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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 WATERFIX	**TESTIMONY OF MICHAEL MACHADO**

I, Michael Machado, a board member with Restore the Delta, do hereby declare:

INTRODUCTION

1. I earned a bachelor's degree in economics from Stanford University and a master's degree in agricultural economics from the University of California, Davis. For many years, I have owned and operated P & M Farms, a diversified Central Valley family farming corporation based in Linden (San Joaquin County), which has been in my family for three generations spanning over 100 years. Our farm possesses riparian pre-1914, and post-1914 water rights. In 1988 I attended Harvard Agribusiness School in London, England. I subsequently served three terms in the California State Assembly between 1994 and 2000 representing the 17th district, and two terms in the California State Senate between 2001 and 2008 representing the 5th district. From 2010 to 2013, I served as executive director of the Delta Protection Commission (DPC), where among my duties I implemented direction from the Delta Legislative Package of 2009 for the commission to prepare and implement a Delta Economic Sustainability Plan (DESP). (Public Resources Code [PRC] Section 29759.)

SUMMARY

2. I address the following issue prompts for Part 1 of the evidentiary hearing from the Notice of Petition and Public Hearing, dated October 30, 2015, concerning the petition to change points of diversion and rediversion concerning the California WaterFix project:

a. Will the proposed changes cause injury to any municipal, industrial or agricultural uses of water, including associated legal users of water?

b. Will the proposed changes in points of diversion alter water flows in a manner that causes injury to municipal, industrial, or agricultural uses of water?

c. Will the proposed changes in points of diversion alter water quality in a manner that causes injury to municipal, industrial, or agricultural uses of water?

3. The 2011 DESP studied impacts of salinity changes that would result from flow and water quality alterations that were known in broad terms at the time the Plan was prepared. My testimony will summarize the study methodology and describe its results.

RELATIONSHIP OF THE DESP TO THE CHANGE PETITION

4. Nearly all water right holders in the Delta are either farmers irrigating crops or owners of recreation and tourism enterprises, diverting and using water from Delta channels to benefit their businesses. Water flow and quality alterations are expected from the Petition facilities. My testimony summarizes how the DESP examined the economic impact of changes to salinity in the Delta and what impacts would be expected from such changes. Its findings are relevant to SWRCB's evaluation of the Petition. Injury is measurable at a broad scale through economic analysis of the biophysical changes wrought by changes in flow and salinity conditions. These conditions feedback through economic and irrigation decisions that farmers must make at the field level. Every irrigation season, they decide whether and how much to use irrigation water from Delta channels on their crops.

5. The Delta Protection Commission retained Dr. Jeffrey Michael, an economist with the University of the Pacific's Eberhardt School of Business, to prepare the DESP. Among the DESP's goals, the plan was to model effects on Delta agriculture of water policy proposals affecting salinity.

AGRICULTURAL ECONOMIC BACKGROUND OF THE DELTA

6. This section of my testimony summarizes the geography of Delta agriculture.

7. Close to eighty (80) percent of all Delta farmland is categorized as prime farmland according to California Farmland Mapping and Monitoring Program. (RTD-301, p. 107, and Figure 20, p. 112) In 2010, total cropped acreage covered 423,727 acres, not including 38,000 acres of grazing land. The top five Delta crops in terms of acreage in 2010 were corn, alfalfa, processing tomatoes, wheat, and wine grapes. The top five crops in 2010 in terms of value were processing tomatoes, wine grapes, corn, alfalfa, and asparagus. Total direct crop value in 2010 came to $702 million, with truck and vineyard crops combining for 59 percent of this value. The highest per-acre crop values come from truck crops mainly in the south Delta and from deciduous crops in the north Delta. Animal production in the Delta came to about $93 million in 2010. (RTD-301, p. 107.)

8. The DESP mapped the agricultural crop pattern of the Legal Delta based on publicly available 2009 crop data. Appendix G of the DESP defines the broad crop categories used in its

economic analysis of agriculture. (RTD-301, Appendix G, p. G-5) Field and grain crops were concentrated along the corridors of the Cache Slough complex, Ryer Island, the lower Sacramento River south of Isleton, the vicinity of Georgiana Slough and the Mokelumne River, the mainstem San Joaquin River, and the Old and Middle River corridors. These crops also occur in small pockets from the northern end of the Delta along the Sacramento Deep Water Ship Channel to the southern end in the corridors of Victoria and Grant Line canals almost to Vernalis. (RTD-301, p. 113, Figure 21.)

