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BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATER FIX	TESTIMONY OF MICHAEL BRYAN (EXHIBIT DWR-81)

I, Michael Bryan, do hereby declare:

I. INTRODUCTION

I am a Principal Scientist and Managing Partner at Robertson-Bryan, Inc. (RBI). I received a Bachelor of Science degree in Fisheries Biology from the University of Wisconsin-Stevens Point in 1986, a Master of Science degree in Fisheries Biology from Iowa State University in 1989, and a Doctor of Philosophy degree in Toxicology and Fisheries Biology from Iowa State University in 1993. I have 23 years of experience in assessing impacts of water resource projects on water quality and aquatic biological resources in California. My expertise includes assessing measured and modeled data developed to characterize the environmental effects of projects for determining impacts to beneficial uses of waters throughout northern California, with a focus on Central Valley water bodies from Shasta Reservoir to the Sacramento-San Joaquin River Delta (Delta).

For the California WaterFix (CWF), I led a team of scientists and engineers at RBI in the preparation of the Water Quality Chapter of the Bay Delta Conservation Plan (BDCP)

Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS), BDCP/CWF Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement (RDEIR/SDEIS), and Final EIR/EIS.

II. SUMMARY OF TESTIMONY

This testimony has been prepared to rebut certain aspects of testimony provide by other parties regarding the CWF effects on water quality of the lower Sacramento River, lower American River, and Delta. Specifically, my testimony addresses the following topics, in the order listed:

1. Harmful algal blooms (HABs), disinfection byproduct formation and dissolved metals in the lower Sacramento River and lower American River at the City of Sacramento water treatment plant (WTP) intakes.
2. HABs in the Delta
3. Water quality and HABs at the City of Stockton's water treatment plant intake location on the San Joaquin River

I have prepared three technical reports, one for each of the three topics enumerated above, that: 1) identify the specific testimony by other parties being addressed by this rebuttal testimony, and 2) provide in-depth analyses pertaining to the three topics listed above to support my opinions set forth in this testimony (included in DWR's case as Exhibits DWR-651, DWR-652, and DWR-653).[1] Those reports are incorporated into this testimony.

III. REBUTTAL OF TESTIMONY REGARDING CWF EFFECTS AT THE CITY OF SACRAMENTO WTPS

This section of my testimony addresses lower Sacramento River and lower American River water quality at the City of Sacramento water treatment plant (WTP) intakes pertaining to the following, in the order listed:

[1] Exhibits DWR-651, DWR-652 and DWR-653 are true and correct copies of the reports I prepared for this rebuttal testimony.

- Harmful algal blooms (HABs) at the: (1) Sacramento River WTP intake, and (2) E.A Fairbairn WTP intake;
- Disinfection byproduct formation potential at the WTPs; and
- Levels of dissolved metals in diverted river water.

A. Effects of the CWF on HABs and their Impacts to the Sacramento River WTP

Testimony on behalf of the City of Sacramento provided by Ms. Bonny Starr and Ms. Pravani Vandeyar stated that the CWF could cause increased HABs in the lower Sacramento River at the Sacramento River WTP intake due to lower flows, velocities, increased water column stability and residence times; and increased water temperatures.[2] When using the term HABs this rebuttal testimony is referring to cyanobacteria blooms, and primarily the genera *Microsystis*. The HABs that have been documented in the Delta and rivers upstream of the Delta are primarily comprised of *Microcystis aeruginosa*. Other pelagic cyanobacteria including *Aphanizomenon spp., Anabaena spp.* (recently renamed *Dolichospermum*) and *Oscillatoria* have also been detected in the region, although generally to a lesser extent than *Microcystis aeruginosa*. This testimony focuses principally upon *Microcystis* because, as stated above, it is the primary species in the Delta and has received the most study. Because the HABs addressed by this testimony are those associated with cyanobacteria, this testimony, and its supporting technical reports, use the terms HABs, cyanoHABs, and cyanobacteria synonymously.

The following separately discusses CWF effects on flow velocities and temperature in the Sacramento River. In my testimony, I utilize velocity (ft/s) rather than flow (cfs) as a more informative way to assess the hydrodynamic conditions necessary for HABs, which I explain further below. River velocity determines the magnitude of turbulent flow and thus mixing that occurs within a channel. This physical mixing of water throughout the water column physically disrupts water column stability, generates in-channel turbidity, and

[2] See Exhibits CITYSAC-6, CITYSAC-8, CITYSAC-10, CITYSAC-29, and CITYSAC-30.

disrupts *Microcystis*' ability (and *Anabaena*'s ability) to control its location in the water column and to form mats of dense colonies/filaments at the surface of the water, thereby out-competing other algae. Channel velocity also dictates residence time within a channel reach because velocities dictate the flushing rate for the reach. In the lower Sacramento and American rivers, velocities are typically relatively high and constant in a downstream direction, and thus flushing rates are high and residence time is low. Hence, to assess the effects of flow changes caused by the CWF on cyanobacteria, this assessment evaluates channel velocity because velocity is the primary driver of channel turbulence and mixing, in-channel generated turbidity, and residence time – all of which can affect cyanobacteria and its ability to produce blooms. It should be noted, however, that numerous factors interact in a complex manner to determine whether a *Microcystis* bloom would occur at a given location and, once initiated, the size and duration of the bloom. At any given site, these include the abiotic factors of channel velocity, turbulence and mixing; water column irradiance; nutrient levels; and water temperature; and the biotic factors of competition with other algae and grazing by zooplankton. Consequently, decreased channel velocity and associated increased residence time at a site does not always translate into increased bloom occurrence or duration at the site, even where *Microcystis* is present.

