4.8 GEOLOGY AND SOILS

The information below is based on the Preliminary Geologic/Geotechnical Feasibility Studies prepared by Kleinfelder in July 2004. These reports are available for public review at the Solano Transportation Authority (STA), One Harbor Center, Suite 130, Suisun City, CA 94585, during regular business hours.

Methodology
This section discusses geology, soils, and seismic concerns as they relate to public safety and Project design. Earthquakes are prime considerations in the design and retrofit of structures and seismic hazards must be assessed prior to development of projects pursuant to the California Environmental Quality Act (CEQA).

The preliminary Geological/Geotechnical Feasibility Studies were prepared through a review of available geotechnical and geological literature and by a field reconnaissance conducted by a California Certified Engineering Geologist and licensed Geotechnical Engineer.

EXISTING CONDITIONS

Regional Geology
The Project area is located in the hills bordering the northwesterly margin of the intertidal estuary northwest of Grizzly Bay, along the northeasterly edge of the Coast Range Geomorphic Province of California. The Coast Ranges Province is a geologically complex and seismically active region characterized by sub-parallel northwest-trending faults, mountain ranges, and valleys. The topography within this province varies from gently sloping foothills to steep mountain flanks.

Local Geology

West End
The West End is underlain by the Markley Sandstone of the Kreyenhagen Formation. The Markley Sandstone generally consists of poorly consolidated silty sandstones, crudely interbedded with sandy siltstone and claystone that was deposited rapidly in a deep submarine canyon. Due to its rapid deposition, bedding in the Markley Sandstone may be variable and discontinuous, with lensing of material.

East End
The East End of the Project area is underlain by Holocene fan deposits, which are projected to be underlain at depth by Jurassic-Cretaceous age Great Valley Sequence of sedimentary bedrock. The fan deposits are made up of interbedded layers of clay, silts, sands and gravels. These deposits are identified as having low to moderate liquefaction potential.

Subsurface soils are generally consistent within the East End. Surface soils typically consist of moderate to highly plastic silty clays, which have a moderate to high potential for expansion pressures with variations in moisture content. Underlying the surface layers there are alternating layers of sandy silts and silty clays which are considered to be prone to liquefaction during seismic events. Groundwater at the Suisun Creek site was at an approximate depth of 20 feet.

The East End Project area primarily consists of nearly flat and level land currently being utilized for agricultural purposes.

Faulting and Seismicity

West End

In the vicinity of Red Top Road, the West End of the Project crosses above the Green Valley fault. The Green Valley fault extends at least 19 miles northwest from Bahia on Suisun Bay northward to Wooden Valley. In addition, the Project alignment is located between 0.5 to 1.3 miles west of the Cordelia fault zone, which is considered to be potentially active. Both faults have been included on the Alquist-Priolo Earthquake Fault Zone map. The Cordelia fault zone is generally considered to be part of the San Andreas Fault system and represents a relatively minor fault zone compared to the major fault zones of the San Andreas system.

The Green Valley and Cordelia faults are the only active faults known to show surface displacement within Solano County. Though the Cordelia Fault is considered a relatively minor fault zone, the Green Valley Fault is a major fault zone within the San Andreas fault system. It is likely that a pattern of seismicity similar to seismicity that has been displayed historically will persist into the foreseeable future. The probability of a magnitude 6.7 or greater earthquake occurring somewhere in the Bay Area region on one of the major faults of the San Andreas fault system in the 30 year period ending in 2030, is estimated to be 70 percent or greater. To minimize potential structural distress, the Project should be designed and constructed according to the most current earthquake resistance standards for Seismic Zone 4, as outlined in the current Uniform Building Code (UBC).

A paleoseismic study was conducted across the western three traces of the Green Valley fault, as mapped by Hart and Bryant (1977). This study was conducted on the property immediately south of Freehorn Creek and east of Red Top Road near the West End of the Project by Borchard and others (2001). That study found no evidence of Holocene age shears or offsets indicative of active faulting within the study area. Kleinfelder (2002) performed a geologic fault investigation for a Pacific Gas & Electric (PG&E) gas pipeline replacement project that crosses the Mangels Ranch north of State Route 12 (SR12). That study included geophysical profiling and trenching and identified two active traces of the Green Valley fault. The faults exposed in the trenches of that study were characterized by zones of sheared bedrock 20 to 30 feet wide with prominent shears bounding the zone. In the proposed Project area north of SR12, the two fault splays were identified in the same general location as those shown by Hart and Bryant (1997). The potential for ground rupture within the identified fault zones (Kleinfelder 2002) is high and possible future ground shearing is considered in a zone 50 feet on either side of the identified fault zone. Therefore, the potential for future surface fault rupture in the Project area is high.

