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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 XAVIER IRIAS

I, Xavier Irias, do hereby declare:

I. INTRODUCTION

I am the Director of Engineering and Construction for the East Bay Municipal Utility District ("EBMUD"). I have held this position for ten years. In my capacity as Director, I lead the development and implementation of EBMUD's biennial $1.4 Billion Five-Year Capital Improvement Program. Implementation of the capital program in any given year includes completing dozens of complex and diverse multi-disciplinary projects. My responsibilities also include championing sustainable infrastructure such as developing long-term infrastructure renewal plans for all asset classes. For the five years prior to my current position, I served as the Manager of Engineering Services at EBMUD. I have been employed by EBMUD for over thirty years. Before joining EBMUD, I worked for two years as a civil engineering trainee for Alameda County Flood Control. I have been registered as a Civil Engineer in the State of California since 1989.

This testimony addresses injury to EBMUD's Mokelumne Aqueducts (Mokelumne Aqueducts or Aqueducts), to EBMUD's proposed Mokelumne Aqueducts Delta Tunnel (Delta Tunnel), and to EBMUD's use of water under its Mokelumne River municipal water rights, that would be caused by the Joint Change Petition (Change Petition) filed on August 26, 2015 by the California Department of Water Resources (DWR) and United States Bureau of Reclamation (USBR) (collectively, Petitioners).

The Change Petition seeks to add new points of diversion and rediversion to Petitioners' water rights to allow the State Water Project (SWP) and Central Valley Project (CVP) (collectively, Projects) to move water from the Sacramento River through new North Delta intakes identified by Alternative 4A in the Bay Delta Conservation Plan/California WaterFix Partially Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement (RDEIR/SDEIS). Petitioners would use the new points of diversion and rediversion on the Sacramento River to divert water in the North Delta and convey it through two proposed large diameter (40 foot) tunnels (Twin Tunnels) approximately 30 miles in length underneath the Delta to the Projects' export facilities in the South Delta. The Twin Tunnels

would pass directly beneath the existing Mokelumne Aqueducts and in the area of EBMUD's proposed Delta Tunnel.

The Mokelumne Aqueducts consist of three aqueducts. The first of the Mokelumne Aqueducts was completed in 1929, and two additional aqueducts were later constructed. EBMUD uses the Aqueducts to convey EBMUD's Mokelumne River water to EBMUD's service area. The Aqueducts are a vital supply line in EBMUD's water distribution system; on a long-term basis, the Aqueducts provide virtually all of EBMUD's drinking water supply to its East Bay service area and its nearly 1.4 million inhabitants. EBMUD therefore takes great care in safeguarding the Aqueducts. The threat of injury posed by the Twin Tunnels to the Mokelumne Aqueducts concerns EBMUD greatly, as the Twin Tunnels construction and operation could have significant and adverse impacts on the integrity and operation of the Aqueducts. This testimony describes those impacts, and proposes a suite of measures to address them.

The proposed alignment for the Twin Tunnels crosses the Mokelumne Aqueducts and the alignment for EBMUD's proposed Delta Tunnel on Woodward Island. The construction and operation of the Twin Tunnels could impact the Mokelumne Aqueducts and the proposed Delta Tunnel through the following mechanisms, resulting in disruption of EBMUD water service operations:

1. Right-of-way (ROW) encroachment and disruption of EBMUD water service operations;
2. Directly interfering with the Mokelumne Aqueducts' deep foundations and/or the proposed EBMUD Delta Tunnel;
3. Undermining and settlement;
4. Soil settlement due to lower groundwater levels;
5. Twin Tunnels construction shafts causing lateral earth movement;
6. Seepage into Twin Tunnels during the Twin Tunnels' lifespan causing settlement or sinkholes;
7. Twin Tunnels lining failure causing settlement or sinkholes;

8. Additional costs for EBMUD Delta Tunnel construction and long-term operation due to the Twin Tunnels.

9. Damage to existing Mokelumne Aqueducts due to access roads and utilities;

10. Twin Tunnel power transmission foundations affecting existing Mokelumne Aqueducts;

11. Twin Tunnel power transmission and AC induced interference on existing Mokelumne Aqueducts;

12. Twin Tunnel power transmission lines fall hazard for existing elevated Mokelumne Aqueducts pipelines;

This testimony first describes the Mokelumne Aqueducts and associated water rights, and then describes EBMUD's efforts to evaluate and develop its proposed Delta Tunnel. The testimony then addresses the various categories of significant and adverse potential impacts to the Mokelumne Aqueducts and EBMUD's proposed Delta Tunnel posed by the Twin Tunnels, and provides reasonable measures to avoid, reduce, and compensate for those impacts.

II. EBMUD'S MOKELUMNE AQUEDUCTS

EBMUD is a public entity formed under the Municipal Utility District (MUD) Act passed by the California Legislature in 1921. In accordance with the MUD Act's provisions, voters in the East San Francisco Bay area created EBMUD in 1923 to provide water service. EBMUD filed its first water right application for a right to appropriate Mokelumne River water in 1924. A water right permit was granted under that application in 1926, following which EBMUD constructed Pardee Dam and Reservoir. In 1929, EBMUD completed construction of Pardee Dam, the highest dam in the world at the time, and Mokelumne Aqueduct No. 1. EBMUD's first water deliveries from the Sierra Nevada Mountains to EBMUD's service area occurred on June 23, 1929. Currently, EBMUD provides high-quality drinking water for approximately 1.4 million customers in Alameda and Contra Costa counties. On a long-term basis, approximately 90% of the EBMUD water supply is conveyed by the Mokelumne Aqueducts.

The Aqueducts consist of three steel pipelines approximately 90 miles in length running from Pardee Reservoir to EBMUD's service area. (See Figure 1, Appendix A, for a map of EBMUD's existing Mokelumne Aqueducts alignment.) The diameters of the three pipelines are as follows:

- Aqueduct No. 1: 65-inch inside diameter constructed in 1929
- Aqueduct No. 2: 67-inch inside diameter constructed in 1949
- Aqueduct No. 3: 87-inch inside diameter constructed in 1963

The Aqueducts are constructed with a combination of riveted and welded joints, and operate at internal pressures that vary with location and operational condition. The internal pressure of the Aqueducts within the Delta is about 250 pounds per square inch. The Aqueducts have several support configurations depending on the aqueduct and the location including: 1) buried, 2) buried on piles, 3) elevated on piles, and 4) dredged/covered river crossings.

As the Aqueducts cross the Delta in the reach from approximately Holt to Bixler, they are primarily elevated on pile supported bents at typical intervals of 60 feet. (See Figure 2, Appendix A, for a depiction of the existing EBMUD Mokelumne Aqueduct System in the Delta; and Photos 1-3, Appendix B, for views of the Mokelumne Aqueducts as they cross the Delta.) In addition to the support bents, there are expansion joints and temperature anchors at intervals of 1,000 feet along the Aqueducts. The piles are a combination of timber and precast concrete with pile tip elevations typically ranging from -35 to -72 feet mean sea level (msl). Within this reach the Aqueducts are typically buried in dredged trenches at river and slough crossings.

EBMUD has implemented a program to survey the Mokelumne Aqueducts and monitor observed settlement. As part of this program, EBMUD replaces Aqueduct temperature anchors as needed to rectify observed settlement problems. The current temperature anchor replacement projects replace piles with recommended pile tip elevations of approximately -72 feet msl, and, in the future, replacement projects may be at elevations greater than that, depending on ground conditions. As an example of these types of projects, EBMUD recently replaced two temperature anchors in the Delta. In addition, there is a current temperature anchor replacement project in

design that is scheduled for construction in 2017 at Station 2505+00 on Woodward Island. This project is located approximately 0.5 miles from the Twin Tunnels alignment.

EBMUD's water supply that is conveyed through the Mokelumne Aqueducts, and that would be conveyed through EBMUD's proposed Delta Tunnel described below, comes from the Mokelumne River and is based on State Water Resources Control Board-issued License 11109 and Permit 10478, which have the following key parameters and attributes:

1. License 11109

- Priority Date: September 22, 1924
- Direct Diversion: year-round up to 310 cubic feet per second (cfs)
- Point of Diversion: Pardee Dam
- Collection to Storage: 209,950 acre-feet (af) a year diverted to storage October 1 – July 15
- Total Combined Direct Diversion and Withdrawal From Storage: 310 cfs/200 million gallons per day (MGD)
- Total Taken From the Source (Direct Diversion Plus Collection to Storage): 316,250 af
- Total Placed to Beneficial Use (Direct Diversion Plus Withdrawal From Storage): 224,037 af
- Purpose of Use: Municipal and recreational

2. Permit 10478

- Priority Date: June 16, 1949
- Direct Diversion: December 1 – July 1 up to 194 cfs
- Point of Diversion: Pardee Dam and/or Camanche Dam
- Collection to Storage: 353,000 af a year diverted to storage December 1 – July 1 at Pardee and Camanche
- Purpose of Use: Municipal and industrial, recreation, and fish and wildlife preservation and enhancement

EBMUD diverts water from the Mokelumne River in accordance with the legal rights provided by License 11109 and Permit 10478. As described above, the Mokelumne Aqueducts are the facilities that convey water from the Mokelumne River, across the Delta, to EBMUD's service area. Interference with and/or damage to the Aqueducts caused by the Twin Tunnels would harm EBMUD's legal use of its Mokelumne River water.

III. EBMUD'S PROPOSED DELTA TUNNEL

EBMUD has been evaluating risks to the existing Mokelumne Aqueducts since at least 1980, when the Middle River levee failed on the west levee of Lower Jones Tract. This event resulted in the failure of a parallel railroad embankment which caused two locomotives and rail cars to derail and be deposited by flood waters dangerously close to the Mokelumne Aqueducts. The flood waters also inundated the Mokelumne Aqueducts' pipelines. When the railroad embankment failed, EBMUD was fortunate that scour from flood flows from Lower Jones Tract to Upper Jones Tract did not destroy the pile supported foundation of one or more of the Mokelumne Aqueducts in the area.

The vulnerability of the pipelines was again highlighted in 2004 when the Middle River levee failed and inundated the Mokelumne Aqueducts on Upper Jones Tract. (See Photos 4-5, Appendix B, for views of the 2004 Jones Tract flood and repair.) In response to this flood, in 2005 the Middle River levee repairs were completed and EBMUD began repairing the damage to the elevated pipelines. These events and other levee failures in the Delta highlight the significant risk of damage to the Mokelumne Aqueducts due to flooding and seismic events. Consequently, in 2005, EBMUD began a comprehensive hazard assessment, risk evaluation and alternatives analysis on the Mokelumne Aqueducts to safeguard this critical infrastructure in its alignment through the Delta. The results of this study were presented in a summary staff report entitled "Strategy for Protecting the Mokelumne Aqueducts in the Delta." (EBMUD-177). Following completion of the report, in 2007, the EBMUD Board of Directors approved Motion Number 185-07 to accept the staff report. The Board then directed staff to use the report's findings and recommendations in planning future water conveyance capital improvement programs. The staff

report evaluated various short-term and long-term measures and concluded that a deep tunnel below the Delta would be the most cost-effective solution to mitigate the hazards associated with seismic events, scour, flooding, liquefaction and lateral spreading risks.

A. Short-Term Measures

The short-term recommendations in the 2007 report included installing valves and piping to interconnect the three Mokelumne Aqueducts on the east and west side of the Delta, Stockton and Bixler, respectively. The 2007 report concluded that a significant flood or seismic event in the Delta would likely cause significant damage to one or more of the Aqueducts. The purpose of the interconnections is to allow the more vulnerable aqueduct segments within the Delta to be shut down and isolated in the event of an emergency. Provided that at least one of the three aqueduct pipelines remained intact across the Delta, transmission capacity of the system can be increased by utilizing the capacity of the surviving portions of the aqueduct pipelines on either side of the Delta. In 2010, EBMUD designed interconnections among the Aqueducts on both sides of the Delta. Providing this type of operational flexibility was seen as a needed, though short-term, measure to help address facility risk identified in the 2007 staff report. The construction of the interconnection facilities was completed in 2013 for a total project cost of about $14 million.

The short-term recommendations in the 2007 report also included conducting preliminary planning studies of the Delta Tunnel concept, such as geotechnical investigations and conceptual design activities. As described below, EBMUD has conducted such studies and continues to do so, as part of the process of developing its Delta Tunnel.

