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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	PART 2 TESTIMONY OF THOMAS C. CANNON

I Thomas C. Cannon hereby declare:

My testimony focuses on whether the WaterFix proposed infrastructure and operation provide reasonable protections for the environment, specifically for fish and fish habitat in the Central Valley and Bay-Delta. Where protections are inadequate, I suggest reasonable further protections for fish populations and their important habitats.

WATERFIX PROPOSAL AND PERMIT CONDITIONS

WaterFix would add new North Delta screened intakes near Hood to the present South Delta diversions of the State (SWP) and Federal (CVP) water projects at Clifton Court and Tracy. The WaterFix North Delta diversion capacity would be 9,000 cfs that would be routed via twin tunnels to Clifton Court Forebay in the south Delta. The South

Delta diversion capacity would remain 15,000 cfs (presently restricted to 11,400 cfs except in floods). The total export pumping capacity for water diverted from the north Delta diversions (NDD) and the south Delta diversions (SDD) would remain 15,000 cfs at the two existing south Delta pumping plants (10,500/4,400).

Would the addition of the NDD reasonably protect fish? No.

- The proposed NDD intake screen systems or proposed operational constraints will not protect passing fish from entrainment, impingement, or predation. The risks are higher than assessed by project proponents and regulatory and resource agencies, and are unreasonable.
    - The location of the three diversions of the NDD within the river channel poses a serious risk to migrating juvenile fish. The intakes are located on straight stretches of the river with low gradient and low potential sweeping velocities that would carry fish by intake screens. See full discussion in Exhibit CSPA-400.
    - **Entrainment** through and **Impingement** onto the intake screens of the NDD is a serious concern. Small fish can only combat the currents for short periods until fatigue sets in and they succumb to the water flowing into and through the screens. The large, long screens would lead to severe fatigue stress. Exposures beyond 60 seconds would lead to fatigue setting in and the fish eventually succumbing to the water flowing into the screens. Approach velocity hot spots will occur due to operational limitations and debris loading.

Screen cleaning systems pose an additional threat to young fish contacting the screens. See full discussion in Exhibit CSPA-401.

- **Predation** at the NDD intakes is a serious concern. Even when the intakes are not diverting, just the physical structures increase predation by providing predator habitat. When operating, the diversions will draw juvenile fish more toward the east bank increasing the exposure to predators. Juvenile fish will become concentrated and continually exposed in three consecutive intake systems, with predators concentrated just downstream of each intake structure. See full discussion in Exhibit CSPA-403. Proposed refugia from predators within the screen systems have never been tested and have a high probability of failure. See full discussion in Exhibit CSPA-402.

- The proposed NDD would allow more of the total watershed inflow to be exported from the Delta, leading to less total Delta outflow to the Bay. MWD's analyses shows directly increased export of uncontrolled Delta outflow. See discussion and reference graphics in Exhibit CSPA-404. Less outflow will affect Valley and Bay-Delta fish populations and their habitat quantity, quality, and productivity. WaterFix would add directly and indirectly to ever-increasing exploitation of Central Valley river flows, and reservoir and groundwater storage, which will impact fishery resources throughout the Central Valley and Bay-Delta.
- The added NDD export capacity under less constraints compared to the present south Delta exports, places potential risks to short and long term reservoir storage with potential ramifications to fish dependent on reservoir cold-water-pool

resources. The NMFS assessment concludes that conditions will worsen with WaterFix only in critically dry years like 2014 and 2015, and possibly in below normal water years. See discussion on pages 4 and 5 of Exhibit CSPA-405, which quotes from Exhibit SWRCB-106, p. 282.

  - The WaterFix proponents propose no rules governing potential operation of storage reservoirs and reservoir releases to Valley rivers leading to the Delta. The nearly unrestricted additional capacity of WaterFix would allow further exploitation of both unregulated Delta inflow/outflow and reservoir storage supplies.
  - Existing rules could change in revisions to the biological opinions for the long-term operations of the SWP and CVP. The rules set forth in D-1641 may also change. More restrictive changes to export and storage rules could greatly affect the water supply benefits touted in the WaterFix proposal.

- Risk from continued operation of the south Delta diversions would not be alleviated with moving some of diversions to the NDD. Continuing south Delta diversion risks would potentially increase without the freshwater inflow diverted at the NDD. Existing rules governing SDD are to be unchanged. Yet with the added burden of NDD, all the conditions used in setting SDD export restrictions (e.g., OMR limits, export to inflow ratios, water temperatures, Delta outflow, etc.) could change.

The other major feature of the WaterFix is a new water management operational scheme for the Central Valley and Delta to accommodate the new infrastructure. In

addition to the present operating criteria under the biological opinions for the long-term operations of the SWP and CVP and D-1641 water quality standards, the WaterFix Final EIR/EIS considered rules for north Delta bypass flows to maintain Delta inflow and outflow criteria as measured at Rio Vista. The WaterFix Final EIR/EIS also evaluated protection of the initial fall-winter flow pulse that supports the majority of the Winter-Run salmon smolt production for the year on their emigration from the upper Sacramento River near Redding to the Bay. The Final EIR/EIS also evaluated minimum spring (Mar-May) Delta outflow criteria and summer operations that would minimize North Delta diversions and focus on South Delta exports to maintain freshwater inputs into the interior Delta for agriculture.

