crop out and/or are anticipated at depth in the study area. According to the dominant rock type, the following rocks are mapped as several members as follows (from older to younger): sandstone, shale, and siltstone units. The formation has the potential for naturally occurring gases such as methane and/or hydrogen sulfide.

The middle-Miocene-age Topanga Formation occurs as three separate units within the study area. These units include a lower siltstone member, a middle sandstone member, and an upper conglomerate/breccia member. The rocks of the Topanga Formation tend to be coarser-grained north of the Raymond fault.

The northern part of the study area contains the Cretaceous-age basement complex rocks exposed in the San Rafael Hills where they are designated as Wilson diorite or quartz diorite; however, these rocks comprise a wide suite of lithologies, including diorite, monzonite, quartz diorite, quartz monzonite, and gneissic diorite. They are likely to be very fractured and weathered.

### Geologic Structure

The convergence of the Peninsular Ranges and the Transverse Ranges has resulted in a very complex geologic structure. As the northwest vergent blocks of the Peninsula Ranges interact with the south vergent Transverse Ranges, a series of new structures has formed to accommodate the collision, including east-west compressional folding and thrusting and east-west trending left lateral faulting to shunt structural blocks off to the west.
The San Gabriel Basin is a large down-warp created by regional north-northeast to south-southwest directed compressional geological forces that have uplifted the San Gabriel Mountains and folded the rocks in adjacent hills. Although they are called blind, these contractional thrust faults do express themselves at the surface by the uplift of the hills and valleys within the study area. The Elysian, Repetto, and San Rafael Hills in the western part of the study area are primarily a result of late-Quaternary-age folding and uplift (less than about 500,000 years old). The faults and folds in the hills largely trend southeasterly from the Santa Monica Mountains to the Puente Hills and are commonly referred to as the Elysian Park Fold and Thrust Belt (EPFT). Known active surface faults in the SR 710 Study area are the Raymond and Alhambra Wash faults. The Eagle Rock and San Rafael faults are generally considered to be potentially active because there is inadequate evidence as to their recency of activity.

## Local Geologic Setting

### Regional Faulting

The surface faults of greatest significance to the project are described in detail as follows. They include the Raymond fault, the Alhambra Wash fault, the Eagle Rock fault, and the San Rafael fault. The Raymond fault is the major active fault in the project area. It is a left-lateral, reverse-oblique fault that dips steeply (approximately 80 degrees) to the north. It extends southwesterly from the Sierra Madre Fault Zone at the base of the San Gabriel Mountains through the communities of Monrovia, Arcadia, San Marino, and Pasadena to the Raymond Hill area of South Pasadena, where the Raymond fault trends more westerly through the communities of South Pasadena, Highland Park, and possibly into Los Angeles for a length of 12 to 15.5 miles. The most-recent major surface rupture on the Raymond fault occurred sometime about 1,000 to 2,000 years ago and the recurrence interval for surface rupturing events may be about 3,300 years. There is little consensus on the rate of slip, with estimates varying from 0.1 to 0.4 millimeters per year (mm/yr) up to 1.5 mm/yr. Earthquake magnitude estimates are moment magnitude ($M_W$) 6.0 to 7.0, with 6.7 preferred (an event that would generate 3 to 5 feet of displacement). The State of California (California Geological Survey [CGS]) has established an Alquist-Priolo Earthquake Fault Zone (APEFZ) along the Raymond fault from the San Gabriel Mountains in the east to near the intersection of Avenue 50 and York Boulevard on the west.

The Alhambra Wash fault is a short northwest-southeast-trending fault in the southern part of the San Gabriel Valley that steps the Whittier fault northward. The surficial expression of the fault segment is approximately 1.5 miles long extending from SR 60 on the southeast to San Gabriel Boulevard on the northwest. The fault is designated as an APEFZ and, therefore, is considered to be active. The potential for surface displacement on the Alhambra Wash fault is poorly known but unpublished work has confirmed multiple late Pleistocene to Holocene ruptures. The maximum magnitude of an event on the Alhambra Wash fault could be about 6.25 if it ruptures separately, but it likely ruptures in larger events with the Whittier fault. The potential for surface rupture displacements along the Alhambra Wash fault would be expected to be lower than for the Raymond fault.

The San Rafael fault trends along the southerly side of the San Rafael Hills across the Arroyo Seco then along the north sides of Grace and Raymond Hills in southwestern Pasadena (Lamar, 1970). To the northwest, the fault apparently dies out north of the Eagle Rock fault as a series of disjointed strands in the basement complex of the San Rafael Hills. It has been observed to dip northeast at 80 degrees with basement rock to the north against Tertiary-age sediments to the south. The kinematics and recency of activity for this fault are unknown. The San Rafael fault is believed to merge with the Raymond fault near Lacy Park in San Marino. The fault is not known to be active; however, a recent geotechnical study at the Blair International Baccalaureate Magnet School identified subsurface faulting in seismic imaging, the age of which is unknown and still under study.

The Eagle Rock fault, mapped as an eastward continuation of the Verdugo fault, lies between the San Rafael and Raymond faults (Lamar, 1970). Southeast of the San Rafael Hills, the fault may be expressed by irregular terrain in a nearly flat surface of overlying terrace deposits. The fault is well exposed where it separates granitic rocks from conglomerate-breccia of the Topanga Formation west of Arroyo Seco. The fault appears to merge with the Raymond fault at Raymond Hill. A combined rupture of the Verdugo and Eagle Rock faults is the most likely scenario for the maximum earthquake magnitude on the Eagle Rock fault.

Numerous additional faults are mapped (Lamar, 1970) in the southwestern part of the study area, forming a complicated region of intersecting faults and fault-bounded blocks. The largest of these faults corresponds to the trace of the northwest-trending Highland Park fault. The Highland Park fault trends for approximately 6.5 miles from Monterey Park through Alhambra and El Sereno to Highland Park. The Highland Park fault appears to terminate against the western continuation of the Raymond fault in the vicinity of York Boulevard. The Highland Park fault is not considered by the CGS (2002) and California Division of Mines and Geology (1977) as active. The Highland Park fault also has not been included in the Uniform California Earthquake Rupture Forecast, Version 2 (UCERF2) catalog.

## Geology and Geotechnical Characterization for Each Alternative

This section summarizes the local geology and geologic hazards anticipated for each alternative. Figure 1 presents the legend used for the geology maps; Figures 2 through 12 show each alternative on the geology map (see attached figures). The 12 proposed alternatives and 3 design variations are as follows:

- No Build
- TSM/TDM
- BRT-1
- BRT-6A
- BRT-6
- LRT-4A
- LRT-4B
- LRT-4D
- LRT-6
- F-2
- F-5
- F-6
- F-7
- H-2
- H-6

## No Build and TSM/TDM

### Local Geology

The study area consists of young and old alluvial materials (fine- and coarse-grained soils) along the Los Angeles River and Arroyo Seco Washes. Alluvial fan deposits are also present within the San Gabriel Valley portion of the study area (see Figure 2). The remainder of the study area consists of Fernando, Puente, and Topanga formational materials and Cretaceous-age basement complex rocks.

### Geologic Hazards

There are two active faults (Raymond and Alhambra Wash) and two potentially active faults (Eagle Rock and San Rafael) present within the study area. Several alluvial areas are zoned as having a liquefaction hazard by the CGS.

## BRT-1

### Local Geology

Alignment BRT-1 primarily traverses areas of young and old alluvium, comprising the Los Angeles River and Arroyo Seco washes, as well as alluvial fan deposits sourced from the nearby San Gabriel Mountains. It generally skirts zones of Late Miocene Puente Formation marine deposits (see Figure 3).

### Geologic Hazards

Alignment BRT-1 crosses one active fault (Raymond) and one fault that is potentially active (San Rafael). The potentially active Eagle Rock fault, lying between the Raymond and San Rafael faults, is mapped as ending immediately west of the alignment. Alignment BRT-1 crosses several areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program. The areas are primarily associated with the Los Angeles River and Arroyo Seco washes. Of the approximately 13.8-mile-long BRT-1 alignment, approximately 3.2 miles cross soil considered to be liquefiable.