B. Long-Term Measures

To continue pursuing the long-term solution recommended by the 2007 report (i.e., a deep tunnel across the Delta), in 2014 EBMUD completed the Delta Tunnel Study Conceptual Design, for replacing its existing Mokelumne Aqueducts through the Delta with the Delta Tunnel. (EBMUD-178.) EBMUD's proposed Delta Tunnel has been developed to the conceptual design level. The conceptual design identifies the proposed horizontal alignment and vertical profile for the proposed Delta Tunnel. Refinements to the Delta Tunnel alignment and profile

may occur in the future and would be fixed at the completion of the preliminary design phase. The proposed Delta Tunnel horizontal alignment follows the existing EBMUD Mokelumne Aqueducts ROW beginning near Interstate 5 in Stockton at the east, to Bixler at the west, a distance of 16.6 miles. (See Figures 3 and 4, Appendix A.) Seven shafts, at approximate three mile intervals, are planned for the construction of the Delta Tunnel and future access to the carrier pipes. (See Figures 5 and 6, Appendix A.)

Based on EBMUD's current conceptual design, the proposed Delta Tunnel is expected to have an excavated diameter of approximately 21 feet and will be constructed using pressurized face tunnel boring machines (TBMs) and supported with precast concrete segments. The Delta tunnel would house twin 87-inch inside-diameter pressurized steel carrier pipes secured with cellular concrete backfill of the annular space.

The proposed Delta Tunnel profile has been identified within a vertical envelope, or band, about 50 feet high. This band represents the tunnel diameter plus allowances for a range of likely profiles to be determined during the preliminary design phase. (See Figure 8, Appendix A.).

In 2015, EBMUD advertised a request for proposals (RFP) for engineering consultant services to conduct subsurface explorations of the Delta to support preliminary design of EBMUD's proposed Delta Tunnel. On February 23, 2016, EBMUD's Board of Directors awarded a $2.3 million contract to an engineering consultant with soft ground tunnel expertise to perform an extensive geotechnical investigation program across the Delta and prepare the Geotechnical Data Report (GDR), a geologic interpretative memo and a seismicity report, in furtherance of EBMUD's Delta Tunnel Project.

IV. PETITIONERS' PROPOSED TWIN TUNNELS AND SHAFTS

In Alternative 4A – Modified Pipeline / Tunnels Option, the "WaterFix" Project (Project), Petitioners propose dual 40-foot-inside-diameter main tunnels to convey water 30.1 miles from a new intermediate forebay on Glanville Tract to a pumping plant near Clifton Court Forebay. The Twin Tunnels would cross the existing Mokelumne Aqueducts ROW on

Woodward Island. (See Figure 7, Appendix A; and Photo 6, Appendix B.) The Twin Tunnels would be constructed with large-diameter TBMs through launch/retrieval shafts at approximately 3-mile intervals. The 2013 DEIR/DEIS showed the crown of the Twin Tunnels at an elevation of approximately – 56 msl and the tunnel invert at - 100 msl. Based on a subsequent Conceptual Engineering Report (DWR-202), the Testimony of John Bednarski states that the 40-foot-diameter Twin Tunnels inverts are now projected to be between elevations -147 to -163 msl. (DWR-57, p. 17.) (See Figure 8, Appendix A, for a depiction of these elevation ranges and that of EBMUD's proposed Delta Tunnel.)

EBMUD owns the ROW, including surface and subsurface rights, within which the existing Mokelumne Aqueducts are located and where EBMUD's proposed Delta Tunnel would be situated as well. The Petitioners' proposed Twin Tunnels would cross the Mokelumne Aqueducts and EBMUD's ROW on Woodward Island, thereby raising substantial concerns over the Twin Tunnels' interfering with and damaging the Mokelumne Aqueducts. (See Figure 7, Appendix A.) The general concerns of EBMUD are:

1. Protecting EBMUD customers from water service outages due to damage or disruption to the Mokelumne Aqueducts caused by construction and/or operation of the Twin Tunnels.
2. Avoiding costly repairs to EBMUD facilities caused by damage to the Mokelumne Aqueducts from construction and/or operation of the Twin Tunnels.
3. Avoiding potential consequential third party damages from flooding and scour due to failure of the Aqueducts caused by damage thereto from construction and/or operation of the Twin Tunnels.
4. Avoiding interference between the vertical position (elevation) of the Twin Tunnels and EBMUD's proposed Delta Tunnel vertical alignment.
5. In the event that EBMUD's Delta Tunnel is constructed first, avoiding damage and service disruption to the Delta Tunnel, which would endanger water service to EBMUD's customers and result in costly repairs.

6. In the event that the Petitioners' Twin Tunnels are constructed first, avoiding additional costs for construction and operation of EBMUD's proposed Delta Tunnel due to construction and operation of the Twin Tunnels.

Petitioners will need to secure a tunnel ROW agreement with EBMUD in order to gain access and construct the Twin Tunnels in the Mokelumne Aqueducts ROW, which is proposed to contain EBMUD's proposed Delta Tunnel. EBMUD suggests that this process begin immediately in order for the Twin Tunnels design work to include appropriate safeguards as outlined in the impacts and conditions below. EBMUD's ROW procedures were appended to EBMUD's 2014 and 2015 comments on the Project's environmental documentation. (EBMUD-176.)

A. <u>EBMUD's Previously Raised Concerns</u>

EBMUD's concerns over impacts from the Project's tunnels on the existing Mokelumne Aqueducts and the District's planned Delta Tunnel are not new. Instead, they have been repeatedly raised by EBMUD over a period of years. But they have not yet been addressed.

In 2012, while the Bay Delta Conservation Plan (BDCP) and the Draft EIR/EIS were being developed, EBMUD raised its concerns with DWR. Notwithstanding that, the subsequent 2013 BDCP Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) did not address the District's Aqueduct/Delta Tunnel concerns. To address this omission, EBMUD's July 28, 2014 comment letter on the EIR/EIS stated the concerns, noting that the proposed BDCP tunnels would intersect and conflict with the Mokelumne Aqueducts and planned Delta Tunnel, and that the EIR/EIS must address how the BDCP proponents will mitigate the impacts resulting from those conflicts. (EBMUD-176, pages 8-9.[1]) EBMUD also included an Attachment 3 to its 2014 comment letter, a detailed document setting forth the potentially significant and adverse impacts of the Project on the integrity and operation of the Mokelumne Aqueducts and on the

[1] EBMUD-176 is EBMUD's October 28, 2015 comment letter on the RDEIR/SDEIS, which letter has attached to it the entirety of the District's July 28, 2014 comment letter on the original 2013 BDCP EIR/EIS.

District's planned future Delta Tunnel, and providing a suite of measures that would address those impacts.

Despite this explicit identification by EBMUD of impacts and its request for measures to address the impacts, the subsequent 2015 Bay Delta Conservation Plan/California WaterFix Partially Recirculated Draft EIR/Supplemental Draft EIS (RDEIR/SDEIS) did not address these issues. This forced EBMUD to again point out, this time in its October 28, 2015 comment letter on the RDEIR/SDEIS, that the Project's tunnels would pass directly underneath the existing Mokelumne Aqueducts, and that the impacts of this undercrossing must be examined and could not be deferred to a future date. The District attached its 2014 EIR/EIS comment letter to its 2015 letter, because the tunneling concerns it had previously raised remained relevant, as they had not been addressed.

Similarly, DWR's July 1, 2015 Conceptual Engineering Report (CER) for the Project did not assess the impacts of the proposed Twin Tunnels on the Mokelumne Aqueducts or the District's planned future Delta Tunnel. Instead, this report, identified as DWR Exhibit No. 212, states while the Project's Twin Tunnels will cross the Mokelumne Aqueducts at the north end of Woodward Island, these crossings will be evaluated later, at the preliminary design level. (DWR Exhibit No. 212, p. 156.)

This displays a pattern of repeated neglect by the Petitioners of the District's issues concerning the impacts of the proposed Twin Tunnels on the existing Mokelumne Aqueducts and its future planned Delta Tunnel. Those impacts are significant, and are described in the following section of this testimony concerning the impacts of the Twin Tunnels Project on the existing Mokelumne Aqueducts and on EBMUD's proposed Delta Tunnel.

V. IMPACTS ON EXISTING MOKELUMNE AQUEDUCTS AND PROPOSED EBMUD DELTA TUNNEL

Construction of the Twin Tunnels would adversely impact the existing EBMUD Mokelumne Aqueducts, potentially resulting in a disruption in water service operations. Also, it is important to recognize that miles of levees in the vicinity of the Twin Tunnels could be

adversely impacted by construction and operation of the Twin Tunnels resulting in direct impacts to the Mokelumne Aqueducts. The current proposed path for the Twin Tunnels crosses Delta islands (i.e., Bacon Island and Victoria Island) that are adjacent to Woodward Island, which the Mokelumne Aqueducts traverse, and are protected by relatively vulnerable levees. Levee damage on any of these islands could result in damage to the Mokelumne Aqueducts through stability and/or flood impacts such as embankment and/or foundation instability, lateral spreading of levee materials, scour, wave forces, and inundation. As described below, EBMUD has identified potential impacts to the existing Mokelumne Aqueducts from the Twin Tunnels construction and long-term operation.

The alignments of the Twin Tunnels and the Delta Tunnel cross on Woodward Island. (See Figure 7, Appendix A.) Regardless of which tunnel project is constructed first, the Twin Tunnels will need to avoid or mitigate impacts on the design and construction of the EBMUD Delta Tunnel as well as potential long-term operational impacts. To avoid interference with the Twin Tunnels within the tunnel crossing zone, it may be necessary to modify the design and construction of the proposed EBMUD Delta Tunnel such as by using shallower or deeper vertical alignments, additional vertical curves and shafts, more robust tunnel system design, and/or altered construction methods.

The impacts of construction of the Twin Tunnels Project on the proposed EBMUD Delta Tunnel are similar to the Project impacts identified for the existing Mokelumne Aqueducts. However, in most instances the impacts are more severe due to the closer proximity of the proposed Twin Tunnels to the proposed Delta Tunnel alignment. These impacts result from the siting of the Twin Tunnels, ground loss, settlement, heave, vibrations, direct interference, hydrostatic head, and exfiltration from the Twin Tunnels. The results of these impacts are damage and potentially failure of the pipelines (e.g., carrier pipes) within the proposed EBMUD Delta Tunnel and may also include potential higher construction and operation costs to EBMUD. These impacts will be acute due to the close proximity of the tunnels (small vertical separation), low tolerances and sensitivity of the pipelines to movement within the tunnel, and the difficult access to repair damages to the integrity of the pipelines.

The following table summarizes the Petitioners' Twin Tunnels Project impacts to the existing Mokelumne Aqueducts (AQ) and to the proposed EBMUD Delta Tunnel (DT):

No.	AQ	DT	Impact Description
1	**X**	**X**	ROW encroachment and disruption of EBMUD water service operations
2	**X**	**X**	Direct interference with structures
3	**X**	**X**	Undermining and settlement
4	**X**	**X**	Soil settlement due to lower groundwater levels
5	**X**	**X**	Twin Tunnels construction shafts cause lateral earth movement
6	**X**	**X**	Seepage into Twin Tunnels during the Twin Tunnels' lifespan
7	**X**	**X**	Twin Tunnels' lining failure
8		**X**	Additional costs for EBMUD tunnel construction and long-term operation
9	**X**		Damage from access roads and utilities
10	**X**		Twin Tunnel power transmission foundations
11	**X**		Twin Tunnel power transmission and AC induced interference
12	**X**		Twin Tunnel power transmission fall hazard

Impact 1: ROW encroachment and disruption of EBMUD water service operations

EBMUD owns the ROW for the Mokelumne Aqueducts. The proposed Twin Tunnels would cross the Mokelumne Aqueduct ROW. The Mokelumne Aqueducts provide 90% of EBMUD's water supply. EBMUD must protect its water service customers from outages due to damage or disruption to the Mokelumne Aqueducts from construction and/or operation of the Twin Tunnels, must avoid costly repairs to EBMUD facilities, avoid potential consequential third party damages from failure of the Aqueducts, and protect EBMUD's anticipated needs for future construction, operation, maintenance, and risk mitigation measures, such as the proposed EBMUD Delta Tunnel.

Impact 2: Direct interference with Structures

Existing piles supporting the Aqueducts extend into the ground to pile tip elevations ranging from approximately -35 to -72 feet msl. If the Twin Tunnels are relatively shallow, the tunnel excavation would encounter the piles supporting the Aqueducts. Encountering the piles during tunnel construction would cause settlement of the pile cap and pipelines with associated high risk for damage and failure of the Aqueducts.