East End

Though there are no mapped faults within the East End, this part of the Project area is located between 1.1 and 2.1 miles east of the Cordelia fault zone. Of greater significance to the Project due to its status as a major fault zone, is the active Green Valley fault, which is situated 2.4 to 3.8 miles west of the East End.

Landslide Deposits

West End
Large-scale landslides have been mapped in the general vicinity of the West End. There is a large, ancient landslide mass immediately west of the Project site. The ridgeline is classified as being marginally susceptible to the occurrence of debris flow with the highest areas being those underlain by Markley Sandstone. The slopes in the area of the ridgeline should be considered naturally unstable.

East End
The topography of the East End is flat and level; therefore, landslide potential is not considered to be a geologic hazard.

Groundwater

West End
Groundwater has been encountered at relatively shallow depths in the vicinity of Jameson Creek and at the transition to Business Center Drive. In 1996, groundwater level was measured at a depth of 5.5 feet in borings drilled south of Business Center Drive. In 1998, on a site adjacent to Business Center Drive, stabilized groundwater levels were measured at 12 feet below the existing ground surface. In July 2003 groundwater was encountered at a depth of 24.6 feet in a boring drilled along the western shoulder of Red Top Road, 100 feet south of the railroad crossing.

East End
Groundwater has been encountered at a depth of approximately 20 feet in the vicinity of Suisun Creek. In a 1988 study, on the southerly side of I-80, groundwater was encountered at a depth of approximately 6.5 feet. Free groundwater has been encountered in borings in the general area at depths of about 6 to 7 feet below grade.

REGULATORY SETTING

The Alquist-Priolo Earthquake Fault Zoning Act
The Alquist-Priolo Earthquake Fault Zoning Act, Public Resources Code (PRC) §§ 2621 et seq., governs zoning as it relates to earthquake fault zones within the State of California. The act prohibits the location of developments and structures for human occupancy across the trace of active fault lines. In addition, the State Geologist is charged with mapping and identifying active fault lines throughout the state for purposes of assisting communities in developing land use and public safety policies.

Seismic Hazards Mapping Act of 1990
The Seismic Hazards Mapping Act of 1990, PRC §§ 2690– 2699.6, charges the state with identifying and mapping areas at risk for strong ground shaking, liquefaction, and seismically induced landslides for purposes of assisting communities in developing land use and public safety policies.

California Building Code
The California Building Code (CBC) is the California adapted version of the UBC that is regularly updated and published by the International Conference of Building Officials (ICBO). The CBC provides design guidelines for structures subject to seismic hazards.

Chapter 16 of the CBC pertains to earthquakes, Chapter 18 addresses foundations and retaining walls, and Chapter A33 addresses excavation and grading.

GEOLOGY AND SOILS IMPACTS ANALYSIS

Significance Criteria

California Environmental Quality Act (CEQA)

Appendix G of the CEQA Guidelines identifies environmental issues to be considered when determining whether the project could have a significant effect on the environment. STA has applied these standards of significance for evaluating impacts of the Project.

The Project would have a significant impact if it would

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
    - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault
    - Refer to Division of Mines and Geology Special Publication 42
    - Strong seismic ground shaking
    - Seismic-related ground failure, including liquefaction
    - Landslides
- Result in substantial soil erosion or the loss of topsoil,
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse,
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property, or
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Issues Not Discussed Further

Involve soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems.
The Project would construct a roadway and as such would not produce or result in the production of wastewater. Furthermore, the Project would not require the installation or use of septic tanks or alternative waste water disposal systems. Therefore, there are no impacts related to the involvement with soils incapable of supporting the use of septic tanks or alternative wastewater disposal systems.

ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

Less than Significant Impacts

No less than significant impacts related to geology and soils were identified for this Project.

Significant and Potentially Significant Impacts and Mitigation Measures

4.8-1: The Project is located in an area that could expose people or structures to substantial adverse effects due to rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map. This is considered a potentially significant adverse impact.

The Project does not include the construction of any buildings where people would reside or congregate. However, the Project would construct a roadway alignment and associated structures (bridge) over which people could drive. The Project would cross the Green Valley fault on the West End, in the vicinity of Red Top Road. The Division of Mines and Geology Special Publication 42 reports the Green Valley fault as active and records indicate that the fault has ruptured historically. Potential seismic activity in the West End is high, particularly in the vicinity of Red Top Road. In addition, the West End is located between 0.5 and 1.3 miles west of the Cordelia Fault and the East End is located between 1.1 and 2.1 miles east of the Cordelia fault. The Cordelia Fault is also considered potentially active and is included on the Alquist-Priolo Earthquake Fault Zone Map. Therefore, potential impacts related to seismic activity are considered significant.

