

## 4.3.5 Geology and Seismicity

### **Impact GEO-1: Loss of Property, Personal Injury, or Death from Structural Failure Resulting from Strong Seismic Shaking of Water Conveyance Features during Construction**

Earthquakes could be generated from local and regional seismic sources during construction of the Alternative 4A water conveyance facilities. Seismically induced ground shaking could cause injury of workers at the construction sites as a result of collapse of facilities.

As stated under Alternative 4, the results of the seismic study (California Department of Water Resources 2007a) show that the ground shakings in the Delta are not sensitive to the elapsed time since the last major earthquake (i.e., the projected shaking hazard results for 2005, 2050, 2100, and 2200 are similar).

The hazard of structural failure from seismic shaking under Alternative 4A resulting in loss of property, personal injury, or death during construction would be identical to Alternative 4.

**NEPA Effects:** Seismically-induced ground shaking could cause loss of property or personal injury at the Alternative 4A construction sites (including intake locations, pipelines from intakes to the intermediate forebay, the tunnels, the pumping plant, and the expanded Clifton Court Forebay) as a result of collapse of facilities. Facilities lying directly on or near active blind faults may have an increased likelihood of loss of property or personal injury in the event of seismically-induced ground shaking.

During construction, all active construction sites would be designed and managed to meet the safety and collapse-prevention requirements of the relevant state codes and standards listed under the Alternative 4 analysis, and discussed in Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS, for the anticipated seismic loads. Generally, the applicable codes require that facilities be built so that they incur minimal damage in the event of a foreseeable seismic event and that they remain functional following such an event and that the facility is able to perform without catastrophic failure in the event of a maximum design earthquake (the greatest earthquake reasonably expected to be generated by a specific source on the basis of seismological and geological evidence).

The worker safety codes and standards specify protective measures that must be taken at construction sites to minimize the risk of injury or death from structural or earth failure (e.g., utilizing personal protective equipment, practicing crane and scaffold safety measures).

Conformance with these health and safety requirements and the application of accepted, proven construction engineering practices would reduce any potential risk such that construction of Alternative 4A would not create an increased likelihood of loss of property, personal injury or death of individuals. Therefore, there would be no adverse effect.

**CEQA Conclusion:** Seismically induced ground shaking that is estimated to occur and the resultant ground motion anticipated at Alternative 4A construction sites, including the intake locations, the tunnels, the pipelines and the forebays, could cause collapse or other failure of project facilities while under construction. As described under Alternative 4, DWR would conform to Cal-OSHA and other state code requirements, such as shoring, bracing, lighting, excavation depth restrictions, required slope angles, and other measures, to protect worker safety. Conformance with these standards and codes is an environmental commitment of the project (see Appendix 3B,

1 *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS. Conformance with these health  
2 and safety requirements and the application of accepted, proven construction engineering practices  
3 would reduce this risk and there would be no increased likelihood of loss of property, personal  
4 injury or death due to construction of Alternative 4A. This impact would be less than significant. No  
5 mitigation is required.

6 **Impact GEO-2: Loss of Property, Personal Injury, or Death from Settlement or Collapse**  
7 **Caused by Dewatering during Construction of Water Conveyance Features**

8 As with Alternative 4, settlement of excavations could occur as a result of dewatering at Alternative  
9 4A construction sites with shallow groundwater. Dewatering can stimulate settlement in excavation  
10 and tunneling sites. The settlement could cause the slopes of excavations to fail. Locations where  
11 dewatering would occur during construction of Alternative 4A water conveyance features would be  
12 identical to that under Alternative 4 and the potential impacts are identical under both alternatives.

13 **NEPA Effects:** This potential effect could be substantial because settlement or collapse during  
14 dewatering could cause injury of workers at the construction sites as a result of collapse of  
15 excavations.

16 The hazard of settlement and subsequent collapse of excavations would be evaluated by assessing  
17 site-specific geotechnical and hydrological conditions at intake locations, as well as where intake  
18 and forebay pipelines cross waterways and major irrigation canals. A California-registered civil  
19 engineer or California-certified engineering geologist would recommend measures in a geotechnical  
20 report to address these hazards, such as seepage cutoff walls and barriers, shoring, grouting of the  
21 bottom of the excavation, and strengthening of nearby structures, existing utilities, or buried  
22 structures. As described in Section 9.3.1, *Methods for Analysis*, the measures would conform to  
23 applicable design and building codes, guidelines, and standards, as described under Alternative 4.

24 DWR has made an environmental commitment to also conform to appropriate code and standard  
25 requirements to minimize potential risks (Appendix 3B, *Environmental Commitments*, in Appendix A  
26 of this RDEIR/SDEIS). Generally, the applicable codes require that facilities be built in such a way  
27 that settlement is minimized. Mandatory worker safety codes and standards specify protective  
28 measures that must be taken at construction sites to minimize the risk of injury or death from  
29 structural or earth failure (e.g., utilizing personal protective equipment, practicing crane and  
30 scaffold safety measures).

31 Conformance to these and other applicable design specifications and standards would ensure that  
32 construction of Alternative 4A would not create an increased likelihood of loss of property, personal  
33 injury or death of individuals from settlement or collapse caused by dewatering. Therefore, there  
34 would be no adverse effect.

35 **CEQA Conclusion:** Settlement or failure of excavations during construction could result in loss of  
36 property or personal injury. However, DWR would conform to Cal-OSHA and other state code  
37 requirements to protect worker safety as described under Alternative 4. DWR has also made an  
38 environmental commitment to conform to appropriate codes and standards to minimize potential  
39 risks (Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS). Additionally,  
40 DWR has made an environmental commitment that a geotechnical report be completed by a  
41 California-certified engineering geologist, that the report's geotechnical design recommendations be  
42 included in the design of project facilities, and that the report's design specifications are properly  
43 executed during construction to minimize the potential effects from settlement and failure of

1 excavations. Proper execution of these environmental commitments to minimize potential risks  
2 would result in no increased likelihood of loss of property, personal injury or death due to  
3 construction of Alternative 4A. The impact would be less than significant. No mitigation is required.

4 **Impact GEO-3: Loss of Property, Personal Injury, or Death from Ground Settlement during**  
5 **Construction of Water Conveyance Features**

6 The potential for ground settlement under Alternative 4A would be identical to that under  
7 Alternative 4. The geologic units in the area of the Alternative 4A modified pipeline/tunnel  
8 alignment are the same as those shown for Alternative 4 in Figure 9-3 and summarized in Table 9-  
9 26 of the Draft EIR/EIS. The characteristics of each unit would affect the potential for settlement  
10 during geotechnical investigation and tunneling operations. Segments 1 and 3, located in the  
11 Clarksburg area and the area west of Locke, respectively, contain higher amounts of sand than the  
12 other segments, so they pose a greater risk of settlement.

13 Given the likely design depth of the tunnels, the potential for excessive systematic settlement  
14 expressed at the ground surface caused by tunnel installation is thought to be relatively low.  
15 Operator errors or highly unfavorable/unexpected ground conditions could result in larger  
16 settlement. Large ground settlements caused by tunnel construction are almost always the result of  
17 using inappropriate tunneling equipment (incompatible with the ground conditions), improperly  
18 operating the machine, or encountering sudden or unexpected changes in ground conditions.

19 **NEPA Effects:** The potential effect could be substantial because ground settlement could occur  
20 during geotechnical investigations and the tunneling operation. During detailed project design, a  
21 site-specific subsurface geotechnical evaluation would be conducted along the modified  
22 pipeline/tunnel alignment to verify or refine the findings of the preliminary geotechnical  
23 investigation. These effects would be reduced with implementation of DWR's Environmental  
24 Commitments and Avoidance and Minimization Measures (Appendix 3B in Appendix A of this  
25 RDEIR/SDEIS). As required by DWR's Environmental Commitments, the results of the site-specific  
26 evaluation and the California-registered civil engineer or California-certified engineering geologist's  
27 recommendations would be documented in a detailed geotechnical report prepared in accordance  
28 with state guidelines, in particular *Guidelines for Evaluating and Mitigating Seismic Hazards in*  
29 *California* (California Geological Survey 2008).

