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BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATER FIX	TESTIMONY OF TOM WILLIAMS

I, Clyde Thomas (aka Tom) Williams, do hereby declare:

EDUCATION AND EXPERIENCE

My name is Tom Williams. I have a Bachelor's of Science and PhD in geology and zoology. I have been a senior engineer and environmental manager for planning, design, assessment, and implementation of major development and engineering projects around the world, including major underground, infrastructure, and marine projects. My statement of qualifications is exhibit DDJ-160.[1]

My tunneling and underground experience includes construction management for the Los Angeles Metro Red Line Subway. As Environmental Controls Supervisor for Phase One Metro Rail Construction, I managed all aspects of environmental planning, design, and compliance for construction related activities including hazardous materials, geological and groundwater resources, protection and remediation of groundwater, regional receiving water quality and flow monitoring, and permitting and monitoring for all water discharges, and hazardous waste abatement and restoration. I was also the Senior Environmental Specialist for the EIR/EIS for the East LA tunnel extension and Orange Line of the Metro Rail for routing and physical environmental sectors.

I have also done planning, routing and environmental reviews and assessments, including geology and groundwater, for several pipeline projects, including the following:

- *Environmental Impact Report for CDC/DGS Jamestown Effluent Disposal Pipeline Project.* Prepared and developed the project and Environmental Impact Report.
- *US Navy - Elk Hills Oil Development and Transmission Systems.* Senior Environmental Scientist.
- *Chevron-Morro Bay Oil Transmission Systems-Richmond and El Segundo Segments.* Senior Environmental Planner.
- *Los Angeles Shell Refineries-Marine Terminal Pipelines* Project manager and route engineer for environmental aspects and permitting.

[1] Exhibit DDJ-160 is a true and correct copy of the document.

- *Alyeska-Los Angeles-Midland Oil Terminal and Pipeline*. Assessed and prepared combined EIR/EIS. Conducted routing surveys and prepared environmental assessment elements.

INTRODUCTION TO TESTIMONY

The construction of two forty foot diameter, 40 mile long tunnels in soft wet sedimentary and peat soils is a significant engineering challenge. Given the large diameter of the tunnels, the amount of water they will be carrying, and the soft ground conditions above, below, and at tunnels profiles, significant surveys, research, and monitoring are required to support development of conceptual and preliminary designs with sufficient integrity to protect the project, itself, the water supply, and structures and people on the surface under normal and dynamic conditions of central California.

GENERAL DISCUSSION OF ISSUES

Feasibility of Proposed Tunnel Design not Adequately Analyzed

According to the Final Draft Design and Construction Enterprise Agreement (DCE Agreement)[2], the option of a single-pass liner design has been chosen in part because of

[2] Exhibit DDJ-156, California Department of Water Resources, *Final Draft Agreement Regarding Construction of Conveyance Project between the Department of Water Resources and the Conveyance Project Coordination Agency*, 2015. Obtained from http://cms.capitoltechsolutions.com/ClientData/CaliforniaWaterFix/uploads/Draft_Final_DCE_Agreement_Combined.pdf. Accessed on January 16, 2017. Exhibit DDJ-156 is a true and correct copy of the document.

considerations of cost and construction timing (p. 9.) However, DWR's preliminary engineering analysis, which was not publicly noticed or distributed and not provided by DWR for this hearing, showed that the joints in a single-pass liner could leak in an earthquake. As discussed below, DWR's engineers recommended that the option of a second steel liner be retained until the feasibility of the single-pass liner was fully demonstrated. The option is not discussed in the Final Draft Conceptual Engineering Report for the Modified Pipeline/Tunnel Option (MPTO), (Final Draft CER), submitted by the Department of Water Resources for the WaterFix Change Petition hearing (Exhibit DWR-212.)

The potential problems with a single-pass liner are further obfuscated with analyses in the Final Draft CER, which use significantly weaker ground-motion assumptions than the preliminary engineering analysis. This gap in the analysis is of particular concern where the tunnels pass under important structures, including Delta island levees and channels, the Stockton Deep Water Shipping Channel, State Route 4, State Route 12, the Mokelumne Aqueduct, and natural gas and other product and services pipelines and where tunnels are joined with other structures (vents and shafts). Failures under a levee or channel could result in catastrophic flooding, endangering human life. Rapid failure under State Route 4 or 12 could also cause loss of life.

Final Engineering Design Criteria Not Specified

The Final Draft Conceptual Engineering Report (Exhibit DWR-212) states that the final seismic design criteria have not yet been adopted: "[f]inal design liquefaction analyses should be performed when final seismic design criteria for the MPTO/CCO facilities have been adopted." (p. 49.) No discussions of leakage and movement criteria for the tunnels or of separations at shaft/vent connections have been developed for long-term operations. Criteria for acceptable surface settlement before, during, and following tunnel construction have not been adopted and no mitigation has been proposed. Without these clear, specific design criteria and their required information base and mitigation, the tunnels and vents/shafts are inadequately documented and incompletely assessed for impacts during project construction and operation and are not assessed for environmental impacts and mitigation on legal stakeholders of water in the WaterFix Change Petition Hearing.

Assessments, monitoring, and mitigation for the WaterFix Change in Point of Diversion cannot be adequately addressed until completion of adequate preliminary setting description and analyses of the probability of seismic-induced tunnel lining and ground failures, settlement during tunnel boring, and tunnel leakage.

DISCUSSION OF SPECIFIC ISSUES

Delta Route

The proposed Delta Route crosses some of the most complex ground conditions in the Central Valley and is typical of Holocene delta of soft ground and alluvium filling over a more Pleistocene complex riverine terrain. See, for example, Unruh and Hitchcock, 2009. (Exhibit DDJ-142.)[3] Such terrain requires intense documentation program and detailed and complex analyses and modeling for settlement and movement during tunnel boring, during seismic event, and longer term and related tunnel/structure leakages and failures.

[3] Exhibit DDJ-142, Jeffrey R. Unruh and Christopher S. Hitchcock, *Characterization of Potential Seismic Sources in the Sacramento-San Joaquin Delta*, California, Final Technical Report, U. S. Geological Survey National Earthquake Hazards Reduction Program, 2009. Obtained from USGS website. I certify that this is a true and correct copy of the document.

