APPENDIX D: Preliminary Geologic and Seismic Hazards Report
A Report Prepared for:

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PRELIMINARY GEOLOGIC AND SEISMIC HAZARDS REPORT
SANTA ANA RIVER TRAIL PHASE VI
ORANGE COUNTY, CALIFORNIA

Project No. 2018-020

by

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1 INTRODUCTION

Diaz•Yourman & Associates (DYA) has prepared this preliminary Geologic and Seismic Hazards Report for the proposed Santa Ana River Trail (SART) Phase 6 (Project) for the Riverside County Transportation Commission (RCTC). In addition to RCTC, Riverside County Regional Parks and Open-Space Districts (Parks), Chino Hills State Park, San Bernardino County, and Orange County Public Works (OCPW) are part of the Project stakeholders. The Project proposes a new trail segment through the Green River Golf Course. The Project is currently in the Project Approval and Environmental Document (PA/ED) phase. DYA is a subconsultant to Michael Baker International. Michael Baker International authorized our services in May 18, 2018 with a written contract.

This report is intended to be used by the Project team to assist in the development of the Initial Study/Mitigated Negative Declaration (IS/MND) documents. The information provided in this report is based on available information from desktop study. No geotechnical field exploration and/or geotechnical laboratory testing has been performed for preparation of this report.

1.1 PROJECT DESCRIPTION

The proposed Project consists of a 1.5-mile multi use trail segment through the Green River Golf Course and a 0.2-mile segment between Phase 5 and Phase 3 of the larger 110-mile Regional SART. The Project consists of two build alternatives as discussed in Section 1.2. The Project Vicinity is shown in Figure 1. More specifically, the Project proposes construction of a paved Class 1 bikeway and a natural surface riding and hiking trail, connecting the future Santa Ana River Parkway Extension on the west in Orange County with the existing SART Phase 5 in Chino Hills State Park on the east within Riverside County. Additionally, the 0.2-mile segment involves a Class 1 multi-use path/natural surface trail connecting the eastern terminus of the SART – Phase 5 and the western terminus of SART Phase 3 near the SR-91 and SR-71 interchange in Riverside County. The Project site encompasses a separate surface parking lot and staging area located to the south off Green River Road west of Green River Golf Course Drive.
A comprehensive schematic of the proposed alternative details can be found in Attachment A.

![Project Site Map]

**Figure 1 - VICINITY MAP**

### 1.2 PROJECT ALTERNATIVES

The design team evaluated two alternatives for the proposed Project, see Appendix A. These alternatives include the following:

- **Alternative 1**: This Alternative will extend along the western boundary of the golf course.
- **Alternative 2**: This Alternative will extend along the eastern boundary of the golf course.

Both build alternatives would have similar trail characteristics and would close the gap between the Santa Ana River Parkway Extension and SART Phase 5 as well as between SART Phase 5 and SART Phase 3.

#### 1.2.1 Alternative 1

The southwesterly end of the proposed project alignment would connect with the eastern terminus of the future Santa Ana River Parkway Extension at the Orange County/San Bernardino County line south of the existing Burlington Northern Santa Fe (BNSF) rail line.
Alternative 1 generally extends east-west (within the existing golf course) south of, and parallel to, the BNSF rail line until it reaches the golf course parking lot.

From the parking lot, Alternative 1 would extend north, spanning the BNSF railroad tracks via a proposed bridge. Once it crosses the BNSF railroad tracks, the trail would continue north along the existing maintenance road. A bridge or low water crossing is planned to cross Aliso Creek. The trail would then continue north/northeast and connect with the SART Phase 5 in Chino Hills State Park. See Appendix A for proposed Alternative 1 alignment.

### 1.2.2 Alternative 2

Similar to Alternative 1, Alternative 2 would connect with the eastern terminus of the future Santa Ana River Parkway Extension at the Orange County/San Bernardino County line south of the BNSF railroad tracks. Prior to the golf course parking lot, the Class I multi-use path/natural surface trail would extend north over the BNSF railroad tracks via a proposed bridge, similar to Alternative 1.

After crossing over the BNSF tracks, the trail would extend east parallel to the rail line before heading north along an existing dirt maintenance road parallel to the Santa Ana River. A low water crossing would be installed to cross Aliso Creek. Alternative 2 would continue in a northeast direction before turning to the northwest along the northern boundary of the golf course to intersect with an existing dirt maintenance road (Alternative 1) and connect with SART Phase 5 in Chino Hills State Park.

### 1.2.3 ADDITIONAL TRAIL ALIGNMENT

Both build alternatives would include construction of the approximate 1,000-foot long segment of the SART located east of the golf course. This portion of the SART would connect the eastern terminus of the existing SART Phase 5 with the western terminus of future SART Phase 3 near the State Route 91 and State Route 71 interchange.
2 SCOPE OF WORK

The purpose of our study was to address potential geologic and seismic hazards that could impact the Project. The scope of our services consisted of the following tasks:

• Reviewing available data.
• Preparing this Geologic and Seismic Hazards Report.

The future scope is expected to include preparing Preliminary Foundation Report (PFR) for type selection phase. Once the type selection phase is completed, we will perform site specific geotechnical exploration and laboratory testing to prepare a foundation report (FR) for proposed bridge(s). A material report will be prepared to address trail pavement sections and grading recommendations.

3 DATA REVIEW

Geological and geotechnical data from the Project vicinity presented in publications and previous reports were reviewed. A list of the documents reviewed is presented in the bibliography (Section 8). Our review included published documents available from the following:

• California Geologic Survey (CGS, 2020).
• United States Geologic Survey (USGS 2020).
• Federal Emergency Management Agency (FEMA 2008).
• General Plan and Safety Element for the County of Riverside (2019).
• General Plan for the City of Chino Hills (2015).
• General Plan 2040 for the City of Corona (2019).
• California Department of Water Resources website (2020).

