WATER QUALITY

OVERVIEW OF TESTIMONY

- **CWF effects on harmful algal blooms (HABs) and water quality at City of Sacramento water treatment plant (WTP) intakes**
- **CWF effects on HABs in the Delta**
- **CWF effects on HABs and water quality at City of Stockton WTP intake on the San Joaquin River**

CWF EFFECTS AT CITY OF SACRAMENTO WTP INTAKES

- **Opinions presented regarding:**
  - Harmful algal blooms (HABs)
    - Effects of river velocity
    - Effects of river temperature
  - Disinfection byproduct formation potential
    - Effects of river temperature
  - Water Quality
    - Dissolved metals concentrations
    - Dissolved organic carbon

OPINION 1

Lower Sacramento River HABs

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 River WTP intake, relative to the NAA.

HABS
RIVER FLOW AND VELOCITY ANALYSES

- **Sacramento River**
  - Velocity exceedance plots for River Mile 58
    - About two miles downstream of Sacramento River WTP
  - Daily maximum and absolute 15-minute velocities
  - 16-year period modeled (1976 to 1991)

- **American River**
  - Flow below Nimbus Dam from CalSim II
  - 82-year period modeled (1922 to 2003)

HABS
RIVER VELOCITY ANALYSIS (CONT.)

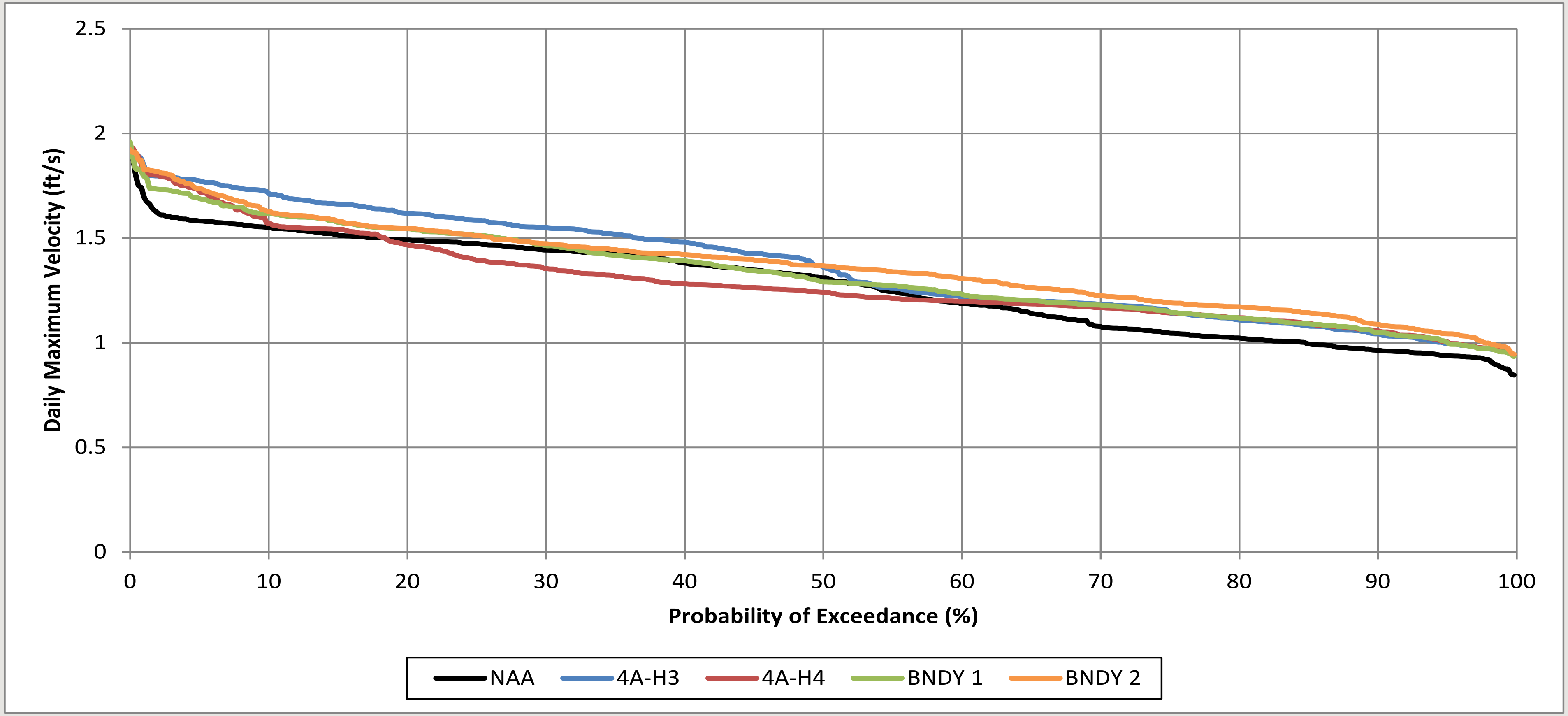
- **Flow velocity in range of 0.1 to 1.3 ft/s disrupts *Microcystis* blooms** **(Mitrovic et al. 2003, Zhang et al. 2007, Long et al. 2011, as cited in Zhang et al. 2015, Mitrovic et al. 2011, Li et al. 2013).**
- **Velocities of 0.2 to 1.0 ft/s disrupted *Microcystis* blooms and shifted the dominant phytoplankton to green algae and diatoms** **(Li et al. 2013, Zhang et al. 2015).**
- **Velocities above 1.0 ft/s quickly disrupted an established cyanobacteria bloom in Darling River, Australia (Mitrovic et al. 2011)**
- ***Channel velocities above about 0.2 ft/s become increasing less favorable for cyanobacteria, including Microcystis.***

HABS
RIVER TEMPERATURE EFFECTS ANALYSIS

- **Temperature modeling output for 82-year period (1922 to 2003) as contained in BA**

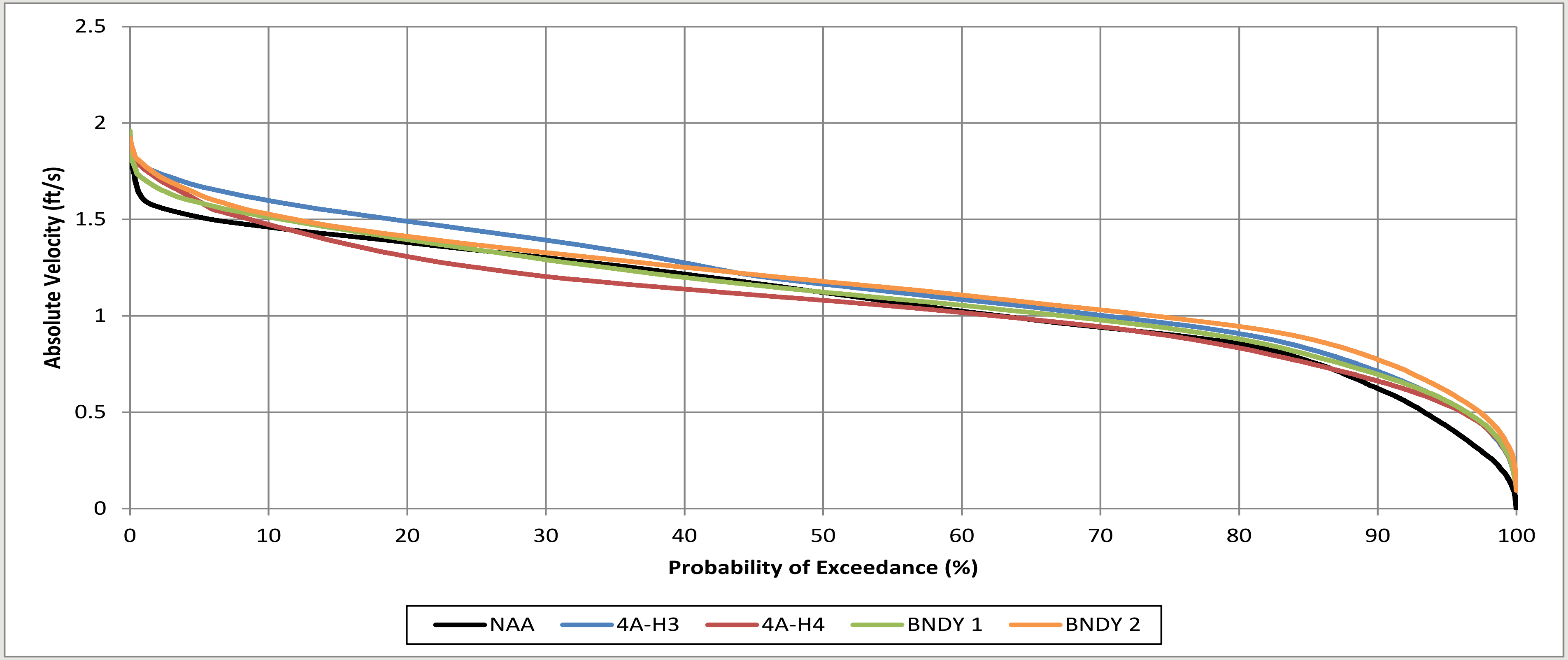
- **Locations:**
  - Sacramento River at Knights Landing
  - American River at Watt Avenue

LOWER SACRAMENTO RIVER VELOCITY



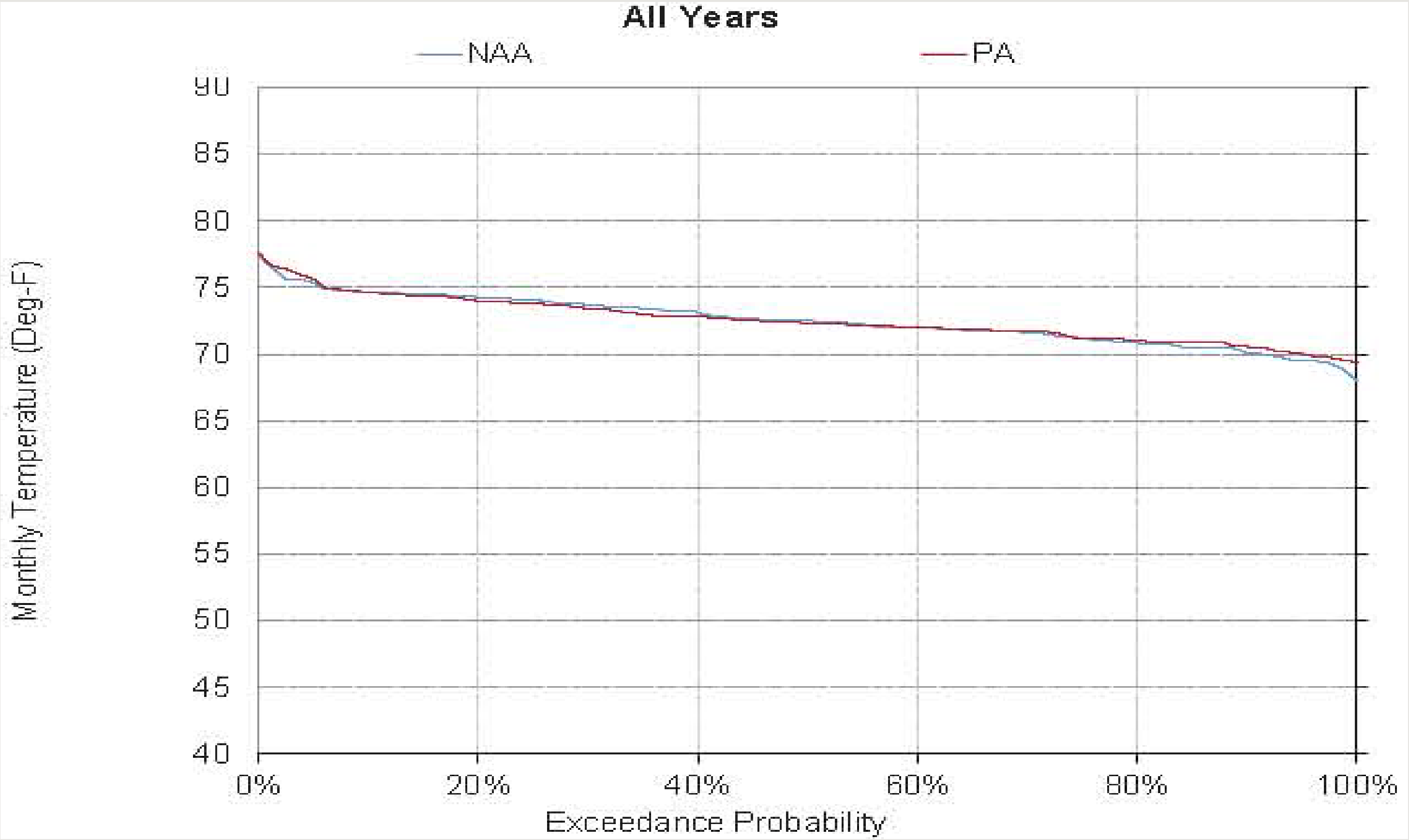
Probability of exceedance of **daily maximum** velocity in the lower Sacramento River at RM 58 for **August** (1976–1991 period of record modeled).

LOWER SACRAMENTO RIVER VELOCITY



Probability of exceedance of **15-minute** velocity in the lower Sacramento River at RM 58 for **August** (1976–1991 period of record modeled).