<u>Opinion #1</u>

The effects of the CWF on lower Sacramento River flow velocity and water temperatures would not be sufficient to change the frequency or magnitude of cyanobacteria blooms that could potentially occur in the river upstream of the Sacramento WTP intake, relative to the NAA.

This opinion and following testimony is supported by analysis presented in Section 3 of my technical report, *Report on the Effects of the California WaterFix on HABs, Disinfection Byproducts, Organic Carbon and Metals at the City of Sacramento Water Treatment Plant Intake Locations on the Lower Sacramento and American Rivers* [Exhibit DWR-651].

1. flow and residence time effects

Based on scientific information regarding flow velocity and *Microcystis* blooms, lower Sacramento River daily maximum and 15-minute velocities for the period modeled for the CWF and the NAA were evaluated to determine effects of the CWF on river flow velocity upstream of the Sacramento River WTP intake, and velocity-related effects on *Microcystis* and other cyanobacteria blooms. The velocities are from the Delta Simulation Model II (DSM2) modeling that was conducted in support of DWR's water right petition and case-in-chief for Alternative 4A, operations scenarios 4A-H3 and 4A-H4 (called 4A-H3 and 4A-H4 herein), and Boundary 1 and Boundary 2 scenarios. Exceedance plots of modeled daily maximum and 15-minute time-step velocities for the modeled period (water years 1976–1991) for the months May through October were prepared. The months May through October are the focus of this analysis because this is the period of the year when water temperatures were modeled to be above 19°C (66.2°F), which is the temperature above which *Microcystis* blooms have been observed in nearby Delta waters. In order to assess the effect of changes in velocity, I completed a literature search and found that the magnitude of water velocity required to disrupt *Microcystis* blooms varies by system, but has been reported in the scientific literature to be in the range of 0.1 to 1.3 ft/s. Turbulent water mixes all algae throughout the photic zone of the water column, inhibits the ability of cyanobacteria to control their position in the water column, and reduces light through turbidity. Velocities in the 0.2 to 1.0 ft/s range have been shown in studies to disrupt *Microcystis* blooms and shift the dominant phytoplankton species to green algae and diatoms.

The following summarizes the modeled velocity changes for these months [see Exhibit DWR-651 Section 3.2.1]:

- <u>May and June</u>: The frequency with which any given river velocity would occur for 4A-H3, 4A-H4, Boundary 1, and Boundary 2 would typically be similar to or greater than that for the NAA, particularly when flow velocities are less than 1.0 ft/s. The range of velocities modeled to occur would be about the same for the CWF scenarios and the NAA.

- July: Daily maximum and 15-minute velocities for 4A-H3, 4A-H4, Boundary 1, and Boundary 2 would occasionally be lower than that for the NAA, but daily maximum velocity would range between about 1.0 ft/s and 2.25 ft/s for all five alternatives at all times. The frequency with which any given velocity in the river would occur would not differ substantially (i.e., less than 10%) for the CWF scenarios, relative to the NAA, and the range of velocities modeled to occur would be the same for the CWF scenarios and the NAA.
- August: The frequency with which daily maximum and 15-minute river velocities would be at levels below 1.25 ft/s for the CWF would be similar to or lesser than that for the NAA. Hence, when river velocities are at their lowest during August, the CWF would more frequently be at higher velocities compared to velocities for the NAA.
- September and October: Daily maximum river velocities below 1.0 ft/s would occur about 30% of the time for the NAA, and would be below this level a similar or lesser percentage of the time for 4A-H3, 4A-H4, Boundary 1, and Boundary 2. The remaining 70% of the time, daily maximum velocity would be greater than 1.0 ft/s for all five alternatives. The frequency with which any given velocity in the river less than 0.75 ft/s would occur would not differ substantially (i.e., less than 10% in September and less than 5% in October) for the CWF scenarios, relative to the NAA, and the range of velocities modeled to occur would be similar for the CWF scenarios and the NAA, differing only slightly on the high end of the velocity range. The frequency with which the lowest velocities would occur would be about the same for all five scenarios, with Boundary 2 having the lowest frequency of low velocities among the five scenarios in September.

The lower Sacramento River has not had a history of cyanoHABs largely because of the river's turbulent flows, turbidity, and temperatures. The CWF would maintain sufficiently high channel velocities to result in turbulent, well mixed flows in the lower Sacramento River channel and thus would not increase the frequency or magnitude of cyanoHABs in the river near and upstream of the Sacramento River WTP due to increased water column stability as claimed by Ms. Starr and Ms. Vandeyar in their testimony. Based on my assessment of best available information from both modeling of the CWF and the scientific literature pertaining to the effects of river velocity on cyanobacteria, I conclude that the CWF would not alter channel velocities in the lower Sacramento River channel upstream of the Sacramento WTP by frequency and magnitude that would result in more frequent or greater magnitude cyanobacteria blooms in the river than would otherwise occur under the NAA.