Even if these evaluated protections were required, would they be adequate? No.

- Proposed bypass flows are insufficient to protect fish migrating through the Delta from misdirection, and longer exposure to Delta hazards. Migrating young salmon would be subject to greater tidal reverse flows in north Delta migratory channels. NMFS's own biological opinion concludes WaterFix would have significant adverse effects on fish migratory habitat conditions. For more complete discussion, see Exhibit CSPA-406, which quotes Exhibit SWRCB-106, p. 602.
    - Channel velocities would change below the NDD, increasing migratory travel time and the risk of predation on juvenile salmonids.
    - NMFS's conclusion that there would be a positive change in channel velocities in the south Delta is unfounded because net downstream channel velocities would be less with less inflow from the north Delta making up any effect from

lower SDD exports. NMFS's conclusion that exports from the south Delta will decline from November through June because of WaterFix is not true, because south Delta exports are already constrained during those months. South Delta exports would continue under existing rules, while NDD exports would add to the combined export of Delta inflows.

- Protecting the first winter flow pulse is commendable to help winter run salmon pass through the Delta, but would not protect fry, parr, and smolt spring and fall run salmon, or subsequent winter run emigration in later winter flow pulses. The WaterFix operational constraints do not appear to provide for winter storage releases in dry years to create or enhance winter flow pulses.
- Delta inflow and outflow rules and provisions are insufficient to maintain Delta or Bay productivity or habitat conditions beneficial to the fish. Existing BOs and D-1641 criteria do not protect fishes dependent on adequate Delta inflow and outflow.
- The Low Salinity Zone, critical habitat of the Delta smelt and other native fish, will receive less freshwater inflow and will thus be located further upstream, and will be more subject to Delta diversions, warmer air temperatures, poor water quality, and reverse flows in tidal channels of the Delta.
- There are no rules for operating Central Valley reservoir and river conditions under WaterFix demands on reservoir storage, therefore putting upstream resources at additional risk.

Other criteria under the biological opinions for the long-term operations of the SWP and CVP and D-1641 (barring revisions in the Bay-Delta Plan update process) would remain the same. Exceptions could occur under D-1641 emergency orders or BO adaptive management. Examples of such historical exceptions include temporary urgent change petitions to the State Board (TUCPs) to relax salinity standards during the 2013-2015 drought and recent changes to BO RPAs (Fall X2 criteria were relaxed for October 2017).

Biological opinion criteria that would be unchanged include Fall X2, OMR restrictions (Jan-June), Delta Cross Channel operations, and reservoir storage and release requirements. Also unchanged would be State Board D-1641 criteria for salinity, export curtailment, and outflow requirements (subject to TUCPs). Note that any formal temporary or permanent changes to these criteria would be adopted by WaterFix.

- These criteria and their relaxation in drought periods are the primary cause of drastic declines in Bay-Delta fish populations over the past five decades. These rules have not proven effective in protecting the fish and fish habitat.
- The Reasonable and Prudent Actions (RPAs) in the 2008-09 BO's and their updates have proven insufficient to protect fish and fish habitat.
- WaterFix proposes few changes or improvements to this existing array of ineffective protections.

There is discussion in WaterFix documents of some additional commitments to protect listed fish populations. One of these is a non-physical barrier at the upstream entrance of Georgiana Slough to limit juvenile fish leaving the Sacramento River channel

for the Central Delta. Another is predator removal at north and south Delta diversions to limit predation of juvenile fish at the intake systems. The WaterFix proponents explicitly propose adaptive management in response to monitoring to provide further unknown active protections if they are necessary.

- Neither predator removal nor non-physical barriers have proven feasible or effective. Localized reductions in predators will be short-lived with abundant regional mobile predator populations. With lower freshwater inflow below the NDD, there will be greater likelihood of the movement of emigrating salmon, steelhead, and sturgeon into other Delta channels from the Sacramento River channel. Tidal exchanges into Steamboat Slough, Georgiana Slough, the Delta Cross Channel, Three-mile Slough, and Cache Slough will increase, drawing more juvenile salmon into these routes.
- While monitoring has shown real-time risks, the resources and authority needed by resource managers to respond timely and effectively to threats are insufficient. Groups such as the Delta smelt and salmon management groups will continue to have limited authority to make needed changes in operations.

ADDITIONAL PERMIT CONDITIONS NEEDED

The protections offered and discussed in the WaterFix documents are not adequate to protect fish and their habitat. Additional mitigation and enhancement actions are necessary to reasonably protect potentially affected fish and habitat resources.

In this section I propose additional reasonable protections that should be included in WaterFix to protect aquatic habitats and fish populations of the Central Valley. Some

suggested added conditions reflect lack of existing protection for fish and affected habitat. Others protection prescriptions are suggested to make proposed and existing conditions more protective.