LOWER SACRAMENTO RIVER TEMPERATURE



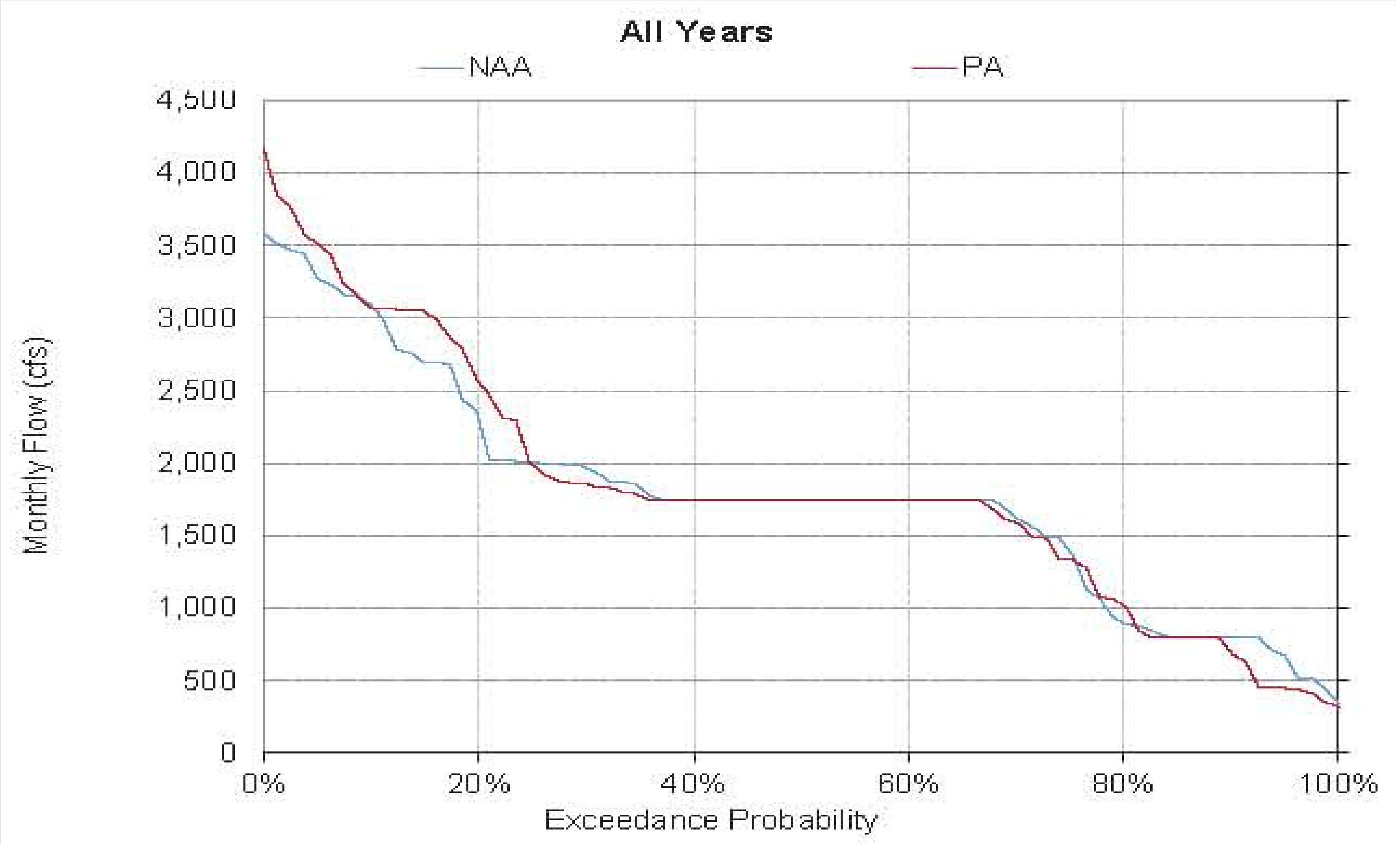
Probability of exceedance of **temperature** for **August** at Knights Landing (1922 – 2003 period of record modeled).

OPINION 2

Lower American River HABs:

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.

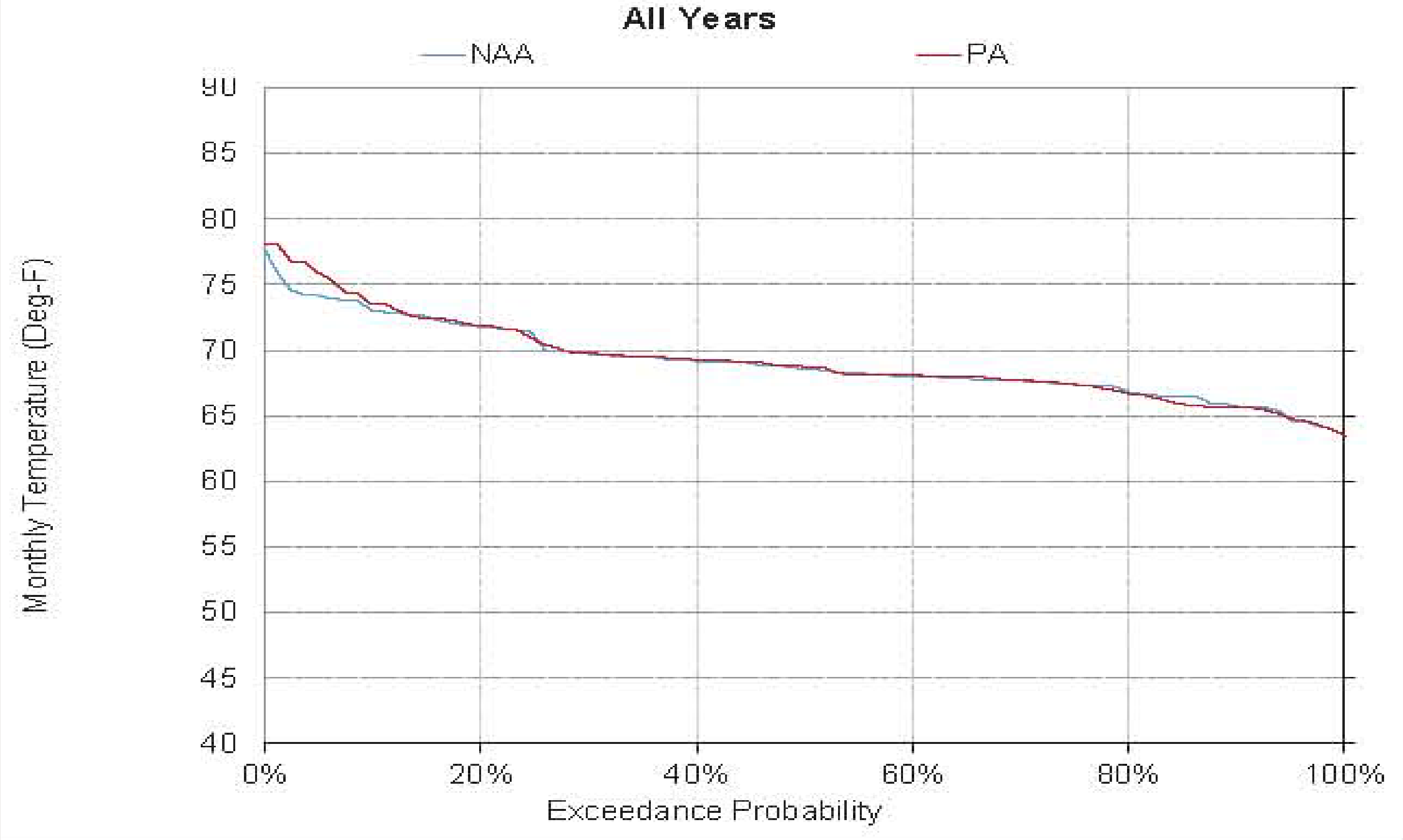
LOWER AMERICAN RIVER FLOW



Probability of exceedance of river flow for August below Nimbus Dam (1922–2003 period of record modeled).

Conclusion: The frequency of low flows is very similar for the CWF and NAA

LOWER AMERICAN RIVER TEMPERATURE



Probability of exceedance of **temperature** for **August** at Watt Avenue (1922 – 2003 period of record modeled).

Conclusion: Range and frequency of river temperatures are very similar for CWF and NAA

OPINION 3

DBPs at City of Sacramento WTPs:

The CWF would not cause increases 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.

TEMPERATURE AND DBP FORMATION POTENTIAL

Lower Sacramento River

- **CWF Max annual average temperature increase = 0.1°F**
- **Max potential TTHM increase (5 models):**

  0.4%

Lower American River

- **CWF Max annual average temperature increase = 0.5°F**
- **Max potential TTHM increase (5 models):**

  1.6%

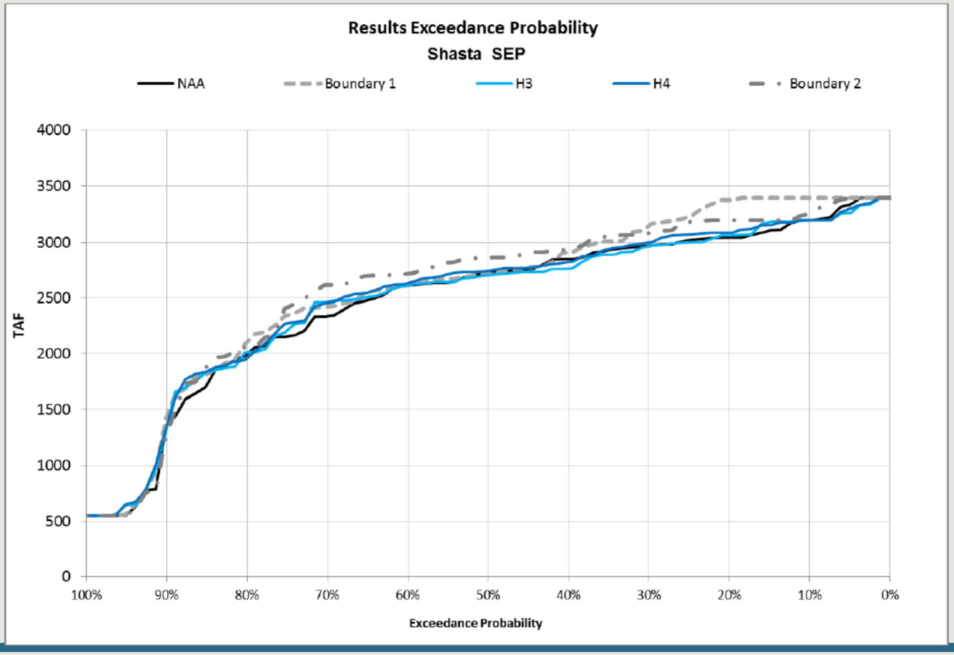
ORGANIC CARBON AND DBP FORMATION POTENTIAL

- **Cyanobacteria:**
  - Would not change notably in either river between the CWF and the NAA, and thus would not contribute to higher DOC in river
- **Reservoir Storage:**
  - No relationship between storage and river organic carbon concentrations, as claimed
  - Potential additional exposed Folsom Reservoir shoreline in fall months <0.01% of watershed

NO SIGNIFICANT CHANGE IN STORAGE

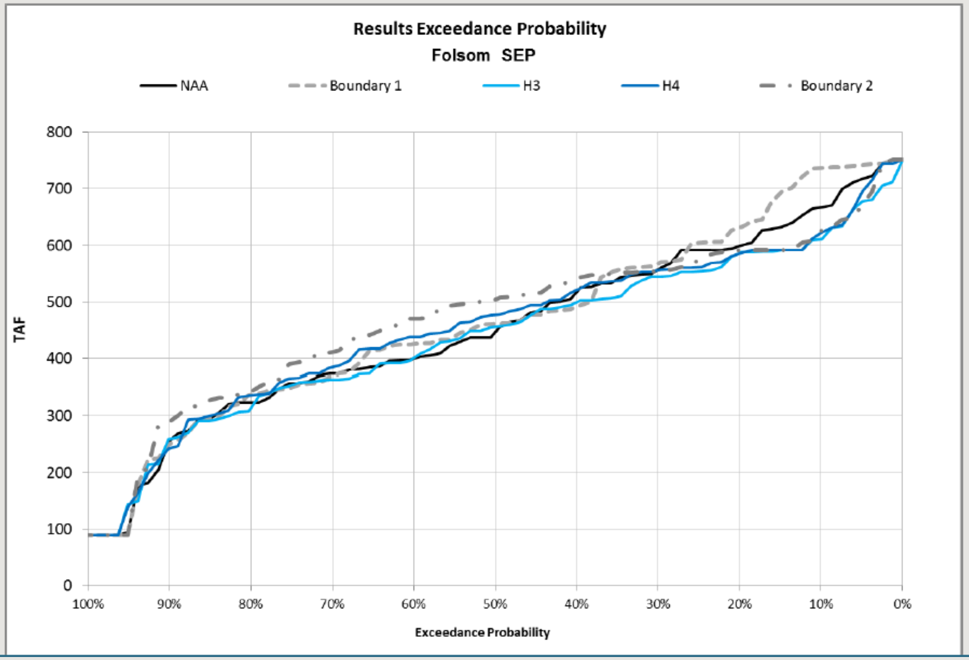
SHASTA LAKE END OF SEPTEMBER STORAGE

Early Long-Term (ELT) alternatives are simulated with 2025 climate change & sea level rise



