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RECLAMATION DISTRICT 999,
RECLAMATION DISTRICT 2060,
RECLAMATION DISTRICT 2068,
RECLAMATION DISTRICT 407,
RECLAMATION DISTRICT 317,
RECLAMATION DISTRICT 551,
RECLAMATION DISTRICT 105,
RECLAMATION DISTRICT 563,
RECLAMATION DISTRICT 2067, and
RECLAMATION DISTRICT 2098,

BEFORE THE CALIFORNIA STATE WATER RESOURCE CONTROL BOARD

In the matter of 2016 SWRCB Hearing re CalWaterFix Petition for Change	**TESTIMONY OF GILBERT COSIO, JR.**

BACKGROUND AND QUALIFICATIONS

1. My name is Gilbert Cosio, Jr. I am a registered civil engineer in California (No. 36308). I specialize in the areas of hydrology, hydraulics, levee rehabilitation and maintenance, irrigation, drainage, project management, and related areas. I joined MBK Engineers (MBK) in 1984 and have been a Principal since 1990. MBK specializes in water rights, water supply, flood control and water resource planning. MBK provides these services for cities, counties, state agencies, federal agencies, irrigation districts, flood control agencies, individual landowners, and other entities. Exhibit DGCG-2 is a true and correct copy of my professional resume.

2. I have been providing expertise in this area for over 32 years throughout the Central Valley. During that time, I have developed a broad range of knowledge in the field of levee rehabilitation and maintenance. In the Sacramento – San Joaquin Delta (Delta), I am currently the district engineer for 33 reclamation districts. I have also, the past, been district engineer for an additional 13 reclamation districts. Exhibit DFCG-3 is a list of reclamation districts for which I have served as district engineer. Exhibit DFCG-4 is a map highlighting the locations of my experience as district engineer for Delta reclamation districts.

3. As district engineer, I am responsible for all aspects of levee rehabilitation and maintenance, and drainage of district lands. Duties relative to levee rehabilitation include, but are not limited to, surveys and cost estimates, coordination of geotechnical exploration and development of design parameters, compilation of plans and specifications, construction inspection and contract administration, environmental documentation and regulatory approval. Levee maintenance responsibilities include, but are not limited to, levee inspections, monitoring of problem areas, development of encroachment standards, development of maintenance plans, periodic levee surveys, coordinating floodfighting and levee repairs, and environmental documentation and regulatory approval.

OVERVIEW OF TESTIMONY

4. In preparation for this testimony, I have reviewed and relied on three main documents; the Water Fix Conceptual Engineering Report Final Draft, July 2015 (Exhibit DWR 212), the Water Fix 401 permit application package to the Corps of Engineers (Public Notice

SPK-2008-00861), and relevant portions of the 2015 WaterFix RDEIR/SDEIS (Exhibit SWRCB 3) Construction Assumptions for Water Conveyance Facilities (Appendix 3C), Alternative 4A maps, and portions of several chapters covering issues addressed in testimonty). I have also reviewed the written testimonies of DWR witnesses John Bednarski (Exhibit DWR-57) and Parviz Nader-Tehrani (Exhibit DWR-66).

5. My testimony will focus on the effects of the California Water Fix (WaterFix) project's design and operation, and impacts of that construction on the ability of reclamation districts to perform their duties related to maintaining levee integrity (routine operation and maintenance), as well as the function of the system of drainage and irrigation ditches and canals on individual Delta islands.

6. Ground motion impacts anticipated to affect the stability and operation of levees and drainage systems throughout the WaterFix vicinity include intense and prolonged ground vibrations from extensive pile driving combined with a significant increase in daily volumes of heavy construction trucks. Several obstructions will also encroach into multiple waterways, narrowing the channels, reducing the flood flow capacities throughout Project area and altering the flow velocity and direction at all flow levels.

OVERVIEW OF DELTA ENGINEERING PRACTICES

7. Dealing with Delta levees and drainage issues tends to be more complicated than other regions of the Central Valley due to the unique soil types, shallow groundwater, and varying materials used to construct levees. Due to the unique characteristics of the area, engineering structures in the Delta can only be understood from years of experience of construction in the Delta. The unique circumstances complicating engineering, design and construction in the Delta are the result of a number of factors such as organic levee and foundation materials, lands subsided below the adjacent waterways and water table, uncompacted levee materials such as loose sands, inconsistency of levee materials, and seepage from adjacent waterways.