Many of the suggested actions are included at least in part in 2017 amendments to the NMFS Biological Opinions for the long-term operations of the SWP and CVP and its RPAs. See Exhibit CSPA-413.

Central Valley Reservoir Storage

With the added Delta export capacity there is a need to protect reservoir storage and cold-water pools of Shasta, Oroville, and Folsom reservoirs. Reclamation and NMFS recognize they will be unable to restrict reservoir storage use and protect fish without the assistance of the State Board in limiting deliveries to state water right holders in drier years (Exhibit CSPA-413, page 30: Enclosure 1). New and more comprehensive storage and release rules are necessary to protect Central Valley fishes under the proposed WaterFix.

River Flows and Water Temperatures

WaterFix proponents suggest no permit conditions to protect beneficial uses upstream of the Delta. The State Board should require that Reclamation and DWR meet existing WR Order 90-05 and Basin Plan temperature objectives for the lower Sacramento River downstream of Shasta at Redding, Red Bluff, Hamilton City, Wilkins Slough, and Verona gages. These standards include 56^0F at Hamilton City near Red Bluff and 68^0F below Hamilton City to the Delta. In addition, the spring (Mar-May) and fall (Oct-Nov) 68^0F criteria should be reduced to 65^0F to protect spawning, incubating,

and rearing salmon, steelhead, and sturgeon. For full analysis, see Exhibit CSPA-434. Similar criteria should be put in place on the lower Feather and American Rivers to protect salmon, sturgeon, and steelhead below Oroville and Folsom reservoirs, respectively.

High Summer Water Temperatures in the Sacramento River

The problems with high summer water temperature on the Sacramento River are well documented. I discuss recent changes for the worse in wet year water temperature management in Exhibit CSPA-407.

Lack of Spring Flows

Low spring river flows fail to support natural processes. I describe these processes and discuss how Shasta operations in particular reduce spring flows in Exhibit CSPA-408.

Low Summer Flows

Low summer flows lead to deadly water temperatures in various locations in the Sacramento River and in the Delta. I discuss recent disturbing increases in the frequency of low summer flows in the Sacramento River and the Delta in Exhibit CSPA-409.

Uncontrolled Flows

The diversion of winter-spring uncontrolled flows derived from smaller, un-dammed, lower Sacramento River tributaries and minimum reservoir release requirements, presently restricted at South Delta project diversions, would be unrestricted at the proposed NDD. Each year, hundreds of thousands of acre-ft of water that would normally pass through the Delta to the Bay would instead be diverted at the NDD. New

spring outflow, pulsed flow protections, and existing D-1641 criteria would protect some of the uncontrolled flow. The remainder of the uncontrolled flow that could be new diversion water at the NDD should be protected to the greatest extent possible by the State Board should it grant the WaterFix petitions.

Delta Conditions

The NDD Bypass flow and other criteria analyzed in the Final EIR/EIS, together with existing OCAP BO OMR and D-1641 criteria, are not sufficient to protect salmon, steelhead, sturgeon, smelt, striped bass, shad, and other fish species and their habitat in the Delta. Tidal flow, bypass flow, water temperature, and salinity criteria are needed to protect Delta fishes.

Operations of the NDD and SDD should be further restricted to protect fish.

- NDD should be restricted to the minimum diversion when Freeport net daily average flows fall below 30,000 cfs in winter-spring to minimize tidal flow reversals in North Delta channels. Tidal flow reversals impede juvenile and adult salmon migration through the North Delta, increase predation on young salmon, and increase adult Delta smelt upstream migration into the lower Sacramento River channel of the North Delta.
- NDD and SDD should be restricted to the minimum diversion when Emmaton and Jersey Point gages exceed a daily average 500 EC. Such criteria will limit the upstream movement of the Low Salinity Zone into the Delta and the degradation of the designated critical habitat of Delta smelt. It will also maintain low-salinity rearing habitat for juvenile salmon in Suisun Bay/Marsh.

The SDD will continue to be a stress on the Delta fish community by drawing fish to the south Delta, entraining larval and juvenile fish into the large pumping plants, and exporting Delta nutrients and plankton from the Delta. Stress in the south Delta may even increase without the freshwater taken at the NDD.

Massive fish losses at the south Delta pumps would continue. Exhibit CSPA-412 more extensively discusses south Delta losses with WaterFix in place.

Given past practice, it is likely that rules governing the SDD will continue to be violated. Exhibit CSPA-253 details a history of violations of Delta water quality standards.

Existing rules are not adequately protective. I have discussed this on multiple occasions. Exhibit CSPA-414 is a presentation I made at a Board workshop in 2012. It describes how in drier years in particular, Delta smelt are caught in a "vice" beginning in late spring. They are trapped in the central Delta by tidal pressure from the west, Sacramento River water from the north, and weak flow in the San Joaquin River. This late spring and summer operation is unlikely to change with the WaterFix facilities in place. CSPA-414 provides a clear graphic description of this phenomenon.

More stringent salinity criteria are necessary. In Exhibit CSPA-415, I describe how insufficient outflow in the summer allows the Low Salinity Zone to move into the central Delta, restricting habitat for Delta smelt.

