Chapter 9
Geology and Seismicity

9.1 Summary Comparison of Proposed Project

A summary comparison of an impact related to geology and seismicity is provided in Figure 9-0. This figure provides information on an impact related to ground settlement that is expected to result from the proposed project compared with the approved project. These incremental values, together with consideration of the severity of the underlying impacts as set forth in the Final EIR/EIS, are the basis for making both NEPA and CEQA impact significance findings. The incremental analysis addresses whether the proposed project, compared with the approved project, would lead to any new significant environmental effects or to any substantial increase in the severity of previously identified significant effects. The incremental difference between the original impacts and the newly anticipated impacts is then considered against the backdrop of the original significance determinations for the original underlying impacts as described in the Final EIR/EIS.

Figure 9-0. Comparison of Impacts Related to Geology and Seismicity

Chapter 9 – Geology and Seismicity	Approved Project	Proposed Project (Total)	Proposed Project (Increment)
Impact GEO-3: Loss of Property, Personal Injury, or Death from Ground Settlement during Construction of Water Conveyance Features (number of segments that pose greatest risk of settlement per alternative)	2	2	0
	Less than significant/ not adverse	Remains less than significant/not adverse. No change from the approved project	

As depicted in Figure 9-0, the proposed project would not result in new impacts or a substantial increase in the severity of previously identified impacts related to geology and seismicity. This chapter contains the information necessary to make the Final EIR/EIS adequate for the approved project as revised.

9.2 Environmental Setting/Affected Environment

9.2.1 Affected Environment

The Existing Conditions related to geology and seismicity that would be affected by construction and operation of the proposed project are slightly different from those described in Final EIR/EIS Chapter 9, G*eology and Seismicity*, Section 9.1 *Environmental Setting/Affected Environment*. Specifically, some of the proposed project facilities would be closer to an earthquake fault that may be capable of surface deformations. The Final EIR/EIS provides a discussion of geologic substrates, seismicity including ground shaking and surface fault rupture, liquefaction, ground settlement, slope instability, seiche, tsunami, and mudflow hazards found within the Plan Area and region. The proposed project would be located entirely within the previously analyzed project area and,

consequently, the Existing Conditions have not changed. Figure 9-2, *Geologic Borehole Locations*, is based on boring logs contained in the 2009 through 2012 DWR geotechnical data reports and shows a cross-section of the stratigraphy of the sediments and peat (expressed as Unified Soil Classification System abbreviations) generally oriented along the proposed project alignment.

Among the regulatory design codes and standards for project structures that are presented in Final EIR/EIS Section 9.2.2.6, more recent versions have been issued for five.

- American Association of State Highway and Transportation Officials Guide Specifications for LRFD [load and resistance factor] Seismic Bridge Design, 1st Edition, 2009. Updated as 2nd edition in 2011.
- American Railway Engineering and Maintenance-of-Way Association *Manual for Railway Engineering*, Volume 2, Chapter 9, *Seismic Design for Railway Structures*, 2008. Updated in 2017.
- California Building Standards Code, 2010 (Title 24 California Code of Regulations). Revised edition published in 2016.
- California Department of Transportation *Seismic Design Criteria*, Version 1.6, Nov 2010. Updated with Version 1.7 in 2013 and includes changes regarding liquefaction and lateral spreading considerations, new design provisions for pile foundations in poor and marginal soils, and other substantive design issues.
- U.S. Army Corps of Engineers (USACE) Engineering and Design—*Earthquake Design and Evaluation for Civil Works Projects*, ER 1110-2-1806, 1995. Superseded by 2016 version.

Proposed project design and construction techniques would consider and adhere to all relevant changes in the requirements of these codes and standards from the versions in effect at the time that the Final EIR/EIS was prepared.

9.3 Environmental Consequences

This section describes the potential effects of the modifications to the approved project on geology and seismicity within the study area. The focus of this assessment is on determining the incremental effect from geology and seismicity that is attributable to these modifications. With the exception of focusing on the incremental effects, the methods of analysis and determination of effects is the same as indicated in the Final EIR/EIS.

Effects are evaluated for severity and, where appropriate, mitigation measures are identified. Where mitigation measures identified in the Final EIR/EIS remain sufficient, such sufficiency is noted. This section describes potential direct and reasonably foreseeable indirect effects on geology and seismicity that would result from construction of the proposed project. Some impact topics addressed in the Final EIR/EIS are not addressed herein because the change in the footprint of the water conveyance facilities would not result in a changed impact. This chapter does not address impacts at the restoration opportunity areas. Additionally, the impacts resulting from implementation of Environmental Commitments 3, 4, 6–12, 15, and 16, whether they occur under the proposed project or approved project, are fully disclosed in the Final EIR/EIS and would not change if the footprint changes described for the proposed project are constructed.

Direct or indirect effects from geology and seismicity in areas upstream of the Delta are not anticipated; thus, the geology and seismicity in these areas are not discussed further in this section. Potential effects on upstream areas are discussed in Final EIR/EIS Chapter 5, *Water Supply*.

The methods applied to the analysis of impacts on geology and seismicity are the same as indicated in Section 9.3.1 in the Final EIR/EIS.