2. temperature effects

My analysis of temperature effects of the CWF on lower Sacramento River temperature is based on modeled temperature at Knights Landing (RM 90), which is the location closest to the Sacramento River WTP for which temperature modeling output is available. The period of the year when river temperatures at Knights Landing would be above the 19°C (66.2°F) – the threshold temperature above which we see *Microcystis* blooms in the region – is May through October. For the rest of the year, river temperatures upstream of the Sacramento River WTP would be too cold for both the CWF and the NAA to support cyanobacteria blooms. Each month of the May through October period was analyzed based on mean monthly temperature data output from the Bureau of Reclamation's lower Sacramento River temperature model for the 82-year (1922–2003) hydrologic period of record. My analyses performed used tables of period and water year type mean temperatures and probability exceedance plots for the CWF and the NAA for the entire simulation period and for each water year type separately.

My conclusions from this analysis [See Exhibit DWR-651, Section 3.2.1.] are that the CWF would not adversely affect (via its effects on river temperatures) the frequency or magnitude of cyanobacteria blooms that could potentially occur in the lower Sacramento

River, upstream of the Sacramento River WTP because the CWF would not affect river temperatures, relative to the NAA, sufficiently to have an effect. In general, cyanobacteria blooms of any magnitude have rarely occurred in the lower Sacramento River upstream of the Sacramento River WTP, primarily because the river velocity is too high and mixing too great to enable cyanobacteria to outcompete diatoms and green algae. In the event that a cyanobacteria bloom were to occur in the future in the river, upstream of the Sacramento River WTP, the frequency and magnitude of temperature effects of the CWF, relative to the NAA, would not make the bloom sufficiently worse such that it would cause an adverse impact to the City of Sacramento in operating its Sacramento River WTP where such impact would not occur for the NAA scenario. In other words, in the event that a cyanobacteria bloom were to occur in the river, it would occur in a similar manner (i.e., magnitude and duration) whether the river experiences the water temperatures modeled for the CWF or those modeled for the NAA scenario.

B. Effects of the CWF on Harmful Algal Blooms and their Impacts to the E.A. Fairbairn Water Treatment Plant

Testimony on behalf of the City of Sacramento by Bonny Starr and Pravani Vandeyar stated that the CWF could cause increased HABs in the lower American River at the E.A. Fairbairn Water Treatment Plant due to lower flows and resulting increased water column stability and residence times, and increased water temperatures.[3]

Opinion #2

The effects of the CWF on lower American River flows (and associated channel turbulence, mixing, and residence time) and water temperatures would not be sufficient to substantially change the frequency or magnitude of cyanobacteria blooms that could potentially occur in the river upstream of the E.A. Fairbairn WTP intake, relative to the NAA.

[3] See Exhibits CITYSAC-6, CITYSAC-8, CITYSAC-10, CITYSAC-29, and CITYSAC-30.

This opinion and following testimony is supported by analysis presented in DWR-651, Section 3.

1. flow effects

The effects of the CWF on lower American River flow velocity could not be directly evaluated in the same manner as was done above for the lower Sacramento River because DSM2 does not include the lower American River within its modeled domain and CalSim II does not output river velocity data. Thus, the potential for the CWF to affect flow velocity was evaluated using CalSim II modeling output for Nimbus Dam flow releases. I provide an assessment of the flow-related effects of the CWF in the lower American River, relative to the NAA, and discuss whether such modeled flow effects are expected to be sufficiently large to encourage cyanobacteria blooms within the river, when such blooms would not otherwise occur for the NAA.

Because the swift-moving, turbulent, non-stratified flowing waters of the lower American River have historically prevented problem-level cyanobacteria blooms from forming in the river, this is also generally expected to be the case in the future, even if flows for the CWF are somewhat lower than those that would occur for the NAA. Only the lower flow conditions that the lower American River may experience could potentially provide hydrodynamic conditions, in some areas of the river, which may allow cyanobacteria blooms to occur. As such, my assessment focused on differences in flows between the CWF and the NAA when flow below Nimbus Dam was modeled to be below 1,000 cfs – a relatively low May-October flow condition for this river. I assessed the May through October period of the year when temperature conditions for cyanobacteria blooms are met.

Modeling results indicate that the CWF is not expected to alter lower American River flows in wet, above normal, and below normal years in a manner that would reduce channel turbulence and mixing and increase water column stability and residence times sufficiently to change the potential for cyanobacteria blooms in the river, relative to the NAA. Moreover, this is typically the case in dry and critical years as well. However, the CWF could result in lower American River flows below 1,000 cfs in dry and critical water years more often than would occur for the NAA.

With the CWF, the frequency with which flows below Nimbus Dam would be below 1,000 cfs during the months May through October of dry and critical years would be about the same in eight of the twelve cases (6 months x 2 water year types = 12 cases), would be 5–10% more frequent in three cases (June of critical years, July of dry years, and October of dry years), and would be 10% less frequent in October of critical years. Modeled flows were below 500 cfs more often in June, August, and September for the CWF, relative to the NAA. The lowest Nimbus release flow modeled for the CWF and the NAA was the same for each month of the May through October period for both dry and critical years.