8. Many of the levees in the WaterFix project area were constructed to U. S. Army Corps of Engineer (USACE) standards as part of the Sacramento River Flood Control Project, and have not been improved since then. In accordance with assurances that the State gave to the

federal government, the repair and maintenance of these project levees must be to USACE standards.

CONDITIONS IN NORTH DELTA

9. The levees of the North Delta in particular are predominately constructed of loose sand. The material used to build existing levees was dredged from the local channels and placed on the original natural levees of the Sacramento River floodway. These natural levees were formed as the heaviest material of the sediment load carried downstream during floods dropped out of the floodwater depositing along the original stream bank. As a result, the foundation supporting the loose sand levee material is porous, consisting of material that can be even more porous than the loose sand levees. In addition to the obvious propensity of these materials to seep, the levee and foundation are also susceptible to consolidation and instability when experiencing changes in water levels within the levee section.

10. Another condition that must be considered when designing and constructing structures near Delta levees is that they also contain a myriad of other materials such as silts, clays and organics. These materials appear as differing strata in the levee section. The existence of these varying materials in a predominately sandy levee can create unexpected problems miles away that must also be considered when constructing facilities on and around levees in the North Delta.

11. The levee and foundation materials in the North Delta make it very difficult, if not impossible, to predict how they will react under loading because sometimes the complexities associated with these levees defy standard engineering logic and practice, which are designed for simpler situations. In the absence of extensive local knowledge, levee design and construction based on generally acceptable engineering practices can lead to levee failure.

12. During my many years working on Delta levees, I have encountered numerous instances of this phenomenon. These levee impacts include, but are not limited to, separation of differing soil strata, densification of materials, instability due to dewatering, movement of material during loading, deep underground seepage sources, internal cracking, differential settlement, instability caused by changes in water surface levels, impacts due to channel flow

velocity and direction, and changes in levee equilibrium. I will describe in more detail how levee stability has been compromised when local projects have failed to properly account for some of the unique and unpredictable characteristics of Delta levees.

IMPACTS TO RECLAMATION DISTRICTS, LEVEES, AND CHANNELS

13. As previously stated, the predominant fill material in the upper portion of the North Delta levees consists of sand and silts dredged from the river channels. The levee foundation typically consists of sands, silts and gravels. However, since most of the Delta was originally swamp and overflow land, these levees also contain a considerable amount of organic clays and peats.

14. In Mr. Bednarski's testimony, he characterizes the levees of the North Delta as "in place and stable for decades." However, because levees are comprised of natural materials that always have water against them, they are constantly subjected to changing forces affecting their stability.

15. When surrounding conditions are not changing, the levees are not necessarily stable, but have reached a state of equilibrium with the forces placed upon them. Any change in the forces acting on the levee will cause the levee to be out of equilibrium, and likely result in levee damage or channel migration that could undermine the levee stability.

16. The degree to which these levees are affected by changing conditions depends on the duration and severity of these external forces. Therefore, Delta levees as they exist today are better characterized as being in equilibrium with the forces currently acting upon them; but could change in an instant if the current condition of the levees is subjected to the intense and prolonged disturbances described in WaterFix documents that I have reviewed.

18. According to the Alt. 4A RDEIR/SDEIS maps that I reviewed, the physical impacts to levees and farmlands on several Delta islands will be significant. Based on the description of construction activities I have read, implementation of the WaterFix project will substantially interfere with and hinder the ability of reclamation districts to perform routine inspection and maintenance of levees and drainage systems during the entire 14-year construction period.

19. Construction of three new intakes will impact flood control and farming operations on three reclamation districts (RD 744 south of Scribner Road, RD 813 Erheardt Club, and RD 551 Pearson District). Based on my review of maps for Alt. 4A, it appears that Intake #2 will take up approximately one-third of the acreage in RD 744. RD 813 is where Intake #5 will be located, with Intake #3 also adjacent to its northern border and a tunnel shaft installed at its southern boundary. A portion of Intake #5 will also cross over into RD 551 at Randall Island Road, as well as a barge loading facility built on 200 feet of its Sacramento River project levee (about 1,400 feet north of Twin Cities Road), and the Intermediate Forebay constructed across from the Snodgrass Slough levee at the southeast end of the island.