9. Deciduous and vineyard crops were concentrated in the north Delta from north of Clarksburg along the Sacramento River, past Walnut Grove to nearly Isleton. These crops occur along Elk, Sutter, and Steamboat Sloughs, as well as occurring on the east side of the Sacramento River from south of Hood to areas just east of Walnut Grove. A few parcels of vineyard and deciduous crops dot agricultural lands southwest of Stockton. (RTD-301, *Id.*)

10. Truck crops are varied and numerous, and include such crops as artichoke, asparagus, lima beans, tomatoes, peppers, celery, cucumber, eggplant, berries, beets, sweet corn, garlic and herbs, turnips, melons, lettuce and chard, onion, carrots, peas, potatoes, and squashes. (RTD-305, Appendix G, p. G-5, Table G-3.) Truck crops were concentrated in the south Delta, with pockets along Steamboat Slough, Georgiana Slough, Terminous, Bouldin, McDonald, and King Islands, Rindge Tract, Victoria, Union, and Roberts Islands, and along Fabian Tract. (RTD-301, p. 113, Figure 21.)

11. Pasture lands for animal grazing typified western Delta islands (for example, Bradford, Jersey, and Holland tracts, as well as in the northern lands north and west of the Cache Slough complex and in the southwestern vicinity of Clifton Court Forebay. (RTD-301, *Id.*)

Delta agricultural revenues came to $702.4 million based on 2009 acreage, according to the DESP. (RTD-301, p. 114, Table 9.) The spatial distribution of crop revenues per acre was mapped in the DESP. Higher revenue-per-acre fields (those with $801 per acre and above) are found throughout the legal Delta, but are concentrated along the mainstem Sacramento River from Freeport to Isleton, as well as in eastern Delta lands from north and east of Walnut Grove to Stockton. Such higher revenue fields are also interspersed throughout the south Delta where truck crops are grown. Lower revenue-

per-acre fields (generally coinciding with field, grain, and pasture crops) are found along the Sacramento Deep Water Ship Channel and the Cache Slough complex (interspersed with higher revenue-per-acre vineyards), as well as on Staten Island between the Mokelumne River and Georgiana Slough; Bouldin, Venice and King Islands; and Empire and Rindge Tracts. Much of the south Delta area also shows many lower revenue-per-acre field and grain crops among the higher revenue truck crops. This crop pattern in the south Delta reflects in part the contingency of salinity conditions in south Delta river, slough, and canal channels. Neither truck nor field crops entail permanent investments the way deciduous and vineyard crops do, and switching between such crops can provide south Delta farmers with some revenue stability while controlling for other input costs of planting and cultivating. By contrast, in the north Delta, prevailing salinity conditions in the recent past are generally fresher than in the south, allowing north Delta farmers to invest in higher revenue-per-acre permanent crops like deciduous and vineyard crops, especially along the Sacramento River and Elk, Sutter, and Steamboat Slough areas. (RTD-301, Figure 22.)

12. The importance and impact of Delta agriculture goes beyond the local economy. The DESP states that "the four most significant crops in the Delta—alfalfa, corn, processing tomatoes, and wine grapes—are supporting a significant value-added chain in the region and state." (RTD-301, p. 117.) Linkages between the Delta's key crops and other economic sectors from animal production to the food processing of tomato canning and wine production are accounted for in the DESP to arrive at the Delta's wider economic impact.

13. Delta agriculture's direct economic effects (not including food processing effects) on the five Delta counties in 2009 included 4,132 jobs, $146.7 million in labor income, $361.7 million in total value added, and about $816 million in total output in the Delta region. The total effect of Delta agriculture, including its indirect and induced effects, includes 9,600 jobs and $1.4 billion in total output. (RTD-301, p. 120, Table 13.) The Delta's impact on California (not including effects on food processing) represented 12,900 jobs and total output of $1.64 billion in 2009. (RTD-301, p. 120, Table 14.)