It is uncertain whether the modeled flow reductions with the CWF would reduce channel turbulence and mixing and increase water column stability and residence time sufficiently to encourage establishment of cyanobacteria within areas of the river notably beyond that which would occur for the NAA scenario. This is, in part, because the flow reductions for the CWF under low-flow river conditions, relative to the NAA, are generally small. In addition, it remains unclear how the other key drivers of cyanobacteria blooms (i.e., water temperature, water column irradiance, and nutrients) and competition with other members of the phytoplankton community interact with channel hydrodynamic to determine whether or not blooms will form in the lower American River, where they have not historically been an issue. Research has shown that cyanobacteria ecology is complex and that reduced flows on the order modeled for the lower American River for the CWF, relative to the NAA, do not necessarily indicate that cyanobacteria presence in the river would differ between the CWF and the NAA scenarios. Consequently, based available flow modeling and scientific studies on cyanobacteria and the factors that drive their blooms, and the fact that the lower American River is a riverine environment where cyanoHABs have not historically occurred at problem levels, I conclude that any changes in the frequency or magnitude of cyanobacteria blooms that could potentially occur in the lower American River for the CWF due to changed hydrodynamics would not be substantial and would be expected to differ minimally, if at all, to that which would occur for the NAA.

2. temperature effects

The E.A. Fairbairn WTP is located on the lower American River at river mile (RM) 7.3. To determine the effects of the CWF on lower American River temperatures in the vicinity of the E.A. Fairbairn WTP, modeling output included in the CWF Biological Assessment for the lower American River at Watt Avenue (RM 9.4) was used. The period of the year when river temperatures at Watt Avenue would be above the 19°C (66.2°F) – the threshold temperature above which we see *Microcystis* blooms in the region – is May through October, and thus the assessment was limited to these months of the year.

Each month of the May through October period was analyzed based on mean monthly temperature data output from Reclamation's lower American River temperature model for the 82-year (1922–2003) hydrologic period of record. My analyses performed used tables of period mean temperatures and probability exceedance plots for the CWF and the NAA for the entire simulation period, and for each water year type separately. My conclusions from this analysis are that the CWF would not adversely affect (via its effects on river temperatures) the frequency or magnitude of cyanobacteria blooms that could potentially occur in the lower American River, upstream of the E.A. Fairbairn WTP because the CWF would not affect river temperatures, relative to the NAA, sufficiently to have a notable effect. In the event that a cyanobacteria bloom were to occur in the future, upstream of the E.A. Fairbairn WTP, the frequency and magnitude of temperature effects of the CWF, relative to the NAA, would not make the bloom sufficiently worse such that it would cause an adverse impact to the City of Sacramento in operating its E.A. Fairbairn WTP where such impact would not occur for the NAA scenario. In other words, in the event that a cyanobacteria bloom was to occur in the lower river, it would occur in a similar manner (i.e., magnitude and duration) whether the river experiences the temperatures modeled for the CWF or those modeled for the NAA scenario.

C. Effects of the CWF on Disinfection Byproducts at the City of Sacramento WTPs

Ms. Starr's and Ms. Vandeyar's testimony asserts that disinfection byproduct (DBP) formation at City of Sacramento WTPs may increase due to increased river temperatures caused by the CWF. Their testimony also asserts that DBP may increase due to increases in organic carbon in the rivers.[4]

<u>Opinion #3</u>

The CWF would not cause changes in temperature or organic carbon in the lower Sacramento River or lower American River of frequency and magnitude that would cause substantial adverse impacts to DBP formation potential at the City's WTPs.

This opinion and following testimony is supported by analysis presented in DWR-651, Section 4.

1. temperature effects

Based on the hydrologic period of record modeled for temperature (water years 1922–2003), the annual average temperature of the Sacramento River at Knights Landing ranged from 58.0°F to 63.6°F, and the greatest modeled annual average river temperature increase for the CWF, relative to the NAA, is 0.1°F in the lower Sacramento River near Knights Landing. The modeled annual average temperature of the American River at Watt Avenue ranged from 54.3°F to 64.8°F, and the greatest modeled annual average temperature increase was 0.5°F.

For the highest average annual temperature increase modeled for the lower Sacramento River at Knights Landing of 0.1°F, the maximum modeled increase in TTHM concentration is 0.4%. For the highest average annual temperature increase modeled for the lower American River at Watt Avenue of 0.5°F, the maximum modeled increase in

[4] See Exhibits CITYSAC-6, CITYSAC-8, CITYSAC-10, CITYSAC-29, and CITYSAC-30.

TTHM concentration is 1.6%. A 1.6% increase corresponds to a 0.5 µg/L increase when the TTHM concentration is low (e.g., 30 µg/L) and a 1 µg/L increase when the TTHM concentration is high (e.g., 75 µg/L). Based upon a four quarter running annual average, the TTHM concentration measured in finished drinking water at the City of Sacramento WTPs were reported by the City to be 57 µg/L, 63 µg/L, 73 µg/L, and 74 µg/L in 2012, 2013, 2014, and 2015. Hence, annual average TTHM concentrations at the City's WTPs vary from year to year by an order of magnitude more than the predicted maximum incremental TTHM increase due to CWF-related river temperature changes.

2. Organic Carbon Effects

Concerns raised by the other parties regarding organic carbon effects of the CWF were related to effects of cyanobacteria on organic carbon levels in the rivers and effects of reservoir storage on organic carbon levels in the rivers. As described above, because cyanobacteria bloom frequency and magnitude in the lower Sacramento and lower American river are not anticipated to change substantially, if at all, between the CWF and the NAA, the effect of cyanobacteria on organic carbon levels in the river and its effect, in turn, on WTP DBP production also would not differ substantially, if at all, between the CWF and the NAA.

