# Chapter 11
# Soils

This chapter describes the environmental setting and study area for soils; analyzes impacts that could result from construction, operation, and maintenance of the project; and provides mitigation measures to reduce the effects of potentially significant impacts. This chapter also analyzes the impacts that could result from implementation of compensatory mitigation required for the project and describes any additional mitigation necessary to reduce those impacts, and analyzes the impacts that could result from other mitigation measures associated with other resource chapters in this Draft Environmental Impact Report (Draft EIR).

## 11.0 Summary Comparison of Alternatives

Table 11-0 provides information on the magnitude of the most pertinent and quantifiable impacts on soils that are expected to result from implementation of the alternatives and the compensatory mitigation. The table presents the CEQA finding after all mitigation is applied. If applicable, the table also presents quantitative results after all mitigation is applied.

Overall, the alternatives would be constructed on near-surface soils having very similar water erosion and wind erosion hazards. Although the southernmost portion of Alternative 5 is in an area where the near-surface soils have a slightly higher water erosion hazard than that of the soils of the other alternatives, this would be offset by the fact that the disturbance area and therefore the area of potential erosion is less because no Southern Forebay would be constructed under Alternative 5. Therefore, the overall potential impact of accelerated water and wind erosion would be similar among the alternatives.

Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c vary somewhat with respect to the extent of topsoil that would be lost from excavation and overcovering. Overall, Alternative 5 would result in a loss of topsoil less than that of the other alternatives.

Parts of all nine of the alternatives would be constructed on or in soil materials that are subject to subsidence, with the alternatives based on the eastern alignment and Alternative 5 comparatively less so because overall they would be constructed where the soil materials have a lower organic matter content or a thinner peat layer.

The alternatives overall would be constructed in areas of near-surface soils having similar expansion potential and corrosivity to concrete and uncoated steel, but with the southern portion of Alternative 5 being underlain by near-surface soils that have relatively low corrosivity to concrete. Therefore, the potential impact of corrosive soils would be lower with Alternative 5.

All of the alternatives would entail construction of temporary and permanent septic tanks or alternative wastewater disposal systems on near-surface soils that are rated as being very limited for such use. Consequently, the potential impact of a wastewater disposal system failure would be similar among all of the project alternatives.

Table ES-2 in the Executive Summary provides a summary of all impacts disclosed in this chapter.

1 **Table 11-0. Comparison of Impacts on Soils by Alternative**

| | Alternative | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Chapter 11 – Soils | 1 | 2a | 2b | 2c | 3 | 4a | 4b | 4c | 5 |
| Impact SOILS-1: Accelerated Soil Erosion Caused by Vegetation Removal and Other Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities | LTS | LTS | LTS | LTS | LTS | LTS | LTS | LTS | LTS |
| Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities | 2,797 acres/ LTS | 3,052 acres/ LTS | 2,465 acres/ LTS | 2,668 acres/ LTS | 2,324 acres/ LTS | 2,703 acres/ LTS | 1,963 acres/ LTS | 2,194 acres/ LTS | 1,302 acres/ LTS |
| Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage as a Result of Constructing the Proposed Water Conveyance Facilities on or in Soils Subject to Subsidence | LTS | LTS | LTS | LTS | LTS | LTS | LTS | LTS | LTS |
| Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive or Corrosive Soils | LTS | LTS | LTS | LTS | LTS | LTS | LTS | LTS | LTS |

| | Alternative | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Chapter 11 – Soils | 1 | 2a | 2b | 2c | 3 | 4a | 4b | 4c | 5 |
| Impact SOILS-5: Have Soils Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems Where Sewers Are Not Available for the Disposal of Wastewater | LTS | LTS | LTS | LTS | LTS | LTS | LTS | LTS | LTS |

LTS = less than significant.

# 11.1 Environmental Setting

This section describes the environmental setting for soils in the study area. Depending on the context, the terms *soil* and *soils*, as used in this chapter, refer to the upper approximately 5 feet of earthen material as mapped and classified by the Natural Resources Conservation Service (NRCS) (see the discussion below) and to any unconsolidated earthen material, irrespective of the depth at which it occurs. These terms are not used to refer to reusable tunnel material (RTM). For the purposes of this chapter, the soils study area (see Figure 11-1) refers to all areas that could involve excavation, filling, stockpiling, constructing, or otherwise disturbing the ground to construct the conveyance facilities and appurtenant features, such as tunnels, intakes, forebays, tunnel access shafts, levees, new roads and improved existing roads, power lines, temporary and permanent RTM storage areas, laydown/staging areas, and compensatory mitigation areas for all of the project alternatives. The soils study area also includes a 0.5-mile buffer beyond the footprints of these areas, except for power transmission lines, metering areas, and park-and-ride lots, which have a 0.125-mile buffer.

The soils study area was selected for the geographic scope of the analysis because all soil-related effects and constraints are restricted to the immediate location of the potential effect and possibly adjacent areas. Areas outside of the soils study area were not considered because no ground disturbance would occur in those areas.

The information is primarily based on the NRCS (formerly Soil Conservation Service) online Soil Survey Geographic (SSURGO) database, supplemented by printed soil survey reports for the five counties in the study area. Other sources used include Delta Conveyance Design and Construction Authority (DCA) project-specific reports, California Department of Water Resources (DWR) and U.S. Geological Survey data and publications, academic technical reports and publications, and county general plans.

This section describes soil characteristics in the study area with respect to the following.

- Soil associations.
- Soil chemical and physical characteristics.
- Soil suitability/limitations for various uses.
- Wind and water erosion hazards.
- Land subsidence resulting from biological oxidation of organic carbon in organic soil.

Other chapters that contain information related to soils are listed below.

- Soil resources, as they pertain to crop production (including potential salinization caused by irrigation), are discussed in Chapter 15, *Agricultural Resources*.
- Geotechnical properties of soils, as they pertain to the potential for settlement under load or as a result of tunneling, soil stability, levee stability, and liquefaction, are described in Chapter 10, *Geology and Seismicity*.
- Carbon dioxide ($CO_2$) flux to the atmosphere from oxidation of organic matter in peat soil is discussed in Chapter 30, *Climate Change*, and Chapter 23, *Air Quality and Greenhouse Gases*.

- Water quality concerns and regulatory implications associated with soil erosion and sedimentation are summarized in this chapter, but are more thoroughly discussed in Chapter 9, *Water Quality*.
- Land subsidence from groundwater extraction is described in Chapter 8, *Groundwater*.
- Ground settlement is described in Chapter 10, *Geology and Seismicity*.

This chapter does not describe the soil setting or potential project effects in the State Water Project (SWP) and Central Valley Project (CVP) export service areas. As appropriate, this topic is addressed in Chapter 31, *Growth Inducement*.

## 11.1.1 Study Area

The area evaluated for potential effects on soils is the study area, which includes portions of Sacramento, Yolo, San Joaquin, Contra Costa, and Alameda Counties.

### 11.1.1.1 NRCS Soil Associations

Because the study area is large, the soils are best described at a landscape scale, rather than at a detailed scale. NRCS maps soils at a landscape scale by mapping soil associations. Soil associations are groupings of individual soils that occur together in the landscape and are typically named after the two or three dominant soil series. For example, the dominant soil components in the Sycamore-Sailboat-Egbert soil association in Sacramento County are the Egbert and Sailboat soil series. Soil associations cover broad areas that have a distinctive pattern of soils, relief, and drainage. Figure 11-1 shows the soil associations in the study area and Appendix 11A, *Soil Associations,* describes their context in the landscape and summarizes their general characteristics. The appendix also shows which detailed soil map units occur within each association, within the study area (Soil Conservation Service 1966, 1972, 1977, 1992, 1993; Natural Resources Conservation Service 2021a). This generalized soil map (Figure 11-1) is useful for understanding the general characteristics of the soils and for comparing the suitability of large areas for general land use planning purposes. Appendix 11B, *Soil Map Units, Taxonomic Classifications, Soil Limitations, and Risk of Corrosion*, provides the detailed soil map unit names and the soils' suitability for certain uses that are relevant to the project.

Soil associations within the study area can be generally grouped based on relationships with the following physiographic settings (see Appendix 11A*).*

- Basins and delta.
- Basin rims.
- Floodplains and stream terraces.
- Valley fill, alluvial fans, and low terraces.
- Uplands.

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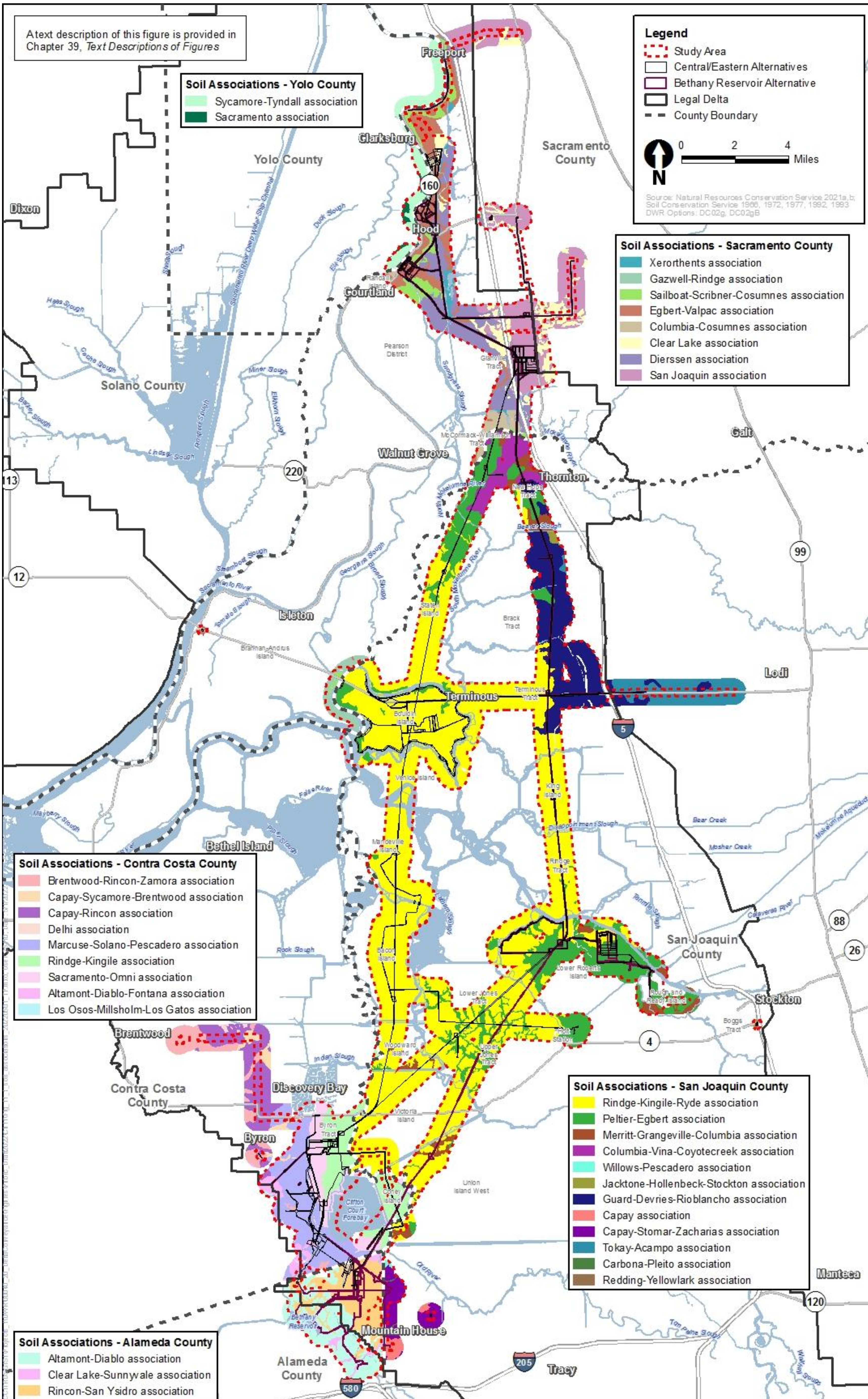


**Figure 11-1. Soil Associations**

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## Basin and Delta Soils

Basin and delta soils occupy the lowest elevations and are often protected by levees (Soil Conservation Service 1992:5, 1993:12–13). Most of these low-lying soils contain substantial organic matter content and are classified as muck or peat[1] (Soil Conservation Service 1992:11, 1993:12); Figure 11-2 shows the percent organic matter content of the upper 5 feet of soils in the study area. Examples of soil associations containing organic soils in the study area include the Egbert-Valpac association in Sacramento County (Soil Conservation Service 1993:13), the Rindge-Kingile-Ryde association in San Joaquin County (Soil Conservation Service 1992:11), and the Rindge-Kingile association in Contra Costa County (Soil Conservation Service 1992:5).

Organic soils (consisting of muck and peat) contain large accumulations of partially decomposed plant material. In muck soils, plant material is decomposed to a greater degree than in peat soils. (In this chapter, unless specified otherwise, the term *peat* is used in a general way to refer to both types of organic soils.) In the Delta, most of the near-surface soils are mucks (Natural Resources Conservation Service 2021b). In some areas, unaltered peat soils occur, which are characterized as having two layers: one relatively thin layer with plant material derived from tules (*Schoenoplectus* spp.), and an underlying, deeper layer of plant material derived from common reed, primarily *Phragmites australis* (Weir 1950:37–39). Peat soils are in the soil order Histosols. By definition, Histosols contain more than 18% organic carbon if the mineral fraction of the soil contains at least 60% clay, or more than 12% organic carbon if no clay is present). Histosols are further classified into suborders according to level of decomposition in the subsurface. Fibrists (i.e., peat) exhibit relatively minor decomposition, with fibric material dominant in the subsurface; Hemists are moderately decomposed with hemic organic matter in the subsurface; and Saprists (i.e., muck) are the most decomposed, with sapric material in the subsurface (Natural Resources Conservation Service 1999:473).

Soils along the margin of the Delta contain more mineral material and less organic matter than those in the central Delta. Mineral soils that occur in the Delta are typically fine textured with poor drainage (e.g., the Clear Lake association in Sacramento County [Figure 11-1]) (Soil Conservation Service 1993:15).

The topsoil[2] layer of the soils in this physiographic setting generally ranges between 16 and 60 inches thick, with the thickest topsoil layers occurring among the Histosols (i.e., muck soils) (Soil Conservation Service 1977:13; 1992:11; 1993:13).

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[1] NRCS differentiates organic soils from non-organic soils (i.e., “mineral” soils); the former contains 12% to 18% or more organic carbon, depending on the clay content and water saturation conditions (Natural Resources Conservation Service 2018:127–128).

[2] As used in this discussion of the specific soil characteristics in the study area, the term *topsoil* refers to the native mineral or organic (i.e., peat or muck) soil horizon(s) that have appreciable amounts of organic matter and occur in the upper part of the soil profile. In a given soil profile, these horizons may include the O, Oi, Oe, Oa, A, Ap, A1, A2, A3 horizons. (There are no soil profiles in the study area that contain all of these soil horizons.) However, where used elsewhere in this chapter, the term *topsoil* is used in a more general way to refer to the upper 12 inches that has the highest concentration of organic matter, microorganisms, and biological soil activity and has more favorable conditions for plant growth compared to lower part of the soil profile.

## Basin Rim Soils

Basin rim soils are found along the rims (edges) of basins. Soils in this physiographic setting are mineral soils that are moderately well drained to well drained and have fine textures in their surface horizons. Some areas contain soils with a claypan layer[3] in the subsurface, such as the soils in the Rincon-San Ysidro association in Alameda County near Clifton Court Forebay (Figure 11-1). Dierssen soils in western Sacramento County have a sandy clay loam texture at the surface, a calcareous clay subsoil, and a hardpan at a depth of 20 to 45 inches (Figure 11-1) and also can have a perched water table at a depth of 6 to 36 inches in winter and early spring (Soil Conservation Service 1993:46–47).[4]

The topsoil layer of the soils in this physiographic setting generally ranges between 5 and 14 inches thick (Soil Conservation Service 1992:197, 203, 248: 1993:167, 217).

## Floodplain and Stream Terrace Soils

Floodplain and stream terrace soils are mineral soils located adjacent to major rivers and other streams and may be associated with landward sediment accumulations behind natural levees. Soils are stratified, with relatively poor drainage and fine textures. Examples include Sailboat-Scribner-Cosumnes and Egbert-Valpac associations adjacent to the Sacramento River, and the Columbia-Cosumnes association other streams in Sacramento County (Figure 11-1).

The topsoil layer of the soils in this physiographic setting generally ranges between 8 and 20 inches thick (Soil Conservation Service 1992:204; 1993:162, 164).

## Valley Fill, Alluvial Fan, and Low Terrace Soils

Valley fill, alluvial fan, and low terrace soils are typically very deep with variable texture and ability to transmit water. Alluvial fan soils range from somewhat poorly drained fine sandy loams and silty clay loams (e.g., the Sycamore-Tyndall association in Yolo County). Soils on low terraces include the San Joaquin soils in Sacramento County in the vicinity of Stone Lakes National Wildlife Refuge, which are moderately well drained with a claypan subsoil and have a hardpan at a depth of 26 to 48 inches (Soil Conservation Service 1992:227). A shallow water table may be present in some areas (e.g., the Capay-Sycamore-Brentwood association in Contra Costa County [Soil Conservation Service 1977:13,16]), or a shallow water table may sometimes be present as the result of irrigation (e.g., the Capay association on interfan basins of San Joaquin County [Soil Conservation Service 1992:16]). Delhi soils are sandy, very deep and somewhat excessively drained. They occur in the Delhi association in Contra Costa County (Soil Conservation Service 1977:8).

The topsoil layer of the soils in this physiographic setting generally ranges between 5 and 26 inches thick (Soil Conservation Service 1972:33, 36; 1977:20; 1992:26; 1993:200).

[3] A naturally occurring subsurface layer of significant clay accumulation.

[4] A naturally occurring subsurface layer cemented by silica and iron.

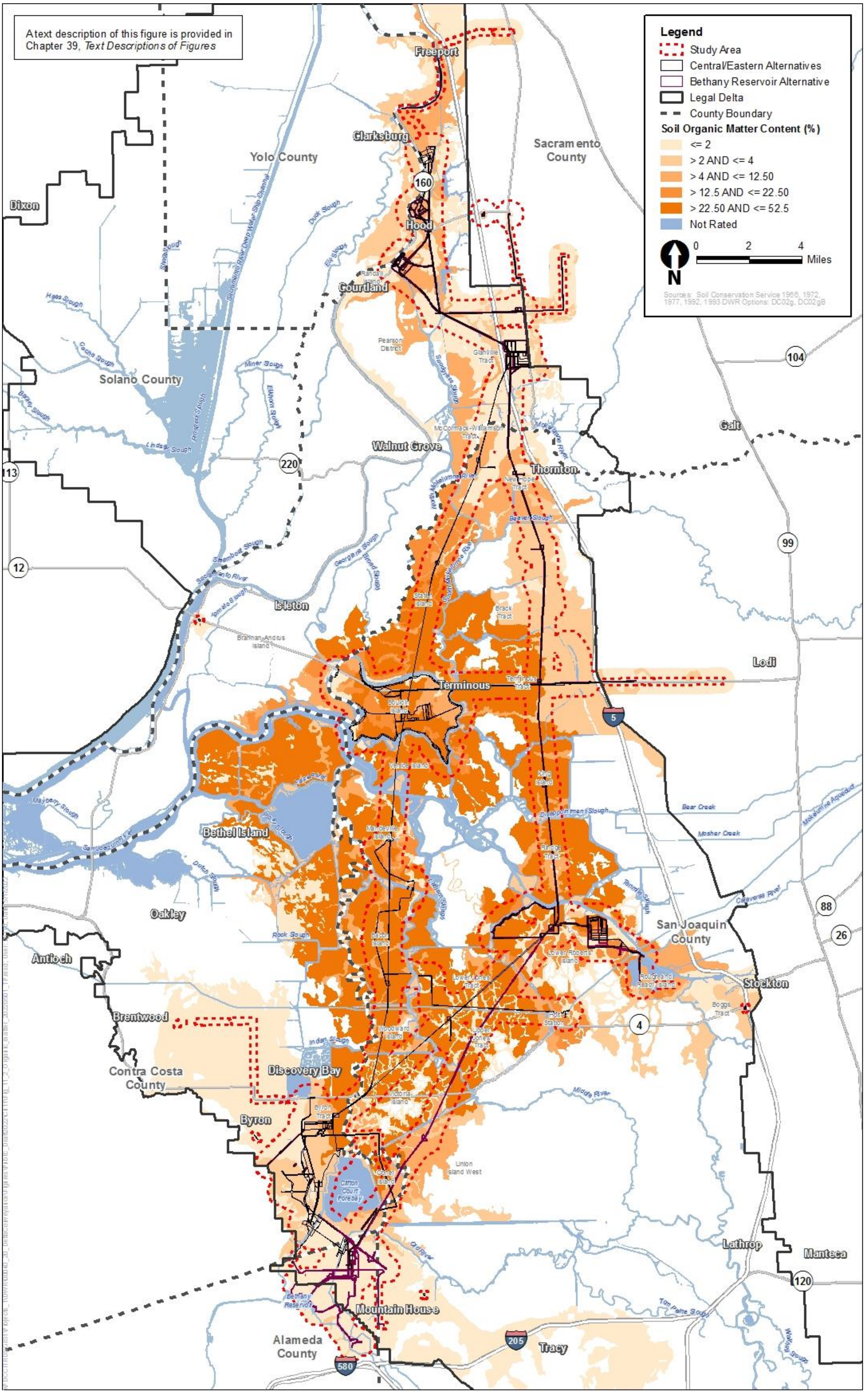


Figure 11-2. Soil Organic Matter Content in Near-Surface Soils

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### Upland Soils

Upland soils, which are of very limited extent in the study area, occur only southwest and southeast of Byron, southeast of the Byron Airport, and in the vicinity of the Bethany Reservoir. They occur on hills with slopes ranging from 5% to 15%. Limited to the Linne series, which in the study area occurs only within the Los Osos-Millsholm-Los Gatos association, the upland soils are underlain by soft sandstone and shale, are calcareous, well drained, and typically are fine-loamy throughout (Soil Conservation Service 1977:30).

The topsoil layer of the Linne series is typically 29 inches thick (Soil Conservation Service 1972:30).