## BRT-6A and 6

### Local Geology

Alignments BRT-6A and 6 primarily traverse areas of young and old alluvium and alluvial fan deposits sourced from the nearby San Gabriel Mountains in the western San Gabriel Valley. The alignments generally skirt zones of late Miocene Puente and middle Miocene Topanga Formation marine deposits (see Figure 4).

### Geologic Hazards

Alignments BRT-6A and 6 cross one active fault (Raymond) and one fault that is potentially active (San Rafael). The potentially active Eagle Rock fault, lying between the Raymond and San Rafael faults, is mapped as ending immediately west of the alignments. Alignments BRT-6A and 6 cross no areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program.

## LRT-4A, 4B, and 4D

### Local Geology

Alignments LRT-4A, 4B, and 4D primarily traverse areas of young and old alluvium, and alluvial fan deposits sourced from the nearby San Gabriel Mountains in the western San Gabriel Valley. The alignments generally skirt zones of late Miocene Puente and middle Miocene Topanga Formation marine deposits (see Figure 5). The Puente Formation material has potential for naturally occurring gas. It should be considered in the evaluation of the proposed tunnel portion of the alternatives.

### Geologic Hazards

Alignments LRT-4A, 4B, and 4D cross one active fault (Raymond) and one fault that is potentially active (San Rafael). The potentially active Eagle Rock fault, lying between the Raymond and San Rafael faults, is mapped as ending immediately west of the alignments. Alignments LRT-4A, 4B, and 4D cross no areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program.

## LRT-6

### Local Geology

Alignment LRT-6 primarily traverses areas of young and old alluvium, and alluvial fan deposits sourced from the nearby San Gabriel Mountains in the western San Gabriel Valley. It generally skirts zones of late Miocene Puente and middle Miocene Topanga Formation marine deposits (see Figure 6). The Puente Formation material has potential for naturally occurring gas. It should be considered in the evaluation of the proposed tunnel portion of the alternative.

### Geologic Hazards

Alignment LRT-6 crosses one active fault (Raymond) and one fault that is potentially active (San Rafael). The potentially active Eagle Rock fault, lying between the Raymond and San Rafael faults, is mapped as ending immediately west of the alignment. Alignment LRT-6 crosses no areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program.

## F-2

### Local Geology

At the proposed depth, Alignment F-2 primarily traverses through late Miocene Puente and middle Miocene Topanga Formation marine deposits. Nearly the entire length of the 4.3-mile proposed tunnel passes through interbedded marine siltstone and sandstone members of the late Miocene Puente Formation. Approximately 2.5 miles of the alignment lies within or near the Highland Park Fault Zone, which may expose weakened rock conditions at the tunnel level (see Figure 7). Because this alignment lies within or near the Highland Park Fault Zone for approximately 2.5 miles, higher material variability is considered for this alignment. The Puente Formation material has potential for naturally occurring gas. It should be considered in the evaluation of the proposed tunnel portion of the alternative.

### Geologic Hazards

Alignment F-2 crosses one active fault (Raymond). However, the alignment trends for almost 2.5 miles within or near the inactive Highland Park fault, which could pose rock quality issues for a tunnel. Alignment F-2 crosses several areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program. These areas are associated with Arroyo Seco. The liquefaction impact at tunnel depths greater than 100 feet is unlikely. However, liquefaction at the north tunnel portal will impact this alternative.

## F-5

### Local Geology

At the proposed depth, Alignment F-5 primarily traverses areas of Late Miocene Puente and Middle Miocene Topanga Formation marine deposits. Of the approximately 3.8 miles of the proposed tunnel, approximately 1.3 miles pass through interbedded marine siltstone and sandstone members of the late Miocene Puente Formation. The remaining 2.5 miles of the alignment pass through interbedded marine siltstone, sandstone, and conglomerate members of the middle Miocene Topanga Formation (see Figure 8). The Puente Formation material has potential for naturally occurring gas. It should be considered in the evaluation of the proposed tunnel portion of the alternative.

### Geologic Hazards

Alignment F-5 crosses one active fault (Raymond) and two faults that are potentially active (Eagle Rock and San Rafael). Alignment F-5 crosses several areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program. At tunnel depths greater than 100 feet, liquefaction is unlikely to be an issue. However, liquefaction at the north tunnel portal will impact this alternative.

## F-6

### Local Geology

Alignment F-6 primarily traverses areas of young and old alluvium, and alluvial fan deposits sourced from the nearby San Gabriel Mountains in the western San Gabriel Valley. Of the approximately 6 miles of the proposed roadway, approximately 1.5 miles pass through interbedded marine siltstone, sandstone, and conglomerate members of the late Miocene Puente Formation or the middle Miocene Topanga Formation (see Figure 9).

### Geologic Hazards

Alignment F-6 crosses one active fault (Raymond) and one fault that is potentially active (San Rafael). The potentially active Eagle Rock fault, lying between the Raymond and San Rafael faults, is mapped as ending immediately west of the alignment. Alignment F-6 crosses no areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program.

## F-7

### Local Geology

At the proposed depth, Alignment F-7 primarily traverses areas of Late Miocene Puente and Middle Miocene Topanga Formation marine deposits. Of the approximately 4.2 miles of the proposed tunnel, approximately 1.4 miles pass through interbedded marine siltstone and sandstone members of the late Miocene Puente Formation. Approximately 2.6 miles of the alignment pass through interbedded marine siltstone, sandstone, and conglomerate members of the middle Miocene Topanga Formation (see Figure 10). At the northern end, the proposed tunnel may pass through the Cretaceous-age basement complex rocks designated as Wilson diorite or quartz diorite. This will create hard rock conditions at the tunnel level. The Puente Formation material has potential for naturally occurring gas. It should be considered in the evaluation of the proposed tunnel portion of the alternative.

### Geologic Hazards

Alignment F-7 crosses one active fault (Raymond) and one fault that is potentially active (San Rafael). The potentially active Eagle Rock fault, lying between the Raymond and San Rafael faults, is mapped as ending immediately west of the alignment. Alignment F-7 crosses no areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program.

## H-2

### Local Geology

Alignment H-2 primarily traverses areas of young and old alluvium, and alluvial fan deposits sourced from the nearby San Gabriel Mountains in the western San Gabriel Valley. The northern end of alignment H-2 crosses interbedded marine siltstone, sandstone, and conglomerate members of the middle Miocene Topanga Formation for approximately 1.8 miles (see Figure 11).

### Geologic Hazards

Alignment H-2 crosses one active fault (Raymond) and two faults that are potentially active (Eagle Rock and San Rafael). Alignment H-2 crosses several areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program. These areas are associated with Arroyo Seco Wash. Approximately 1.4 miles of the H-2 alignment transects soil considered to be liquefiable.

## H-6

### Local Geology

Alignment H-6 primarily traverses areas of young and old alluvium, and alluvial fan deposits sourced from the nearby San Gabriel Mountains in the western San Gabriel valley. It generally skirts zones of Late Miocene Puente and Topanga Formation marine deposits (see Figure 12).

**Geologic Hazards**

Alignment H-6 crosses one active fault (Raymond) and one fault that is potentially active (San Rafael). The potentially active Eagle Rock fault, lying between the Raymond and San Rafael faults, is mapped as ending immediately west of the alignment. Alignment H-6 crosses no areas zoned as having a liquefaction hazard by the CGS Seismic Hazard Zonation Program.

# Summary of Geotechnical Screening

## Level I Screening

Geological and geotechnical conditions were not considered as part of the Level I screening for each alternative.

## Level II Screening

Table 3 summarizes the geological/geotechnical conditions and how they relate to the evaluation criteria and performance measures for each of the 12 alternatives and 3 design variations. The percentage of impact or number of faults crossing each alternative is provided in Table 3. Table 4 summarizes the rating for each of the performance measures.