14. When the Delta's linkages include the food processing sector of the region's five counties and California were factored in, Delta agriculture's regional impact supports nearly 13,200

jobs, $594 million in labor income, over $1 billion in value added to products, and total output in the region of $2.65 billion. (RTD-301, p. 121, Table 15.) This represents about $200,859 of total output per Delta farm job in the Delta region.

15. Its linkages into California's economy mean that Delta agriculture supports over 25,000 jobs statewide, $1.25 billion in labor income (nearly $50,000 on average per job that year), $2.1 billion in value added to the state's products, and in all, total output contributed to the state's economy of $5.4 billion. (RTD-301, p. 121, Table 16.) Such indirect and induced output and jobs employ workers as varied as machinists repairing and making agricultural equipment and vehicles, seasonally-hired food processing workers in plants throughout the Delta region, and truck drivers hauling raw crops and finished products to market.

METHOD OF MODELING CROP PATTERNS IN THE DELTA

16. Farmers choose to plant crops (or not) based on a number of factors. These can include: anticipated market demand for the crop, access to transportation routes for efficient delivery to market, soil conditions, underlying land value, potential for conversion of their land to urban or other use than agriculture, irrigation water availability, and irrigation water quality. The geographic pattern of crops in the Legal Delta in 2010 reflects many of these factors. The DESP reported that Delta farmers monitor salinity levels closely in their current operations and that some already incur costs in chemicals and drainage systems to deal with current levels of salinity. (RTD-301, p. 127.)

17. Dr. Michael employed in the DESP a multinomial logit (MNL) model to estimate farmers' crop choice at the field level in the Delta. He described in the DESP how such a model, and related models, has wide usage in professional economic analysis. One of the model's developers, economist Daniel McFadden at the University of California, Berkeley, was awarded the Nobel Prize for these methods in 2000. Dr. Michael notes that MNL model methods have been used previously to study irrigation technology choices and crop management practices. He applied an MNL approach to Delta crop patterns in relation to urbanization potential as a method to estimate or predict future Delta crop patterns given regional urbanization pressure on the Delta land market. The model predicted that urbanization will reduce agricultural production in the Delta due to the loss of 26,625 acres of land to urban uses. (RTD-301, p. 123, Table 17.) Some farm land where probability of

urbanization was considered high or very high were confined to the western and southeastern peripheries of the Legal Delta, including Bethel Island, Bishop and Shima tracts, Stewart Tract, an area due west of French Camp and Lathrop, and around the northern periphery of the city of Tracy. A few parcels in the north Delta were also identified to have very high probability of urbanizing, but are small in size, and dispersed from each other. (RTD-301, p. 124, Figure 23.)

18. While taking account of potential farmland conversions to urban use, the DESP states that urbanization pressure can also offer opportunities for agricultural entrepreneurs, particularly for vineyard, fresh vegetables, and nursery products, as well as agri-tourism at the urban fringe. (RTD-301, pp. 122-126.) Dr. Michael's use of MNL model methodology found that urbanization and the increased income it can bring to the region can stimulate planting and cultivation of high value crops in the Delta's future. With such stimulus from regional urbanization, there would be an estimated $111 million increase in total agricultural revenue, assuming current crop acreage and average crop class revenue from 2009 prices (which were already $702 million in 2009). But accounting for urban pressure, the model predicted a decrease of $43 million in direct Delta crop values relative to the "baseline" model scenario in which no lands converted to urban uses. Future net crop revenue growth factoring in urbanization was estimated at a net positive $68 million. (RTD-301, p. 125, Table 19.)

IMPACTS OF SALINITY CHANGES IN THE SOUTH DELTA

19. Turning to salinity impacts, the DESP reported that the MNL model found salinity to have a statistically significant impact on crop choice in the Delta. (RTD-301, p. 130.) Dr. Michael's modeling effort used salinity data from over 50 sites in the Delta region, and focused on salinity effects during the irrigation season of May through August, when sensitive crops are most vulnerable to salinity changes in irrigation supplies. Salinity values were mapped to each individual crop field by using averaged salinity measurements across all measurement stations within a three-mile radius of each crop field. If there were no measurement stations within that radius, then the nearest station's measurements were used for that crop field. Salinity data were obtained from the Interagency Ecological Program and the California Data Exchange Center. (RTD-301, pp. 129-130, including Figure 24; RTD-305, Appendix G, pp. G-6 to G-9.)