Inadequate Soil Analysis

Analyses of ground integrity and seismic properties are an essential part of planning, design, and construction of large tunnels in deep, wet, soft, non-uniform alluvial deposits and must be supported by appropriate borings, samplings, and surveys. Without adequate knowledge of ground and geologic properties, the technical and economic feasibility cannot be adequately assessed for the proposed tunnel systems and lining and other components and alternatives and for the proposed tunnel alignment and alternatives.

The Revised EIR/EIS (Exhibit SWRCB-3) references the American Society of Civil Engineers 07-05 standards, *Minimum Design Loads for Buildings and Other Structures* as applying to the WaterFix tunnel design (Chapter 9, p. 9-19.) The Final EIR/EIS (Exhibit DDJ-158) references the updated ASCE 07-10 standards, also entitled, *Minimum Design Loads for Buildings and Other Structures.*[4] The standards provide clear soil classification criteria. ASCE-7-10 states the following:

> 20.1 SITE CLASSIFICATION The site soil shall be classified … based on the upper 100 ft (30 m) of the site profile […] Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless 11.4.5 the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site. (p.234)

Many project soils are designated as Class F and subject to liquefaction or have greater than 10 feet of peat (equivalent to Soft or Flowing Ground, in tunneling) with significantly different seismic and long-term movement responses. The Department of Water Resources needs to develop site-specific response analyses based on actual field information for use in the

[4] Exhibit DDJ-148, American Society of Civil Engineers, Standard 7-10, *Minimum Design Loads for Buildings and Other Structures*, 2010. Obtained from http://www.avant-garde-engineering.com/ASCE_7.pdf Accessed on January 16, 2017. Exhibit DDJ-148 is a true and correct copy of the document

Conceptual Engineering Report for seismic analyses of the tunnels and related structures. An inadequate and very limited set of initial borings is available, and site-specific response analyses should have been developed for borings close to the revised alignment.

Non-uniformity of ground conditions should also have been evaluated based on field borings and geophysical surveys. Evaluation of variation in soil conditions is essential to assess differential stresses on the tunnel lining. Behavior of buried water supply pipelines in earthquake zones have been described in Iain Tromans' dissertation (2004) which has important information on seismic factors associated with damage to buried pipelines.[5] With respect to non-uniformity, Tromans stated:

> Many field observations and theoretical studies have shown, however, that for transient earthquake effects, the level of non-uniformity of ground conditions is also extremely important in the seismic behaviour of buried pipelines (Liang & Sun, 2000). Lateral variation of ground conditions has been shown to cause strain concentrations during ground shaking due to significant differences in ground-motion characteristics even over short distances. Strong-motion array measurements have shown variations by a factor of five in velocity over a distance of 200 m and by a factor of two in acceleration over the same distance, all caused by variable site conditions (Zerva, 2000). (p. 68)

Given this variance in seismic velocities and ground responses, the proposed tunnel design may not be feasible in its current alignment.

Complicated Design and Analysis

The current analyses have focused primarily on a typical single tunnel by itself rather than the conveyance system (e.g., intake/outfall, vents, shafts, and various twin tunnel drive lengths, 5-10 mile length, etc.) along the current alignment but over and through complicated

[5] Exhibit DDJ-152, Iain Tromans, *Behaviour of buried water supply pipelines in earthquake zones*, PhD dissertation, Department of Civil and Environmental Engineering Imperial College of Science, Technology and Medicine, London, 2004. Obtained from https://workspace.imperial.ac.uk/geotechnics/Public/tromans.pdf. Accessed on January 29, 2017. Exhibit DDJ-152 is a true and correct copy of the document.

soft ground conditions.   Similarly, as a system the project has temporal components related to shaft and vent construction and tunnel connections, tunnel drive starts and arrivals, and connections to intakes/outfalls. Construction of these components further change the ground conditions in the project vicinity for the next construction period.

Inadequate Leakage Analysis

Leakage through the tunnel liner could cause failure of the lining.   The Final Draft Conceptual Engineering Report (Exhibit DWR-212) states:

> In addition to strength requirements, leakage control through the liner is essential to ensure liner performance. Excessive leakage through the liner could lead to potential soil erosion, hydraulic fracturing, and loss of liner support. Water leakage from the tunnel to the surrounding area also translates to economic loss. (p. 142.)

The Department of Water Resources did an initial engineering analysis of the tunnel design in 2010[6] (Exhibit DDJ-141.) The initial analysis showed that the tunnels could have significant leakage (exfiltration) when they are first operated (Exhibit DDJ-141, p. 4-9.):

> The analyses showed that a tunnel at a depth to springline of 80 ft would have a considerable amount of exfiltration (Table 4-2), and the impact on groundwater could reach the surface, while a tunnel at depth of 160 ft would experience a moderate amount of exfiltration and would have a negligible impact on the groundwater.

Table 4-2 Summary of Tunnel Exfiltration Estimates

Depth, d (ft)	Exfiltration from tunnel at maximum internal pressure, q (ft^2/sec/ft)	Total exfiltration (ft3/s)	Exfiltration (acre-ft/day)
80	1.4×10^{-2}	1100	2200
120	2.9×10^{-3}	180	360
160	4.5×10^{-4}	24	48

[6] Exhibit DDJ-141, California Department of Water Resources, *Draft Report Of the Initial Analysis & Optimization of the Pipeline/Tunnel Option*, December 17, 2010.   Obtained from DWR's ftp site in 2012 via Google search.

The tunnel design was modified to move the pumping plant to near Clifton Court Forebay to reduce internal pressure and presumably, potential exfiltration. The Final Draft Conceptual Engineering Report (Exhibit DWR-212) does not disclose the preliminary leakage analysis or any subsequent leakage analyses, only stating:

> Once detailed geotechnical data is available during preliminary design, the segment liner will be designed to limit water leakage by considering surrounding ground-liner interaction and ground permeability. At the same time, design factors such as effective ground overburden, high strength bolts, shear dowels, post-tensioning system, ferrous push-fit connectors, and proprietary joint connectors will be more fully analyzed as part of the final segment design.
>
> (p. 142.)

This Final Draft CER discussion is inadequate and incomplete to evaluate potential impacts of tunnel liner leakage due to initial or continued operation. Referral to later considerations and prospective measures does not meet requirements for assessment of impacts in the WaterFix Change Petition hearing.