20. RD 1002 will have to deal with construction related impacts such as pile driving as well as increased seepage of levees and farmlands associated with having the new Intermediate Forebay and barge loading facility located on their Snodgrass Slough levee, plus five large muck storage areas placed throughout the district.

21. RD 150 and RD 999 will also experience erosion from changes in flow velocities, seepage from altered surface water elevations, flow velocity and direction, and intense ground shaking from pile driving associated with construction of three intakes across from their project levees on the Sacramento River.

22. Several islands throughout the Delta will also have to deal with impacts to levees and operations associated with construction of approximately a dozen shaft locations placed about every three miles of the twin tunnel alignment. Reclamation Districts 38, 756, 2023, 2028, 2040, and 2110 all will also have one or more shafts constructed on their islands.

23. According to the Recreation Chapter 15 of the RDEIR/SDEIS, there will be a total of eight barge loading facilities located throughout the Delta. All of these require construction of cofferdams and will encroach into the waterways for the entire 14-year construction period. Any loss of flood flow capacity from the narrowing of channels designed to carry flood flows can result in increased surface water elevations. These barge loading facilities will also alter the flow velocity and direction during all levels of flow which will lead to levee erosion.

24. In addition to RD 551 and RD 1002, reclamation districts 756, 2023, 2028, 2040,

and Kings Island will have barge facilities built on their levees, plus another at Clifton Court that is across from the Kings Island levee. The distance that each of these facilities encroaches into the waterway impacts flows varies by location. The barge facility on Pearson District (RD 551) will occupy about 200 feet of their Sacramento River project levee, and extend approximately 130 feet into the river, leaving less than 100 feet for navigation and flood flows in that location. About 185 feet of a Glanville Tract (RD 1002) levee on Snodgrass Slough will be occupied by a barge facility that will extend approximately 135 feet into the channel, leaving about 50 feet for navigation and flood flows. Bouldin Island (RD 756) will have about 980 feet of its Little Potato Slough levee occupied by barge facility extending approximately 210 feet into the channel, which allows nearly 700 feet for passage of boats and flood flows. Venice Island (RD 2023) will have a barge facility occupy about 928 feet of its San Joaquin River levee on a wide bend on the south side of the island where the channel is more than 2,000 feet wide. Bacon Island (RD 2028) will have about 665 feet of its levee on Connection Slough extend approximately 250 feet into the channel, leaving about 150 feet for passage of boats and flood flows due to a small remnant island located in the middle of the channel.

RISKS TO DELTA LEVEE STABILITY

25. Recently, two DWR flood protection programs, the Non-Urban Levees Evaluation (NULE) and the Flood System Repair Project (FSRP) have identified 106 sites in the North Delta that levees are in need of improvement or repair. The recommended repairs are either to control seepage or to repair erosion. The sites have been described as “serious” or “critical” in the FSRP. Thirty-five (35) of these sites are along the main stem of the Sacramento River in the region where WaterFix intakes are proposed to be constructed.

26. Levees typically breach due to levee problems associated with stability, seepage, erosion, and overtopping. Levees in the Delta are particularly susceptible to breaches caused by water overtopping the levee and eroding the landside slope to the point of failure; from water seeping through the levee foundation, which is much more difficult to identify; and piping problems created by industrious burrowing animals, such as beavers and squirrels, building dens and mazes inside levees. Preventing overtopping is the easiest to recognize, prepare for, and

repair. If there are uncertainties regarding base flood elevations when designing a project, or concern about wave action during flood water surface elevations, additional levee height, commonly known as freeboard, can be added prior to project construction to account for these uncertainties. Preventing water from seeping through the levee, by contrast, is harder to prevent or account for in design.

27. In my experience, forces placed on the levees by a project such as WaterFix will increase the likelihood of levee failure under all four scenarios (stability, seepage, erosion, and overtopping), including undetectable erosion and piping damage to levees that may not be apparent until the levee is on the brink of, or is experiencing, a failure.