## 11.1.1.2 Soil Physical and Chemical Properties

The physical and chemical properties of soil affect the way a soil "behaves" under specific land uses. These characteristics are especially important for engineering considerations. Soil suitability and limitation ratings, derived from NRCS soil survey mapping of the upper 5 feet of soil, for various engineering uses are identified in Appendix 11B, *Soil Map Units, Taxonomic Classifications, Soil Limitations, and Risk of Corrosion.* Relevant soil physical properties described in this section are expansiveness (i.e., shrink-swell potential) and erodibility by water and wind.

Physical and chemical properties of the upper approximately 5 feet of soils in the study area are detailed in Appendix 11C, *Soil Chemical and Physical Properties, Soil Interpretations, and Land Classifications*, and are described in the following sections. Other soil properties shown in Appendix 11C but not discussed below include those properties that are important for evaluation of soil suitability for agriculture, including Storie Index, Land Capability Classification, and Prime Farmland soils. A discussion of these characteristics, which are relevant to agricultural use, is provided in Chapter 15, *Agricultural Resources*.

### Expansive Soils (Shrink-Swell Potential)

Expansive soils increase in volume when wet and shrink in volume when dry. The degree of expansiveness, or shrink-swell potential, depends on the type and amount of clay content in the soil. The highest shrink-swell potential exists in soils with high amounts of smectite clays. Expansiveness can be characterized by measuring a soil's linear extensibility percent (LEP) and coefficient of linear extensibility (COLE). The LEP is the linear expression of the volume difference of natural soil fabric at 1/3-bar or 1/10-bar water content and oven dryness. The volume change is reported as percent change for the whole soil. The COLE is the change in length of an unconfined soil clod as moisture content is decreased from a moist to a dry state, reported as a percentage (Natural Resources Conservation Service 2019:618-A.41).

See Appendix 11C for the linear extensibility of the soil map units for the upper 5 feet of the soil profile. Table 11-1 shows the shrink-swell soil classes based on LEP, as defined by the *National Soil Survey Handbook* (Natural Resources Conservation Service 2019:41).

**Table 11-1. NRCS Shrink-Swell Soil Classes Based on Linear Extensibility Percent and Coefficient of Linear Extensibility**

| Shrink-Swell Class | LEP | COLE |
|---|---|---|
| Low | <3 | <0.03 |
| Moderate | 3–6 | 0.03–0.06 |
| High | 6–9 | 0.06–0.09 |
| Very High | ≥9 | ≥0.09 |

Source: Natural Resources Conservation Service 2019:618-A.41.
COLE = coefficient of linear extensibility; LEP = linear extensibility percent; NRCS = Natural Resources Conservation Service.

Figure 11-3 shows the LEP and COLE classes for the upper 5 feet of soil material. The LEP of soil materials below approximately 5 feet is not rated. Where one soil layer in the soil profile has a different LEP than other layers, the layer with the highest LEP is shown on the figure. Areas of the study area with the highest soil shrink-swell potential occur in the southwestern part of the study area (Figure 11-3). Soils with the lowest shrink-swell potential occur in the central part of the study area.

In addition to the near-surface soil expansion ratings available from the NRCS, the soil plasticity index (PI) values were measured from soil borings extending to deeper depths for 15 conveyance facility sites, such as the intakes, Southern Forebay, Bethany Reservoir Pumping Plant, and shaft sites, as shown in the Conceptual Design Phase Seismic Site Response Analysis (Final Draft) technical memorandum (Delta Conveyance Design and Construction Authority 2022a:1, 5–18). The PI is a measure of the plasticity of a soil and reflects the size of the range of water contents in which the soil exhibits plastic properties. Soils with a high PI tend to be clayey and those with a low PI tend to have little or no silt- or clay-sized particles. The type of clay mineral present also greatly affects the PI. The 15 sites at which the PI was measured cover both the central and eastern alignments and the Bethany Reservoir alignment. PI was measured at multiple depths at each site. The Conceptual Design Phase Seismic Site Response Analysis shows that the measured PI values ranged from 8 to 45 among the 15 sites. A PI greater than 17 is generally considered to be highly plastic.

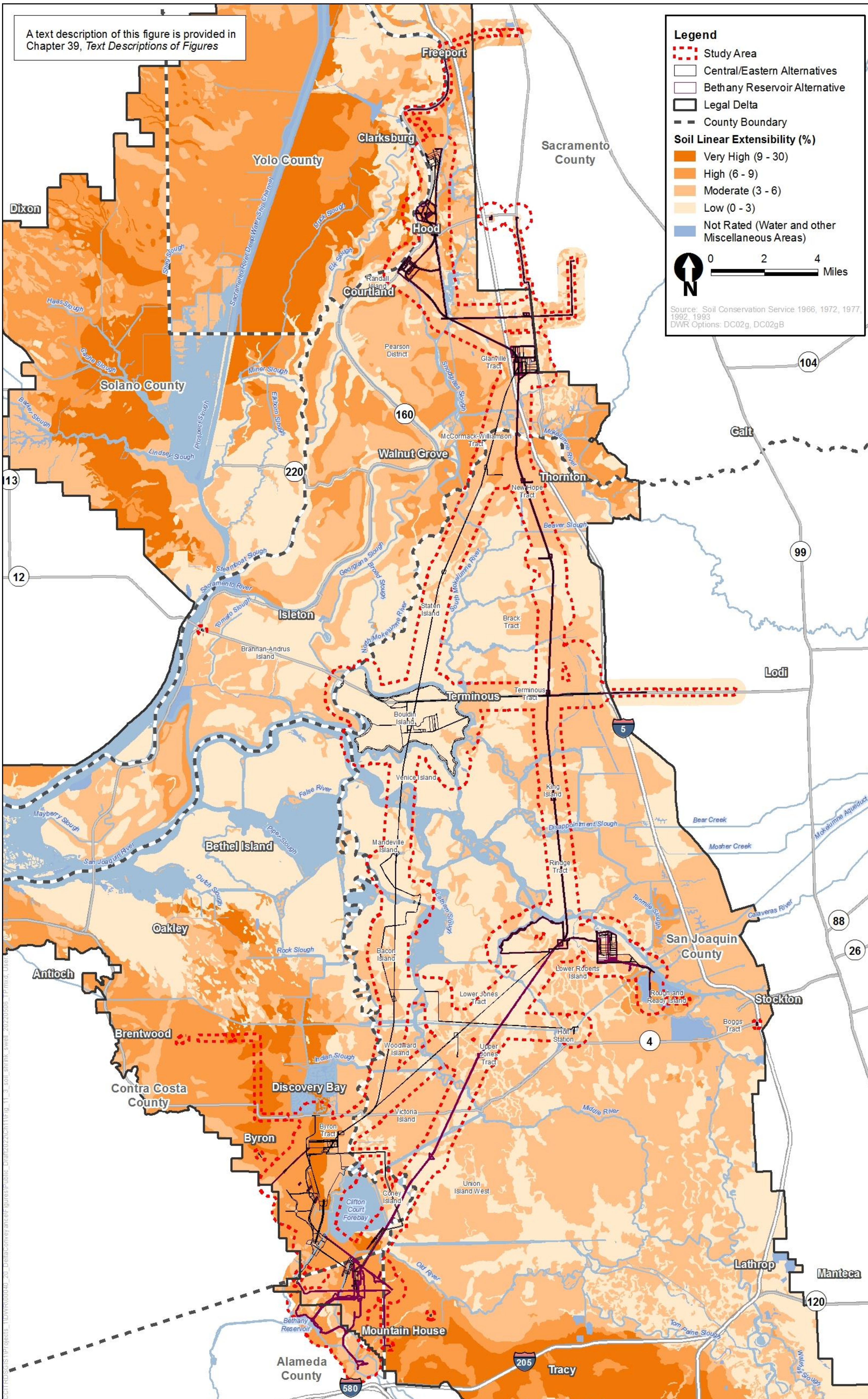


Figure 11-3. Soil Shrink-Swell Potential – Near-Surface Soils

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## Soil Compression

Soil compression is defined as a decrease in soil volume when soil is subjected to a mechanical load. Soil compression behavior is influenced by soil organic matter content, moisture content, and bulk density. Structures constructed on soils subject to compression can be damaged or fail when part or all of the structure settles under the load. Utilities connecting to the settled facilities can also be damaged.

Based on the Unified Soil Classification System, soils that are most subject to compression or that may otherwise not suitable for construction depending on the applied load without remediation include some inorganic silts and very fine sands, organic clays, and peat soils (Natural Resources Conservation Service 2012:3-27). For construction of facilities requiring fill soil (e.g., shaft pads), the Unified Soil Classification System groups that are subject to "high" or "very high" compressibility are those in groups "PT", "OL," "MH," "CH," and "OH" (Natural Resources Conservation Service 2012:3-27). Appendix 11C, *Soil Chemical and Physical Properties, Soil Interpretations, and Land Classifications*, shows the Unified Soil Classification System group for each NRCS soil map unit in the study area.

The Unified Soil Classification System group for the near-surface soils in the study area was identified using NRCS GIS-based detailed soil survey mapping data (i.e., SSURGO) (Natural Resources Conservation Service 2021b). As shown in Appendix 11C, many of the soil map units in the study area consist of soils that are in one of the five Unified classes mentioned above that would be subject to high compression or otherwise would not be suitable for use in construction without remediation. Maps of organic soils and geologic boring logs were used to infer the compressibility of soil materials below a depth of approximately 5 feet.

## Soil Erodibility by Water

Water erosion results when raindrop impact detaches soil particles and flowing water removes and transports soil material. Sheet erosion removes soil from an area in a fairly uniform manner without development of discrete channels. Rill erosion removes soil through the cutting of many small but discrete channels where runoff concentrates. Gully erosion occurs when water cuts down into the soil along the line of flow and the cut channels are deep enough that they cannot be obliterated through tillage.

Soil loss through sheet and rill erosion can be predicted through models, such as the Revised Universal Soil Loss Equation (RUSLE2). RUSLE2 predicts soil loss based on numerous factors, including rainfall erosivity, soil erodibility (defined below), slope length and steepness, vegetative cover, and management practices (U.S. Department of Agriculture Agricultural Research Service 2020).

Appendix 11C includes wind and water soil erodibility factors for each soil map unit in the study area. The soil erodibility factor (Kw) is a relative index of the susceptibility of a bare, cultivated soil to particle detachment and transport by raindrop impact and runoff, but does not reflect the influence of slope on potential erosion rates. Therefore, the erosion hazard may be low in a level area with soils that have a high Kw value. Experimentally measured Kw values vary from 0.02 to 0.69, with the higher end of the range representing soils with greater susceptibility to particle detachment and transport. Clayey and sandy soils have low Kw values because the soil particles are resistant to detachment from raindrop impact (as with clayey soils) or because of their higher infiltration capacity (as with sandy soils). Loamy soils have moderate Kw values. Silty soils are the most susceptible to water erosion, with high Kw values (U.S. Department of Agriculture Agricultural Research Service 2020).

Figure 11-4 provides water erosion hazard ratings for the surface layer of soils in the study area (Natural Resources Conservation Service 2021b). *Erosion hazard* refers to the degree to which a soil will be subject to accelerated erosion[5] rates when the land surface is disturbed. Erosion hazard is primarily controlled by the RUSLE2 soil erodibility factor and the steepness of the slope. The soil survey hazard ratings shown in Figure 11-4 are based on sheet or rill erosion in areas outside of roads and trail areas, where 50%–75% of the land surface has been exposed by ground-disturbing activities.[6] Hazard ratings range from "slight," which indicates that erosion is unlikely under ordinary climatic conditions, to "very severe," which indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical (Natural Resources Conservation Service 2019). The ratings show the relative water erosion hazard that would exist during construction or other ground-disturbing activities. Because of the level to nearly level slopes, water erosion hazard is rated as "slight" throughout nearly all of the study area. In more sloping areas, specifically in the vicinity of the Bethany Reservoir, the erosion hazard is generally "moderate."

### Soil Erodibility by Wind

Soil erodibility by wind is related to soil texture, organic matter content, calcium carbonate content, rock fragment content, mineralogy, and moisture content. NRCS assigns soil map units to one of nine wind erodibility groups (WEGs) based on susceptibility to blowing: 1, 2, 3, 4, 4L, 5, 6, 7, and 8, progressing from the most to the least susceptible (Natural Resources Conservation Service 2019:618-A.99). The WEGs assume that the soil that has been cultivated or is bare. Appendix 11C shows the WEGs of the soil map units in the study area; the appendix shows that the map units consisting of sandy and organic soils are most susceptible to wind erosion. The organic soils of the central Delta have a high susceptibility to wind erosion, as indicated by their classification in WEGs 1 through 3. Figure 11-5 shows much of the study area is underlain by surface layer soils that have a relatively high wind erosion hazard.

[5] *Accelerated erosion* refers to the increased erosion rates, largely the consequence of human activities, that are greater than natural erosion rates.

[6] For the purpose of this analysis, the erosion hazard rating for areas of Histosols and mucky mineral soils was modified from that provided in the SSURGO database to compensate for the influence of high organic matter content on the rating. The Histosols and mucky mineral soils in the study area typically have a very low Kw value (i.e., 0.02). This low soil erodibility, combined with level to nearly level slopes, results in a "slight" erosion hazard in such areas; this characterization is consistent with the printed versions of the county soil survey reports (Soil Conservation Service 1966, 1972, 1977, 1992, 1993).

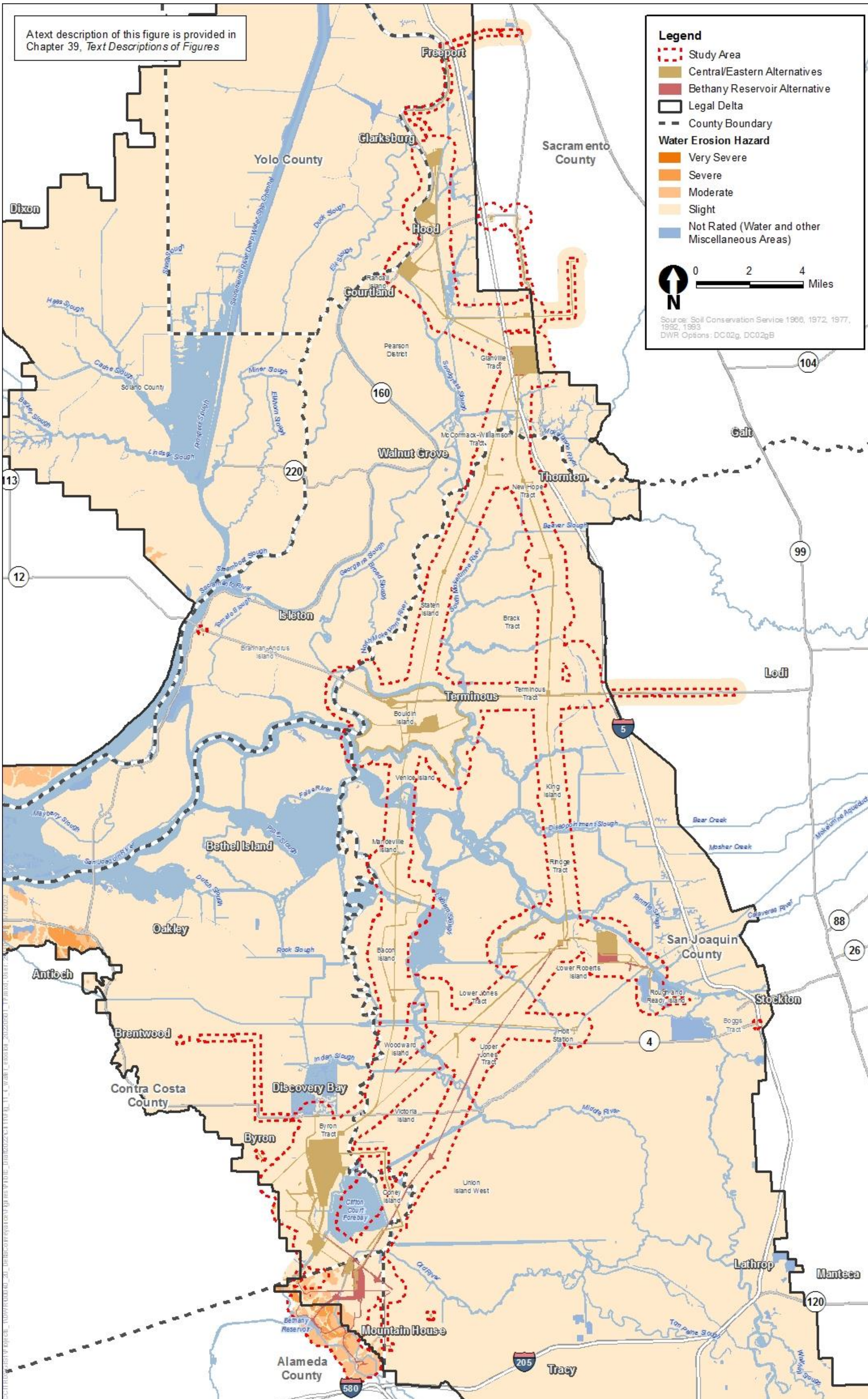


Figure 11-4. Water Erosion Hazard

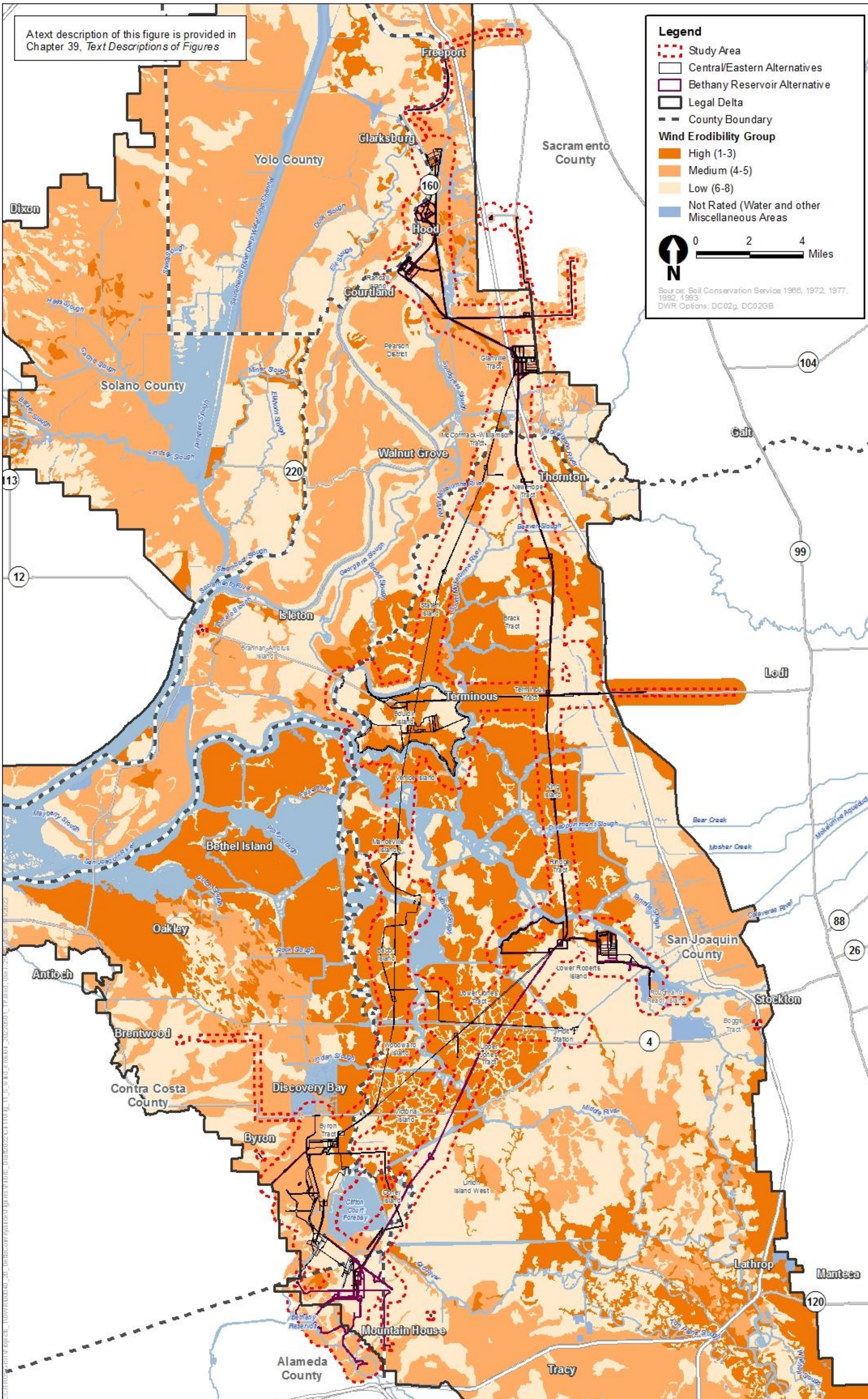


Figure 11-5. Wind Erosion Hazard

#### 11.1.1.3 Soil Suitability and Use Limitation Ratings

Physical and chemical properties of soils are used by NRCS to determine suitability for various uses, such as for agriculture, levee construction, urban development, or wildlife habitat (Soil Survey Staff 2021). Soil suitability for agricultural use is evaluated in Chapter 15, *Agricultural Resources*. NRCS suitability and use limitation ratings for soil use in embankments, dikes, and levees; shallow excavations; and corrosivity are identified in Appendix 11B, *Soil Map Units, Taxonomic Classifications, Soil Limitations, and Risk of Corrosion.*

##### Limitations for Embankments, Dikes, and Levees

Construction of embankments, dikes, and levees or other fills requires soil material that is resistant to seepage, piping, and erosion and that has favorable compaction characteristics. Soils with limited suitability for construction of embankments and levees include those with high organic matter content, high stone content, elevated sodium, high shrink-swell potential, and high gypsum (calcium sulfate) content (Soil Survey Staff 2021).

Appendix 11B provides soil use limitation ratings for use for embankments, dikes, and levees or other fills for each soil map unit. The rating is given for the whole soil, from the surface to a depth of approximately 5 feet, based on the assumption that soil horizons will be mixed in loading, dumping, and spreading. The ratings do not indicate the suitability of the undisturbed soil for supporting the fill. Soil properties to a depth of the fill height have an effect on the performance and safety of the embankment (e.g., low-density and soft soils in the supporting foundation generally have low strength and are subject to excessive settlement and failure); therefore, geotechnical studies must generally be made to evaluate suitability as load-bearing surfaces. Nearly all soil map units in the study area have some restrictions associated with use for fills, and the suitability of most soil types for these features is very limited without amendments (Appendix 11B).