No Leakage Criteria

In DWR's initial engineering analysis (Exhibit DDJ-141)[7] under section 4.3.5 of Preliminary Evaluation of Gasket Capabilities, the engineers stated:

> Exfiltration (leakage) criteria will need to be developed and adopted during Preliminary Engineering. Search of technical literature identified criteria used for sewer tunnel exfiltration (0.008 gpm x 100 ft x ft resulting in 515 gpm or 2.3 acre-ft/day) and infiltration, or the AWWA criteria for leakage from pressure pipes (3,700 gal/hr or 0.3 acre-ft/day). Depending on the exfiltration criterion adopted for this project, a tunnel at a depth of 160 feet could be acceptable without additional structural restraint. (p. 4-9.)

[7] Exhibit DDJ-141, California Department of Water Resources, *Draft Report Of the Initial Analysis & Optimization of the Pipeline/Tunnel Option*, December 17, 2010. Previously cited.

However, the Final Draft CER (Exhibit DWR-212) does not indicate that any leakage criteria have been adopted. The initial recommended depth of 160 feet was not kept for the North tunnels. The Final Draft Design and Construction Enterprise Agreement[8] (Exhibit DDJ-156) states:

> The preliminary tunnel inverts range from 122 to 135 feet below mean sea level (msl) for the North Tunnels and from 147 to 163 feet below msl for the Main Tunnels. (p. 20.)

The analysis in the Conceptual Engineering Report (Exhibit DWR-212) is inadequate without the specification of leakage criteria and evaluation of adequate monitoring and response to and mitigation for leakage.

Inadequate Analysis of Access Shafts

Given the ground plasticity and potential liquefaction of the soft ground surrounding the tunnels, the issue of differential movement of the tunnels, intakes/outlets, access shaft, and vents is substantial. These must be carefully analyzed and their impacts adequately addressed and mitigated.

Differential movements between the WaterFix tunnels, intakes/outlets, and access shafts also need a differential analysis and appropriate assessment of impacts and required mitigation. This is especially important because the access shafts will be fixed vertically in very large concrete slabs to protect the shafts from flooding, while the tunnels will be bedded in deep alluvial deposits.

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[8] Exhibit DDJ-156, California Department of Water Resources, *Final Draft Agreement Regarding Construction of Conveyance Project between the Department of Water Resources and the Conveyance Project Coordination Agency*, 2015. Obtained from http://cms.capitoltechsolutions.com/ClientData/CaliforniaWaterFix/uploads/Draft_Final_DCE_Agreement_Combined.pdf. Accessed on January 16, 2017. Exhibit DDJ-156 is a true and correct copy of the document.

No Construction Settlement Criteria

The Revised Draft EIR/EIS (Exhibit SWRCB-3) and Final EIR/EIS Chapter 9 (Exhibit DDJ-158) does not consider settlement during construction for the project components and for those of the East and West project alignments. Although the E/W alignments are separated, no analyses for ground responses (e.g., mud wave) were provided for phased or simultaneous construction of shafts, vent, and tunnels in soft wet ground. Monitoring parameter, criteria, and methods have not been established and documented; generally response plans for criteria exceedance have not been provided or developed.

No Settlement Criteria

Chapter 9 of the Final EIR/EIS (Exhibit DDJ-158) adds the following guidelines for settlement criteria to those discussed in Chapter 9 of the Revised EIR/EIS (Exhibit SWRCB-3, Chapter 9, p. 9-197):

> In particular, conformance with the following federal design manuals and professional society and geotechnical literature would be used to predict the maximum amount of settlement that could occur for site-specific conditions, to identify the maximum allowable settlement for individual critical assets, and to develop recommendations for tunneling to avoid excessive settlement, all to minimize the likelihood of loss of property or personal injury from ground settlement above the tunneling operation during construction.
>
> - *Technical Design Manual for Design and Construction of Road Tunnels* (U.S. Department of Transportation, Federal Highway Administration 2009).
> - *A Method of Estimating Surface Settlement above Tunnels Constructed in Soft Ground* (National Research Council of Canada 1983).
> - *Predicting the Dynamics of Ground Settlement and its Derivatives Caused by Tunnelling in Soil* (Attewell and Woodman 1982).
> - *Predicting the Settlements above Twin Tunnels Constructed in Soft Ground* (Chapman et al. 2004).
> - *Report on Settlements Induced by Tunneling in Soft Ground* (International Tunneling Association 2007).

- *Closed-Face Tunnelling Machines and Ground Stability: A Guideline for Best Practice* (British Tunnelling Society 2005).

A more complete and up to date discussion of empirical methods for estimating potential settlement during tunneling is available in “Analysis of ground settlement caused by tunnel construction” by Maraš-Dragojević.[9] Empirical methods, such as those specified in the above referenced technical papers, should have been used for preliminary estimates of potential settlement during tunneling. Without such preliminary estimates, and discussion of criteria for acceptable settlements, adequate assessment of potential impacts cannot be established and verified for the WaterFix hearing. Future “recommendations for tunneling” fail to provide adequate and complete commitments for monitoring, mitigation, and reporting of impacts.

Ground loss during the London Channel Tunnel Rail Link construction

The Final EIR/EIS (Exhibit DDJ-158, p. 9-62) refers to *Settlements induced by tunneling in Soft Ground*, by the International Tunneling and Underground Space Association, 2007 in a discussion of mitigation for impact GEO-3: Loss of Property, Personal Injury, or Death from Ground Settlement during Construction of Water Conveyance Features. *Settlements induced by tunneling in Soft Ground* is provided for the hearing record as Exhibit DDJ-149.[10] The graphs

[9] Exhibit DDJ-160, S. Maraš-Dragojević, *Analysis of ground settlement caused by tunnel construction*, 2012. Available at http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=126712&lang=en Accessed on January 20, 2016. Exhibit DDJ-160 is a true and correct copy of the document.