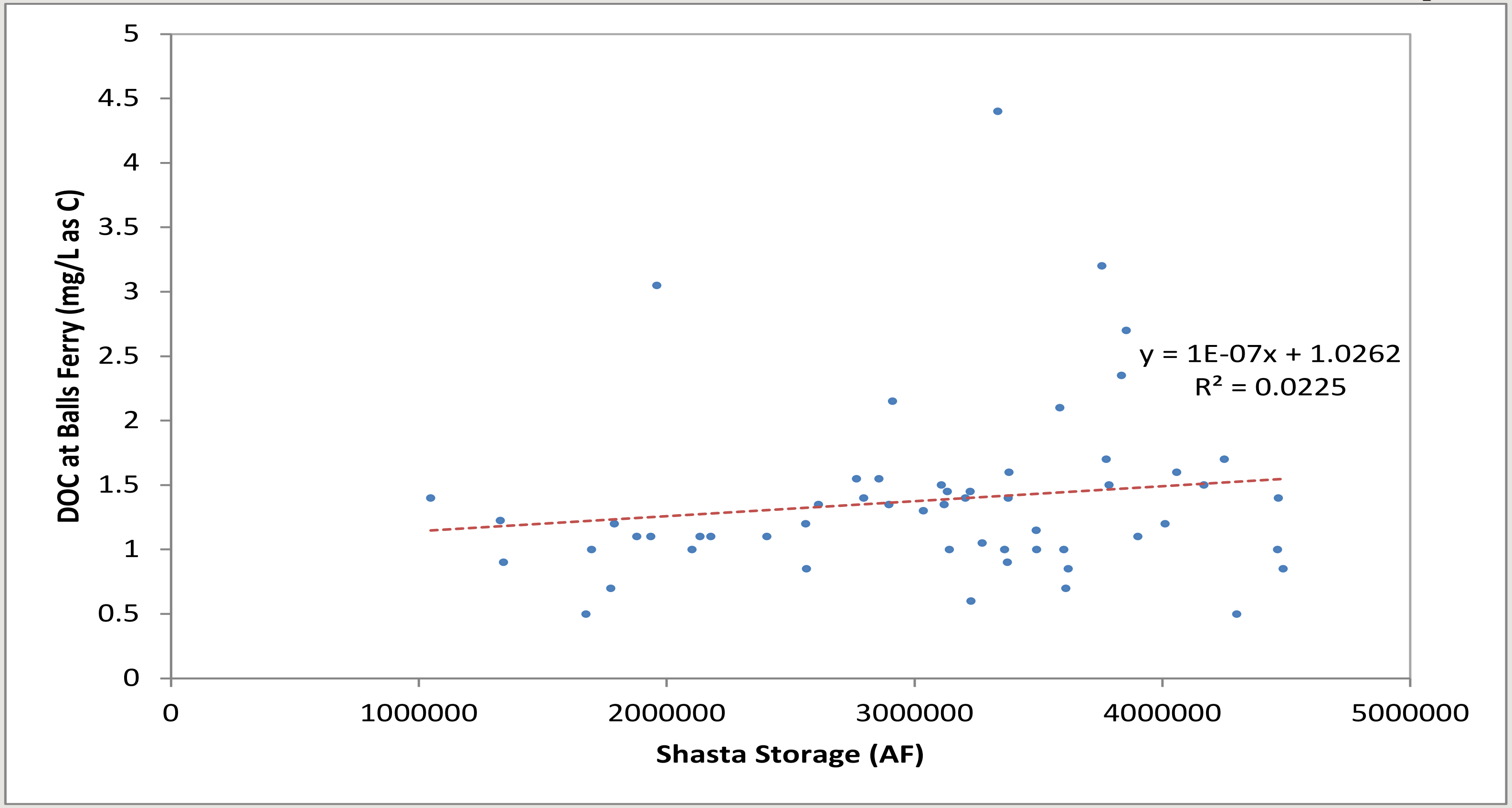
FOLSOM LAKE END OF SEPTEMBER STORAGE

Early Long-Term (ELT) alternatives are simulated with 2025 climate change & sea level rise



Figures from DWR Exhibit 5 (Errata) pp. 47 and 48

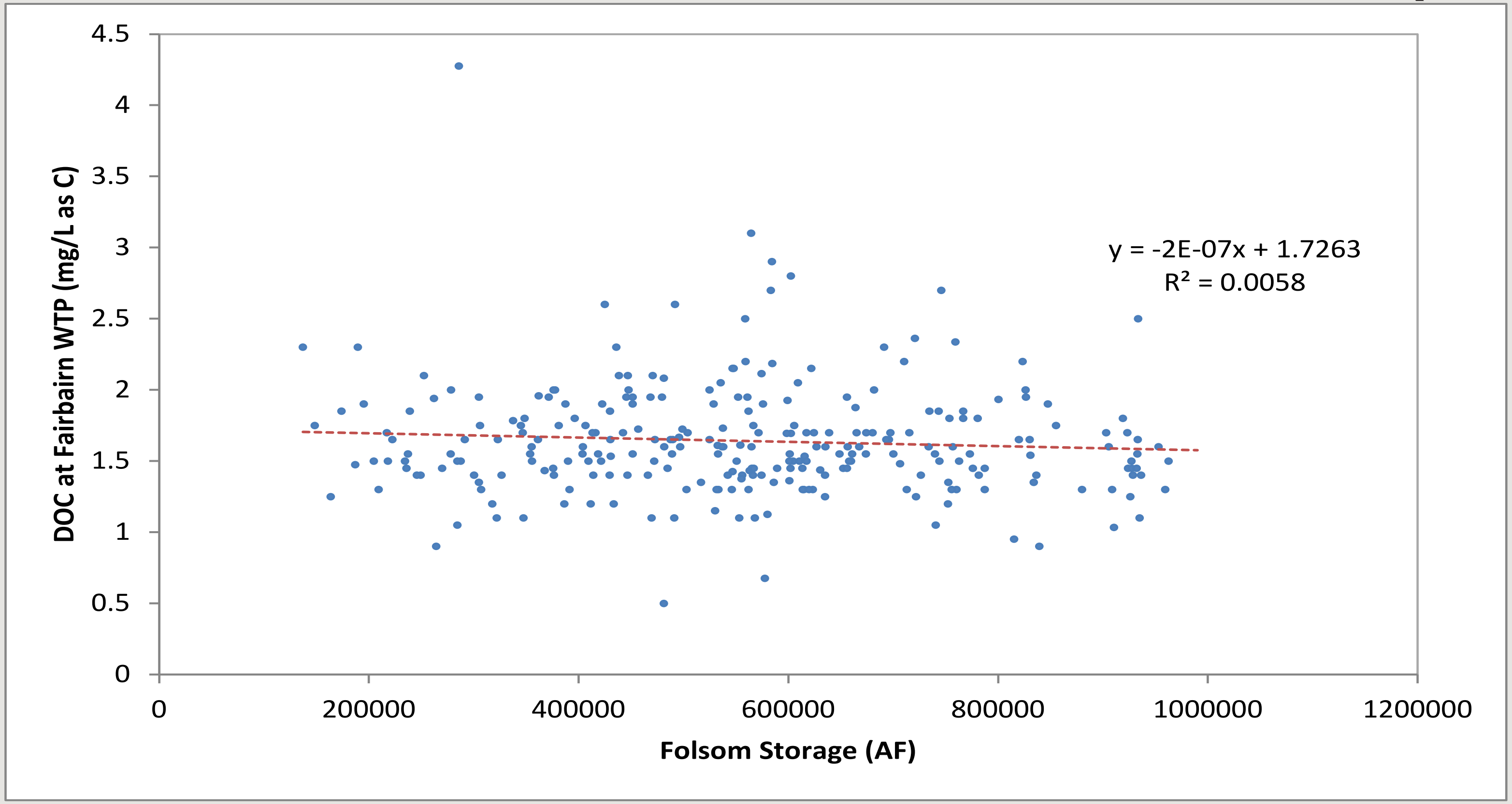
SHASTA RESERVOIR STORAGE VS. RIVER DISSOLVED ORGANIC CARBON (DOC)



Dissolved organic carbon (DOC) concentration in the lower Sacramento River at Balls Ferry versus end-of-month Shasta Reservoir storage for 2005–2016.

Conclusion: DOC in river does not go up as storage goes down

FOLSOM RESERVOIR STORAGE VS. RIVER DISSOLVED ORGANIC CARBON (DOC)



Dissolved organic carbon (DOC) concentration in the lower American River at E.A. Fairbairn WTP versus end-of-month Folsom Reservoir storage for 1994–2016.

Conclusion: DOC in river does not go up as storage goes down

OPINION 4

Reservoir Storage and Dissolved Metals in Rivers:

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 rivers and thus would not cause additional treatment requirements at either WTP

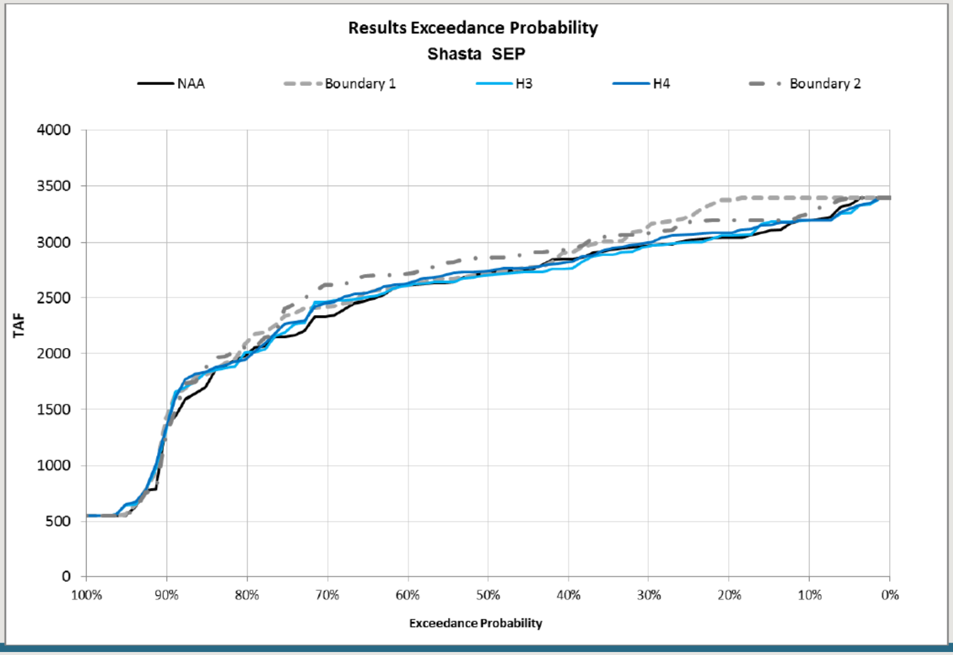
RESERVOIR STORAGE AND DISSOLVED METALS

- **No change in dissolved metals**
  - No significant difference in end-of-September reservoir storage levels (NAA v. CWF)
  - Lower reservoir storage not correlated with increased river metals concentrations

NO SIGNIFICANT CHANGE IN STORAGE

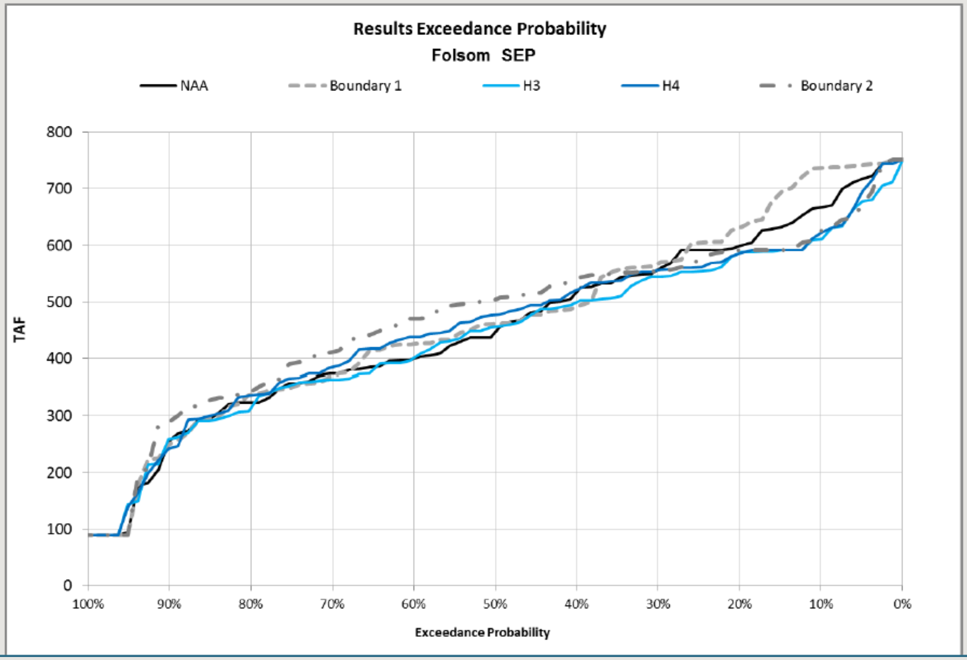
SHASTA LAKE END OF SEPTEMBER STORAGE

Early Long-Term (ELT) alternatives are simulated with 2025 climate change & sea level rise