Regarding reservoir storage, analysis of organic carbon concentrations for the lower Sacramento River and lower American River relative to end-of-month storage for Shasta Reservoir and Folsom Reservoir, respectively, showed that there is no correlation between dissolved organic carbon (DOC) in the rivers and storage level in the upstream reservoir. Also, the additional amount of exposed shoreline that would occur from reduced Folsom Reservoir storage modeled for CWF for fall months would constitute <0.01% of the overall watershed and, therefore, would result in insignificant differences in first-flush storm effects (solids, microbial, and organic content) to the downstream source water. Therefore, the discharge from reservoirs having somewhat lower summer and fall storage for the CWF, relative to the NAA, would not degrade lower Sacramento or lower American river water quality with regards to DOC, and thus would not cause increased treatment requirements at either WTP or an increase in DBP levels in the treated water, based on DOC levels.

D. Effects of the CWF on Dissolved Metals in Water Diverted by the City of Sacramento

Ms. Starr asserts that the CWF would cause lower reservoir levels that could in turn cause increased concentration of dissolved metals, which could increase treatment requirements at the City of Sacramento WTPs.

<u>Opinion #4</u>

The discharge from reservoirs having somewhat lower summer and fall storage for the CWF, relative to the NAA, would not cause increased dissolved metals in the rivers below the reservoirs and thus would not cause additional treatment requirements at either WTP, based on river dissolved metals levels.

This opinion and following testimony is supported by analysis presented in DWR-651, Section 5.

Dissolved iron and manganese concentrations measured in the Sacramento River at Balls Ferry were plotted against end-of-month Shasta Reservoir storage for 2004–2016 (this was the period when these metals were measured regularly using modern analytical methods). Lower reservoir storage is not correlated with increased dissolved metals concentrations in the river. In fact, weak positive correlations are apparent—meaning that, lower Shasta Reservoir storage might be correlated with lower dissolved metals concentrations in the lower Sacramento River. This analysis could not be conducted for dissolved metals in the lower American River, because there was insufficient data for metals in the lower American River to develop a correlation between Folsom Reservoir storage and dissolved metal concentrations. Nevertheless, I would expect similar relationships for the lower American River and Folsom Reservoir storage as shown for the lower Sacramento River and Shasta storage.

II. REBUTTAL OF TESTIMONY REGARDING THE EFFECTS OF THE CWF ON HARMFUL ALGAL BLOOMS IN THE DELTA

This section of my testimony addresses the effects of the CWF on HABs in the Delta as affected by the following, in the order listed:

- Flow effects;
- Residence time effects;
- Temperature effects;
- Turbidity effects; and
- Nutrient effects.

This following testimony is supported by analysis presented in my technical report, *Report on the Effects of the California WaterFix on Harmful Algal Blooms in the Delta* [Exhibit DWR-653].

A. Flow Effects

Testimony by other parties, including Mr. Erik Ringelberg on behalf of San Joaquin County, assert that the CWF would increase HABs in the Delta due to decreased flows.[5]

Opinion #5

Although *Microcystis* blooms are expected to occur at certain Delta locations in the future, as they have historically, channel velocities at various Delta locations would not be altered to a degree that would make hydrodynamic conditions substantially more conducive to *Microcystis* blooms for the CWF, relative to that which would occur for the NAA.

This opinion and following testimony is supported by analysis presented in DWR-653, Section 4.2.

As stated above and restated here, numerous factors interact in a complex manner to determine whether a *Microcystis* bloom would occur at a given location and, once

[5] Exhibit SJC-004, and see more generally Janet McCleary [SCDA-62-errata], Frank Morgan [SCDA-61-errata], Michael Broadsky [SCDA-60-errata], Tom Burke [SCDA-35; SDWA-76], Tim Stroshane [RTD-10-rev2], Barbara Barrigan-Parrilla [RTD-20] and Fred Lee [CSPA-6-Revised].

initiated, the size and duration of the bloom. At any given site in the Delta, these include the abiotic factors of channel velocity, turbulence and mixing; water column irradiance; nutrient levels; and water temperature and the biotic factors of competition with other algae and grazing by zooplankton, fish, and clams. Consequently, changes in channel velocity and associated increased residence time or simply long residence time at a site does not always translate to increased bloom frequency, size or duration at the site, even when *Microcystis* is present.

My assessment of flow-related effects of the CWF on HABs in the Delta utilized daily maximum and 15-minute flow velocities modeled by DSM2 for nine (9) Delta locations: Sacramento River at Freeport and Rio Vista; San Joaquin River at Brandt Bridge, Buckley Cove, and Antioch; Old River at Tracy Road and Rock Slough; Grant Line Canal; and Middle River at Bacon Island. The CWF would have minor effects on daily maximum and 15-minute flow channel velocities at these locations, relative to the NAA, and almost no effect when daily maximum channel velocities are at their lowest. Hence, from a channel flow and velocity perspective, the CWF would not be expected to affect the frequency or magnitude of *Microcystis* blooms in the Delta, relative to that which would occur for the NAA scenario.