9.3.1 Effects and Mitigation Approaches

9.3.1.1 No Action Alternative

Under the No Action Alternative, the new Byron Tract Forebay, reusable tunnel material (RTM) storage, and other footprint changes described for the proposed project would not occur. For the purposes of this Supplemental EIR/EIS, the No Action Alternative, against which this proposed project is compared, is consistent with the No Action Alternative Early Long-Term in the Final EIR/EIS. No differing effects resulting from geologic conditions and seismic hazards would occur along the proposed project alignment from what was previously described in the No Action Alternative Early Long-Term in the Final EIR/EIS if the No Action Alternative were to occur.

9.3.1.2 Proposed Project

The proposed project would result in permanent effects on geologic conditions and the water conveyance facility's susceptibility of seismic hazards in the study area associated with construction of a forebay, tunnels, and canal. Nearby areas would be altered as work or staging areas, concrete batch plants, fuel stations, or be used for spoils storage areas. Transmission lines, access roads, and other incidental facilities would also be needed for operation of the project and construction of these structures would have a permanent effect on the geologic substrate.

Implementation of the proposed project would also result in permanent changes in the geologic substrate associated with the water conveyance structures. Other feature modifications that would result in effects on the geologic substrate include soil borrow, spoil, reusable tunnel material storage areas, and access roads.

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

RTM Storage

Changes related to moving RTM storage from Zacharias Island to Bouldin Island under the proposed project would result in a similar impact with respect to potential loss of property, personal injury, or death from structural failure resulting from strong seismic shaking of the RTM storage area as described for the approved project in Final EIR/EIS Section 9.3.4.2, *Alternative 4A*. The RTM itself would be identical in composition and be placed in a manner similar to that for the approved project. The RTM storage site used for the proposed project would have a similar ground shaking potential as the site that would be used for the approved project. Therefore, its potential for failure and consequent potential loss of property, personal injury, or death from caused by seismic shaking at the RTM storage area during construction would be similar to that of the approved project.

Byron Tract Forebay and Conveyance

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

Changes related to constructing the new Byron Tract Forebay, south tunnels, and canal instead of the Clifton Court Forebay modifications could result in a greater risk to property, personal injury, or death from structural failure resulting from seismic shaking of conveyance features during construction because the Byron Tract Forebay would be located closer to a potential shaking source (i.e., the West Tracy fault) than would the expanded Clifton Court Forebay.

Similarly, the south tunnels and new canal section would be constructed through an area more closely associated with the West Tracy fault compared with the area the Clifton Court Forebay expansion would have covered. Therefore, the potential for failure and consequent potential loss of property, personal injury, or death caused by seismic shaking at the Byron Tract Forebay could be greater with the proposed project compared to that of the approved project.

As stated in the analysis of Alternative 4A in Section 9.3.4.2 of the Final EIR/EIS, the results of the seismic study (California Department of Water Resources 2007) show that ground shaking hazards 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).

NEPA Effects: Seismically induced ground shaking could cause loss of property or personal injury at the proposed project construction sites (including the Byron Tract Forebay pumping plant, the Byron Tract Forebay, and new canal) 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 4A analysis in Section 9.3.4.2 of the Final EIR/EIS, and discussed in Appendix 3B, *Environmental Commitments, AMMs, and CMs*, for the anticipated seismic loads.

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 the proposed project would not create an increased adverse effect or 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 proposed project construction sites, including the Byron Tract Forebay pumping plant, the Byron Tract Forebay, and new canal, could cause collapse or other failure of project facilities while under construction. As described for the approved project, DWR would conform to California Occupational Safety and Health Administration (Cal-OSHA) and other state code requirements, such as shoring, bracing, lighting, excavation depth restrictions, required slope angles, to protect worker safety. Conformance with these standards and codes is an environmental commitment of the project (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*).

Incremental Impact: Under the proposed project, the construction of the Byron Tract Forebay, south tunnels, and canal would involve a slightly greater risk of property, personal injury, or death from seismic shaking during construction than would construction of the approved project, because the Byron Tract Forebay, south tunnels, and canal would be located closer to a potential shaking source (i.e., the West Tracy fault) than would the expanded Clifton Court Forebay. However, conformance with the health and safety requirements described above and the application of accepted, proven construction engineering practices would reduce this risk and there would not be an increased likelihood of loss of property, personal injury, or death due to construction of the proposed project. Therefore, the impact would remain less than significant. No additional mitigation is required.

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

This potential effect could be substantial because settlement or collapse during dewatering could cause injury of workers at the construction sites as a result of collapse of excavations. The risk to and potential effects on life and property as a result of settlement or collapse caused by dewatering during construction would be similar in mechanism and magnitude to those described for the approved project. As with the approved project, settlement of excavations could occur as a result of dewatering at the proposed project construction sites with shallow groundwater. Dewatering can stimulate settlement in excavation and tunneling sites.

RTM Storage

Proposed changes to RTM locations and other footprint changes would not require any additional dewatering activities.

Byron Tract Forebay and Conveyance

Dewatering would be required for constructing the new Byron Tract Forebay and conveyance. The settlement could cause the slopes of excavations to fail. Other locations where dewatering would occur during construction of proposed project water conveyance features would be identical to that under the approved project and the potential impacts from construction of the other water conveyance features are identical under both the proposed and approved projects.