30 As described in Section 9.3.1, *Methods for Analysis*, the measures would conform to applicable design  
31 and building codes, guidelines, and standards, such as USACE design measures. See Alternative 4 for  
32 a specific list of applicable codes and standards DWR has made this conformance and monitoring  
33 process an environmental commitment (Appendix 3B, *Environmental Commitments*, in Appendix A  
34 of this RDEIR/SDEIS).

35 Generally, the applicable codes require that facilities be built so that they are designed for a landside  
36 slope stability and seepage/underseepage factors of safety greater than 1.0 (i.e., stable) and would  
37 therefore be less impacted in the event of ground settlement. The worker safety codes and  
38 standards specify protective measures that must be taken at construction sites to minimize the risk  
39 of injury or death from structural or earth failure (e.g., utilizing personal protective equipment,  
40 practicing crane and scaffold safety measures). Conformance to these and other applicable design  
41 specifications and standards would ensure that construction of Alternative 4A would not create an  
42 increased likelihood of loss of property, personal injury or death of individuals from ground  
43 settlement. Therefore, there would be no adverse effect.

1 **CEQA Conclusion:** Ground settlement above the tunneling operation could result in loss of property  
2 or personal injury during construction. However, DWR would conform to Cal-OSHA, USACE and  
3 other design requirements to protect worker safety as described under Alternative 4. DWR has  
4 made conformance to geotechnical design recommendations and monitoring an environmental  
5 commitment (Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS).  
6 Hazards to workers and project structures would be controlled at safe levels and there would be no  
7 increased likelihood of loss of property, personal injury or death due to construction of Alternative  
8 4A. The impact would be less than significant. No mitigation is required.

9 **Impact GEO-4: Loss of Property, Personal Injury, or Death from Slope Failure during**  
10 **Construction of Water Conveyance Features**

11 Excavation of borrow material could result in failure of cut slopes and application of temporary  
12 spoils and RTM at storage sites could cause excessive settlement in the spoils, potentially causing  
13 injury of workers at the construction sites. The potential for slope failure under Alternative 4A  
14 would be identical to that under Alternative 4.

15 **NEPA Effects:** The potential effect could be substantial because excavation of borrow material and  
16 the resultant cutslopes and potential failure of spoils/RTM fill slopes could cause injury of workers  
17 at the construction sites. The potential for slope failure under Alternative 4A would be identical to  
18 that under Alternative 4.

19 During design, the potential for native ground settlement below the spoils would be evaluated by a  
20 geotechnical engineer using site-specific geotechnical and hydrological information. The use of  
21 shoring, seepage cutoff walls, and ground modifications to prevent slope instability, soil boiling, or  
22 excessive settlement would be considered in the design. As described in Section 9.3.1, *Methods for*  
23 *Analysis*, the measures would conform to applicable design and building codes, guidelines, and  
24 standards.

25 In addition to the risk of slope failure at borrow sites and spoils and RTM sites, there are also  
26 potential impacts on levee stability resulting from construction of Alternative 4A water conveyance  
27 facilities. All levee reconstruction/building pad construction would conform to applicable state and  
28 federal flood management engineering and permitting requirements.

29 DWR would ensure that the geotechnical design recommendations are included in the design of  
30 project facilities and construction specifications and are properly executed during construction to  
31 minimize the potential effects from failure of excavations. Conformance with relevant codes and  
32 standards would reduce the potential risk for increased likelihood of loss of property or personal  
33 injury from settlement/failure of cutslopes of borrow sites and failure of soil or RTM fill slopes  
34 during construction. The worker safety codes and standards specify protective measures that must  
35 be taken at construction sites to minimize the risk of injury or death from structural or earth failure  
36 (e.g., utilizing personal protective equipment, practicing crane and scaffold safety measures). The  
37 relevant codes and standards represent performance standards that must be met by contractors and  
38 these measures are subject to monitoring by state and local agencies. DWR has made this  
39 conformance and monitoring process an environmental commitment (Appendix 3B, *Environmental*  
40 *Commitments*, in Appendix A of this RDEIR/SDEIS).

41 Conformance to these and other applicable design specifications and standards would ensure that  
42 construction of Alternative 4A would not create an increased likelihood of loss of property, personal  
43 injury or death of individuals from slope failure at borrow sites and spoils and RTM storage sites.

1 The reconstruction of levees would improve levee stability over existing conditions due to improved  
2 side slopes, erosion countermeasures (geotextile fabrics, rock revetments, riprap, or other material),  
3 seepage reduction measures, and overall mass. Therefore, there would be no adverse effect.

4 **CEQA Conclusion:** Settlement/failure of cutslopes of borrow sites and failure of soil/RTM fill slopes  
5 could result in loss of property or personal injury during construction. However, because DWR  
6 would conform with Cal-OSHA and other state code requirements and conform to applicable  
7 geotechnical design guidelines and standards, such as USACE design measures, the hazard would be  
8 controlled to a safe level and there would be no increased likelihood of loss of property, personal  
9 injury or death due to construction of Alternative 4A at borrow sites and spoils and RTM storage  
10 sites. The reconstruction of levees would improve levee stability over existing conditions due to  
11 improved side slopes, erosion countermeasures, seepage reduction measures, and overall mass. The  
12 impact would be less than significant. No mitigation is required.

13 **Impact GEO-5: Loss of Property, Personal Injury, or Death from Structural Failure Resulting**  
14 **from Construction-Related Ground Motions during Construction of Water Conveyance**  
15 **Features**

16 Pile driving and other heavy equipment operations would cause vibrations that could initiate  
17 liquefaction and associated ground movements in places where soil and groundwater conditions are  
18 present to allow liquefaction to occur. The consequences of liquefaction could result in damage  
19 nearby structures and levees. The potential for liquefaction under Alternative 4A would be identical  
20 to that under Alternative 4.

21 **NEPA Effects:** The potential effect could be substantial because construction-related ground motions  
22 could initiate liquefaction, which could cause failure of structures during construction, which could  
23 result in injury of workers at the construction sites. The potential for liquefaction under Alternative  
24 4A would be identical to that under Alternative 4.

25 During design, the facility-specific potential for liquefaction would be investigated by a geotechnical  
26 engineer. The investigations are an environmental commitment (Appendix 3B, *Environmental*  
27 *Commitments*, in Appendix A of this RDEIR/SDEIS). In areas determined to have a potential for  
28 liquefaction, the California-registered civil engineer or California-certified engineering geologist  
29 would develop design strategies and construction methods to ensure that pile driving and heavy  
30 equipment operations do not cause liquefaction which otherwise could damage facilities under  
31 construction and surrounding structures, and could threaten the safety of workers at the site.

32 Design measures to avoid pile-driving induced levee failure may include predrilling or jetting, using  
33 open-ended pipe piles to reduce the energy needed for pile penetration, using CIDH piles/piers that  
34 do not require driving, using pile jacking to press piles into the ground by means of a hydraulic  
35 system, or driving piles during the drier summer months. Field data collected during design also  
36 would be evaluated to determine the need for and extent of strengthening levees, embankments,  
37 and structures to reduce the effect of vibrations. These construction methods would conform with  
38 current seismic design codes and requirements, as described in Appendix 3B, *Environmental*  
39 *Commitments*, in Appendix A of this RDEIR/SDEIS. Such design standards include USACE's  
40 *Engineering and Design—Stability Analysis of Concrete Structures and Soil Liquefaction during*  
41 *Earthquakes*, by the Earthquake Engineering Research Institute.