B. Residence Time Effects

Testimony by other parties, including Mr. Erik Ringelberg on behalf of San Joaquin County and Mr. Burke on behalf of the South Delta Water Agencies asserts the CWF will increase residence time, which will contribute to increased blooms of nuisance algae, such as *Microcystis*.[6]

<u>Opinion #6</u>

Increased residence time alone does not equate with increased *Microcystis* bloom frequency or magnitude. Based on current science, it is uncertain how

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[6] Exhibit SJC-004, and see more generally Janet McCleary [SCDA-62-errata], Frank Morgan [SCDA-61-errata], Michael Broadsky [SCDA-60-errata], Tom Burke [SCDA-35; SDWA-76], Tim Stroshane [RTD-10-rev2], Barbara Barrigan-Parrilla [RTD-20] and Fred Lee [CSPA-6-Revised].

cyanoHABs, and *Microcystis* in particular, would react to the CWF-driven changes in residence time.

This opinion and following testimony is supported by analysis presented in DWR-653, Section 4.6.

An increase in residence time for a tidally influenced channel reach that maintains high in-channel velocities (in both directions each day on the tidal cycle) would not be expected to affect *Microcystis* in the same manner as a similar increase in residence time (number of days) in a channel reach where velocities are very low throughout the day, and thus extended periods of water column stability exists. In addition, residence time changes between the CWF and the NAA may not occur as modeled because real-time operations would be used to optimize the balanced use of the north and south Delta diversions. Channel velocity is the driver of residence time, channel turbulence and mixing (which affects cyanobacteria competition with other algae), and in-channel derived turbidity. Because these and other factors (e.g., temperature, irradiance, grazing by zooplankton, fish, and clams) interact in a complex manner to affect cyanobacteria, increased or long residence times do not always result in bloom occurrence or increased bloom magnitude. The relationship between residence time (or increases in residence time at a location) and the size of *Microcystis* blooms would be expected to vary substantially by location within the Delta and by year due to how the factors listed above and other environmental factors vary temporally and spatially.

C. Temperature Effects

Testimony by Other Parties, including Mr. Erik Ringelberg on behalf of San Joaquin County, asserts that the CWF would increase Delta water temperature.

<u>Opinion #7</u>

The small differences in water temperature between the CWF and NAA scenarios modeled for various locations across the Delta would not substantially increase the frequency or magnitude of cyanobacteria blooms within the Delta.

This opinion and following testimony is supported by analysis presented in DWR-653, Section 4.3.

Modeling shows negligible differences in the frequency with which any given temperature would occur at the nine (9) Delta locations assessed. A key reason the temperature changes are minor at these locations within the Delta is because by the time water released from upstream reservoirs reaches the Delta, it is typically at or close to equilibrium with ambient air temperatures. As such, flow differences between the CWF and the NAA generally result in minor temperature difference within the Delta. The minor differences in water temperatures between the CWF and NAA scenarios modeled for the nine Delta locations assessed would not be expected to affect the frequency or magnitude of cyanobacteria blooms in these water bodies within the Delta, relative to that which would occur for the NAA.

D. Turbidity Effects

Testimony by other parties, including Mr. Erik Ringelberg on behalf of San Joaquin County, asserts the CWF will reduce turbidity, which will allow more light to enter the water column and cause greater problems with HABs.[7]

<u>Opinion #8</u>

Any minor change in turbidity that may occur from the CWF would not have a substantial effect on the frequency or magnitude of HABs in the Delta.

This opinion and following testimony is supported by analysis presented in DWR-653, Section 4.4.

The daily maximum and 15-minute absolute channel velocities throughout the Delta for the CWF would differ minimally from that which would occur for the NAA. Because channel velocities between the CWF and NAA scenarios differ little at the Delta locations assessed, in-channel, velocity driven turbidity also would be expected to differ little

[7] Exhibit SJC-004, and see more generally Janet McCleary [SCDA-62-errata], Frank Morgan [SCDA-61-errata], Michael Broadsky [SCDA-60-errata], Tom Burke [SCDA-35; SDWA-76], Tim Stroshane [RTD-10-rev2], Barbara Barrigan-Parrilla [RTD-20] and Fred Lee [CSPA-6-Revised].

between these scenarios. Also, cyanobacteria in the Delta are not light limited during the period of the year (June–November) when temperatures are warm enough to support cyanobacteria growth. Because cyanobacteria in the Delta are not light limited, minor changes in turbidity would not have notable affects on cyanobacteria blooms. Furthermore, the Final EIR/EIS addressed this point on pages 8-971 through 8-973 and found that turbidity and total suspended solids changes would not be of sufficient frequency, magnitude, and geographic extent to result in adverse effects on beneficial uses in the Delta region, or substantially degrade the quality of water bodies, with regard to turbidity and total suspended solids.

E. Nutrient Effects

Testimony by other parties, including Mr. Erik Ringelberg and Mr. Burke on behalf of the South Delta Water Agencies and Mr. Lee on behalf of the California Sports Fishing Alliance asserts the CWF will increase nutrients in areas of the Delta thereby causing cyanoHABs to become worse.[8]

Opinion #9

Relatively small increases in nutrients in portions of the Delta due to the CWF would not be expected to increase the frequency, magnitude, or duration of cyanoHAB in the Delta, relative to that which would occur for the NAA.

This opinion and following testimony is supported by analysis presented in DWR-653, Section 4.5.