NEPA Effects: The hazard of settlement and subsequent collapse of excavations would be evaluated by assessing site-specific geotechnical and hydrological conditions at intake locations, as well as where intake and forebay pipelines cross waterways and major irrigation canals. A California-registered civil engineer or California-certified engineering geologist would recommend measures in a geotechnical report to address these hazards which would conform to applicable design and building codes, guidelines, and standards, as described for the approved project in Final EIR/EIS Section 9.3.4.2, *Alternative 4A*.

DWR has made an environmental commitment to also conform to appropriate code and standard requirements to minimize potential risks (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*). Therefore, there would be no adverse effect.

***CEQA Conclusion*:** Settlement or failure of excavations during construction could result in loss of property or personal injury. However, DWR would conform to Cal-OSHA and other state code requirements to protect worker safety, as described for the approved project. DWR has also made an environmental commitment to conform to appropriate codes and standards to minimize potential risks (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*). Additionally, DWR has made an environmental commitment that a geotechnical report be completed by a California-certified engineering geologist, that the report's geotechnical design recommendations be included in the design of project facilities, and that the report's design specifications are properly executed during construction to minimize the potential effects from settlement and failure of excavations. Proper execution of these environmental commitments to minimize potential risks would result in no increased likelihood of loss of property, personal injury or death due to construction of the proposed project.

Incremental Impact: The dewatering required for constructing the new Byron Tract Forebay and conveyance would be similar to that required for constructing the Clifton Court Forebay, such that the hazard of settlement or collapse of excavations during construction of the proposed project would be similar to that of the approved project. The impact of the proposed project would remain less than significant. No mitigation is required.

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

RTM Storage and Footprint Changes

The risk to and potential effects on life and property as a result of ground settlement of the soil underlying the RTM and the RTM itself during construction would be identical in mechanism and magnitude to those described for the approved project. The geologic substrate (Peat and Muck – Holocene) and the near-surface soils underlying the relocated RTM storage area under the proposed project is the same as under the approved project, as those shown in Figure 9-1, *Geology of the Plan Area.* Additionally, the RTM would be identical in composition and would be placed in the same manner, and the RTM slope geometry would be the same under the proposed project as under the approved project.

Byron Tract Forebay and Conveyance

The potential for settlement of the forebay berms, tunnels, and canal embankment under the proposed project could be greater compared than that of the approved project. The proposed project requires construction of berms to create the Byron Tract Forebay, whereas construction of the Clifton Court Forebay would be achieved largely by excavating into native soils. Unless they are properly engineered and constructed, settlement of the berms and canal embankments could cause these facilities to fail, potentially causing a loss of property, personal injury, or death.

NEPA Effects: Although the potential effect is expected to be minor, during detailed project design, a site-specific subsurface geotechnical evaluations would be conducted for the Byron Tract Forebay levees, the south tunnels, the canal embankments, and RTM footprints to verify or refine the findings of the preliminary geotechnical investigations. These effects would be reduced with implementation of DWR's environmental commitments and avoidance and minimization measures (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*). The results of the site-specific evaluation and the engineer's recommendations would be documented in a detailed geotechnical report, which will

contain site-specific evaluations of the settlement hazard associated with the site-specific soil characteristics used to construct the levee berms and canal embankments.

As described in Final EIR/EIS Section 9.3.1*, Methods for Analysis,* the measures would conform to applicable design guidelines and standards, such as USACE design measures (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*).

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. Conformance to these and other applicable design specifications and standards would ensure that construction of the proposed project would not create an increased likelihood of loss of property, personal injury or death of individuals from ground settlement. Therefore, there would be no adverse effect.

***CEQA Conclusion*:** Ground settlement of the Byron Tract Forebay berms, canal embankments, and RTM and settlement associated with the south tunnels could result in loss of property or personal injury during construction. However, DWR would conform to Cal-OSHA, USACE, and other design requirements to protect worker safety, as described for the approved project. DWR has made conformance to geotechnical design recommendations and monitoring an environmental commitment (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*). Hazards to workers and project structures would be controlled at safe levels and there would be no increased likelihood of loss of property, personal injury or death due to construction of the proposed project.

> ***Incremental Impact:*** The potential for settlement of the Byron Tract Forebay berms and canal embankments and in association with the south tunnels during construction of the proposed project could be greater than settlement resulting from the approved project. The proposed project requires construction of berms to create the Byron Tract Forebay, whereas construction of the expanded Clifton Court Forebay would be achieved largely by excavating into native soils. Consequently, there could be an increased likelihood of loss of property, personal injury, or death. However, hazards to workers and project structures would be controlled at safe levels such that there would be no significant increased likelihood of loss of property, personal injury or death due to construction of the proposed project. Therefore, the impact would be similar to the impact of the approved project and would remain less than significant. No mitigation is required.

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

RTM Storage

The risk to and potential effects on life and property as a result of slope failure during construction would be similar in mechanism and magnitude to those described for the approved project. Excavation of borrow material could result in failure of cut slopes and application of temporary spoils and RTM at storage sites could cause excessive settlement in the spoils, potentially causing injury of workers at the construction sites. The potential for slope failure under the proposed project would be identical to that under the approved project. Despite changes to certain RTM locations, the discussion for Alternative 4A in Section 9.3.4.2 of the Final EIR/EIS remains applicable here.

Byron Tract Forebay and Conveyance

Construction of the Byron Tract Forebay and conveyance would create no additional or differing impacts than would the approved project.