WaterFix documents discuss increasing Yolo Bypass flows to increase Delta productivity below the NDD. However, higher inflow from Yolo Bypass inflow will add

warm water in the north Delta below the NDD. Exhibit CSPA-416 describes this phenomenon.

Bay Conditions

The WaterFix would indirectly affect Bay fish and habitat through modification of Delta outflow to the Bay. An array of habitats would help to minimize effects of WaterFix on the Bay. Exhibit CSPA-417 discusses some of the opportunities for habitat improvements, but also calls attention to pitfalls if those improvements are not designed properly and maintained.

In the California Department of Fish and Wildlife's Conditions of Approval (Incidental Take Permit, Exhibit SWRCB-107, p. 66), there are criteria for spring outflow to protect the State-listed longfin smelt population. The criteria simply retain existing outflow levels to maintain the longfin population at existing levels, rather than contribute to the population's recovery. Delta outflow should be further enhanced by limiting diversion of uncontrolled flows and using reservoir releases targeted for Delta outflow pulses.

Delta outflow to the Bay should be protected by limiting diversion of uncontrolled Delta inflow at the NDD and SDD. In high water supply years, Delta outflow should be enhanced through winter, spring, and fall flow pulses from reservoir releases designated to aid salmon and steelhead migrating to and through the Bay.

Reduced outflow to the Bay will increase the prevalence of invasive species such as Asian clams. Bay habitat for Delta and longfin smelt will be reduced. The productivity of the Bay is reduced with less freshwater input. Exhibit CSPA-419

discusses some of the consequences of low outflow to the Bay that were evident in drought conditions in 2015.

HABITAT RESTORATION/PROTECTION/ENHANCEMENT

Recovery Plans

Recovery plans for listed salmon, steelhead, sturgeon, and smelt include recommendations for habitat restoration in the Central Valley and Bay-Delta. A comprehensive array of actions from the recovery plans should be required as conditions of any approval of the new WaterFix facilities in order to ensure that recovery takes place.

Habitat Continuity

In the area of the NDD, habitats should be added-restored-enhanced to provide continuity for migrating salmon, steelhead, and sturgeon especially on the west side of the river channel in the area of the proposed diversion intakes.

Predation

WaterFix documents analyze predator removal at the NDD intakes. However, predation problems have traditionally been controlled by removing predator habitat, not by creating it, as would happen if the NDD facilities were constructed. Removing predators at the site will not work. Placing bounties will also not work. Eliminating fish regulations on predator fish will also not work. Providing flow pulses through the Delta during migration periods will help to reduce predation.

Predators have increased with the changes in habitat brought about by watershed water developments. Focusing on predators will not solve the root problem: changes in

habitats. The following exhibits discuss predation and approaches to reducing it: CSPA-420; CSPA-421 and CSPA-422.

Low Salinity Zone (LSZ)

Reducing freshwater inflow into the Delta below the NDD will allow the LSZ to move further upstream into the Delta in drier years. Seasonal Delta flow and water temperature standards should be instituted for the Delta to protect the LSZ.

Closing the Delta Cross Channel in summer negatively affects the LSZ. Reducing the inflow into the central Delta by WaterFix NDD exports will similarly affect the LSZ in the central and west Delta. Exhibit CSPA-423 discusses the effects of changing the flow through the Delta Cross Channel in the summer. Negative effects can include temperature increases at Sherman Lake as well as movement of the LSZ. This exhibit includes a map that traces flow direction.

Weakening Delta standards led to drastic effects on native Delta fishes through degradation of the LSZ. WaterFix will lead to similar adverse effects by reducing Delta outflow in winter-spring of all year types. A bypass flow of 7000 cfs at the NDD is insufficient to protect Bay-Delta fish and their LSZ habitat.

Tides

Astronomical forces controlling the tides vary over the year and within the month causing changes in the tides in the Delta. Management of flows, water temperature, and salinity in the Delta should be adjusted with changes in the tides. Exhibit CSPA-425 describes how changing tides dramatically pulled the LSZ into the Delta during the 2015

drought when the outflow index was 4000 cfs. A bypass flow of 7000 cfs is insufficient to protect the Delta from saltwater intrusion in some tidal conditions.

Habitat Conditions

During spring and fall migration periods, NDD and SDD exports should be restricted unless optimal upstream and downstream salmon passage conditions occur. Factors would include streamflow, water temperature, and turbidity. For example, when large releases of hatchery smolts occur upstream of the Delta, Delta inflows should increase to provide higher transport rates, higher turbidity, and lower water temperatures to minimize direct and indirect mortality at the NDD and SDD intakes.

- Spring plankton blooms are sustained by flow pulses. Exhibits CSPA-426 and CSPA-427 show graphic representation of this phenomenon.