28. In my experience in the Delta, I have seen many things happen that defy standard engineering theory and practice that should be considered prior to completing design of the WaterFix facilities and included as mitigation requirements in permits issued by state and federal agencies. In my opinion, the WaterFix project has underestimated the scope and severity of potential impacts to levees and flood flows, and will therefore need to expand the number of levees that are actively evaluated, monitored, and mitigated for prior to and during construction. Following are local levee conditions that provide insight into the type of circumstances and impacts that I anticipate may occur during construction of the WaterFix project:

- Recently, the City of Stockton built a new water diversion pumping plant on a levee along the San Joaquin River. In order to build the plant, Stockton had to build a new levee behind the existing levee. Although standard geotechnical practice determined the new levee would be quite stable, it did not consider the issues that would be associated with rapid construction on the soft soils prevalent in the Delta. As a result, the levee almost failed when the immediate forces of fill placement pushed the foundation landward 13-feet in less than about two weeks. In one day alone, it moved 3.5-feet.
- Several years ago a subdivision was under construction in Contra Costa County. The developer was required to construct a levee, and that work involved densification of the foundation. This densification process produced ground vibrations similar to pile driving. Approximately 3 miles from the project a sandy levee experienced consolidation and the foundation of two structures on the levee cracked due to the vibrations. In addition, the project construction area experienced an increase in the number of beaver dens, which often occur in areas where the beaver can find fractures in a levee that are easier to penetrate, compared to levees that are uniformly compacted and more resistant to their industrious digging. In my experience, the combined effects of densification and

pile driving create opportunities for interior levee cracking, which substantially increases the likelihood of levee failure.

- In the North Delta, seepage is a major concern due to the sand and gravel levee foundation. For years on Grand Island we monitored a particular seepage site that would be wet during high water and dry up after the water went down. In 2006, during what has been described as a 10-year flood, the seepage forces caused water to flow with such intensity that the water was expressed as an artesian flow shooting about 6-inches in the air landward of the levee toe. After the river receded, artesian flow did not stop, saturating the soils to the point that the ground in the area became unfarmable. The only recourse was to acquire an easement from the landowner and build a large and expensive seepage berm to permanently control the seepage. What happened to knock this area out of historic equilibrium is unknown and could not be predicted.
- Due to the differing soil types in Delta levees, these soil types sometimes separate due to vibration, or intensified saturation. This separation does not express itself at the surface until it reaches the point that a sinkhole develops as soil moves to fill the voids caused by the separation. During 2006 flood, we had one day when unusual high winds came out of the southeast. The wave fetch from these wind caused tremendous erosion that had to be repaired by the Corps of Engineers under the PL84-99. Up until that unusual wind direction changed the equilibrium on the levee, we had not experienced erosion during the high flows alone. But the change in forces acting upon the levee changed the equilibrium that maintained the levee in a particular configuration. When the forces changed, the levee changed as well.
- Changes in water table levels have caused subsidence and cracking of levees throughout the Delta. This cracking occurs both on the surface and within the interior of the levee structure.

29. In my professional opinion and experience, I anticipate similar conditions and circumstances to be exacerbated in the North Delta due to the numerous impacts to levees and flows associated with the construction of the Water Fix project.

PILE DRIVING IMPACTS ON LEVEES

30. According to the pile driving assumptions in Table 3C-2 of the 2015 RDEIR/SDEIS Appendix 3C, the construction of Water Fix will involve installation of a tremendous number of piles at several different construction sites, including the three new intakes and sedimentation basins, new Intermediate Forebay, and barge loading facilities in the North Delta (9,650 piles in the North Delta, with a total of 8,830,000 strikes). These piles will be driven close to the levees and other local structures. The piles will consist of either pole type piles or sheet piles. The piles will be driven by impact hammers or vibratory hammers. Both of these pile

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driving methods produce vibrations that travel a considerable distance that will impact levees and properties throughout a large area of the North Delta. For instance, the project in Contra Costa County described above caused levee settlement and damaged a building foundation approximately three miles from the source of the construction ground vibrations.