[10] Exhibit DDJ-149, International Tunneling and Underground Space Association, 2007. *Settlements induced by tunneling in Soft Ground*, report of the Working Group of the International Tunneling Association, Tunneling and Underground Space Technology 22 (2007) 119–149. Obtained from https://www.ita-aites.org/en/news/download/76_fc32374761a17cde8d72f432244168b0. Exhibit DDJ-149 is a true and correct copy of the document.

on the following page, from that document (Exhibit DDJ-149, p. 12), show the ground volume loss in the tunneling for three London segments of the London Channel Tunnel Rail Link. The mean ground loss was around 0.5% for many segments, but the maximum was over 2.5% in the initial trials. In the Stratford to St Pancras link, once the tunnel ground volume loss exceeded 1%, the boring was stopped and the tunnel boring machine was reconfigured for clay soils.

The LCRT construction was tightly monitored and had provisions to stop tunneling when ground loss exceeded 1%. The 1% ground volume loss would be an appropriate criteria for maximum allowed ground loss for tunnel boring. Without specification of ground loss criteria, evaluation and alternatives cannot be determined if the criteria are appropriate protection of the surface and other project subsurface structures that are in the tunnel alignment, including water diversion structures.

Pre-Construction Surveys, Monitoring and Restoration

The BART standard specifications on Excavation Support and Protection[11] state the following under 1.0.9 Site Conditions:

> A. Pre-construction surveys: The Contractor shall submit to the Engineer, for review and approval, pre-construction surveys for existing structures and facilities located above or adjacent to the new construction and which may be affected by the work. These surveys shall include photographs, maps, plans, written descriptions, and surveyed foundation levels as necessary to fully document pre-construction conditions.

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[11] Exhibit DDJ-150, Bay Area Rapid Transit, *BART Facilities Standards, Standard Specifications, Revision 3.03, Section 31.50.00, Excavation Support and Protection*, January 2014. Exhibit DDJ-150. Obtained from https://webapps.bart.gov/BFS/BFS_3_0_3_Spec/STDSPEC/31%2050%2000.pdf. Accessed on January 26, 2017. Exhibit DDJ-150 is a true and correct copy of the document.

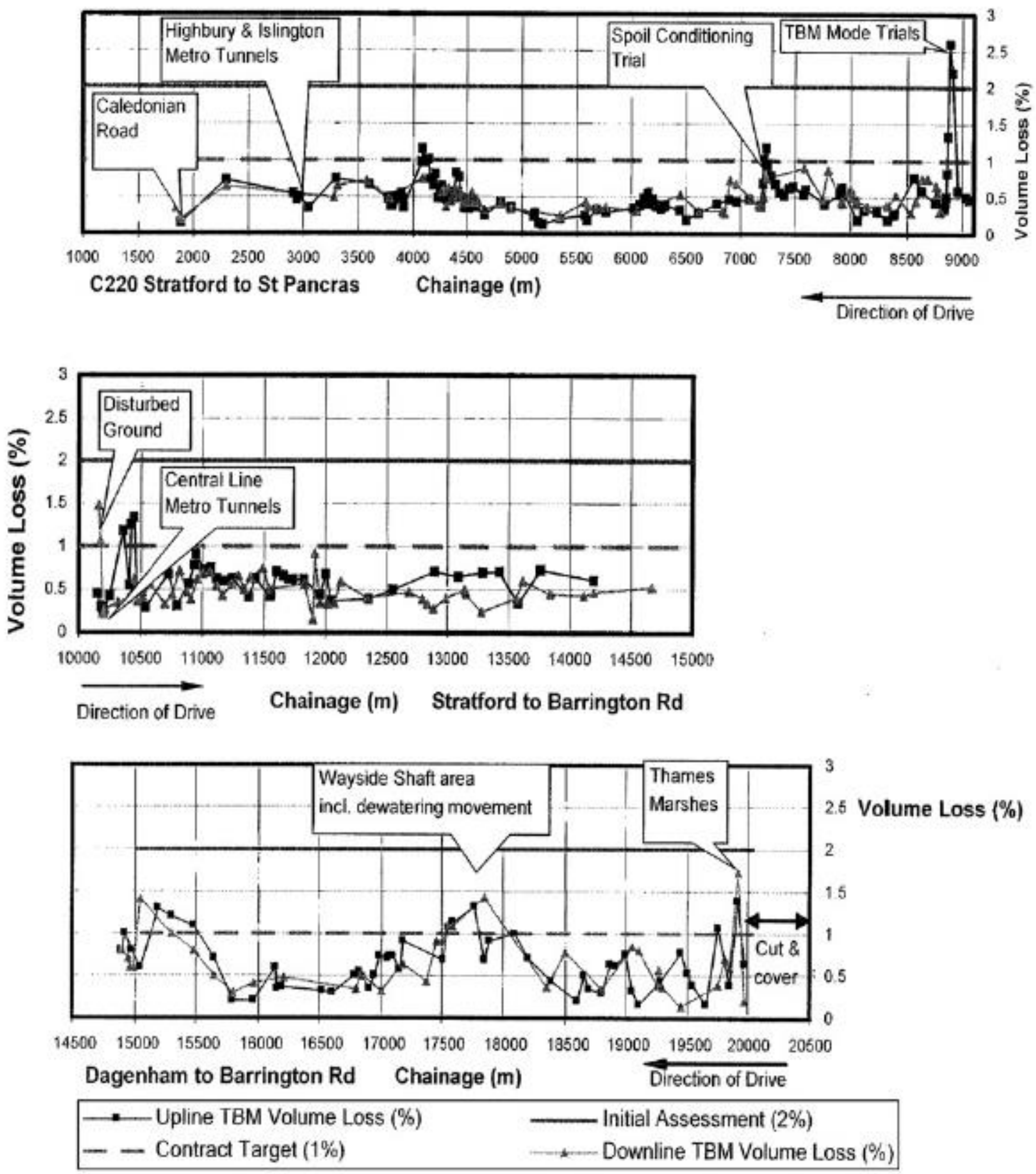

Figure 1 Volume Losses Observed on the CTRL Source: ITA 2007

The BART standard specifications on Excavation Support and Protection state the following under part 3, Execution:

Section 3.0.1, Detection of Movement

A. For each existing structure or facility within a zone extending upward from the bottom of the excavation on a slope of 2 horizontal to 1 vertical, install settlement detection devices on each footing, foundation, wall, or other feature to be monitored. Settlement detection devices shall be capable of being read to an accuracy of 0.005 foot.