On Woodward Island where the ground surface is at approximately -12 feet msl, current temperature anchor replacement projects for the Aqueducts to replace failing temperature anchors and support bents specify new 60 foot long piles with corresponding pile tip elevations of approximately -72 feet msl. It is possible that future projects (as needed) will extend deeper than the current pile tip elevations due to continuing ground subsidence and variable ground conditions. Thus, depending on the depth of the Twin Tunnels, the Project could interfere with EBMUD's replacement of the support structures for the Mokelumne Aqueducts.

Both the Project's and EBMUD's tunnel systems cannot be located at the same elevation. Additionally, vertical separation and buffer zones will be necessary between the tunnels to avoid adverse impacts on both tunnel systems. It may be necessary to modify the design and construction of the proposed EBMUD Delta Tunnel to avoid interference with the Twin Tunnels within the tunnel crossing zone, such as by using shallower or deeper vertical alignments, additional vertical curves and shafts, more robust tunnel system design, and altered construction methods.

The first tunnel project constructed will result in a change in the soil properties and surrounding ground conditions that may include development of a zone of loosened soil above the tunnel that extends to the ground surface, changing the permeability, and potentially creating voids. With the second tunnel positioned above the first, this zone of loosened soil will likely make construction of the second tunnel more difficult due to necessary ground control and addressing lost ground. Loading of the second TBM on the structural lining of the first tunnel structural support is also a potential impact.

With the second tunnel positioned below the first, ground loss and settlement from construction of the second tunnel would adversely impact and endanger the first tunnel from settlement and potential construction irregularities.

Impact 3: Undermining and settlement

The Twin Tunnels would likely be constructed within the zone of influence for the piles supporting the Mokelumne Aqueducts and could reduce the ground support for the piles and/or cause settlement of the piles. This could occur even if the tunnels do not directly encounter the piles. Depending on the magnitude of the settlement, the Mokelumne Aqueduct pipelines would be deflected, potentially resulting in failure with significant consequences, such as loss of water supply to EBMUD customers, flooding and scour of the area surrounding the failure site causing further structural damage, and damage to adjacent landowners and potentially to the levees on Woodward Island, Orwood Tract, and Jones Tract.

Common tunnelling methods result in some ground settlement from stress redistribution in the ground, face losses, radial overcut greater than the shield diameter, and voids around the segmental lining that have not been quickly filled by tailskin grouting and secondary grouting through ports in the precast concrete segments. Additionally, tunnelling and other construction activities can cause vibrations resulting in pile support system settlement. Ground loss beginning at the tunnel level migrates upward resulting in loose soils and causing settlement within a zone of influence. Although tunnelling equipment and methods may be employed to control the ground (e.g., utilization of a pressurized face TBM, tailskin grouting, compensation grouting, etc.), localized zones of settlement may occur unexpectedly due to ground conditions, mechanical problems with the tunnel excavation process, and less than desirable face control pressure due to TBM operator error, resulting in major ground loss, large voids in the soil profile, and sinkholes near the ground surface. Such ground loss could result in major settlements extending to the ground surface. Even if loosened ground associated with tunnel construction did not directly cause settlement of the Aqueducts or the proposed EBMUD Delta Tunnel immediately, the loosened ground would be susceptible to settlement over time, and this

settlement may be exacerbated by soil liquefaction causing associated ground movements post-construction during seismic events.

Also, if the proposed EBMUD Delta Tunnel is forced to occupy a shallower vertical alignment to avoid the Twin Tunnels, there is a higher risk of damage from seismic liquefaction and long-term settlements.

Impact 4: Soil settlement due to lowered groundwater level

Complications during construction could result in lowering of the groundwater table, or the groundwater table may be lowered temporarily to address a construction complication, or could be lower for a longer period of time if groundwater is infiltrating the Twin Tunnels' gaskets. If the groundwater table is lowered for any reason, such as tunnelling or shaft construction, it would likely result in consolidation from an increase in effective stress on soft soils, especially the peat. This settlement would impart an increased risk of damage to the existing Mokelumne Aqueducts, surrounding levees that protect the Mokelumne Aqueducts in the Delta, and the proposed EBMUD Delta Tunnel. In addition, accelerated deterioration of wooden piles supporting the Aqueducts would likely occur due to lowering or fluctuation of groundwater levels.

Impact 5: Twin Tunnels construction shafts cause lateral earth movement

Shafts for the Twin Tunnels are shown in the 2015 BDCP RDEIR/SEIS to be located about two miles to the north on Bacon Island and to the south of the existing Mokelumne Aqueducts on Victoria Island. At these locations and distances, the shafts would not be expected to have direct impacts on the existing Mokelumne Aqueducts or the proposed EBMUD Delta Tunnel. However, shaft locations near the EBMUD ROW are possible during future design development, if a different tunnels alternative is implemented, based on contract packaging, or if a rescue or maintenance shaft were deemed necessary during construction due to problems with the TBM. Construction of the Twin Tunnels shafts could result in ground movements, especially lateral displacements in the foundation or levee embankment, in the vicinity of the shafts. These ground movements could result in detrimental impacts on the existing Mokelumne Aqueducts

and its pile foundations, either directly or indirectly due to damage to the surrounding levees, and to the EBMUD Delta Tunnel, if constructed first.

Impact 6: Seepage into Twin Tunnels during the Twin Tunnels' lifespan

The presence of the Twin Tunnels could result in adverse impacts such as settlement and sinkholes beneath the existing Mokelumne Aqueducts alignment or settlement of the proposed EBMUD Delta Tunnel throughout the service life of the Twin Tunnels. The Twin Tunnels are currently designed as a single pass system of bolted and gasketed precast concrete segments. Unlike many large diameter water conveyance tunnels, the design does not include a secondary lining, such as welded steel. The proposed single-pass segmental lining system with bolted and gasketed joints has the risk of long-term degradation of the gasketed joints that may result in groundwater infiltration into the tunnels. This seepage could carry soil particles resulting in piping and erosion that may cause voids, settlement, and/or potentially sinkholes. Depending on the magnitude of the soil erosion, the existing Mokelumne Aqueducts or the proposed Delta Tunnel could be damaged or there could be failure due to settlement and/or the formation of large sinkholes.

Impact 7: Twin Tunnels' lining failure

Long-term degradation of the Twin Tunnels' segmental concrete lining may result in failure of the lining. In the event that the tunnel lining fails or there is a collapse of one or both of the tunnels, it would result in major ground movement propagating to the ground surface and potential creation of a sinkhole. With such an event, the resulting settlement would likely result in damage and potential failure of the existing Mokelumne Aqueducts.

Impact 8: Additional costs for Delta Tunnel construction and operation due to Twin Tunnels

The measures required to construct both the Twin Tunnels and the Delta Tunnel with alignments crossing on Woodward Island may have significant cost impacts during construction and over the service life of the projects. Likely cost impacts include higher design, construction, and operational costs of EBMUD's Delta Tunnel in order to avoid interference. The close proximity of the two alignments requires a more robust design of the tunnel system and/or the use of certain construction methods to avoid adverse impacts and potentially higher construction

and operation costs if the EBMUD Delta Tunnel alignment needs to be adjusted to avoid interference.

Impact 9: Damage from Twin Tunnel access roads and utilities

Haul routes and utilities necessary for construction of the Twin Tunnels will have impacts to the region and may have adverse impacts on the existing Mokelumne Aqueducts. Adverse impacts may include direct impacts to the Aqueducts from potential access road/utility crossings or parallel alignments to Mokelumne Aqueducts or other impacts from traffic or damage to the surrounding levee system. Access roads to support construction activities may be planned to cross, or parallel, the existing Mokelumne Aqueducts. These roads may result in adverse loadings, ground settlement, vibrations, direct impacts, and other unforeseen damages to the Mokelumne Aqueducts. Additionally, access roads planned on the crest of nearby levees may cause levee failure resulting in damage to the Mokelumne Aqueducts through flooding and erosion impacts such as embankment and/or foundation instability, lateral spreading of levee materials, scour, wave forces, and inundation.

Also, utilities such as water and gas lines to support construction activities may be planned to cross over (or under), or parallel to the existing Mokelumne Aqueducts. Construction of these utilities may result in ground settlement, direct impacts, and other unforeseen damages to the Mokelumne Aqueducts.

Impact 10: Twin Tunnel power transmission foundations

The Recirculated DEIR/DEIS provides limited details concerning the likely high voltage power transmission line corridors being considered for supplying construction power for the Twin Tunnels. The Conceptual Engineering Report (DWR-212), Section 19.0 presents power demand estimates and anticipated power transmission corridors. The current proposed transmission corridor has a north-south alignment which parallels the Twin Tunnels on Woodward Island (See, e.g., Figure 19-2, DWR-212, page 196). The new transmission lines may have adverse impacts on the existing Mokelumne Aqueducts. Transmission line foundations located near the existing Mokelumne Aqueducts may adversely impact the Mokelumne

Aqueducts' foundations or the surrounding levee system from lateral ground movements and settlement.

Impact 11: Twin Tunnel power transmission and AC induced interference

Overhead power transmission lines can induce voltages on pipelines that may cause alternating current (AC) induced corrosion on buried pipelines and create an electrical shock hazard for people, depending on the location of the transmission lines. AC induced corrosion is a significant issue resulting in metal loss on existing buried pipelines and a reduction in the service life of the water transmission system. Voltages can also be induced onto both buried pipelines and elevated pipelines similar to existing Mokelumne Aqueducts (containing a grounding system) located in close proximity to power transmission lines. AC interference on pipelines is a potentially serious problem which can place both operator safety and pipeline integrity at risk.

Impact 12: Twin Tunnel power transmission fall hazard

Damage to the Project's transmission line towers could result in transmission lines falling and coming into direct contact with the elevated portion of the Mokelumne Aqueducts welded steel pipelines, creating a potentially life-threatening situation for operations personnel. The integrity of the transmission line towers might also be compromised by a natural hazards event (e.g., earthquake, flooding, wind).

VI. CONDITIONS TO PROTECT THE EXISTING MOKELUMNE AQUEDUCTS & PROPOSED EBMUD DELTA TUNNEL

In order to focus on the impacts of Twin Tunnels on EBMUD facilities, the "Tunnel Crossing Zone" has been defined as the area of the Twin Tunnel's final right-of-way (ROW) width extending outward 1,000 feet in both directions from the centreline of the EBMUD ROW where the Twin Tunnels cross underneath the Mokelumne Aqueduct's ROW.

At this point in time there are many unknowns related to the ground conditions and the proposed tunnel vertical alignment, tunnel and shaft design, construction means and methods, and operation of the Twin Tunnels. If not for the Twin Tunnels, the risk profile associated with EBMUD's existing and future Mokelumne Aqueduct system across the Delta would be drastically different. Due to the critical nature of EBMUD's Mokelumne Aqueducts, and the

risks to that infrastructure posed by the Project's Twin Tunnels, it is important to provide conservative and redundant conditions to eliminate potential impacts, especially those resulting from a catastrophic event. The following conditions have been developed to address the 12 impacts identified above.

A. ROW Encroachment

As described above, EBMUD owns the ROW for the Mokelumne Aqueducts. Therefore, prior to commencement of construction of the Twin Tunnels, Petitioners must enter a tunnel right of way agreement with EBMUD to obtain the right to construct the Twin Tunnels in EBMUD's Mokelumne Aqueducts ROW and to address all remaining potential Project impacts on EBMUD Aqueducts facilities, including those impacts resulting from Project construction, operation, and maintenance.

The ROW Agreement would allow Petitioners to evaluate the crossing of its proposed Twin Tunnels with the existing Mokelumne Aqueducts and EBMUD's proposed Delta Tunnel in conjunction with EBMUD at the preliminary design level and implement provisions discussed below.

B. Geotechnical Investigations

Petitioners will perform additional geotechnical investigations in the vicinity of the Twin Tunnels – Mokelumne Aqueduct crossing location. EBMUD will review, comment upon and approve the Petitioners Geotechnical Investigation Workplan for the Tunnel Crossing Zone. Data obtained from the geotechnical investigations will be used to support the development of a geological model for the characterization of ground conditions within the water conveyance alignments and as necessary for the implementation of ground improvement, and aid in the avoidance of geologic risks associated with the construction of the water conveyance facilities, as well as the long-term risk of seismic induced liquefaction and settlement. The acceptable program will include but is not limited to a large number of deep borings, sampling, in-situ testing, laboratory testing, and geophysical surveys. Petitioners will share geotechnical data with EBMUD. Petitioners will coordinate with EBMUD on the model development and refine it to

accurately analyze potential interference of the Project Twin Tunnels with pile supports of the Mokelumne Aqueducts and the proposed EBMUD Delta Tunnel.