31. Because the levees in the North Delta consist of various sand and gravels which were either part of the original "natural" levee or dredged from the channels to raise and widen the natural levee, these loose sands tend to settle and densify when they are vibrated. As a result, when vibrations occur in the area of the Water Fix construction, the material will densify, causing the levee to consolidate and lower in elevation (settle and subside). During the densification, the slopes of the levee could also become unstable and slide on either the waterside or landside of the levees and potentially lead to a breach.

32. Much of the deformation caused by vibration due to pile driving will be on the interior of the levee and not visible at the surface. Failed levee slopes and lowered levee crowns can be measured; however, within the levee section itself, deformation may occur that cannot be seen or measured. Within these loose sands, strata of organics or clay materials exist. These materials tend to fracture as the sand densifies and consolidates. These fractures would remain as cracks within the levee section. If these cracks occur during a time of low water, and remain unseen when the water rises during the winter, a seepage path develops through the cracks. This seepage path could lead to water running through the levee at a velocity high enough to move sand and cause damage and failure to the levee. This phenomenon is call piping, or interior erosion.

33. During the non-flood months, typically the spring, summer and fall seasons, the water table is just above mean sea level along the levees of the Sacramento River. In the winter months, the issues related to vibrations of the levees will change because during flood periods, the water surface elevations in the Delta increase substantially, often by about 20 feet. The vibrations of saturated levees will cause pore pressures of the saturated area to increase as the sand attempts to densify, which eventually leads to liquefaction. The increase of the water table in the loose-sand levee, and the resulting liquefaction, could cause a fracturing, or failure, of the levee during

work caused by pile driving vibrations, similar to failure caused by seismic vibrations from an earthquake. During construction these problems will be very difficult, if not impossible, to identify, which will be an even bigger problem if reclamation districts are unable to access portions of their levees to conduct inspections and perform routine maintenance due to conflicts with construction equipment and activities

34. In addition to the damage experienced by the levees, any structures on or near the levees will likely also experience damage. There are many homes, packing sheds, wineries and other farm and domestic structures on, or near, the levees in the North Delta.

35. To mitigate against seepage damage, the Water Fix design includes a slurry wall through the center of the levee. This wall can also act as a "crack stopper" which may alleviate some of the ground shaking issues noted, above. However, the pile driving vibrations will travel a considerable distance and I fully anticipate that the fracturing will occur well outside the area the Water Fix project has proposed installing cut off/slurry walls. As mentioned previously, I have seen sand densification and resulting levee and building foundation damage occur up to three miles from the source of the construction vibration.

36. In my professional opinion, the Water Fix pile construction will damage the levees and structures in the North Delta. Unfortunately, the extent and severity of this impact on Delta levees is unknown because the intensity, duration, and cumulative impacts associated with simultaneous pile driving at multiple construction sites has not been analyzed by the Project Proponents. Because much of this damage will occur within the interior of the levee, as a precautionary measure, monitoring devices that can detect levee movement and instability will need to be installed. The only measure that would probably be sufficient to prevent levee failures from intense ground shaking would be installing slurry walls on all Delta levees within 2-3 miles from locations where WaterFix construction sites involve pile-driving.

IMPACTS OF FLOODWAY OBSTRUCTIONS

37. The construction of the Water Fix project will create encroachments into several water channels that will obstruct and limit the existing capacity of floodways of the North Delta. Three construction sites that are located close together in a four mile stretch of the Sacramento

River are the intake structures and a barge loading facility that will include cofferdams jutting out into waterway. The cumulative impacts to entire flood control system in the Delta will be significant, due to the combined effects of twelve cofferdams installed during construction of the three north Delta diversion (NDD) intakes, eight barge loading facilities, and a new operable gate. Each of these facilities could, during its construction, or while it is in place, cause levee damage individually, but their combined effects will significantly increase the probability of damage and levee failure.

38. As mentioned previously, the eight cofferdams installed for the construction of barge loading facilities will narrow channels, constrict flood flows, and alter flow direction and velocity for all flow levels in the Sacramento River near Twin Cities Road, Snodgrass Slough near Walnut Grove, Potato Slough, Connection Slough in the Delta north of the San Joaquin River.