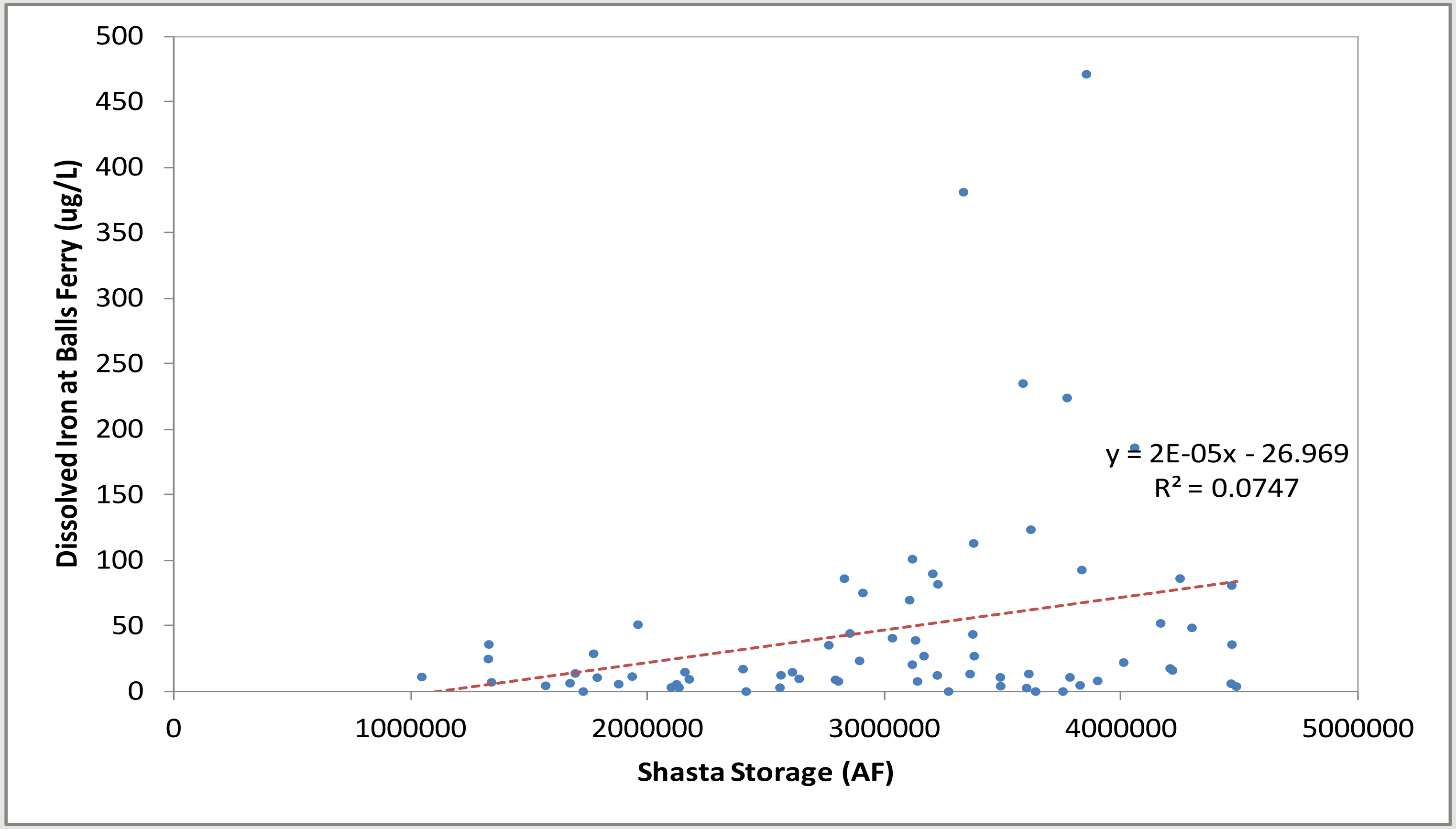
FOLSOM LAKE END OF SEPTEMBER STORAGE

Early Long-Term (ELT) alternatives are simulated with 2025 climate change & sea level rise



Figures from DWR Exhibit 5 (Errata) pp. 47 and 48

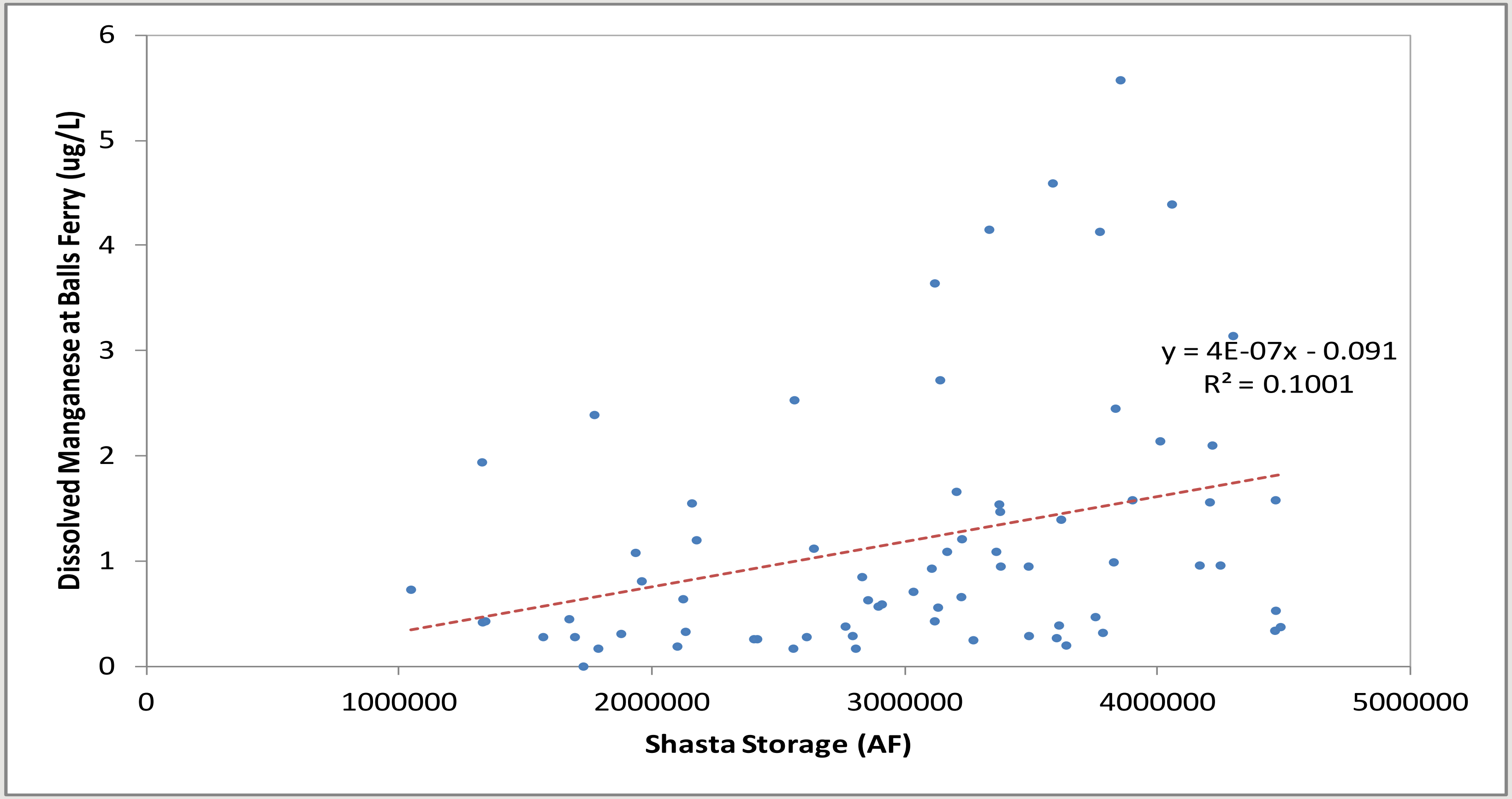
RESERVOIR STORAGE VS. RIVER DISSOLVED IRON CONC.



Dissolved iron concentration in the lower Sacramento River at Balls Ferry versus end-of-month Shasta Reservoir storage for 2004–2016.

Conclusion: Lower storage may be weakly related to lower metals, not higher

RESERVOIR STORAGE VS. RIVER DISSOLVED MANGANESE CONC.



Dissolved manganese concentration in the lower Sacramento River at Balls Ferry versus end-of-month Shasta Reservoir storage for 2004–2016.

Conclusion: Lower storage may be weakly related to lower metals, not higher

CWF EFFECTS ON DELTA HABS

- **Opinions presented regarding CWF effects on HABs in the Delta as affected by:**
  - Flow and associated velocity and residence time
  - Temperature
  - Turbidity
  - Nutrients

OPINION 5

Delta Flows and HABs:

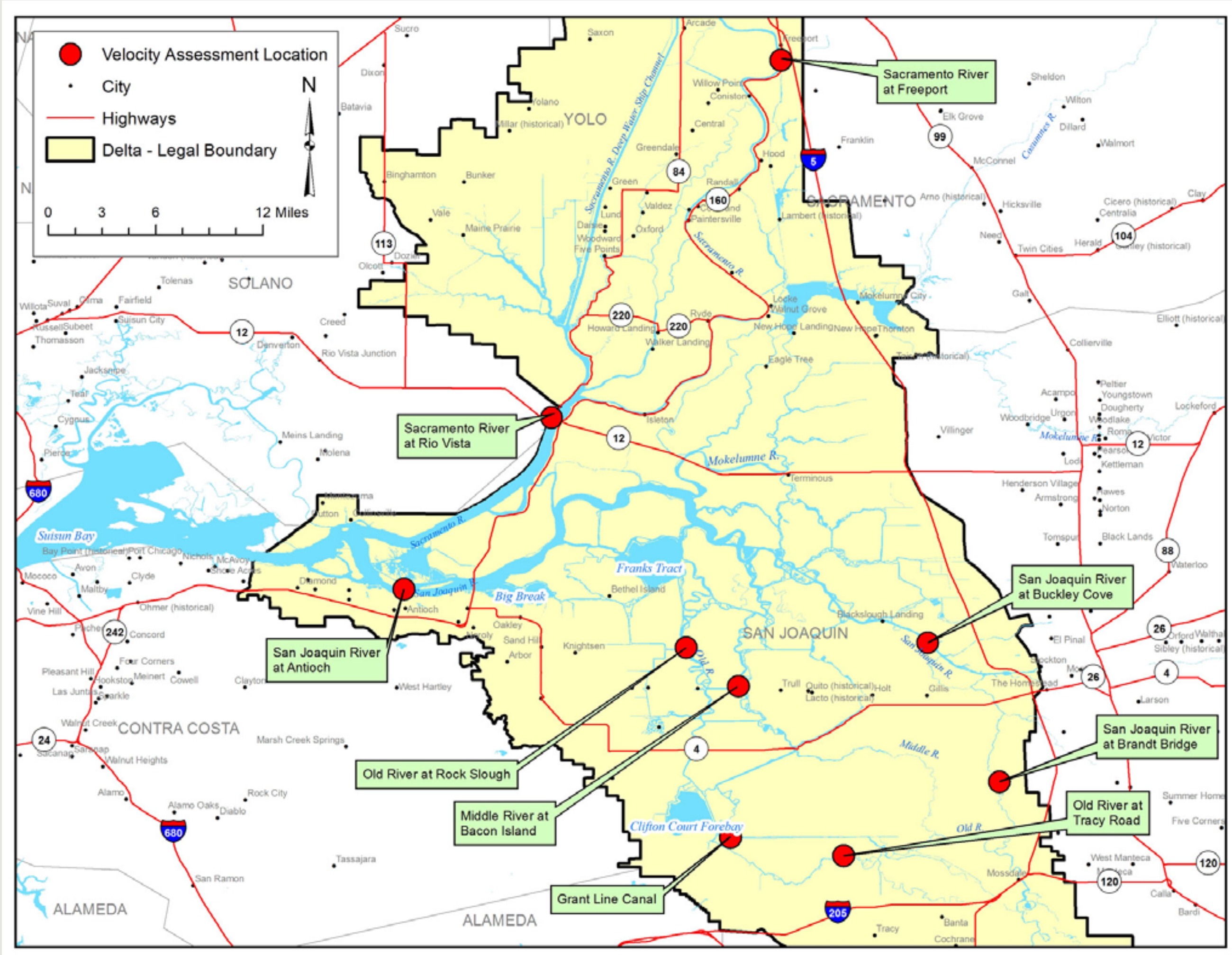
Although *Microcystis* blooms are expected to occur at certain Delta locations in the future, as they have historically, channel velocities at various Delta locations would not be altered to a degree that would make hydrodynamic conditions substantially more conducive to *Microcystis* blooms for the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