TABLE 3
**Measurement Scale in Each Alternative**
*SR 710 Study Alternative Analyses*

| Performance Measure | No Build | TSM/ TDM | BRT-1 | BRT-6A | BRT-6 | LRT-4A | LRT-4B | LRT-4D | LRT-6 | F-2 | F-5 | F-6 | F-7 | H-2 | H-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Approximate percentage of alternative alignment within potential liquefiable zone(s) that could impact proposed improvements | 5% to 10% | 10% to 20% | 20% to 30% | 0% to 5% | 0% to 5% | 5% to 10% | 5% to 10% | 5% to 10% | 0% to 5% | 5% to 10% | 5% to 10% | 0% to 5% | 0% to 5% | 20% to 30% | 0% to 5% |
| Number of active and potentially active faults crossing within the alternative alignment that could impact proposed improvements | 3 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 2 |
| Approximate percentage of subsurface material variability that could impact the proposed improvements within the alternative alignment | 0% to 10% | 0% to 10% | 0% to 10% | 0% to 10% | 0% to 10% | 50% to 60% | 50% to 60% | 50% to 60% | 0% to 10% | 40% to 50% | 40% to 50% | 20% to 30% | 50% to 60% | 0% to 10% | 0% to 10% |
| Approximate percentage of alternative alignment constructed within formational materials known for natural gas potential | 0% to 10% | 0% to 10% | 0% to 10% | 0% to 10% | 0% to 10% | 10% to 20% | 10% to 20% | 10% to 20% | 0% to 10% | 60% to 70% | 20% to 30% | 10% to 20% | 20% to 30% | 0% to 10% | 0% to 10% |

TABLE 4
**Rating for Each Alternative**
*SR 710 Study Alternative Analyses*

| Performance Measure | No Build | TSM/ TDM | BRT-1 | BRT-6A | BRT-6 | LRT-4A | LRT-4B | LRT-4D | LRT-6 | F-2 | F-5 | F-6 | F-7 | H-2 | H-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Approximate percentage of alternative alignment within potential liquefiable zone(s) that could impact proposed improvements | 6 | 5 | 4 | 7 | 7 | 6 | 6 | 6 | 7 | 6 | 6 | 7 | 7 | 4 | 7 |
| Number of active and potentially active faults crossing within the alternative alignment that could impact proposed improvements | 4 | 7 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 1 | 3 | 3 | 1 | 3 |
| Approximate percentage of subsurface material variability that could impact the proposed improvements within the alternative alignment | 7 | 7 | 7 | 7 | 7 | 2 | 2 | 2 | 7 | 3 | 3 | 5 | 2 | 7 | 7 |
| Approximate percentage of alternative alignment constructed within formational materials known for natural gas potential | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 7 | 1 | 5 | 6 | 5 | 7 | 7 |

## Summary of Geotechnical Screening of Each Alternative

The overall geotechnical ratings for the alternatives were developed by taking the average of the four performance measure ratings. Table 5 summarizes the overall geotechnical ratings for each of the 12 alternatives and 3 design variations.

TABLE 5
**Summary of Level II Geotechnical Screenings**
*SR 710 Study Alternative Analyses*

| Alternatives | Overall Geotechnical Rating |
|---|---|
| No Build | 6 |
| TSM/TDM | 7 |
| BRT-1 | 5 |
| BRT-6A | 6 |
| BRT-6 | 6 |
| LRT-4A | 4 |
| LRT-4B | 4 |
| LRT-4D | 4 |
| LRT-6 | 6 |
| F-2 | 4 |
| F-5 | 4 |
| F-6 | 5 |
| F-7 | 4 |
| H-2 | 5 |
| H-6 | 6 |

# Figures

## Quaternary Deposits

- Qc, Colluvium
- Qf, Alluvial-fan deposits
- Qoaa, Old alluvium, arenaceous
- Qoa1a, Old alluvium, Unit 1
- Qoa2g, Old alluvium
- Qoa3a, Old alluvium, Unit 3
- Qof, Old alluvial-fan deposits
- Qyaa, Young alluvium, arenaceous
- Qyf1g, Young alluvial-fan deposits
- Qyf, Young alluvial-fan deposits

## Bedrock Deposits

### Topanga Group

- Tt, Topanga Group, undivided
- Ttcg, Topanga Group, conglomerate
- Tf1, Fernando Formation, member 1
- Tta, Topanga Group, sandstone
- Ttz, Topanga Group, siltstone

## Puente Formation

- Tpnz, Puente Formation, siltstone
- Tpna, Puente Formation, sandstone
- Tpns, Puente Formation, siliceous shale

## Fernando Formation

- Tf2, Fernando Formation member 2
- Tfuf, Frenando Formation, Upper Member, fossiliferous

## Basement Rocks

- Mzbhd, Biotite-Hornblende diorite

## Lines

- contact, approx. located
- contact, certain
- contact, concealed
- fault, approx. located
- fault, concealed
- thrust fault, approx. located
- thrust fault, concealed
- thrust fault, inferred
- Alquist-Priolo Special Studies Zone
- Interstate
- US Highway
- State/Local Highway
- SR-710 Study Alignment

## Liquefaction and Landslide Hazard Zones

- Seimically-Induced Landslide Hazard Zone
- Liquefaction Hazrd Zone

## Local Improvements

- I-20: Local Street Improvements
- L-5: Local Intersection Improvements

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FIGURE 1
**Legend**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*

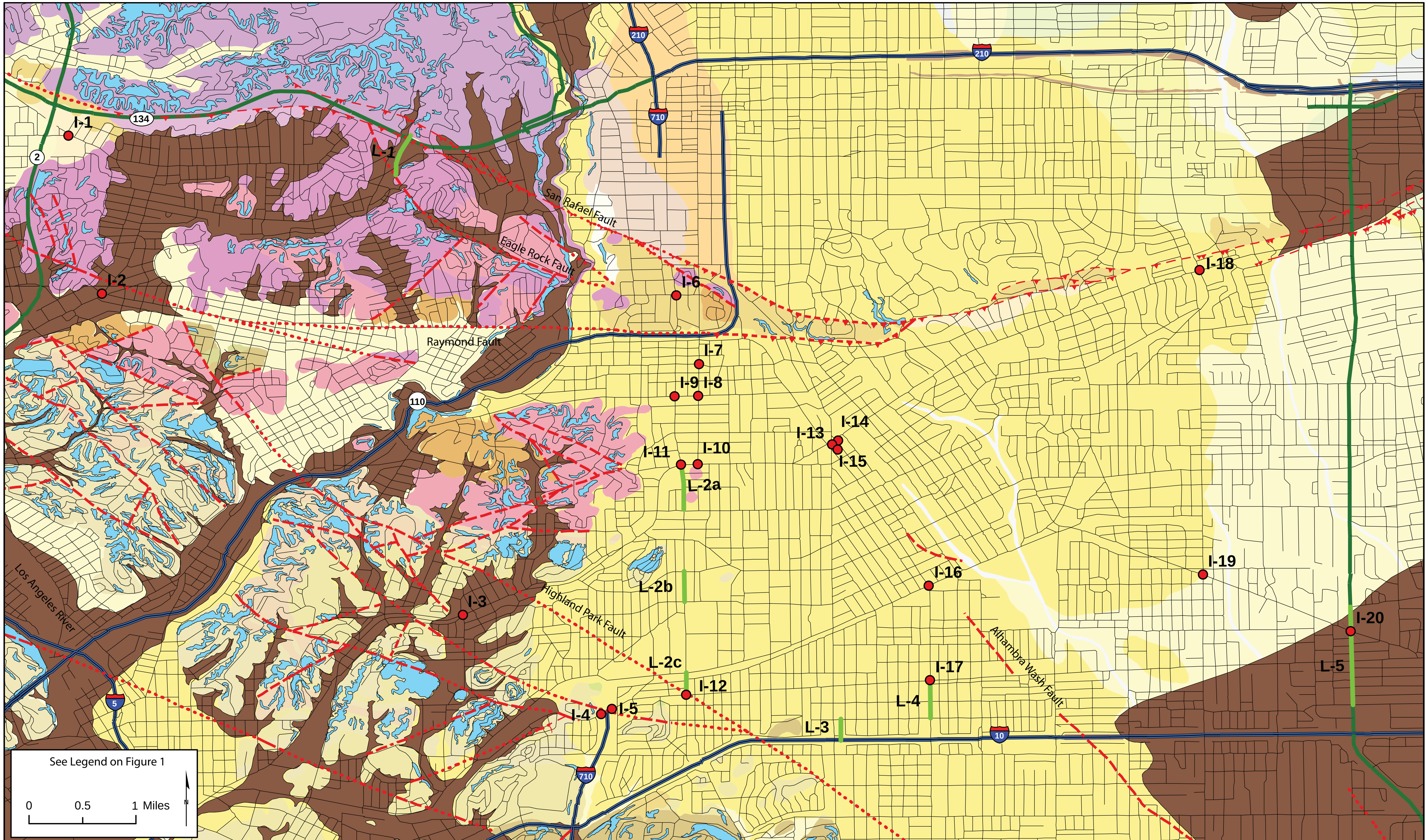


FIGURE 2
**Geologic Map of the TDM/TSM Alternatives**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*