Selected relevant data are included in Appendix B.
4 EXISTING CONDITIONS AND POTENTIAL HAZARDS

Site Geology, seismicity, and groundwater level are important factors to be considered when determining the design criteria and the possible impacts they may have on the Project. This section will discuss geology, faults, groundwater level, and liquefaction hazards as well as other subsurface conditions that affect the Project alignment.

4.1 GEOLOGY, SURFACE/SUBSURFACE CONDITIONS, AND GROUNDWATER LEVEL

4.1.1 Regional and Local Geologic Setting

The Project Alignment lies within Peninsular Ranges geomorphic province of Southern California. The province is bounded to the east by the Colorado Desert and extends south into lower California and west to include the Santa Catalina, Santa Barbara, and San Clemente Island groups. The province includes the Los Angeles Basin and is bounded to the north/northwest by the Transverse Ranges (CGS, 2002). The Project alignment is located within the Santa Ana River Floodplain along the Orange County and San Bernardino County boundaries and is bounded to the northwest by the Chino Hills and to the south by the Santa Ana Mountains. Over time, the Santa Ana River has incised the underlying bedrock creating varying levels of terraces. These bedrock terraces were then overlain by alluvial deposits. The geology in the area is mapped as containing Older Elevated Terrace (Qt) and (Qtl) deposits, which are described as dense to very dense silty sand, sand, and gravel as well as Quaternary Active Wash (Qal) described as loose silty sand and gravelly sand deposits and Quaternary Slope Wash deposits consisting of sand and silty sand. All deposits were also indicated to include cobbles.

4.1.2 Topography, Slopes, and Major Drainage

The topography map of the proposed Project alignments was provided by Michael Baker (2020) for our review. In general, the proposed Project alignments are on flat topography with minor elevations in surface grades. The Alternative 1 begins in the south at an approximate elevation of 430 feet and gradually increases to an approximate elevation of 450 feet at the north end. The proposed Alternative 2, begins in the south at an approximate elevation of 420 feet and gradually increases to an approximate elevation of 450 feet at the north end. These elevations are based on NADV 88 datum.
The Santa Ana River is the major drainage system adjacent to the proposed Project alignments. The proposed Project alignments would be north of the Santa Ana River.

4.1.3 Subsurface Soil Conditions

The subsurface information developed by URS (2017) from a site approximately 0.5 to 1 mile east of the Project site, was used to interpolate the subsurface conditions as there is no other existing subsurface information available to us. In general, the soil consisted of sandy silt or silty sand, well-graded or poorly graded sand with silt and gravel, well-graded or poorly graded gravel with silt and sand, and occasional layers of lean clay or fat clay to depths of about 20 to 30 feet bgs. Below those layers to a depth of 60 to 75 bgs, the soil consisted of silty sand, well-graded or poorly graded sand with silt and gravel, well-graded or poorly graded gravel with silt and sand, and occasional layers of lean clay or fat clay. Cobbles were encountered throughout the depths of exploration. See Appendix B for the subsurface data from the boring logs prepared by URS.

4.1.4 Groundwater

Based on review of CGS Prado Dam Quadrangle Historically Highest Ground Water (HHGW) Contours (2000), the groundwater in the vicinity of the Project has been reported as shallow as 10 feet bgs. No relevant groundwater data from the Water Data Library of the Department of Water Resources (2020) was available in the immediate vicinity of the Project. The most recent groundwater data comes from the borings performed in 2011 (URS, 2017) that are approximately 0.5 to 1 mile east of the Project site. Groundwater was encountered from a depth of 6 to 15 feet bgs. Based on the data above and the proximity of the Project location to the Santa Ana River running just south of the Project, groundwater may be encountered for excavations greater than five (5) feet bgs. See Appendix B for the groundwater information found in the boring logs prepared by URS and Appendix C for the CGS HHGW Contours.

Based on the information provided above, the potential to encounter groundwater in excavations as shallow as 6 feet bgs.

Relevant groundwater data is provided in Appendix C.
4.2 FAULTING AND SEISMIC HAZARDS

Southern California is in a region with many known faults and high seismic activity. Faults are fractures in the Earth’s crust, and when they are subjected to displacement, earthquakes can occur. The displacement of the fault can occur in four different ways: strike slip, normal, reverse, and thrust.

- Strike-slip faults are vertical fractures where the blocks have mostly moved horizontally.
- Normal, reverse, and thrust faults are inclined fractures where the blocks have mostly shifted vertically. If the rock mass above an inclined fault moves down, the fault is termed normal, whereas if the rock above the fault moves up, the fault is termed reverse. A thrust fault is a reverse fault with a dip of 45 degrees or less.
- Blind (buried) thrust faults do not rupture all the way up to the surface, so there is no evidence of the fault on the surface.

Depending on the fault displacement and amount of stress that has accumulated, the magnitude of the earthquakes can have a wide range. For the purpose of this Project, Table 1 was generated to show all the types of active faults and their respective maximum magnitude earthquake within the vicinity of the Project alignment.
### Table 1 - MAJOR FAULT CHARACTERIZATION IN THE PROJECT VICINITY

<table>
<thead>
<tr>
<th>FAULT</th>
<th>FID</th>
<th>SITE-TO-SOURCE DISTANCE (km)</th>
<th>TYPE</th>
<th>M(_{\text{MAX}})</th>
<th>DIP AND DIRECTION</th>
<th>BASIN EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elsinore (Glen Ivy) rev</td>
<td>365</td>
<td>0.70</td>
<td>0.872</td>
<td>SS</td>
<td>7.7</td>
<td>90°/V</td>
</tr>
<tr>
<td>Elsinore fault zone (Whittier Section)</td>
<td>352</td>
<td>0.936</td>
<td>0.904</td>
<td>SS</td>
<td>6.9</td>
<td>75°/NE</td>
</tr>
<tr>
<td>Elsinore fault zone (Chino section)</td>
<td>355</td>
<td>3.774</td>
<td>2.891</td>
<td>SS</td>
<td>6.6</td>
<td>50°/SW</td>
</tr>
</tbody>
</table>

Notes:
- Fault characterization is based on Caltrans ARS V2.3.09 database (2012).
- Project location: latitude = 33.878192° and longitude = -117.671304°
- FID = Fault Identification Number
- \(R_x\) is defined as the closest distance to the fault trace or surface projection of the top of the rupture plane.
- \(R_{\text{rup}}\) is defined as the closest distance from the Project site to the fault rupture plane. The distance measurements are approximate.
- \(M_{\text{MAX}}\) = Maximum magnitude earthquake
- SS = Strike Slip
- V = Vertical
- NE = Northeast
- SW = Southwest
- \(Z_{1.0}\) = Depth to shear wave velocity of 1,000 m/s.
- \(Z_{2.5}\) = Depth to shear wave velocity of 2,500 m/s.