There are no mapped faults within the East End of the Project area. However, the area is susceptible to seismic activity arising from nearby faults, including the Green Valley and Cordelia faults.

> **Mitigation Measure 4.8-1**: To minimize potential damage from ground shaking, development associated with this Project must meet Solano County seismic safety standards, as established by the Health and Safety Element of the Solano County General Plan. All Project structures (including roadways) would be designed to the Maximum Credible Earthquake (MCE) in accordance with current design standards under the Solano County Road Improvement Standards and Land Development and Subdivision Requirements.

Significance after Mitigation: Less than significant.

4.8-2: **The Project is located in an area that has the potential to expose people or structures to substantial adverse effects due to strong seismic ground shaking caused by a moderate or major earthquake within the local vicinity.**

As discussed above, the West End is located on a portion of the Green Valley Fault and adjacent to the Cordelia Fault. Movement along one or more of the faults in the immediate area could result in strong seismic shaking in both the West End and the East End during the lifetime of the Project. Therefore, potential impacts related to seismic ground shaking are considered significant. It should be noted that the Project does not

include the construction of any buildings other than the roadway alignment and associated structures.

> **Mitigation Measure 4.8-2**: To minimize potential structural distress, the Project shall be designed and constructed according to the most current earthquake resistance standards for Seismic Zone 4, as outlined in the current California Building Code.

Significance after Mitigation: Less than significant.

4.8-3: **The Project is located in an area that has the potential to expose people or structures to substantial adverse effects due to seismic-related ground failure, including liquefaction. This is considered a potentially significant adverse impact.**

A portion of the West End of the Project alignment that connects to Red Top Road is in an area with liquefaction potential considered to be moderate to very high. Liquefaction is a condition where saturated, granular soils undergo a substantial loss of strength and suffer deformation due to pressure resulting from earthquakes. The Project area is also at risk for lurching and lateral spreading. Lurching describes the detachment, lateral movement and failure of steep slopes or cut banks and occurs as the result of strong seismically induced shaking. Lateral spreading is a potential hazard commonly associated with liquefaction where extensional ground cracking and settlement occur as a response to lateral migration of subsurface liquefiable material. The potential for ground rupture and possible shearing at the West End is high, and there is potential for seismic shaking and landslides in this area, representing a potentially significant impact. Secondary seismic effects are considered to be low, except in the vicinity of Red Top Road where potential for seismic activity is high. Additionally, there is a low to moderate potential for liquefaction in the East End during seismic events. Therefore, potential impacts due to seismic-related ground failure are considered significant.

> **Mitigation Measure 4.8-3**: Any new bridges/overcrossing structures shall be supported upon a deep foundation system, which extends through the potentially liquefiable zones and bears upon the underlying dense gravelly layers. The most suitable method(s) would be selected based on site-specific subsurface investigations conducted during the detailed design phase. Furthermore, to minimize potential liquefaction impacts, sub-excavation, dynamic compaction, or dewatering methods would be implemented during construction. The most suitable method(s) would be selected based on site-specific subsurface investigations conducted during the final design phase of the Project.

Significance after Mitigation: Less than significant.

4.8-4: **The Project is located in an area that has the potential to expose people or structures to substantial adverse effects due to landslides. This is considered a potentially significant adverse impact.**

The West End is in an area where large landslides have and may continue to occur. Large landslides have been identified along the ridgeline of SR12. Areas containing

existing landslide deposits may be subject to re-activation during a major or moderate earthquake on one of the local active faults, representing a potentially significant impact.

> **Mitigation Measure 4.8-4**: Soil investigations, including geologic mapping and soil/rock borings, shall be conducted and used in the design of the proposed grading of the Project to address issues of weak soil, existing landslides, colluvial movement and the composition of bedrock material. The investigations shall be conducted during the final design phase of the Project. In the event that potential for landslide is identified, stabilization measures, including physical reinforcement of the hillside, shall be evaluated for installation, as required by the Project Geotechnical Engineer or Engineering Geologist.

Significance after Mitigation: Less than significant.

4.8-5: The use of on-site soils for fill material during Project construction could result in substantial soil erosion or the loss of topsoil. This is considered a potentially significant adverse impact.

Inadequate fill material can lead to soil instability and erosion. The on-site bedrock-derived materials, existing fills, and native soils within the Project area can be used as general fill throughout the Project, provided they do not contain more than three percent organic material. Higher organic content in soil mixtures may be permissible in landscape areas. As a result, the use of on-site soils for fill could result in a potentially significant impact.