39. In the reach of the Sacramento River, adjacent to the proposed intakes, any increase in the surface elevation of water will have secondary effects. First, increased water flows during flood events will change the frequency of the levee overtopping and failure. According to the USACE report, "Sacramento-San Joaquin Delta, California Special Study: Hydrology", issued in February 1992 (Exhibit DFCG-5)[1], the flood levels in this area of the Sacramento River offer very little margin for error. The report indicates that the difference from a 50-year and 100-year flood at the Sacramento River at Snodgrass Slough (approximate location of intake number five) is only 0.5 feet. (Exhibit DFCG-5, Table 6.) Additionally, the difference between the flood elevation between the 100 and 200-year flood is approximately, 0.3 feet. (Exhibit DFCG-5, Chart 6.) In other words, any change in flood elevations will change the flood frequency. This means that, if the WaterFix project increased water stage 0.1 feet, as suggested by Dr. Nader-Tehrani's testimony, then what would have been a 200 year flood would have the effects of a 300-year flood. Thus, the obstruction of flows in the Sacramento River by the WaterFix project will increase the probability of flooding in the areas adjacent to the proposed new intakes and barge

[1] Exhibit DFCG-5 is a true and correct copy of the document.

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facilities.

40. Based on my professional experience, obstructions of any kind in Delta channels can raise the water surface elevations, and also cause secondary impacts due to the changes in flow velocities, and flow directions, causing problems upstream, downstream and across the channel from the obstruction. Impacts caused by changes in flow velocity and direction will occur at every level of flow. None of these hydraulic impacts on flood flow capacity and levee stability has been analyzed by the Water Fix project.

41. It is important to note that damages resulting from these obstructions would also have an adverse effect on landowners adjacent to levees that overtop. According to Mr. Bednarski's testimony, the WaterFix project itself has been designed to withstand a 200-year flood event. But, the actual level of protection for WaterFix structures (including the intakes) is less than 100-year flood protection because that is what the surrounding levees currently provide. I believe that it is not realistic for DWR to believe that it would be able to operate the intake structures if all of the lands immediately surrounding those structures were inundated. Using standard flood probabilities, there is a significant chance that the lands immediately adjacent to the WaterFix intake compound could be inundated within thirty years of construction, because the cumulative probability of a 100-year flood in that time exceeds 26%.

42. Although the Water Fix petition documents explain that the construction of the intakes will be limited to the levee slope, they do not acknowledge that the cofferdam and permanent intake structure will protrude approximately 100 feet water-ward of the levee crown. Based on the approximate width of these channels, that is almost 20 percent of the entire channel width. Based on the cross sectional area of the flow under the 200-year flood, we estimate that this obstruction constitutes approximately 9 percent of the flowage area. This blockage would result in an increase of flood flow water surface elevations of approximately 0.1 feet. Since the increase in water surface leads to a very small increase in cross sectional area, the velocity of the flow will increase. Since flow is the product of velocity and area, if the area is reduced, then the velocity increases proportionally.

43. Other Water Fix construction sites that will obstruct even larger portions of other

Delta channels and alter the flow of water are several barge facilities. The size and magnitude of obstruction of these features is described in the Recreation Chapter 15 of the 2015 WaterFix RDEIR/SDEIS, but not well detailed the Water Fix petition project description, even though they will cumulatively add to the impacts of flow changes.

44. The introduction of obstructions in the channel also changes the velocity of the flow and the direction of the flow. When calculating floodwater surface elevation increases, a one-dimensional model is typically used, but is limited because it disregards these changes in velocities and directions of flow. Therefore, in order to adequately analyze the impacts of the proposed WaterFix obstructions, a two-dimensional model should have been used by DWR for the change in diversion petition. Even with a two-dimensional model, it is very difficult to calculate the impacts due to these changes in flow, velocity, and direction. In addition, these obstruction produce impacts at all flow levels, adding complexity to the analysis.

45. As I noted earlier in my testimony, any change in the forces acting on a Delta levee will cause the levee to be out of equilibrium, and likely result in levee damage or channel migration that could undermine the levee stability. We have seen this occur after Corps of Engineers bank protection projects on the Sacramento.

46. In addition, a stockpile of reusable tunnel material will be placed along Snodgrass Slough on a property commonly known as Zacharias Island. Although this property is not flooded during normal tidal cycles, the levees are inadequate to keep the property from flooding during most floods. Therefore, during times of high water, this property becomes part of the Snodgrass Slough floodway. The stockpiling of the RTM will essentially reduce the capacity of the slough to carry water and affect the forces in a manner similar to the Sacramento River obstructions.