### 4.2.1 Surface Faulting/Ground Rupture Hazard

Surface fault rupture refers to the extension of a fault from depth to the ground surface along which the ground breaks, resulting in displacement, such as vertical or horizontal offset. Surface fault ruptures are the result of stress relief during an earthquake event and often cause damage to structures within the rupture zone.

California’s Alquist-Priolo Earthquake Fault Zoning Act (AP Act; CGS 2018) was enacted to identify and reduce the hazard from surface fault rupture by regulating project developments near active faults. The purpose of the AP Act is to prohibit the location of most structures intended for human occupancy across the trace of an active fault. The AP Act requires that projects in defined “Earthquake Fault Zones” conduct geologic investigations that demonstrate that the sites are not threatened by surface displacement from future fault rupture. To be zoned under the AP Act, a fault must be considered Holocene-active as defined (CGS 2018). CGS defines a Holocene-active fault as one that has had surface displacement within Holocene time.
(approximately the last 11,700 years). CGS considers a fault to be well defined if its trace is clearly detectable as a physical feature at or just below the ground surface.

CGS defines the following types of faults:

- **Age-undetermined Faults**: A fault whose age of most recent movement is not known or is unconstrained by dating methods or by limitations in stratigraphic resolution.
- **Holocene-active Faults**: A fault that has had surface displacement within Holocene time (last 11,700 years).
- **Pre-Holocene Faults**: A fault whose recency of past movement is older than 11,700 years, and thus does not meet criteria of Holocene-active fault.

According to the CGS Earthquake Zones of Required Investigation for the Prado Dam Quadrangle (2003), no part of the Project falls within an AP zone; see Attachment D. In addition, no part of the Project is within 1,000 feet of any Holocene or young age fault (Caltrans, 2013). Therefore, the potential for surface faulting with the Project alignments is low.

### 4.2.2 Seismic Ground Motion

Ground shaking intensity is influenced by several factors, such as distance to the epicenter and hypocenter from the site, the magnitude of the earthquake, and subsurface geologic structures, as well as surface topography, depth of groundwater, and strength of the earth materials underlying the site. The peak ground acceleration (PGA) was estimated based on the results of the Caltrans Acceleration Response Spectrum (ARS) V3.0.1 online tool (Caltrans, 2020). According to Caltrans Seismic Design Criteria V2.0 (2019) and the latest version of Caltrans ARS online tool, the ARS is developed based on probabilistic seismic hazard analysis (see Table 2). The shear wave velocity for the upper 30 meters (100 feet) of soils ($V_{S30}$) was considered to be 1,148 feet/second (approximately 350 meters per second [m/s]) based on published data (USGS, 2020).

Based on the results obtained from Caltrans ARS V3.0.1 online, the PGA for the Project site was 0.73g, with an associated mean magnitude (M) of 6.7.
### Table 2 - DESIGN CALTRANS SPECTRAL ACCELERATION

<table>
<thead>
<tr>
<th>Period (Second)</th>
<th>Spectral Acceleration $S_{a2014} (g)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGA</td>
<td>0.73</td>
</tr>
<tr>
<td>0.10</td>
<td>1.31</td>
</tr>
<tr>
<td>0.20</td>
<td>1.72</td>
</tr>
<tr>
<td>0.30</td>
<td>1.81</td>
</tr>
<tr>
<td>0.50</td>
<td>1.57</td>
</tr>
<tr>
<td>0.75</td>
<td>1.31</td>
</tr>
<tr>
<td>1.0</td>
<td>1.11</td>
</tr>
<tr>
<td>2.0</td>
<td>0.50</td>
</tr>
<tr>
<td>3.0</td>
<td>0.30</td>
</tr>
<tr>
<td>4.0</td>
<td>0.21</td>
</tr>
<tr>
<td>5.0</td>
<td>0.15</td>
</tr>
</tbody>
</table>

**Note(s):**
- PGA = Peak Ground Acceleration.
- Based on Caltrans ARS Online Tool V3.0.1 (2020).
- Based on 2014 version of USGS seismic hazard.

There is no direct geotechnical solution that we are aware of to mitigate the high seismic ground motion at a site. However, mitigation of high seismic ground motion consequences has been discussed in Section 4.2.3 in detail.

In general, this high seismic ground motion will have impact on the design of the proposed improvements such as bridge supports and retaining walls. Bridges shall be designed with isolation bearings which are placed between the super structure and supports to dampen ground shaking, providing large support width to minimize unseating potential of bridge structure, and providing highly ductile structure to withstand very large seismic displacement. Special analyses and design can also be implemented such as performing non-linear time history analyses for the ground motion evaluation. Accordance with Caltrans design guidelines, when a site PGA exceeds 0.6g, like this site, Caltrans standard walls cannot be used. A special design is required. Based on our experience, we understand that designers take the Caltrans standard plan walls and modify based on the seismic demands.
4.2.3 Liquefaction Potential and Seismic Settlement

Liquefaction occurs when saturated, low-relative-density, low-plastic materials are transformed from a solid to a near-liquid state. This phenomenon occurs when moderate to severe ground shaking causes pore-water pressure to increase. Site susceptibility to liquefaction is a function of the depth, density, soil type, and water content of granular sediments, along with the magnitude and frequency of earthquakes in the surrounding region. Saturated sands, silty sands, and unconsolidated silts within 50 feet of the ground surface are most susceptible to liquefaction. Liquefaction-related phenomena include lateral spreading, ground oscillation, flow failures, loss of bearing strength, subsidence, and buoyancy effects.