Reinitiation of Consultations and Adaptive Management

The WaterFix proposal includes options to change proposed operations or even weaken existing criteria under D-1641, WR Order 90-05, Basin Plan, and BOs, through reinitiating consultation, TUCPs, and WaterFix adaptive management procedures. Such actions may alter important protective criteria such as Fall X2, salinity standards, and outflow and temperature requirements. The State Board should not allow changes in standards without a comprehensive review process involving all stakeholders. Once set, criteria should remain in place and not subject to arbitrary re-designation in an adaptive management process. For example:

- Water temperature criteria below Shasta were weakened in summer 2017 despite a near record water supply year to the detriment of salmon and sturgeon. Exhibit CSPA-435 describes these events.
- Fall-X2 protections for Delta smelt were removed in October 2017 under "adaptive management," eliminating the benefit to Delta smelt required in the smelt BO. See discussion in Exhibit CSPA-430.

MONITORING

Entrainment, impingement, predation, abundance at NDD and SDD

A comprehensive monitoring and assessment program is necessary at the NDD and SDD facilities to assess real time risk and effects of the diversions. Entrainment of plankton including larval fish and aquatic invertebrates (fish food) should be monitored behind diversion screens. Impingement of fish upon fish screens should be monitored. The general abundance of fish in the area of the diversions should be monitored. Predation by predatory fish should be monitored and the population effects assessed.

Delta Outflow to the Bay

Delta outflow should be measured accurately. Exhibit CSPA-429 describes the inaccuracy of the Net Delta Outflow Index.

Distribution and Abundance Monitoring

A comprehensive monitoring and risk assessment program is necessary to determine the risks and impacts of WaterFix.

Working Groups and Oversight

Appropriate technical and managerial working groups should provide ongoing evaluation and assessment of the effects of WaterFix. The responsibility and authority of these groups should be well-defined.

Adaptive Management

Monitoring and assessment activities will identify potential actions that would ensure protections as prescribed in the WaterFix plan. Adaptive management should recommend and implement improvements through tests and experiments.

Water Transfers

More thought, analyses, criteria, and review should be put into water transfers that could be allowed under WaterFix rules. Transfers can have severe environmental effects. Exhibit CSPA-431 describes some of the problems that summer transfers in particular cause in the Delta.

Hatchery Programs

Hatchery mitigation programs are essential elements of the ongoing SWP and CVP water projects. Because of the additional risks and impacts of the WaterFix program, a new comprehensive conservation hatchery program is necessary to support recovery of many of listed species. The conservation hatchery program should add spring Chinook, green sturgeon, Delta smelt, and steelhead to the existing winter run Chinook conservation hatchery program.

Expanded Populations

WaterFix should support existing programs to add salmon and steelhead populations in the Central Valley including Battle Creek, the San Joaquin River, and above Shasta, Oroville, Folsom, and Englebright dams.

Fish populations at risk

Basic life histories, habitats, population abundance and dynamics, and recovery needs of Central Valley fishes as they relate to the vulnerability to the Water Fix.

Salmon

There are four runs of Chinook salmon that may be affected directly or indirectly by the WaterFix.

- WaterFix would negatively affect Sacramento River salmon through changes in water storage and release. Exhibit CSPA-428 quotes Section 2.5.1.2 of the NMFS WaterFix BO (Exhibit SWRCB-106) on the nature of these potential negative effects, and adds commentary.

Winter Run

Winter run salmon spawn, egg incubate, and early rear in the upper 50 miles of the Sacramento River near Redding. WaterFix may cause changes in storage and release patterns that may affect spawning, incubation, and early rearing survival in those 50 miles. From late fall to early spring young winter run must migrate nearly 300 miles of river, Delta, and Bay to reach the ocean. WaterFix may affect flow, water temperatures, and turbidity in that 300-mile reach through changes in reservoir storage and releases, and increased exports from the Delta. Young salmon survival will likely be

compromised as they pass through the Delta in winter by exposure to the screened intakes, predators taking advantage of intake habitats, and changes in streamflow patterns and flow splits below the NDD and SDD intakes. Any new population established in Battle Creek would be exposed to many of these same risks.

- Project operations severely affected winter run production in 2015. Exhibit CSPA-432 provides discussion and graphic description.
- The population suffers during droughts and dry years. Exhibit CSPA-433 describes the effects to winter run of both the 2014-2015 drought and previous dry periods.
- The population suffers from lack of adherence to water permit conditions and Basin Plan water quality criteria. CSPA-249 is a complaint CSPA filed with the State Board on August 2, 2015 that details the history and consequences of failure to meet these conditions and standards.

Spring Run

Spring run salmon spawn, egg incubate, and early rear in the Sacramento River mainstem near Redding and in many tributary streams. Late summer and early fall spawning in the mainstem near Redding is affected by cold-water pool supply in Shasta. Reductions in fall flows expose spawning beds to dewatering. Fry and fingerlings leaving the mainstem and tributary spawning reaches in winter for the Bay-Delta and ocean depend on adequate flows to speed their decent and avoid predators and diversion screens. Spring adult immigrants require adequate attraction flows and cooler water temperatures.

- Spring run salmon suffer from lack of fall protections. CSPA-442 discusses recent dewatering of redds in the Sacramento River.
- Spring run suffer from lack of adherence to water permit conditions and Basin Plan water quality criteria. Exhibit CSPA-443 describes how high water temperatures in the Sacramento River inhibited upstream migration of adult Feather River spring run in June of 2017, a wet year, as well as the problems Feather River juvenile spring run face in outmigration.