##### Limitations for Shallow Excavations

Shallow excavations are trenches or holes dug in the soil for construction of pipelines, telephone and power transmission lines, basements, and open ditches. These excavations are most commonly made by trenching machines or backhoes. The limitation ratings are designated as “slight,” “somewhat limited,” “limited,” and “very limited” based on the soil properties that influence ease of excavation and resistance to sloughing. Restrictive properties adversely influence the ease of digging. Presence of a seasonal high water table and flooding may restrict the period when excavations can be made. Slope influences the ease of using machinery and accessibility. Soil texture and depth to water table influence the resistance of the walls of an excavation to sloughing (Soil Survey Staff 2021).

The limitations for shallow excavations in the study area are predominantly a result of caving potential of clay soils, slopes greater than 15%, soil saturation at less than 2.5 feet depth, and presence of high organic matter content to a depth of 20 inches below the ground surface (Soil Survey Staff 2021). Nearly all soil map units in the study area have some restrictions associated with shallow excavations, and many soil map units have a rating of very limited (Appendix 11B).

### Limitations for Septic Tank Absorption Fields

Septic tank absorption fields, commonly called leach fields, are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. NRCS soil map units are rated for their suitability based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. Saturated hydraulic conductivity (Ksat), depth to a water table, ponding, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Subsidence interferes with system installation and maintenance. Only that part of the soil between depths of 24 and 60 inches is evaluated and rated (Soil Survey Staff 2021).

The ratings are both descriptive and numerical. The descriptive rating class indicates the extent to which a soil is limited by all of the soil features that affect the specified use. The rating "not limited" indicates that the soil has features that are very favorable for the specified use. Good system performance and very low maintenance can be expected. A rating of "somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. A soil rating of "very limited" indicates that the soil has one or more features that are unfavorable for the specified use. These limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor system performance and high maintenance can be expected (Soil Survey Staff 2021).

For the central alignment, temporary or permanent septic tank absorption fields or other wastewater disposal systems would be constructed at the intakes (between one and three depending on the alternative), the Twin Cities Complex, the Bouldin Island launch shaft site, the Byron Tract working shaft site, and the South Delta Pumping Plant. For the eastern alignment, disposal systems would be constructed at the intakes (between one and three depending upon the alternative), the Twin Cities Complex, the Lower Roberts Island launch/reception shaft site, the Byron Tract working shaft site, and the South Delta Pumping Plant. For the Bethany Reservoir alignment, disposal systems would be constructed at the intakes, the Twin Cities Complex, the Lower Roberts Island double launch shaft site, and the Bethany Reservoir Pumping Plant. All other facilities would be served by portable rest rooms and therefore would not require absorption fields.

A review of the NRCS soil map units underlying the absorption field locations indicates that all are underlain by soils with a rating of "very limited" for use for septic tank absorption fields (Natural Resources Conservation Service 2021b). Such a limitation rating indicates that poor system performance and high system maintenance can be expected, as previously described.

## 11.1.1.4 Risk of Corrosion to Uncoated Steel

Uncoated steel corrodes when soil-induced electrochemical or chemical actions convert iron from steel into its respective ions and cause the uncoated steel to dissolve or weaken. The rate of deterioration of uncoated steel is influenced by soil moisture content, soil texture, acidity, and soluble salt content. NRCS (2019:Part 618.80) provides three classes of corrosion risk to uncoated steel ("low," "medium," and "high"); Table 11-2 shows the NRCS guidance[7] for estimating corrosion

[7] Other systems for identifying the hazard of soil corrosion on uncoated steel have been developed (e.g., Caltrans guidelines). The NRCS soil corrosivity rating system is used in this document because the NRCS near-surface soil mapping data are available for the entire study area.

risk. (For steel structures that would be buried deeper than 5 feet, the soil corrosion potential for these structures would be evaluated at specific facility locations during project design.)

**Table 11-2. Guidance for Estimating Corrosion Risk to Uncoated Steel**

| | Limits | | |
|---|---|---|---|
| Property | Low | Moderate | High |
| Internal free water occurrence class (or drainage class) and general texture group | • Very deep internal free water occurrence (or excessively drained to well drained) coarse to medium textured soils; or<br>• Deep internal free water occurrence (or moderately well drained) coarse textured soils; or<br>• Moderately deep internal free water occurrence (or somewhat poorly drained) | • Very deep internal free water occurrence (or well drained) moderately fine textured soils; or<br>• Deep internal free water occurrence (or moderately well drained) moderately coarse and medium textured soils; or<br>• Moderately deep internal free water occurrence (or somewhat poorly drained) moderately coarse textured soils; or<br>• Very shallow internal free water occurrence (or very poorly drained) soils with a stable high water table | • Very deep internal free water occurrence (or well drained) fine textured or stratified soils; or<br>• Deep internal free water occurrence (or moderately well drained) moderately fine and fine textured or stratified soils; or<br>• Moderately deep internal free water occurrence (or somewhat poorly drained) medium to fine textured or stratified soils; or<br>• Shallow or very shallow internal free water occurrence (or poorly or very poorly drained) soils with a fluctuating water table |
| Total acidity (cmol(+)/kg-1 <10) | <10 | 1–25 | ≥25 |
| Conductivity of saturated extract (dS/m-1) | <1 | 1–4<br>4–10 for saturated soils | >4<br>>10 for saturated soils |
| Resistivity at saturation (ohm/cm) | >5,000 | 2,000–5,000 | <2,000 |

Source: Natural Resources Conservation Service 2019:Part 618.80.
cmol = centimoles of positive charge per kilogram; dS/m = deciSiemens per meter; ohm/cm = ohms per centimeter.

In the study area, many of the soil map units are rated as having a high potential to cause corrosion to uncoated steel (Figure 11-6 and Appendix 11B). (Site-specific testing of soil corrosivity to uncoated steel would be conducted by DWR at conveyance facilities that would involve installation of steel components, if used.)

### 11.1.1.5 Risk of Corrosion to Concrete

Corrosion to concrete results from a chemical reaction between a base (the cement) and a weak acid (the soil solution). Construction of facilities may need to use special types of cement when local soils have a high risk of corrosion (Natural Resources Conservation Service 2019:618.81). The rate of concrete deterioration depends on soil texture and acidity, the amount of sodium, or magnesium sulfate and calcium sulfate (gypsum) present in the soil. In particular, soils containing gypsum generally require a special cement to reduce the risk of corrosion. The NRCS *National Soil Survey*

*Handbook*[8] (Natural Resources Conservation Service 2019) classifies risk of corrosion to concrete as low, moderate, or high, in accordance with the guidelines provided in Table 11-3. (For concrete structures that would be buried deeper than 5 feet, the soil corrosion potential for these structures would be evaluated at specific facility locations during project design.)

**Table 11-3. Soil Classification for Risk of Corrosion to Concrete**

| | Limits | | |
|---|---|---|---|
| Property | Low | Moderate | High |
| Texture and Reaction | Sandy and organic soils with pH >6.5 or medium and fine textured soils with pH >6.0 | Sandy and organic soils with pH 5.5 to 6.5 or medium and fine textured soils with pH 5.0 to 6.0 | Sandy and organic soils with pH <5.5 or medium and fine textured soils with pH <5.0 |
| Sodium and/or Magnesium Sulfate (ppm) | <1,000 | 1,000–7,000 | >7,000 |
| Sodium Chloride (ppm) | <2,000 | 2,000–10,000 | >10,000 |

Source: Natural Resources Conservation Service 2019:618.81.
pH = measure of acidity or alkalinity; ppm = parts per million.

In the study area, the soil map units are rated as having a low to high potential to cause corrosion to concrete (Figure 11-7 and Appendix 11B). (Site-specific testing of soil corrosivity to concrete would be conducted by DWR at conveyance facilities that would involve installation components consisting of concrete.)

[8] Other systems for identifying the hazard of soil corrosion on concrete have been developed (e.g., Caltrans guidelines). The NRCS soil corrosivity rating system is used in this document because the NRCS near-surface soil mapping data are available for the entire study area.

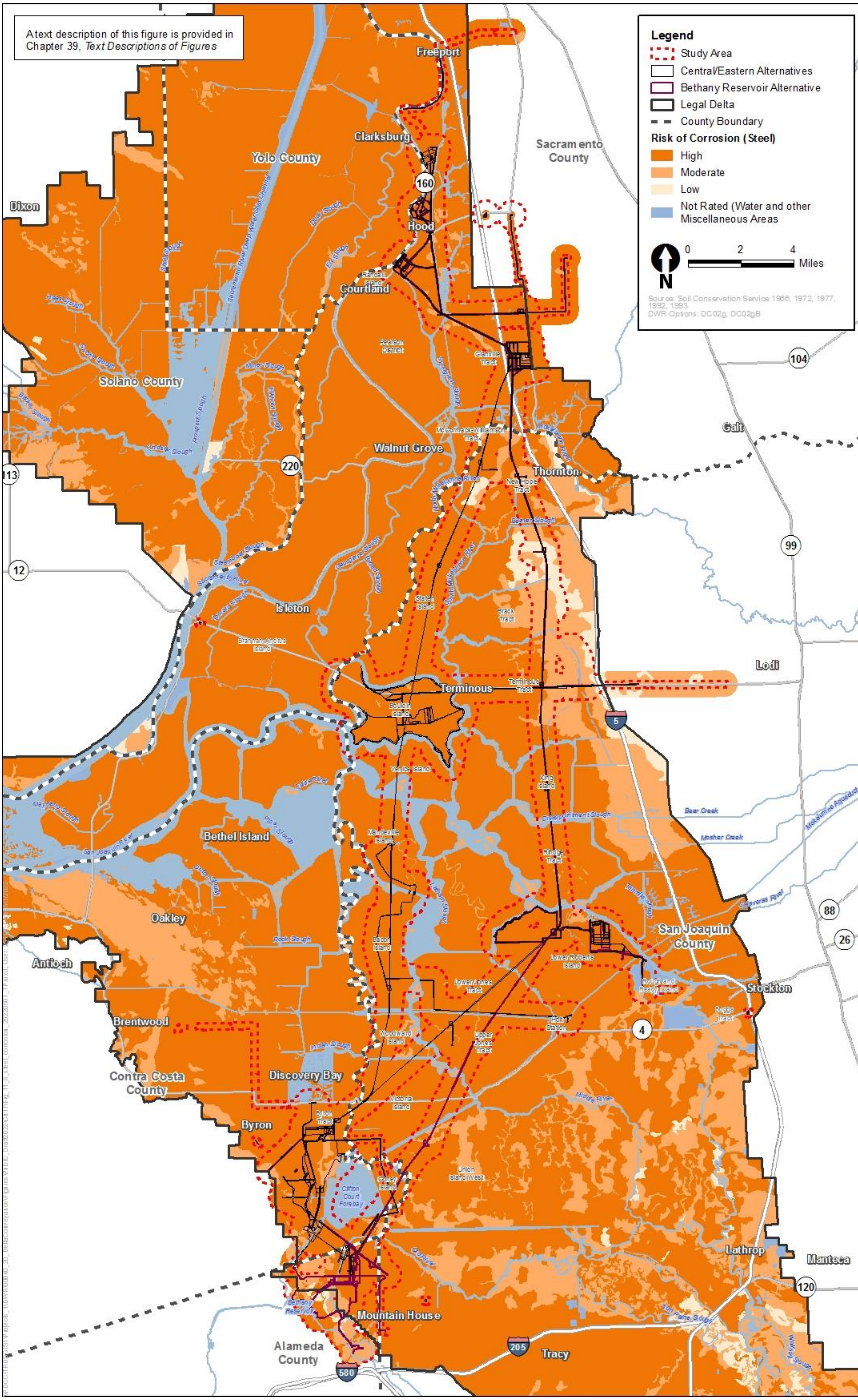


Figure 11-6. Risk of Corrosion to Uncoated Steel – Near-Surface Soils

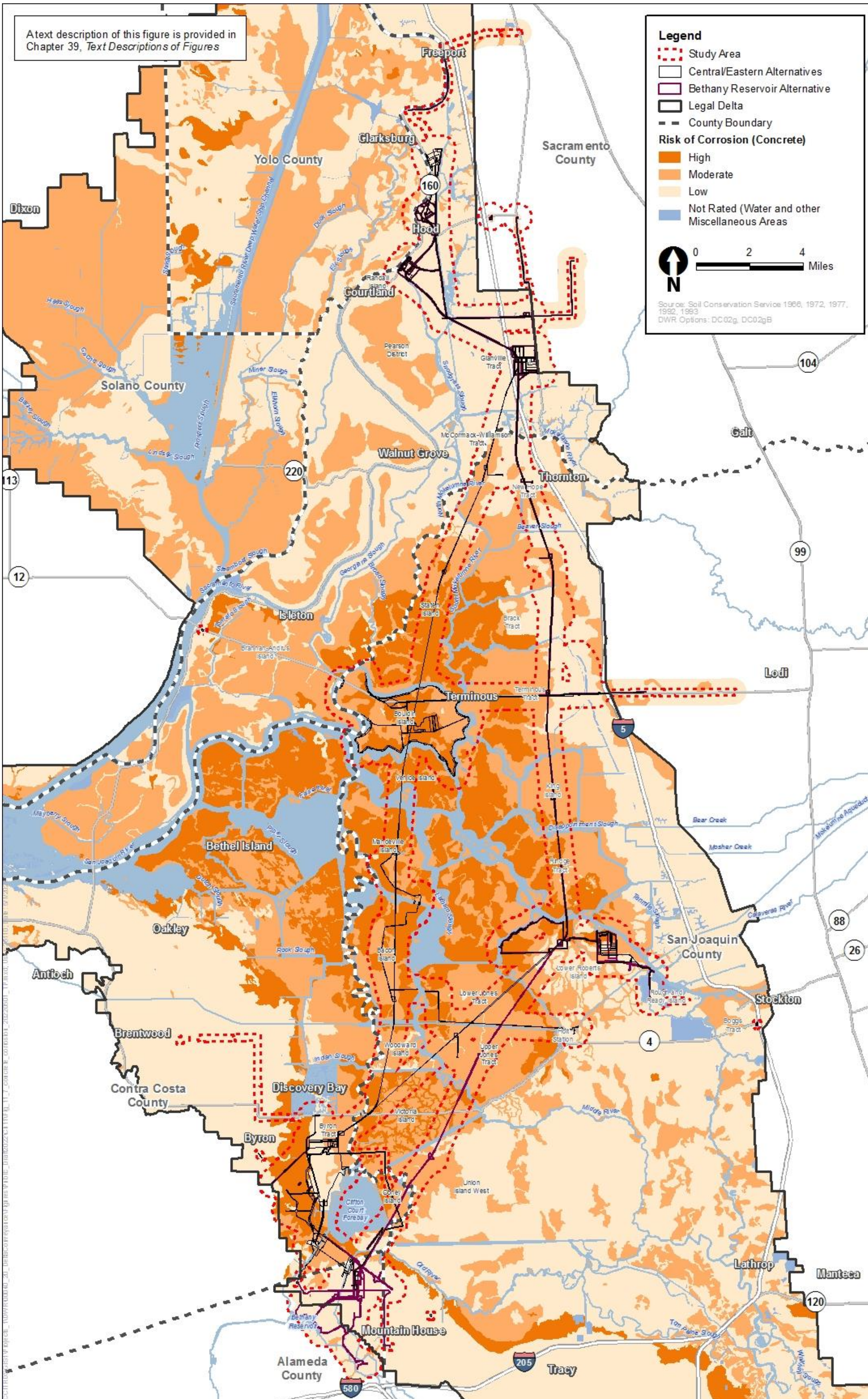


Figure 11-7. Risk of Soil Corrosion to Concrete – Near-Surface Soils

## 11.1.2 Land Subsidence

Land subsidence is a gradual settling or sudden sinking of the Earth's surface resulting from subsurface movement of earth materials (U.S. Geological Survey 2000a:1). Although subsidence can have various causes, such as aquifer compaction, drainage of organic soils, underground mining, extraction of oil and natural gas, natural compaction, tectonic movement (changes resulting from movements in the Earth's crust), and sinkholes, the primary cause in the Delta is drainage and subsequent decomposition of organic carbon in the peat soils. Under levees, soil consolidation has contributed to subsidence. This section summarizes the findings of scientific and technical literatures on land subsidence in the Delta.

### 11.1.2.1 History of Subsidence in the Delta

For more than 7,000 years, a balance existed between sediment influx to the Delta, production of organic sediment in the Delta, and export of sediment to San Francisco Bay. During this time, marsh conditions were supported. Much of the area was covered with dense stands of tules (*Schoenoplectus* spp.), with riparian plant species occupying higher stream banks (natural levees) where soils with a higher mineral content were present. The land elevation was at or near sea level, and the land surface was inundated at high tide and when flood conditions were present. Equilibrium conditions promoted the development of peat soils (Weir 1950:37) which reached up to 65 feet in thickness in the central Delta (Whipple et al. 2012:125) The thickness of organic soil material is greatest on islands of the central Delta. Figure 11-8 shows the total thickness of the organic soil material,[9] which extends well below the 5-foot depth typically described in NRCS soil surveys. The areas with the thickest organic soil material include southern Grand, southern Tyler, southern Brannan, Twitchell, northern and southern Sherman, Venice, Medford, and western Bouldin Islands in Sacramento and San Joaquin Counties. As shown on Figure 11-8, organic soil material within the study area, where present, ranges from approximately less than 5 to 30 feet thick (California Department of Water Resources 2009:Figure 6-34).

This equilibrium was first disrupted when large volumes of sediment influx occurred from hydraulic mining in the mid-1800s, then by subsequent reclamation of Delta tule marsh islands that took place from the late 1800s through about 1930. With passage of the Swamp and Overflow Act of 1850 (when title of lands in the Delta passed from federal to state control), the marshlands began to be drained for conversion to agricultural use. Levees were constructed around Delta islands to exclude floods and tidal overflow (Whipple et al. 2012:25). Much of the construction material was channel sediment excavated by a clamshell dredge. Following levee construction, tule marshes on island interiors began to die and were burned, drainage ditches were constructed along the interior of levees, and pumps were installed to transfer drainage water from the island interiors into the adjacent waterways (Weir 1950:40). The land was cultivated when it was dry enough for plowing.

The "ages" of Delta islands are related to the date they were reclaimed. For example, Lower Jones Tract was drained and put into cultivation in 1902, cultivation on Bacon Island began in 1915, and Mildred Island was first farmed in 1921. Most of the Delta was in cultivation in 1922, when land subsidence was first investigated (Weir 1950:43). The Delta's present form dates to the 1930s, when

[9] The original source of Figure 11-8 (California Department of Water Resources 2009:Figure 6-34) does not define *organic soils* but is assumed to be those soil materials with a minimum of 12% organic matter content.

approximately 100 islands and tracts had been drained and more than 1,100 miles of levees had been constructed (U.S. Geological Survey 2000b:1).

### 11.1.2.2 Historical Causes of Subsidence in the Delta

The primary cause of land subsidence in the Delta has been attributed to microbial decomposition of peat soils (U.S. Geological Survey 2000b:1; Deverel and Rojstaczer 1996:2362). Waterlogged soils contain little oxygen, which is necessary for microbial decomposition of organic matter. Under these anaerobic conditions, organic matter from plant materials accumulates faster than it can decompose. When the Delta islands were drained for agricultural cultivation, the formerly saturated, oxygen-poor soils became oxygen-rich, and conditions favored microbial oxidation. When organic carbon is oxidized from peat soils, it is emitted as $CO_2$ gas to the atmosphere, thereby reducing the soil carbon pool and soil volume (Deverel and Rojstaczer 1996:2361, 2364), resulting in subsidence.

Other processes that may be contributing to land subsidence in the Delta are discussed below.

- **Soil compaction caused by consolidation and farm equipment.** Shrinkage, consolidation, and compaction are responsible for the initial subsidence, specifically within about the first 3 years after the water table is lowered. After this, a degree of stability is reached and subsidence declines to a steady rate, primarily because of oxidation (Natural Resources Conservation Service 2019:618–A.77). However, the peat soil under levees has continued to subside as it consolidates under continued additions of soil material added to the levees to maintain the freeboard and prevent overflow by high water levels.
- **Aerobic decomposition and resultant soil shrinkage.** The primary mechanism of present-day subsidence appears to be the result of microbial oxidation of organic carbon contained in the soils (Deverel and Leighton 2010:4).
- **Burning.** This practice was common between 1900 and 1950, and was used to add nutrients to the soil, expose fresh peat, and control weeds and disease. Burning was especially common during World War II, when potatoes and sugar beets, crops with a high potassium requirement, were most in demand. Each burning event could result in a loss of 3–5 inches of soil, and fields were typically burned every 5 to 10 years (Weir 1950:51–52). Burning has not been performed routinely since the 1960s.
- **Wind erosion.** Wind erosion was estimated to result in the removal of 0.25–0.5 inch of topsoil per year. Peat soils have a low bulk density (often less than 1 gram per cubic centimeter before decomposition). During cultivation, clouds of dust surround tractors unless the soil is moist. If bare soils are exposed when fields are not being cropped, such as occurred historically on asparagus fields in the springtime, large amounts of soil can be lost to wind erosion (Weir 1950:53).
- **Dissolution of organic matter.** This process is estimated to account for only about 1% of observed subsidence (Deverel and Rojstaczer 1996:2366).