NEPA Effects: The potential effect could be substantial because excavation of borrow material and the resultant cutslopes and potential failure of spoils/RTM fill slopes could cause injury of workers at the construction sites. The potential for slope failure under the proposed project would be identical to that under the approved project.

During design, the potential for native ground settlement below the spoils would be evaluated by a geotechnical engineer using site-specific geotechnical and hydrological information.

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

DWR would ensure that the geotechnical design recommendations are included in the design of project facilities and construction specifications and are properly executed during construction to minimize the potential effects from failure of excavations. Conformance with relevant codes and standards would reduce the potential risk for increased likelihood of loss of property or personal injury from settlement/failure of cutslopes of borrow sites and failure of soil or RTM fill slopes during construction. 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). The relevant codes and standards represent performance standards that must be met by contractors and these measures are subject to monitoring by state and local agencies. DWR has made this conformance and monitoring process an environmental commitment (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*).

Conformance to these and other applicable design specifications and standards would ensure that construction of the proposed project would not create an increased likelihood of loss of property, personal injury or death of individuals from slope failure at borrow sites and spoils and RTM storage sites. The maintenance and reconstruction of levees would improve levee stability over Existing Conditions due to improved side slopes, erosion control measures (geotextile fabrics, rock revetments, or other material), seepage reduction measures, and overall mass. Therefore, there would be no adverse effect.

***CEQA Conclusion*:** Settlement or failure of cutslopes of borrow sites and failure of soil or RTM fill slopes could result in loss of property or personal injury during construction. However, because DWR would conform to Cal-OSHA and other state code requirements and conform to applicable geotechnical design guidelines and standards, such as USACE design measures, the hazard would be controlled to a safe level and there would be no increased likelihood of loss of property, personal injury, or death due to construction of the proposed project at borrow sites or at spoils and RTM storage sites. The maintenance and reconstruction of levees would improve levee stability over Existing Conditions due to improved side slopes, erosion control measures, seepage reduction measures, and overall mass.

Incremental Impact: There would be no incremental impact of construction of the proposed project over the approved project. The potential impact of slope failure and subsequent loss of property, personal injury, or death during construction of the Byron Tract Forebay and conveyance and RTM storage areas during construction of the proposed project would be similar to the impact of the approved project. The impact of the proposed project would remain less than significant. No mitigation is required.

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

RTM Storage

Relocating RTM storage areas would create no additional or differing impacts than would the approved project.

Byron Tract Forebay and Conveyance

The risk to and potential effects on life and property as a result of structural failure from construction-related ground motions during construction would be similar in mechanism and magnitude to those described for the approved project. Pile driving, shallow tunneling, and other heavy equipment operations would cause vibrations that could initiate liquefaction and associated ground movements in places where soil and groundwater conditions are present to allow liquefaction to occur. The consequences of liquefaction could result in damage to nearby structures and levees. Based on the seismic vulnerability of levees in the vicinity of the Clifton Court Forebay (see Figure 9-4, *Levee Seismic Vulnerability Groups*), work areas at the Byron Tract Forebay would have a similar susceptibility to construction-induced liquefaction as the area for the expanded Clifton Court Forebay. Therefore, the potential for liquefaction under the proposed project would be similar to the potential under the approved project.

As with constructing the expanded Clifton Court Forebay, driving of sheet piles would be required to construct the Byron Tract Forebay and conveyance; therefore, the proposed project would not create any additional or differing impacts.

NEPA Effects: The potential effect could be substantial because construction-related ground motions could initiate liquefaction, which could cause failure of structures during construction, which could result in injury of workers at the construction sites. Some of the potential levee effects that could occur during the construction in the absence of corrective measures may include rutting, settlement, and slope movement. The potential for liquefaction under the proposed project would be identical to that under the approved project.

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

Field data collected during design also would be evaluated to determine the need for and extent of strengthening levees, embankments, and structures to reduce the effect of vibrations. These construction methods would conform to current seismic design codes and requirements, as described in Appendix 3B, *Environmental Commitments, AMMs, and CMs*.

Should the geotechnical evaluations indicate that certain segments of existing levee roads need improvements to carry the expected construction truck traffic loads, DWR is committed to carry out the necessary improvements to the affected levee sections or to find an alternative route that would avoid the potential deficient levee sections (Mitigation Measures TRANS-2a through 2c). As discussed in Final EIR/EIS Chapter 19, *Transportation*, Mitigation Measure TRANS-2c requires that all affected roadways be returned to preconstruction condition or better following construction. Implementation of this measure would ensure that construction activities would not worsen pavement and levee conditions, relative to Existing Conditions. Prior to construction, DWR would make a good faith effort to enter into mitigation agreements with or to obtain encroachment permits from affected agencies to verify what the location, extent, timing, and fair share cost to be paid by the DWR for any necessary pre- and post-construction physical improvements. Levee roads that are identified as potential haul routes and expected to carry significant construction truck traffic would be monitored to ensure that truck traffic is not adversely affecting the levee and to identify the need for corrective action.

DWR has made the environmental commitment that the construction methods recommended by the geotechnical engineer are included in the design of project facilities and construction specifications to minimize the potential for construction-induced liquefaction (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*). DWR also has committed to ensure that these methods are followed during construction.