42 DWR has made the environmental commitment (see Appendix 3B, *Environmental Commitments*, in  
43 Appendix A of this RDEIR/SDEIS), that the construction methods recommended by the geotechnical

1 engineer are included in the design of project facilities and construction specifications to minimize  
2 the potential for construction-induced liquefaction. DWR also has committed to ensure that these  
3 methods are followed during construction.

4 Generally, the applicable codes require that facilities be built so that if soil in the foundation or  
5 surrounding area are subject to liquefaction, the removal or densification of the liquefiable material  
6 should be considered, along with alternative foundation designs. Additionally, any modification to a  
7 federal levee system would require USACE approval under 33 USC 408 (a 408 Permit).

8 The worker safety codes and standards specify protective measures that must be taken at  
9 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
10 utilizing personal protective equipment, practicing crane and scaffold safety measures).

11 Conformance to construction method recommendations and other applicable specifications would  
12 ensure that construction of Alternative 4A would not create an increased likelihood of loss of  
13 property, personal injury or death of individuals due to construction-related ground motion and  
14 resulting potential liquefaction in the work area. Therefore, there would be no adverse effect.

15 **CEQA Conclusion:** Construction-related ground motions could initiate liquefaction, which could  
16 cause failure of structures during construction. However, because DWR would conform to Cal-OSHA  
17 and other state code requirements and conform to applicable design guidelines and standards, such  
18 as USACE design measures, the hazard would be controlled to a level that would protect worker  
19 safety (see Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS). Further,  
20 DWR has made an environmental commitment (see Appendix 3B, *Environmental Commitments*, in  
21 Appendix A of this RDEIR/SDEIS) that the construction methods recommended by the geotechnical  
22 engineer are included in the design of project facilities and construction specifications to minimize  
23 the potential for construction-induced liquefaction. DWR also has committed to ensure that these  
24 methods are followed during construction. Proper execution of these environmental commitments  
25 would result in no increased likelihood of loss of property, personal injury or death due to  
26 construction of Alternative 4A. The impact would be less than significant. No mitigation is required.

27 **Impact GEO-6: Loss of Property, Personal Injury, or Death from Structural Failure Resulting**  
28 **from Rupture of a Known Earthquake Fault during Operation of Water Conveyance Features**

29 **NEPA Effects:** Alternative 4A would include the same physical/structural components as Alternative  
30 4, and therefore, the effects of Alternative 4A would be the same as Alternative 4. The effect would  
31 not be adverse because like Alternative 4, no active faults extend into the Alternative 4A alignment.  
32 Additionally, although the Thornton Arch and West Tracy blind thrusts occur beneath the  
33 Alternative 4A alignment, they do not present a hazard of surface rupture based on available  
34 information, including the AP Earthquake Fault Zone Map showing faults capable of surface rupture  
35 (Figure 9-5 of the Draft EIR/EIS).

36 However, because there is limited information regarding the depths of the Thornton Arch and West  
37 Tracy blind thrusts, seismic surveys would be performed on the blind thrust during the design phase  
38 to determine the depths to the top of the faults. More broadly, design-level geotechnical studies  
39 would be prepared by a geotechnical engineer licensed in the state of California during project  
40 design. Consistent with the environmental commitments (see Appendix 3B, *Environmental*  
41 *Commitments*, in Appendix A of this RDEIR/SDEIS), DWR would ensure that the geotechnical  
42 engineer's recommended measures to address adverse conditions would conform to applicable  
43 design codes, guidelines, and standards, would be included in the project design and construction

1 specifications, and would be properly executed during construction. Generally, the applicable codes  
2 require that facilities be built so that they incur minimal damage in the event of a foreseeable  
3 seismic event and that they remain functional following such an event and that the facility is able to  
4 perform without catastrophic failure in the event of a maximum design earthquake (the greatest  
5 earthquake reasonably expected to be generated by a specific source on the basis of seismological  
6 and geological evidence). As described in Section 9.3.1, *Methods for Analysis* in Chapter 9, *Geology  
7 and Seismicity*, of the Draft EIR/EIS, such conformance with design codes, guidelines, and standards  
8 are considered environmental commitments by DWR (see Appendix 3B, *Environmental  
9 Commitments*, in Appendix A of this RDEIR/SDEIS).

10 DWR would ensure that the geotechnical design recommendations are included in the design of  
11 project facilities and construction specifications to minimize the potential effects from seismic  
12 events and the presence of adverse soil conditions. DWR would also ensure that the design  
13 specifications are properly executed during construction.

14 The worker safety codes and standards specify protective measures that must be taken at  
15 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
16 utilizing personal protective equipment).

17 Conformance to these and other applicable design specifications and standards would ensure that  
18 operation of Alternative 4 would not create an increased likelihood of loss of property, personal  
19 injury or death of individuals in the event of ground movement in the vicinity of the project. There  
20 would be no adverse effect.

21 **CEQA Conclusion:** There are no active faults capable of surface rupture that extend into the  
22 Alternative 4A modified pipeline/tunnel alignment. Design-level geotechnical studies would be  
23 prepared by a geotechnical engineer licensed in the state of California during project design. The  
24 studies would further assess site-specific conditions at and near all the project facility locations,  
25 including seismic activity, soil liquefaction, and other potential geologic and soil-related hazards.  
26 This information would be used to verify assumptions and conclusions included in the EIR/EIS.  
27 Consistent with the project's environmental commitments (see Appendix 3B, *Environmental  
28 Commitments*, in Appendix A of this RDEIR/SDEIS), DWR would ensure that the geotechnical  
29 engineer's recommended measures to address adverse conditions would conform to applicable  
30 design codes, guidelines, and standards, would be included in the project design and construction  
31 specifications, and would be properly executed during construction. Conformance to these and other  
32 applicable design specifications and standards would ensure that operation of Alternative 4 would  
33 not create an increased likelihood of loss of property, personal injury or death of individuals in the  
34 event of ground movement in the vicinity of the project. Therefore, such ground movements would  
35 not jeopardize the integrity of the surface and subsurface facilities along the Alternative 4A  
36 conveyance alignment or the proposed expanded Clifton Court Forebay and associated facilities  
37 adjacent to the existing Clifton Court Forebay. There would be no impact. No mitigation is required.

38 **Impact GEO-7: Loss of Property, Personal Injury, or Death from Structural Failure Resulting**  
39 **from Strong Seismic Shaking during Operation of Water Conveyance Features**

40 Earthquake events may occur on the local and regional seismic sources during operation of the  
41 Alternative 4A water conveyance facilities. The ground shaking could damage pipelines, tunnels,  
42 intake facilities, pumping plants, and other facilities disrupting the water supply through the  
43 conveyance system. In an extreme event of strong seismic shaking, uncontrolled release of water  
44 from damaged pipelines, tunnels, intake facilities, pumping plant, and other facilities could cause

1 flooding, disruption of water supplies to the south, and inundation of structures. These effects are  
2 discussed more fully in Appendix 3E, *Potential Seismicity and Climate Change Risks to SWP/CVP*  
3 *Water Supplies*, of the Draft EIR/EIS.

4 **NEPA Effects:** This potential effect could be substantial because strong ground shaking could  
5 damage pipelines, tunnels, intake facilities, pumping plant, and other facilities and result in loss of  
6 property or personal injury. The effects of Alternative 4A would be identical to Alternative 4. The  
7 damage could disrupt the water supply through the conveyance system. In an extreme event, an  
8 uncontrolled release of water from the conveyance system could cause flooding and inundation of  
9 structures. Please refer to Chapter 6, *Surface Water*, and Appendix 3E, *Potential Seismicity and*  
10 *Climate Change Risks to SWP/CVP Water Supplies*, of the Draft EIR/EIS for a detailed discussion of  
11 potential flood effects.