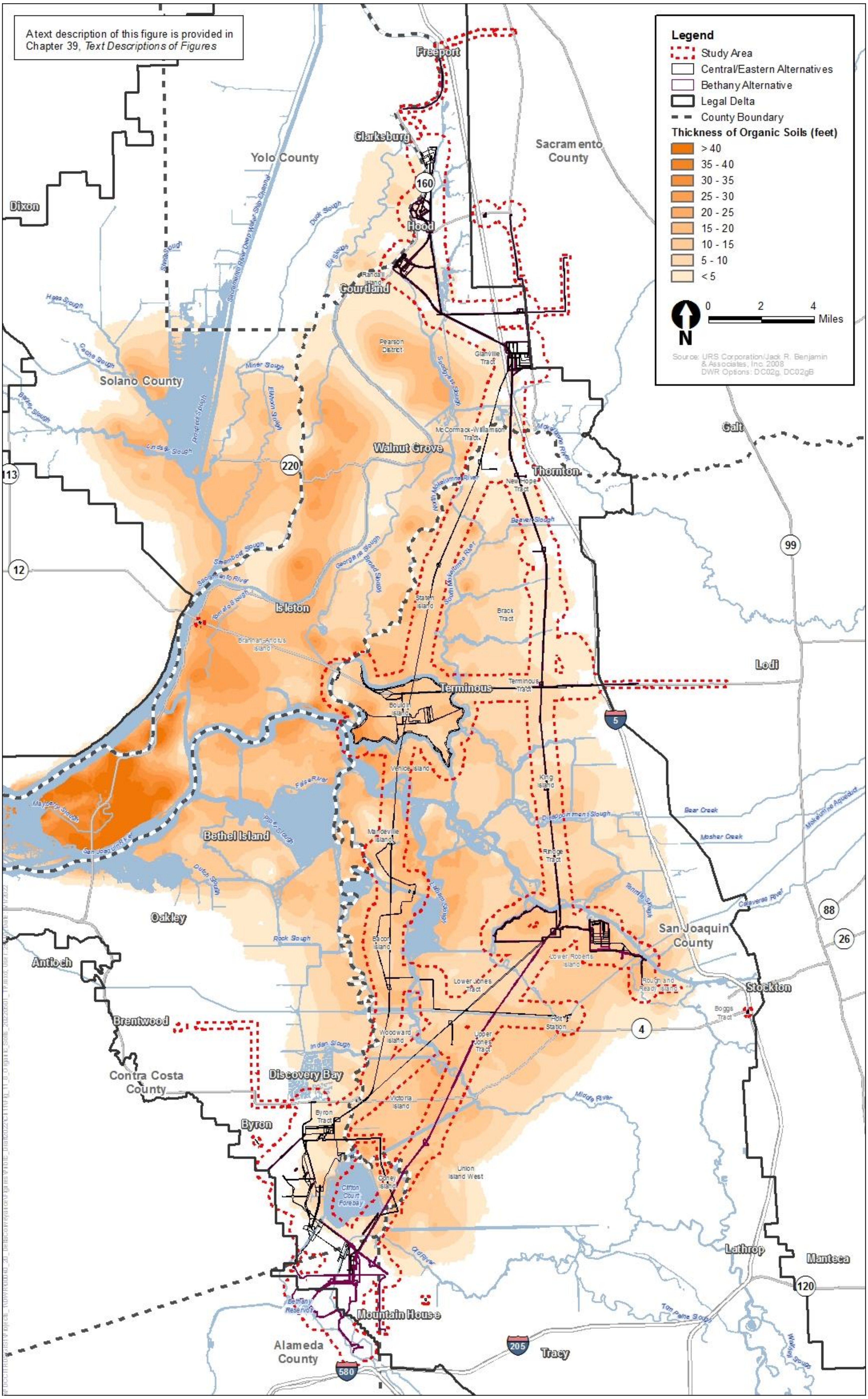


Figure 11-8. Thickness of Organic Soils

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- **Water, oil, and gas extraction.** Synthetic aperture radar interferometry (a method of remote sensing used to generate maps of surface deformation or digital elevation) data suggests that the elevation of McDonald Island rises and falls with the injection and withdrawal gas cycles from the Pacific Gas and Electric Company gas storage system. Although slight groundwater-induced subsidence may occur during the summer months, elevations rebound during the winter months. On the other hand, groundwater extraction has historically resulted in substantial subsidence in the San Joaquin Valley outside of the Delta, and reduced imported water deliveries could lead to increased groundwater reliance and renewed subsidence in the areas outside of the Delta (U.S. Geological Survey 2000b:3).

### 11.1.2.3 Rates of Subsidence and Current Conditions

The rate of decomposition of organic soils is related to temperature, moisture, and other conditions (Buol et al. 1980:312). The microbial activity that drives the oxidation of peat soils approximately doubles with a 10-degree Fahrenheit increase in soil temperature. However, the rate of $CO_2$ loss is reduced when soils are wet and contain little oxygen (Deverel and Rojstaczer 1996:2366). Therefore, activities that increase oxygen in the subsurface (e.g., construction of underdrains to improve drainage) lead to decomposition of peat soils and levees, and the rate of decomposition increases during warmer times of the year.

Historical subsidence rates in the Delta have been found to strongly correlate with the organic matter content of the soil and the age of the reclaimed island (Rojstaczer and Deverel 1995:1166). In 1948, Lower Jones Tract, Mildred Island, and Bacon Island were all between 10 and 11 feet below sea level and were continuing to subside at the rate of 3–4 inches per year. Rojstaczer and Deverel (1995:1163) quoted sources that suggest historical subsidence rates ranged from 1.8 to 4.6 inches per year, with higher rates associated with areas in the central Delta. U.S. Geological Survey (2000b:1) indicated that long-term average rates of subsidence are 1–3 inches per year.

Subsidence rates in the Delta in general have decreased substantially since the first half of the twentieth century, as a result of cessation of burning, reduced wind erosion from changes in cropping, and depletion of organic carbon (Deverel et al. 2016:5).

However, more recent, high resolution satellite data from 2015 to 2020 were used to track surface and levee elevations and ground deformations of Victoria and Bouldin Islands and the Rindge Tract (which are crossed by the tunnel alignments), as described in the InSar Monitoring Study technical memorandum (Delta Conveyance Design and Construction Authority 2022b). On Victoria Island, the study found that the center of the island was slightly uplifting from 2015 to 2016, but since 2017, a pattern of very localized and strong subsidence was detected. The Victoria Island levees were determined to be relatively stable over time, with deformation rates of less than ¼ inch per year), except in 2015 where localized and permanent subsidence was measured at a rate more than ½ inch per year (Delta Conveyance Design and Construction Authority 2022b:27).

Bouldin Island was the only island of the three that was determined to be subsiding as a whole and in which a general subsidence trend was measured, and with subsidence of approximately ½ inch per year of the southern levee of the island from 2015 to 2020.

On the Rindge Tract, the levees were determined to be relatively stable over time, except in 2015, 2017 and 2019 for the northwestern levee, where strong localized subsidence was measured, locally reaching ¼ to ½ inch per year. Rojstaczer and Deverel (1993:1384) and Mount and Twiss (2005:10) also showed that subsidence rates specifically on Lower Jones Tract, Mildred Island, and Bacon

Island have slowed with time. Deverel and Rojstaczer (1996:2366) found that, while a certain amount of subsidence was caused by seasonal fluctuation in water table elevations, subsidence due primarily to biological oxidation of peat soils on three islands (Jersey Island, Orwood Tract, and Sherman Island) occurred at a rate of 0.27 inch per year, 0.32 inch per year, and 0.18 inch per year, respectively, in the 1990s. Dissolved organic carbon flux contributed less than 1% of the measured subsidence. Flux of dissolved organic carbon was greater and pH was lower in drainage waters when water table levels were seasonally located in soil layers containing highly decomposed organic matter.

Geographically, the soils within the centers of Delta islands typically have greater organic matter content than those near the margins and close to the natural levees. Consequently, the center areas also experience greater subsidence, and the land surface tends toward a saucer shape with the lowest elevation at island centers. Since drainage and cultivation began in the 1850s, many of the Delta islands are now 10 to more than 26 feet below sea level (U.S. Geological Survey 2000b:1; Deverel and Leighton 2010:1). Figure 11-9 shows the existing generalized elevations throughout most of the study area.[10] Based on the understanding that Delta islands originally were likely at or slightly above sea level because they were subject to tidal influence (Whipple et al. 2012:67), areas that are at elevations lower than approximately -5 feet are inferred to have subsided. The figure shows that the maximum subsidence within the study area is to an elevation below -15 feet sea level, which primarily occurs on Staten, Bouldin, Mandeville, and Bacon Islands and on the Webb Tract (California Department of Water Resources 2009:Figure 5-14).

Drainage ditches now maintain the water table at about 2.5–5 feet below the land surface. In areas undergoing continuing subsidence, however, ditches must be deepened periodically to keep the water table below the crop root zone.

Some recent estimates, including those developed as part of the DWR’s Delta Risk Management Strategy, predict that 3–4 feet of additional subsidence will occur in the central portion of the Delta by 2050 (California Department of Water Resources 2009:25). Deverel and Leighton (2010:21) predicted that decreases in elevation from 2007 to 2050 will range from approximately 2 inches to more than 4.3 feet, with the largest elevation declines to occur in the central Delta and lesser declines in elevation to occur in the western, northern, and southern Delta.

[10] Figure 11-9 shows elevations that are up to 15 feet above mean sea level. The DWR mapping (California Department of Water Resources 2009:Figure 5-14) conducted to prepare the figure presumably did not extend above elevation 15 feet presumably because subsidence would not affect elevations that are above 15 feet.

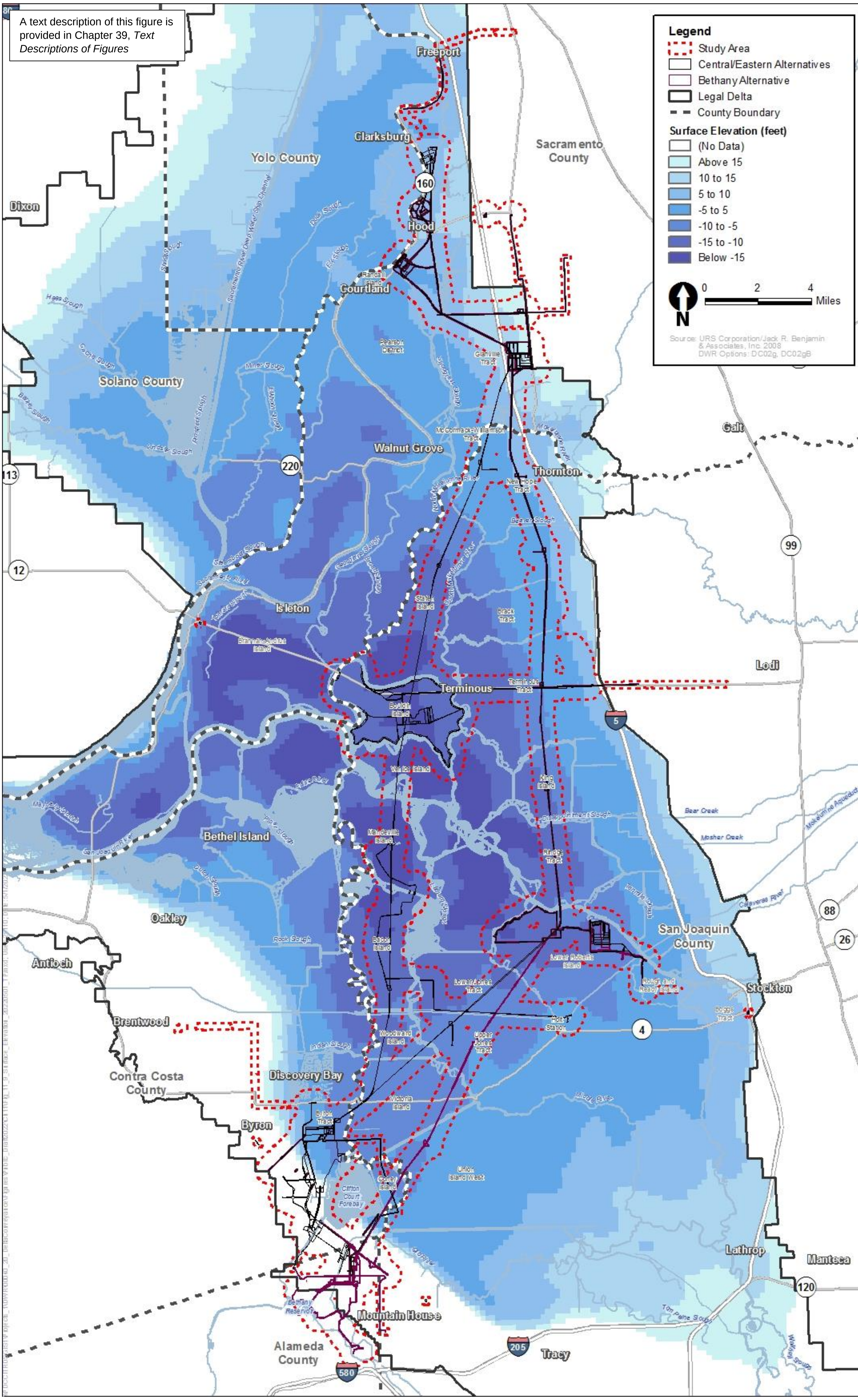


Figure 11-9. Surface Elevation

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#### 11.1.2.4 Consequences of Land Subsidence

Land subsidence has direct or indirect consequences on land use, water supply and quality, flood protection, power consumption and other operations and uses of the Delta.[11] The effects of subsidence on flood protection are discussed in Chapter 7, *Flood Protection*. The remaining consequences are discussed in this section.

##### Levee Instability

As land subsides, the difference in water surface elevation between channels and the island interior becomes greater. Subsidence of the levees and levee foundation soils relative to river and channel water levels also decreases the available freeboard, which can result in overtopping by waves and consequently increase the risk of levee failure. This hydraulic head difference between the water surface of the channels and the island interiors increases hydrostatic forces on levees as well as seepage forces inside the levee, which decreases levee stability and contributes to seepage through and under levees (Mount and Twiss 2005:7). Furthermore, as the land subsides, the shallow groundwater level becomes nearer to the ground surface, and drainage ditches along the toe of the levee must be deepened to ensure that the water table remains below the crop root zone. This practice decreases levee stability by reducing lateral support to levee foundations, which also leads to increased risk of levee failure. Many of the Delta islands have experienced levee breaches. Levee instability is described more thoroughly in Chapter 7, *Flood Protection*.

##### Infrastructure Damage

In addition to levees, subsidence can damage infrastructural improvements such as pipelines, roads, railroads, canals, bridges, utility tower foundations, storm drains, and sanitary sewers, as well as public and private buildings and water, oil, and gas well casings. These effects can be particularly acute in areas of differential subsidence, in which the amount of ground level lowering varies over short distances or at key transition points in the infrastructure where deep-founded sections connect to shallow-founded sections, such as at bridges and deep pipeline undercrossings of waterbodies.

##### Water Supply Disruption

Levee instability because of subsidence could disrupt the water source for more than two-thirds of California's population. The presence of the western Delta islands is believed to inhibit the migration of the salinity interface between the San Francisco Bay and the Delta. Were these islands to experience a levee breach and become inundated, water in the southern Delta might become too saline to use as drinking water (U.S. Geological Survey 2000b:3). Effects related to salinity and water quality are discussed in Chapter 9, *Water Quality*. Chapter 15, *Agricultural Resources*, addresses potential salinity effects on agricultural productivity.

##### Greenhouse Gas Emissions and Climate Change

On a global scale, soil organic carbon lost by oxidation and combustion can significantly contribute to the amount of $CO_2$ in the atmosphere. Worldwide annual input of carbon to the atmosphere from

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[11] Subsidence causes drainage ditches to subside. With deeper ditches, more pumping is required to lift the water to drain them, thereby increasing power consumption.

agricultural drainage of organic soils may be as much as 6% of that produced by fossil fuel combustion; the Delta has been estimated to contribute 2 million tons of carbon per year to the atmosphere through oxidation of peat soils (Rojstaczer and Deverel 1993:1). Rising atmospheric concentrations of $CO_2$ and other greenhouse gases in excess of natural levels result in increasing global surface temperatures—a process commonly referred to as global warming. Higher global surface temperatures, in turn, result in changes to Earth's climate system, including increased ocean temperature and acidity, reduced sea ice, variable precipitation, and increased frequency and intensity of extreme weather events (Intergovernmental Panel on Climate Change 2018:238). Large-scale changes to Earth's system are collectively referred to as climate change. Greenhouse gas emissions and global climate change are discussed in Chapter 30, *Climate Change,* and Chapter 23, *Air Quality and Greenhouse Gases*.

### Water Quality Degradation

Land subsidence can indirectly affect water quality by reducing levee integrity and increasing the risk of breaches. The present configuration of Delta islands may help ensure salinity intrusion does not increase salinity levels in Delta waterways, which would potentially reduce suitability of these waters for various uses, including drinking water supply and agricultural water supply. Although not a major cause of subsidence, dissolution of peat soils contributes dissolved organic carbon in drainage waters, which further reduces water quality. Water quality is discussed in Chapter 9, *Water Quality*. Chapter 15, *Agricultural Resources*, addresses potential salinity effects on agricultural productivity.

### Soil Productivity Degradation

As the land surface subsides, the plant root zone becomes nearer to the shallow groundwater level. This is of particular significance in areas that are close to or below sea level, such as the organic soils of the Delta. A shallow water table can cause saturation of the root zone, making a soil less productive and limiting the types of crops that can be grown. The effects of subsidence on crop production and types are further discussed in Chapter 15, *Agricultural Resources*.

## 11.2 Applicable Laws, Regulations, and Programs

The applicable laws, regulations, and programs considered in the assessment of project impacts on soils are indicated in this section, in Section 11.3.1, *Methods for Analysis*, or the impact analysis, as appropriate. Applicable laws, regulations and programs associated with state and federal agencies that have a review or potential approval responsibility have also been considered in the development CEQA impact thresholds or are otherwise considered in the assessment of environmental impacts. A listing of some of the agencies and their respective potential review and approval responsibilities, in addition to those under CEQA, is provided in Chapter 1, *Introduction*, Table 1-1. A listing of some of the federal agencies and their respective potential review, approval, and other responsibilities, in addition to those under NEPA, is provided in Chapter 1, Table 1-2.

# 11.3 Environmental Impacts

This section describes the direct and cumulative environmental impacts associated with soils that would result from project construction and operation and maintenance of the project. It describes the methods used to determine the impacts of the project and lists the thresholds used to conclude whether an impact would be significant. Measures to mitigate (i.e., avoid, minimize, rectify, reduce, eliminate, or compensate for) significant impacts are provided. Indirect impacts are discussed in Chapter 31, *Growth Inducement*.

## 11.3.1 Methods for Analysis

This section describes the methods used to evaluate soil limitations, soil-related hazards, and potential effects of the project alternatives in the area and the potential for the elements of the alternatives to increase human health risk and loss of property or other associated risks. These effects would be associated with construction activities, the footprint of disturbance from new facilities, and operations of the alternatives including potential effects of implementing the operations. Lands outside of the project area were not considered because there are no structures or earthwork being proposed. Both quantitative and qualitative methods were used to evaluate these effects, depending on the type of effect.

Field investigations would be conducted at all facilities to identify the subsidence potential and types of soil avoidance or soil stabilization measures that should be implemented to ensure that subsidence beneath facilities is within the design limits or that facilities are constructed to withstand subsidence and would conform to applicable state and federal standards.

A range of specific design and construction approaches are normally available to address a specific soil condition. For example, the potential for expansive soils to affect structural integrity could be controlled by use of soil lime treatment, a post-tensioned foundation, or other measure. Irrespective of the engineering approach to be used, the same stability criteria must be met to comply with code and standard requirements. Design solutions would be guided by relevant building codes and state and federal standards for foundations, earthworks, and other project facilities.

### 11.3.1.1 Process and Methods of Review for Soils

The following description of the site evaluation and design process is intended to clarify how site-specific hazard conditions are identified and fully addressed through data collection, analysis, and compliance with existing design and construction requirements.

Soil information in the project area has been compiled under the supervision of professional engineers and documented in the project's *Volume 1, Delta Conveyance Final Draft Engineering Project Report, Central and Eastern Options* (C-E EPR) and the *Volume 1, Delta Conveyance Final Draft Engineering Project Report, Bethany Reservoir Alternative* (Bethany EPR) (Delta Conveyance Design and Construction Authority 2022c:96–110, 2022d:60–65, 68–69). The C-E EPR and Bethany EPR and their associated technical memoranda include engineering details that were used to develop the sizing and locations of facilities. DWR also compiled data relevant to soils from cities and from power, gas, water, sewer, flood control, and transportation agencies. Additionally, the *Geology, Soils and Mineral Resources* section of the *Delta Plan Ecosystem Amendment Draft Program Environmental Impact Report* (Delta Stewardship Council 2021:5.9–5.35) was reviewed for relevant soils information.

The impact analysis for soils was performed using the C-E EPR narrative (Delta Conveyance Design and Construction Authority 2022c) and Bethany EPR narrative (Delta Conveyance Design and Construction Authority 2022d) and the following technical memoranda.

- Soil Balance—Central and Eastern Corridor Options (Delta Conveyance Design and Construction Authority 2022e)
- Reusable Tunnel Material—Central and Eastern Corridor Options (Delta Conveyance Design and Construction Authority 2022f)
- Soil Balance and Reusable Tunnel Material Supplement—Bethany Reservoir Alternative (Delta Conveyance Design and Construction Authority 2022g)
- Post-Construction Land Reclamation—Central and Eastern Corridor Options (Delta Conveyance Design and Construction Authority 2022h)
- Post-Construction Land Reclamation—Bethany Reservoir Alternative (Delta Conveyance Design and Construction Authority 2022i)
- Potential Future Field Investigations—Central and Eastern Corridor Options (Delta Conveyance Design and Construction Authority 2022j)
- Potential Future Field Investigations—Bethany Reservoir Alternative (Delta Conveyance Design and Construction Authority 2022k)

Maps of peat thickness, soil organic matter content, and an elevation map (California Department of Water Resources 2009:6) in which the amount of subsidence can be inferred were considered in the analysis. Finally, the analysis of near-surface soil characteristics and limitations was based on the NRCS general (i.e., association-level) and detailed (i.e., based on SSURGO data) soil survey mapping.

The soils impact analysis focused on identifying how and where soils could be adversely affected by erosion or by excavation, overcovering, or inundation and by identifying those soil characteristics that could pose a potentially serious threat to the integrity of structures. The analysis determines whether these conditions and associated risks can be reduced to an acceptable level by conformity with existing codes and standards, and by the application of accepted, proven engineering design and construction practices and with implementation of mitigation measures where needed.

### 11.3.1.2 Evaluation of Construction Activities

The analysis methods for soil-related effects as a result of construction activities were based on the following.

#### Accelerated Wind and Water Erosion

Soil disturbance (e.g., grading, excavating, tunneling, borrow material excavating, and stockpiling) during construction can lead to soil loss from water and wind erosion unless adequate management practices are implemented to control erosion and sediment transport.

NRCS soil survey and geographic information system (GIS) data (i.e., SSURGO data [Natural Resources Conservation Service 2021b]) for each county in the project area were used to identify and map variations in the soil's water and wind erosion hazard.

### Loss of Topsoil

Loss of topsoil as a resource can be caused by excavation, overcovering, or inundation. Additionally, the condition (soil health) and productivity of the topsoil can be degraded as a result of construction activities, such as compaction.