DELTA FLOW VELOCITY EFFECTS ANALYSIS

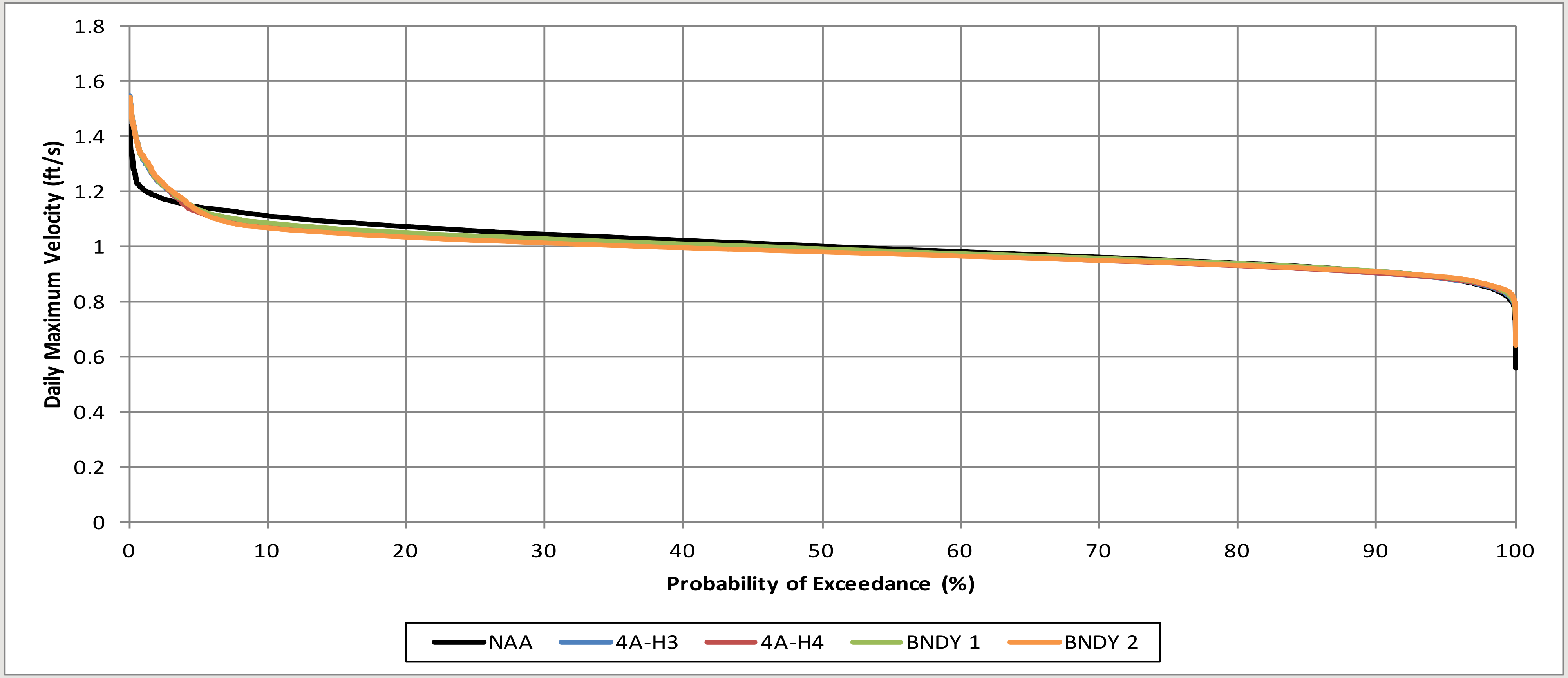
- **Velocity exceedance plots**
  - Daily maximum velocities
  - Absolute 15-minute velocities (regardless of flow direction in channel)
  - 16-year period modeled (1976 to 1991)

- **Nine Delta locations, which are representative of the entire Delta.**

DELTA FLOW VELOCITY EFFECTS ANALYSIS

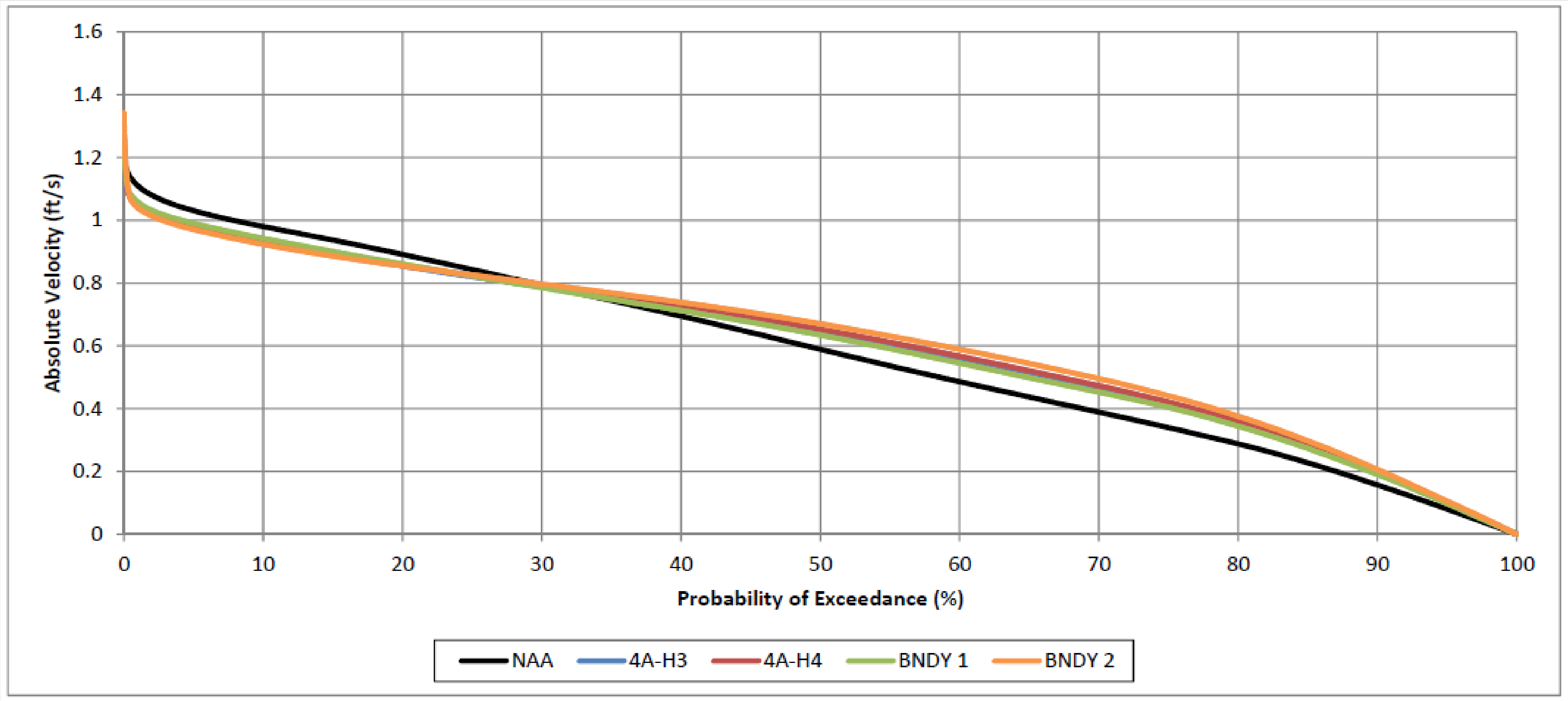


DAILY MAX VELOCITY: OLD RIVER AT ROCK SLOUGH



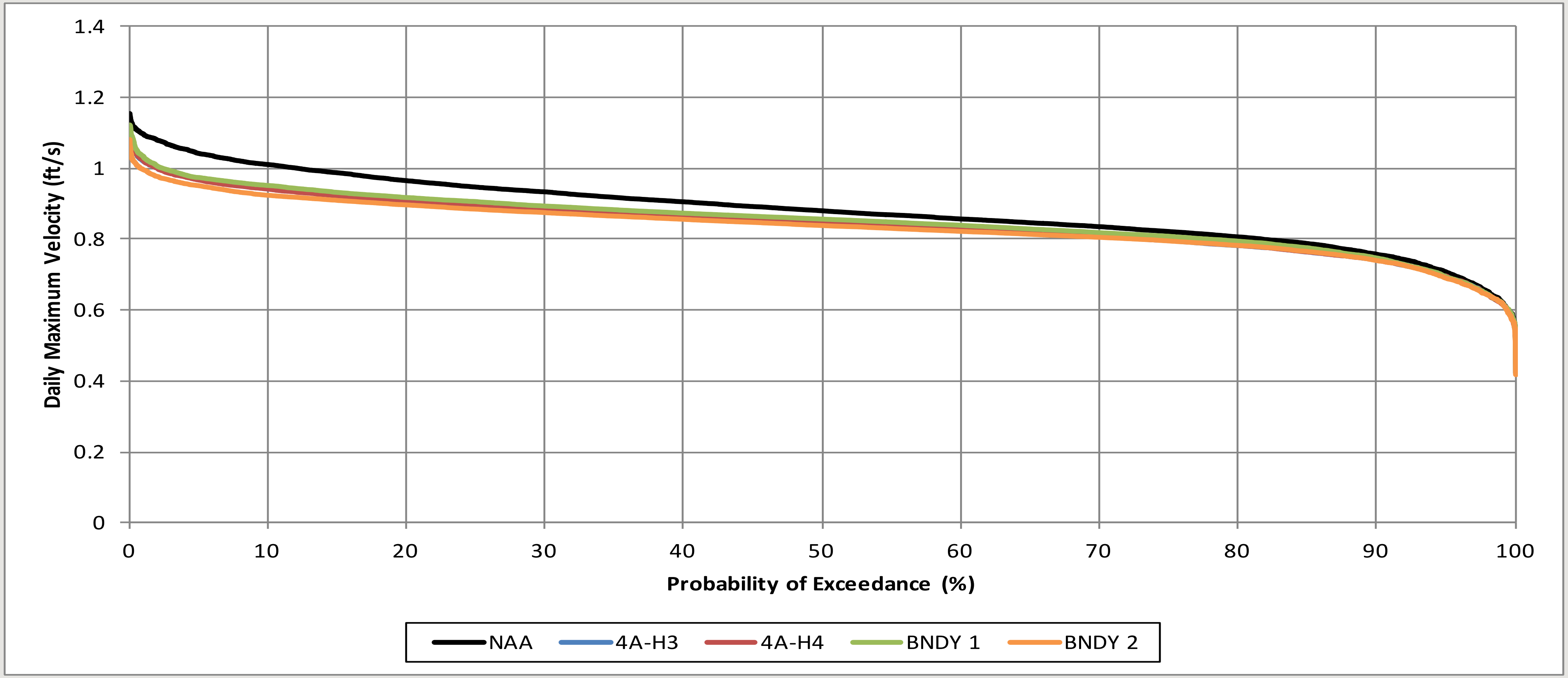
Probability of exceedance of daily maximum velocity for the 1976–1991 period of record modeled.

15-MINUTE VELOCITY
OLD RIVER AT ROCK SLOUGH



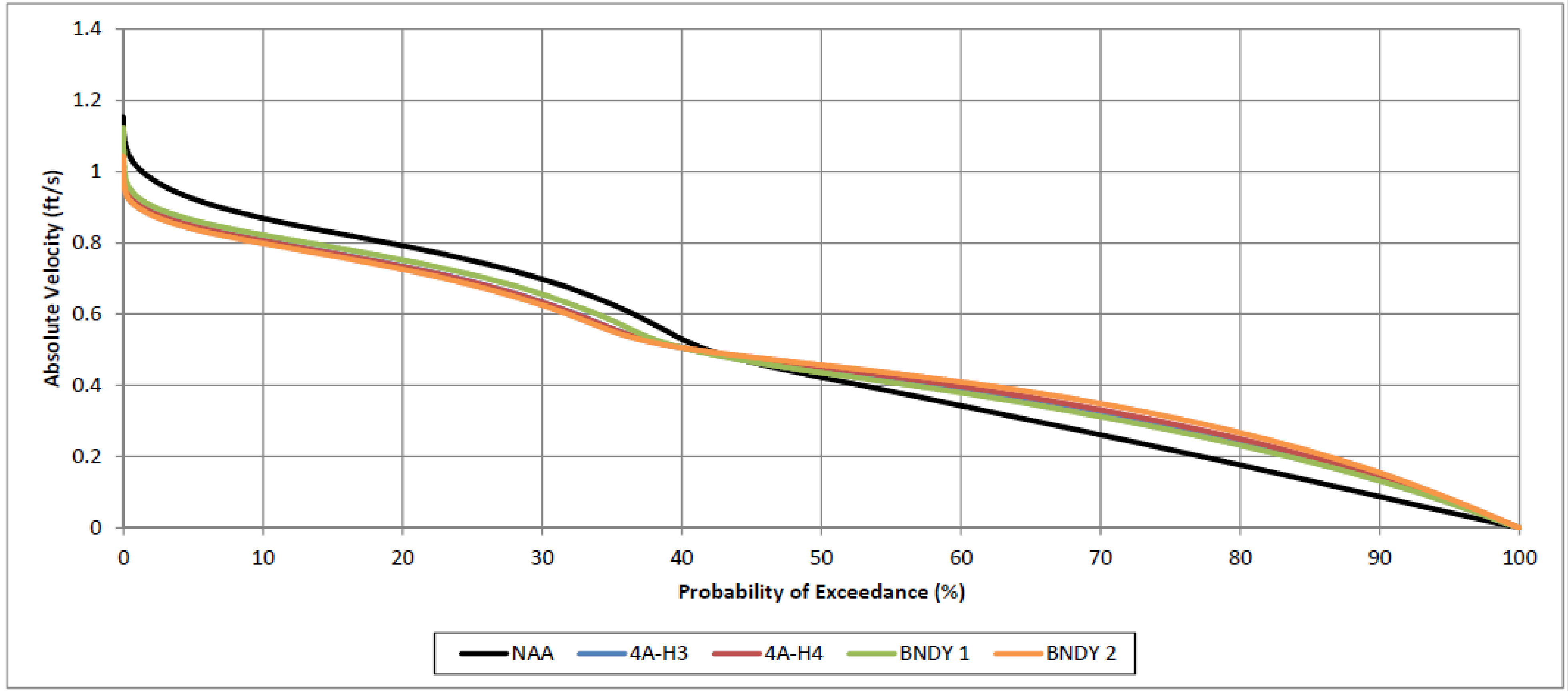
Probability of exceedance of absolute values of daily velocities, on a 15-minute time-step, for the **June through November period** (1976–1991 period of record modeled).