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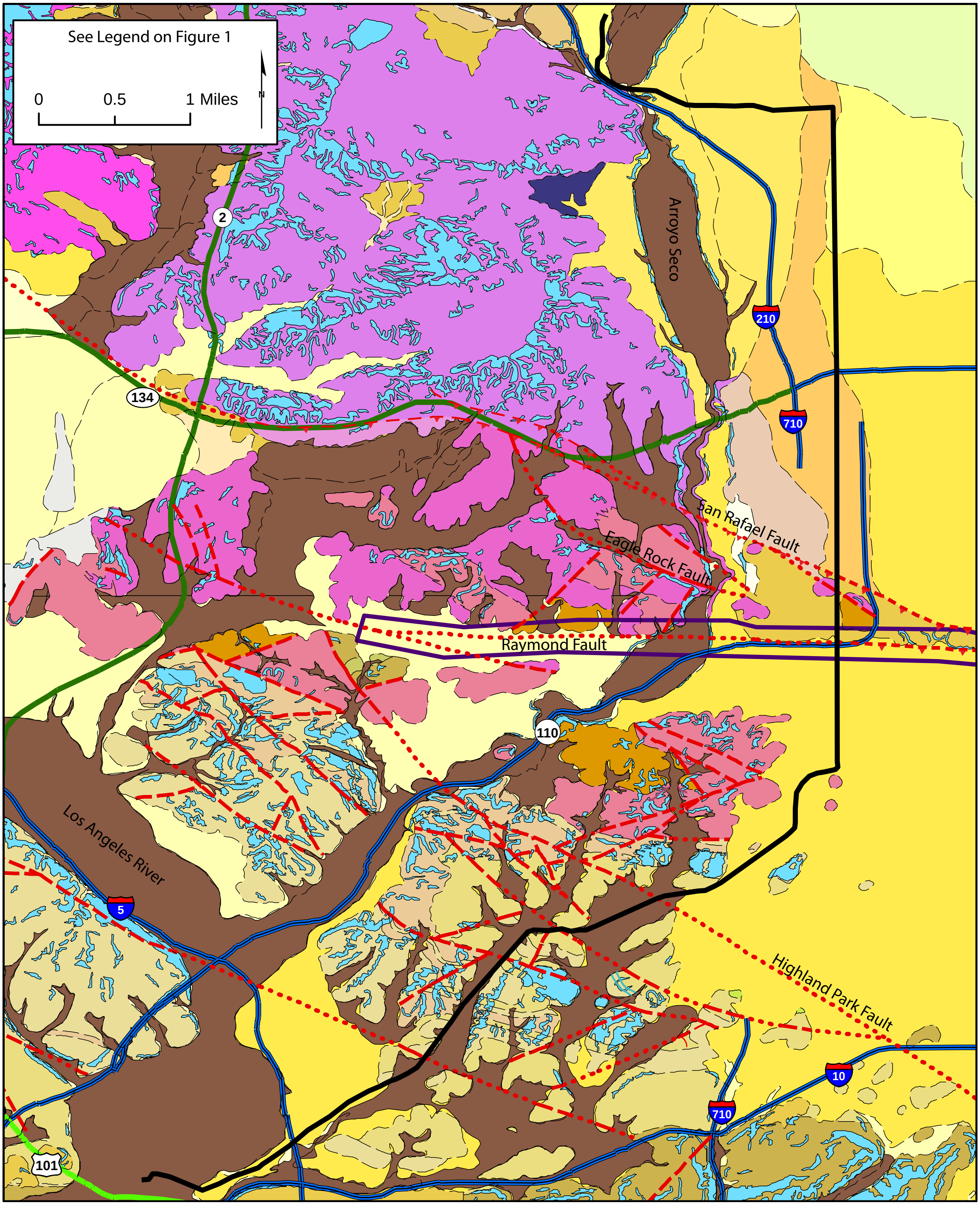


FIGURE 3
**Geologic Map of Alignment BRT-1**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*

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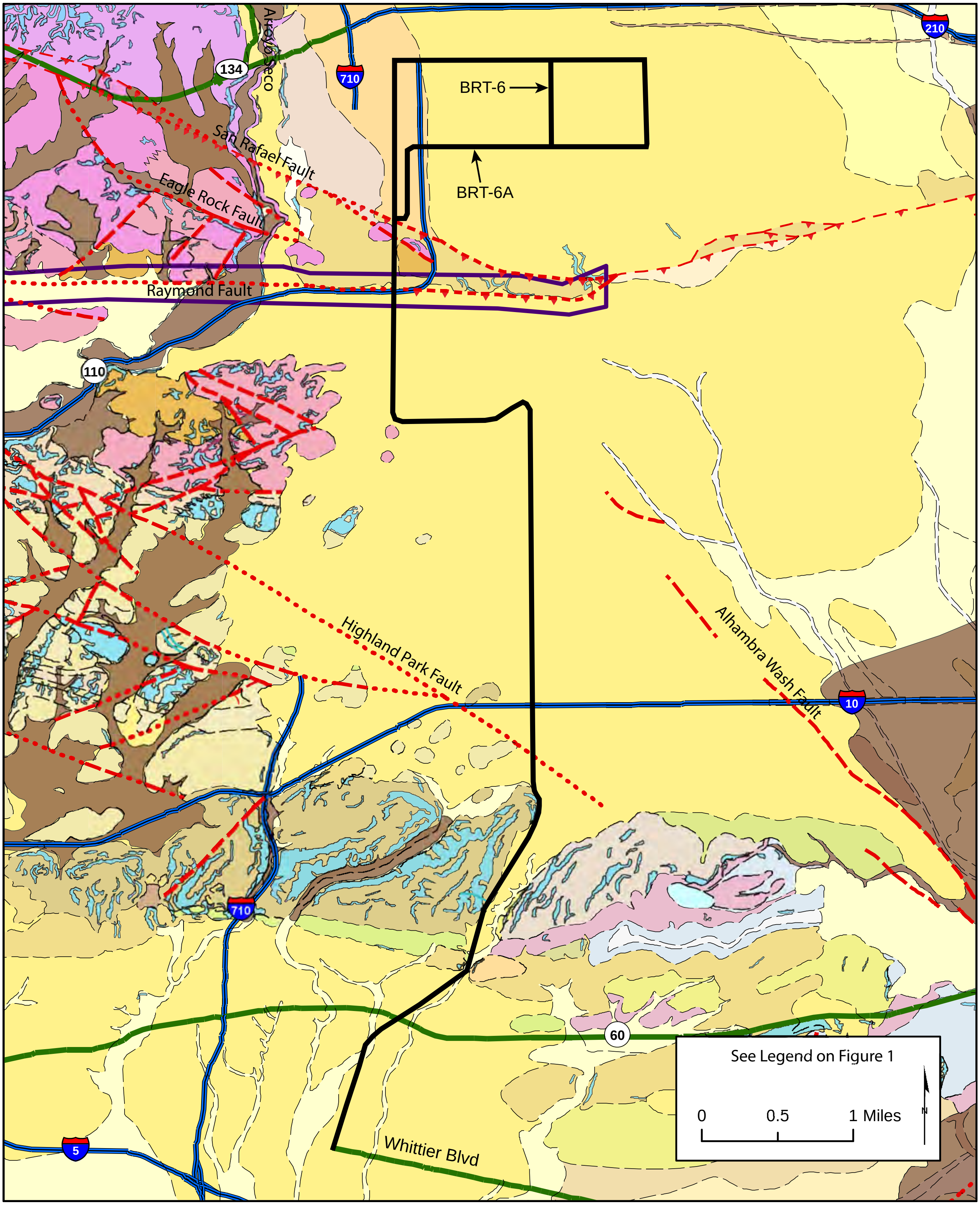