12 The structure of the underground conveyance facility would decrease the likelihood of loss of  
13 property or personal injury of individuals from structural shaking of surface and subsurface  
14 facilities along the Alternative 4A conveyance alignment in the event of strong seismic shaking.

15 In accordance with the DWR's environmental commitments (see Appendix 3B, *Environmental*  
16 *Commitments*, in Appendix A of this RDEIR/SDEIS), design-level geotechnical studies would be  
17 conducted by a licensed civil engineer who practices in geotechnical engineering. The California-  
18 registered civil engineer or California-certified engineering geologist's recommended measures to  
19 address this hazard would conform to applicable design codes, guidelines, and standards.

20 DWR would ensure that the geotechnical design recommendations are included in the design of  
21 project facilities and construction specifications to minimize the potential effects from seismic  
22 events and the presence of adverse soil conditions. Generally, the applicable codes require that  
23 facilities be built so that they incur minimal damage in the event of a foreseeable seismic event and  
24 that they remain functional following such an event and that the facility is able to perform without  
25 catastrophic failure in the event of a maximum design earthquake (the greatest earthquake  
26 reasonably expected to be generated by a specific source on the basis of seismological and geological  
27 evidence). DWR would also ensure that the design specifications are properly executed during  
28 construction. See Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS.

29 The worker safety codes and standards specify protective measures that must be taken at  
30 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
31 utilizing personal protective equipment).

32 Conformance to these and other applicable design specifications and standards would ensure that  
33 operation of Alternative 4A would not create an increased likelihood of loss of property, personal  
34 injury or death of individuals from structural shaking of surface and subsurface facilities along the  
35 Alternative 4A conveyance alignment in the event of strong seismic shaking. Therefore, there would  
36 be no adverse effect.

37 **CEQA Conclusion:** The impacts of Alternative 4A would be identical to Alternative 4. Seismically  
38 induced strong ground shaking could damage pipelines, tunnels, intake facilities, pumping plant, and  
39 other facilities. The damage could disrupt the water supply through the conveyance system. In an  
40 extreme event, an uncontrolled release of water from the damaged conveyance system could cause  
41 flooding and inundation of structures. (Please refer to Chapter 6, *Surface Water*, of the Draft EIR/EIS  
42 for a detailed discussion of potential flood impacts.) However, through the final design process,  
43 which would be supported by geotechnical investigations required by DWR's environmental

1 commitments (see Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS),  
2 measures to address this hazard would be required to conform to applicable design codes,  
3 guidelines, and standards. Conformance with these codes and standards is an environmental  
4 commitment by DWR to ensure that ground shaking risks are minimized as the water conveyance  
5 features are operated. The hazard would be controlled to a safe level and there would be no  
6 increased likelihood of loss of property, personal injury or death due to operation of Alternative 4A.  
7 The impact would be less than significant. No mitigation is required.

8 **Impact GEO-8: Loss of Property, Personal Injury, or Death from Structural Failure Resulting**  
9 **from Seismic-Related Ground Failure (Including Liquefaction during Operation of Water**  
10 **Conveyance Features**

11 **NEPA Effects:** The potential effect could be substantial because seismically induced ground shaking  
12 could cause liquefaction, and damage pipelines, tunnels, intake facilities, pumping plant, and other  
13 facilities. The damage could disrupt the water supply through the conveyance system. In an extreme  
14 event, an uncontrolled release of water from the damaged conveyance system could cause flooding  
15 and inundation of structures. The effects of Alternative 4A would be identical to Alternative 4. Please  
16 refer to Appendix 3E, *Potential Seismicity and Climate Change Risks to SWP/CVP Water Supplies*, of  
17 the Draft EIR/EIS for a detailed discussion of potential flooding effects.

18 In the process of preparing final facility designs, site-specific geotechnical and groundwater  
19 investigations would be conducted to identify and characterize the vertical (depth) and horizontal  
20 (spatial) extents of liquefiable soil. During final design, site-specific potential for liquefaction would  
21 be investigated by a geotechnical engineer. In areas determined to have a potential for liquefaction,  
22 a California-registered civil engineer or California-certified engineering geologist would develop  
23 design measures and construction methods to meet design criteria established by building codes  
24 and construction standards to ensure that the design earthquake does not cause damage to or  
25 failure of the facility. Such measures and methods include removing and replacing potentially  
26 liquefiable soil, strengthening foundations (for example, using post-tensioned slab, reinforced mats,  
27 and piles) to resist excessive total and differential settlements, and using *in situ* ground  
28 improvement techniques (such as deep dynamic compaction, vibro-compaction, vibro-replacement,  
29 compaction grouting, and other similar methods). The results of the site-specific evaluation and  
30 California-registered civil engineer or California-certified engineering geologist's recommendations  
31 would be documented in a detailed geotechnical report prepared in accordance with state  
32 guidelines, in particular *Guidelines for Evaluating and Mitigating Seismic Hazards in California*  
33 (California Geological Survey 2008). Conformance with these design requirements is an  
34 environmental commitment by DWR to ensure that liquefaction risks are minimized as the water  
35 conveyance features are operated (see Appendix 3B, *Environmental Commitments*, in Appendix A of  
36 this RDEIR/SDEIS).

37 DWR would ensure that the geotechnical design recommendations are included in the design of  
38 project facilities and construction specifications to minimize the potential effects from liquefaction  
39 and associated hazards. DWR would also ensure that the design specifications are properly executed  
40 during construction.

41 Additionally, any modification to a federal levee system would require USACE approval under 33  
42 USC 408 (a 408 Permit).

43 The worker safety codes and standards specify protective measures that must be taken at  
44 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,

1 utilizing personal protective equipment). Conformance to these and other applicable design  
2 specifications and standards would ensure that the hazard of liquefaction and associated ground  
3 movements would not create an increased likelihood of loss of property, personal injury or death of  
4 individuals from structural failure resulting from seismic-related ground failure along the  
5 Alternative 4A conveyance alignment during operation of the water conveyance features. Therefore,  
6 the effect would not be adverse.

7 **CEQA Conclusion:** The impacts of Alternative 4A would be identical to Alternative 4. Seismically  
8 induced ground shaking could cause liquefaction. Liquefaction could damage pipelines, tunnels,  
9 intake facilities, pumping plant, and other facilities, and thereby disrupt the water supply through  
10 the conveyance system. In an extreme event, flooding and inundation of structures could result from  
11 an uncontrolled release of water from the damaged conveyance system. (Please refer to Chapter 6,  
12 *Surface Water*, of the Draft EIR/EIS for a detailed discussion of potential flood impacts.) However,  
13 through the final design process, measures to address the liquefaction hazard would be required to  
14 conform to applicable design codes, guidelines, and standards. Conformance with these design  
15 standards is an environmental commitment by DWR to ensure that liquefaction risks are minimized  
16 as the water conveyance features are operated. See Appendix 3B, *Environmental Commitments*, in  
17 Appendix A of this RDEIR/SDEIS. The hazard would be controlled to a safe level and there would be  
18 no increased likelihood of loss of property, personal injury or death due to operation of Alternative  
19 4A. The impact would be less than significant. No mitigation is required.

#### 20 **Impact GEO-9: Loss of Property, Personal Injury, or Death from Landslides and Other Slope** 21 **Instability during Operation of Water Conveyance Features**

22 Alternative 4A would involve excavation that creates new cut-and-fill slopes and construction of  
23 new embankments and levees. As a result of ground shaking and high soil-water content during  
24 heavy rainfall, existing and new slopes that are not properly engineered and natural stream banks  
25 could fail and cause damage to facilities. The effects of Alternative 4A would be identical to  
26 Alternative 4.