DAILY MAX VELOCITY: MIDDLE RIVER AT BACON ISLAND



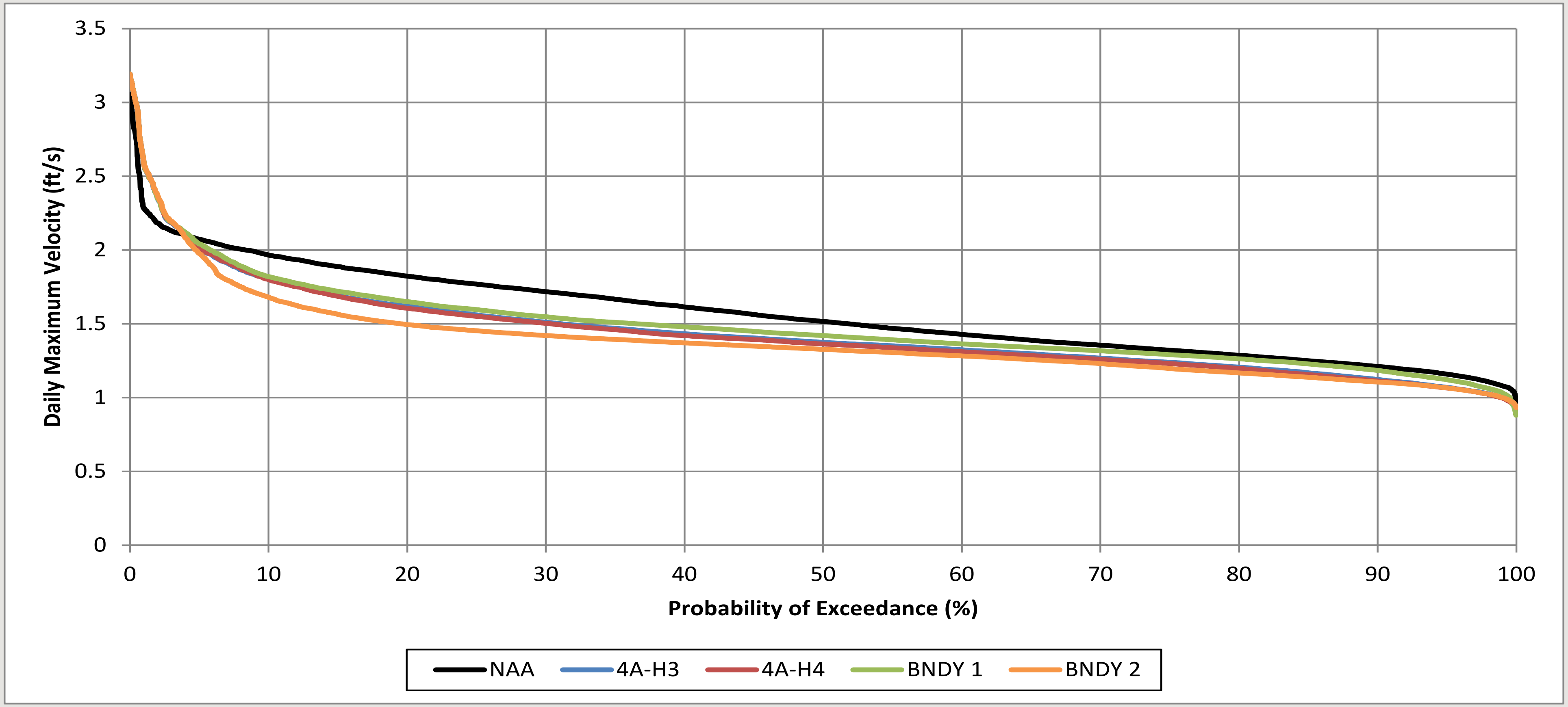
Probability of exceedance of daily maximum velocity for the 1976–1991 period of record modeled.

15-MINUTE VELOCITY:
MIDDLE RIVER AT BACON ISLAND



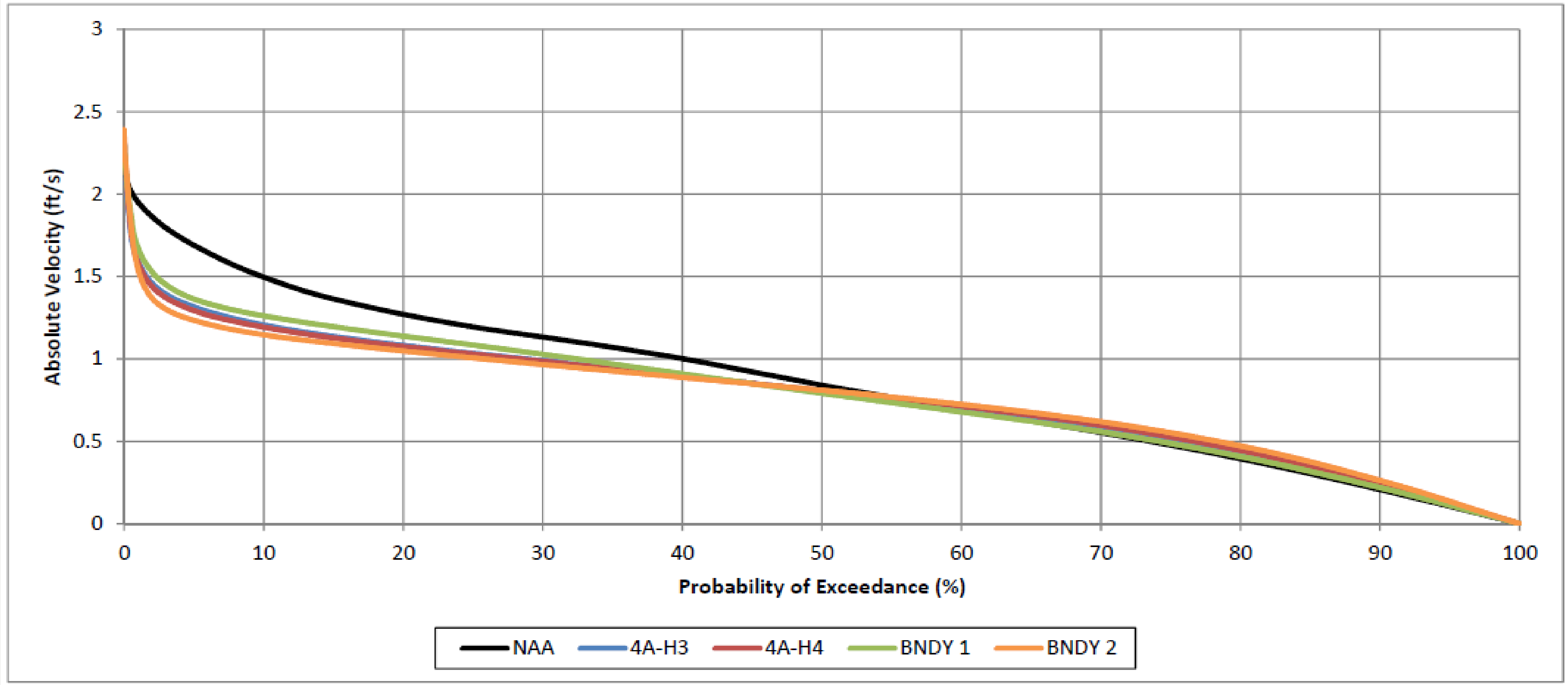
Probability of exceedance of absolute values of daily velocities, on a 15-minute time-step, during the months **June through November** for the 1976–1991 period of record modeled.

CWF EFFECTS ON VELOCITY OLD RIVER AT HWY 4



Probability of exceedance of daily maximum velocity during for the 1976–1991 period of record modeled.

CWF EFFECTS ON VELOCITY
OLD RIVER AT HWY 4



Probability of exceedance of absolute values of daily velocities, on a 15-minute time-step, during the months **June through November** for the 1976–1991 period of record modeled.

OPINION 6

Delta Residence Time and HABs:

Increased residence time alone does not equate with increased *Microcystis* bloom frequency or magnitude. Based on current science, it is uncertain how cyanoHABs would react to the CWF-driven changes in residence time.

RESIDENCE TIME

- **Channel velocity is the driver of:**
  - Residence time
  - Channel turbulence and mixing (which affects competition with other algae for resources)
  - In-channel turbidity
- **Because these and other factors interact in a complex fashion to affect cyanoHABs, increased or “long” residence times do not always result in bloom occurrence or increased bloom magnitude.**

RESIDENCE TIME DOES NOT ACT ALONE IN AFFECTING *MICROCYSTIS* BLOOM SIZE

- Other factors affecting *Microcystis* bloom magnitude in the Delta include:
  - daily in-channel absolute velocities, turbulence, and mixing
  - turbidity and irradiance
  - temperature
  - competition with other algal species
  - grazing losses to zooplankton, fish, and clams
- 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.

LONG RESIDENCE TIME DOES NOT ALWAYS TRANSLATE INTO LARGE *MICROCYSTIS* BLOOMS

- In the Stockton DWSC, where long summer residence times occur annually, a three year study documented a large persistent *Microcystis* bloom in 2012 but not in 2009 or 2011 (Spier et al. 2013).
- Environmental conditions were similar in 2012 and 2009 and *Microcystis* cells were present in 2009, yet no large bloom occurred in 2009.
- No specific environmental factor could be attributed to the 2012 bloom (Spier et al. 2013).
- This suggests *Microcystis* ecology and competition with other algae is complex, and longer residence times do not necessarily indicate that a bloom will form.

OPINION 7

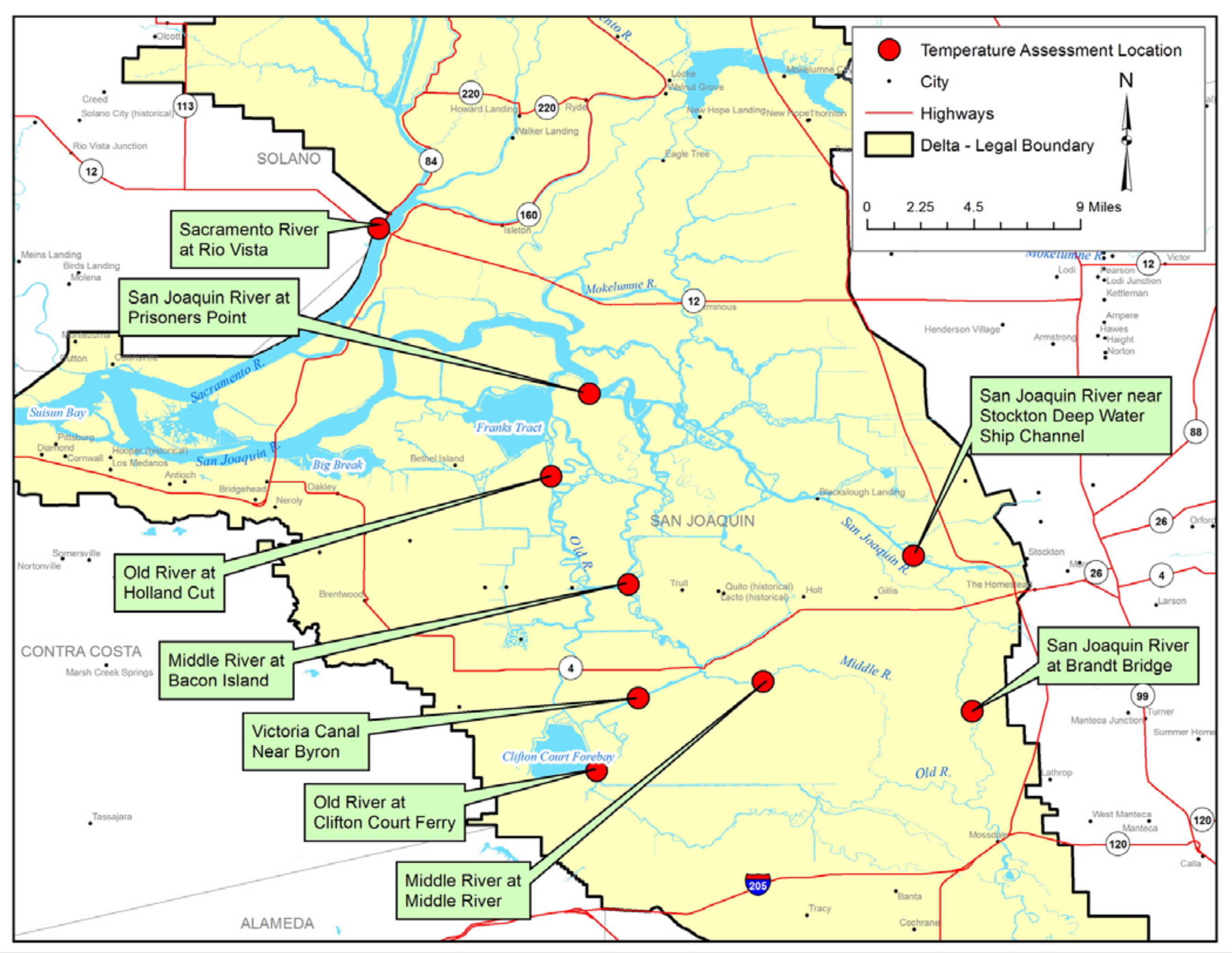
Delta Temperature and HABs:

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.