Conformance to construction method recommendations and other applicable specifications, as well as implementation of Mitigation Measures TRANS-2a through 2c, would ensure that construction of the proposed project would not create an increased likelihood of loss of property, personal injury or death of individuals due to construction- and traffic-related ground motions and resulting potential liquefaction in the work area. These measures, as written in the Final EIR/EIS, remain adequate without change for dealing with the impacts of the proposed project. Therefore, there would be no adverse effect.

***CEQA Conclusion*:** Construction-related ground motions and traffic effects could initiate liquefaction, which could cause failure of structures during construction. The impact could be significant. However, because DWR would conform to Cal-OSHA and other state code requirements and conform to applicable design guidelines and standards, such as USACE design measures, in addition to implementation of Mitigation Measures TRANS-2a and TRANS-2b, as well as the maintenance and reconstruction of levees through Mitigation Measure TRANS-2c, the hazard would be controlled to a level that would protect worker safety (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*). Further, DWR has made an environmental commitment (see Appendix 3B) that the construction methods recommended by the geotechnical engineer are included in the design of project facilities and construction specifications to minimize the potential for construction-induced liquefaction. DWR also has committed to ensure that these methods are followed during construction. Proper execution of these environmental commitments would result in no increased likelihood of loss of property, personal injury or death due to construction of the proposed project.

Incremental Impact: There would be no incremental impact of construction of the proposed project over the approved project. The impact of construction-related ground motions and subsequent liquefaction and associated ground movements during construction on loss of property, personal injury, or death resulting from the proposed project would be similar to the impact of the approved project. The impact of the proposed project would remain less than significant with mitigation.

Mitigation Measure TRANS-2a: Prohibit Construction Activity on Physically Deficient Roadway Segments

Please refer to Mitigation Measure TRANS-2a under Impact TRANS-2 in Chapter 19, *Transportation,* of the Final EIR/EIS.

Mitigation Measure TRANS-2b: Limit Construction Activity on Physically Deficient Roadway Segments

Please refer to Mitigation Measure TRANS-2b under Impact TRANS-2 in Chapter 19, *Transportation,* of the Final EIR/EIS.

Mitigation Measure TRANS-2c: Improve Physical Condition of Affected Roadway Segments as Stipulated in Mitigation Agreements or Encroachment Permits

Please refer to Mitigation Measure TRANS-2c under Impact TRANS-2 in Chapter 19, *Transportation,* of the Final EIR/EIS.

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

RTM Storage

Relocating RTM storage areas would create no additional or differing impacts than would the approved project.

Byron Tract Forebay and Conveyance

The risk to and potential effects on life and property as a result of structural failure from rupture of an earthquake fault during operation of the conveyance facilities would be overall similar in mechanism and magnitude to those described for the approved project. The expanded Clifton Court Forebay would have been located in the approximate vicinity of the hanging wall of the West Tracy blind thrust. However, the northern section of the tunnels south of Byron Tract Forebay would intersect with the northern limit of the hanging wall and synclinal axis of the fault (California Department of Water Resources 2011).

NEPA Effects: The proposed project would include overall similar physical/structural components as the approved project; therefore, the effects of the proposed project would be approximately the same as the effects of the approved project. The effect would not be adverse because like the approved project, no active faults extend into the proposed project alignment or footprint. Additionally, although the Thornton Arch and West Tracy blind thrusts occur beneath the proposed project footprint and may be capable of causing surface deformations, they do not present a hazard of surface rupture based on available information, including the AP Earthquake Fault Zone Map

showing faults capable of surface rupture (see Figure 9-3, *Active Faults and Historical Seismicity of the Bay and Delta Region*).

Under the approved project, the expanded Clifton Court Forebay would have been located on the projected hanging wall of the West Tracy blind thrust fault and the axis of the fault's syncline. Under the proposed project, the new Byron Tract Forebay and south tunnels would not be directly located above the West Tracy blind thrust fault and the axis of the fault's syncline (California Department of Water Resources 2011). Therefore, the proposed project may be subject to a slightly lesser hazard of potential fault related effects including surface deformation caused by fault displacement. However, the northern section of the Byron Tract Forebay canal (west of the forebay) may possibly be located on the hanging wall and synclinal axis of the West Tracy blind thrust fault (California Department of Water Resources 2011).

There is limited information regarding the depths of the Thornton Arch and West Tracy blind thrusts and seismic surveys would be performed on the blind thrusts during the design phase to determine the depths to the top of the faults. More broadly, design-level geotechnical studies would be prepared by a geotechnical engineer licensed in the state of California during project design. Consistent with the environmental commitments specified in Appendix 3B, *Environmental Commitments, AMMs, and CMs*, DWR would ensure that the geotechnical engineer's recommended measures to address adverse conditions would conform to applicable design codes, guidelines, and standards, would be included in the project design and construction specifications, and would be properly executed during construction. Such conformance with design codes, guidelines, and standards is considered an environmental commitment by DWR (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*).

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

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).

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

***CEQA Conclusion*:** With the exception of the West Tracy Trust blind thrust, which may be capable of causing surface deformations, there are no active faults capable of surface rupture that extend into the proposed project alignment or footprint of the Byron Tract Forebay, south tunnels, pumping plant, or canal. However, design-level geotechnical studies would be prepared by a geotechnical engineer licensed in the state of California during project design. The studies would further assess site-specific conditions at and near all the project facility locations, including seismic activity, soil liquefaction, and other potential geologic and soil-related hazards. This information would be used to verify assumptions and conclusions included in the EIR/EIS. Consistent with the project's environmental commitments (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*), DWR would ensure that the geotechnical engineer's recommended measures to address adverse conditions would conform to applicable design codes, guidelines, and standards, would be included

in the project design and construction specifications, and would be properly executed during construction. Conformance to these and other applicable design specifications and standards would ensure that operation of the proposed project would not create an increased likelihood of loss of property, personal injury, or death of individuals in the event of ground movement in the vicinity of the project. Therefore, such ground movements would not jeopardize the integrity of the surface and subsurface facilities within the proposed project conveyance alignment or the proposed Byron Tract Forebay and associated facilities.