27 **NEPA Effects:** The potential effect could be substantial because levee slopes and stream banks may  
28 fail, either from high pore-water pressure caused by high rainfall and weak soil, or from seismic  
29 shaking. Structures built on these slopes could be damaged or fail entirely as a result of slope  
30 instability. As discussed in Impact SW-2 in Chapter 6, *Surface Water*, of the Draft EIR/EIS, operation  
31 of the water conveyance features under Alternative 4A would not result in an increase in potential  
32 risk for flood management compared to existing conditions. Peak monthly flows under Alternative  
33 4A in the locations considered were similar to or less than those that would occur under existing  
34 conditions. Since flows would not be substantially greater, the potential for increased rates of  
35 erosion or seepage are low. For additional discussion on the possible exposure of people or  
36 structures to impacts from flooding due to levee failure, please refer to Impact SW-6 in Chapter 6,  
37 *Surface Water*, of the Draft EIR/EIS.

38 During project design, a geotechnical engineer would develop slope stability design criteria (such as  
39 minimum slope safety factors and allowable slope deformation and settlement) for the various  
40 anticipated loading conditions. The design criteria would be documented in a detailed geotechnical  
41 report prepared in accordance with state guidelines, in particular *Guidelines for Evaluating and*  
42 *Mitigating Seismic Hazards in California* (California Geological Survey 2008).

43 Site-specific geotechnical and hydrological information would be used, and the design would  
44 conform with the current standards and construction practices. The design requirements would be

1 presented in a detailed geotechnical report. Conformance with these design requirements is an  
2 environmental commitment by DWR to ensure that slope stability hazards would be avoided as the  
3 water conveyance features are operated. See Appendix 3B, *Environmental Commitments*, in  
4 Appendix A of this RDEIR/SDEIS. DWR would ensure that the geotechnical design recommendations  
5 are included in the design of cut and fill slopes, embankments, and levees to minimize the potential  
6 effects from slope failure. DWR would also ensure that the design specifications are properly  
7 executed during construction.

8 Generally, the applicable codes require that facilities be built to certain factors of safety in order to  
9 ensure that facilities perform as designed for the life of the structure despite various soil  
10 parameters.

11 The worker safety codes and standards specify protective measures that must be taken at  
12 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
13 utilizing personal protective equipment). Conformance to the above and other applicable design  
14 specifications and standards would ensure that the hazard of slope instability would not create an  
15 increased likelihood of loss of property, personal injury of individuals along the Alternative 4A  
16 conveyance alignment during operation of the water conveyance features. Therefore, the effect  
17 would not be adverse.

18 **CEQA Conclusion:** Unstable levee slopes and natural stream banks may fail, either from high pore-  
19 water pressure caused by high rainfall and weak soil, or from seismic shaking. Structures  
20 constructed on these slopes could be damaged or fail entirely as a result of slope instability.

21 However, during the final project design process, as required by DWR's environmental  
22 commitments (see Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS),  
23 a geotechnical engineer would develop slope stability design criteria (such as minimum slope safety  
24 factors and allowable slope deformation and settlement) for the various anticipated loading  
25 conditions during facility operations.

26 DWR would also ensure that measures to address this hazard would be required to conform to  
27 applicable design codes, guidelines, and standards. Conformance with these codes and standards is  
28 an environmental commitment by DWR to ensure cut and fill slopes and embankments will be stable  
29 as the water conveyance features are operated and there would be no increased likelihood of loss of  
30 property, personal injury or death due to operation of Alternative 4A. The impact would be less than  
31 significant. No mitigation is required.

### 32 **Impact GEO-10: Loss of Property, Personal Injury, or Death from Seiche or Tsunami during** 33 **Operation of Water Conveyance Features**

34 The effects of Alternative 4A would be identical to Alternative 4.

35 **NEPA Effects:** The effect of a tsunami generated in the Pacific Ocean would not be adverse because  
36 the distance from the ocean and attenuating effect of the San Francisco Bay would likely allow only a  
37 low (i.e., less than 2 feet) tsunami wave height to reach the Delta (Contra Costa Transportation  
38 Agency 2009).

39 In most parts of the Plan Area, the effects of a seiche would not be adverse because the seismic  
40 hazard and the geometry of the water bodies (i.e., wide and shallow) near conveyance facilities are  
41 not favorable for a seiche to occur. However, assuming that the West Tracy fault is potentially active,  
42 a potential exists for a seiche to occur in the expanded Clifton Court Forebay. The effect could be

1 adverse because the waves generated by a seiche could overtop the expanded Clifton Court Forebay  
2 embankments, causing erosion of the embankments and subsequent flooding in the vicinity.

3 However, design-level geotechnical studies would be conducted by a licensed civil engineer who  
4 practices in geotechnical engineering. The studies would determine the peak ground acceleration  
5 caused by movement of the West Tracy fault and the maximum probable seiche wave that could be  
6 generated by the ground shaking. The California-registered civil engineer or California-certified  
7 engineering geologist's recommended measures to address this hazard, as well as the hazard of a  
8 seiche overtopping the expanded Clifton Court Forebay embankment, would conform to applicable  
9 design codes, guidelines, and standards. Conformance with these codes and standards is an  
10 environmental commitment by DWR to ensure that the adverse effects of a seiche are controlled to  
11 an acceptable level while the forebay facility is operated. See Appendix 3B, *Environmental*  
12 *Commitments*, in Appendix A of this RDEIR/SDEIS.

13 DWR would ensure that the geotechnical design recommendations are included in the design of  
14 project facilities and construction specifications to minimize the potential effects from seismic  
15 events and consequent seiche waves. DWR would also ensure that the design specifications are  
16 properly executed during construction.

17 Generally, the applicable codes provide guidance on estimating the effects of climate change and sea  
18 level rise and associated effects when designing a project and ensuring that a project is able to  
19 respond to these effects.

20 The worker safety codes and standards specify protective measures that must be taken at  
21 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
22 utilizing personal protective equipment). Conformance to these and other applicable design  
23 specifications and standards would ensure that the embankment for the expanded portion of the  
24 Clifton Court Forebay would be designed and constructed to contain and withstand the anticipated  
25 maximum seiche wave height and would not create an increased likelihood of loss of property,  
26 personal injury or death of individuals along the Alternative 4A conveyance alignment during  
27 operation of the water conveyance features. Therefore, the effect would not be adverse.

28 **CEQA Conclusion:** The height of a tsunami wave reaching the Suisun Marsh and the Delta would be  
29 small because of the distance from the ocean and attenuating effect of the San Francisco Bay.  
30 Similarly, the potential for a significant seiche to occur in most parts of the Plan Area is considered  
31 low because the seismic hazard and the geometry of the water bodies (i.e., wide and shallow) near  
32 conveyance facilities are not favorable for a seiche to occur. However, assuming the West Tracy fault  
33 is potentially active, a potential exists for a seiche to occur in the expanded Clifton Court Forebay  
34 (Fugro Consultants 2011).

35 However, design-level geotechnical studies would be conducted by a licensed civil engineer who  
36 practices in geotechnical engineering. The studies would determine the peak ground acceleration  
37 caused by movement of the West Tracy fault and the maximum probable seiche wave that could be  
38 generated by the ground shaking. The California-registered civil engineer or California-certified  
39 engineering geologist's recommended measures to address this hazard, as well as the hazard of a  
40 seiche overtopping the expanded Clifton Court Forebay embankment, would conform to applicable  
41 design codes, guidelines, and standards. Conformance with these codes and standards is an  
42 environmental commitment by DWR to ensure that the adverse effects of a seiche are controlled to  
43 an acceptable level while the forebay facility is operated. DWR would ensure that the geotechnical  
44 design recommendations are included in the design of project facilities and construction

1 specifications to minimize the potential effects from seismic events and consequent seiche waves.  
2 DWR would also ensure that the design specifications are properly executed during construction.