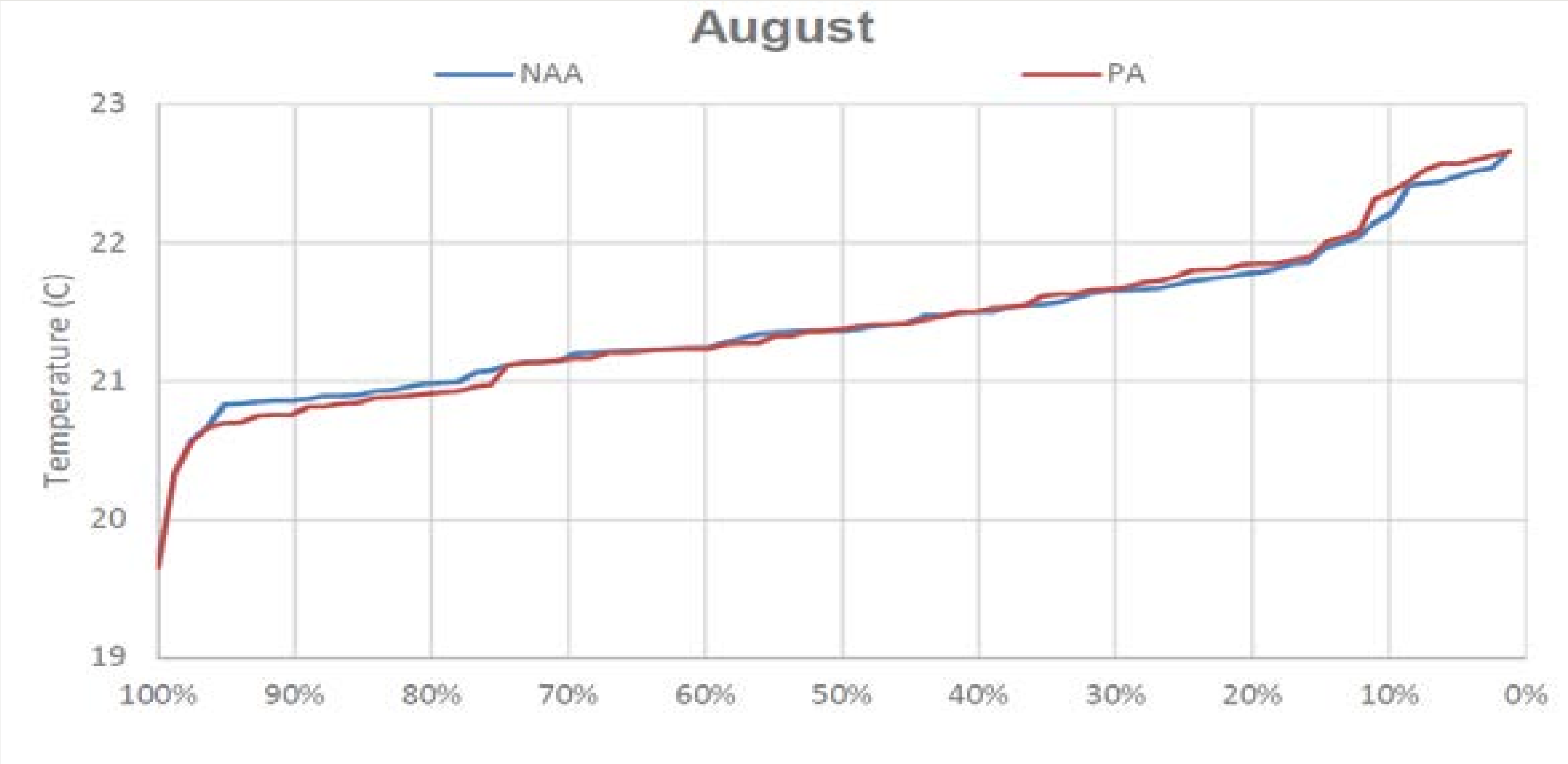
DELTA TEMPERATURE EFFECTS ANALYSIS

- **Modeling for NAA and 4A-H3+ for Biological Assessment**
- **DSM2 Temperature Model**
- **Exceedance plots**
  - 82-year period modeled (1922 to 2003)
- **Nine Locations, representative of the Delta**

DELTA TEMPERATURE EFFECTS ANALYSIS

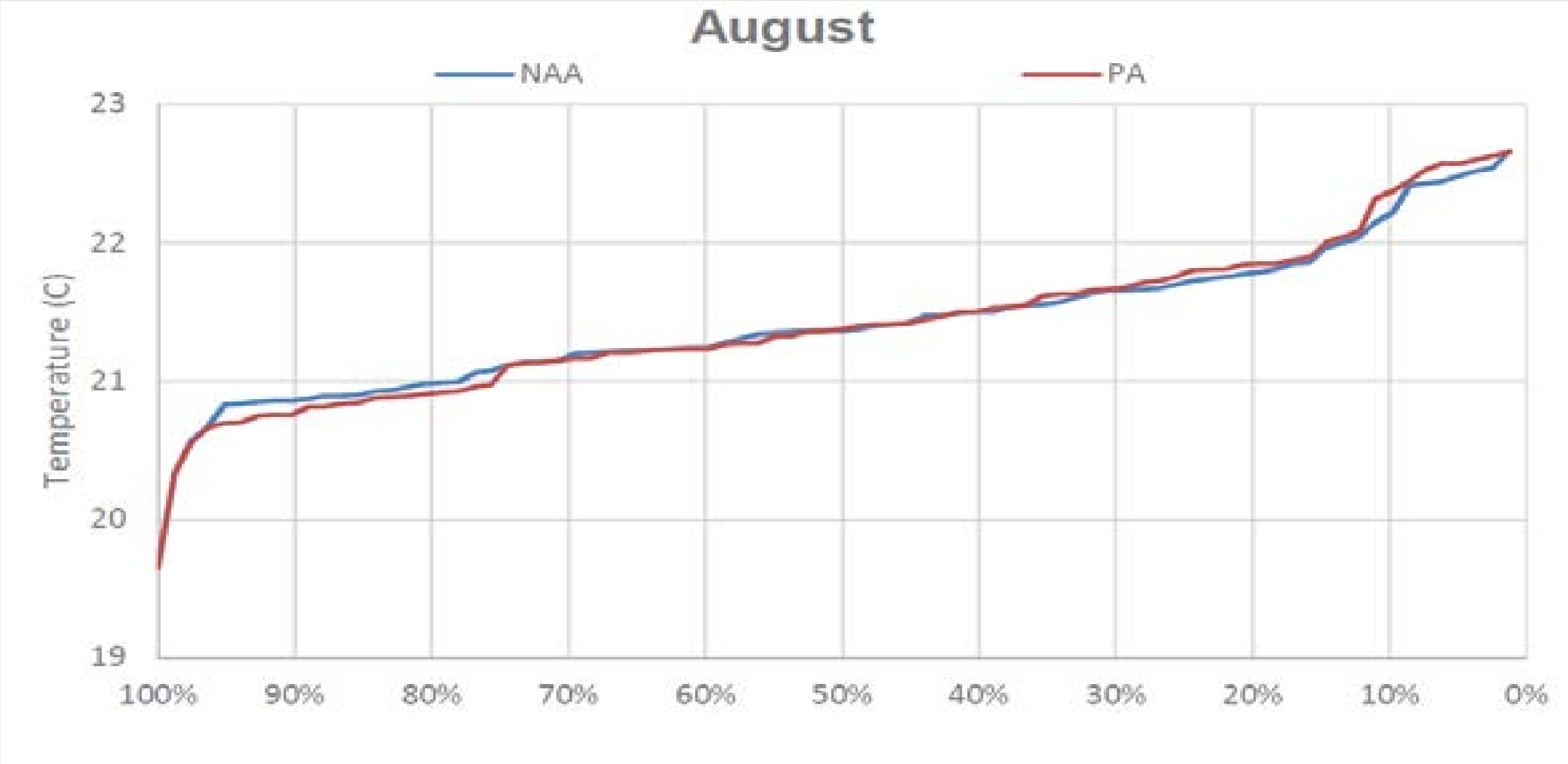


DELTA TEMPERATURE: SACRAMENTO RIVER AT RIO VISTA



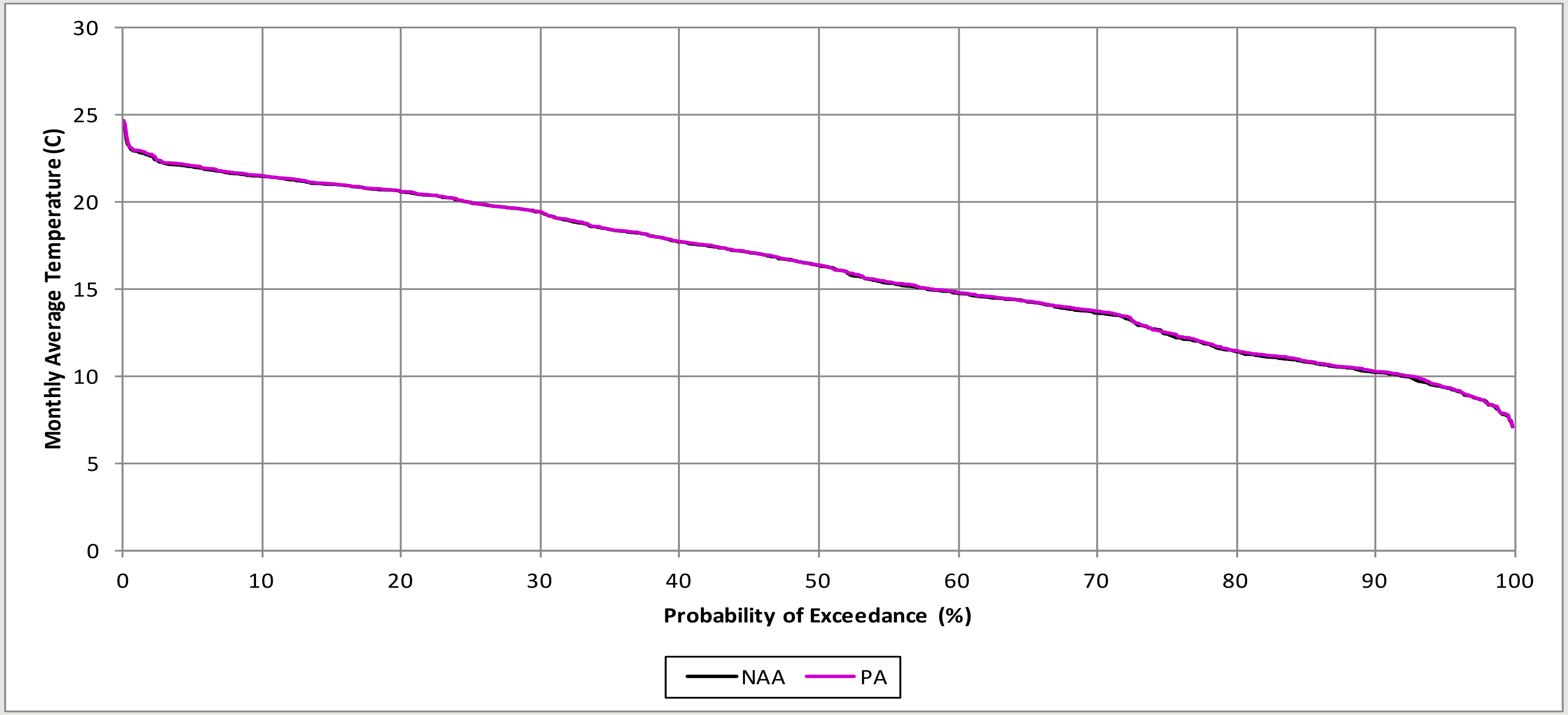
Probability of exceedance of temperatures for **August** for the 1922–2003 period of record modeled. Source: Biological Assessment, Appendix 5B, Figure 5.B.5.40-1

DELTA TEMPERATURE: SJR AT PRISONER'S POINT



Probability of exceedance of temperatures for **August** for the 1922–2003 period of record modeled. Source: Biological Assessment, Appendix 5B, Figure 5.B.5.41-1.