Incremental Impact: Because of their closer proximity to the West Tracy fault, the proposed project's Byron Tract Forebay, south tunnels, and canal would be more subject to ground deformation than would the expanded Clifton Court Forebay of the approved project. However, because the West Tracy fault does not appear to be subject to surface rupture, the proposed project would have a similar hazard of loss of property, personal injury, or death from rupture of a known earthquake fault as compared with the approved project during operation of the facilities. The impact of the proposed project would be similar to the impact of the approved project and would remain less than significant. No mitigation is required.

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

RTM Storage

Relocating RTM storage areas would create no additional or differing impacts than would the approved project.

Byron Tract Forebay and Conveyance

Changes related to constructing the new Byron Tract Forebay and south tunnels instead of the Clifton Court Forebay modifications could result in a greater risk to property, personal injury, or death from structural failure resulting from seismic shaking of conveyance features during operation of the water conveyance features because the Byron Tract Forebay and south tunnels would be located closer to a potential shaking source (i.e., the West Tracy fault) than would the Clifton Court Forebay.

Similarly, the new canal section would be constructed through an area more closely associated with the West Tracy fault than would the canal to the Clifton Court Forebay. Therefore, the potential for failure and consequent potential loss of property, personal injury, or death caused by seismic shaking at the Byron Tract Forebay could be greater with the proposed project compared with that of the approved project.

Additionally, the Byron Tract Forebay would impound water behind embankments rather than within an excavated basin, as would be the case with the expanded Clifton Court Forebay. Seismically induced failure of the embankments, unless properly engineered and constructed, could cause an uncontrolled release of the impounded water, possibly causing loss of property, personal injury, or death. Similarly, most of the new canal section would consist of embankment fills elevated above the surrounding grade. Failure of the embankments, unless properly engineered and constructed, could cause an uncontrolled release of the impounded water, possibly causing loss of property, personal injury, or death.

Further, failure of the Byron Tract Forebay berms as a result of seismic shaking and subsequent catastrophic release of impounded water could pose a greater risk of loss of property, personal injury, and death than with the modified Clifton Court Forebay because the Byron Tract Forebay would be located closer to developed areas than would the Clifton Court Forebay and because more water would be impounded behind berms instead of within an excavation.

Earthquake events may occur on the local and regional seismic sources during operation of the proposed project water conveyance facilities. The ground shaking could damage pipelines, tunnels, intake facilities, pumping plants, and other facilities, disrupting the water supply through the conveyance system. In an extreme event of strong seismic shaking, uncontrolled release of water from damaged pipelines, tunnels, intake facilities, pumping plant, and other facilities could cause flooding, disruption of water supplies to the south, and inundation of structures. These effects are discussed more fully in Final EIR/EIS Appendix 3E, *Potential Seismic and Climate Change Risks to SWP/CVP Water Supplies*.

NEPA Effects: This potential effect could be substantial because strong ground shaking could damage pipelines, tunnels, intake facilities, pumping plant, and other facilities and result in loss of property or personal injury. The potential effects of the proposed project would be greater than effects of the approved project. The damage could disrupt the water supply through the conveyance system. In an extreme event, an uncontrolled release of water from the conveyance system could cause flooding and inundation of structures, possibly causing loss of property, personal injury, or death. Please refer to Final EIR/EIS Chapter 6, *Surface Water*, and Final EIR/EIS Appendix 3E, *Potential Seismic and Climate Change Risks to SWP/CVP Water Supplies*, for a detailed discussion of potential flood effects.

Except for the new Byron Tract Forebay and conveyance, the design (i.e., pre-cast, reinforced concrete tunnel segments with high performance gaskets) of the underground conveyance facility would decrease the likelihood of loss of property or personal injury of individuals from structural shaking of surface and subsurface facilities along the proposed project conveyance alignment in the event of strong seismic shaking.

The new Byron Tract Forebay embankments would be constructed by excavating the embankment foundations down to suitable soil material, dewatering the excavation, and installing a slurry cutoff wall. The embankment fill material would consist either of excavated tunnel material or imported material from borrow sites. Dewatering, moisture conditioning, and compaction of the embankment material would be conducted to the onsite soils. It is assumed that the new Byron Tract Forebay would be subject to the jurisdiction of the Department of Water Resources Division of Safety of Dams (DOSD) because it would store water at an elevation more than 6 feet higher than the surrounding land and therefore would be designed and constructed according to DOSD requirements and be subject to periodic inspections by the DOSD.

In accordance with the DWR's environmental commitments specified in Appendix 3B, *Environmental Commitments, AMMs, and CMs*, design-level geotechnical studies would be conducted by a licensed civil engineer who practices in geotechnical engineering. The California-registered civil engineer or California-certified engineering geologist's recommended measures to address this hazard would conform to applicable design codes, guidelines, and standards.