3 The effect would not be adverse because the expanded Clifton Court Forebay embankment would be  
4 designed and constructed according to applicable design codes, guidelines, and standards to contain  
5 and withstand the anticipated maximum seiche wave height, as required by DWR's environmental  
6 commitments (see Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS).  
7 There would be no increased likelihood of loss of property, personal injury or death due to  
8 operation of Alternative 4A from seiche or tsunami. The impact would be less than significant. No  
9 additional mitigation is required.

10 **Impact GEO-11: Ground Failure Caused by Increased Groundwater Surface Elevations from**  
11 **Unlined Canal Seepage as a Result of Operating the Water Conveyance Facilities**

12 **NEPA Effects:** Alternative 4A would not involve construction of unlined canals; therefore, there  
13 would be no increase in groundwater surface elevations and consequently no effect caused by canal  
14 seepage. There would be no adverse effect.

15 **CEQA Conclusion:** Alternative 4A would not involve construction of unlined canals; therefore, there  
16 would be no increase in groundwater surface elevations and consequently no impact caused by  
17 canal seepage. The impact would be less than significant. No mitigation is required.

18 **Impact GEO-12: Loss of Property, Personal Injury, or Death Resulting from Structural Failure**  
19 **Caused by Rupture of a Known Earthquake Fault at Restoration Opportunity Areas**

20 According to the available AP Earthquake Fault Zone Maps, only the Suisun Marsh ROA could be  
21 affected by rupture of an earthquake fault. The active Green Valley fault crosses the southwestern  
22 corner of the ROA. The active Cordelia fault extends approximately 1 mile into the northwestern  
23 corner of the ROA. Rupture of these faults could damage levees and berms constructed as part of the  
24 restoration, which could result in failure of the levees and flooding of otherwise protected areas.  
25 Under Alternative 4A, no Environmental Commitments would occur in the Suisun Marsh ROA.

26 Within the Delta, active or potentially active blind thrust faults were identified in the seismic study  
27 (California Department of Water Resources 2007a). The extreme southeastern corner of the Suisun  
28 Marsh is underlain by the Montezuma blind thrust zone. Parts of the Cache Slough and Yolo Bypass  
29 ROAs are underlain by part of the North Midland blind thrust zone. The Cosumnes/Mokelumne  
30 River and East Delta ROAs are underlain by the Thornton Arch zone. Although these blind thrusts  
31 are not expected to rupture to the ground surface during earthquake events, they may produce  
32 ground or near-ground shear zones, bulging, or both. In the seismic study (California Department of  
33 Water Resources 2007a), the Thornton Arch blind thrust was assigned a 20% probability of being  
34 active. The depth to the Thornton Arch blind fault is unknown. Based on limited geologic and  
35 seismic survey information, it appears that the potential of having any shear zones, bulging, or both  
36 at the sites of the habitat levees is low because the depth to the blind thrust faults is generally deep.

37 **NEPA Effects:** Effects related to rupture of a known earthquake fault within an ROA under  
38 Alternative 4A would be similar in mechanism to those described for Alternative 4, but to a  
39 substantially smaller magnitude based on the conservation activities proposed under Alternative 4A  
40 (and as described in Section 4.1, *Introduction*, of this RDEIR/SDEIS).

41 Because there is limited information regarding the depths of the blind faults mentioned above,  
42 seismic surveys would be performed in the vicinity of the faults as part of final design. These surveys

1 would be used to verify fault depths where levees and other features would be constructed.  
2 Collection of this depth information would be part of broader, design-level geotechnical studies  
3 conducted by a geotechnical engineer licensed in the state of California to support all aspects of site-  
4 specific project design. The studies would assess site-specific conditions at and near all the project  
5 facility locations, including the nature and engineering properties of all soils and underlying geologic  
6 strata, and groundwater conditions. The geotechnical engineers' information would be used to  
7 develop final engineering solutions to any hazardous condition, consistent with the code and  
8 standards requirements of federal, state and local oversight agencies. Conformance with these  
9 design standards is an environmental commitment by the project proponents to ensure that risks  
10 from a fault rupture are minimized as levees for habitat restoration areas are constructed and  
11 maintained (see Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS).  
12 The hazard would be controlled to a safe level by following the proper design standards.

13 The project proponents would ensure that the geotechnical design recommendations are included in  
14 the design of project facilities and construction specifications to minimize the potential effects from  
15 seismic events and the presence of adverse soil conditions. The project proponents would also  
16 ensure that the design specifications are properly executed during implementation.

17 Generally, the applicable codes require that facilities be built so that they incur minimal damage in  
18 the event of a foreseeable seismic event and that they remain functional following such an event and  
19 that the facility is able to perform without catastrophic failure in the event of a maximum design  
20 earthquake (the greatest earthquake reasonably expected to be generated by a specific source on  
21 the basis of seismological and geological evidence).

22 The worker safety codes and standards specify protective measures that must be taken at  
23 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
24 utilizing personal protective equipment, practicing crane and scaffold safety measures).  
25 Conformance to these and other applicable design specifications and standards would ensure that  
26 the hazard of ground movement in the vicinity of the blind thrusts underlying the ROAs would not  
27 jeopardize the integrity of the levees and other features constructed in the ROAs and would not  
28 create an increased likelihood of loss of property, personal injury or death of individuals in the  
29 ROAs. This effect would not be adverse.

30 **CEQA Conclusion:** As noted above, effects related to rupture of a known earthquake fault within an  
31 ROA under Alternative 4A would be similar in mechanism to those described for Alternative 4, but  
32 to a substantially smaller magnitude based on the restoration activities proposed under Alternative  
33 4A. Rupture of the Cordelia and Green Valley faults could occur at the Suisun Marsh ROA and  
34 damage ROA facilities, such as levees and berms. Damage to these features could result in their  
35 failure, causing flooding of otherwise protected areas. Environmental Commitments under  
36 Alternative 4A would not occur in the Suisun Marsh area.

37 However, through the final design process for conservation activities in the ROAs and because there  
38 is limited information regarding the depths of the blind faults mentioned above, seismic surveys  
39 would be performed in the vicinity of the faults as part of final designs. These surveys would be used  
40 to verify fault depths where levees and other features would be constructed. Collection of this depth  
41 information would be part of broader, design-level geotechnical studies conducted by a geotechnical  
42 engineer licensed in the state of California to support all aspects of site-specific project design. The  
43 studies would assess site-specific conditions at and near all the project facility locations, including  
44 the nature and engineering properties of all soils and underlying geologic strata, and groundwater

1 conditions. The geotechnical engineer's information would be used to develop final engineering  
2 solutions and project designs to any hazardous condition, consistent with DWR's environmental  
3 commitments (see Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS).

4 Additionally, measures to address the fault rupture hazard would be required to conform to  
5 applicable design codes, guidelines, and standards. Conformance with these design codes,  
6 guidelines, and standards is an environmental commitment by the project proponents to ensure that  
7 fault rupture risks are minimized as the conservation activities are implemented. The hazard would  
8 be controlled to a safe level and there would be no increased likelihood of loss of property, personal  
9 injury or death in the ROAs. The impact would be less than significant. No mitigation is required.

10 **Impact GEO-13: Loss of Property, Personal Injury, or Death from Structural Failure Resulting**  
11 **from Strong Seismic Shaking at Restoration Opportunity Areas**

12 Effects related to strong seismic shaking within an ROA under Alternative 4A would be similar in  
13 mechanism to those described for Alternative 4, but to a substantially smaller magnitude based on  
14 the conservation activities proposed under Alternative 4A (and as described in Section 4.1,  
15 *Introduction*, of this RDEIR/SDEIS).