C. Ground Treatment

Petitioners will develop a Ground Treatment Plan to treat the ground within the zone of influence at and/or above the Twin Tunnel alignments prior to tunneling to form a more stable ground mass not susceptible to ground movement. Ground treatment will include corrective actions such as jet grouting, permeation grouting, and potentially other methods prior to tunneling through this area. EBMUD will review, comment and approve the Petitioners Ground Treatment Plan for the Tunnel Crossing Zone. The Petitioners Ground Treatment Plan will be designed to protect both the existing Mokelumne Aqueducts and the proposed EBMUD Delta Tunnel.

D. Monitoring

Prior to construction, Petitioners will, in consultation with EBMUD, develop a Monitoring Plan for the Tunnel's Crossing Zone. Petitioners will implement the Monitoring Plan which will include installation, data collection and maintenance of surface settlement points and instrumentation, that includes, but is not limited to extensometers, piezometers, and inclinometers. The purpose of the Monitoring Plan is to allow rapid detection of problems during construction within the Tunnel Crossing Zone by monitoring:

- Groundwater levels,
- All three Mokelumne Aqueduct pipelines and structural supports,
- Woodward Island levee elevations,
- Ground surface within the Mokelumne Aqueduct ROW,
- EBMUD Delta Tunnel, if applicable.

The duration of the Monitoring Plan will cover the period of construction within the Tunnel Crossing Zone, in addition to a minimum one (1) year period prior to construction to establish a pre-construction baseline. EBMUD will review, comment and approve the Petitioners Monitoring Plan for the Tunnel Crossing Zone. After construction of the Twin Tunnels commences, groundwater levels, settlements, and structural deformations within the Tunnel

Crossing Zone will be carefully monitored by Petitioners to ensure they do not exceed the established pre-construction baseline specified limits. Specified intermediate trigger levels and action levels for structures and ground surfaces will be established and mutually agreed upon between Petitioners and EBMUD after completion of the analysis of settlement risks. The Monitoring Plan will identify measures to improve the construction performance at trigger level exceedance and, in the event of exceedance of action levels, Petitioners will design and implement corrective actions approved by EBMUD. Monitoring data will be made continuously available to EBMUD.

Petitioners will, in consultation with EBMUD, develop a robust long-term plan for groundwater and settlement monitoring, and Petitioners will take corrective action that contains allowable groundwater and ground surface changes within the Tunnel Crossing Zone. In the event that increased seepage or water inflow is detected during construction or during the operational life of the Twin Tunnels, the situation will be addressed by Petitioners repair of the lining and/or using ground improvement techniques such as permeation (cement or chemical) grouting immediately outside the permanent lining to cut off groundwater infiltration. Additionally, compensation grouting will be used by Petitioners to fill voids and/or to densify the ground to stabilize the ground and prevent soil erosion and ground settlement above the tunnel.

Petitioners will conduct routine condition assessment inspections during the operational life of the Twin Tunnels. In the event that structural deficiencies of the segmental concrete lining are detected, the situation will be addressed by Petitioners with localized structural patches.

E. <u>Preliminary and Final Design</u>

Petitioners will coordinate with EBMUD during the preliminary design and construction of the portion of the Twin Tunnels to avoid direct interference with pile tips of the Mokelumne Aqueducts and the proposed EBMUD Delta Tunnel. Specific conditions include:

1) Petitioners will locate the Twin Tunnels at a depth, or low enough elevation, to avoid direct interference with pile tips of the Mokelumne Aqueducts and future aqueduct foundation repair projects, and the proposed EBMUD Delta Tunnel.

See Condition F, Property Acquisition, below, regarding safeguarding EBMUD's future Delta Tunnel.

2) Petitioners will obtain construction records of piles supporting the Mokelumne Aqueducts and position the Twin Tunnels at suitable depth to avoid impacts to the existing and future (deeper) pile supports planned. It is recognized that record documents for the existing Mokelumne Aqueducts may be incomplete and imprecise, so a margin of safety will be needed.

3) Within the Tunnel Crossing Zone, Petitioners will provide special detailing in recognition of the high risk associated with tunnelling under the Mokelumne Aqueducts due to the high consequences of failure. That detailing will supplement the currently proposed Twin Tunnels single-pass lining system with an additional watertight interior system to provide redundancy, such as a secondary tunnel lining system to mitigate potential gasket and/or bolt failure in the joints of precast concrete segmental tunnel liner.

4) Petitioners will design the permanent segmental lining for long-term performance with a design minimum service life of 100 years, which may include additional reinforcement, stronger or more durable concrete, a more robust gasket sealing system, and joint design.

5) Petitioners will select a tunnel vertical alignment in soils that minimizes the potential for ground settlement and reduces construction impacts.

6) For design shafts and potential rescue shafts, Petitioners will select appropriate shaft construction methods to provide stable lateral support and groundwater control for the deep excavations (e.g., secant pile walls, slurry walls).

7) In advance of the Twin Tunnels construction, Petitioners will design a ground improvement program, such as jet grouting, permeation grouting, or alternative methods, to stabilize the ground, reducing interference or impacts during construction, such as settlement risk, and facilitating construction.

8) Petitioners will treat the ground in the vicinity of the Twin Tunnels shafts prior to construction to stabilize the ground conditions by utilizing methods such as jet grouting and ground freezing.

9) Petitioners will work in good faith with EBMUD to establish a set of protocols, protective measures and monitoring to address road access, utility corridor concerns, or levees within the Tunnel Crossing Zone.

10) Petitioners will provide appropriate cover or separation between the alignments of the Twin Tunnels and EBMUD's future Delta Tunnel to reduce adverse impacts. The separation distance needs to be addressed during design development of each project with consideration of ground conditions, construction methods, ground improvement, lining types and designs, and other factors.

F. <u>Property Acquisition</u>

The EBMUD Delta Tunnel vertical alignment is constrained from being close to the ground surface by the existing Mokelumne Aqueduct pile tip elevations and risk of damage from seismic liquefaction and long-term settlements. The depth of liquefaction and acceptable settlement design criteria have not been developed yet for design. Better estimates will be developed as part of the EBMUD current geotechnical exploration program to be completed in 2017. The EBMUD Delta Tunnel vertical alignment is also constrained from being deep by the approximately 44 feet outside-diameter of the Twin Tunnels with proposed invert elevations ranging from -147 to -163 feet msl (DWR-57, p. 17). As a result of the proposed Twin Tunnels Project, higher design and construction costs of EBMUD's Delta Tunnel are anticipated in order to avoid interference. The close proximity of the Twin Tunnels alignment to that of EBMUD's future tunnel requires a more robust design of the tunnel system and/or the use of certain construction methods to avoid adverse impacts and potentially higher operational costs due to changed vertical alignment of the EBMUD Delta Tunnel. EBMUD shall be compensated by Petitioners for the extra costs incurred to accommodate the Twin Tunnels through the EBMUD ROW. A shallower vertical alignment for EBMUD's Delta Tunnel will require horizontal alignment changes to avoid interference with the existing pile support system of the existing

Mokelumne Aqueducts and will involve a higher risk of damage to the Delta Tunnel from seismic liquefaction and long-term settlements. Therefore, Petitioners shall implement the following conditions:

1) New Additional ROW:

Prior to advertising for construction bids for the Twin Tunnels, Petitioners shall purchase and convey to EBMUD a land parcel south of, and adjacent to, the Mokelumne Aqueduct ROW of approximate extents 5 miles long and 100 feet wide. This estimate is based on the following assumed design elements for the proposed EBMUD Delta Tunnel.

a. EBMUD will locate a shaft on Orwood Tract East at approximately Mokelumne Aqueduct Station 2580+00

b. The drive length will be limited to 5 miles. The exact drive length will be determined during the design phase after completion of EBMUD's current Geotechnical Exploration Program.

c. The shaft at Station 2580+00 will be designed with an air release facility for the steel carrier pipe within the Delta Tunnel to accommodate this unnecessary local high point in the pipeline.

d. From the shaft at Station 2580+00, the Delta Tunnel will slope 0.125% downward in the easterly direction until clearing the Twin Tunnels on Woodward Island and then the downward slope can be increased to 3.0% to reduce risk of liquefaction induced settlement. Upon reaching the optimal design elevation the Delta Tunnel slope will be maintained at approximately 0.125% to the shaft on Jones Tract.

e. The total length of the Delta Tunnel that must be installed at a shallower depth to avoid the Twin Tunnels is estimated to be a minimum of 9,000 feet depending on the estimated liquefaction induced settlement depths for the Delta Tunnel alignment. A 20 foot minimum vertical clearance between the Delta Tunnel and the Twin Tunnels was assumed. This also

assumes the Twin Tunnels' invert elevations will be -160 msl at the crossing location and have 44 foot outside diameters.

2) Ground Treatment for EBMUD Delta Tunnel:

Within the additional ROW purchased, the Delta Tunnel will be installed at a shallower vertical alignment. Petitioners will mitigate the higher risk of damage from seismic liquefaction and long-term settlements by conducting ground improvement. In coordination with Petitioners, EBMUD will evaluate the liquefaction potential for the tunnel elevation at an alignment with a shallower depth, approximately 9,000 feet long, and develop a Ground Treatment Plan for Petitioners to implement.

If EBMUD determines in the future that the additional ROW is not necessary, EBMUD will quit claim the land deed to Petitioners.

G. Construction

EBMUD will review, comment and approve the Petitioners critical contractor submittals and schedules for the Tunnel Crossing Zone.

1) Within the Tunnel Crossing Zone, Petitioners will maintain instrumentation and a monitoring program of groundwater levels, all three Mokelumne Aqueduct pipelines and structural supports and settlement monuments for Woodward Island levees and the ground surface elevations, including the EBMUD Delta Tunnel, if applicable.

2) Petitioners will select a suitable TBM design appropriate for the ground conditions.

3) Petitioners will engage qualified and experienced contractors, with contractor selection to be based on a best value procurement approach.

4) Petitioners will utilize ground improvement to pre-treat and stabilize the ground in the tunnel zone of influence prior to excavation by TBM.

5) Petitioners will implement tight quality controls and monitoring during construction per industry practice.

6) Petitioners will implement appropriate levels of full-time construction inspection.

7) Petitioners will use tailskin grout and secondary grout during tunnelling to fill voids and/or densify the loosened ground conditions to prevent the upward migration of settlement.

8) Petitioners will require continuous excavation through the zone of influence of the Twin Tunnels beneath the Tunnel Crossing Zone without stoppages or any intervention locations.

9) In the event that voids occur due to ground loss from tunnelling, Petitioners will employ compensation grouting to fill voids and/or consolidate the adjacent ground to mitigate potential ground settlement or the formation of sinkholes at the ground surface that might impact the existing Mokelumne Aqueducts, the proposed EBMUD Delta Tunnel, and/or impact the integrity of the Twin Tunnels.

10) Petitioners will coordinate with EBMUD to establish a set of protective measures and monitoring to address potential power transmission line effects where the Project's temporary transmission lines cross the existing Mokelumne Aqueducts steel pipelines. These measures will provide protection for AC induced interference and electrocution hazards resulting from downed power lines. Petitioners will implement this condition only during the construction period for the Twin Tunnels.

11) Petitioners will coordinate construction activities with EBMUD operations and the construction of the proposed EBMUD Delta Tunnel, if applicable.

H. <u>Damages</u>

Upon written notice from EBMUD describing damages to facilities in reasonable detail, Petitioners shall promptly work with EBMUD to determine cause of damages. Petitioners and EBMUD will determine reasonable compensation if damages are determined to have been caused by Petitioners activities, in accordance with terms set forth below.

During the period of construction for the Twin Tunnels Project, there shall be a rebuttable presumption that any damage or disruption to EBMUD facilities, including the existing

Mokelumne Aqueduct(s) or to the proposed Delta Tunnel, within the Tunnel Crossing Zone, was caused by the Twin Tunnels construction activities. Compensation for damage or disruption to EBMUD facilities such as the existing Mokelumne Aqueduct(s) including associated pipes, supports, levees, roads or to the proposed Delta Tunnel will include:

1) Actual Damages:

Actual Damages include all costs that EBUMD can quantify, direct and indirect, such as:

a. Direct costs:

i. Damage assessment

ii. Design of repairs

iii. Repair of damage to Mokelumne Aqueducts, pipelines and structural supports

iv. Repair of damage to Mokelumne Aqueducts Delta Tunnel, if applicable

v. Repair of levees, access road, etc. as needed to maintain safe access to the aqueducts

vi. Documentation of damage and cost-tracking

vii. Third-party liability.

b. Indirect costs:

i. Start-up of standby or mothball treatment plants including O&M labor, equipment and materials to clean, test, repair and start up the plant(s)

ii. Increased cost for treatment and residuals for alternative water supply, such as increased chemical, power, sludge handling, O&M labour

iii. Increased transmission costs associated with using alternative water supply, including differential costs for pumping of raw and treated water

iv. Lost water revenue due to decreased water sales, if there is a significant delay between the time of damage to EBMUD's facilities and Petitioners' delivery of replacement water pursuant to Section 2, below.

v. Public communications and outreach

vi. Crisis management costs including labor

vii. Post-repair monitoring

2) Lost Water:

Petitioners commit to replace any loss to EBMUD water supply caused by Petitioners' construction activities associated with implementation of the Project's Twin Tunnels, at no cost to EBMUD. Provision of replacement water in no way diminishes the required compensation for direct and indirect damages as described above. Those damages may depend upon many factors, including the timing, location and quality of the replacement water provided by Petitioners.