The Project site has not yet been mapped in the liquefaction zone mapping program by CGS as part of the Seismic Hazards Mapping Act. Review of geologic hazards maps (General Plan – Safety Element) available in the County of Riverside, revealed that a portion of the Project falls within an area mapped as moderately susceptible to liquefaction (2019); see Appendix E. Therefore, the potential for encountering liquefiable soils within the Project area is likely.

The liquefaction mitigation can be implemented by either performing appropriate ground improvements (mitigating the subsurface soils) or accommodating a structural solution to the foundation, typically a deep pile foundation tipping below the liquefiable layer.

To mitigate the effects from earthquake-induced liquefaction, several ground improvement techniques are available to consider. Deep dynamic compaction, vibro stone columns, deep cement-soil mixing, and jet grouting are some of the most common types of ground improvement techniques. Liquefaction mitigation measures, such as densification of subsurface soils or deep remedial grading, will likely not be cost effective. In addition to this, we recommend that the design team evaluate both options of either performing ground improvements for liquefaction mitigation or performing repairs after a seismic event.

The structural solution includes considering the liquefaction-induced downdrag loads because of the settling soils. The downdrag load calculation includes downward movement of any non-liquefiable layer (crust) and liquefiable layer. In order to accommodate these downdrag loads, the deep pile foundation will be selected so that the piles will be tipped below the bottom of the liquefiable layer.
The selection of the final option should also consider Project requirements, proposed improvements, availability of material locally, adjacent structures, proximity to residential/commercial facilities, and owner’s and Project stakeholders’ preferences and budget constraints. We believe during final design this issue can be analyzed in detail.

Because liquefaction potential exists at the Project site, lateral spreading due to liquefaction is a possibility at the Project site due to the sloping nature of the Project alignments from south to north.

Any proposed structures such as bridges, retaining walls, and habitable buildings that fall within the liquefaction zone will need to be designed based on an in-depth analysis of liquefaction and lateral spreading potential based on further investigations.

4.3 LANDSLIDE AND SLOPE INSTABILITY

The Project site has not yet been mapped by CGS for seismic hazards including landslides. A review of the County of Riverside Earthquake-Induced Slope Instability Map (2019), City of Chino Hills Landslide Susceptibility (2011), and the City of Corona Landslide Hazards Map (2011) determined that the Project is in an area that has a low susceptibility to landslides caused by earthquakes; see Appendix F. Therefore, the potential for the Project to be impacted by landslides is low.

4.4 SEICHES AND TSUNAMI

Seiches are large waves generated in enclosed bodies of water induced by ground shaking. The County of Riverside and the Cities of Corona and Chino Hills General Plans were reviewed to understand the potential effects from seiches for the Project site. Information about the potential for seiches was not provided in these plans. However, the Project site is located approximately two miles downstream from Prado Dam. According, to the County of Riverside Dam Hazard Map, the Project site is located in the Prado Dam Hazard Zone; see Attachment G.

Tsunamis are large waves generated in the sea by significant disturbance of the ocean flow, causing the water column above it to displace rapidly. Tsunamis are predominately caused by shallow underwater earthquakes and landslides. Because the Project location is not near any coastline, CGS has not mapped the Project quadrangle for any tsunami inundation; therefore, there is no potential risks from a tsunami for the Project site.
4.5 FLOODING AND INUNDATION

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) for the Counties of San Bernardino (2008), Riverside (2008), and Orange (2009), the Project alignment is in areas mapped as Zone X and in other areas towards the south that have no printed FIRM data. Zone X refers to “areas determined to be outside the 0.2% annual chance floodplain.” However, according to the City of Corona Flood Hazards Map (2016), the Project alignment is within a 100-year flood zone. Based on the proximity of the Santa Ana River and the Prado Dam to the Project alignment, the potential of flooding during extreme rain event(s) or dam failure could result in flooding of the Project area. See Appendix H for the FEMA FIRM maps and the City of Corona Flood Hazards Map. Therefore, the potential for the Project to be impacted by flooding is likely if the necessary events were to happen such as the failure of the Prado Dam or a 100-year storm event.

4.6 EXPANSIVE POTENTIAL

Expansive soils will undergo changes in volume with changes in moisture content (expand when saturated and shrink when dried), which can result in lifting and cracking of flatwork or paved surfaces. The County of Riverside and the City of Corona General Plans expansive soil potential maps were not available to review. However, according to the City of Chino Expansive Soils Map (2011), a portion of the Project alignment is in an area determined to have near surface soils with a moderate shrink-swell potential; see Appendix I. Therefore, the potential for encountering expansive soils within the Project site is low.

If expansive soils are encountered during geotechnical field exploration, removing these expansive soils and replacing with non-expansive soils is considered a possible remediation solution. Soil improvements such as lime or cement treating of the subsurface soils can also be considered another feasible option. Depending on the extent of the expansive soil and availability of the import materials such as fill soils, cement, and lime, and Project schedule and cost will mainly dictate the selection of appropriate method to be implemented.

As another remedial option to minimize the expansive potential during subsurface preparation is to compact soils beneath the pavement structural section with moisture content at least 2% higher than optimum.
4.7 **TOPSOIL EROSION**

The erodibility of the topsoil can happen when water and wind come in contact with a loosely compacted topsoil. The City of Chino Hills and Corona general plans documents did not have any information regarding the erodibility of the soil due to wind. According to the County of Riverside Wind Erosion Susceptibility Areas figure in the General Plan (2019), the Project site is in an area that is rated as low wind erodibility; see Appendix J. Therefore, the potential for the Project to be impacted by wind erosion is low.