47. Floodway obstruction caused by the Water Fix project will result in erosion damage to the levees in the North Delta. We have seen these impacts occur when structures such as boat docks, pump plants, and bank protection projects have narrowed Delta channels and changed velocity and direction of flows.

DEWATERING AND SEEPAGE IMPACTS

48. Levee stability in the North Delta is significantly compromised when exposed to seepage resulting from changes in the surface water elevations, while seepage in the interior of the island is heavily influenced by changing elevations of the groundwater table. Local flood control facilities (levees, and drainage ditches/canals) and irrigation canals have reached a state of equilibrium with the current water table elevations. See page through, and under, the levees of the North Delta, and within the nearby farming areas has been well documented. Attached as Exhibit DFCG-7 is a true and correct copy of Plate 10, excerpted from DWR Bulletin 125, "Sacramento Valley Seepage Investigation" (August 1967) (Exhibit DFCG-6) [2].

49. The Water Fix RDEIR/SDEIS states that dewatering pumps will be placed up to 300-foot depth and as close as 50-foot spacing around the intake facilities, Intermediate Forebay, and other facilities. To lower the water table in order to facilitate construction, the plans indicate that slurry or sheet pile cut off walls will be installed through the levee fronting the intake facilities. .

50. However, as described in DWR Bulletin 125, the current seepage condition in this area is expansive and emanates from a very porous soil condition and shallow groundwater table that underlies the entire North Delta. Therefore, the cut off walls may not perform as designed, since seepage will originate from upstream, downstream, and landward of the cut off walls, and continually provide seepage water to the construction area without regard for a cut off wall. As a result, there will be an extremely large amount of water generated by the dewatering wells since they will be pulling water directly from the river. The Water Fix documents do not adequately address the volume of water removed on a daily basis by the dewatering pumps or the specific Delta channels that it would be discharged.

51. It appears the WaterFix RDEIR/SDEIS proposes to discharge an unknown volume of water from dewatering into existing irrigation and drainage ditches, which would inundate them. This would not only interfere and hinder the ability of reclamation districts to perform their

[2] Exhibit DFCG-6 is a true and correct copy of the document.

drainage flood control responsibilities, but would also contaminate and obstruct water supplies for farming operations in the area.

52. In addition to lowering the water table in the construction area, these wells will also lower the water table in the levee, levee foundation and underneath surrounding properties. The WaterFix RDEIR/SDEIS indicates groundwater will be lowered within a 2600-foot radius of the intake construction areas. My experience in the Delta has shown that lowering the water table, and thus disturbing the equilibrium, results in subsidence of the levee that leads to cracks that create seepage paths through the levee. This subsidence is similar to subsidence caused by over drafting of groundwater. Attached as Exhibits DFCG-8 through DFCG-10, are photos of levee cracking caused by tree roots searching for water while water surface levels were lowered during the recent drought. Exhibit DFCG-11 shows this effect on the cross-section of a levee. In addition to levee damage, structures built on the levee will likely experience damage due to the lowering of the water table as well. Also, a home near the levee in this area suffered foundation damage.

53. Operation of the Water Fix project will pull water from the Sacramento River, thus lowering the water surface for a distance downstream of the intakes. Levees are typically designed to hold back high water, so low water scenarios are generally not of concern. However, levee design requires support on the waterside of the levee. The water itself supplies this support. Although water weighs less than levee soil material, it still provides a buttressing force for the waterside slope.

54. Lowering of the low tide water surface levels as described in Mr. Nader-Tehrani's testimony affects the levee in two ways. First, it reduces the buttressing force of the water, thus making the waterside slope less stable. Secondly, the lower surface elevation exposes the lower levee slope to wind wave and boat wake forces, which represent significant forces acting on the waterside of levees.

55. Once these conditions change, the forces also change and knock the levees out of equilibrium. While it is not possible to predict exactly how the levee will respond, I am confident that a less stable levee will result when historic water surfaces are lowered; specifically, the

waterside slope becomes less stable and it fails, or slips to a point that it would need to be repaired. Significant slippage could lead to levee failure.