GIS-based mapping of those project components that would involve excavation, temporary or permanent overcovering, or inundation was used to calculate the acreage of areas in which the topsoil would be permanently lost or potentially degraded.

### Septic Tank Absorption Fields

Soils with low saturated hydraulic conductivity; soils with a shallow depth to a water table, bedrock or a cemented layer; and soils that are subject to ponding or flooding may be limited to a degree for their ability to absorb effluent from septic tanks and therefore ability to treat the effluent to protect water quality and public health.

NRCS GIS-based detailed soil survey mapping data (i.e., SSURGO) (Natural Resources Conservation Service 2021b) were used to identify the degree to which the soils at the proposed septic system locations are limited for use for septic tank absorption fields, and consequently, where specific design measures for the disposal systems may be required to avoid water quality and public health impacts.

## 11.3.1.3 Evaluation of Operations and Maintenance

This section describes potential mechanisms that could cause impacts *during* operations and maintenance. Unless otherwise specified, the potential impacts covered in this section could occur *during* operations and maintenance.

### Soil Expansion and Corrosion

Soils with a high content of expansive clay are subject to shrinking and swelling with seasonal changes in moisture content. Clay soils below the depth of the permanent water table are not subject to shrinking and swelling. Soil expansion and contraction can cause damage or failure of shallow foundations, utilities, and pavements.

NRCS GIS-based detailed soil survey mapping data (i.e., SSURGO) (Natural Resources Conservation Service 2021b) were used to identify and map variations in shrink-swell potential and in corrosivity to concrete and uncoated steel. This information was used to identify areas where such soils could adversely affect public safety and the structural integrity of proposed facilities, and consequently, where specific design measures for facilities and incorporated mitigation measures would need to be implemented to avoid these effects.

### Subsidence

Soil subsidence could result from a variety of factors, but in the Delta, it is primarily from oxidation of soil organic matter and primarily in high organic matter content soils (i.e., peats and mucks). Subsidence can cause damage or failure of structures, utilities, and levees.

NRCS GIS-based detailed soil survey mapping data (i.e., SSURGO) (Natural Resources Conservation Service 2021b) on the organic matter content of the near-surface soils (Figure 11-2), a map of the thickness of peat soils (Figure 11-8), and an elevation map (Figure 11-9) were used to identify areas that may be subject to continued subsidence.

### Septic Tank Absorption Fields

The potential mechanisms for septic tank absorption fields that could cause impacts during operations and maintenance are identical to the septic tank absorption fields mechanism for construction activities, described in Section 11.3.1.2, *Evaluation of Construction Activities*.

## 11.3.2 Thresholds of Significance

The analysis of the project alternatives includes review of soil survey data and the C-E EPR and Bethany EPR, as well as other information previously described, to determine if potential impacts caused by soil hazards and limitations can be reduced to a less-than-significant level by applying accepted and proven engineering design and construction practices and mitigation measures.

The impacts of soil hazards and limitations would be substantial if the risk of potential loss, injury, or death cannot be significantly reduced by engineering or best management practice (BMP) solutions. Significance thresholds do not require the elimination of the potential for structural damage from a construction site's soil conditions. Rather, the project design criteria require evaluation of whether site conditions can be maintained in substantially the same as the preconstruction condition through engineering design or BMP solutions and applied mitigation measures that reduce the substantial risk of people and structures to loss, injury, or death to less-than-significant levels. The evaluation under CEQA determines whether conformity with existing federal, state, and local standards, guidelines, codes, ordinances, and other regulations and application of accepted and proven engineering design and construction practices and applied mitigation measures would reduce the substantial risk of people and structures to loss, injury, or death to a less-than-significant level. The codes and design standards ensure that foundations, earthwork, and other facilities are designed and constructed such that, while they may sustain damage caused by a soil hazard, the substantial risk of loss, injury, or death due to structural failure or collapse is reduced to a less-than-significant level.

Implementation level design would not be completed until after the CEQA process is complete and the lead agency determines whether to approve a project alternative. After CEQA document certification and project approval, the final design would be developed. At the time of final design, additional geotechnical studies would be prepared to refine DWR's understanding of site-specific conditions. These soil investigations would characterize, log, and test soils on a site-specific basis to determine their load-bearing capacity, shrink-swell potential, corrosivity, and other parameters. The soil investigations and the recommendations that are derived from them would be presented in geotechnical reports by a California registered geotechnical engineer. The types of geotechnical investigation reports that would be prepared would be specific to the type of facility and intended to meet its governing agency requirements, such as California Building Code for buildings, Division of Safety of Dams for dams and forebays, California Department of Transportation/county requirements for roadways, and many other larger structures governed by American Society of Civil Engineers design guidelines. These geotechnical investigation reports would be reviewed and approved by DWR.

As part of the project design, DWR would incorporate the results of the field investigations, Environmental Commitment EC 4b: *Develop and Implement Stormwater Pollution Prevention Plans,* and post-construction land reclamation as part of the project for all alternatives. The project would also conform with applicable design standards.

Based on the final geotechnical reports and code and standards requirements, the final design of levees, foundations, and related engineering structures would be developed by a California registered civil engineer or a California registered geotechnical engineer with participation and review by DWR, and governing agency review to ensure that design standards are met. The design and construction specifications and applied mitigation measures would then be incorporated into the construction contract for implementation. During project construction, unanticipated soil conditions may be found that are different from those described in the detailed, site-specific geotechnical reports that guide the final design. Under these circumstances, the soil condition would be evaluated and the appropriate method to meet the design specification and any possible additional CEQA compliance would be recommended by the project engineer and approved by DWR.

This impacts analysis assumes that a project alternative would have a significant impact under CEQA if implementation would result in one of the following conditions.

- Result in substantial soil erosion or the loss of topsoil.
  - For purposes of this analysis, *substantial soil erosion* would occur when effluent monitoring indicates that the daily average turbidity of site runoff if a construction activity is likely to result in runoff exceeding 250 nephelometric turbidity units (NTU). This measurement is in accordance with Construction General Permit numeric action level (NAL) requirements under site-specific stormwater pollution prevention plans (SWPPPs).
  - For the purposes of this analysis, *substantial loss of topsoil* would occur if project construction activities cause a large proportion of the topsoil acreage in the Delta to be overcovered, inundated, or removed such that the loss is irreversible, for example, by permanently applying RTM on it.
- 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 subsidence. (The term *subsidence* generally refers to a gradual lowering of the ground elevation over a large area or region, while the term *settlement* [evaluated in Chapter 10, *Geology and Seismicity*] as used in this Draft EIR refers to the downward vertical movement of the soil underlying a structure or facility as a result of an increased load on the soil or from tunneling.) For purposes of this analysis, a significant impact would occur if project construction or operation and maintenance created an increased likelihood of potential loss, injury, or death related to soil instability caused by soil subsidence that cannot be reduced to a less-than-significant level by an engineering solution that reduces the risk to people and structures to an acceptable level. An "acceptable *engineering solution"* means conformity with all applicable government and professional standards, codes, ordinances, and regulations for site assessment, design, and construction practices, including the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (American Society of Civil Engineers 2016), California Building Code, and U.S. Army Corps of Engineers (USACE) Design and Construction of Levees.
- Create substantial risks to life or property as a result of being located on expansive or corrosive soil and for which there is no engineering solution.
  - For the purposes of this analysis, an *expansive soil* is defined as a soil survey map unit that has a USDA NRCS coefficient of linear extensibility (COLE) equal to or greater than 0.09 (i.e.,

corresponding to the shrink-swell classes of "High" and "Very High") (Natural Resources Conservation Service 2019:618–A.45).

  - For the purposes of this analysis, a *corrosive soil* is defined as a soil survey map unit that is rated as "high" for risk of corrosion to concrete or uncoated steel by the *National Soil Survey Handbook* (Natural Resources Conservation Service 2019:618–B.1, 618-B.3).

- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

#### 11.3.2.1 Evaluation of Mitigation Impacts

CEQA also requires an evaluation of potential impacts caused by the implementation of mitigation measures. Following the CEQA conclusion for each impact, the chapter analyzes potential impacts associated with implementing both the Compensatory Mitigation Plan and the other mitigation measures required to address with potential impacts caused by the project. Mitigation impacts are considered in combination with project impacts in determining the overall significance of the project. Additional information regarding the analysis of mitigation measure impacts is provided in Chapter 4, *Framework for the Environmental Analysis*.

### 11.3.3 Impacts and Mitigation Approaches

#### 11.3.3.1 No Project Alternative

As described in Chapter 3, *Description of the Proposed Project and Alternatives,* CEQA Guidelines Section 15126.6 directs that an EIR evaluate a specific alternative of "no project" along with its impact. The No Project Alternative in this Draft EIR represents the circumstances under which the project (or project alternative) does not proceed and considers predictable actions, such as projects, plans, and programs that would be predicted to occur in the foreseeable future if the Delta Conveyance Project is not constructed and operated. This description of the environmental conditions under the No Project Alternative first considers how soils could change over time and then discusses how other predictable actions could affect soils.

##### Future Soils Conditions

For soils, future conditions could change by mid-century or by the end of the century (California Governor's Office of Planning and Research, California Energy Commission, and California Natural Resources Agency 2018a:20) compared to the existing conditions as indirect impacts of climate change related to sea level rise and/or changes in precipitation and temperature.

Sea level rise could cause the water table underlying Delta islands (both leveed and unleveed) to become shallower, which could reduce the rate of soil organic matter decomposition and subsequently reduce the rate of subsidence to a degree. Along with continued subsidence, sea level rise could increase the potential for levee erosion caused by overtopping (California Governor's Office of Planning and Research, California Energy Commission, and California Natural Resources Agency 2018a:12) and increase rates of scour along the waterside of levee slopes.

Precipitation and temperature changes (e.g., prolonged drought, precipitation variability, increased temperature) may result in reduced State Water Project water supply availability to Delta farmers (California Governor's Office of Planning and Research, California Energy Commission, and

California Natural Resources Agency 2018b:7), and as a result some areas that are presently irrigated may no longer be irrigated. Ceasing application of irrigation water could cause an increased rate of soil organic matter decomposition and consequently increase the rate of subsidence in such areas. Additionally, formerly cultivated areas that are left fallow (due to reduced irrigation and water availability) would be subject to reduced wind erosion rates compared to the existing conditions since they would no longer be tilled.

## Predictable Actions by Others

A list and description of actions included as part of the No Project Alternative are provided in Appendix 3C, *Defining Existing Conditions, No Project Alternative, and Cumulative Impact Conditions*. As described in Chapter 4, *Framework for the Environmental Analysis,* the No Project Alternative analyses focus on identifying the additional water supply–related actions public water agencies may opt to follow if the Delta Conveyance Project does not occur.

Public water agencies participating in the Delta Conveyance Project have been grouped into four geographic regions. The water agencies within each geographic region would likely pursue a similar suite of water supply–projects under the No Project Alternative (see Appendix 3C). Construction of water supply reliability projects would result in ground-disturbing activities that could impact soil resources. Desalination projects would most likely be pursued in the northern and southern coastal regions. The southern coastal regions would likely require larger and more desalination projects than the northern coastal region to replace the water yield that otherwise would have been received through the Delta Conveyance Project. These projects would be sited near the coast. Groundwater recovery (brackish water desalination) would involve similar types of ground disturbance but could occur across the northern inland, southern coastal, southern inland regions and in both coastal and inland areas, such as the San Joaquin Valley. Grading and excavation at the desalination and groundwater recovery plant sites would be necessary for construction of foundations, and trenching would occur for installation of water delivery pipelines and utilities. These types of water supply–projects are expected to result in the loss of and disturbance to soils because of the size of the area needed to accommodate construction activities and permanent facilities. The permanent loss of soils as a result of these facilities is not expected to result in a substantial loss to soils on a regional level as these facilities would most likely be constructed in an already developed environment.

The northern and southern coastal regions are also most likely to explore constructing groundwater management projects. The southern coastal region would require more projects than the northern coastal region under the No Project Alternative. Groundwater management projects would occur in association with an underlying aquifer but could occur in a variety of locations and therefore affected a variety of soil resources. Construction activities for each project could require excavation for the construction of the recharge basins, and pipelines and drilling for the construction of recovery wells (with completion intervals between approximately 200 and 900 feet below ground surface). Construction activities would include site clearing; excavation and backfill; and construction of basins, pipelines, pump stations, and the turnout. Grading activities associated with the construction of recharge basins would involve earthmoving, excavation, and grading pipelines would likely be constructed using typical open trench construction methods. In some cases where siphons would be installed, jack and bore methods could be used to tunnel under and avoid disruption of surface features. Excavation of varying depths could be required, and these construction activities have the potential to affect soil resources. The extent of the impacts on soils would depend on the location of each project and the proximity to existing water conveyance facilities.

Soils would be disturbed and topsoil could be lost as a result of earthwork associated with ongoing levee projects in the Delta to address ongoing, long-term subsidence and to maintain levee geometry. The earthwork could involve raising the levee crown, flattening levee slopes, and constructing berms, including constructing cutoff walls at some locations. Additionally, it is likely that ongoing placement of riprap on the waterside slopes would be conducted. Although soil eroded from disturbed areas on the landside of levees would be deposited on the island interiors, soil eroded from the disturbed top and water side of levees could reach adjoining waterways.

Water recycling projects could be pursued in all four regions. The northern inland region would require the fewest number of wastewater treatment/water reclamation plants, followed by the northern coastal region, followed by the southern coastal region. The southern inland region would require the greatest number of water recycling projects to replace the anticipated water yield that it otherwise would have been received through the Delta Conveyance Project. These projects would be located near water treatment facilities. Construction techniques for water recycling projects would vary depending on the type of project (e.g., for landscape irrigation, groundwater recharge, dust control, industrial processes) but could require earth moving activities, grading, excavation, and trenching. Because construction would involve ground-disturbing activities, such actions could disturb soil resources. In the southern inland region where a greater number of projects would be needed as a substitute for the Delta Conveyance Project, the potential for impacts on soils could be greater when compared to other regions.

Water efficiency projects could be pursued in all four regions and involve a wide variety of project types, such as flow measurement or automation in a local water delivery system, lining of canals, use of buried perforated pipes to irrigate fields, additional detection and repair of commercial and residential leaking pipes, and in-home or business efficiency measures such as low water use appliances and low flow plumbing fixtures. These projects could occur anywhere in the regions, and most would involve little ground disturbance or would occur in previously disturbed areas.

As detailed above, all project types across all regions would involve relatively typical construction techniques (i.e., no large-scale tunnels or deep soil mixing) and would be required to conform with the requirements of CEQA and/or state and local regulations protecting soil resources, and mitigation measures would be developed to protect these resources, such as requiring monitoring in areas known to have soil resources and requiring soil resources to be preserved. In addition, these activities would occur in a wide variety of soil resources, and impacts would not be focused on a single soil resource area.

### 11.3.3.2 Impacts of the Project Alternatives on Soils

**Impact SOILS-1: Accelerated Soil Erosion Caused by Vegetation Removal and Other Disturbances as a Result of Constructing the Proposed Water Conveyance Facilities**

***Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, 4c***

*Project Construction*

For both central and eastern alignment alternatives (Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c), field investigations conducted prior to the start of construction would involve a variety of ground-disturbing activities, most of which would be of limited extent and duration. Soil borings would use augers to sample 4- to 8-inch-diameter holes and cone penetration tests would involve 1- to 2-inch-diameter rods pushed into the ground. Groundwater monitoring wells and groundwater testing wells would involve installing well casings in boreholes up to 24 inches in diameter. Utility “potholing” would be between 5 to 10 feet in depth, and test trenches would be approximately 30 feet long, 3 feet wide, and 10 feet deep. Five test trenches—approximately 1,000 feet long and 20 feet deep—would be excavated to study the West Tracy Fault trace. Along the trenches would be a 200-foot-wide temporary work area. Additional, minor soil disturbance could occur in the immediate vicinity of the test locations. A given trench would remain open for up to 6 weeks, would be backfilled upon completion of the investigation at that trench, and erosion and sediment control measures would be immediately implemented. Soil disturbance would also occur at the agronomic testing areas, estimated to extend over approximately 2 acres. The disturbances caused by the field investigations are expected to result in minimal increases in water and wind erosion rates.

The extent of construction site and post-construction work areas for the Bouldin Island levee modifications would be approximately 251 acres, with an additional 90 acres for temporary levee modification access roads. The extent of construction site and post-construction work areas for the Lower Roberts Island levee modifications would be approximately 30 acres, plus an additional 37 acres for temporary levee modification access roads. The levee improvements would remain following construction. Such work could result in accelerated soil erosion. To account for ongoing work by levee maintenance agencies, the extent of levee repairs would be reevaluated during the design phase and coordinated with the local levee maintenance agency.

For Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c, construction of water conveyance facilities would involve vegetation removal; construction of building pads, levees, and embankments; excavation for facility foundations; surface grading; trenching; road construction; RTM storage; soil stockpiling; and other activities over approximately 3,588 acres (for Alternative 4b) to 4,997 acres (for Alternative 2a) during the construction period, depending on the alternative (Table 11-4). The extent of such activities would be greatest at the Southern Forebay and its work area. Some of the work would be conducted in agricultural areas that would be fallow at the time.

**Table 11-4. Extent of Total Ground Disturbance (acres) by Alternative**

| Alt 1 | Alt 2a | Alt 2b | Alt 2c | Alt 3 | Alt 4a | Alt 4b | Alt 4c | Alt 5 |
|---|---|---|---|---|---|---|---|---|
| 4,560 | 4,997 | 4,033 | 4,430 | 4,149 | 4,634 | 3,588 | 4,006 | 3,090 |

Note: Ground disturbance figures in this table is based on the extent of area that would experience either temporary or permanent surface disturbance.
Alt = Alternative.

These conditions could result in one or more of the following mechanisms: soil compaction, degraded soil structure, reduced soil infiltration capacity, and increased runoff rates, all of which could accelerate erosion.

The excavation, grading, and other soil disturbances described above that are conducted in gently sloping to level areas, such as the interiors of Delta islands, are expected to experience little or no accelerated water erosion because of the lack of runoff energy to entrain and transport soil particles. Any soil that is eroded within island interiors would tend to remain on the island, provided that existing or project levees are in place to serve as barriers keeping the eroded soil (i.e., sediment) from entering receiving waters.

In contrast, graded and otherwise disturbed tops and side slopes of existing and project levees and other embankments are of greater concern for accelerated water erosion because of their steep gradients. Although soil eroded from the landside of levees would be deposited on the island interiors, soil eroded from the disturbed top and water side of levees could reach adjoining waterways. As described in the EPR for the central and eastern alignments, at the intakes, erosion-control measures would entail placement of riprap at the junction of the intake structure and existing levees. Disturbed soils would be hydroseeded with native plant seeds. At the levee modification areas on Bouldin Island and Lower Roberts Island and at tunnel shaft sites, erosion control of disturbed soils would also entail hydroseeding with native plant seeds. At the Southern Forebay, riprap would be placed along the inside embankment slopes, and native grasses would be established along the outside embankment slopes for erosion control.

Most of the areas that would involve extensive soil disturbance are underlain by soils with a "medium" or "high" susceptibility to wind erosion (Natural Resources Conservation Service 2021b) (Figure 11-5, Appendix 11C).

The construction activities (e.g., clearing and grubbing, and RTM stockpiling) that could lead to accelerated wind erosion are generally the same as those that could cause accelerated water erosion. These activities may result in vegetation removal and degradation of soil structure, both of which would make the soil much more subject to wind erosion during the period between grubbing and placement of the RTM stockpiles. Removal of vegetation cover and grading increase exposure to wind at the surface and obliterate the binding effect of plant roots on soil aggregates. These effects make the soil particles much more subject to entrainment by wind. Many of the areas that would be extensively disturbed by construction activities, however, are already routinely disturbed by agricultural activities such as disking and harrowing.

Consequently, with the exception of loading and transporting soil material and RTM to storage areas, the disturbance and increase in water and wind erosion rates that would result from constructing the conveyance facilities in many areas would effectively would be the same as the existing conditions (i.e., regular tillage of agricultural land), provided that the length of time that the soil is left exposed during the year does not increase compared to that associated with agricultural operations. The extent of soil disturbance and exposure to wind and water erosion would vary by project alternative. Using the extent of Important Farmland that would be converted to non-farmland uses to represent the extent of soil disturbance, approximately 3,900 acres would be disturbed, using Alternative 2a as a basis (See Chapter 15, *Agricultural Resources*). (Because the project would be constructed over the course of years, not all 3,900 acres would be exposed at a given time.) Much of the land within the 725,600-acre statutory Delta is cultivated, and during part of the year, many fields are fallow and therefore subject to water and wind erosion. Therefore, the maximum extent of soil disturbance that would be caused by the project is small in relation to the statutory Delta and many of the conveyance facilities would be constructed in areas where, under the existing conditions, the soil is disturbed and exposed to erosion as a result of agricultural operations.

Excavation of soil from borrow areas and transport of RTM material to storage areas would potentially subject soils to wind erosion. Based on the Reusable Tunnel Material (Final Draft) technical memorandum (Delta Conveyance Design and Construction Authority 2022f:14, 33), approximately 7.5 to 19.5 million cubic yards of wet excavated (bulked) RTM would be transported, unloaded, and placed as permanent stockpiles, depending on the project alternative. Although wet RTM would not be susceptible to wind erosion, processed and dried RTM (which represents 77%–

80% of all the RTM that would be generated) would be susceptible to wind erosion while it is being handled. Unlike water erosion, the potential significant impacts of wind erosion are generally not dependent on slope gradient and location relative to levees or receiving waters. However, the RTM would be dried only to a state that is suitable for transport and/or permanent stockpiling, which is not expected to be completely dry. For RTM that is left at the launch sites, it would likely be spread out and compacted in place; therefore, minimal handling would be required to transport the RTM to a temporary stockpile. RTM transport and compaction at the permanent stockpiles to reach the final stockpile configuration would involve moisture conditioning to reduce wind erosion of the RTM. Additionally, Environmental Commitment EC-11: *Fugitive Dust Control*, which applies to all active construction sites, would minimize wind erosion. EC-11 requires preparation and implementation of a dust control plan, which would specify measures to control wind erosion such as watering exposed soil and stabilizing stockpiles with biopolymers.

*Operations and Maintenance*

Site stabilization (e.g., vegetation cover minimum of 70% of the preconstruction vegetation cover and rock slope protection) is required for a project or project component covered by the State Water Resources Control Board (State Water Board) Stormwater Construction General Permit to be removed from permit coverage, which is expected at the completion of construction of a given conveyance facility component or work area. Once the disturbed areas have been stabilized at a given conveyance facility component or work area, erosion rates are expected to be not substantially greater than preconstruction rates.