FIGURE 4
**Geologic Map of Alignment BRT-6 and BRT-6A**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*

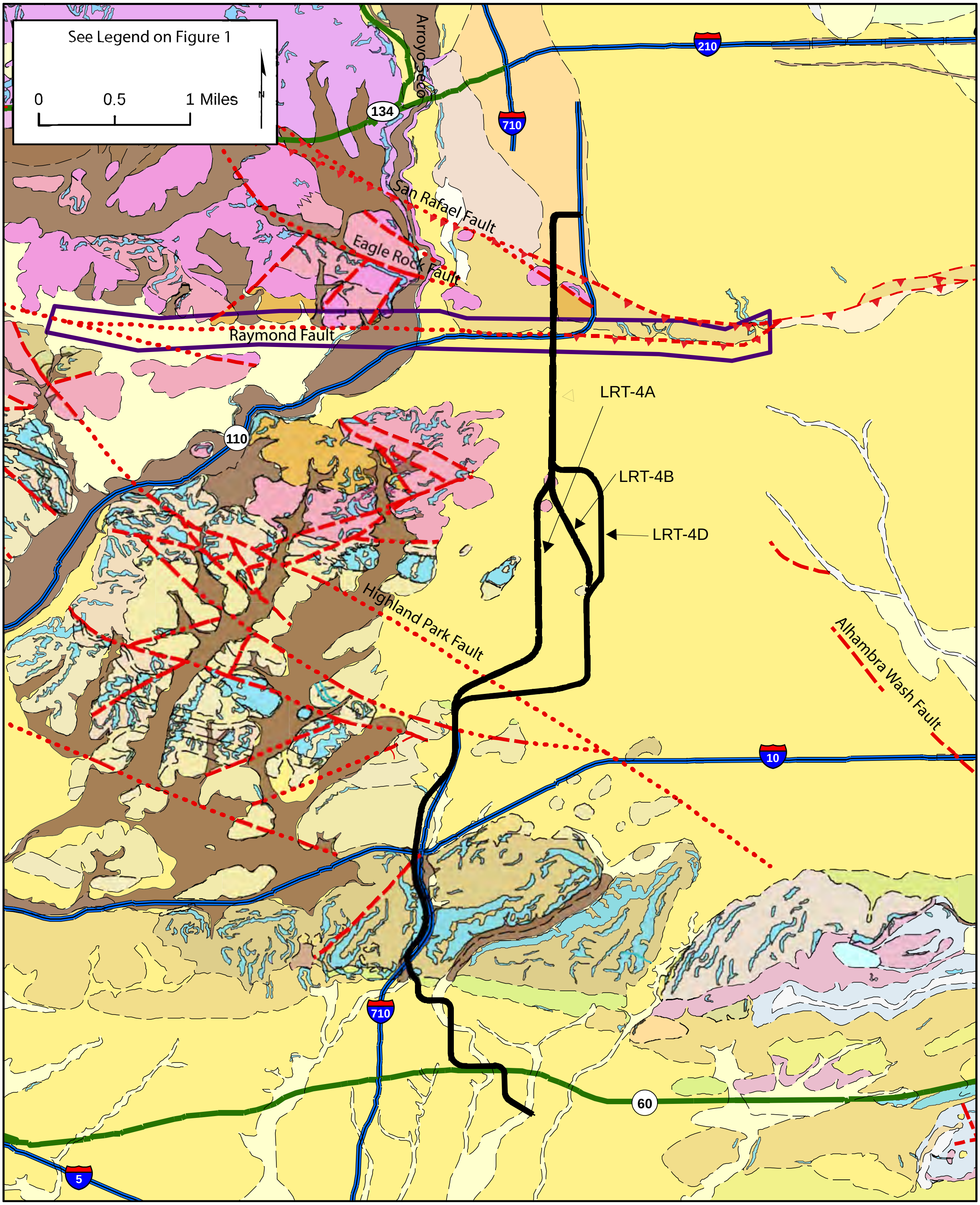


FIGURE 5
**Geologic Map of Alignment LRT-4 (A, B, D)**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*



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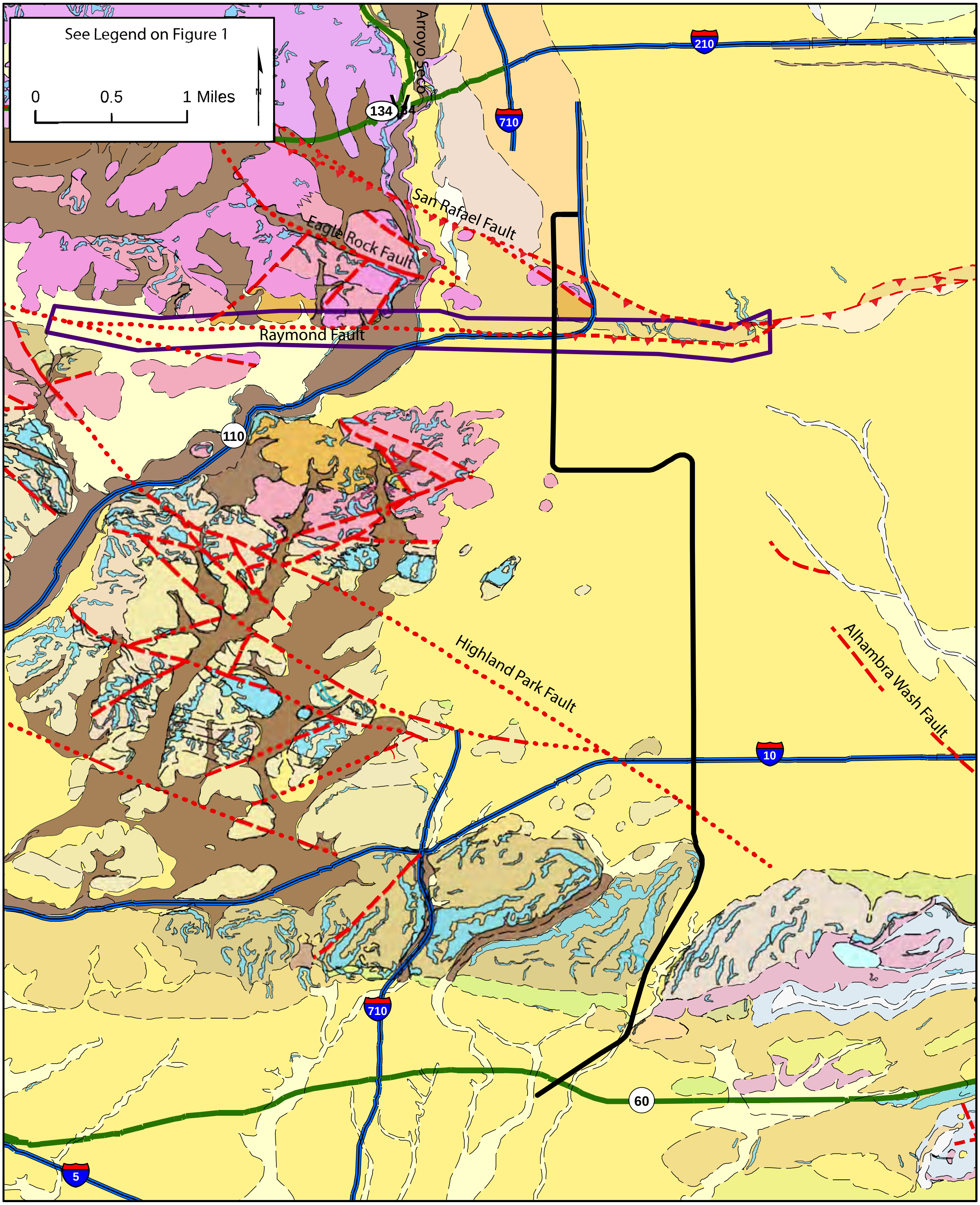