Fall Run

Late summer and fall adult immigrants to the mainstem and tributaries require adequate flows and cooler water temperatures in 200 miles of the mainstem to hold and spawn. Egg incubation is compromised by existing conditions of stranding and high water temperatures. Fry and fingerling winter-spring emigration to the Delta, Bay, and ocean is compromised by low flows, high water temperatures, water diversions, and predators. With existing conditions already compromised, WaterFix will only exacerbate these conditions. With most fall run entering the Delta as fry in winter, the risks to impingement and predation at the NDD is extreme.

- The end of the Vernalis Adaptive Management Program (VAMP) coincided with a reduction in San Joaquin River fall run salmon population. For discussion, see Exhibit CSPA-436.
- Poor salmon runs in recent years are a consequence of poor management, especially during the 2012-2015 drought. Exhibit CSPA-444 discusses some of the causes and consequences of recent salmon declines.

- Exhibit CSPA-446 shows in Figure 2 the importance of flows during both spawning and rearing for increasing recruitment.

Late Fall Run

The late fall run are unique to the mainstem between Redding and Red Bluff. After hatching in spring, they must over-summer in the mainstem where flows and water temperatures continue to degrade year after year by ignoring water temperature standards and permit requirements. WaterFix ignores the problem and will only increase the water supply and cold-water pool issues. While late fall run through-Delta emigrants are large capable smolts in late fall and early winter storm pulses, NDD diversions will make the journey through the remainder of the Delta and Bay more difficult by reducing transport, net flows, salinity patterns, and affecting flow splits.

Steelhead

Steelhead adults and smolts immigrate-emigrate to-and-from the ocean to Valley rivers in higher flows of winter-spring. NDD diversions will make already difficult Delta passage more difficult. Lower flows and higher water temperatures in spring and summer that already compromise migration, spawning, and over-summer rearing will be further compromised by WaterFix. Emigrating smolts, especially, will be subject to passing the large diversion screens and their likely concentrations of predators.

Pacific Lamprey

Pacific lamprey adults migrate from the ocean to Central Valley tributaries to spawn in gravels beds in spring, much like salmon. After a year rearing in in river sediment, young lamprey migrate to the ocean as alevins much like salmon smolts. Their

survival is also likely a function of flow and flow splits, as well as likely interaction with the WaterFix screens and enhanced predator habitat near the intakes.

Sturgeon

White and green sturgeon migrate up the Sacramento River and its tributaries to spawn in spring. Egg viability and embryo survival depend on flow and cool water temperatures in the lower Sacramento River, factors that are presently compromised by existing water management and permitting. Sturgeon are especially vulnerable to spring conditions in the lower Sacramento River that could be affected by WaterFix. Exhibit CSPA-447 discusses the lack of adequate flows and water temperatures to support sturgeon in the lower Sacramento River even in 2017, a very wet year. Under such conditions, juvenile sturgeon passing the NDD screens in June and July would be at increased risk to entrainment, impingement or predation because of thermal stress.

WaterFix will further complicate reservoir storage, cold-water pool availability, and flows and water temperatures in the lower Sacramento River and Delta. Sturgeon larvae, fry and fingerling sturgeon are weak swimmers, and will be vulnerable to entrainment, impingement, and predation at the proposed WaterFix intakes in the north Delta.

Striped Bass and American Shad

Striped bass leave the Bay-Delta to spawn in the Sacramento River and its tributaries in spring. Buoyant eggs and larvae must pass the WaterFix intakes in spring, where they will be vulnerable to entrainment, impingement, and predation. If by chance

they can successfully pass the NDD, they will have a lower productive Delta and SDD to contend with.

Delta Smelt

Delta smelt migrate to and from the Delta's low salinity zone to spawn each spring. Adults ride the incoming tides to reach freshwater tidal spawning habitat. Larvae and early juveniles ride the outgoing tides to return to the low salinity zone subadult rearing habitats of the Bay. Less freshwater inflow to the Delta makes these journeys less successful and habitats less productive. Delta diversions take the smelt off the migration routes, stranding them far from the low salinity zone. Many larvae are lost to entrainment. Many young starve or are preyed upon. The WaterFix will only make matters worse.

The Delta smelt population drastically declined in 2013, 2014, and 2015 as a consequence of relaxation of water standards in the Delta combined with poor management of the reservoir water supplies. The Delta smelt population had the lowest summer production of juveniles on record during these drought years. The cause of this record low abundance was low Delta outflow exacerbated by relaxed Delta standards for outflow and salinity. Low Delta outflow resulted in an upstream position of the LSZ that extended into the Central Delta. For an extensive review of this decline and its causes, see Exhibits CSPA-437 and CSPA-438.

The agencies' 2013 MAST report failed to understand the important dynamics that controlled smelt production in the drought or what may happen with WaterFix. Exhibit CSPA-439 discusses the shortcomings of the MAST report. CSPA published Exhibit

CSPA-440 in July, 2014. This report entitled "Delta Smelt on the Scaffold" reviews the history of the location of Delta smelt in the summer from 2002 through 2014 and calls out the effects of low Delta outflow in 2014.