VII. CONCLUSION

The Mokelumne Aqueducts are the vital link between EBMUD's metropolitan service area and its Mokelumne River water supply. The Petitioners' proposed Twin Tunnels Project would pass directly underneath the Mokelumne Aqueducts on Woodward Island, thereby causing the potential impacts to the Mokelumne Aqueducts and EBMUD's planned Delta Tunnel explained in this testimony. EBMUD proposes Conditions A through H to avoid or mitigate these potential impacts.

Executed this 30th day of August, 2016 in Oakland, California.

XAVIER IRIAS

APPENDIX A

List of Figures

Testimony of Xavier Irias

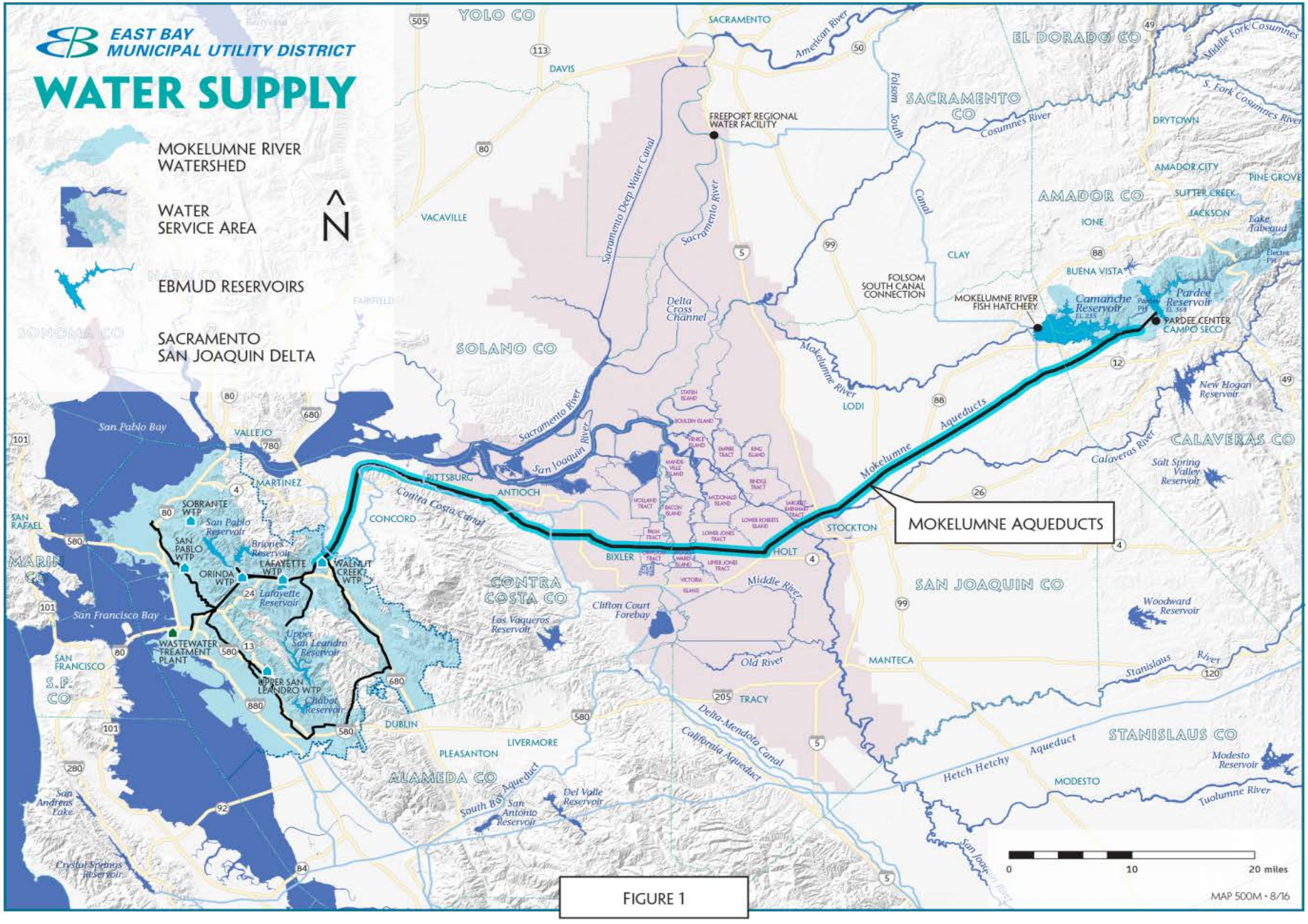

EAST BAY MUNICIPAL UTILITY DISTRICT
WATER SUPPLY
MOKELUMNE RIVER WATERSHED
WATER SERVICE AREA
EBMUD RESERVOIRS
SACRAMENTO SAN JOAQUIN DELTA
N
MOKELUMNE AQUEDUCTS
FREEPORT REGIONAL WATER FACILITY
FOLSOM SOUTH CANAL CONNECTION
MOKELUMNE RIVER FISH HATCHERY
PARDEE CENTER CAMPO SECO
Camanche Reservoir
Pardee Reservoir
New Hogan Reservoir
Salt Spring Valley Reservoir
Lake Tabeaud
Woodward Reservoir
Modesto Reservoir
San Pablo Reservoir
Briones Reservoir
Lafayette Reservoir
Upper San Leandro Reservoir
Chabot Reservoir
Los Vaqueros Reservoir
Clifton Court Forebay
Del Valle Reservoir
San Antonio Reservoir
Crystal Springs Reservoir
San Andreas Lake
SOBRANTE WTP
ORINDA WTP
LAFAYETTE WTP
WALNUT CREEK WTP
UPPER SAN LEANDRO WTP
WASTEWATER TREATMENT PLANT
SACRAMENTO
YOLO CO
SOLANO CO
CONTRA COSTA CO
ALAMEDA CO
SAN JOAQUIN CO
STANISLAUS CO
CALAVERAS CO
AMADOR CO
EL DORADO CO
SACRAMENTO CO
MARIN CO
S.F. CO
DAVIS
VACAVILLE
FAIRFIELD
VALLEJO
MARTINEZ
PITTSBURG
ANTIOCH
CONCORD
SAN RAFAEL
SAN FRANCISCO
DUBLIN
PLEASANTON
LIVERMORE
TRACY
MANTECA
STOCKTON
LODI
HOLT
BIXLER
CLAY
IONE
BUENA VISTA
JACKSON
SUTTER CREEK
AMADOR CITY
PINE GROVE
DRYTOWN
MODESTO
San Pablo Bay
San Francisco Bay
Delta Cross Channel
Sacramento Deep Water Canal
Sacramento River
San Joaquin River
Contra Costa Canal
Middle River
Old River
Delta-Mendota Canal
California Aqueduct
South Bay Aqueduct
Hetch Hetchy Aqueduct
Mokelumne River
Calaveras River
Stanislaus River
Tuolumne River
San Joaquin River
American River
Middle Fork Cosumnes
S. Fork Cosumnes River
Cosumnes River
Folsom South Canal
0
10
20 miles
MAP 500M • 8/16

FIGURE 1

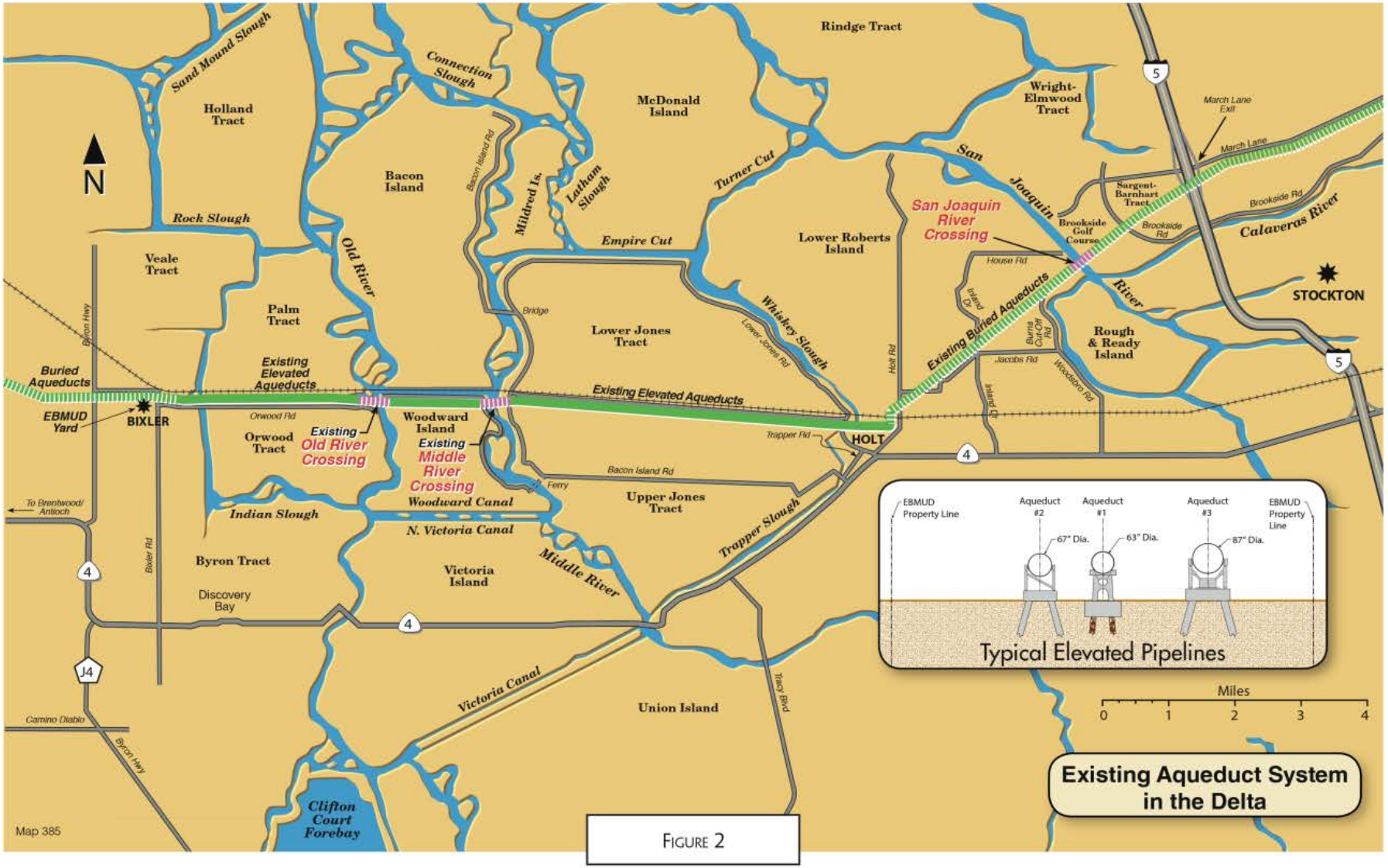
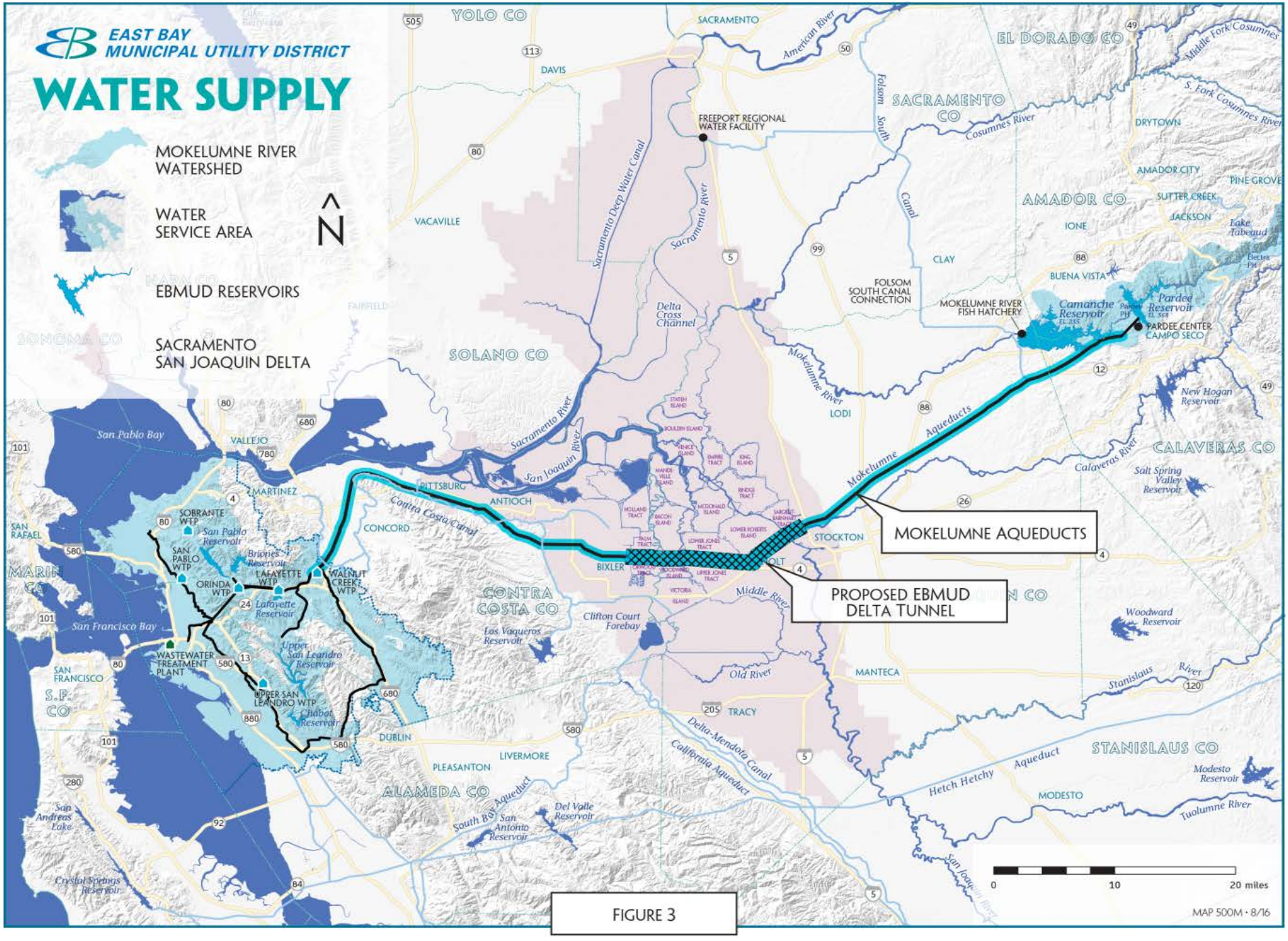