Minor, localized washouts of Southern Forebay embankments and side slopes of the RTM stockpiles that may occur as a result of unusually heavy rainfall would be stabilized using routine erosion and sediment control practices. Any areas in which operations and maintenance entail soil disturbance of 1 acre or more in extent would be required to gain coverage under the Stormwater Construction General Permit, which would require preparation and implementation of a SWPPP. Proper implementation of the SWPPP for a given work area and other compliance measures required under the Construction General Stormwater Permit would prevent excessive accelerated erosion from occurring.

#### ***Alternative 5***

*Project Construction*

Alternative 5 would include the same intakes, tunnel shafts, and tunnel structures as Alternative 3 as far as Lower Roberts Island, and would contain a larger, double tunnel launch shaft at a slightly different location on Lower Roberts Island than for Alternative 3. The tunnel would then follow a different route to the Bethany Reservoir Surge Basin and Pumping Plant, with different shaft locations, and would not involve the Southern Complex facilities. Alternative 5 also would involve segmental concrete-lined tunnel construction between the Bethany Reservoir Pumping Plant and the Bethany Reservoir Discharge Structure and would entail soil disturbance related to constructing the trenched and tunneled Bethany Aqueduct pipeline, which is not part of Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c.

For Alternative 5, some of the field investigations conducted prior to the start of construction and the effects of the investigations on soil erosion rates would be similar in nature to those described above for Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c. However, because the aqueduct pipeline in Alternative 5 would be constructed in different geologic conditions and would require different construction methods (e.g., cut and cover trenching and tunnel excavation in consolidated rock) than those of Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c, the field investigations required for the aqueduct pipeline would be different. Additionally, because the Bethany Reservoir is an existing dam site subject to the Division of the Safety of Dams requirements, specific geotechnical investigations not required for Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c may be conducted at the dam site to comply with such requirements.

For Alternative 5, construction of water conveyance facilities could cause accelerated soil erosion and erosion effects similar to Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c. However, because Alternative 5 does not include a Southern Complex, the extent of ground disturbance (approximately 3,090 acres) under Alternative 5 would be less than all of the other project alternatives.

The extent of construction site and post-construction work areas for the Lower Roberts Island levee modifications would be approximately 30 acres, plus an additional 37 acres for temporary levee modification access roads. The levee improvements would remain following construction. Such work could result in accelerated soil erosion. To account for ongoing work by levee maintenance agencies, the extent of levee repairs would be reevaluated during the design phase and coordinated with the local levee maintenance agency.

The water erosion hazard (i.e., “slight”) of the soils that underlie most of the Bethany Reservoir alternative (Alternative 5) facilities is the same as that of the soils that underlie Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c. However, the water erosion hazard of the soils underlying the Bethany Reservoir alternative facilities that are in the sloping area east of the Bethany Reservoir is higher (i.e., generally “moderate”) than the erosion hazard of the soils found in the footprints of Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c (i.e., generally “slight”) (Figure 11-4). Therefore, soil-disturbing activities in the part of Alternative 5 specifically in the vicinity of the Bethany Reservoir are subject to comparatively greater erosion rates than those in the footprints of Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c.

Similar to the soils that that underlie Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c, the soils that underlie the Bethany Reservoir alternative (Alternative 5) facilities that would involve extensive soil disturbance generally have a “medium” or “high” susceptibility to wind erosion (Natural Resources Conservation Service 2021b) (Figure 11-5, Appendix 11C). Therefore, soil-disturbing activities under the Alternative 5 are likely to be subject to similar wind erosion rates as the soils under Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c.

As described in the Bethany EPR, erosion-control measures implemented at the Bethany Reservoir Pumping Plant, Surge Basin, and Aqueduct would include hydroseeding of disturbed soils. At the Bethany Reservoir Discharge Structure, erosion-control measures implemented along the existing embankments would include riprap installed along the reservoir side slope in front of the discharge area and along the embankments on each side of the structure. As described in Table A9 in the EPR for the Bethany Reservoir alignment, permanent hydroseeding, fiber rolls, and temporary silt fencing would be installed on any slope greater than 2:1 (horizontal to vertical; H:V), including the embankments near the Bethany Reservoir embankment.

*Operations and Maintenance*

Potential impacts on accelerated soil erosion under Alternative 5 during operations and maintenance would be similar overall in mechanism and magnitude as for Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c.

### *CEQA Conclusion—All Project Alternatives*

Construction of water conveyance facilities proposed under all project alternatives could cause substantial accelerated water and wind erosion and subsequent impacts on receiving waters unless appropriate erosion-control BMPs are implemented. Although most of the project area is underlain by soils that have a "slight" water erosion hazard (refer to Section 11.1.1.2, *Soil Physical and Chemical Properties*, for discussion of erosion hazard classes), because the soil disturbance would be extensive and, in some cases, would be adjacent to a receiving water, the potential impact of accelerated water erosion would be significant.

Additionally, large areas of topsoil and RTM, both in transport and in stockpiles, would be temporarily exposed to wind erosion. Although some of the areas that would be extensively disturbed by construction activities are already regularly disturbed by agricultural activities (e.g., disking and harrowing) and result in soil exposure under existing conditions, some conveyance facility components would be in areas that are not cultivated. The aggregate acreage of these areas would be substantial. However, to prevent accelerated water or wind erosion from occurring, DWR would incorporate Environmental Commitment EC-4b: *Develop and Implement Stormwater Pollution Prevention Plans.* The General Permit requires that SWPPPs be prepared by a Qualified SWPPP Developer (QSD) and implemented under the supervision of a Qualified SWPPP Practitioner (QSP). As part of the procedure to gain coverage under the General Permit, the QSD would determine the Risk Level (1, 2, or 3) of the project site, which involves an evaluation of the site's Sediment Risk and Receiving Water Risk. Sediment Risk is based on the tons per acre per year of sediment that the site could generate in the absence of erosion and sediment control BMPs. Receiving Water Risk is an assessment of whether the project site is in a sediment-sensitive watershed.

The results of the Risk Level determination partly drive the contents of the SWPPP. In accordance with the General Permit, the SWPPP would describe site topographic, soil, and hydrologic characteristics; construction activities and a project construction schedule; construction materials to be used and other potential sources of pollutants at the project site; potential non-stormwater discharges (e.g., trench dewatering); erosion and sediment control, non-stormwater, and "housekeeping" BMPs to be implemented; a BMP implementation schedule; a site and BMP inspection schedule; and ongoing personnel training requirements.

The SWPPPs would prescribe BMPs that are site-specific and tailored to project component characteristics. All SWPPPs, irrespective of the site and project characteristics, are likely to contain the following BMPs.

- Preservation of existing vegetation
- Perimeter control
- Fiber roll and/or silt fence sediment barriers
- Watering to control dust entrainment
- Tracking control and "housekeeping" measures for equipment refueling and maintenance
- Solid waste management

Most construction sites would require temporary and permanent seeding and mulching. Any sites that involve disturbance or construction of slopes steeper than 3H:1V may require installation of erosion-control blankets or rock slope protection. Temporary turbidity curtains and cofferdams may be prescribed for in-water work. Excavations that would require dewatering (such as for underground utilities and footings) would require proper storage of the water, such as reuse, land application, or filtration. Soil and material stockpiles (such as for borrow material) would require perimeter protection, use of tackifying agents, and/or covering or watering to control wind erosion.

The QSP would be responsible for day-to-day implementation of the SWPPP, including BMP inspections, maintenance, water quality sampling, and reporting to the State Water Board. In the event that the water quality sampling results indicate an exceedance of allowable turbidity levels, the QSD would be required to modify the type and/or location of the existing BMPs by amending the SWPPP.

For purposes of this analysis, substantial soil erosion would occur when effluent water quality monitoring indicates that the daily average turbidity of site runoff exceeds 250 NTUs. This limit is set by Construction General Permit NAL requirements for SWPPP implementation and requires permittees to provide additional BMPs or modify BMPs throughout project construction as required to ensure that any exceedances of the turbidity NAL are quickly resolved. Proper implementation of the SWPPPs prepared for the various project components and compliance with other requirements of the State Water Board Stormwater Construction General Permit is expected to avoid exceeding the turbidity threshold in site runoff as specified in the Construction General Permit and thereby prevent excessive accelerated water and wind erosion. Because environmental commitments and BMPs are incorporated into the project alternatives and because project construction would be required to comply with the SWPPP, this impact would be less than significant.

***Mitigation Impacts***

Compensatory Mitigation

Although the Compensatory Mitigation Plan (CMP) described in Appendix 3F, *Compensatory Mitigation Plan for Special-Status Species and Aquatic Resources*, does not act as mitigation for impacts on soils from project construction or operations and maintenance, its implementation could result in impacts on soils.

Compensatory mitigation would be built to mitigate, in part or in whole, the potential impacts resulting from the construction and operation and maintenance of the project on terrestrial and aquatic biological resources. These efforts are described in detail in Appendix 3F. Several major habitat types are targeted under the CMP for restoration, including freshwater marsh, riparian, seasonal wetland, tidal marsh, channel margin, lacustrine (lake/pond), and grasslands.

Most of the compensatory mitigation efforts would require developing temporary facilities, such as staging areas, access haul roads, work areas, and borrow sites. These facilities could involve clearing and grubbing, excavation, and other grading activities that entail soil disturbance. Further, assuming that the areas planned for habitat creation (as opposed to habitat enhancement) would entail soil disturbance, a total of 786 acres would be disturbed at the Bouldin Island site. At the Interstate (I-) 5 ponds site, 56 acres would be disturbed. Unless measures are implemented to control erosion, these construction activities could result in accelerated water and wind erosion. The compensatory mitigation habitat construction work (e.g., excavation, grading, construction of setback levees) itself is estimated to take 2 years, and post-construction vegetation establishment of the newly constructed wetland habitats may take several years. Consequently, the accelerated erosion could occur over a period of years, depending on the type of habitat being restored and the rate of vegetation establishment.

The remaining elements of the compensatory mitigation efforts at the Bouldin Island site and I-5 ponds site would involve protection or enhancement of existing terrestrial biological resources that would not require earthwork or other soil disturbance, such as installing plantings and implementing weed control. These areas (168 acres at the Bouldin Island site and 117 acres at the I-5 ponds site) would not be subject to accelerated soil erosion.

The habitat restoration and enhancement activities broadly described in Appendix 3F focus on the I-5 ponds and Bouldin Island. The clearing, grubbing, excavation and other grading activities, and other activities to construct the mitigation would entail soil disturbance, removal of vegetation, and exposure of bare soil and could result in accelerated water and wind erosion unless measures were implemented to control erosion. The hazard and potential impact on receiving waters of accelerated water erosion would be greatest in sloping project features, such as new and modified existing levees, particularly on the waterside. Areas that would be subject to concentrated flow, such as newly constructed and naturally formed tidal channels, would be subject to scour.

As with the project, construction related to the CMP would be required to gain coverage under the State Water Board Stormwater Construction General Permit, compliance with which would ensure that there would be no excessive accelerated water or wind erosion caused by the project. As described above in the CEQA conclusion for Impact SOILS-1, a SWPPP must be prepared to gain coverage under a Construction General Permit, which sets limits on the daily average turbidity of site runoff caused by erosion. If the 250 NTU turbidity level is exceeded, development of additional BMPs or modification of existing BMPs would be required to resolve the potential impact from erosion. Therefore, the impact on soil erosion from the project combined with compensatory mitigation at the Bouldin Island and I-5 ponds mitigation sites would not be substantial and, combined with the project alternatives, would not change overall impact conclusions.

As described in Appendix 3F, compensatory mitigation would also involve excavation and other earthwork at undetermined tidal wetland or channel margin restoration sites within the North Delta Arc, which could result in increased erosion rates. It cannot be known at this time the extent of the disturbed area and therefore the area that could be subject to increased erosion. Any disturbed areas greater than 1 acre would be required to gain coverage under the State Water Board Stormwater Construction General Permit, compliance with which would require development and implementation of a SWPPP to ensure that there would be no excessive accelerated water or wind erosion caused by the project, as described above. Therefore, the project alternatives combined with compensatory mitigation at the undetermined tidal wetland and channel margin restoration sites would not change the overall impact conclusion of less than significant.

*Other Mitigation Measures*

Some mitigation measures would involve the use of heavy equipment such as graders, excavators, dozers, and haul trucks that would have the potential to accelerate soil erosion as a result of excavation and other soil disturbance. The mitigation measures with potential to result in accelerated soil erosion are: Mitigation Measures BIO-2c: *Electrical Power Line Support Placement*, AG-3: *Replacement or Relocation of Affected Infrastructure Supporting Agricultural Properties*, AES-1c: *Implement Best Management Practices to Implement Project Landscaping Plan,* CUL-1: *Prepare and Implement a Built-Environment Treatment Plan in Consultation with Interested Parties*, and AQ-9: *Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero*. Temporary increases in accelerated soil erosion caused by disturbances resulting from implementation of mitigation measures would be similar to construction effects of the project alternatives in certain construction areas and would contribute to soil erosion impacts of the project alternatives. Implementation of erosion and sediment control BMPs, as defined in EC-4b: *Develop and Implement Stormwater Pollution Prevention Plans,* would prevent accelerated erosion from occurring. Therefore, implementation of mitigation measures is unlikely to accelerate soil erosion caused by disturbances and the impact of soil erosion would not be substantial.

Overall, accelerated soil erosion impacts for construction of compensatory mitigation and implementation of other mitigation measures, combined with project alternatives, would not change the impact conclusion of less than significant.

## Impact SOILS-2: Loss of Topsoil from Excavation, Overcovering, and Inundation as a Result of Constructing the Proposed Water Conveyance Facilities

### *Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, 4c*

#### *Project Construction*

For both central and eastern alignment alternatives (Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c), field investigations conducted prior to the start of construction would involve a variety of ground-disturbing activities, most of which would be of limited extent, as described under Impact SOILS-1. Virtually all the field investigations, such as soil borings and groundwater test well installation, would result in minimal losses of topsoil.[12] Those investigations involving a more substantial extent of possible topsoil loss are the five 1,000-foot-long West Tracy Fault test trenches, which together could result in an estimated 2 acres of topsoil loss. Along each trench would be a 200-foot-wide temporary work area which would be disturbed but which would not result in a loss of topsoil. At the agronomic testing areas (approximately 2 acres), the upper 12 inches of the topsoil would be stripped and stockpiled before the testing work begins, then replaced once testing is completed, such that there would be no loss of topsoil.

Construction of the conveyance facilities would involve various forms of soil excavation and overcovering, such as borrow areas; construction of building pads, levees, trenches, and embankments; road and parking area construction; and permanent RTM storage. Although salvaged topsoil would be spread over some completed work areas such as embankments and backfilled trenches, topsoil nevertheless would be lost as a resource as a result of these activities during construction of all the project alternatives.

The extent of the construction site and post-construction work areas for the Bouldin Island levee modifications and potential topsoil loss would be approximately 251 acres, with an additional 90 acres for temporary levee modification access roads. The extent of construction site and post-construction work areas for the Lower Roberts Island levee modifications and, therefore, the potential topsoil loss would be approximately 30 acres, plus an additional 37 acres for temporary levee modification access roads. The levee improvements would remain following construction. To account for ongoing work by levee maintenance agencies, the extent of levee repairs would be reevaluated during the design phase and coordinated with the local levee maintenance agency.

[12] The thickness of the topsoil varies depending on the physiographic setting within the study area. See Section 11.1.1, *Study Area*, for a discussion of the topsoil thickness in each of the physiographic settings that occur in the study area.

As described in the Soil Balance Technical Memorandum (Delta Conveyance Design and Construction Authority 2022e:2–5), various measures would be undertaken to minimize the extent of topsoil loss and to promote revegetation of cut and fill areas. Peat and mineral topsoil would be excavated and stockpiled locally. Excavated peat soil would be placed in stockpiles and covered with mineral topsoil or RTM to limit oxidation of the peat. At the Southern Complex, the intakes, and all tunnel shaft sites, a 6-inch-thick layer of native topsoil would be stripped and stockpiled for later reuse on-site. Salvaged topsoil would be reused to cover the outboard slopes of the Southern Forebay embankments and emergency spillway channel embankments. Approximately 458,086 cubic yards (loose volume) of topsoil would be placed in a 5-foot-thick cover over the permanent peat stockpile. The remaining topsoil generated would be placed over surplus RTM and peat soil in an area to the north of the South Delta Pumping Plant to support plant growth.

Additionally, degradation of soil health could occur at construction sites at which the topsoil would be stripped, stockpiled, and reapplied to the work area because the soil could be compacted as a result of handling and trafficking. Additionally, compaction of the soil layer beneath the stripped layer could occur as a result of trafficking. The near-surface native soils within the construction areas could be inadvertently compacted from construction activities and consolidated beneath material stockpiles. The effects of construction commonly include increased bulk density, loss of soil carbon, degraded aggregate stability, reduced growth of the mycorrhizal fungi, and reduced nutrient cycling. Such effects may make the soil less productive after it is applied to its destination site, compared to its pre-salvage condition. Depending on the inherent soil characteristics, the manner in which it is handled and stockpiled, and the duration of its storage, the reapplied topsoil may recover quickly to its original condition or require many years to return to its pre-salvage physical, chemical, and biological condition (Strohmayer 1999:1; Vogelsang and Bever 2010:5).

As described in Chapter 3, Section 3.4.14, *Land Reclamation*, land reclamation efforts would ameliorate, to the extent practicable, areas outside the footprints of permanent facilities that have been compacted from construction equipment activities, that have consolidated beneath material stockpiles, and that have properties less suitable for agriculture or habitat restoration due to construction activities. Several treatments (e.g., ripping, disking and incorporating amendments to address compaction and seeding) which are articulated in the Post-Construction Land Reclamation (Final Draft) Technical Memorandum for the central and eastern alignments (Delta Conveyance Design and Construction Authority 2022h:6) and the Post-Construction Land Reclamation Supplement—Bethany Reservoir Alternative (Final Draft) Technical Memorandum (Delta Conveyance Design and Construction Authority 2022i:6) on a site-by-site basis, are expected to effectively ameliorate any significant degradation of soil health that may have occurred during topsoil handling and storage. After demobilization of equipment, materials, and temporary facilities, sites would be graded and leveled to generally meet adjacent lands. Initial soil treatments would depend on the actual disturbance, but for soils that have undergone more than minimal impact, the work would be expected to include ripping the soil and incorporating amendments (e.g., gypsum) to reduce compaction and to promote soil health. This would be followed by spreading topsoil, cross disking, and fine grading/leveling to prepare the soil surface for future use. At this point, if an end user (for example, agricultural or conservation entity) is ready to take over activities at the site to transition it to long-term use, the project reclamation steps would be complete. However, if an end user is not ready to take over use of the site, the areas would be drill seeded using a grass seed mix appropriate for the desired end use to provide water and wind erosion control. Areas to be restored to natural area/habitat would be seeded with a native grass mix, whereas areas to be restored to agricultural use could be seeded with a temporary erosion-control seed mix.

At the end of construction, as described in the Reusable Tunnel Material Technical Memorandum (Delta Conveyance Design and Construction Authority 2022f:7) at launch shafts, areas that were excavated to create borrow soil materials would be refilled to existing grade with suitable soil material from shaft excavation and/or with RTM from existing stockpiles, then covered with (mineral) topsoil that had been salvaged and stockpiled prior to excavation of the shafts.

Treatments for reclamation using RTM base soil would be similar to those recommended for reclamation with native soils; however, additional treatments could be required to address soil conditions (e.g., excessively high or low pH). Topsoil would be spread to a thickness of approximately 12 inches over the RTM base material. As described in the C-E and Bethany EPRs (Delta Conveyance Design and Construction Authority 2022c:97, 99, 2022d:69), mineral topsoil would also be placed over excavated peat to limit oxidation of the organic peat material and subsequent release of carbon dioxide to the atmosphere.

Table 11-5 presents a summary of the effects on soils caused by the impact mechanisms of excavation and overcovering by project alternative, based on GIS analysis by conveyance facility type. Due to the nature of the earthwork to construct many of the facilities, both mechanisms of soil loss may be involved at a given facility. For example, embankment construction would require both excavation to prepare the subgrade and overcovering with fill soil to construct the levee.

As a point of reference, the statutory Delta extends over approximately 725,600 acres, approximately 65,900 acres of which are open water (Hickson and Keeler-Wolf 2007:33), such that there are 659,700 acres of land areas (i.e., acres of topsoil). The project would affect a small proportion of those 659,700 acres as a result of constructing Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c (see Table 11-5), ranging from 0.30% to 0.46%, depending on the alternative.

**Table 11-5. Extent of Permanent Topsoil Loss (acres) by Alternative**

| Alt 1 | Alt 2a | Alt 2b | Alt 2c | Alt 3 | Alt 4a | Alt 4b | Alt 4c | Alt 5 |
|---|---|---|---|---|---|---|---|---|
| 2,797 | 3,052 | 2,465 | 2,668 | 2,324 | 2,703 | 1,963 | 2,194 | 1,302 |

Note: Topsoil loss in this table is based on the extent of area classified as being a permanent surface impact.
Alt = Alternative.

As a different point of reference, the study area (Section 11.1.1, *Study Area*), which encompasses all of the project alternatives, contains 115,879 acres of topsoil. In relation to the study area, the extent of project-related topsoil loss would also be a small proportion, ranging from 1.69% to 2.63%, depending on the alternative.

*Operations and Maintenance*

The operations and maintenance of the project would not entail substantial excavation, filling, grading, or other soil disturbances. Therefore, no substantial losses of topsoil are expected to occur during operations and maintenance of the central and eastern alignment alternatives (Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c).

### *Alternative 5*

#### *Project Construction*

As described under Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c, field investigations conducted prior to the start of construction would involve a variety of ground-disturbing activities. The loss of topsoil caused by these activities under Alternative 5 would be similar to that described under Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c.

Based on the Soil Balance and Reusable Tunnel Material Supplement—Bethany Reservoir Alternative (Delta Conveyance Design and Construction Authority 2022g:6, 7), construction of the conveyance facilities under Alternative 5 would entail a loss of topsoil less than that of all of the other alternatives (Table 11-5), partly because there would be no Southern Forebay.