16 Earthquake events may occur on the local and regional seismic sources at or near the ROAs. Because  
17 of its proximity to these faults, the Suisun Marsh ROA would be especially subject to ground shaking  
18 caused by the Concord-Green Valley fault. The Cache Slough ROA would be subject to shaking from  
19 the Northern Midland fault zone, which underlies the ROA. Although more distant from these  
20 sources, the other ROAs would be subject to shaking from the San Andreas, Hayward-Rodgers  
21 Creek, Calaveras, Concord-Green Valley, San Gregorio, Greenville, and Mt. Diablo Thrust faults and  
22 the more proximate blind thrusts in the Delta.

23 Among all the ROAs, the Suisun Marsh ROA would be most subject to ground shaking because of its  
24 proximity to active faults. The Suisun Marsh ROA is subject to a PGA of approximately 0.31–0.35 g  
25 for 200-year return interval, while the PGA for the other ROAs ranges from approximately 0.11–0.26  
26 g. The ground shaking could damage levees and other structures, and in an extreme event cause  
27 levees to fail such that protected areas flood. However, Environmental Commitments under  
28 Alternative 4A would not occur in the Suisun Marsh area.

29 **NEPA Effects:** All temporary facilities would be designed and built to meet the safety and  
30 collapse-prevention requirements for the above-anticipated seismic loads. Therefore, this effect is  
31 considered not adverse. No additional mitigation measures are required.

32 Site-specific geotechnical information would be used to further assess the effects of local soil on the  
33 OBE and MDE ground shaking and to develop design criteria that minimize the potential of damage.  
34 Design-level geotechnical studies would be prepared by a geotechnical engineer licensed in the state  
35 of California during project design. The studies would assess site-specific conditions at and near all  
36 the project facility locations and provide the basis for designing the levees and other features to  
37 withstand the peak ground acceleration caused by fault movement in the region. The geotechnical  
38 engineer's recommended measures to address this hazard would conform to applicable design  
39 codes, guidelines, and standards. Conformance with these design standards is an environmental  
40 commitment by the project proponents to ensure that strong seismic shaking risks are minimized as  
41 the conservation activities are implemented (see Appendix 3B, *Environmental Commitments*, in  
42 Appendix A of this RDEIR/SDEIS).

1 The project proponents would ensure that the geotechnical design recommendations are included in  
2 the design of project features and construction specifications to minimize the potential effects from  
3 seismic events and the presence of adverse soil conditions. The project proponents would also  
4 ensure that the design specifications are properly executed during implementation.

5 Generally, the applicable codes require that facilities be built so that they incur minimal damage in  
6 the event of a foreseeable seismic event and that they remain functional following such an event and  
7 that the facility is able to perform without catastrophic failure in the event of a maximum design  
8 earthquake (the greatest earthquake reasonably expected to be generated by a specific source on  
9 the basis of seismological and geological evidence).

10 The worker safety codes and standards specify protective measures that must be taken at  
11 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
12 utilizing personal protective equipment, practicing crane and scaffold safety measures).  
13 Conformance to these and other applicable design specifications and standards would ensure that  
14 the hazard of seismic shaking would not jeopardize the integrity of levees and other features at the  
15 ROAs and would not create an increased likelihood of loss of property, personal injury or death of  
16 individuals in the ROAs. This effect would not be adverse.

17 **CEQA Conclusion:** Ground shaking could damage levees, berms, and other structures. Among all the  
18 ROAs, the Suisun Marsh ROA would be the most subject to ground shaking because of its proximity  
19 to active faults. However, Environmental Commitments under Alternative 4A would not occur in the  
20 Suisun Marsh area. Damage to these features could result in their failure, causing flooding of  
21 otherwise protected areas. Conformance with these design standards is an environmental  
22 commitment by the project proponents to ensure that strong seismic shaking risks are minimized as  
23 the conservation activities are operated and there would be no increased likelihood of loss of  
24 property, personal injury or death in the ROAs (see Appendix 3B, *Environmental Commitments*, in  
25 Appendix A of this RDEIR/SDEIS). The impact would be less than significant. No mitigation is  
26 required.

27 **Impact GEO-14: Loss of Property, Personal Injury, or Death from Structural Failure Resulting**  
28 **from Seismic-Related Ground Failure (Including Liquefaction) Beneath Restoration**  
29 **Opportunity Areas**

30 Effects related to seismic-related ground failure beneath an ROA under Alternative 4A would be  
31 similar in mechanism to those described for Alternative 4, but to a substantially smaller magnitude  
32 based on the conservation activities proposed under Alternative 4A (and as described in Section 4.1,  
33 *Introduction*, of this RDEIR/SDEIS).

34 New structural features are proposed at the ROAs, such as levees as part of Environmental  
35 Commitment 4, setback levees as part of Environmental Commitment 6. However, the amount of  
36 restoration being proposed under Alternative 4A is much smaller in breadth than under Alternative  
37 4. Earthquake induced ground shaking could cause liquefaction, resulting in damage to or failure of  
38 these levees and other features constructed at the restoration areas. The consequences of  
39 liquefaction are manifested in terms of compaction or settlement, loss of bearing capacity, lateral  
40 spreading (horizontal soil movement), and increased lateral soil pressure. Failure of levees and  
41 other structures could result in flooding of otherwise protected areas in Suisun Marsh and behind  
42 new setback levees along the Sacramento and San Joaquin Rivers and in the South Delta ROA

1 The ROAs vary with respect to their liquefaction hazard (Figure 9-6 of the Draft EIR/EIS). All of the  
2 levees in the Suisun Marsh ROA have a medium vulnerability to failure from seismic shaking and  
3 resultant liquefaction. The liquefaction vulnerability among the other ROAs in which seismically-  
4 induced levee failure vulnerability has been assessed (Figure 9-6 of the Draft EIR/EIS) (i.e., in parts  
5 or all the Cache Slough Complex and South Delta ROAs) is medium or high.

6 **NEPA Effects:** The potential effect could be substantial because earthquake-induced liquefaction  
7 could damage ROA facilities, such as levees and berms. Damage to these features could result in  
8 their failure, causing flooding of otherwise protected areas.

9 During final design of conservation facilities, site-specific geotechnical and groundwater  
10 investigations would be conducted by a geotechnical engineer to identify and characterize the  
11 vertical (depth) and horizontal (spatial) extent of liquefiable soil.

12 In areas determined to have a potential for liquefaction, the engineer would develop design  
13 parameters and construction methods to meet the design criteria established to ensure that design  
14 earthquake does not cause damage to or failure of the facility. Conformance with these design  
15 standards is an environmental commitment by the project proponents to ensure that liquefaction  
16 risks are minimized as the conservation activities are implemented.

17 Generally, the applicable codes require that facilities be built so that if soil in the foundation or  
18 surrounding area are subject to liquefaction, the removal or densification of the liquefiable material  
19 should be considered, along with alternative foundation designs. The hazard would be controlled to  
20 a safe level.

21 The worker safety codes and standards specify protective measures that must be taken at  
22 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
23 utilizing personal protective equipment, practicing crane and scaffold safety measures). As required  
24 by the environmental commitments (see Appendix 3B, *Environmental Commitments*, in Appendix A  
25 of this RDEIR/SDEIS), the project proponents would ensure that the geotechnical design  
26 recommendations are included in the design of levees and construction specifications to minimize  
27 the potential effects from liquefaction and associated hazard. The project proponents would also  
28 ensure that the design specifications are properly executed during implementation and would not  
29 create an increased likelihood of loss of property, personal injury or death of individuals in the  
30 ROAs. This effect would not be adverse.