20. The DESP summarized nine years of salinity conditions in Delta waters by Bay Delta Conservation Plan (BDCP) conservation zone. (RTD-305, Appendix G, p. G-6.) Conditions are generally fresher in the north Delta, with higher average electrical conductivities in the south Delta. Averaging the data for the irrigation season has unfortunately masked spikes in the salinity data that may occur during years when the average is considerably lower. The data set also contained salinity conditions for six dry years out of nine. On average, the south Delta experiences significantly higher salinity levels and more variability than do north Delta channels. This is due in part to significant ambient differences in water quality, presence of reverse flows along Old and Middle rivers due to State Water Project pumped diversions, and flow conditions on the Sacramento and San Joaquin Rivers, as well as to climatic and hydrologic conditions. (RTD-301, p. 130.)

21. The DESP also provided background analysis of salinity issues as known in 2011. On one hand, Phase 1 of SWRCB's Bay-Delta Estuary WQCP was proposing to increase salinity objectives at interior south Delta channel monitoring locations from 700 to 1000 µS/liter EC[1] (at San Joaquin River at Brandt Bridge, Old River at Middle River, and Old River at Tracy Boulevard Bridge) as well as San Joaquin River at Vernalis during the irrigation season (April through August).[2] This Phase 1 proposal by SWRCB would increase salinity objectives, and likely salinity concentrations, in south Delta channels by as much as 40 to 42 percent. (RTD-301, p. 126.) On the other hand was a conceptual proposal from the BDCP for isolated conveyance around or under the Delta. (RTD-301, *Id.*) At the time the DESP was completed and adopted, neither the tunnels facilities of the BDCP (announced by the state in 2012) nor California WaterFix (announced in 2015) had yet been formally proposed. Consequently, the DESP considered an "isolated conveyance" proposal which, like the Petition facilities, was described as dual conveyance.

22. In either case, however, broad salinity changes in the Delta would be similar. The Phase 1 changes to the WQCP focus on increasing San Joaquin River inflow while simultaneously relaxing salinity objectives for the River and its distributaries Old and Middle Rivers. In the case of

[1] The units of µS/liter EC are translated as microSiemens per liter for electrical conductivity.

[2] The rest of the year, SWRCB proposed increasing the salinity objective from 1000 to 1400 µS/liter EC at these same monitoring stations during the rest of the year. This is not pertinent to the salinity impact analysis, however, which focuses on the May through August irrigation season.

isolated conveyance, fresh water from the Sacramento River would be subtracted during the irrigation season upstream of the Delta Cross Channel near Walnut Grove. Its absence would be filled by more flows from the San Joaquin River bypassing Banks and Jones pumping plants and more tidal flows reaching other Delta channels from San Francisco Bay. (SWRCB-3, Appendix B.4.2, pp. B-191 to B-256; RTD-130, pp. 60-61, Figure 5.) While salinity concentrations in north Delta channels are also likely to increase as a result of isolated conveyance diversions, baseline salinity levels were lower there. (RTD-301, Appendix G, page G-6.) The MNL model work done by Dr. Michael focused on south Delta channels where existing salinity conditions were already higher.

23. The DESP focused on south Delta crop fields within BDCP conservation zones 6 through 9 since they contain south, west and central Delta channels directly affected by both San Joaquin River and tidal flows. These zones were selected for use in establishing percentage increases in salinity for fields in these zones. (RTD-301, p. 130, Figure 25.) The DESP acknowledges that "salinity would not increase uniformly across the region, and future simulations of the model with more spatially precise estimates of salinity changes could generate more accurate and detailed results." (RTD-301, p. 130.)

24. In addressing salinity changes, the MNL model predicted a large shift from high-value truck and vineyard crops to lower-value grain and pasture crops should salinity levels rise in the south Delta. (RTD-301, p. 131, Table 20, and p. 132.) These shifts would reflect choices by south Delta farmers to plant more salt-tolerant crops as salinity conditions worsened under either or both scenarios (that is, should isolated conveyance be operated and/or salinity objectives relaxed significantly). The model does not estimate any potential impacts from yield declines as salinity increases. (RTD-301, p. 132.)