I have conducted population dynamics analyses that show the importance of Delta conditions in maintaining the smelt population. The WaterFix will reduce Delta outflow in the spring to the detriment of Delta smelt. Poor summer conditions will continue in the south Delta due to the ongoing operation of the SDD, resulting in poor production of first year progeny. Wet year conditions result in approximately 10 times the production as dry years. Spring and summer conditions are both important. Exhibit CSPA-441 describes Delta smelt population dynamics.

The Delta smelt spawning migration is dependent on tidal surfing. Reductions in Delta inflow at the NDD will affect the distribution of spawning and possibly increase the smelt run up the main channel of the lower Sacramento River into the area of the intakes. More adult smelt are likely to enter the lower San Joaquin channel of the Delta and become more susceptible to the SDD. Exhibit CSPA-445 discusses the phenomenon of tidal surfing and its relation to low Delta outflow.

WaterFix may affect the food supply of Delta smelt by altering Delta hydrodynamics and the distribution and concentrations of key nutrients. Exhibit CSPA-449 discusses some of the dynamics of food supply as well as how food supply interacts with the location of the LSZ and water temperature.

The key habitat of Delta smelt is the Low Salinity Zone. The LSZ will be significantly affected by the WaterFix NDD. Proposed bypass flows are insufficient to

maintain the LSZ in the eastern Bay where it is most productive and habitat conditions optimal. Exhibit CSPA-450 focuses on the importance of Delta outflow in June and July.

Late spring Delta and LSZ habitat will suffer with WaterFix. South Delta export restrictions will be minimal with poor NDD bypass flows. Low June Delta outflows will result in less protection for Delta smelt. Exhibit CSPA-451 discusses a loophole in existing OMR protections under the Delta smelt Biological Opinion, under which low outflows create high June temperatures that trigger an exception to OMR limitations.

Delta smelt are on a likely path to extinction. Nothing offered in the WaterFix proposal would reduce such likelihood. Exhibits CSPA-453 and CSPA-454 discuss the dire condition of Delta smelt and limited opportunities for a turnaround.

With WaterFix, the potential for future Temporary Urgency Change Petitions remains possible. Such changes could wreak great damage on the Delta smelt in the future. Exhibit CSPA-455 discusses the effects on Delta smelt of the TUCPs in 2015.

Any take limits set for Delta smelt are likely to be ineffective. They may be changed in the future, as they have in the past. Exhibit CSPA-456 describes how the Bureau of Reclamation requested higher take limits for Delta smelt in March 2017.

Longfin Smelt

Longfin smelt migrate from the Bay and ocean into the freshwater zones of the estuary in winter to spawn. Less freshwater inflow requires they migrate up into the Delta for spawning and rearing, where chances of their young surviving and successfully reproducing are greatly reduced. The WaterFix will take more of the limited uncontrolled winter freshwater flow to the detriment of longfin smelt.

The longfin smelt population is very low. The population depends on maintaining a large adult segment to ensure production. Recruitment of young into the adult population is approximately 10 times higher in wet years than dry years. Population abundance and recovery depend on good winter-spring Delta outflow; WaterFix will reduce outflow to the Bay. Exhibit CSPA-460 describes the dismal condition of longfin smelt at the end of 2016. Exhibit CSPA-461 describes some of the causes of the collapse of longfin smelt in 2016 and previous years, including low Delta outflow. In Exhibit CSPA-462 (April, 2016), I had recommended higher Delta outflow in 2016 to jumpstart a longfin smelt population in serious decline. This recommendation was not adopted.

The population of longfin smelt is very low and the possibility of extinction exists. Further compromise of the winter-spring Delta outflow will bring the population closer to extinction. Exhibits CSPA-457, CSPA-458 and CSPA-459 discuss the near-disappearance of longfin smelt in 2014 and 2015, and the long-term trends that preceded this collapse.

Native Delta Minnows, Suckers, and Other Fishes

Many native Delta fish including splittail, pikeminnow, suckers, perch, blackfish, hardhead, hitch, tule perch, sculpin, and flounder will pass the NDD Waterfix intakes. Many have larvae and juvenile life stages that will be lost to the intakes and predators associated with the intakes. Many of these native species were previously devastated from the interior Delta by the SDD; they will now be threatened by the NDD.

Bay-Delta Fish Habitats

The Delta is important for many fish species that take advantage of tidal fresh and brackish water habitats on a seasonal basis for spawning, rearing, feeding, and migrating. These habitats depend on the natural interaction of saltier water from the Bay and freshwater from rivers through tidal circulation. The WaterFix will alter freshwater inflow, tidal circulation, and the tidal prism, and thus the characteristics of all the important habitats.

The Bay is an important habitat and nursery area for estuarine and ocean fishes such as anchovies, herring, and crabs. Freshwater input to the Bay is directly related to Bay productivity and habitat suitability. For decades uncontrolled freshwater flows (watershed precipitation not stored in reservoirs or exported from the Delta) have been left for the Bay. WaterFix will significantly reduce freshwater flows to the Bay in most years.