B. Take and record readings not less than once per week during performance of the work.

C. Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work. All construction activities shall be immediately halted when the settlement of any structure or facility reaches 0.3 inch, and shall not be resumed until after implementation of approved remedial measures.

D. Upon completion of the work, take weekly readings of the measurement points for a period of 4 weeks, or longer if movement persists, and report the results to the Engineer.

E. The detection of movement shall be performed by a qualified licensed civil engineer or land surveyor.

Section 3.12 Restoration

A. Restore existing structures to conditions existing prior to the start of work, including repair of settlement-induced damage

The WaterFix analysis is incomplete without the specification of guidelines for a pre-construction survey and monitoring for ground movement during the WaterFix shaft, vent, intake/outfall, and tunnel borings. Criteria for responses, work stoppages, and mitigation for damage, such as BART's restoration commitment, require thorough discussion.

No Analysis of Tunneling Effects on Levees

Economic costs of a levee failure due to tunneling damage are potentially very high. The 2004 failure of the Upper Jones Tract, an island of 6,259 acres, cost approximately $120 million to restore, exclude damage to buildings and crops.

While the effect of the maximum settlement on the freeboard of levees in the Delta is negligible, the horizontal and vertical stresses on the levees from the tunneling movements through soft ground could cause cracks, especially in levee areas that are prone to slope instability. Cracks in a levee could result in seepage and failure if they happened during times of high flows and tides in the Delta, or if they happened during times of low flow and were not identified and repaired.

Neither the Revised Draft EIR/EIS, Final EIR/EIS nor the Conceptual Engineering Report discusses seasonal limitations on tunneling under levees, but considering the consequences, tunneling should not be done when storms could cause high flows.

No Plan for Leakage Monitoring and Mitigation

While the Conceptual Engineering Report mentions access for inspection, the CER does not indicate an inspection, monitoring, and remediation program and does not discuss response contingencies, controls, and recovery following indication and evidence of leakage of the tunnel lining or component dislocations. A program of inspection, monitoring, and remediation is standard practice in maintenance of water supply pipelines and tunnels.

The Bureau of Reclamation discussed concrete pipeline vulnerabilities and inspections standards in a 2007 Environmental Assessment for maintenance of Santa Clara conduit (Santa

Clara Conduit EA) (Exhibit DDJ-144.)[12] The Santa Clara Conduit is an 8-foot diameter concrete pipeline between San Luis Dam and the Santa Clara Valley Water District. The Santa Clara Conduit EA states:

> Leaks usually occur at pipeline joints, or connections such as at valves. A leak is easily detected within a vault but can also be detected through pressure drops and localized ground saturation or ponding. Once a month all pipelines would be inspected via helicopter to verify integrity. The helicopter crew scans for saturated ground or ponding near the facilities. Small, buried leaks would be harder to detect in winter months than in the summer when the ground is dry.

The Santa Clara Conduit EA also states:

> ***2.2.2.4 Internal Inspection***
> Internal inspections are necessary to determine the integrity of joints and all sections of pipeline, pipeline materials, and equipment, especially in seismically active areas. Internal inspections are planned every 5-10 years, depending on the pipeline. Internal inspection activities usually occur on all pipelines as preventative maintenance although the inspection interval varies by pipeline.

The Santa Clara Conduit pipeline failed in August 2015 and spilled 60 acre-feet of water into nearby Pacheco Creek (Exhibit DDJ-145),[13] (Exhibit DDJ-146.)[14] The pipeline was completed in 1985 and was 30 years old. A later failure analysis by the District found the last inspection had been in 2008 (Exhibit DDJ-147.)[15]

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[12] Exhibit DDJ-144, Bureau of Reclamation, Draft *Environmental Assessment for Pipeline Maintenance Program for the Pacheco and Santa Clara Conduits and Tunnels, Santa Clara Valley Water District.* Obtained from https://www.usbr.gov/mp/nepa/documentShow.cfm?Doc_ID=2868. Accessed on January 29, 2016. Exhibit DDJ-144 is a true and correct copy of the document.

[13] Exhibit DDJ-145, Paul Rogers, *Failure of key water pipeline into Silicon Valley may have exposed wider problems*, San Jose Mercury News, March 1, 2016. Obtained from: http://www.mercurynews.com/2016/03/01/failure-of-key-water-pipeline-into-silicon-valley-may-have-exposed-wider-problems/. Accessed on March 21, 2016. Exhibit DDJ-145 is a true and correct copy of the document.

[14] Exhibit DDJ-146, Santa Clara Valley Water District, CEO Bulletin 8-27-15 has the District water loss estimate. Obtained from http://valleywater.org/WorkArea/DownloadAsset.aspx?id=12939. Accessed on January 17, 2016. Exhibit DDJ-146 is a true and correct copy of the document.

[15] Exhibit DDJ-147, Santa Clara Valley Water District, CEO Bulletin 1-24-16. Obtained from

Inadequate Seismic Structural Analysis

As explained in more detail in Appendix A, the seismic structural analysis in the Final Draft Conceptual Engineering Report is inadequate and incomplete for a preliminary stage of design. An initial analysis was reported and showed that the tunnel joints could leak in a large earthquake. Impacts on the project and surface could be significant.

As detailed in Appendix A, the assumption in the CER (Exhibit DWR-212) that peak ground acceleration is attenuated by 50% at depths over 100 feet is not supported by available downhole seismic data or analyses for soft ground conditions.

The Department of Water Resources has stated in Chapter 9 of the Revised DEIR/DEIS (Exhibit SWRCB-3) and Chapter 9 of the Final EIR/EIS (Exhibit DDJ-158) that future tunnel design and construction will be done to engineering standards; however, the DWR's seismic loading criteria leave selection of seismic sources completely up to the discretion of the final design engineer and is not subject to public review and comments. This delay could result in weaker seismic source assumptions that are not supported by the Delta Risk Management study. Tunnel construction standards are recommendations only.

Inadequate Seismic Standards and Criteria

The Final Draft CER (Exhibit DWR-212) indicates that the final seismic design criteria for the Modified Preferred Tunnel Option has not yet been adopted (Appendix B), and application of external standards cited in the Revised Draft EIR/EIS (or Final EIR/EIS) remains unclear for the final seismic design of the project facilities, including tunnels, shafts/vents, and

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http://www.valleywater.org/WorkArea/DownloadAsset.aspx?id=13522. Accessed on January 17, 2016. Exhibit DDJ-147 is a true and correct copy of the document.

intake/outfall facilities. Analyses remain inadequate without application of final seismic design standard and their criteria for the project facilities.