4.8 **CORROSION POTENTIAL**

Soil corrosivity involves the measure of the potential for corrosion to steel and concrete in contact with the soil. Knowledge of potential soil corrosivity is often critical for the effective design parameters associated with cathodic protection of buried steel and concrete mix design for plain or reinforced-concrete buried project elements. Factors including soil composition, soil and pore water chemistry, moisture content, and pH affect the response of steel and concrete to soil corrosion. Soils with high moisture content, high electrical conductivity, high acidity, high sulfates, and high dissolved salts content are most corrosive. Generally, sands and silty sands do not present a corrosive environment. Clay soils, including those that contain interstitial saltwater, can be highly corrosive.

No corrosion test results were performed, but previous soil investigation and corrosion potential test results (0.5 to 1 mile east of Project site) were obtained from URS (2017). Based on review, the soils were interpreted to be non-corrosive based on Caltrans Corrosion guidelines (2018); see Appendix K for URS corrosion tests results. A summary of the corrosion test results is presented in Table 3.
Table 3 - EXISTING CORROSION TEST RESULTS

<table>
<thead>
<tr>
<th>SAMPLE LOCATION</th>
<th>DEPTH (ft.)</th>
<th>pH</th>
<th>SULFATE (ppm)</th>
<th>CHLORIDE (ppm)</th>
<th>RESISTIVITY (ohm-cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pier Group 2</td>
<td>6</td>
<td>6.6</td>
<td>11</td>
<td>ND</td>
<td>13,200</td>
</tr>
<tr>
<td>Pier Group 3</td>
<td>0 – 10</td>
<td>7.2</td>
<td>55</td>
<td>21</td>
<td>4,800</td>
</tr>
<tr>
<td>Pier Group 4</td>
<td>7</td>
<td>7.1</td>
<td>89</td>
<td>53</td>
<td>2,840</td>
</tr>
<tr>
<td>Pier Group 5</td>
<td>8</td>
<td>6.8</td>
<td>82</td>
<td>64</td>
<td>2,000</td>
</tr>
</tbody>
</table>

Note(s):
- Based on existing data from URS (2017).
- Based on Caltrans Corrosion Guidelines (Caltrans 2018): pH greater than 5.5, resistivity greater than 1,100 ohm-cm, Sulfate less than 1,500 ppm and Chloride less than 500 ppm.
- N.D. indicates not detected.
- ppm = parts per million.

We recommend that soil samples be collected where the new pavements and structures will be constructed and be tested during the design phase to evaluate corrosion potential in accordance with Caltrans corrosion criteria. In general, Caltrans requires that the soils or water have a minimum electrical resistivity of 1,100 ohm-cm; anything less indicates the presence of high soluble salts and a higher propensity for corrosion. For structural elements, the on-site soils should have a chloride concentration of 500 parts per million (ppm) or less, a sulfate concentration of 1,500 ppm or less, and a pH of 5.5 or greater per Caltrans corrosion guidelines (Caltrans, 2018). For any proposed fills, corrosion tests should be performed prior to importation.
5 LIMITATIONS

This Geologic and Seismic Hazard Report has been prepared for this Project in accordance with accepted geotechnical engineering practices common to the local area. No other warranty, expressed or implied, is made.

The information contained in this report is based on literature review only. The results of the previous field exploration indicate subsurface conditions only at the specific locations and times, and only to the depths penetrated. The information presented in this report should be confirmed or modified based on appropriate site-specific investigation during the preliminary/final design phases.

The data, opinions, and information contained in this report are applicable to the specific design element(s) and location(s) that is (are) the subject of this report. They have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of DYA.

Services performed by DYA have been conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.

This report is intended for use only for the Project described. In the event that any changes in the nature, design, or location of the facilities are planned, the information contained in this report should not be considered valid unless the changes are reviewed and information presented in this report is modified or verified in writing by DYA. We are not responsible for any claims, damages, or liability associated with the interpretation of subsurface data or reuse of the subsurface data or engineering analyses without our express written authorization.
6 BIBLIOGRAPHY


California Geological Survey, 2000, Seismic Hazard Zone Report for the Prado Dam 7.5 Minute Quadrangle, Orange County, California.


Caltrans, 2012, Caltrans Fault Database (V2.3.09) for ARS online, October 23, 2012


Caltrans, 2019, Seismic Design Criteria V2.0, April 2019.


City of Chino Hills, 2011, Landslide Susceptibility Figure 5-5, General Plan, Ch.5 Safety Element, March 14, 2011.

City of Chino Hills, 2011, Expansive Soils Figure 5-6, General Plan, Ch.5 Safety Element, March 14, 2011.


City of Corona, 2011, Landslide Hazard Figure PS-3, General Plan, 2011.

City of Corona, 2016, Flood Hazards Figure PS-5, General Plan, Public Review Draft 2019.

County of Riverside General Plan, 2019, Safety Element, revised August 6, 2019.

Department of Water of Resources, 2020, Water Data Library.

Federal Emergency Management Agency (FEMA), Flood Insurance Rate Map, Riverside County (2008), Map Number 06065C0868G, Effective Date August 28, 2008.


APPENDIX A - PROJECT EXHIBITS
APPENDIX B - EXISTING DATA
NOTES:
1. SEE SHEET G-3 FOR KEYS TO SYMBOLS.
2. SEE SHEETS G-24 AND G-25 FOR THE REMAINING LOG INFORMATION.
3. SEE SHEET G-1 FOR LOCATION OF EXPLORATION.