Rindge Tract
Sand Mound Slough
Connection Slough
Holland Tract
McDonald Island
Wright-Elmwood Tract
March Lane Exit
March Lane
N
Bacon Island
Bacon Island Rd
Mildred Is.
Latham Slough
Turner Cut
San Joaquin
Sargent-Barnhart Tract
Brookside Rd
Calaveras River
Rock Slough
San Joaquin River Crossing
Brookside Golf Course
Empire Cut
Lower Roberts Island
House Rd
Veale Tract
Old River
Bridge
Whiskey Slough
Lower Jones Rd
Inland Dr
Burns Cut-Off Rd
River
STOCKTON
Palm Tract
Lower Jones Tract
Holt Rd
Existing Buried Aqueducts
Rough & Ready Island
Byron Hwy
Buried Aqueducts
Existing Elevated Aqueducts
Jacobs Rd
Woodsboro Rd
Inland Dr
Existing Elevated Aqueducts
EBMUD Yard
BIXLER
Orwood Rd
Existing Old River Crossing
Woodward Island
Existing Middle River Crossing
Orwood Tract
Trapper Rd
HOLT
Bacon Island Rd
Ferry
To Brentwood/ Antioch
Indian Slough
Woodward Canal
N. Victoria Canal
Upper Jones Tract
Trapper Slough
Byron Tract
Victoria Island
Middle River
Discovery Bay
Bixler Rd
J4
Victoria Canal
Union Island
Tracy Blvd
Camino Diablo
Byron Hwy
Clifton Court Forebay
Map 385
EBMUD Property Line
Aqueduct #2
Aqueduct #1
Aqueduct #3
EBMUD Property Line
67" Dia.
63" Dia.
87" Dia.
Typical Elevated Pipelines
Miles
0 1 2 3 4
Existing Aqueduct System in the Delta

FIGURE 2


EAST BAY MUNICIPAL UTILITY DISTRICT
WATER SUPPLY
MOKELUMNE RIVER WATERSHED
WATER SERVICE AREA
EBMUD RESERVOIRS
SACRAMENTO SAN JOAQUIN DELTA
N
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FOLSOM SOUTH CANAL CONNECTION
MOKELUMNE RIVER FISH HATCHERY
PARDEE CENTER CAMPO SECO
Pardee Reservoir
Camanche Reservoir
New Hogan Reservoir
Salt Spring Valley Reservoir
Lake Tabeaud
Woodward Reservoir
Modesto Reservoir
Los Vaqueros Reservoir
Clifton Court Forebay
San Pablo Reservoir
Briones Reservoir
Lafayette Reservoir
Upper San Leandro Reservoir
Chabot Reservoir
San Antonio Reservoir
Del Valle Reservoir
San Andreas Lake
Crystal Springs Reservoir
SOBRANTE WTP
SAN PABLO WTP
ORINDA WTP
LAFAYETTE WTP
WALNUT CREEK WTP
UPPER SAN LEANDRO WTP
WASTEWATER TREATMENT PLANT
Contra Costa Canal
Sacramento Deep Water Canal
Delta Cross Channel
Folsom South Canal
Mokelumne Aqueducts
California Aqueduct
Delta-Mendota Canal
South Bay Aqueduct
Hetch Hetchy Aqueduct
Tuolumne River
Stanislaus River
Middle River
Old River
San Joaquin River
Sacramento River
Calaveras River
Cosumnes River
American River
Middle Fork Cosumnes
S. Fork Cosumnes River
Mokelumne River
YOLO CO
SOLANO CO
CONTRA COSTA CO
ALAMEDA CO
SAN F. CO
MARIN CO
SONOMA CO
SACRAMENTO CO
EL DORADO CO
AMADOR CO
CALAVERAS CO
STANISLAUS CO
SACRAMENTO
DAVIS
VACAVILLE
FAIRFIELD
VALLEJO
MARTINEZ
PITTSBURG
ANTIOCH
CONCORD
SAN RAFAEL
SAN FRANCISCO
DUBLIN
PLEASANTON
LIVERMORE
TRACY
MANTECA
STOCKTON
LODI
CLAY
IONE
BUENA VISTA
DRYTOWN
AMADOR CITY
PINE GROVE
SUTTER CREEK
JACKSON
MODESTO
BIXLER
San Pablo Bay
San Francisco Bay
0
10
20 miles
MAP 500M • 8/16

FIGURE 3

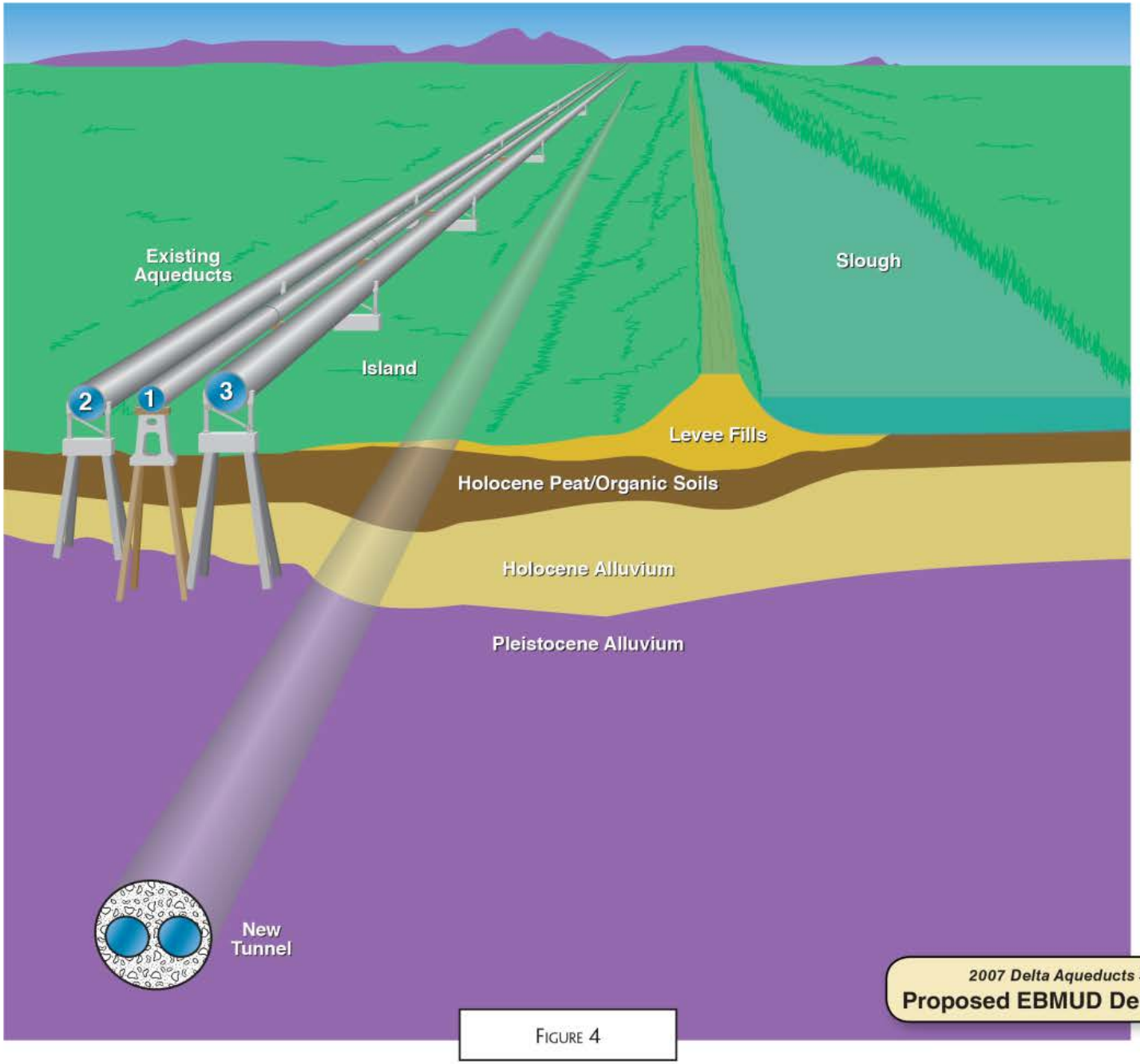

Existing Aqueducts
Island
Slough
2
1
3
Levee Fills
Holocene Peat/Organic Soils
Holocene Alluvium
Pleistocene Alluvium
New Tunnel
2007 Delta Aqueducts Study
Proposed EBMUD Delta Tunnel