As discussed under Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c, degradation of soil health could occur at Alternative 5 construction sites at which the topsoil would be stripped, stockpiled, and reapplied to the work area because the soil could be compacted as a result of handling and trafficking. Additionally, compaction of the soil layer beneath the stripped layer could occur as a result of trafficking. The near-surface native soils within the construction areas could be inadvertently compacted from construction activities and consolidated beneath material stockpiles. The effects of construction commonly include increased bulk density, loss of soil carbon, degraded aggregate stability, reduced growth of the mycorrhizal fungi, and reduced nutrient cycling. Such effects may make the soil less productive after it is applied to its destination site, compared to its pre-salvage condition. Depending on the inherent soil characteristics, the manner in which it is handled and stockpiled, and the duration of its storage, the reapplied topsoil may recover quickly to its original condition or require many years to return to its pre-salvage physical, chemical, and biological condition (Strohmayer 1999:1; Vogelsang and Bever 2010:5).

Several treatments (e.g., ripping, disking, and incorporating amendments to address compaction and seeding), which are articulated in the Post-Construction Land Reclamation Supplement—Bethany Reservoir Alternative Technical Memorandum (Delta Conveyance Design and Construction Authority 2022i:8–37) on a site-by-site basis, are expected to effectively ameliorate any significant degradation of soil health that may have occurred during topsoil handling and storage. After demobilization of equipment, materials, and temporary facilities, sites would be graded and leveled to generally meet adjacent lands. Initial soil treatments would depend on the actual disturbance, but for soils that have undergone more than minimal impact, the work would be expected to include ripping the soil and incorporating amendments (e.g., gypsum) to reduce compaction and to promote soil health. This would be followed by spreading topsoil, cross disking, and fine grading/leveling to prepare the soil surface for future use. If the end user (e.g., farmer, conservation entity) transitions the site shortly after construction, they would be consulted to determine the types and quantities of amendments that would be required. However, if the transition of the land to the end user does not occur in a relatively short period of time, the areas would be drill seeded to provide water and wind erosion control using a grass seed mix appropriate for the desired end use. Areas to be restored to natural area/habitat would be seeded with a native grass mix, whereas areas to be restored to agricultural use could be seeded with a temporary erosion-control seed mix.

With the statutory Delta having topsoil extending over 659,700 acres (Hickson and Keeler-Wolf 2007:33), the proportion of the topsoil areas of the statutory Delta that would experience topsoil loss as a result of constructing Alternative 5 (see Table 11-5) would be very small—0.20%.

In relation to the 115,879 acres of the study area that has topsoil (see discussion under Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, 4c), the extent of project topsoil loss would also be a small proportion—1.12%.

*Operations and Maintenance*

Due to the same reasons as for Alternatives 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c, no substantial losses of topsoil are expected to occur during operations and maintenance phase of Alternative 5.

***CEQA Conclusion—All Project Alternatives***

Extensive areas of native topsoil effectively would be lost as a resource as a result of excavation and overcovering during construction of all of the project alternatives. Table 11-5 presents a summary of the estimated topsoil losses by alternative. The table shows that between 1,302 and 3,052 acres of topsoil would be lost, with the smallest loss occurring under Alternative 5 and the greatest loss occurring under Alternative 2a. These acreages represent 0.20% to 0.46% (i.e., less than 1%) of the total topsoil area of the statutory Delta. In relation to the part of the study area that has topsoil, these acreages represent 1.12% to 2.63% of the topsoil area. Consequently, the loss of topsoil would be small in relation to the extent of topsoil in the statutory Delta and in the study area.

In addition to the direct loss of topsoil, soil health degradation could also occur at sites in which the topsoil would not be excavated or overcovered, such as at construction staging and laydown areas where the soil could be compacted or otherwise affected.

As described in Chapter 3, *Description of the Proposed Project and Alternatives*, the Post-Construction Land Reclamation technical memoranda for the central and eastern alignments and for the Bethany Reservoir alternative (Delta Conveyance Design and Construction Authority 2022h:6, 2022i:6) include measures that would be undertaken to strip and manage (mineral) topsoil, RTM, and excavated peat, as well as for revegetating areas in which topsoil and other materials have been applied. Additionally, the Soil Balance Technical Memorandum for the central and eastern alignments in the C-E EPR (Delta Conveyance Design and Construction Authority 2022e:2, 3) and the Soil Balance and Reusable Tunnel Material Supplement—Bethany Reservoir Alternative (Final Draft) (Delta Conveyance Design and Construction Authority 2022g:3) specify that 6 inches of topsoil would be removed and stockpiled from construction work areas at all tunnel shafts, the Southern Complex, and the Bethany Complex for all project alternatives. Some of the topsoil would be placed in permanent stockpiles and some would be used to cover permanent RTM stockpiles. With respect to sites in which trenching would be done to install conveyance facilities or to install or relocate underground utilities, the topsoil would be segregated from the subsoil excavated from open-cut trenches, stockpiled, and reapplied in reverse order to the surface after the pipe or utility has been installed. No salvaging of organic (peat) topsoil would occur beneath permanent RTM stockpile sites and RTM would be permanently stockpiled on top of the peat. This approach would have the benefit of reducing greenhouse gas emissions which would otherwise occur if peat were first salvaged and applied to the top of the RTM stockpile, where it would be subject to oxidation. Therefore, the project would minimize the extent of topsoil that would be lost and minimize impacts on soil health to the maximum extent practicable.

Further, compliance with the State Water Board Stormwater Construction General Permit, as described in project Environmental Commitment EC-4b: *Develop and Implement Stormwater Pollution Prevention Plans*, requires that the extent of vegetation removal and soil disturbance be minimized to the maximum extent practical in project design and during construction.

Implementing this environmental commitment would help reduce the extent of topsoil loss and of degradation of soil health

Because the loss of topsoil would be minimal in relation to the extent of topsoil that exists in the statutory Delta and the study area and because the technical memoranda mentioned above specify measures that would substantially ameliorate effects on soil health, the impact would be less than significant.

***Mitigation Impacts***

*Compensatory Mitigation*

Although the CMP described in Appendix 3F does not act as mitigation for impacts on soils from project construction or operations and maintenance, its implementation could result in impacts on soils.

As described under Impact SOILS-1, compensatory mitigation is expected to be built to mitigate, in part or in whole, the potential impacts resulting from the construction and operation and maintenance of the project on terrestrial and aquatic biological resources. The compensatory mitigation is described in detail in Appendix 3F. The mitigation efforts would require constructing permanent facilities such as access roads and levees/embankments, degrading existing levees, excavating channels, and converting areas that are open water to other, vegetated habitats.

As discussed in Appendix 3F, at the Bouldin Island mitigation site, a new setback levee would be constructed behind and connected to the existing levee, and parts of an existing levee either would be removed or degraded (i.e., reduced in height but not entirely removed). The existing levee segments that are removed would be converted to open water. Both the removed and degraded levee segments would not entail a gain or a loss in topsoil acreage. The plan anticipates that imported fill material would be needed to construct some or all the new setback levee. Because the mitigation effort is in the planning phase, the CMP does not specify the length or footprint area of new setback levee that would be constructed, such that is not possible to accurately calculate the area of topsoil that would be overcovered by fill material. However, based on the CMP's reference to up to 5 miles of new fish-friendly levees being constructed, assuming that the levee cross-section would be 50 feet wide, an estimated maximum loss of 30.3 acres of topsoil would be overcovered. The CMP also would involve converting areas that are now open water (i.e., not underlain by topsoil) to vegetated habitats (i.e., underlain by topsoil). Such conversions would result in a net increase in topsoil areas of 4.2 acres.

At the I-5 ponds mitigation site, conversion of areas that are now open water to vegetated habitats would result in a net increase of approximately 20 acres of areas underlain by topsoil.

Taken together, implementation of the CMP on Bouldin Island and at the I-5 ponds sites would result in an overall net loss of an estimated 6.1 acres of topsoil as a result of overcovering or inundation.

Although construction of the CMP would result in the loss of topsoil, the extent would be small in relation to the area of topsoil that occurs within the study area and the statutory Delta. The impact on topsoil loss from the project combined with the CMP implemented at the Bouldin Island and I-5 ponds mitigation sites would not be substantial and, combined with project alternatives, would not change overall impact conclusions.

As described in Appendix 3F, compensatory mitigation would also involve excavation and other types of earthwork at undetermined channel margin and tidal wetland mitigation sites within the North Delta Arc, which could result in the loss of topsoil and degradation of soil health. The native topsoil loss that could occur at the channel margin sites is not expected to be extensive. The tidal wetland restoration would primarily involve breaching or construction of setback of levees. Where practicable and appropriate, portions of the tidal wetland restoration sites would be graded to raise the ground level to an elevation that would support tidal marsh vegetation. It cannot be known at this time the type and extent of the earthwork and subsequent extent of topsoil loss and soil health effects that could occur at the undetermined tidal wetland and channel margin restoration sites; however, unless extensive native topsoil areas are covered with dredged material or RTM, the amount of topsoil loss is expected to be relatively small in comparison to the extent of topsoil loss that would occur as a result of constructing the conveyance facilities. Therefore, the project alternatives combined with compensatory mitigation would not change the overall impact conclusion of less than significant.

*Other Mitigation Measures*

Some mitigation measures would involve activities such as excavating topsoil, transporting topsoil, and applying and grading topsoil and would result in the potential loss of topsoil. Additionally, soil health degradation could occur at sites in which the topsoil would not be excavated or overcovered, such as at construction staging and laydown areas where the soil could be compacted or otherwise affected. The mitigation measures with potential to result in the loss of topsoil are: Mitigation Measures BIO-2c: *Electrical Power Line Support Placement*, AG-3: *Replacement or Relocation of Affected Infrastructure Supporting Agricultural Properties*, AES-1c: *Implement Best Management Practices to Implement Project Landscaping Plan,* CUL-1: *Prepare and Implement a Built-Environment Treatment Plan in Consultation with Interested Parties,* and AQ-9: *Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero*. Temporary loss of topsoil resulting from implementation of mitigation measures would be similar to construction effects of the project alternatives in certain construction areas and would contribute to loss of topsoil impacts of the project alternatives. Measures would be implemented to manage (mineral) topsoil and ameliorate any adverse effects of soil health. Other mitigation measures would minimize the extent of topsoil that would be lost and minimize impacts on soil health to the maximum extent practicable. In addition, the loss of topsoil would be small in relation to the extent of topsoil that exists in the study area. Therefore, implementation of mitigation measures is unlikely to result substantial loss of topsoil and degradation of soil health.

Overall, loss of topsoil impacts for construction of compensatory mitigation and implementation of other mitigation measures, combined with the project alternatives, would not change the impact conclusion less than significant.

### Impact SOILS-3: Property Loss, Personal Injury, or Death from Instability, Failure, and Damage as a Result of Constructing the Proposed Water Conveyance Facilities on or in Soils Subject to Subsidence

#### *All Project Alternatives*

*Project Construction*

For all project alternatives, field investigations prior to the start of construction would involve a variety of ground-disturbing activities, none of which would involve constructing facilities that would be constrained or affected by soils subject to subsidence, nor would the activities increase the potential for subsidence.

For all project alternatives, some of the project facilities would be constructed in areas where the surface soils and substrates are subject to subsidence, particularly the organic soils. Facilities that would be constructed on or in such soils are certain launch, maintenance, and reception shaft pads and other appurtenant structures; rail spurs and rail-served materials depots; temporary and permanent levees and levee improvements; parts of the Southern Complex (particularly part of the Southern Forebay [excluding Alternative 5, which does not include the Southern Complex]); some topsoil and RTM storage areas; some bridges; and some transmission lines and access roads.[13] Without adequate engineering, facilities constructed on these soils could be subject to the effects of ongoing regional subsidence.

Based on the Tunnel Excavation and Drive Assessment technical memorandum in Attachment B of the C-E EPR, the tunnel would be bored approximately 100 to 170 feet below the current ground surface, beneath the organic soils (which extend up to 40 feet below the ground surface); and subsidence caused by organic matter decomposition at or below tunnel depth is expected to be minimal (Delta Conveyance Design and Construction Authority 2022l:1).

At shaft pad sites underlain by organic soils, ground improvement methods described in the C-E and Bethany EPRs (Delta Conveyance Design and Construction Authority 2022c:98; 2022d:64) could be used to strengthen the pad area.

Damage to certain conveyance facilities such as pumping plants, control structures, and forebay embankments, caused by subsidence under the facilities and consequent damage to or failure of the facility, could occur. Facility damage or failure could cause a rapid release of water to the surrounding area, resulting in flooding, thereby endangering people and property in the vicinity.

Based on site-specific geotechnical investigations, feasible ground improvement measures would be designed for each site in which the soils are subject to subsidence, depending on the nature of the facility. Embankment foundation improvements would be implemented where needed (i.e., cutoff walls for seepage, or ground improvement for embankment stability). The ground improvement measures for a given facility may include various combinations of removal of peat soils, installation of vertical wick drains and preloading of soils to promote soil consolidation prior to construction, installation of seepage cutoff walls, and in situ soil treatments for improving foundation strength such as deep mechanical mixing (DMM) or jet grouting approaches.

[13]As discussed in detail in Section 11.1.2, *Land Subsidence*, subsidence refers to a slow lowering of the ground elevation on a regional scale, typically caused by groundwater withdrawal and peat oxidation. In contrast, ground settlement occurs not on a regional scale but at specific locations where construction would occur.

With respect to the Southern Forebay, shaft pad fills, ring levees, and the intakes, design considerations would include flood management, soil stability and seismic considerations, embankment and foundation stability, and seepage cutoff wall placement. Embankment foundation improvements would be implemented where needed (i.e., cutoff walls for seepage, or ground improvement for embankment stability) because of potentially poorly consolidated or weak foundations and seismic conditions. A 15-foot-wide access road and groundwater monitoring network would be installed along the perimeter of the outboard toe of the embankment (exterior slope). Ground improvement would be implemented under portions of the embankment to minimize risk of ground subsidence. Ground improvement would include excavation and replacement of at least 6 feet of the upper Southern Forebay embankment foundation and would be performed for the entire perimeter. The excavation and replacement, and ground improvement if required, would create a consistent embankment foundation and remove shallow foundation discontinuities. Deeper excavation and replacement could be performed, if practical, to remove unsuitable foundation materials, such as peat and highly organic mineral soils.

In addition to excavation and replacement of the upper foundation soils, three additional methods of ground improvement would be used at the Southern Forebay for improving foundation strength, including a DMM cutoff wall, surcharging, and wick drains.

*Operations and Maintenance*

As described in Chapter 3, *Description of the Proposed Project and Alternatives,* and in the two Potential Future Field Investigations technical memoranda prepared for the project (Delta Conveyance Design and Construction Authority 2022j:2–11, 2022k:2–7), the results of the geotechnical investigations would be used to inform the final design of the facilities underlain by soils subject to subsidence. (The ground improvement measures included in the final design would mitigate subsidence-related settlement only at the facility locations, but they would not address regional subsidence in the project area). Design measures used during construction would compensate for excessive subsidence that could otherwise occur during the operations and maintenance phase. For surficial facilities, such as embankments, levees, and shaft pads, design measures would include removal of peat soils, installation of vertical wick drains, preloading of soils to promote ground settlement prior to construction, and in situ soil treatments for improving foundation strength to prevent excessive ground subsidence beyond allowable tolerances for operations and maintenance. Therefore, no excessive soil subsidence due to implementation of the project is expected to occur during the operations and maintenance phase.

***CEQA Conclusion—All Project Alternatives***

Some of the project facilities would be constructed on soils that are subject to excessive subsidence. Subsidence occurring after the facility is constructed could result in damage to or failure of the facility.

As described in Section 11.3.1, *Methods for Analysis,* geotechnical investigations would be conducted at all facilities to identify the subsidence potential and types of soil avoidance or soil stabilization measures that should be implemented to ensure that subsidence beneath facilities is within the design limits or that facilities are constructed to withstand subsidence and would conform to applicable state and federal standards. These studies would build upon the C-E EPR and Bethany EPR (Delta Conveyance Design and Construction Authority 2022c, 2022d). Such standards include the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures, the California Building Code (CBC), and USACE Design and Construction of Levees. The results of the investigations, which would be conducted by a California registered civil engineer or California registered geotechnical engineer, would be presented in geotechnical reports. The reports would contain recommended measures to prevent subsidence. (See Chapter 10, *Geology and Seismicity,* for discussion of state and federal standards that would be applied to address seismically induced settlement.)

The geotechnical investigations would involve a range of surveys and analyses that would inform the engineering solutions to be carried into detailed project design and construction. Consolidation testing and organic matter content testing would be performed on soil samples collected during the site-specific field investigations to determine site-specific geotechnical properties. Shallow soils with high organic matter content that are subject to subsidence and therefore unsuitable for supporting structures, roadways, and other facilities would be overexcavated and replaced with engineered fill, and the unsuitable soils disposed of off-site, as described in more detail below. Geotechnical evaluations would be conducted to identify soil materials that are suitable for engineering purposes.

Conforming to state and federal design standards would protect the integrity of the project facilities against any subsidence that takes place. As described in Section 11.3.1, *Methods for Analysis*, such design codes and standards include the CBC and resource agency and professional engineering specifications, such as the American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures. Conforming to the standards and guidelines may necessitate such measures as excavation and removal of weak soils and replacement with engineered fill using suitable, imported soil where the native material is unsuitable for construction, construction on deep foundations into competent soil material, and construction of facilities on cast-in-place slabs. These measures would reduce the potential hazard of subsidence to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence.

Because these measures would reduce the potential hazard of subsidence to acceptable limits meeting design standards, this impact would be less than significant.

#### ***Mitigation Impacts***

*Compensatory Mitigation*

Although the CMP described in Appendix 3F does not act as mitigation for impacts on soils from project construction or operations and maintenance, its implementation could result in impacts on soils.

The compensatory mitigation would be constructed on Bouldin Island and the three I-5 ponds. The surface soils underlying the Bouldin Island site are organic and, therefore, subject to subsidence. The compensatory mitigation is not expected to involve construction of habitable structures, significant foundations, etc., but some of the mitigation efforts would entail construction of up to 5 miles of new setback levees on Bouldin Island, which may be founded on soils subject to subsidence. Subsidence of the levee foundation soil of the levee itself over time could cause levee failure and unintentional flooding. However, DWR would construct these levees according to Delta standards such as Federal Emergency Management Agency Hazard Mitigation Plan or Public Law 84-99 and maintain them to keep pace with subsidence of the underlying foundation soils, such as by periodically adding soil material to the levee. The soils underlying the I-5 ponds site are generally inorganic and, therefore, not subject to subsidence.

Construction of setback levees, foundations for water control structures, etc. would be required to be designed and constructed in accordance with resource agency and professional engineering specifications to avoid the effects of subsidence. The impact on subsidence from the project combined with the CMP implemented at the Bouldin Island and I-5 ponds mitigation sites would not be substantial and, combined with the project alternatives, would not change overall impact conclusions.

As described in Appendix 3F, compensatory mitigation would also involve excavation and other earthwork within the North Delta Arc at undetermined tidal wetland or channel margin restoration sites, the latter which would involve construction of setback levees and possibly new levees. The levees would be constructed in areas that are subject to ongoing subsidence. Unless properly engineered, subsidence of the soil underlying the levee foundations over time could result in a loss of freeboard and subsequent overtopping of the levees. However, levee construction would be required to conform to state and federal design standards such that they would withstand any subsidence that occurs. As described in Section 11.3.1, *Methods for Analysis*, such design codes and standards include resource agency and professional engineering specifications. Conforming to the standards and guidelines may necessitate such measures as excavation and removal of weak soils and replacement with engineered fill using suitable, imported soil where the native material is unsuitable for levee construction. These measures would reduce the potential hazard of subsidence to acceptable levels by avoiding construction directly on or otherwise stabilizing the soil material that is prone to subsidence. Therefore, the project alternatives combined with compensatory mitigation would not change the overall impact conclusion of less than significant.

*<u>Other Mitigation Measures</u>*

Some mitigation measures would involve activities such as constructing structures on soils that have the potential to subside. The mitigation measures with potential to be affected by subsidence are: Mitigation Measures BIO-2c: *Electrical Power Line Support Placement*, AG-3: *Replacement or Relocation of Affected Infrastructure Supporting Agricultural Properties*, AES-1c: *Implement Best Management Practices to Implement Project Landscaping Plan,* CUL-1: *Prepare and Implement a Built-Environment Treatment Plan in Consultation with Interested Parties*, and AQ-9: *Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero*. The potential for subsidence underlying structures from implementation of mitigation measures would be similar to construction effects of the project alternatives in certain construction areas. Geotechnical investigations would be conducted at all facilities to identify the subsidence potential and types of soil avoidance or soil stabilization measures that should be implemented to ensure that subsidence beneath facilities is within the design limits or that facilities are constructed to withstand subsidence and would conform to applicable state and federal standards. Geotechnical investigations would inform the site-specific engineering solutions to be carried into project construction and implementation of mitigation measures. Therefore, implementation of mitigation measures is unlikely to result in subsidence and the impact would not be substantial.

Overall, subsidence-related impacts for construction of compensatory mitigation and implementation of other mitigation measures, combined with the project alternatives, would not change the impact conclusion of less than significant.

**Impact SOILS-4: Risk to Life and Property as a Result of Constructing the Proposed Water Conveyance Facilities in Areas of Expansive or Corrosive Soils**

***All Project Alternatives***

*Project Construction*

For all project alternatives, field investigations conducted prior to the start of construction would involve a variety of ground-disturbing activities, most of which would be of limited extent, as described under Impact SOILS-1. The field investigations would not be constrained by expansive or corrosive soils and the investigations would not increase the hazard of such soils to life and property.

For all project alternatives, some of the water conveyance facilities would be constructed in areas where the surface soils and substrates are subject to expansion or where the soil could corrode concrete and uncoated steel. The integrity of the water conveyance facilities, including Bethany Aqueduct pipelines, intakes, pumping plants, underground utilities, footings for above-ground utilities and bridge abutments, access roads, and other features could be adversely affected by such soils.

*Expansive Soils*

Soils with a high shrink-swell potential (i.e., expansive soils) could damage facilities or cause the facilities to fail. For example, foundations and pavements could be cracked or shifted and pipelines could rupture. Soil expansion is a concern only at depths that are subject to seasonal changes in moisture content.

Shrink-swell potential (represented by areas of high linear extensibility in Figure 11-3) of the near-surface soils is generally low or moderate over the majority of the footprints for Alternative 1, 2a, 2b, 2c, 3, 4a, 4b, and 4c. Shrink-swell potential within these footprints is comparatively highest in parts of the Southern Complex.