**SAFETY PAYS**

**VALUE ENGINEERING PAYS**
### Sheet 5 of 6

**Log of Boring URS B-20**

**Project:** BNSF Railroad Bridge  
**Location:** Corvallis, Oregon  
**Number:** 29871699

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Depth (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well-graded gravel,</td>
<td>1.3 - 1.4</td>
</tr>
<tr>
<td>with sand, inequal.</td>
<td></td>
</tr>
<tr>
<td>matrix, fine to</td>
<td></td>
</tr>
<tr>
<td>coarse, moderate</td>
<td></td>
</tr>
<tr>
<td>angular, some clay</td>
<td></td>
</tr>
<tr>
<td>matrix, moderate to</td>
<td></td>
</tr>
<tr>
<td>fine angular</td>
<td></td>
</tr>
<tr>
<td>Well-graded gravel,</td>
<td>1.2 - 1.3</td>
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<tr>
<td>coarse, moderate</td>
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<tr>
<td>Well-graded gravel,</td>
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<td>coarse, moderate</td>
<td></td>
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<tr>
<td>matrix, moderate to</td>
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<tr>
<td>fine angular</td>
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</table>

**Field Notes and Test Results**

- 1.3 - 1.4 ft: Well-graded gravel, fine to coarse, moderately angular, some clay, matrix, moderate to fine angular.
- 1.2 - 1.3 ft: Well-graded gravel, fine to coarse, moderately angular, some clay, matrix, moderate to fine angular.
- 1.1 - 1.2 ft: Well-graded gravel, fine to coarse, moderately angular, some clay, matrix, moderate to fine angular.

---

### Sheet 6 of 6

**Log of Boring URS B-21**

**Project:** BNSF Railroad Bridge  
**Location:** Corvallis, Oregon  
**Number:** 29871699

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<tr>
<td>moderately</td>
<td></td>
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<tr>
<td>angular,</td>
<td></td>
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<tr>
<td>some</td>
<td></td>
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<tr>
<td>clay,</td>
<td></td>
</tr>
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<td>matrix,</td>
<td></td>
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<tr>
<td>Well-graded gravel,</td>
<td>9.5 - 10.5</td>
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<tr>
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<tr>
<td>coarse, moderate</td>
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<tr>
<td>Well-graded gravel,</td>
<td>8.5 - 9.5</td>
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<td>with sand, inequal.</td>
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<tr>
<td>matrix, fine to</td>
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<tr>
<td>coarse, moderate</td>
<td></td>
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<tr>
<td>matrix, moderate to</td>
<td></td>
</tr>
<tr>
<td>fine angular</td>
<td></td>
</tr>
</tbody>
</table>

**Field Notes and Test Results**

- 10.5 - 11.5 ft: Sandstone, dark brown, fine to coarse, moderately angular, some clay, matrix, moderate to fine angular.
- 9.5 - 10.5 ft: Well-graded gravel, fine to coarse, moderately angular, some clay, matrix, moderate to fine angular.
- 8.5 - 9.5 ft: Well-graded gravel, fine to coarse, moderately angular, some clay, matrix, moderate to fine angular.

---

**NOTES:**

- See Sheet G-1 for location of exploration.
- See Sheet G-2 for keys to symbols.
Note: Refer to Figure 6 for section location

"Looking Northeast and upstream along Santa Ana river"

Legend

- Gravel
- Silt and Clay
- Sand
- Bedrock

GEOLOGIC CROSS SECTION 9a-9a'
BNSF SANTA ANA RIVER BRIDGES
Note: Refer to Figure 6 for section location

"Looking Northeast and upstream along Santa Ana river"

Legend

Gravel
Sand
Bedrock

GEOLOGIC CROSS SECTION 9b-9b'
BNSF SANTA ANA RIVER BRIDGES

CHECKED BY: C.S.G. DATE: 06-01-16
PM: MCS PROJ. NO. 29871609.00001

URS
APPENDIX C -
HISTORICALLY HIGHEST GROUNDWATER LEVEL
Plate 1.2 Historically Highest Ground Water Contours and Borehole Log Data Locations, Prado Dam Quadrangle.
APPENDIX D - ALQUIST PRIOLO FAULT MAP
Earthquake Zones of Required Investigation
Prado Dam Quadrangle

California Geological Survey

This map shows both Alquist-Priolo Earthquake Fault Zones and Salient Hazard Zones issued for the Prado Dam Quadrangle.

Seismic Hazard Zones

These zones are defined by the California Geological Survey (CGS) and the California Department of Conservation (DOC) to identify areas that may be affected by earthquakes. The zones are based on geological and geotechnical data, and they are used for planning and risk assessment.

Earthquake Fault Zones

These zones are defined by the CGS and the DOC to identify areas that may be affected by earthquakes caused by surface fault rupture. The zones are based on geological and geotechnical data, and they are used for planning and risk assessment.

ADDITIONAL INFORMATION


For more information on the California Salient Hazard Zone program, please refer to the following: California Geological Survey, Salient Hazard Zone Report SHR-03. http://gmw.conservation.ca.gov/SHP/EZRIM/Reports/SHR/007/

Click the link below to learn how to take greater advantage of the GeoPDF format at www.webgis.com/pdf.

Project Area

AREA NOT EVALUATED FOR LIQUEFACTION OR LANDSLIDES

AREA NOT EVALUATED FOR LIQUEFACTION OR LANDSLIDES

Contour Interval 20 Feet

Scale: 1:20,000

California Geological Survey, Geologic Information and Publications
15100 Vickery Blvd., Suite 500
Sacramento, CA 95818
650-916-4718
www.conservation.ca.gov/cgs

SEISMIC HAZARD ZONES

Seismic Hazard Zones Issued For The Prado Dam Quadrangle

The map above shows the location of both Alquist-Priolo Earthquake Fault Zones and Salient Hazard Zones issued for the Prado Dam Quadrangle.


ADDITIONAL INFORMATION

For more information on the Alquist-Priolo Earthquake Fault Zone program, please refer to the following: California Geological Survey, Earthquake Fault Zones, a Guide for Government Agencies, California Geological Survey, Special Publication SP-14, California Geological Survey, Special Publication SP-16.

For more information on the Salient Hazard Zone program, please refer to the following: California Geological Survey, Salient Hazard Zone Report SHR-03, California Geological Survey, Special Publication SP-14.

Click the link below to learn how to take greater advantage of the GeoPDF format at www.webgis.com/pdf.

Seismic Hazard Zones

These zones are defined by the CGS and the DOC to identify areas that may be affected by earthquakes. The zones are based on geological and geotechnical data, and they are used for planning and risk assessment.

Earthquake Fault Zones

These zones are defined by the CGS and the DOC to identify areas that may be affected by earthquakes caused by surface fault rupture. The zones are based on geological and geotechnical data, and they are used for planning and risk assessment.