IMPACTS ON LEVEES FROM TRUCK TRAFFIC

56. Water Fix construction will involve running loaded trucks well in excess of both the traffic volume and vehicle weight ever seen in the Delta. The main roadways (County roads and State highways) used by these construction trucks in, out, and around the Delta are situated on top of levees.

57. The impacts to the levees caused by truck traffic will be similar to the ground shaking impacts caused by pile driving; therefore the combination of these two construction activities will intensify the impacts to levees.

58. Although superficial repairs to the surface pavement are described in the Water Fix documents and witness testimony, they are all silent regarding the impacts to the interior and slopes of the levee, which underlie and support the roads.

59. Based on my experience with impacts to levees from truck traffic while levee improvements are being constructed by reclamation districts, I anticipate that truck traffic vibrations will cause significant levee damage each year of construction that will remain unseen, and will not be repaired by simply replacing the road pavement surface. Damages to the interior of the levee from ground shaking caused by hundreds of heavy trucks parading through the Delta every day for the 14-year construction period could be disastrous when combined with pile driving vibrations if they occur during high water and generate liquefaction of the saturated sandy levee.

60. As mentioned previously, cracks from intensive ground vibrations will also produce a seepage path for water to flow through the levee and cause structural failure due to piping and movement of levee material. In other words, repair of the roadway surface as proposed by the WaterFix project mitigations will not actually address the true damage to the flood control structure underneath. The only solution to prevent water running through the levee and causing levee failure would be to install a cutoff wall through all of the levees identified as being used during WaterFix construction. Because the Project Proponents did not even address

these impacts in the WaterFix petition or RDEIR/SDEIS, a substantial amount of analysis would need to be conducted prior to construction in order to determine the number and location of cut off walls that would be necessary to mitigate for this impact. It is likely that after thorough geotechnical evaluation of the levees and damage caused by truck traffic, that numerous levees throughout the Delta will require reconstruction.

INTERFERENCE WITH WATER SUPPLY AND DRAINAGE SYSTEMS

61. Due to the unique characteristics of the Delta, groundwater and surface water are linked. Therefore, any changes in groundwater elevation, such as that produced by Water Fix dewatering activities during construction, will impact the function of local domestic water wells, and irrigation and drainage systems that have been designed with management of subsurface water elevation as a component.

62. The lands of the Delta are commonly differentiated as Delta highlands and Delta lowlands. Delta highlands are defined as land with an elevation greater than 5-feet above sea level. Delta lowlands refer to ground below 5-feet above sea level.

63. Generally, water table is typically below the root zone in the Delta highlands, so farmland is traditionally irrigated by placing water above the ground surface. Delta lowlands are quite different. The water table is shallow and often very close to infringing on the root zone. Irrigation water can therefore be supplied by allowing ditches around, and through, fields to fill with water which raises the groundwater table into the root zone. This method is commonly referred to as sub-irrigation.

64. Water Fix proposes to drop subsurface water levels in order to accommodate construction of it facilities. Water Fix estimates this drawdown of the water table will lower the subsurface water level around the intakes and Intermediate Forebay by about 10-feet in a radius of approximately 2,600 feet from the dewatering wells. However, this is merely an estimate, because there has been no analysis of the extent and severity of impacts on groundwater levels. Based on my experience, this lowering of the groundwater table will certainly have an impact on irrigation systems and residential water wells.

65. Ground subsidence will also result from lowering the surface and ground water

table during dewatering. The magnitude of land and levee subsidence will vary throughout the dewatering wells' zone of influence. This will result in uneven fields. If the fields relied on proper sloping for irrigation and drainage, they will be impacted due to this improper grading. In addition, compaction of the subsided soil will impact crop growth, especially permanent crops that have reached a state of equilibrium the existing soil compaction characteristics.

66. Although Mr. Bednarski's testimony indicates the numerous diversion intakes and ditches used for irrigation and drainage that would be disrupted and disconnected will be repaired, the ability to move water through systems that have been carefully designed to operate with the island's ground elevations may not work as effectively, thus rendering the properties unfarmable.

67. For all of the above reasons, the Water Fix project is likely to have an adverse effect on water supply and flood control in the Delta.