FIGURE 4

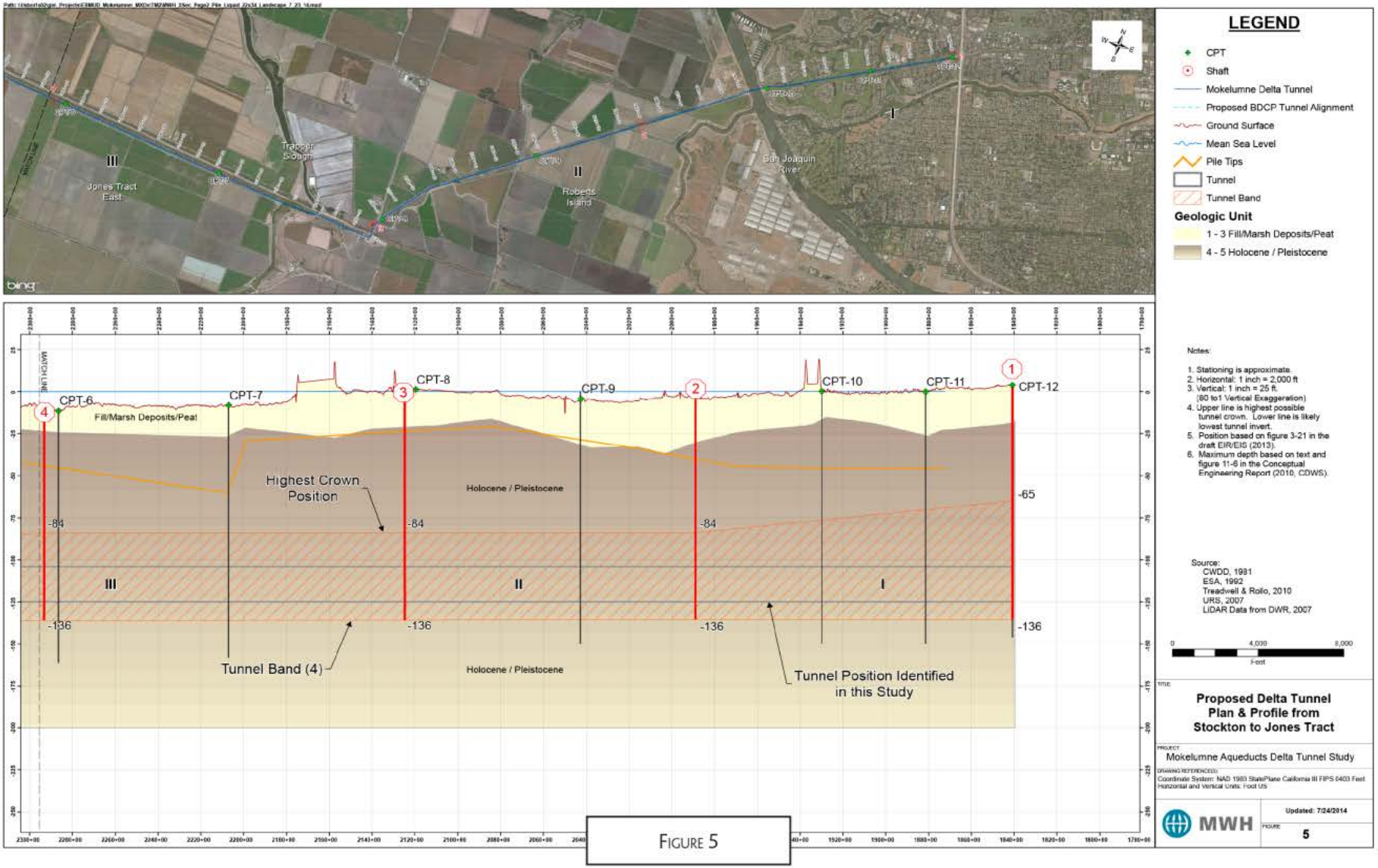

LEGEND
CPT
Shaft
Mokelumne Delta Tunnel
Proposed BDCP Tunnel Alignment
Ground Surface
Mean Sea Level
Pile Tips
Tunnel
Tunnel Band
Geologic Unit
1 - 3 Fill/Marsh Deposits/Peat
4 - 5 Holocene / Pleistocene
Notes:
1. Stationing is approximate.
2. Horizontal: 1 inch = 2,000 ft
3. Vertical: 1 inch = 25 ft. (80 to1 Vertical Exaggeration)
4. Upper line is highest possible tunnel crown. Lower line is likely lowest tunnel invert.
5. Position based on figure 3-21 in the draft EIR/EIS (2013).
6. Maximum depth based on text and figure 11-6 in the Conceptual Engineering Report (2010, CDWS).
Source:
CWDD, 1981
ESA, 1992
Treadwell & Rollo, 2010
URS, 2007
LIDAR Data from DWR, 2007
Feet
Proposed Delta Tunnel Plan & Profile from Stockton to Jones Tract
Mokelumne Aqueducts Delta Tunnel Study
Updated: 7/24/2014
5
Jones Tract East
Tractor Slough
Roberts Island
San Joaquin River
bing
CPT-6
CPT-7
CPT-8
CPT-9
CPT-10
CPT-11
CPT-12
Fill/Marsh Deposits/Peat
Highest Crown Position
Holocene / Pleistocene
-84
-65
-136
Tunnel Band (4)
Tunnel Position Identified in this Study
III
II
I

FIGURE 5

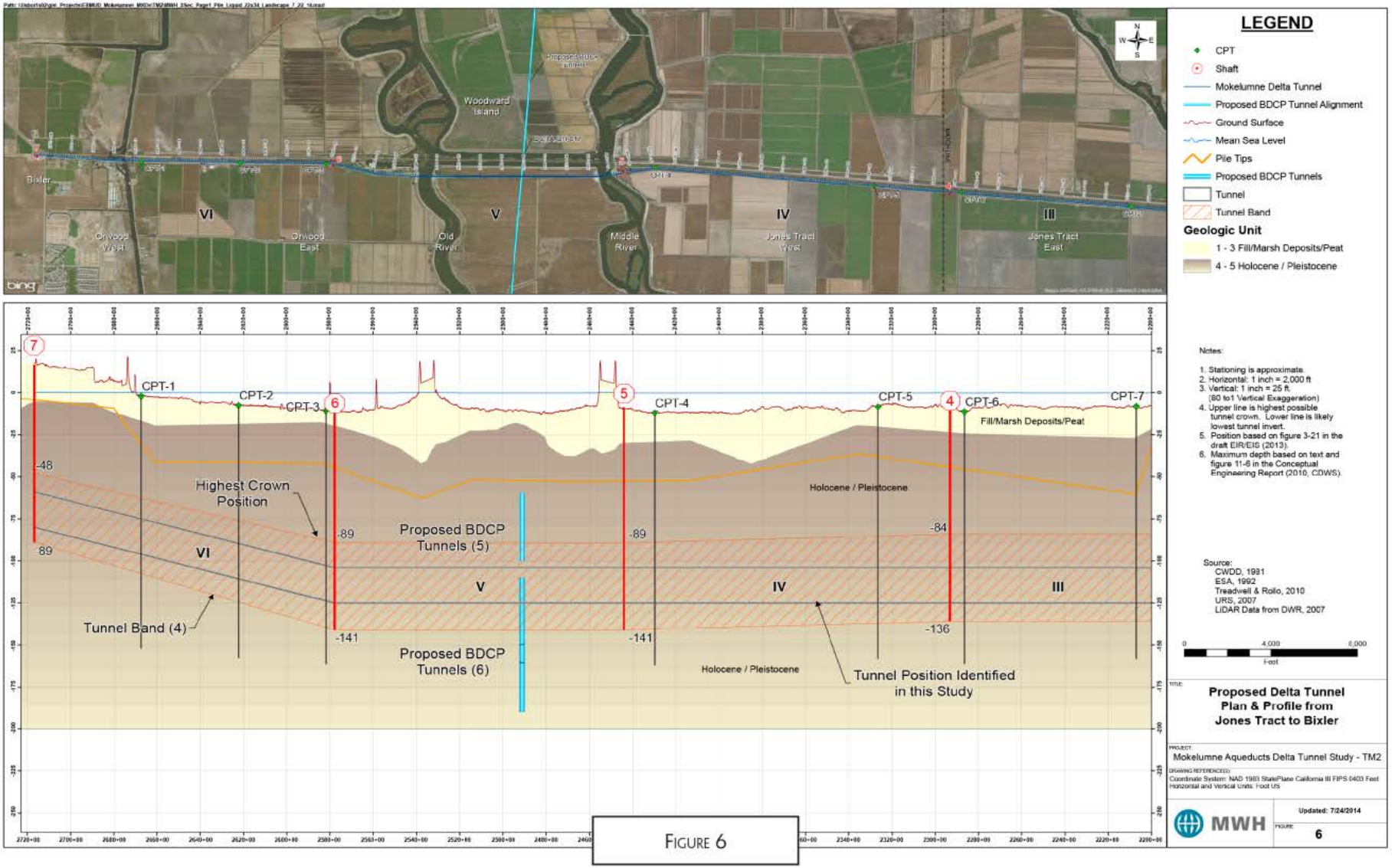

Bixler
Orwood West
Orwood East
Old River
Woodward Island
Middle River
Jones Tract West
Jones Tract East
VI
V
IV
III
LEGEND
CPT
Shaft
Mokelumne Delta Tunnel
Proposed BDCP Tunnel Alignment
Ground Surface
Mean Sea Level
Pile Tips
Proposed BDCP Tunnels
Tunnel
Tunnel Band
Geologic Unit
1 - 3 Fill/Marsh Deposits/Peat
4 - 5 Holocene / Pleistocene
Notes:
1. Stationing is approximate.
2. Horizontal: 1 inch = 2,000 ft
3. Vertical: 1 inch = 25 ft.
(80 to1 Vertical Exaggeration)
4. Upper line is highest possible tunnel crown. Lower line is likely lowest tunnel invert.
5. Position based on figure 3-21 in the draft EIR/EIS (2013).
6. Maximum depth based on text and figure 11-6 in the Conceptual Engineering Report (2010, CDWS).
Source:
CWDD, 1981
ESA, 1992
Treadwell & Rollo, 2010
URS, 2007
LIDAR Data from DWR, 2007
0
4,000
8,000
Feet
CPT-1
CPT-2
CPT-3
CPT-4
CPT-5
CPT-6
CPT-7
Fill/Marsh Deposits/Peat
Holocene / Pleistocene
-48
-89
-89
-89
-84
-141
-141
-136
Highest Crown Position
Proposed BDCP Tunnels (5)
Proposed BDCP Tunnels (6)
Tunnel Band (4)
Tunnel Position Identified in this Study
Proposed Delta Tunnel Plan & Profile from Jones Tract to Bixler
Mokelumne Aqueducts Delta Tunnel Study - TM2
MWH
Updated: 7/24/2014
6