ADDITIONAL INFORMATION


For more information on the California Salient Hazard Zone program, please refer to the following: California Geological Survey, Salient Hazard Zone Report SHR-03. http://gmw.conservation.ca.gov/SHP/EZRIM/Reports/SHR/007/

Click the link below to learn how to take greater advantage of the GeoPDF format at www.webgis.com/pdf.

Prado Dam Quadrangle

EARTHQUAKE FAULT ZONES

Issued in compliance with Chapter 7.6, Division 2 of the California Public Resources Code (Alquist-Priolo Earthquake Fault-Zone Act)

REVISED OFFICIAL MAP

Released: May 1, 2003

State Geologist

SEISMIC HAZARD ZONES

Deemed in compliance with Chapter 7.6, Division 2 of the California Public Resources Code (Seismic Hazards Mapping Act)

OFFICIAL MAP

Released: January 17, 2001

State Geologist
APPENDIX E - LIQUEFACTION POTENTIAL MAP
Bridge Locations

Legend

- Caltrans Faults
- Alquist-Priolo Earthquake Fault Zone
- CGS Landslide Hazard Zone
- CGS Liquefaction Hazard Zone

Riverside County Liquefaction Susceptibility

Low
Moderate

Source: County of Riverside Open Data - Liquefaction (accessed 2017)
CGS, Prado Dam Quadrangle Seismic Hazards Zones Official Map (2001)
CGS, Black Star Canyon Quadrangle Seismic Hazards Zones Official Map (2001)
Caltrans Fault Database Version 2.0.06
APPENDIX F - LANDSLIDE SUSCEPTIBILITY MAP
Figure S-4

Disclaimer: Maps and data are to be used for reference purposes only. Map features are approximate, and are not necessarily accurate to surveying or engineering standards. The County of Riverside makes no warranty or guarantee as to the content (the source is often third party), accuracy, timeliness, or completeness of any of the data provided, and assumes no legal responsibility for the information contained on this map. Any use of this product with respect to accuracy and precision shall be the sole responsibility of the user.

EARTHQUAKE-INDUCED SLOPE INSTABILITY MAP


Figure S-4

Existing Landslides
High susceptibility to seismically induced landslides and rockfalls.
Low to locally moderate susceptibility to seismically induced landslides and rockfalls.

Seismic Hazard Zone Maps

- Earthquake Induced Landslide Zones
- Fault Zones
- Quadrangles
- Area Plan Boundary
- City Boundary
- Waterbodies

(See detail in Elsinore, Southwest, Sun City / Menifee Valley Area Plans)
Figure 5-5 – Landslide Susceptibility
Figure PS-3
Landslide Hazards

Legend
- City Boundary
- Sphere of Influence Areas

ROCK STRENGTH

SLOPE CLASS

LANDSLIDE SUSCEPTIBILITY CLASSES

0 1 2 3 4 5 6 7 8 9 10
increasing susceptibility

Source:
For more information please see:

Landslide Susceptibility—Rock strength and slope are combined according to the methodology of Webster and Fiedler (1985) as implemented by Porti et al. (2008) to create classes of landslide susceptibility. These classes express the generalization that low rock strength and shallow slopes, weak beds, or layers, and high landslides are generally low, whereas steep slopes and strong beds, strong and high landslides are generally high. Very high landslide susceptibility occurs where very steep slopes or weak beds or layers are present.
APPENDIX G - DAM HAZARD MAP
Figure S-10


Disclaimer: Maps and data are to be used for reference purposes only. Map features are approximate and are not necessarily accurate to surveying or engineering standards. The County of Riverside makes no warranty or guarantee as to the content (the source is often third-party), accuracy, completeness, or completeness of any of the data provided and assumes no legal responsibility for the information contained on this map. Any use of this product with respect to accuracy and precision shall be the sole responsibility of the user.
APPENDIX H - FLOODING AND INUNDATION MAP
Disclaimer: Maps and data are to be used for reference purposes only. Map features are approximate and are not intended for surveying or engineering purposes. The County of Riverside makes no warranty or guarantee, express or implied, to the user that the data provided is accurate, complete, or current. The data provided may be subject to errors and omissions. Use of the data is at the user’s sole discretion and risk. The user, and not the County of Riverside, assumes the entire liability for any use of the data provided. The user, and not the County of Riverside, shall be solely responsible for ensuring the accuracy and appropriateness of the data for any intended purpose. The County of Riverside is not responsible for any errors or omissions in the data or any use made thereof. The user is solely responsible for any damages or claims resulting from the use of the data. For any specific information regarding building requirements, users are advised to contact the appropriate local flood control agency.
Figure PS-5
Flood Hazards

Legend
- 100-Year Flood Zone
- 500-Year Flood Zone
- DWR Awareness Floodplain
- City Boundary
- Sphere of Influence Areas

Notes:
100-year flood zone: Includes areas subject to a 100-year flood as defined by FEMA. This area is also referred to as a special flood hazard area.

500-year flood zone: Includes areas between the limits of the 100-year floodplain and subject to a 500-year flood as defined by FEMA. This area is also referred to as a moderate flood hazard area.

DWR Awareness Flood zone: Includes areas defined by the California DWR with a potential for a 100-year flood that may warrant further study to assess the risk of flooding.

This map does not have the official status.

Source:
Department of Water Resources (DWR, 2016)
Federal Emergency Management Agency (FEMA, 2016)
Figure 5-8– FEMA Flood Map
APPENDIX I - EXPANSIVE POTENTIAL MAP
Figure 5-6– Expansive Soils

NOTE: This figure shows the relative shrink-swell potential of the soils that occur at the surface in the City of Chino Hills. Volcanic Ash layers within the Puente Formation generally weather to clay with a high shrink-swell potential. These ash layers may uncover during grading operations, affecting the proposed development at final grade. Site-specific soil studies need to be conducted to evaluate the expansion potential of the soil materials at grade prior to construction. Those ash layers could occur in other areas than those identified herein as having soils with a high expansion potential.
Figure S-8

Disclaimer: Maps and data are to be used for reference purposes only. Maps features are approximate and are not necessarily accurate to surveying or engineering standards. The County of Riverside makes no warranty or guarantee as to the content (the source is often third-party). Accuracy, completeness, or merchantability of any of the data provided and assumes no responsibility for errors or omissions. Any use of this product with respect to accuracy and precision shall be the sole responsibility of the user.