25. The model estimated an 18 percent decrease in truck crop revenue for a 25 percent rise in salinity, as well as a 33.4 percent decrease in truck crop revenue for a 50 percent rise in salinity. Doubling salinity in the south Delta would result in an estimated 57.3 percent decrease in truck crop revenue, and for a 200 percent increase in salinity, an 83 percent drop in estimated truck crop revenue. Similar decreases were estimated by the model for south Delta deciduous and vineyard crops. (RTD-301, p. 131, Table 20; RTD-304, p. 1.)

26. That analysis does not account for loss of 5,404 acres of agricultural land in the Delta (1,495 acres temporarily and 3,909 acres permanently) due to construction and alignment of the Tunnels project. (SWRCB-3, p. 4.3.10-1:22-26.) Relative to $231 million in 2010 crop revenue in the south Delta, a 25 percent increase in salinity on average would result in a $24 million decrease in crop value, as field, grain and pasture crop acreage were predicted by the model to increase at the expense of deciduous, truck and vineyard crops, which are less salt-tolerant. (RTD-301, p. 131, Table 20, columns c and h.) Agricultural land losses at an average crop revenue per acre of $1,651 would result in about $8.9 million losses annually.

27. The 25 percent salinity increase scenario on average would cost Delta counties (not including the food processing sector) an estimated $32.8 million in lost crop revenue, 389 total Delta region jobs, and over 519 jobs statewide. (RTD-304, p. 2.) A 50 percent increase in salinity on average would cause crop losses valued at about $54 million, loss of about 640 total jobs in Delta counties, and 857 jobs statewide. (Id.) The method used to generate these job loss estimates excludes impacts to the region's food processing sector, since food processors can take action to mitigate losses of direct Delta inputs to their production. In addition, the shift to grain and field crops (which are more salt-tolerant) results in production that is less labor-intensive (that is, these crops do not create as many jobs per unit output) than orchard, vineyard, or truck crops.

28. Should salinity concentrations double (a 100 percent rise), the DESP estimates would cost south Delta farmers nearly $89 million, more than a one-third reduction in crop values and land loss due to salinity impacts and tunnels construction and operation, exclusive of food processing. (RTD-301, p. 131, columns e and j; RTD-304, p. 2.) This would trigger an estimated loss of 1,053 total jobs in Delta counties and about 1,406 jobs statewide. (Id.) Tripling salinity concentrations (a 200 percent increase), coupled with agricultural land losses, would shrink direct farm receipts in the south Delta by nearly $132 million. (RTD-301, p. 131, columns f and k.) This would trigger an estimated loss of about 1,100 total jobs in Delta counties, and nearly 2,700 jobs statewide. (RTD-304, p. 2.)

29. These estimates of crop revenue and job losses based on the DESP methodology represent broadly the magnitude of economic injury to agricultural water rights holders, and the

larger impact on total jobs in the Delta region and California that would result from changes to flow and water quality resulting from California WaterFix.

INDEPENDENT REVIEW OF THE DESP STUDY

30. The Delta Science Program of the Delta Stewardship Council was requested to perform an independent review of the Delta Economic Sustainability Plan. (RTD-302.) The review states that, based on the DESP's analysis of "isolated conveyance" and flow and salinity impacts:

> [A]n isolated conveyance to improve water-supply reliability could potentially impact the sustainability of the Delta by increasing salinity and decreasing local water availability because it will reduce through-flow of fresher Sacramento River water in the Delta. Therefore, the costs required to mitigate salinity impacts, local water supply impacts and catastrophic salt-water intrusion in the event of a large earthquake are a relevant consideration in assessing isolated conveyance.

(RTD-302, p. 2, 7.)

31. The SWRCB has determined that "protection of agriculture in the southern Delta is in the public interest" (SWRCB-21, p. 35, Section 6.3.4.2.4) and established interior south Delta salinity objectives to protect these agricultural beneficial uses. (SWRCB-21, pp. 159-160.) The Independent Review Panel noted that the existing water export system keeps salinity sufficiently low in the southern and eastern Delta to facilitate agricultural production. (RTD-302, p. 10.) The Panel further stated that the DESP "demonstrates the potential negative effects of increasing salinity levels on agricultural yields in the southern Delta." (RTD-302, p. 10.)