Risks cannot be adequately addressed or mitigated in the WaterFix Change Petition Hearing until the final seismic design standards and criteria are specified and disclosed.   The final seismic design criteria and their analyses must be provided by the Department of Water Resources and the US Bureau of Reclamation before the design of the project progresses to the Design Construction Enterprise.

Recommendations

My recommendations are as follows:

1. The Board must require that DWR/Reclamation develop and make publicly accessible an adequate and complete geological (including seismicity), groundwater, and soils information base for the WaterFix project components: both tunnels and each/all section(s) and their related shafts, vents and intakes/outfalls and the current seismic guidance based on the best available science and be integrated into an online digital/linked database;
2. The Board must require that DWR/Reclamation disclose and make available online (as a data base or links to public free access) such existing reports or newly produce, if such reports do/did not exist, for information, analyses/modeling, and quality controls and assurance;
3. The Board must require that DWR/Reclamation disclose and provide all such reports that exist, or are newly produce for ten years, if such reports did not previously exist, for testing, monitoring, and calibration for assumptions for the model components that represent geologic processes and events.

4. The Board must require that DWR/Reclamation develop and submit for WaterFix static and dynamic geological, groundwater, and dynamic quantitative models for individual tunnel sections, important stages in tunneling progress, and various combination of project components (e.g., five 5-10-mile sections of two parallel tunnels, four sets of adjacent/nearby twin shafts/vents, and the intake/outlet terminals), and their numerous rigid tunnel/horizontal and shaft-vent/vertical connections;
5. The Board must require that DWR/Reclamation produce a validation report and online database(s) for all involved models used by petitioners and others to model the WaterFix project that includes appropriate input data and assumptions.
6. The Board must require that DWR/Reclamation to submit modeled life-of-project operations soil/alluvium/geology effects using long-term alluvium/soils changes (e.g., compaction, subsidence, and settlement);
7. The Board must require that DWR/Reclamation submit sensitivity analyses for the WaterFix models with long term project operations for 25 and 50 year and differences of 20% and 30% exceedance for all adverse assumptions for the analysis;
8. The Board must require that DWR/Reclamation submit a sensitivity analysis for the WaterFix with short-term dynamic project conditions (i.e., earthquakes) with strengths (= + 1 RM), depths (=-50%), and distances (-50%) for the analysis;
9. The Board must require that DWR/Reclamation collect and submit information on long-term movements (rise/fall) of existing structures (e.g., levees, bridges, causeways, and large concrete structures [>500cuyd], etc.) and gas/oil wells within 5,300ft of any project component;
10. The Board must require that DWR/Reclamation collect and submit information on seismic monitoring and analyses and maximum credible earthquakes (e.g., strengths,

depths, distances, orientation, etc.) for existing structures (e.g., levees, bridges, causeways, large concrete structures [>500cuyd], refineries, and other sensitive facilities) between Vallejo and Stockton;

11. The Board must require that DWR/Reclamation collect and produce a publicly accessible online information databases for past (abandoned) and current gas exploration, production, and storage gas/oil wells, field, and facilities within the zone(s)-of-influence (=distance same as deepest gas zone depth, e.g., 10,000ft depth, within 10,000ft of a WaterFix component) of the WaterFix project route;
12. The Board must require that DWR/Reclamation produce a comprehensive monitoring system for geologic conditions, seismicity (-1 - +6RM), ground movements, groundwater, and ground surfaces to be initiated at least one year before any construction, throughout the construction period, and five year thereafter with publicly accessible online databases and real-time monitoring results.

Executed on this 22nd day of March, 2017 in Los Angeles, California.

Clyde Thomas (aka Tom) Williams

Appendix A

Detailed Assessment of Seismic Structural Analysis

The structural analysis in the Final Draft Conceptual Engineering Report (Exhibit DWR-212) is inadequate to demonstrate the feasibility of this proposed project design with twin 40-ft diameter tunnels of 5-10 miles in length, connected to starter/access shafts, to pressure-relief vent structures, and to intakes and outfalls. As an example of sufficient structural analysis for conceptual design, the California High Speed Rail Project's Technical Memorandum on 15% Seismic Design Benchmarks (Exhibit DDJ-151)[16] states:

> Generally, seismic response of tunnels is dominated by the surrounding ground response, and not the inertial properties of the tunnel itself. The focus of tunnel seismic design shall be on the free-field deformation of the surrounding ground and its interaction with the tunnel.
>
> For 15% Design, two types of deformations which characterize the seismic response of tunnels shall be evaluated:
>
> 1. Longitudinal axial and curvature deformations (see Figure 6-1)
> 2. Transverse ovaling or racking deformation (see Figure 6-3)

The Department of Water Resources 2010 initial design report (Exhibit DDJ-141)[17] shows that a simplified closed form analysis of the tunnel lining only was done. The 2010 initial analysis showed that the tunnel lining joints could "de-stress":

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[16] Exhibit DDJ-151, California High Speed Train Project, *Technical Memorandum 2.10.5, 15% Seismic Design Benchmarks.* Obtained from http://www.hsr.ca.gov/docs/programs/eir_memos/Proj_Guidelines_TM2_10_5R00.pdf Accessed on January 16, 2017. Exhibit DDJ-151 is a true and correct copy of the document.

[17] Exhibit DDJ-141, California Department of Water Resources, *Draft Report Of the Initial Analysis & Optimization of the Pipeline/Tunnel Option*, December 17, 2010. Previously cited.

> The compressive stresses induced by the earthquake are less than the assumed compressive strength of the concrete; however, temporary de-stressing of segment joints could occur, resulting in temporary increase in exfiltration.
> (p. 4-13.)

In Section 10.1, Design Criteria, the report recommended that "a second pass system using a steel liner installed in the areas of higher internal pressures should be maintained as an option until the development of the design and testing during preliminary engineering prove the feasibility of the desired lining system." (p. 10-1.) Results of seismic structural analyses and recommendations for the steel liner are not disclosed in the 2015 Final Draft CER (Exhibit DWR-212.) .