Although the CWF will cause relatively small increases in nutrients (N and P) in areas of the Delta due to more San Joaquin River water and less lower Sacramento River water, the small increase of nutrients is not expected to affect the frequency, magnitude, or duration of *Microcystis* blooms or other cyanoHABs in the Delta for two reasons. First, studies have not been able to link the initiation of *Microcystis* blooms and other

[8] Exhibit SJC-004, and see more generally Janet McCleary [SCDA-62-errata], Frank Morgan [SCDA-61-errata], Michael Broadsky [SCDA-60-errata], Tom Burke [SCDA-35; SDWA-76], Tim Stroshane [RTD-10-rev2], Barbara Barrigan-Parrilla [RTD-20] and Fred Lee [CSPA-6-Revised].

cyanoHABs, or their seasonal or inter-annual variation, to changes in nutrient concentrations or their N:P ratios in the Delta. Second, total N and P are already available in excess in Delta waters and thus are available in non-limiting amounts for *Microcystis* blooms in the Delta. Delta studies have not shown N or P to be depleted during blooms to levels where the magnitude or duration of the bloom is limited. Researchers that have reviewed the available science pertaining to cyanobacteria in the Delta have concluded that the initiation of *Microcystis* blooms and other cyanoHABs are probably not associated with changes in nutrient concentrations or their ratios in the Delta. In addition, studies outside the Delta have shown that the addition of only P in the form of orthophosphate (the form most readily available for algae) does not enhance growth in *Microcystis* blooms.

III. REBUTTAL OF TESTIMONY REGARDING THE EFFECTS OF THE CWF ON WATER QUALITY AT THE CITY'S WATER TREATEMT PLANT INTAKE ON THE SAN JOAQUIN RIVER

Testimony provided by the City of Stockton, presented by Mr. Robert Granberg, raised concerns about how the CWF may affect water quality at the City of Stockton's drinking water diversion location on the San Joaquin River, and how such water quality changes may impact the City in operating its Delta Water Supply Project Water Treatment Plant (DWSPWTP; hence forth "WTP"). Testimony by Mr. G. Fred Lee on behalf of the California Sportfishing Protection Alliance and Ms. Barbara Barrigan-Parrilla on behalf of Restore the Delta also raised concerns about the effects of the CWF at the City of Stockton drinking water diversion location.[9]

<u>Opinion #10</u>

The CWF would not alter water quality at the City of Stockton's WTP intake location in the San Joaquin River for identified constituents of concern in a manner that would cause adverse impacts to the municipal and industrial supply beneficial uses at this river location.

[9] [STKN-010], [CSPA-6],[RTD-20],and [RTD-10-Rev2].

This opinion and following testimony is supported by analysis presented in my technical report, *Report on the Effects of the California WaterFix on Water Quality at City Of Stockton's Water Treatment Plant Intake Location on the San Joaquin River* [Exhibit DWR-652].[10]

The constituent assessments for bromide, chloride, electrical conductivity (EC), nitrate, and organic carbon rely upon DSM2 modeling of operational scenarios for the NAA, 4A-H3, 4A-H4, Boundary 1 and Boundary 2 as presented in DWR's case-in-chief.

Electrical conductivity and organic carbon were directly modeled by DSM2. The mass-balance methodology for calculating concentrations for the other constituents assessed from the DSM2 fingerprinting or flow-fraction modeling output is the same methodology defined in the CWF EIR/EIS[11].

The following provides assessment conclusions based on the analysis presented in my supporting technical report.

- Bromide: Analysis for bromide is provided in Section 3.3.1 of Exhibit DWR-652. The modeling results indicate that the CWF is anticipated to result in bromide conditions at the City's diversion location that would be very similar to that which would occur under the NAA, and more often lower on an annual average basis. The increases in bromide concentrations that could occur at this site due to the CWF, relative to the NAA, would be of a magnitude that would not cause substantial degradation and would result in only small increases (estimated at 4% or less) in TTHM production in the City's treated drinking water supply.

[10] The concerns raised by the City of Stockton regarding water quality at its municipal intake were adequately addressed in the EIR/EIS. In order to demonstrate that their assertions that the EIR/EIS must model each and every point in the Delta in order to be complete, an additional analysis was performed and its results are within the expected results based upon the anlaysis contained in the EIR/EIS.

[11] Section 8.4.1.3, *Plan Area*, in Chapter 8, *Water Quality*, of the Bay Delta Conservation Plan Draft EIR/EIS; Section 8.3.1.3, *Plan Area*, in Chapter 8, *Water Quality*, of the Bay Delta Conservation Plan/California WaterFix Partially Recirculated Draft EIR/Supplemental Draft EIS and Final EIR/EIS.