FIGURE 6

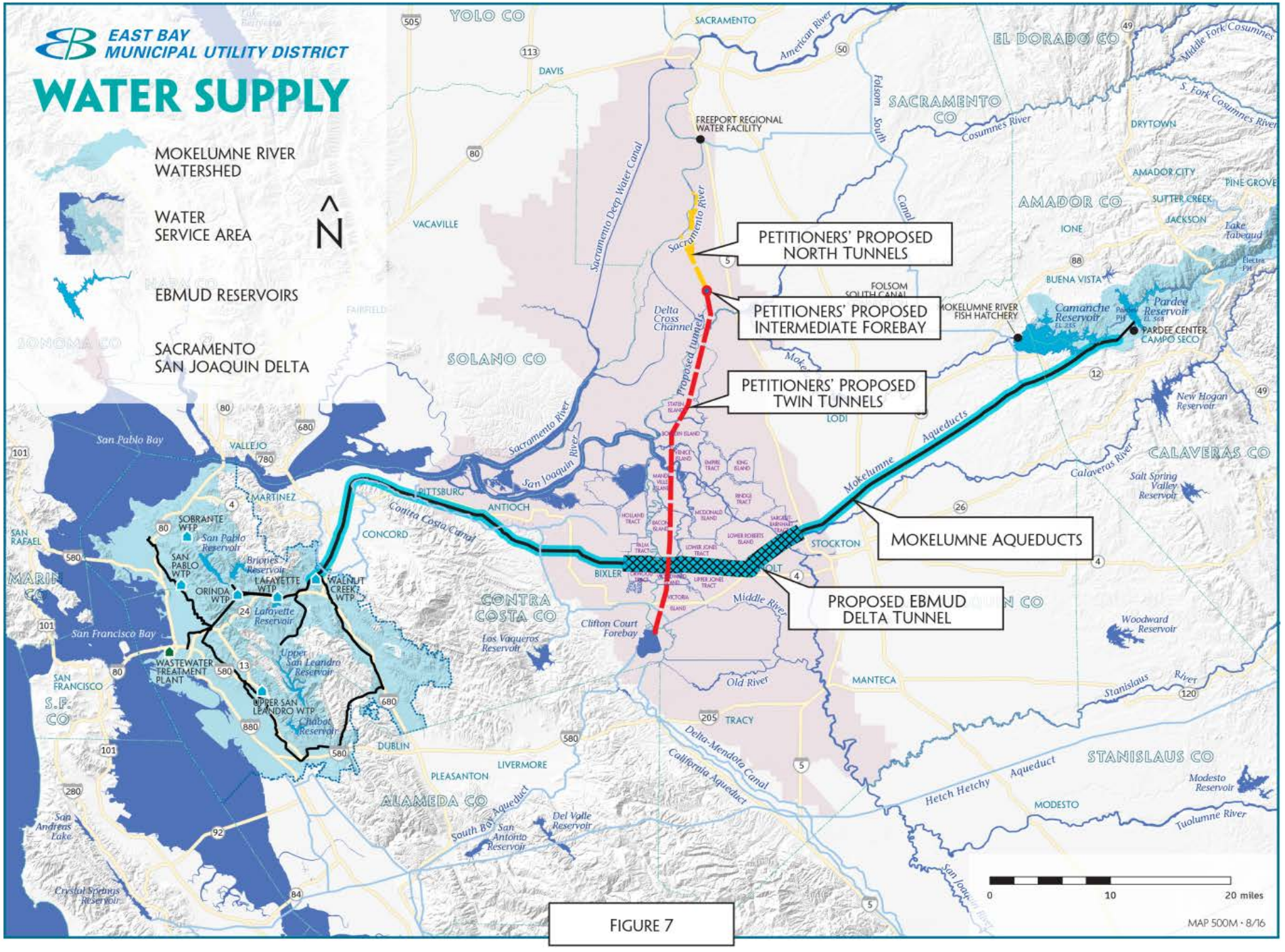

EAST BAY MUNICIPAL UTILITY DISTRICT
WATER SUPPLY
MOKELUMNE RIVER WATERSHED
WATER SERVICE AREA
EBMUD RESERVOIRS
SACRAMENTO SAN JOAQUIN DELTA
N
PETITIONERS' PROPOSED NORTH TUNNELS
PETITIONERS' PROPOSED INTERMEDIATE FOREBAY
PETITIONERS' PROPOSED TWIN TUNNELS
MOKELUMNE AQUEDUCTS
PROPOSED EBMUD DELTA TUNNEL
FREEPORT REGIONAL WATER FACILITY
Sacramento Deep Water Canal
Delta Cross Channel
Proposed Tunnels
Clifton Court Forebay
Contra Costa Canal
Mokelumne Aqueducts
Pardee Reservoir
Camanche Reservoir
PARDEE CENTER
CAMPO SECO
MOKELUMNE RIVER FISH HATCHERY
New Hogan Reservoir
Salt Spring Valley Reservoir
Woodward Reservoir
Los Vaqueros Reservoir
Upper San Leandro Reservoir
Lafayette Reservoir
San Pablo Reservoir
Briones Reservoir
Chabot Reservoir
Del Valle Reservoir
San Antonio Reservoir
San Andreas Lake
Crystal Springs Reservoir
Modesto Reservoir
Delta-Mendota Canal
California Aqueduct
South Bay Aqueduct
Hetch Hetchy Aqueduct
SOLANO CO
CONTRA COSTA CO
ALAMEDA CO
SACRAMENTO CO
AMADOR CO
CALAVERAS CO
STANISLAUS CO
EL DORADO CO
YOLO CO
SONOMA CO
MARIN CO
S.F. CO
SAN FRANCISCO
SAN RAFAEL
VALLEJO
MARTINEZ
PITTSBURG
ANTIOCH
CONCORD
BIXLER
STOCKTON
LODI
MANTECA
TRACY
DUBLIN
LIVERMORE
PLEASANTON
MODESTO
DAVIS
VACAVILLE
FAIRFIELD
SACRAMENTO
DRYTOWN
AMADOR CITY
PINE GROVE
SUTTER CREEK
JACKSON
IONE
BUENA VISTA
FOLSOM SOUTH CANAL
San Pablo Bay
San Francisco Bay
SOBRANTE WTP
SAN PABLO WTP
ORINDA WTP
LAFAYETTE WTP
WALNUT CREEK WTP
WASTEWATER TREATMENT PLANT
UPPER SAN LEANDRO WTP
0
10
20 miles
MAP 500M - 8/16

FIGURE 7

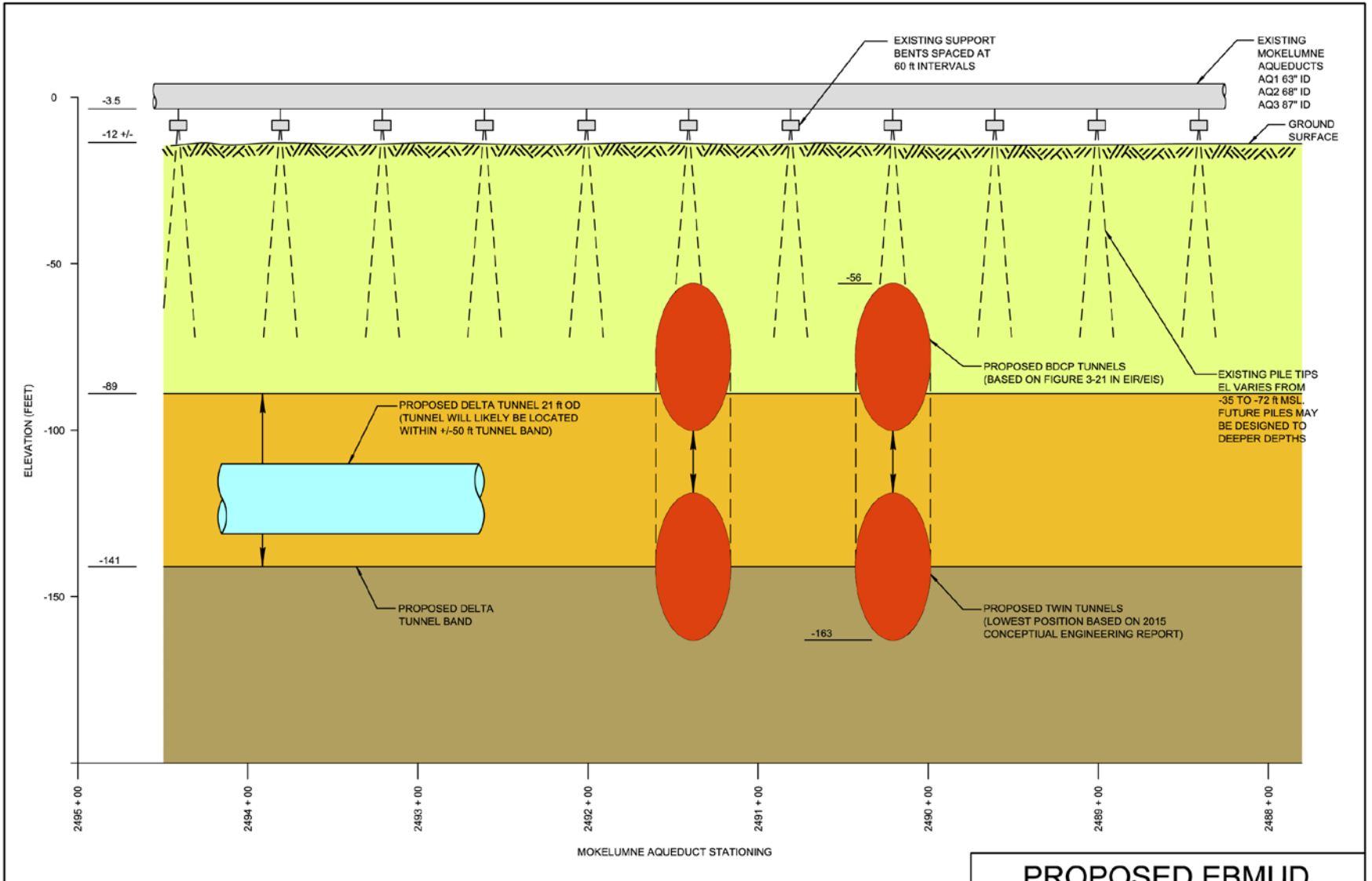

EXISTING SUPPORT BENTS SPACED AT 60 ft INTERVALS
EXISTING MOKELUMNE AQUEDUCTS AQ1 63" ID AQ2 68" ID AQ3 87" ID
GROUND SURFACE
0
-3.5
-12 +/-
-50
-56
-89
-100
-141
-150
-163
ELEVATION (FEET)
PROPOSED BDCP TUNNELS (BASED ON FIGURE 3-21 IN EIR/EIS)
EXISTING PILE TIPS EL VARIES FROM -35 TO -72 ft MSL FUTURE PILES MAY BE DESIGNED TO DEEPER DEPTHS
PROPOSED DELTA TUNNEL 21 ft OD (TUNNEL WILL LIKELY BE LOCATED WITHIN +/-50 ft TUNNEL BAND)
PROPOSED DELTA TUNNEL BAND
PROPOSED TWIN TUNNELS (LOWEST POSITION BASED ON 2015 CONCEPTIUAL ENGINEERING REPORT)
2495 + 00
2494 + 00
2493 + 00
2492 + 00
2491 + 00
2490 + 00
2489 + 00
2488 + 00
MOKELUMNE AQUEDUCT STATIONING
PROPOSED EBMUD DELTA TUNNEL PROFILE

FIGURE 8

APPENDIX B

Photographs

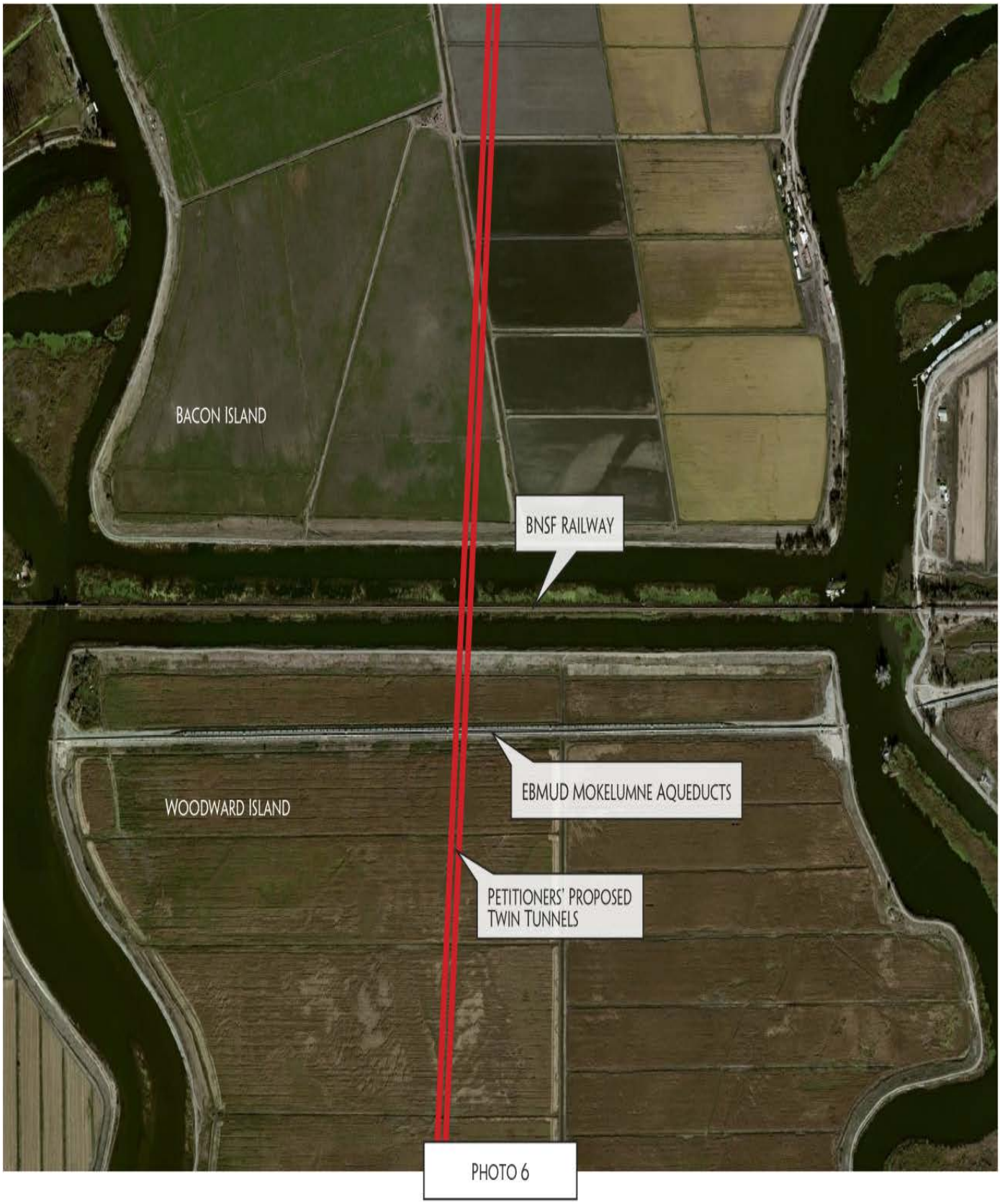
PHOTO 1

PHOTO 2

PHOTO 3

PHOTO 4

PHOTO 5


BACON ISLAND
BNSF RAILWAY
EBMUD MOKELUMNE AQUEDUCTS
WOODWARD ISLAND
PETITIONERS' PROPOSED TWIN TUNNELS
PHOTO 6