- The WaterFix will devastate other fish populations of the Bay-Delta fish community. In Exhibit CSPA-466, I discuss likely impacts of WaterFix to striped bass, steelhead, splittail, Pacific lamprey, native minnows and suckers, and American shad; many of these impacts relate to difficulty these species will have passing the fish screens at the NDD.
- Low Summer Delta inflow/outflow will continue to stress the Bay-Delta fish community under WaterFix. I summarize the general importance of summer inflow and outflow in Exhibit CSPA-463.

- Winter flow pulses into the Bay-Delta are especially important in dry years and drought sequences like 2012-2016. I summarize the importance of high winter flow events in Exhibit CSPA-464.
- The first pulses of late fall and winter rains are very important triggers for many habitat and migratory processes. Although WaterFix protects some of the initial winter pulses, NDD and SDD diversions will significantly affect early winter pulses in many years. I summarize the importance of later fall and winter pulses in Exhibit CSPA-465.

SUMMARY AND CONCLUSIONS

The proposed WaterFix Twin-Tunnels diversion from the north Delta will have measurable and significant effects on the hydrology and ecology of the Central Valley, Delta, and Bay. Changes will come to reservoir storage, river flows, Delta inflows, Delta channel flows and tides, and Delta outflow to the Bay (Figure 1; next page). These changes will have significant adverse effects on Central Valley salmon, steelhead, sturgeon, and other native fish, and non-native gamefish.

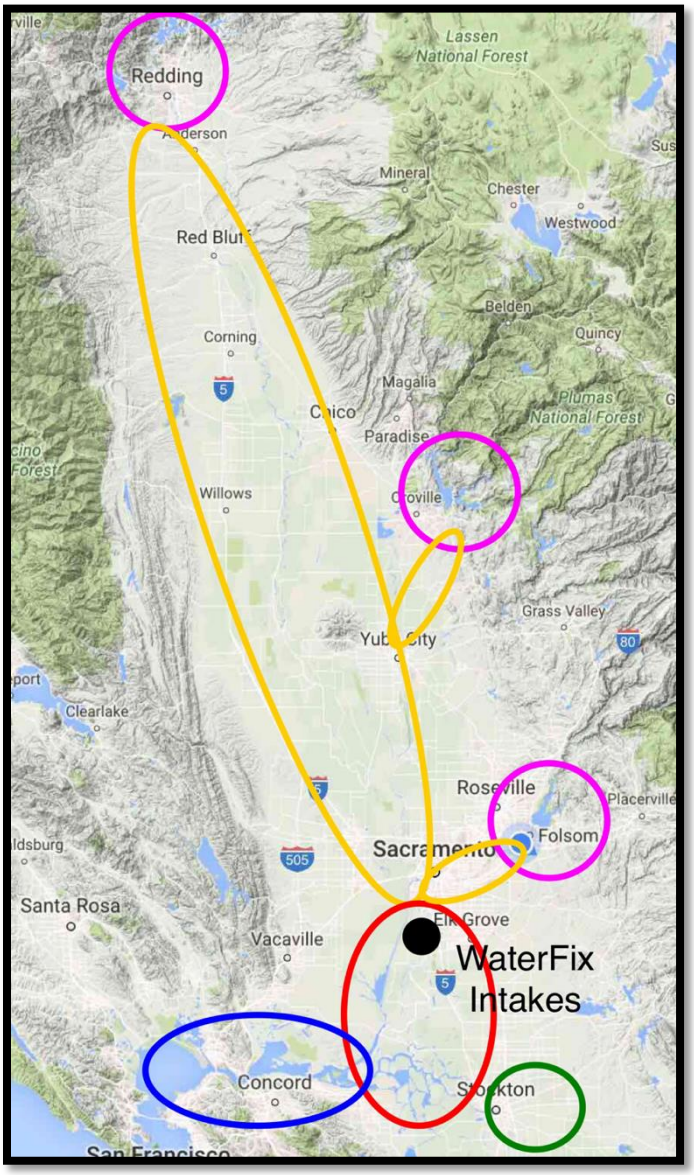

Figure 1. WaterFix effects will extend to Central Valley reservoir storage and releases, river flows and water temperatures, Delta tidal flows and water quality, and freshwater outflow to the Bay.

Proponents of WaterFix believe it is a viable solution if not a necessity to protect endangered species and the environment from the existing use of the Central Valley water supply by the SWP/CVP. However, the solution is not more water diversion, but maintaining critical functions and recognizing that unnecessary excesses are what caused the major ecological problems.

- Recognizing that wet years typically produce ten times the fish as dry years and how water projects exacerbate dry year conditions goes a long way in understanding the Delta fish population dynamics and probability of extinction and recovery.
- Recognizing that fish population recovery requires a slow and arduous journey of building population productivity back to reasonable levels and resiliency. It takes better than average conditions to recover populations.

Executed this 29th day of November, 2017 at Fair Oaks, California.

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Thomas Cannon