- Chloride: Analysis for chloride is provided in Section 3.3.2 of Exhibit DWR-652. The modeling results indicate that the CWF is anticipated to result in chloride conditions at the City's diversion location that would typically be very similar to that which would occur under the NAA. The increases in chloride concentrations that could occur at this site for the CWF during some periods, relative to the NAA, would not be of a frequency and magnitude that would cause substantial degradation or an exceedance of the applicable 250 mg/L MCL, on a mean monthly basis, and thus would not adversely impact the MUN beneficial use.
- EC: Analysis for EC is provided in Section 3.3.3 of Exhibit DWR-652. The modeling results indicate that the CWF is anticipated to result in EC levels at the City's diversion location that would sometimes be higher and other times lower than that for the NAA, with long-term average EC levels for the CWF and NAA being similar (within 5%). The increases in EC levels that would be anticipated to occur at this site for the CWF, relative to the NAA, would not be of a magnitude that would cause substantial degradation or an exceedance of the applicable drinking water MCLs, on a mean monthly basis, with the exception of Boundary 1, where the 900 µS/cm MCL was modeled to be exceeded 1% of the time.
- Nitrate: Analysis for nitrate is provided in Section 3.3.4 of Exhibit DWR-652. The modeling results indicate that the CWF is anticipated to result in nitrate conditions at the City's diversion location that would typically be slightly higher (about 0.1–0.2 mg/L-N on average) than that which would occur under the NAA, but would remain at low levels compared to the applicable nitrate objectives of 10 mg/L-N for the protection of the MUN beneficial use. The increases in nitrate concentrations that would be anticipated to occur at this site for the CWF, relative to the NAA, would not be of a magnitude that would cause substantial degradation or any exceedances of the applicable 10 mg/L MCL, on a mean monthly basis.
- Organic Carbon: Analysis for organic carbon is provided in Section 3.3.5 of Exhibit DWR-652. The modeling results indicate that the CWF would not result in

substantial degradation of water quality with respect to dissolved organic carbon (DOC), and is anticipated to result in small increases in average DOC concentrations at the City's diversion location (typically 0.1–0.2 mg/L), relative to that which would occur for the NAA. DOC concentrations would nearly always remain within the 4–7 mg/L range determined to be acceptable to provide WTPs adequate flexibility in their choice of treatment method to maintain compliance with current Disinfectants and Disinfection Byproducts Rules and the drinking water MCLs. When DOC levels at the City's diversion location would be above 7 mg/L in wet and above normal years, the frequency and magnitude with which DOC levels would be above 7 mg/L would be nearly the same for the CWF scenarios and the NAA.

- Pesticides: Analysis for pesticides is provided in Section 3.3.6 of Exhibit DWR-652. Many of the pesticides regulated by drinking water MCLs have been phased-out of use, some since the 1980s and others as recently as the 2000s. For those with current registered uses, a shifting in the source waters at the City's intake from Sacramento River water to more San Joaquin River water, or vice versa, due to the CWF would not be expected to contribute to drinking water MCLs for pesticides being exceeded in the City's drinking water supply.
- Other Toxins: Analysis for other toxins is provided in Section 3.3.7 of Exhibit DWR-652. A constituent "screening analysis" was performed as the first portion of the overall water quality analysis of the CWF in the EIR/EIS. The overall purpose of the screening analysis was to assess 182 constituents (or classes of constituents) for their potential to adversely affect water quality in the Delta based on changes in hydrodynamics (i.e., mixing of source waters) driven by to the alternatives being assessed, including the CWF. Of the 182 constituents analyzed, no adverse water quality impact was identified for any toxic pollutant due to CWF operations.
- Temperature: Temperature differences between the NAA and CWF, as discussed above, would not be a driving factor in HABs in the Delta. Analysis for temperature is provided in Section 3.3.8 of Exhibit DWR-652, which references Exhibit DWR-653

for an assessment of the CWF effects on water temperatures in the Delta and how such temperature effects could, in turn, affect harmful algal blooms in the Delta.

- Microcystis: Analysis for *Microcystis* is provided in Section 3.3.9 of Exhibit DWR-652. This section of the report analyzes river velocity near the City's WTP intake location, and references Exhibit DWR-653 for analysis of temperature effects of the CWF in the San Joaquin River and the assessment of CWF effects on *Microcystis* blooms in the Delta. Collectively, the key drivers (e.g., channel velocity, temperature, irradiance, nutrients) of *Microcystis* and other cyanobacteria blooms would not be changed sufficiently by the CWF near the City of Stockton's WTP intake location on the San Joaquin River to cause more frequent or larger magnitude *Microcystis* or other cyanobacteria blooms in this river reach, relative to the NAA.
- Turbidity: Analysis for turbidity is provided in Section 3.3.10 of Exhibit DWR-652. Turbidity was a parameter assessed in Chapter 8, Water Quality, of the BDCP Draft EIR/EIS, BDCP/CWF RDEIR/SDEIS, and BDCP/CWF Final EIR/EIS for all project alternatives. Turbidity was assessed in a qualitative manner for the Delta and, thus, addressed the potential impacts at the City of Stockton's drinking water diversion location. The impact determination for all CWF alternatives was "less than significant" for CEQA purposes and "not adverse" for NEPA purposes for the Delta region. Nevertheless, project proponents have developed a sediment reintroduction plan to mitigate for the potential loss of turbidity due to the new north Delta diversions.
- Selenium and Mercury: Analysis for selenium and mercury is provided in Section 3.3.11 of Exhibit DWR-652. Mercury and selenium impacts resulting from construction and operation of the CWF were addressed in Chapter 8, Water Quality, of the BDCP/CWF RDEIR/SDEIS and Final EIR/EIS. Modeling results shows that concentrations of selenium and mercury in Delta waters in the vicinity of the City's WTP intake location are orders of magnitude below drinking water MCLs. Consequently, the construction and operation of the CWF would not result in

mercury, methylmercury, or selenium concentration increases in the San Joaquin River of magnitude that would cause issue with MCL compliance or require increased treatment requirements at the City of Stockton's WTP.

Executed on this 22 day of March, 2017 in Sacramento, California.

(Michael Bryan)