DWR would ensure that the geotechnical design recommendations are included in the design of project facilities and construction specifications to minimize the potential effects from seismic events and the presence of adverse soil conditions. 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). DWR would also ensure that the design specifications are properly executed during construction. See Appendix 3B, *Environmental Commitments, AMMs, and CMs*.

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).

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

***CEQA Conclusion*:** The potential impacts of the proposed project would be similar to or slightly greater than impacts of the approved project. Seismically induced strong ground shaking could damage pipelines, tunnels, intake facilities, pumping plant, and other facilities. The damage could disrupt the water supply through the conveyance system. In an extreme event, an uncontrolled release of water from the damaged conveyance system could cause flooding and inundation of structures. (Please refer to Final EIR/EIS Chapter 6, *Surface Water*, for a detailed discussion of potential flood impacts.)

> ***Incremental Impact:*** Constructing the proposed project's new Byron Tract Forebay and conveyance instead of the approved project's Clifton Court Forebay modifications could result in a slightly greater risk of loss of property, personal injury, or death from structural failure resulting from seismic shaking during operation of the water conveyance features. This increase would be due to the Byron Tract Forebay's closer proximity to a potential shaking source (i.e., the West Tracy fault). The shaking could also result in a greater potential for subsequent catastrophic release of impounded water, posing a greater risk of loss of property, personal injury, and death than with the modified Clifton Court Forebay because the Byron Tract Forebay would be located closer to developed areas than would the Clifton Court Forebay and because more water would be impounded behind berms instead of within an excavation. However, through the final design process, which would be supported by geotechnical investigations required by DWR's environmental commitments (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*), measures to address this hazard would be required to conform to applicable design codes, guidelines, and standards. Conformance with these codes and standards is an environmental commitment by DWR to ensure that ground shaking risks are minimized as the water conveyance features are operated. The hazard would be controlled to a safe level and there would be a slightly greater likelihood of loss of property, personal injury, or death due to operation of the proposed project. The impact would be the same as the impact of the approved project and would remain less than significant. No additional mitigation is required.

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

RTM Storage

Relocating RTM storage areas would create no additional or differing impacts than would the approved project.

Byron Tract Forebay and Conveyance

The risk to and potential effects on life and property as a result of structural failure resulting from seismic-related ground failure during operation of the conveyance facilities would be similar in mechanism and magnitude to those described for the approved project.

Based on the geologic bore hole located closest to the proposed south tunnels that was advanced to the south tunnel depth of 100–150 feet (see bore hole DCBF-DH-012 in Figure 4-2 of Volume 1 of the Conceptual Engineering Report [California Department of Water Resources 2018]), the tunnels would be bored mostly in layers of soil materials ranging from poorly graded sand to fat (i.e., cohesive and compressible) clay, some of which could be subject to liquefaction and subsequent ground failure if saturated. Therefore, the effects of seismic-related ground failure on the proposed project would be similar to the effects under the approved project. Please refer to Final EIR/EIS Appendix 3E, *Potential Seismic and Climate Change Risks to SWP/CVP Water Supplies*, for a detailed discussion of potential flooding effects.

NEPA Effects: The potential effect could be substantial because seismically induced ground shaking could cause liquefaction, and damage pipelines, tunnels, intake facilities, pumping plant, and other facilities. The damage could disrupt the water supply through the conveyance system. In an extreme event, an uncontrolled release of water from the damaged conveyance system could cause flooding and inundation of structures.

In the process of preparing final facility designs, site-specific geotechnical and groundwater investigations would be conducted to identify and characterize the vertical (depth) and horizontal (spatial) extents of liquefiable soil. During final design, site-specific potential for liquefaction would be investigated by a geotechnical engineer. In areas determined to have a potential for liquefaction, a California-registered civil engineer or California-certified engineering geologist would develop design measures and construction methods to meet design criteria established by building codes and construction standards to ensure that the design earthquake does not cause damage to or failure of the facility. The results of the site-specific evaluation and California-registered civil engineer or California-certified engineering geologist's recommendations would be documented in a detailed geotechnical report prepared in accordance with state guidelines, in particular *Guidelines for Evaluating and Mitigating Seismic Hazards in California* (California Geological Survey 2008). Conformance with these design requirements is an environmental commitment by DWR to ensure that liquefaction risks are minimized as the water conveyance features are operated (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*).

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

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

***CEQA Conclusion*:** Seismically induced ground shaking could cause liquefaction. Liquefaction could damage pipelines, tunnels, intake facilities, pumping plant, and other facilities, and thereby disrupt the water supply through the conveyance system. In an extreme event, flooding and inundation of structures could result from an uncontrolled release of water from the damaged conveyance system. (Please refer to Final EIR/EIS Chapter 6, *Surface Water*, for a detailed discussion of potential flood impacts.)

> ***Incremental Impact:*** The proposed project would have a slightly greater incremental risk of property damage, personal injury, or death from structural failure resulting from seismic-related liquefaction and related failures compared with the approved project. This is because the Byron Tract Forebay, south tunnels, and canal would be closer to a shaking source (West Tracy fault) than would the approved project. However, through the final design process, measures to address the liquefaction hazard would be required to conform to applicable design codes, guidelines, and standards. Conformance with these design standards is an environmental commitment by DWR to ensure that liquefaction risks are minimized as the water conveyance features are operated (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*). The hazard would be controlled to a safe level and there would be no increased likelihood of loss of property, personal injury, or death due to operation of the proposed project. The seismic vulnerability of the proposed project's Byron Tract Forebay and the approved project's expanded Clifton Court Forebay would be similar, as shown in Figure 9-4, *Levee Seismic Vulnerability Groups*. The impact would remain less than significant. No additional mitigation is required.