FIGURE 6
**Geologic Map of Alignment LRT-6**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*

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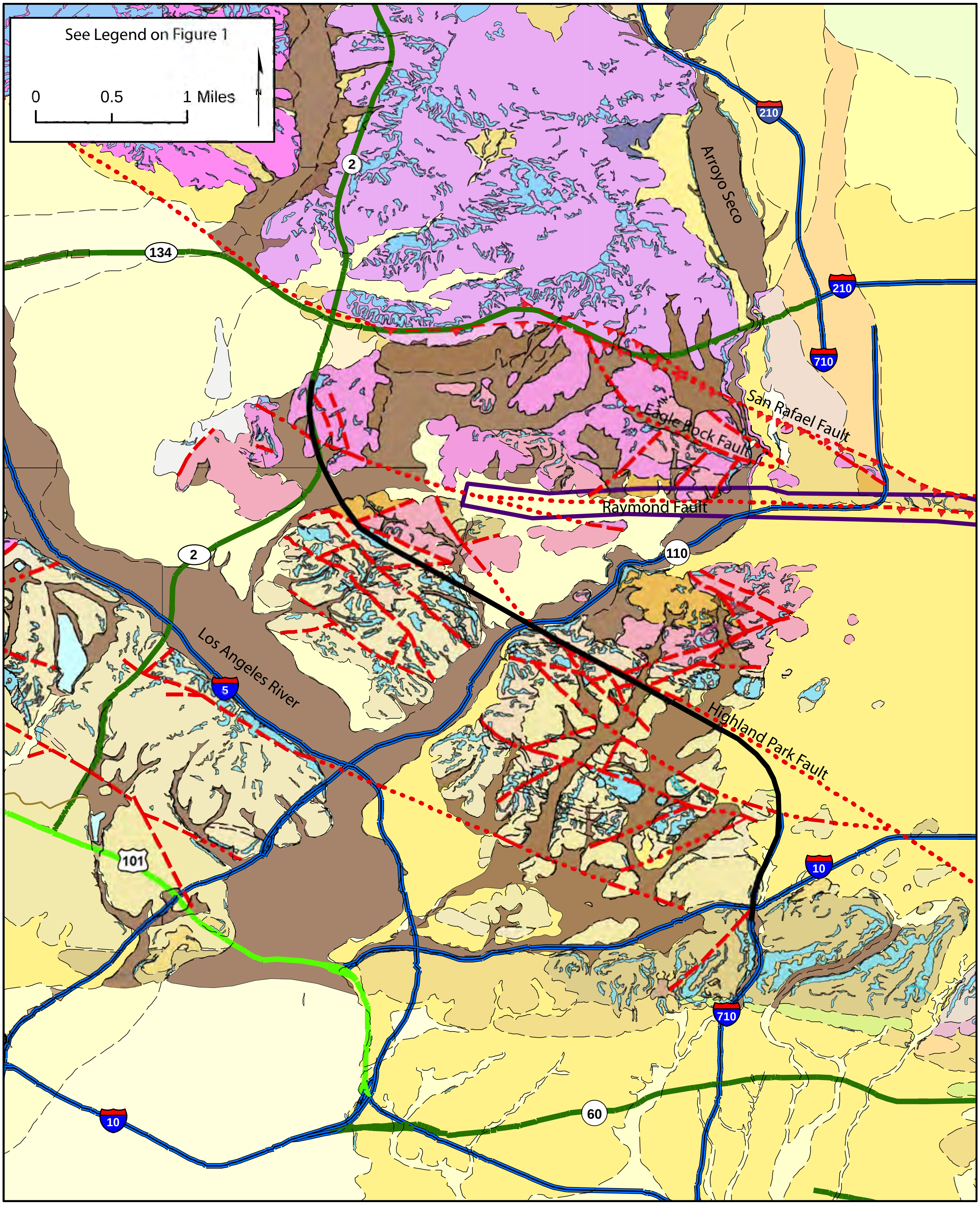


FIGURE 7
**Geologic Map of Alignment F-2**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*

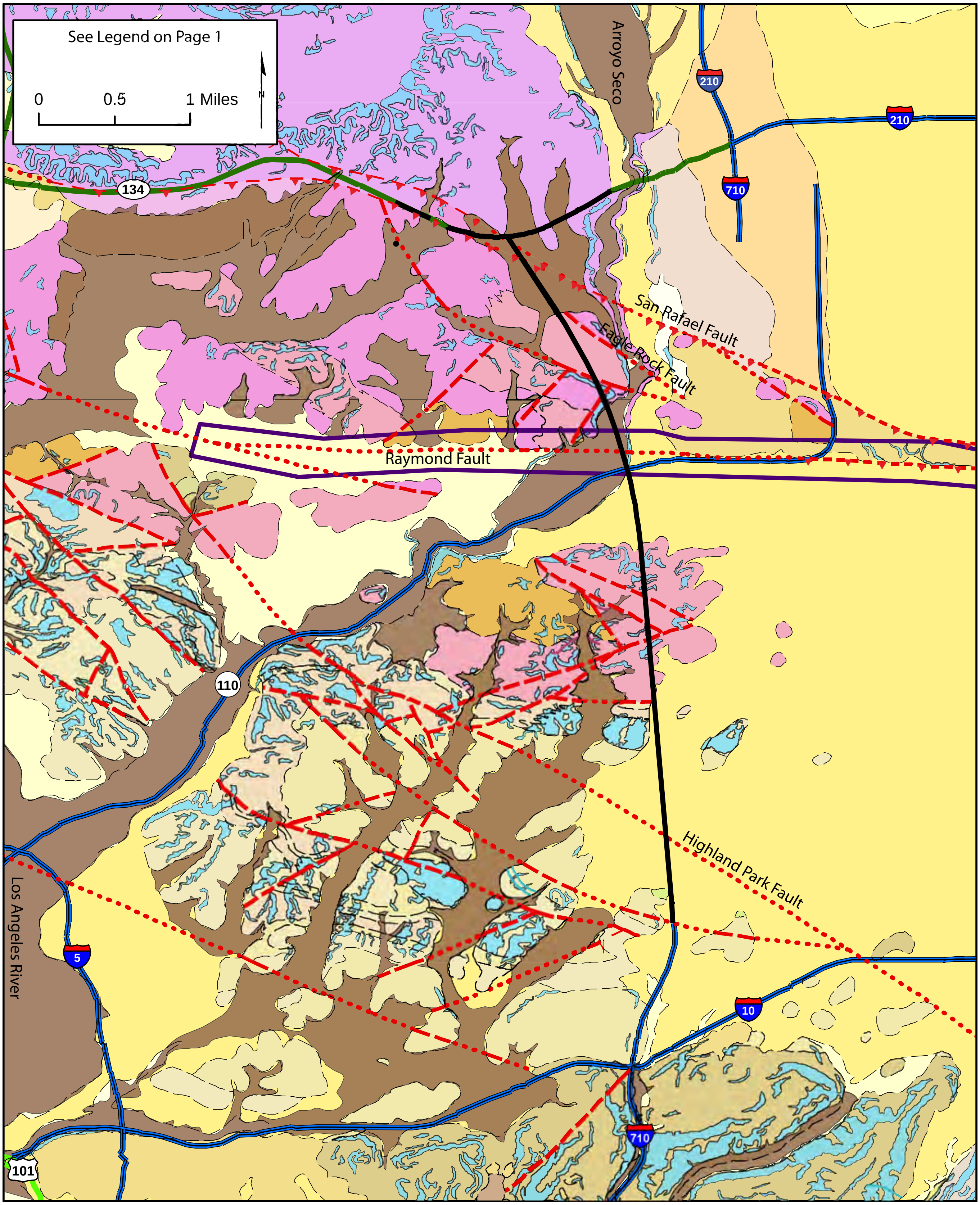


FIGURE 8
**Geologic Map of Alignment F-5**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*