> Although the Sustainability Plan does not document potential changes to salinity levels arising from the operation of an isolated conveyance system, it is reasonable to assume that diversion of up to 15,000 cfs of flow from the Sacramento River (North Delta) and movement via pipelines to the Tracy pumping facilities, would alter Delta through-flows. To the extent that these alterations in flows increase south Delta salinity levels, the economic and ecosystem impacts of these alterations must be recognized, and where appropriate, mitigated. **Given that water exporters will be the primary beneficiaries of such a conveyance system, the DPC and the DSC need to ensure that the sponsors of a conveyance system fully pay for any and all Delta mitigation.**

(RTD-302, *Id.* Emphasis in original.)

32. The Independent Review Panel's charge from the Delta Science Program included question 9, which asked: "Is the multinomial logit model a methodologically sound approach for estimating the impacts of water policy proposals on Delta agriculture and/or on environmental

change, such as salinity, on crop choice and production?" The Panel affirmed that the MNL was a sound approach:

> We commend the authors for using this approach. A multinomial logit (MNL) is a standard, recognized method in the extant literature for problems with discrete, limited dependent variables. However, the authors' discussion of key assumptions and procedures is too brief. For example, in the main text, the authors suggest that the MNL is a conditional MNL, where the conditional is on the current land use (pg 123). More detail of this assumption and its impact would be helpful in the Appendix.

(RTD-302, p. 14.)

33. Dr. Michael and I responded by letter to Dr. Clifford N. Dahm, lead scientist of the Delta Science Program, regarding the Independent Review Panel's report in December 2011. The Panel's report identified six "limitations" of the DESP, but none of the Panel's stated limitations applied to the MNL modeling and the Plan's analysis of salinity impacts of isolated conveyance on crop choice in the Delta. Dr. Michael and I stated to Dr. Dahm that, "[t]he ESP shows that salinity significantly impacts Delta agriculture even at recently observed levels of water quality. It is a myth that Delta water quality standards can be weakened and an isolated conveyance introduced without negative impacts on Delta agriculture." (RTD-303, p. 2.)

SUMMARY OF DIRECT ANSWERS TO SWRCB PETITION PROMPTS

34. As I understand the matters I have addressed herein, I answer to the State Water Board's hearing prompts as follows:

35. *Will the proposed changes cause injury to any municipal, industrial or agricultural uses of water, including associated legal users of water?* Yes, removal of fresh Sacramento River water at new intakes in the north Delta can reasonably be expected to injure agricultural uses of water in the Delta, including those diverting and using water directly from Delta channels to irrigate crops.

36. *Will the proposed changes in points of diversion alter water flows in a manner that causes injury to municipal, industrial, or agricultural uses of water?* Yes, new points of diversion will alter water flows in a manner that causes injury to agricultural uses of water, particularly in the south Delta. The Delta Economic Sustainability Plan analyzed impacts reflecting changes in salinity

to Delta farmers' crop choices based on a broad change in flows that would trigger salinity increases of varying levels.

37. *Will the proposed changes in points of diversion alter water quality in a manner that causes injury to municipal, industrial, or agricultural uses of water?* Yes, the new points of diversion will alter water quality by increasing salinity generally in Delta channels in a manner that will injure agricultural uses of water. The DESP analysis of salinity impacts estimates that for a 25 percent salinity increase, the loss of direct crop revenues would amount to nearly $33 million a year, about 166 direct Delta farm jobs, and about 389 total jobs in Delta counties. (RTD-304, p. 2.) For a 50 percent increase in salinity, crop revenue foregone was estimated to exceed $54 million, about 274 direct Delta farm jobs, and about 640 total jobs to Delta counties. Doubling salinity levels in Delta channels would result in nearly $89 million in foregone crop revenues, about 450 direct Delta farm jobs, and over 1,050 total jobs in Delta counties. Finally, tripling salinity in Delta channels (an increase of 200 percent) would cause an estimated $132 million in lost crop revenue, about 670 Delta farm jobs, and nearly 1,570 total jobs in Delta counties. (RTD-304, p. 2.)

38. Thank you for the opportunity to submit this testimony on the agricultural impacts of flow and water quality alterations posed by this Petition for Change on California WaterFix.

Dated: August 29, 2016

Michael Machado