No apparent consideration is noted regarding seismic responses of tunnels and related vents/shafts during both construction /boring and operations. Similarly, analyses have not considered or provided with orientation of seismic wave progression in relationship to the project orientation (e.g., cross-wise and parallel [90º, 45º, 0º] with tunnel right of way) and different vertical/horizontal components. Without adequate consideration of various failure potential for the project during seismic events and their impacts, the CER remains inadequate if not incomplete.

Questionable Assumptions of Attenuation of Ground Motions

Seismic ground motions may attenuate with depth depending on the strength of materials encountered. However, the Final Draft Conceptual Engineering Report may assume too much attenuation of ground motion with depth. The Final Draft CER cites some engineering guidelines from the Federal Highway Administration *Technical Manual for Design and Construction of Road Tunnels — Civil Elements* (FHWA manual) (Exhibit DDJ-161.)[18] The

[18] Exhibit DDJ-161, U.S. Department of Transportation, Federal Highway Administration, *Technical Manual for*

FHWA manual (Exhibit DDJ-161) provides a table of attenuation values in their tunnel design manual, and states (p. 407):

> The ratios of ground motion values at tunnel depths to those at the ground surface may be taken as the ratios summarized in Table 13-1 unless lower values are justified based on site-specific assessments.

Table 13-1 Ground Motion Attenuation with Depth

Tunnel Depth (m)	Ratio Of Ground Motion At Tunnel Depth To Motion At Ground Surface
≤ 6	1.0
6 -15	0.9
15 -30	0.8
≥ 30	0.7

The value of 70% of PGA at 30 meters (98 feet) would therefore be acceptable to use for the design of the tunnels in the ground assumed for these attenuations, but perhaps not in the soft ground conditions of the project. The Final Draft CER (Exhibit DWR-212) cites the above referenced FHWA manual value of 70%, but then increases attenuation of at-depth PGA to 50%:

> The proposed depths of the tunnels are between 100 to 200 feet bgs. For the conceptual level design, and in the absence of more rigorous analyses, a value of approximately one-half of the surface PGA was assumed for structural analyses of the buried tunnel linings. (p. 46.)

However, seismic data from the CSMIP Strong-Motion Geotechnical Array shows that the assumption of 50% attenuation may be wrong. Following the Santa Monica freeway collapse in the Northridge Earthquake, CalTrans has done long-term seismic monitoring of

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Design and Construction of Road Tunnels — Civil Elements, December 2009. Obtained from http://www.fhwa.dot.gov/bridge/tunnel/pubs/nhi09010/13a.cfm. Exhibit DDJ-161 is a true and correct copy of the document.

boreholes in sites with deep soft alluvial deposits, including La Cienega in Los Angeles, Meloland in El Centro, Eureka, and Vincent Thomas Bridge in Long Beach (Exhibit DDJ-155).[19]

A 2005 study by Chinese engineers Hu Jin-jun and Xie Li-li, *Variation of earthquake ground motion with depth* (Exhibit DDJ-155)[20], analyzed the data from these sites. The 2005 study found that peak ground acceleration (PGA) in the deep alluvial soils falls off slowly for large magnitude earthquakes (Section 3.1.2, Soil site, p. 77.) The graph from section 3.1.2 is reproduced on the following page and indicates that a peak ground surface acceleration is reduced by 30% down to 70% of that at surface at a depth of 40-50 meters (120-160 feet) and is approximately correct for large magnitude events in deep alluvial deposits. An attenuation value of 50% is too large, compared to 30% of PGA.[21]

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[19] Exhibit DDJ-154, Vladimir Graizer, Anthony Shakal and Pat Hipley, *Recent Data Recorded from Downhole Geotechnical Arrays*, SMIP2000 Seminar Proceedings. Obtained from http://www.conservation.ca.gov/cgs/smip/docs/seminar/SMIP00/Documents/paper2_graizer.pdfExhibit DDJ-154 is a true and correct copy of the document.

[20] Exhibit DDJ-155, Hu Jin-jun and Xie Li-li. *Variation of earthquake ground motion with depth*, Acta Seimol. Sin. (2005) 18: 72. DOI:10.1007/s11589-005-0008-x. Obtained from http://link.springer.com/article/10.1007/s11589-005-0008-x Accessed on January 16, 2017. Exhibit DDJ-155 is a true and correct copy of the document.

Appendix B

Analysis of Seismic Engineering Standards

The Final EIR/EIS, Chapter 9, Geology and Seismicity gives a list of seismic design standards that will apply to the design of the WaterFix facilities in section 9.2.2.6, Regulatory Design Codes and Standards for Project Structures (Exhibit DDJ-158, p. 9-31.)[22] Many of the standards are also referenced in Chapter 9 of the Revised Draft EIR/EIS submitted for the WaterFix Change Petition (Exhibit SWRCB-3.) In the following discussion, the list in the Final EIR/EIS, Section 9.2.2.6 is assumed to be the updated, final list of design standards. Section 9.2.2.6 of the Final EIR/EIS, Chapter 9 (Exhibit DDJ-158, p. 9-31) states that risks to people and property will be minimized by conformance with these standards. The strongest standards are the American Society of Civil Engineers 07-10 standards, Minimum Design Loads for Buildings and Other Structures (Exhibit DDJ-148.) However, there are a number of weaker standards, and it is unclear which will apply to the final tunnel design.

According to the American Society of Civil Engineers' Standard 7-10, section 21-2.2 (Exhibit DDJ-148, p. 236) the Maximum Considered Earthquake for structures with Occupancy Class II or III should be consistent with ground motions having a 2% probability of exceedance in 50 years. This generally corresponds to motions having a return period of about 2,475 years. The Delta Risk Management Strategy Report, Section 6, does provide probabilistic seismic

[22] Exhibit DDJ-158, California Department of Water Resources, Bay Delta Conservation Plan/California WaterFix Final EIR/EIS, Chapter 9, Geology and Seismicity. Obtained from http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Final_EIR-EIS_Chapter_9_-_Geology_and_Seismicity.sflb.ashx. Exhibit DDJ-158 is a true and correct copy of the document.

hazard curves and ground motion values for a 2% in 50 years event, which is consistent with ASCE standard 7-10 (Exhibit DDJ-157, Table 6-5 p. 61) [23]

Section 9.2.2.6 of the Final EIR/EIS (Exhibit DDJ-158) includes the US Army Corps of Engineers' Standard EM 1110-2-6050, Response Spectra and Seismic Analysis for Concrete Hydraulic Structures, 1999, in the list of applicable standards. Standard EM 1110-2-6050 is aslo listed in the Revised EIR/EIS on p.9-19.) Standard EM 1110-2-6050 is provided for the hearing record as Exhibit DDJ-159.[24] The USACE standard potentially allows analysis with a maximum design earthquake (MDE) less than the ASCE maximum considered earthquake (MCE):

> For a maximum design earthquake (MDE) which is a maximum level of ground motion for which a structure is designed or evaluated, the associated performance requirement is the that the project performs without catastrophic failure, such as uncontrolled release of a reservoir, although severe damage or economic loss may be tolerated. The damage during an MDE event could be substantial, but should not be catastrophic in terms of loss of life, economics, and social and environmental impacts.