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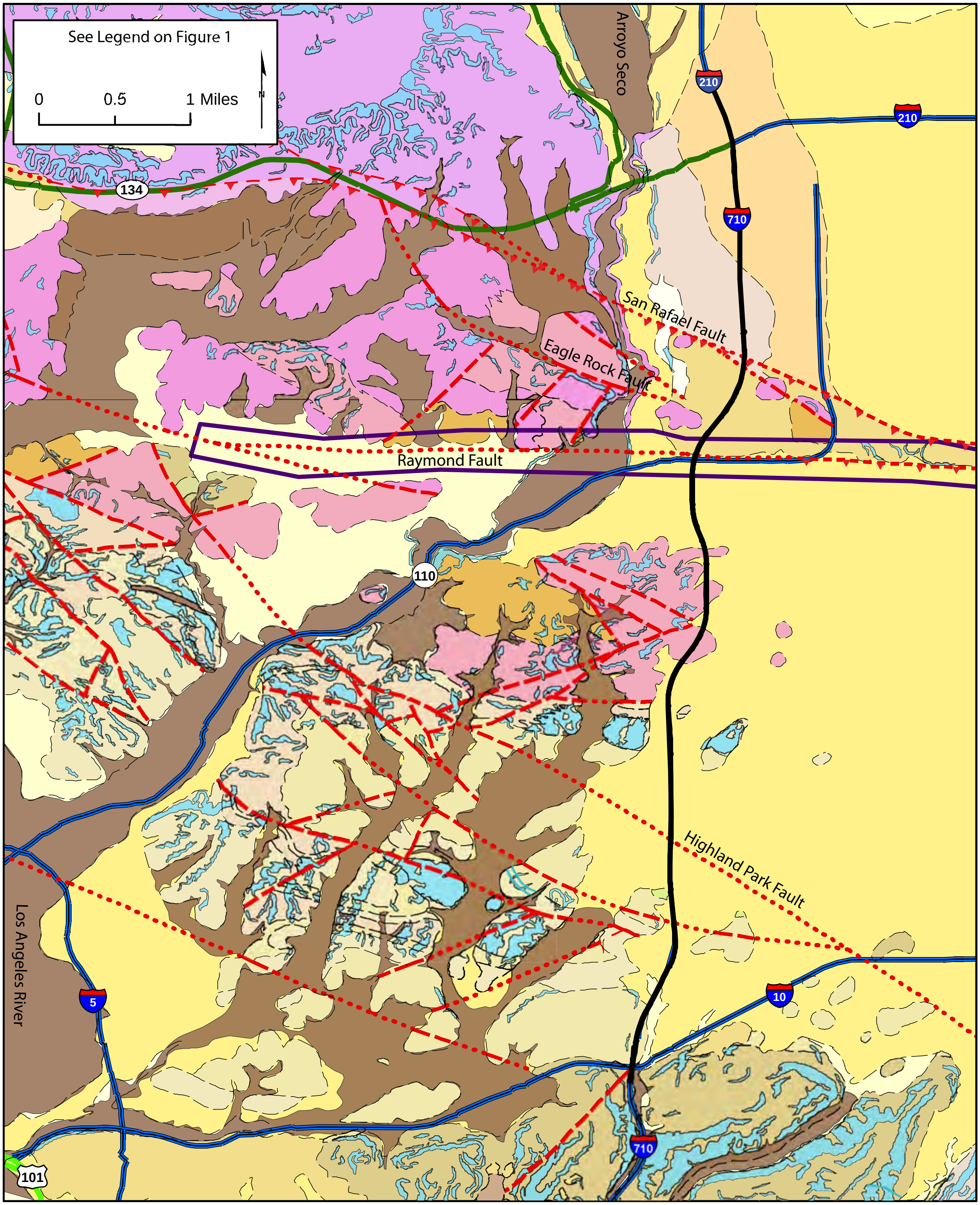


FIGURE 9
**Geologic Map of Alignment F-6**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*


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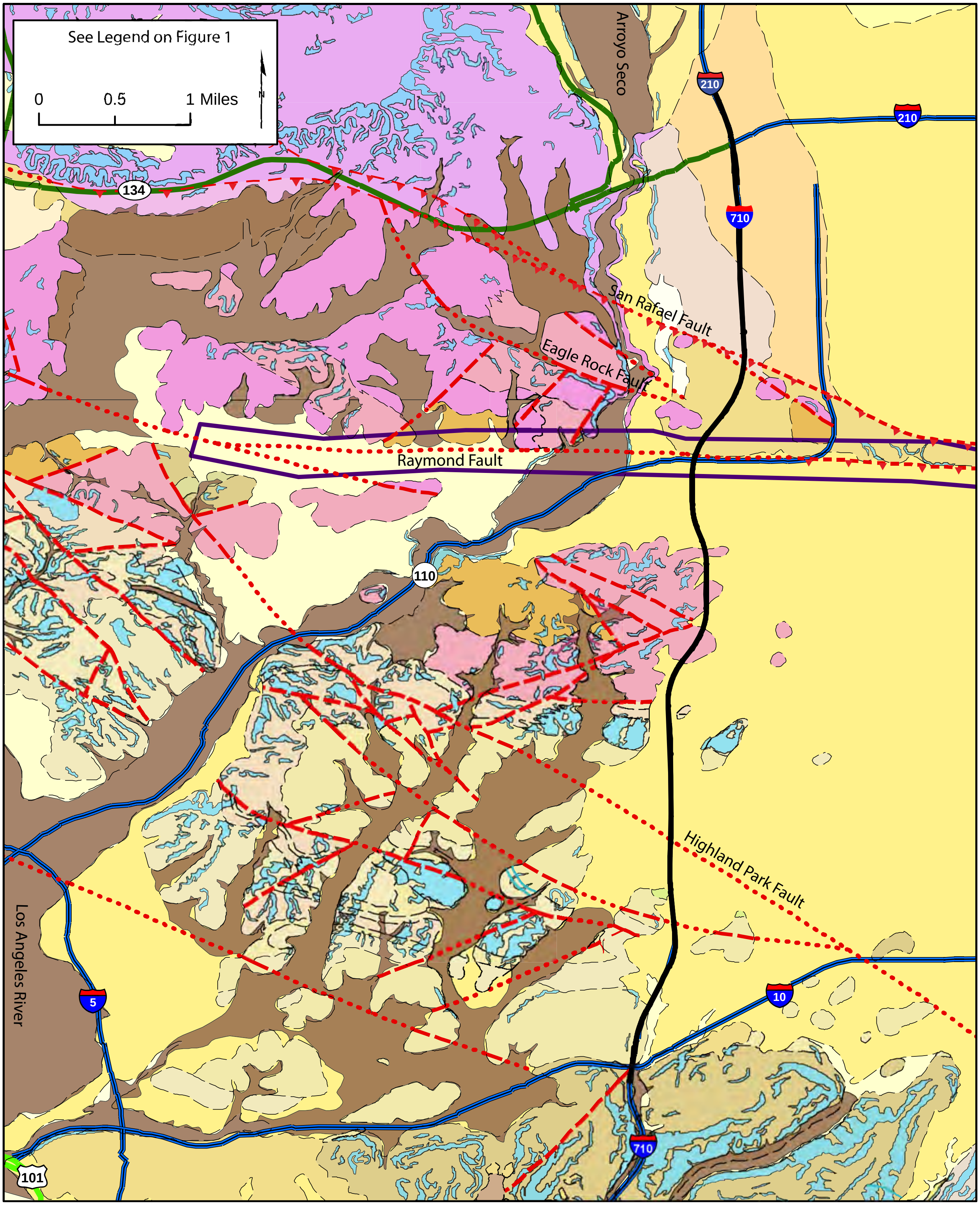