With the exception of the Twin Cities Complex and New Hope Tract shaft sites where the near-surface soils have a high shrink-swell potential, the native near-surface soil surrounding the tunnel shaft sites is low or moderate. The tunnels would be constructed at depths that are below seasonal changes in soil moisture content and therefore are not subject to soil expansion and contraction.

The near-surface soil shrink-swell potential in the project area is highest underlying parts of the Bethany Reservoir alternative (Alternative 5), where clayey mineral soils occur at or slightly below the surface. The pumping plant, pipeline aqueduct, surge tanks, and discharge structure constructed for that alternative could be underlain by expansive soil.

Site-specific soil investigations and tests would need to be conducted to determine the expansion potential of the soils at the depth of each element of the conveyance facility. As described in Chapter 3 and the Potential Future Field Investigations technical memoranda for the project (Delta Conveyance Design and Construction Authority 2022j:2–6, 2022k:2–7), geotechnical investigations would be conducted at all facilities to identify the site-specific engineering characteristics of the soil, including its expansion potential. For structural designs, the soil expansive potential is generally considered with respect to the ASTM D4546 Standard Test Methods related to one-dimensional swell or collapse of soils. This information would be used during design to determine the potential for wetting-induced swell or collapse of unsaturated soils; therefore, development of design methods that could range from removal and replacement of poor soils to site-specific foundation design by registered engineers would be based upon accepted engineering practices. Information to determine the soil characteristics would be collected during field investigations. The resulting geotechnical reports, prepared by a California registered civil engineer or a California registered geotechnical engineer, would describe these hazards and recommend the measures that should be implemented to ensure that the facilities are constructed to withstand expansion and contraction and to conform to applicable state and federal standards, such as the CBC.

*Soils Corrosive to Concrete*

Soils that are moderately or highly corrosive to concrete may cause the concrete to degrade, thereby threatening the integrity of a facility. Degradation of concrete may cause foundations and concrete culverts to weaken and fail.

The near-surface (i.e., upper 5 feet) soil corrosivity to concrete ranges from low to high within the footprints of all the project alternatives (Figure 11-7). The near-surface soils at the intake facilities generally have a low corrosivity to concrete. The near-surface soils at the tunnel shafts have a low to high corrosivity to concrete. Because soil corrosivity to concrete is high among the near-surface peat soils in the Delta, high corrosivity may also be present among the peat soils in the upper part of the shafts.

Site-specific soil investigations would need to be conducted to determine the soil corrosivity potential at depth for each element of the conveyance facility. The results of the investigations would be used by certified corrosion control specialists to prepare a corrosion protection report that recommends the protective measures that should be implemented to ensure that the facilities are constructed to withstand corrosion and to conform to applicable federal and state standards, such as the CBC.

*Soils Corrosive to Uncoated Steel*

Soils that are moderately and highly corrosive to uncoated steel (including, but not limited to Bethany Aqueduct pipelines and steel rebar embedded in concrete) may cause the steel to degrade and weaken, threatening the integrity of these facilities. Corrosion of the Bethany Aqueduct pipelines could cause the aqueduct to leak and fail. However, the Bethany Aqueduct would be constructed of coated steel, such that corrosion would not occur.

The near-surface soils underlying nearly all of the project alternative footprints are highly corrosive to uncoated steel (Figure 11-6). Site-specific soil investigations would need to be conducted to determine the corrosivity potential at depth for each element of the conveyance facility.

However, as described in Section 11.3.1, *Methods for Analysis*, and Chapter 3, geotechnical investigations would be conducted at all facilities to identify site-specific soil corrosivity (which is determined, in part, by the electrical resistivity and certain chemical attributes of the soil) hazards. The results would be used by certified corrosion control specialists to prepare a corrosion protection report that recommends the protective measures that should be implemented to ensure that the facilities are constructed to withstand corrosion and to conform to applicable federal and state standards, such as the CBC. Depending upon the site-specific resistivity values and the type of facility, the corrosion protection report could describe the types of underground metal components and pipe joints to provide electrical continuity, methods to isolate dissimilar metals, provide protective coatings, install cathodic protection to focus corrosion on items that can be easily replaced during operations and maintenance, and/or utilize corrosion monitoring stations.

*Operations and Maintenance*

Provided that corrosion protection systems are properly maintained, no increased risk to life and property is expected by the presence of expansive or corrosive soils during the operations and maintenance phase.

***CEQA Conclusion—All Project Alternatives***

Near-surface soils in the project area that are highly expansive generally occur only in part of the Southern Complex and part of the Bethany Complex, where clayey mineral soils occur at or slightly below the surface. The pipeline aqueduct, pumping plant, surge tanks, and discharge structure constructed under the Bethany Reservoir alignment (Alternative 5) could be underlain by expansive soil. Expansive soils could cause foundations, water control structures, underground utilities, and pavements to crack and fail. However, DWR would be required to design and construct the facilities in conformance with state and federal design standards, guidelines, and building codes. The CBC requires measures such as soil replacement, lime treatment, and post-tensioned foundations to mitigate the effects of seasonal shrinking and swelling.

Nearly all the conveyance facilities would be constructed in areas that are underlain by near-surface soils that are highly corrosive to uncoated steel. Some of the conveyance facilities, such as certain elements of the Southern Complex and control structures, would be constructed in areas underlain by near-surface soils that are highly corrosive to concrete. Additionally, soil materials at depth that are corrosive to concrete may be present that could affect the tunnels and control structures. Corrosive soils could damage in-ground facilities or shorten their service life. The CBC requires such measures as using protective linings and coatings, dielectric (i.e., use of an electrical insulator polarized by an applied electric field) isolation of dissimilar materials, and active cathodic protection systems to prevent corrosion of concrete and steel in conformance with CBC requirements.

Conforming to these codes and standards would ensure that potential effects associated with expansive and corrosive soils and soils subject to compression and subsidence would be avoided. Therefore, the impact would be less than significant.

***Mitigation Impacts***

*Compensatory Mitigation*

Although the CMP described in Appendix 3F does not act as mitigation for impacts on soils from project construction or operations and maintenance, its implementation could result in impacts on soils.

As described under Impact SOILS-1 and in detail in Appendix 3F, the compensatory mitigation is expected to be built to mitigate, in part or in whole, the potential impacts resulting from the construction and operation and maintenance of the project on terrestrial and aquatic biological resources. The mitigation efforts would require constructing permanent facilities water management structures such as concrete culverts and steel tide gates. These facilities could be subject to the effects of corrosive and expansive soils; however, other commonly used non-corrosive products, such as high-density polyethylene (HDPE) culverts and flexible rubber tide gates, can be used in expansive or corrosive soil environments. The impact caused by expansive or corrosive soils from the project combined with the CMP implemented at the Bouldin Island and I-5 ponds mitigation sites would not be substantial and, combined with the project alternatives, would not change overall impact conclusions.

As described in Appendix 3F, compensatory mitigation would also involve excavation and other earthwork within the North Delta Arc at undetermined tidal wetland or channel margin restoration sites, the latter which would involve construction of setback levees and possibly new levees. The levees could be constructed in areas that are underlain by expansive soils. Unless properly engineered, seasonal expansion and contraction of the soil underlying the levee foundations could reduce the integrity of the levees and result in seepage and piping of water from the water side of the levee and, in extreme conditions, cause the levee to fail. However, levee construction would be required to conform to state and federal design standards to avoid the effects of expansive soils, such that any expansion that occurs would be within acceptable limits. As described in Section 11.3.1, *Methods for Analysis*, the levees would be engineered according to resource agency and professional engineering specifications to avoid excessive expansion. Conforming to the standards and guidelines may necessitate such measures as excavation and removal of expansive levee foundation soils and replacement with engineered fill using suitable, imported soil or implementation of soil stabilization measures such as lime treatment. Therefore, the project alternatives combined with compensatory mitigation would not change the overall impact conclusion of less than significant.

*Other Mitigation Measures*

Some mitigation measures would involve construction of structures on expansive and corrosive soils. The mitigation measures with potential to be affected by expansive or corrosive soils are Mitigation Measures BIO-2c: *Electrical Power Line Support Placement*; AG-3: *Replacement or Relocation of Affected Infrastructure Supporting Agricultural Properties*; and CUL-1: *Prepare and Implement a Built-Environment Treatment Plan in Consultation with Interested Parties*. The hazards of constructing structures on expansive and corrosive soils associated with implementation of mitigation measures would be similar to construction effects of the project alternatives in certain construction areas of the project alternatives. Site-specific soil investigations and tests would need to be conducted to determine the expansive soil and soil corrosivity potential. Compliance with CBC requirements, codes and standards would ensure that potential effects associated with expansive and corrosive soils would be avoided. Therefore, implementation of mitigation measures is unlikely to result in expansive or corrosive soil impacts and the impact would not be substantial.

Overall, expansive or corrosive soil impacts for construction of compensatory mitigation and implementation of other mitigation measures, combined with the project alternatives, would not change impact conclusion of the less than significant.

### Impact SOILS-5: Have Soils Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems Where Sewers Are Not Available for the Disposal of Wastewater

#### *All Project Alternatives*

All of the project alternatives would involve construction and use of septic tanks or alternative wastewater disposal systems (generally referred to as on-site wastewater disposal systems). Wastewater facilities for most of the construction sites would be provided with portable restrooms. Septic systems would be constructed at the intakes, Twin Cities Complex, Bouldin Island, Lower Roberts Island, Southern Complex on Byron Tract (at the Byron Tract Working Shaft and the South Delta Pumping Plant), and the Bethany Reservoir Pumping Plant and Surge Basin site (Delta Conveyance Design and Construction Authority 2022c:87, 88; 2022d:56, 57).

Each system would be constructed in soils that have a similar suitability for use for on-site wastewater disposal systems. Consequently, the project alternatives would have similar impact levels and are therefore discussed together with respect to this impact category.

*Project Construction*

The field investigations conducted prior to the start of construction would not involve construction or use of an on-site wastewater disposal system.

Potential impacts from the use of septic tanks or alternative wastewater disposal systems at each intake, the tunnel launch shaft sites, and the South Delta Pumping Plant or the Bethany Reservoir Pumping Plant could occur during project construction. As shown in Appendix 11B, *Soil Map Units, Taxonomic Classifications, Soil Limitations, and Risk of Corrosion,* most of the soil map units in the project area are underlain by soils that have a use limitation rating of very limited for use for septic tank absorption fields. A review of the soil survey mapping and the specific locations of the proposed septic tank/alternative wastewater disposal system locations reveals that these sites have a use limitation rating of very limited for septic tank/alternative wastewater disposal systems. Such limitations are due to slow water movement through the soils, a shallow depth to a saturated zone, or both (Natural Resources Conservation Service 2021b).

*Operations and Maintenance*

During operations and maintenance, potential impacts from the use of septic tanks or alternative wastewater disposal systems could occur at each intake, the tunnel launch shaft sites, and the South Delta Pumping Plant, or the Bethany Reservoir Pumping Plant. The potential impacts during operations and maintenance would be similar to those described for project construction, except that they could occur throughout the design life of the project.

#### *CEQA Conclusion—All Project Alternatives*

The field investigations conducted prior to the start of construction would not involve construction or use of an on-site wastewater disposal system. Therefore, there would be no impact.

Potential impacts of the use of septic tanks or alternative wastewater disposal systems would occur during construction and operations and maintenance. If a conventional disposal system were to be constructed on soils with a rating of very limited for septic tank absorption fields, use of the system could contaminate surface water and groundwater and create objectionable odors during operations and maintenance. The water contamination could raise the risk of disease transmission and human exposure to pathogens. The impact would be significant.

However, county planning and building departments typically require on-site soil percolation tests and other analyses to determine site suitability and type of system appropriate to the site. Along with compliance with county requirements, implementation of Mitigation Measure SOILS-5: *Conduct Site-Specific Soil Analysis and Construct Alternative Wastewater Disposal System as Required*, would reduce the impact to a less-than-significant level.

**Mitigation Measure SOILS-5: Conduct Site-Specific Soil Analysis and Construct Alternative Wastewater Disposal System as Required**

1. At each proposed wastewater disposal system site, a site-specific analysis of soil characteristics and groundwater conditions will be conducted to determine the soil saturated hydraulic conductivity, depth to seasonal high water table, and other factors that affect the suitability of the site for use for on-site wastewater disposal. Should a site analysis determine that a conventional disposal system could fail, an alternative wastewater disposal system, such as a mound system or a pressure-dosed mound system. The components of on-site wastewater systems typically consist of a septic tank for pretreatment, a pump with a small diameter pipe network, and an absorption area (also known as a leach field). A mound-type leach field consists of an elevated mound of suitable imported soil that is constructed atop the native soil to provide 1 to 2 feet of treatment media (i.e., suitable soil), in which distribution drain lines are installed in trenches. The imported soil used to form the mound is unsaturated and allows soil microbes to feed on the waste and nutrients in the wastewater, thereby effectively treating the wastewater before it percolates into the underlying native soil and groundwater. In a pressure-dosed mound system, the wastewater is dispersed into imported fill soil consisting of rapidly permeable sands that contain a high volume of free air within the pore space. This mitigation measure, where necessitated at a particular site, will reduce the impact to a less-than-significant level by requiring construction contractors to provide soil material of sufficient thickness and permeability that is an adequate distance from the groundwater level to ensure that the effluent is treated and does not contaminate groundwater. Implementation of this mitigation measure would not result in an impact.

***Mitigation Impacts***

*Compensatory Mitigation*

Although the CMP described in Appendix 3F does not act as mitigation for impacts on soils from project construction or operations and maintenance, its implementation could result in impacts on soils. However, no on-site wastewater disposal systems would be constructed for the compensatory mitigation at the I-5 ponds or Bouldin Island under any of the project alternatives. As such, potential impacts related to use of on-site wastewater systems would not change the less than significant impact conclusion.

The undetermined tidal wetland and channel margin restoration sites within the North Delta Arc would not have impacts associated with wastewater disposal systems because no such systems would be constructed at the restoration sites. Therefore, the project alternatives combined with compensatory mitigation would not change the overall impact conclusion of less than significant.

<u>*Other Mitigation Measures*</u>

Other mitigation measures proposed would not have impacts associated with wastewater disposal systems because no on-site wastewater disposal systems would be constructed with implementation of mitigation measures. Therefore, implementation of mitigation measures would not involve soils incapable of supporting wastewater disposal system, and there would be no impact.

Overall, wastewater disposal system impacts for construction of compensatory mitigation and implementation of other mitigation measures, combined with project alternatives, would not change the conclusion of less than significant impact with mitigation.

## 11.3.4 Cumulative Analysis

The geographic scope of the analysis for soils is the project area as defined in Chapter 1, *Introduction* (Figure 1-4). This geographic limit was established to coincide with the project area and to encompass the footprints of all construction and conservation-related ground-disturbing activity associated with the project. The geographic scope of the soils cumulative analysis is centered on large-scale ground-disturbing projects in the Delta region. The analysis focuses on large projects and programs within the project area and the broader Delta region that involve substantial ground-disturbing activities. The principal plans, policies, and programs considered in the analysis are listed in Table 11-6. A full list of projects and greater detail about each project shown in the table that involve substantial ground-disturbing activities is provided in Appendix 3C, *Defining Existing Conditions, No Project Alternative, and Cumulative Impact Conditions*.

**Table 11-6. Cumulative Impacts on Soils from Plans, Policies, and Programs**

| Program/Project | Agency | Status | Description of Program/ Project | Effects on Soils |
|---|---|---|---|---|
| Delta Dredged Sediment Long-Term Management Strategy | USACE | Ongoing | Maintaining and improving channel function, levee rehabilitation, and ecosystem restoration | May increase water erosion rates. Loss of topsoil. |
| Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (EcoRestore project) | DWR | Planning phase | Construction of approximately 2.9 miles of new setback levee to restore and enhance approximately 3,164 acres of upland, tidal, and floodplain habitat | May increase water and wind erosion rates. Loss of topsoil. |
| Prospect Island Tidal Habitat Restoration Project (EcoRestore project) | DWR | Ongoing | Convert 1,253 acres of freshwater tidal marshes and associated aquatic habitat | May increase water and wind erosion rates. Loss of topsoil. |
| Dutch Slough Tidal Marsh Restoration Project (EcoRestore project) | DWR | Ongoing | Wetland and upland habitat restoration in area used for agriculture | May increase water and wind erosion rates. Loss of topsoil. |
| Alameda Watershed HCP | Alameda County | Planning phase | Habitat restoration and implementation of best management and maintenance practices for conservation sites | May increase water and wind erosion rates. Loss of topsoil. |
| Restoring Ecosystem Integrity in the Northwest Delta | CDFW | Completed | Management and restoration of up to 1,300 acres of perennial grassland/vernal pool complex in Solano County Island Corridor | May increase water and wind erosion rates. |

| Program/Project | Agency | Status | Description of Program/ Project | Effects on Soils |
|---|---|---|---|---|
| CALFED Levee System Integrity Program | DWR, CDFW, USACE | Planning phase | Reuse of dredge material. Levee maintenance and levee improvement | May increase water and wind erosion rates. Loss of topsoil. |
| Delta Flood Protection Fund | DWR | Ongoing | Maintenance and rehabilitation of non-project levees in the Delta | May increase water and wind erosion rates. Loss of topsoil. |
| Mayberry Farms Subsidence Reversal and Carbon Sequestration Project | DWR | Completed (ongoing maintenance) | Wetland restoration and enhancement to reverse subsidence | Beneficial impact by reducing subsidence in region. |
| Sherman Island Setback Levee-Mayberry Slough | DWR | Completed | Construction of four sections of setback levees to increase levee stability | May increase water and wind erosion rates. Loss of topsoil. |
| Sherman Island—Whale's Belly Wetlands | DWR | Ongoing | Wetland restoration and enhancement and levee construction to reverse subsidence provide 30,000 acres of habitat | May increase water and wind erosion rates. Loss of topsoil.<br><br>Beneficial impact by reducing subsidence in region. |
| Twitchell Island—San Joaquin River Setback Levee | DWR | Planning phase | Levee stabilization and habitat restoration | May increase water and wind erosion rates. Loss of topsoil. |
| Central Valley Joint Venture Program | Central Valley Joint Venture | Ongoing | Restoration of 19,170 acres of seasonal wetland, enhancement of 2,118 acres of seasonal wetland annually, restoration of 1,208 acres of semi-permanent wetland | May increase water and wind erosion rates. Loss of topsoil. |
| Lower Putah Creek Realignment | CDFW | Planning phase | Restoration of 300–700 acres of tidal freshwater wetlands and creation of 5 miles of a new fish channel | May increase water and wind erosion rates. Loss of topsoil. |

BiOps = Biological Opinions; DWR = Department of Water Resources; CDFW = California Department of Fish and Wildlife; NMFS = National Marine Fisheries Service; USACE = U.S. Army Corps of Engineers; USFWS = U.S. Fish and Wildlife Service; FERC = Federal Energy Regulatory Commission.

### 11.3.4.1 Cumulative Impacts of the No Project Alternative

The ongoing projects and programs within and outside of the Delta under the No Project Alternative in addition to the cumulative projects would require ground-disturbing construction to either construct new facilities or implement restoration and habitat enhancement goals. As outlined in Section 11.3.3.1, *No Project Alternative*, projects that could occur in the absence of the Delta Conveyance Project could occur in a variety of areas. Additionally, SWP operations would require repair, maintenance, or protection of infrastructure such as levees, and may also include actions for water quality management, habitat and species protection, and flood management. These continuing actions could occur throughout the project area and could result in effects on soil erosion rates, loss of topsoil, and degradation of soil health, depending on the type of construction needed for repairs or adjustments to potential irrigation water and drainage needed for water quality and flood management. Because of the ground-disturbing activities associated with the plans, policies, and programs listed in Table 11-6 the suite of all ongoing projects and programs in the Delta could both singly and collectively result in impacts on soils.

Impacts of ongoing projects and programs within and outside of the Delta under the No Project Alternative on soil corrosivity, soil expansion, subsidence and compressible soils, and soils unsuited to on-site wastewater disposal are all restricted to the sites of the respective projects and programs.

#### 11.3.4.2 Cumulative Impacts of the Project Alternatives

All project alternatives would involve vegetation clearing, grubbing, excavation, placement of fill and stockpiling of soil for both water conveyance construction and compensatory mitigation. Such soil disturbances could cause increased water and wind erosion rates. Potential increases in water and wind erosion rates would have a less-than-significant impact with implementation of Environmental Commitment EC-4b: *Develop and Implement Stormwater Pollution Prevention Plans.* Additionally, Environmental Commitment EC-11: *Fugitive Dust Control*, which applies to all active construction sites, would minimize wind erosion. EC-11 requires preparation and implementation of a dust control plan, which would specify measures to control wind erosion such as watering exposed soil and stabilizing stockpiles with biopolymers. Therefore, the project alternatives would not substantially combine with other past, present, and probable future projects and programs in the project area because the other projects would be subject to the same State Water Board Construction General Permit requirements for erosion and sediment control BMPs and effluent limitations as would the Delta Conveyance Project. There would be no cumulative impact due to accelerated soil erosion from construction of the Delta Conveyance Project.

All project alternatives would involve excavation, overcovering, and inundation (compensatory mitigation areas only) of topsoil, resulting in the permanent loss of topsoil. The measures described in the Post-Construction Land Reclamation technical memoranda for the central and eastern alignments and the Bethany Reservoir alignment (Delta Conveyance Design and Construction Authority 2022h:5–9, 2022i:6) would minimize the extent of topsoil that would be lost and would ensure that impacts on soil health are minimized to the maximum extent practicable. However, the impact of topsoil loss resulting from constructing the Delta Conveyance Project acting in combination with other past, present, and probable future projects and programs in the region that also involve topsoil losses and other soil disturbances in the region (e.g., Sherman Island—Whale's Belly Wetlands, Central Valley Joint Venture Program) (see Table 11-6) and, could result in a significant cumulative impact, and the project's contribution to this impact would be cumulatively considerable with respect to loss of topsoil and degradation of soil health.

There would be no cumulative impact associated with soil corrosivity; soil expansion; subsidence and compressible soils; and soils unsuited to on-site wastewater disposal. The effects of those impact mechanisms are restricted to the specific impact sites and, therefore, would not act in combination with other projects. Combined with other past, present, and probable future projects and programs in the study area, the impacts of the project alternatives relating to soil corrosivity, soil expansion, subsidence and compressible soils, and soils unsuited to on-site wastewater disposal would be cumulatively less than significant.