However, for critical structures, the USASCE maximum considered earthquake must be used:

> For critical structures (structures of high downstream hazard whose failure during or immediately following an earthquake could result in loss of life), the MDE is set equal to the MCE (the greatest earthquake that can reasonably be expected to be generated by a specific source on the basis of seismological and geological evidence). For other than critical structures, the MDE is selected as a lesser earthquake than the MCE.

Failure of the tunnel lining could cause significant leakage, which could potentially cause significant ground and surface movement and losses. Sewer, drain, and water leaks have caused large sinkholes within their right-of-way. Sinkholes and blowouts are a major risk to both

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[23] Exhibit DDJ- 157, Delta Risk Management Strategy, Final Report, Section 6, *Seismic Risk Analysis,* 2009. Previously cited.

[24] Exhibit DDJ-159 is a true and correct copy of the document.

surface facilities and to people occupying or using surface facilities. Failure of the tunnel lining could also necessitate lengthy and expensive repairs. For these reasons, the WaterFix Tunnel is a critical structure.

The Revised Draft EIR/EIS (Exhibit SWRCB-3, Chapter 9, p. 9-19) as well as the Final EIR/EIS (Exhibit DDJ-158) list the Department of Water Resources' 2012 State Water Project Seismic Loading Criteria Report (SLC Report) as one of the applicable design standards (Exhibit DDJ-143.)[25] DWR's SLC Report states that the Department of Engineering could find no seismic design documents for any previously constructed pipelines or tunnels. It also does not specify any minimum seismic standards for future construction of pipelines or tunnels. DWR's SLC report states, with respect to water supply pipelines:

> Similar to SWP canals, little documentation exists regarding the seismic loading criteria used in the design of existing pipelines including the recently designed pipelines. DWR does not currently use any analytical model to predict the behavior of buried pipelines during earthquake occurrences. This is partly because earthquake loads may not be a concern for pipelines below the ground surface. Furthermore, AWWA manuals do not explicitly include seismic loading criteria for water pipelines. (p. 16)

The assertion in DWR's SLC report that earthquake loads may not be a concern for pipelines below the ground surface is incorrect. Earthquakes in California have resulted in significant damage for buried pipelines.[26] Although DWR's SLC report goes on discuss

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[25] Exhibit DDJ-143, California Department of Water Resources, Division of Engineering, *State Water Project Seismic Loading Criteria Report*, 2012. Obtained from http://www.water.ca.gov/pubs/swp/swp_seismic_loading_criteria_report/swp_seismic_loading_criteria_report.pdf Exhibit DDJ-143 is a true and correct copy of the document.

[26] The assertion that earthquake loads may not be a concern for buried pipelines is incorrect. The American Lifelines Alliance (ALA), a partnership between FEMA, USGS, USDOT, BuRec, and the National Institute of Building Science, developed a database in 2001 which includes pipeline damage rates from 18 earthquakes from 1923-1995. Eight were in California. See Exhibit DDJ-153, American Lifelines Alliance (ALA), *Seismic fragility formulations for water systems*, 2001. Obtained from

recommendations for seismic standards by the American Lifelines Association, the report does not even treat them as guidelines. The section on tunnels is even briefer, stating only:

> The seismic loading criteria that were used in the design of existing SWP tunnels also have not been found. Many references, including the "Seismic Design of Tunnels – A Simple State-of-the-Art Design Approach" monograph (Jaw-Nan Wang and Parson Brinckerhoff, 1993) discuss the seismic loading criteria that could be used for tunnels. (p. 18)

DWR's SLC Report also states:

> These guidelines are a suggested starting point, but do not take the place of the design engineer's judgment and additional information available for a particular project site. Each design engineer should have the knowledge, experience, and insight into the importance of their facility to select the appropriate seismic design load and subsequently to apply that load in an appropriate manner to the structure. Similarly, this report does not prescribe the procedure or process of analyzing the structure. Again, this is design engineer's responsibility to select the method of analyses that best suit the complexity, criticality, and importance of the facility.
> (p. 3)

Thus DWR's SLC Report does not provide any minimum standards for SWP facility design, simply documentation of that Department of Water Resources considers seismic design criteria to be the responsibility of the design engineer.

The Final Draft CER (Exhibit DWR-212) indicates that the final seismic design criteria for the Modified Preferred Tunnel Option has not yet been adopted (p. 49, "Final design liquefaction analyses should be performed when final seismic design criteria for the MPTO/CCO facilities have been adopted.") It is thus unclear which, if any, of the external standards cited in section 9.2.2.6 of the Final EIR/EIS (Exhibit DDJ-158) will apply to the final seismic design of

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http://www.americanlifelinesalliance.com/pdf/Part_2_Appendices.pdf Accessed on March 21, 2017. ALA is a partnership between FEMA, USGS, USDOT, the Bureau of Reclamation, and the National Institute of Building Science. Exhibit DDJ-153 is a true and correct copy of the document.

the MPTO/CCO facilities, including the tunnels and the intake facilities. The analysis is therefore inadequate without final seismic design criteria for the tunnels and the intake facilities. Risks cannot be adequately addressed or mitigated in the WaterFix Change Petition Hearing until the final seismic design criteria is specified and disclosed. The final seismic design criteria should also be specified by the Department of Water Resources and the US Bureau of Reclamation before the design of the project progresses to the Design Construction Enterprise.