> **Mitigation Measure 4.8-5a**: Fill materials (within 5 vertical feet of proposed improvements) shall generally contain rock fragments no larger than 6 inches in maximum diameter. Placement of larger rock fragments or oversized material is possible at the discretion of the Project Geotechnical Engineer or Engineering Geologist in deeper fills, provided that the large fragments are not nested and proper compaction can be achieved. Select fill shall have a Plasticity Index of less than 15, a Liquid Limit of less than 40, maximum aggregate size of 4 inches and have 15 percent to 60 percent of the material passing the No. 200 sieve. Select fill shall be generated from portions of the basalt, sandstone, and some select tuff layers found within the Project area.
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> **Mitigation Measure 4.8-5b**: Due to the moderate to highly expansive nature of some materials that will be generated as fill, exposed within cut slopes, or present within the subgrade of the proposed alignment, for planning purposes new cut and fill slopes shall be planned for gradients no steeper that 2:1. If steeper slopes are required to be constructed, STA shall conduct further investigation, testing, and analysis in order to develop adequate slope design criteria and possible engineered solutions for steeper slopes. Such solutions may include: fill slope construction with select fill; engineered slopes with geotextile reinforcements; soil improvement additives such as lime; the use of retaining walls; or, a combination thereof.
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> **Mitigation Measure 4.8-5c**: Fill and cut slopes shall be constructed in accordance with the requirements of local jurisdictions.

Mitigation Measure 4.8-5d: Any undocumented fills encountered within the proposed alignment shall be removed for their full depth and replaced with compacted engineered fill, under the direction of the geotechnical engineer of record. Earthen fill materials that do not contain more than 3 percent organics can be re-used as general fill. Organic-rich fill shall not be used in areas of proposed roadway or other improvements.

Significance after Mitigation: Less than significant.

4.8-6: **The presence of high groundwater in the Project area (West End only) may result in substantial soil erosion or the loss of topsoil. This is considered a potentially significant adverse impact.**

Groundwater was encountered in 2003 at a depth of 24.6 feet and may be encountered at relatively shallow depths in the vicinity of Jameson Creek and in areas around Suisun Creek. Seepage within cut slopes is a concern with respect to erosion and stability of the cut slope face. This represents a potentially significant impact in the West End of the Project area where cuts and fills would be necessary to construct the new roadway and improvements to the SR12/Red Top Road intersection. No similar cuts and fills are anticipated for the East End, where the Project area is relatively flat. Therefore, no significant impacts for this part of the Project area are anticipated.

Mitigation Measure 4.8-6a: Special dewatering procedures shall be implemented for deep excavations below the groundwater level, depending on the time of year of construction. Special considerations to collect and control seepage, especially at material contacts/faults shall be required.

Mitigation Measure 4.8-6b: Each proposed cut area shall be evaluated for material stability and excavatibility, including providing recommended stable slope inclinations. STA will select the most suitable method(s) based on site-specific subsurface investigations. The investigations will be conducted during the final design phase of the Project.

Mitigation Measure 4.8-6c: Specific recommendations shall be provided for construction and monitoring fill construction including staged construction. STA will select the most suitable method(s) based on site-specific subsurface investigations. The investigations will be conducted during the final design phase of the Project.

Significance after Mitigation: Less than significant.

4.8-7: **Portions of the Project would be located on soil that is unstable, or that would become unstable as a result of the Project, and potentially result in soil subsidence. This is considered a significant adverse impact.**

There is potential for soil subsidence resulting in differential settlement caused by differential fill thickness across the Project area. Soil subsidence is shrinkage of the soil due to varying composition of fill materials. This would represent a significant impact.

Mitigation Measure 4.8-7: Special consideration shall be given to fill placement techniques in order to minimize the settlement potential of the deep fills. Such techniques may include: increasing relative compaction to a minimum of 95 percent (versus the standard 90 percent); surcharging the fills with additional load and later removal; dynamic compaction; use of geotextiles; or a combination thereof. STA will select he most suitable method(s) based on site-specific subsurface investigation. The investigations will be conducted during the final design phase of the Project.

Significance after Mitigation: Less than significant.

4.8-8: The West End of the Project site is located in an area that has expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property. This is considered a potentially significant adverse impact.

The West End alignment would have slopes and some of the on-site materials are expansive and prone to creep, which is the slow downhill movement of soils and weathered bedrock due to gravity.

Mitigation Measure 4.8-8: In the West End, maintenance, repair, and/or occasional replacement of the slopes and/or improvements shall be provided for on an as-needed basis for the lifetime of the Project. Other engineering solutions may also be required to reduce the potential for creep.

Significance after Mitigation: Less than significant.

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