WIND EROSION
SUSCEPTIBILITY AREAS

Wind Erodibility Rating

- Very High
- High
- Moderate
- Low
- Weather Station

Legend: Mileage lines are to be used for reference purposes only. Map features are approximate and are not necessarily accurate to surveying or engineering standards. The County of Riverside makes no warranty or guarantee as to the content (the source is often third-party). Accuracy, completeness, or merchantability of any of the data provided and assumes no responsibility for errors or omissions. Any use of this product with respect to accuracy and precision shall be the sole responsibility of the user.

Disclaimer: For information within City boundary, refer to the City’s General Plan. WIND EROSION
SUSCEPTIBILITY AREAS

August 6, 2019
APPENDIX K -
CORROSION POTENTIAL
TRANSMITTAL LETTER

DATE: December 8, 2016

ATTENTION: Luis Vasquez

TO: AECOM
2110 East First Plaza, Suite 116
Santa Ana, CA 92705

SUBJECT: Laboratory Test Data
BNSF Rail Road Bridge Pot Holing
Your #60417373, HDR Lab #16-0899LAB

COMMENTS: Enclosed are the results for the subject project.

James T. Keegan, MD
Laboratory Services Manager
Table 1 - Laboratory Tests on Soil Samples

AECOM
BNSF Rail Road Bridge Pot Holing
Your #60417373, HDR Lab #16-0899LAB
8-Dec-16

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>East corner of Middler Pier group 3 @ 0-10' SM</th>
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<table>
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<tr>
<th>Resistivity</th>
<th>Units</th>
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<tbody>
<tr>
<td>as-received</td>
<td>ohm-cm</td>
<td>4,800</td>
</tr>
<tr>
<td>minimum</td>
<td>ohm-cm</td>
<td>3,880</td>
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</tbody>
</table>

| pH          | 7.2 |

| Electrical Conductivity | mS/cm | 0.07 |

<table>
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<tr>
<td><strong>Cations</strong></td>
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<tr>
<td>calcium Ca^{2+}</td>
<td>mg/kg 41</td>
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<tr>
<td>magnesium Mg^{2+}</td>
<td>mg/kg 5.1</td>
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<tr>
<td>sodium Na^{+}</td>
<td>mg/kg 37</td>
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<tr>
<td>potassium K^{+}</td>
<td>mg/kg 11</td>
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<tr>
<td><strong>Anions</strong></td>
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<tr>
<td>carbonate CO_{3}^{2-}</td>
<td>mg/kg ND</td>
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<tr>
<td>bicarbonate HCO_{3}^{-}</td>
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<td>mg/kg 55</td>
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<td>ammonium NH_{4}^{1+}</td>
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<td>nitrate NO_{3}^{-}</td>
<td>mg/kg 5.1</td>
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<tr>
<td>sulfide S^{2−}</td>
<td>qual na</td>
</tr>
<tr>
<td>Redox</td>
<td>mV na</td>
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Minimum resistivity per CTM 643, Chlorides per CTM 422, Sulfates per CTM 417.
Electrical conductivity in millisiemens/cm and chemical analyses were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed
TRANSMITTAL LETTER

DATE: April 28, 2017

ATTENTION: Luis Vasquez

TO: AECOM
2110 East First Plaza, Suite 116
Santa Ana, CA 92705

SUBJECT: Laboratory Test Data
BNSF
HDR Lab #17-0289LAB

COMMENTS: Enclosed are the results for the subject project.

James T. Keegan, MD
Laboratory Services Manager
### Sample ID

Pier 2 @ 6 ft  Pier 4 @ 7 ft  Pier 5 @ 8 ft

<table>
<thead>
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<th>Units</th>
<th>Pier 2</th>
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<td>Electrical Conductivity</td>
<td>mS/cm</td>
<td>0.04</td>
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### Chemical Analyses

#### Cations
- calcium $\text{Ca}^{2+}$ mg/kg 51 58 57
- magnesium $\text{Mg}^{2+}$ mg/kg 9.2 12 12
- sodium $\text{Na}^{+}$ mg/kg 18 87 103
- potassium $\text{K}^{+}$ mg/kg 4.6 13 14

#### Anions
- carbonate $\text{CO}_3^{2-}$ mg/kg ND ND ND
- bicarbonate $\text{HCO}_3^{-}$ mg/kg 153 174 198
- fluoride $\text{F}^{-}$ mg/kg 6.6 22 22
- chloride $\text{Cl}^{-}$ mg/kg ND 53 64
- sulfate $\text{SO}_4^{2-}$ mg/kg 11 89 82
- phosphate $\text{PO}_4^{3-}$ mg/kg ND ND 1.9

#### Other Tests
- ammonium $\text{NH}_4^{+}$ mg/kg ND ND ND
- nitrate $\text{NO}_3^{-}$ mg/kg 3.0 ND ND
- sulfide $\text{S}^{2-}$ qual na na na
- Redox mV na na na

Minimum resistivity per CTM 643, Chlorides per CTM 422, Sulfates per CTM 417

Electrical conductivity in millisiemens/cm and chemical analyses were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.

Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed
DISTRIBUTION

One Copy: Ms. Susan Michalski, PE
Michael Baker International
5 Hutton Centre, Suite 500
Santa Ana, California 92707

QUALITY CONTROL REVIEWER

Saroj Weeraratne, PhD, PE, GE
Associate Engineer

BH/SN: sjd/dr

REPORT VERSION LOG

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<td>Final Version for Agency Submittal</td>
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<td>Final Version after Riverside County comments</td>
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