31 **CEQA Conclusion:** Earthquake induced ground shaking could cause liquefaction, resulting in damage  
32 to or failure of levees, berms, and other features constructed at the restoration areas. Failure of  
33 levees and other structures could result in flooding of otherwise protected areas. As required by the  
34 environmental commitments (see Appendix 3B, *Environmental Commitments*, in Appendix A of this  
35 RDEIR/SDEIS), site-specific geotechnical and groundwater investigations would be conducted to  
36 identify and characterize the vertical (depth) and horizontal (spatial) extent of liquefiable soil. The  
37 project proponents would ensure that the geotechnical design recommendations are included in the  
38 design of levees and construction specifications to minimize the potential effects from liquefaction  
39 and associated hazard. The project proponents would also ensure that the design specifications are  
40 properly executed during implementation and would not create an increased likelihood of loss of  
41 property, personal injury or death of individuals in the ROAs. Further, through the final design  
42 process, measures to address the liquefaction hazard would be required to conform to applicable  
43 design codes, guidelines, and standards. Conformance with these design standards is an  
44 environmental commitment by the project proponents to ensure that liquefaction risks are

1 minimized as the water conservation features are implemented and there would be no increased  
2 likelihood of loss of property, personal injury or death in the ROAs. The impact would be less than  
3 significant. No mitigation is required.

4 **Impact GEO-15: Loss of Property, Personal Injury, or Death from Landslides and Other Slope**  
5 **Instability at Restoration Opportunity Areas**

6 Effects related to landslides and slope instability at an ROA under Alternative 4A would be similar in  
7 mechanism to those described for Alternative 4, but to a substantially smaller magnitude based on  
8 the conservation activities proposed under Alternative 4A (and as described in Section 4.1,  
9 *Introduction*, of this RDEIR/SDEIS).

10 Implementation of Environmental Commitments 3, 4, 6, and 7 could involve breaching, modification  
11 or removal of existing levees and construction of new levees and embankments. Levee  
12 modifications, including levee breaching or lowering, may be performed to reintroduce tidal  
13 exchange, reconnect remnant sloughs, restore natural remnant meandering tidal channels,  
14 encourage development of dendritic channel networks, and improve floodwater conveyance.

15 Levee modifications could involve the removal of vegetation and excavation of levee materials.  
16 Excess earthen materials could be temporarily stockpiled, then re-spread on the surface of the new  
17 levee slopes where applicable or disposed of offsite. Any breaching or other modifications would be  
18 required to be designed and implemented to maintain the integrity of the levee system and to  
19 conform to flood management standards and permitting processes. This would be coordinated with  
20 the appropriate flood management agencies. Those agencies may include USACE, DWR, CVFPB, and  
21 other flood management agencies. For more detail on potential modifications to levees as a part of  
22 conservation activities, please refer to Chapter 3, *Conservation Strategy*, of the Draft BDCP, and  
23 Appendix D, *Substantive BDCP Revisions*, of this RDEIR/SDEIS

24 New and existing levee slopes and stream/channel banks could fail and could damage facilities as a  
25 result of seismic shaking and as a result of high soil-water content during heavy rainfall.

26 With the exception of levee slopes, natural stream banks, and part of the Suisun Marsh ROA the  
27 topography of ROAs is nearly level to gently sloping. The areas that may be susceptible to slope  
28 failure are along existing Sacramento and San Joaquin River and Delta island levees and  
29 stream/channel banks, particularly those levees that consist of non-engineered fill and those  
30 streambanks that are steep and consist of low strength soil.

31 The structures associated with conservation activities would not be constructed in, nor would they  
32 be adjacent to, areas that are subject to mudflows/debris flows from natural slopes.

33 **NEPA Effects:** The potential effect could be substantial because levee slopes and embankments may  
34 fail, either from high pore-water pressure caused by high rainfall and weak soil, or from seismic  
35 shaking. Failure of these features could result in loss, injury, and death as well as flooding of  
36 otherwise protected areas.

37 As outlined in Appendix 3B, *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS,  
38 erosion protection measures and protection against related failure of adjacent levees would be  
39 taken where levee breaches were developed. Erosion protection measures would also be taken  
40 where levee lowering is done for the purposes of allowing seasonal or periodic inundation of lands  
41 during high flows or high tides to improve habitat or to reduce velocities and elevations of  
42 floodwaters. Neighboring levees could require modification to accommodate increased flows or to

1 reduce effects of changes in water elevation or velocities along channels following inundation of  
2 tidal marshes. Hydraulic modeling would be used during subsequent analyses to determine the need  
3 for such measures.

4 New levees would be constructed to separate lands to be inundated for tidal marsh from non-  
5 inundated lands, including lands with substantial subsidence. Levees could be constructed as  
6 described for the new levees at intake locations. Any new levees would be required to be designed  
7 and implemented to conform to applicable flood management standards and permitting processes.

8 Additionally, during project design, a geotechnical engineer would develop slope stability design  
9 criteria (such as minimum slope safety factors and allowable slope deformation and settlement) for  
10 the various anticipated loading conditions.

11 Site-specific geotechnical and hydrological information would be used, and the design would  
12 conform with the current standards and construction practices, as described in Appendix 3B,  
13 *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS.

14 The project proponents would ensure that the geotechnical design recommendations are included in  
15 the design of embankments and levees to minimize the potential effects from slope failure. The  
16 project proponents would also ensure that the design specifications are properly executed during  
17 implementation.

18 Generally, the applicable codes require that facilities be built to certain factors of safety in order to  
19 ensure that facilities perform as designed for the life of the structure despite various soil  
20 parameters.

21 The worker safety codes and standards specify protective measures that must be taken at  
22 construction sites to minimize the risk of injury or death from structural or earth failure (e.g.,  
23 utilizing personal protective equipment). Conformance to the above and other applicable design  
24 specifications and standards would ensure that the hazard of slope instability would not jeopardize  
25 the integrity of levees and other features at the ROAs and would not create an increased likelihood  
26 of loss of property, personal injury or death of individuals in the ROAs. This effect would not be  
27 adverse.

28 **CEQA Conclusion:** Unstable new and existing levee and embankment slopes could fail as a result of  
29 seismic shaking and as a result of high soil-water content during heavy rainfall and cause flooding of  
30 otherwise protected areas. However, during project design and as required by the project  
31 proponents' environmental commitments (see Appendix 3B, *Environmental Commitments*, in  
32 Appendix A of this RDEIR/SDEIS), a geotechnical engineer would develop slope stability design  
33 criteria (such as minimum slope safety factors and allowable slope deformation and settlement) for  
34 the various anticipated loading conditions. The project proponents would ensure that the  
35 geotechnical design recommendations are included in the design of embankments and levees to  
36 minimize the potential effects from slope failure. The project proponents would also ensure that the  
37 design specifications are properly executed during implementation.

38 Additionally, as required by the project proponents' environmental commitments (see Appendix 3B,  
39 *Environmental Commitments*, in Appendix A of this RDEIR/SDEIS), site-specific geotechnical and  
40 hydrological information would be used to ensure conformance with applicable design guidelines  
41 and standards, such as USACE design measures. Through implementation of these environmental  
42 commitments, the hazard would be controlled to a safe level and there would be no increased

1 likelihood of loss of property, personal injury or death in the ROAs. The impact would be less than  
2 significant. Therefore, no mitigation is required.

3 **Impact GEO-16: Loss of Property, Personal Injury, or Death from Seiche or Tsunami at**  
4 **Restoration Opportunity Areas as a Result of Implementing the Conservation Actions**

5 **NEPA Effects:** The distance from the ocean and attenuating effect of the San Francisco Bay would  
6 likely allow only a low tsunami wave height to reach the Suisun Marsh and the Delta. Conditions for  
7 a seiche to occur at the ROAs are not favorable. Therefore, the effect would not be adverse.

8 **CEQA Conclusion:** Based on recorded tsunami heights at the Golden Gate, the height of a tsunami  
9 wave reaching the ROAs would be small because of the distance from the ocean and attenuating  
10 effect of the San Francisco Bay. Similarly, the potential for a significant seiche to occur in the Plan  
11 Area that would cause loss of property, personal injury, or death at the ROAs is considered low  
12 because conditions for a seiche to occur at the ROAs are not favorable. The impact would be less  
13 than significant. No mitigation is required.