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

RTM Storage

Relocating RTM storage areas would create no additional or differing impacts than would the approved project.

Byron Tract Forebay and Conveyance

The risk to and potential effects on life and property as a result of slope instability during operation of the conveyance facilities would be similar or slightly greater in mechanism and magnitude to those described for the approved project. The new Byron Tract Forebay would involve construction of embankments, whereas the expanded Clifton Court Forebay under the approved project would involve excavations. Construction of the Byron Tract Forebay canal would also involve construction of embankments.

As a result of ground shaking and high soil-water content during heavy rainfall, existing and new slopes that are not properly engineered and natural stream banks could fail and cause damage to facilities.

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

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

Site-specific geotechnical and hydrological information would be used, and the design would conform to the current standards and construction practices. The design requirements would be presented in a detailed geotechnical report. Conformance with these design requirements is an environmental commitment by DWR to ensure that slope stability hazards would be avoided as the water conveyance features are operated (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*). DWR would ensure that the geotechnical design recommendations are included in the design of cut and fill slopes, embankments, and levees to minimize the potential effects from slope failure. DWR would also ensure that the design specifications are properly executed during construction.

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). Conformance to the above and other applicable design specifications and standards would ensure that the hazard of slope instability would not create an increased likelihood of loss of property, personal injury of individuals along the proposed project conveyance alignment during operation of the water conveyance features. Therefore, the effect would not be adverse.

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

However, during the final project design process, as required by DWR's environmental commitments (see Appendix 3B, *Environmental Commitments, AMMs, and CMs*), a geotechnical engineer would develop slope stability design criteria (such as minimum slope safety factors and allowable slope deformation and settlement) for the various anticipated loading conditions during facility operations.

DWR would also ensure that measures to address this hazard would be required to conform to applicable design codes, guidelines, and standards. Conformance with these codes and standards is an environmental commitment by DWR to ensure cut and fill slopes and embankments would be stable as the water conveyance features are operated and there would be no increased likelihood of loss of property, personal injury or death due to operation of the proposed project.

Incremental Impact: The proposed project would have a slightly greater risk of loss of property, personal injury, or death from slope instability during operation of the facilities, as compared with the approved project. This is because construction of the proposed project's Byron Tract Forebay and conveyance would involve higher embankments than those of the approved project's Clifton Court Forebay. Because of the environmental commitments and other measures taken to conform to applicable design codes, guidelines, and standards, the impact would be the same as the impact of the approved project and would remain less than significant. No additional mitigation is required.

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

RTM Storage

Relocating RTM storage areas would create no additional or differing impacts than would the approved project.

Byron Tract Forebay and Conveyance

The risk of and potential effects of ground failure caused by unlined canal seepage during operation of the conveyance facilities would be identical to those described for the approved project. The proposed and approved projects would not involve construction of unlined canals; therefore, there would be no increase in groundwater surface elevations and, consequently, no effect caused by canal seepage. The canal from the new Byron Tract Forebay leading to the SWP and CVP would either be concrete-lined or earth-lined (California Department of Water Resources 2018).

NEPA Effects: The proposed project would not involve construction of unlined canals; therefore, there would be no increase in groundwater surface elevations and consequently no effect caused by canal seepage. There would be no effect.

***CEQA Conclusion*:** The proposed project would not involve construction of unlined canals; therefore, there would be no increase in groundwater surface elevations and, consequently, no impact caused by canal seepage.

Incremental Impact: There would be no incremental impact of the proposed project over the approved project. Because neither the proposed project nor the approved project would involve the construction of an unlined canal, the risk of ground failure caused by increased groundwater surface elevations from unlined canal seepage would be identical. There would be no impact and no mitigation is required.

9.3.2 Cumulative Analysis

The Final EIR/EIS found that there was not a potential for the approved project to have a cumulative effect on geologic and seismic hazards and potential adverse effects and significant impacts that could occur to structures and persons in association with construction and operation of the approved project would be restricted to the locations of the construction and the operational activities of these alternatives. These effects and impacts include the potential for loss, injury or death as a result of strong seismic shaking, settlement or collapse caused by dewatering, ground settlement, slope failure (including decreased levee stability from construction and operation activities), seismic-related ground failure (including liquefaction), ground shaking, fault rupture,

seiche or tsunami. All of the effects and impacts are mitigated by incorporating standard construction and structural measures into project design and construction.

The analysis for cumulative effects for geology and seismicity remains the same as described in the Final EIR/EIS with consideration of the proposed project modifications. Because the risks of loss of property, personal injury, or death associated with the proposed project would not combine with the geologic and seismic risks from other projects or programs in the Plan Area, there would be no cumulative adverse effect or significant impact.

9.4 References Cited

California Department of Water Resources. 2007. *Technical Memorandum: Delta Risk Management Strategy (DRMS) Phase 1 (Topical Area: Seismology, Final)*. Prepared by URS Corporation/Jack R. Benjamin and Associates, Inc.

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