FIGURE 10
**Geologic Map of Alignment F-7**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*

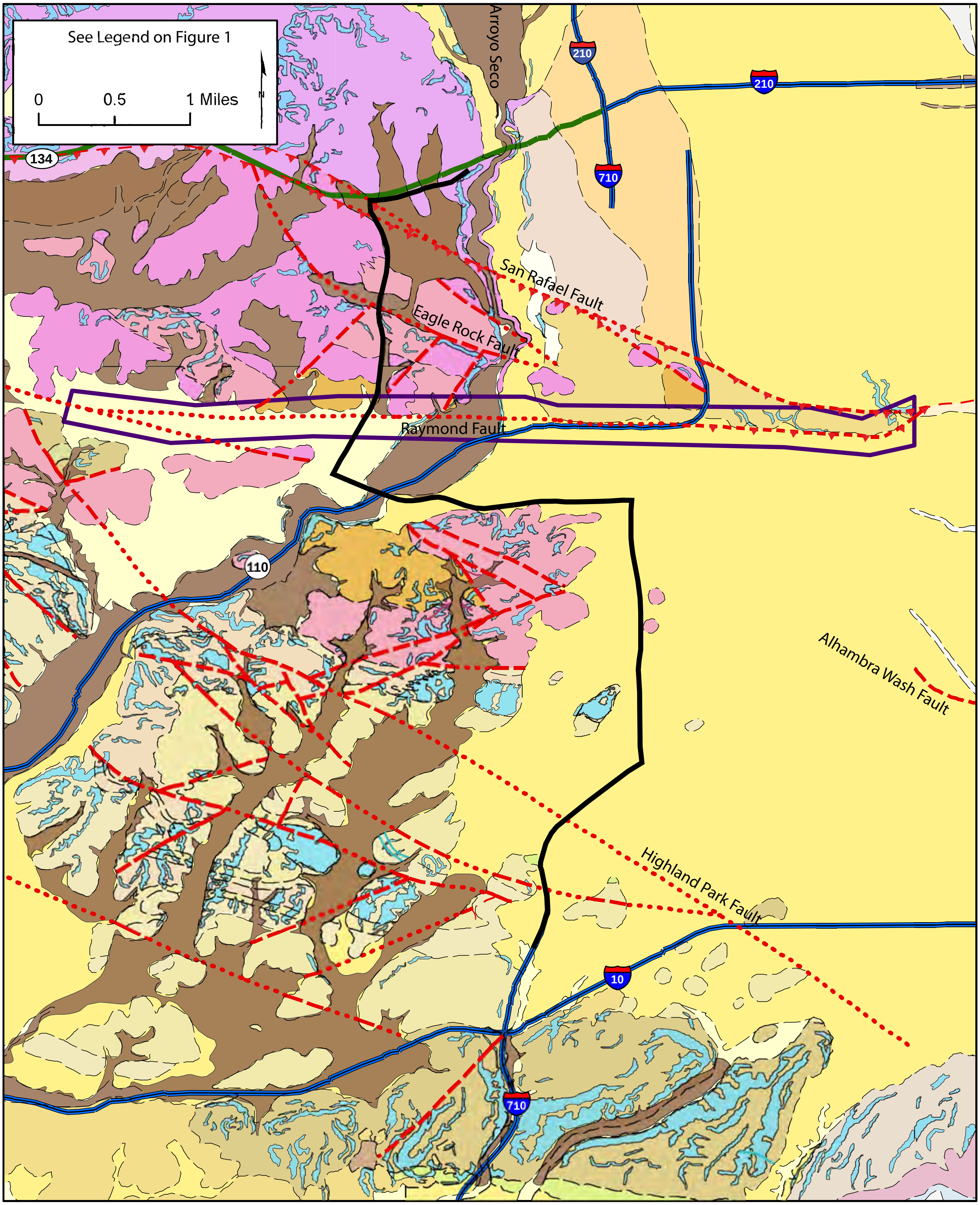


FIGURE 11
**Geologic Map of Alignment H-2**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*

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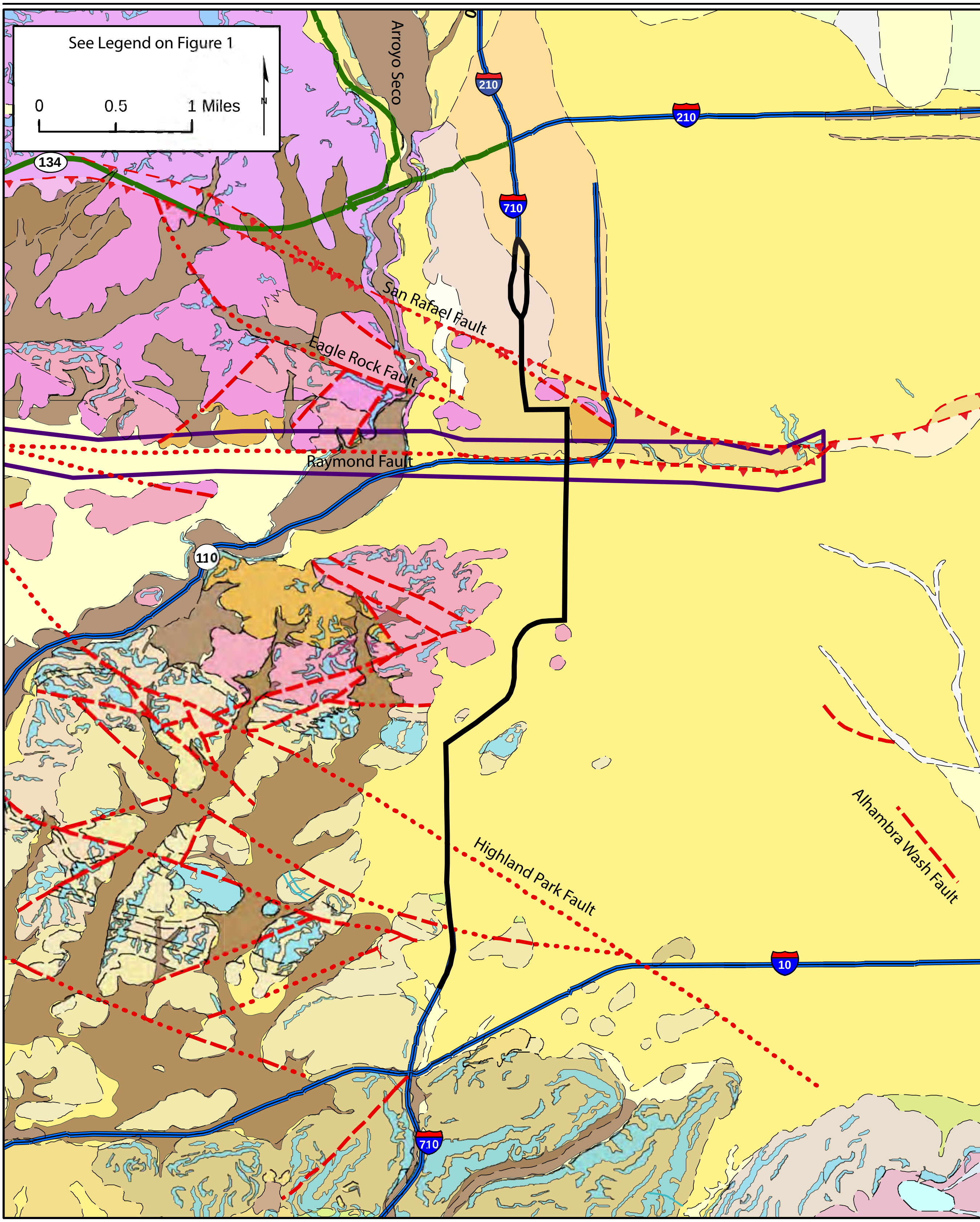


FIGURE 12
**Geologic Map of Alignment H-6**
*SR 710 Study Alternative Analysis*
*Los Angeles County, California*