DELTA TEMPERATURE: SACRAMENTO RIVER AT RIO VISTA



Probability of exceedance of temperatures for the 1922–2003 period of record modeled.

OPINION 8

Delta Turbidity and HABs:

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.

DELTA TURBIDITY EFFECTS ANALYSIS

- **CWF would not cause turbidity levels in the Delta to be outside ranges occurring under Existing Conditions**
- **Channel velocities between the CWF and NAA scenarios generally differ little at the Delta locations assessed**
- **Cyanobacteria are not light limited in the Delta from June through November.**

DELTA TURBIDITY EFFECTS ANALYSIS

- **Final EIR/EIS, Chapter 8, p. 8-971 to 8-972 states: the CWF operations is expected to have a minimal effect on total suspended solids (TSS) and turbidity levels in the Delta, relative to the NAA**
- **In drought year 2014, when *Microcystis* blooms were large in magnitude and duration, light levels in the euphotic zone were no greater than they were in previous years during the peak of the bloom (Lehman et al. 2017)**
- **Delta turbidity in 2014 did not differ significantly from other years**

OPINION 9

Delta Nutrients and HABs:

Relatively small increases in nutrients 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.

DELTA NUTRIENTS

- **Total N and orthophosphate (SRP) are available in non-limiting amounts for *Microcystis* in the Delta (Lehman et al. 2008, 2017; Berg and Sutula 2015)**

- **Studies have shown that the addition of only orthophosphate does not enhance growth in *Microcystis* blooms in the Klamath River, Oregon; Lake Taihu, China; or Lake Erie, Michigan (Moisander et al. 2009, Xu et al. 2010, Chaffin et al. 2013 as cited in Lehman et al. 2017).**

DELTA NUTRIENTS

- **Berg and Sutula (2015) found that nutrient concentrations and N:P ratios do not change sufficiently among years to explain inter-annual variation in *Microcystis* biomass or occurrence.**

- **They further stated: "*Therefore, the initiation of Microcystis blooms and other cyanoHABs are probably not associated with changes in nutrient concentrations or their ratios in the Delta*."**

- **Total N and orthophosphate (SRP) concentrations were well in excess during the *Microcystis* bloom in 2014 and the N:P ratio was not correlated with *Microcystis* biovolume (Lehman et al. 2017).**

OPINION 10

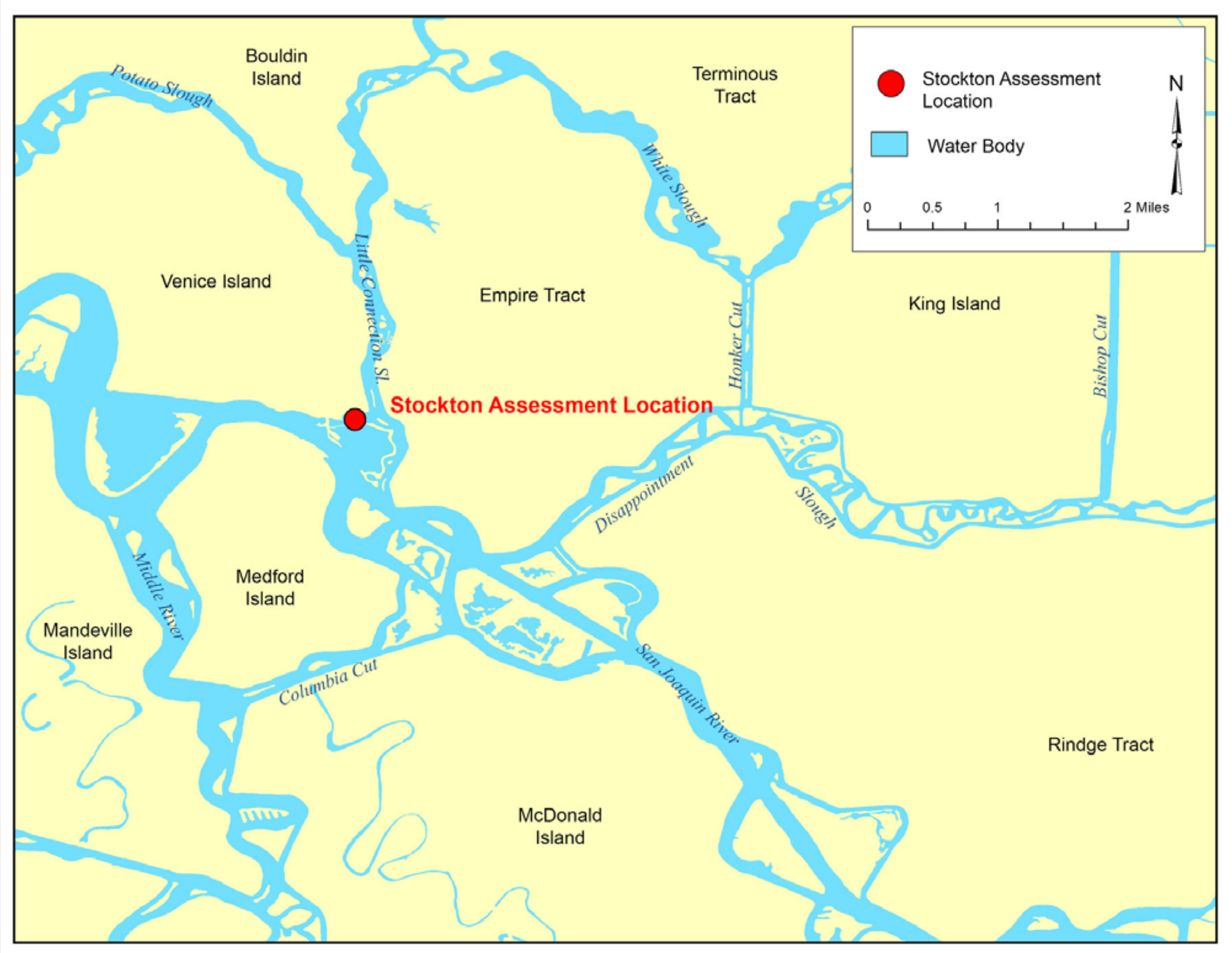
Water Quality at City of Stockton WTP Intake:

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

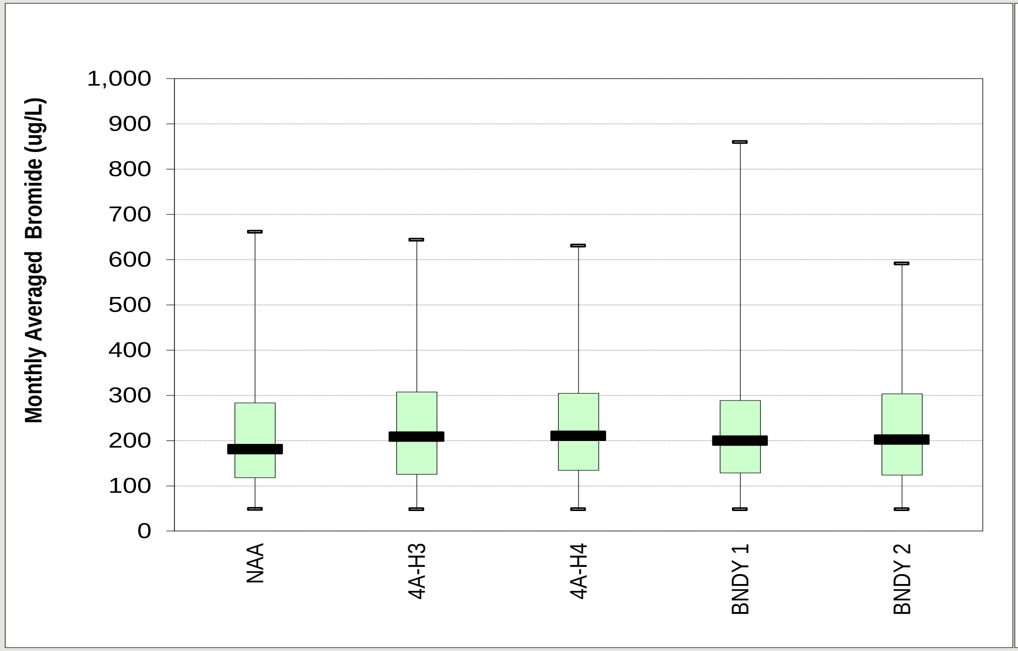
CWF EFFECTS AT CITY OF STOCKTON WTP INTAKE

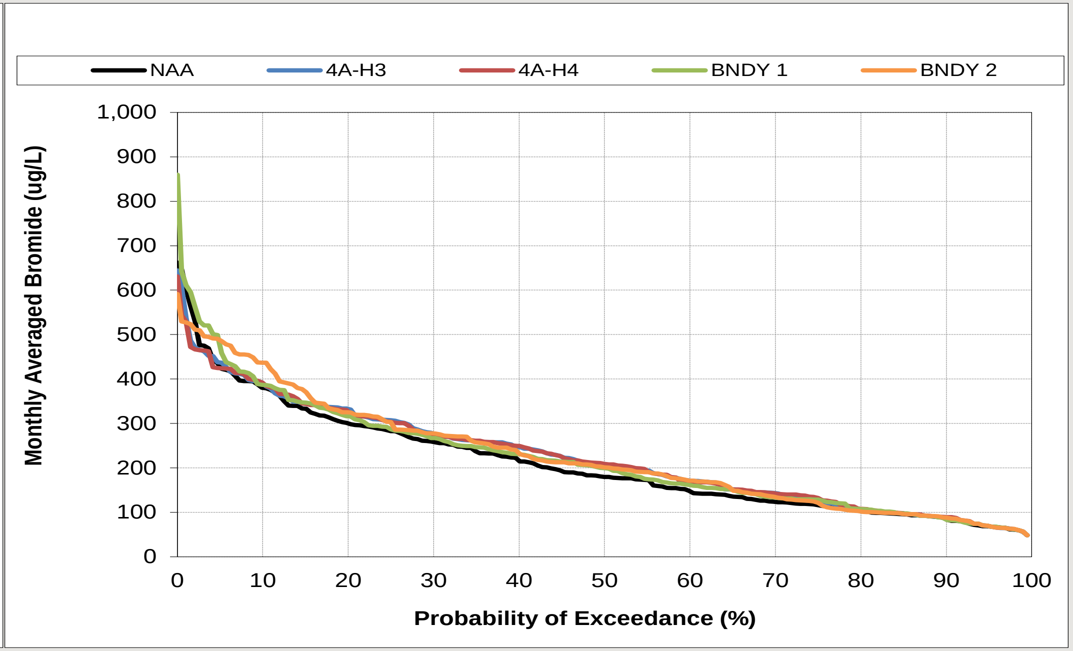
- **City of Stockton concerns:**
  - Bromide
  - Chloride
  - Electrical Conductivity
  - Organic Carbon
  - Nitrate / Nitrite
  - Pesticides
  - Other Toxins
  - Water Temperature
  - Cyanobacteria (e.g., *Microcystis*)

STOCKTON WTP INTAKE ANALYSIS



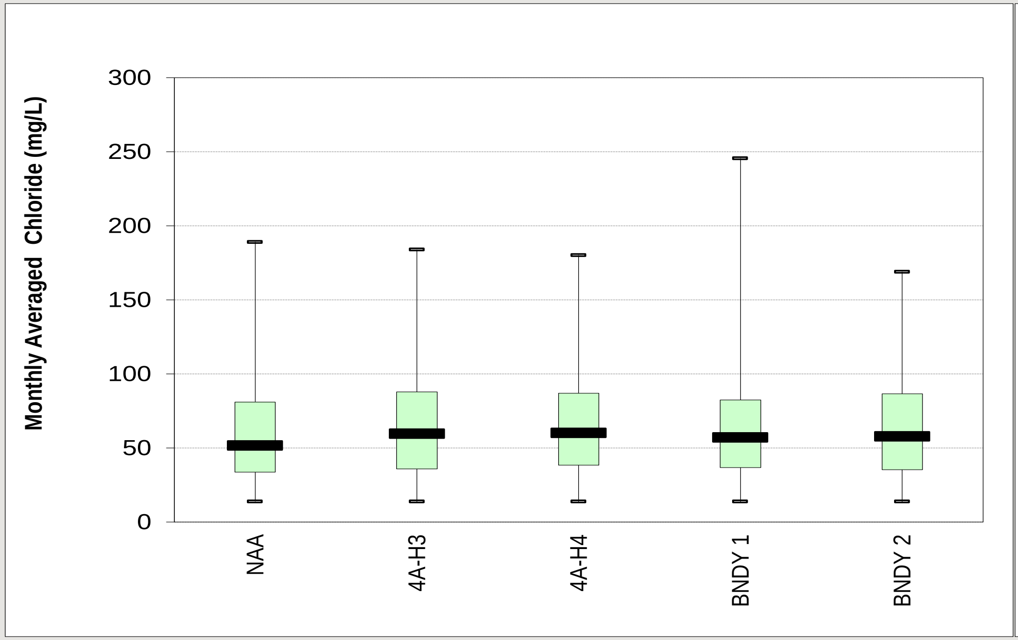
CWF EFFECTS ON BROMIDE AT STOCKTON INTAKE

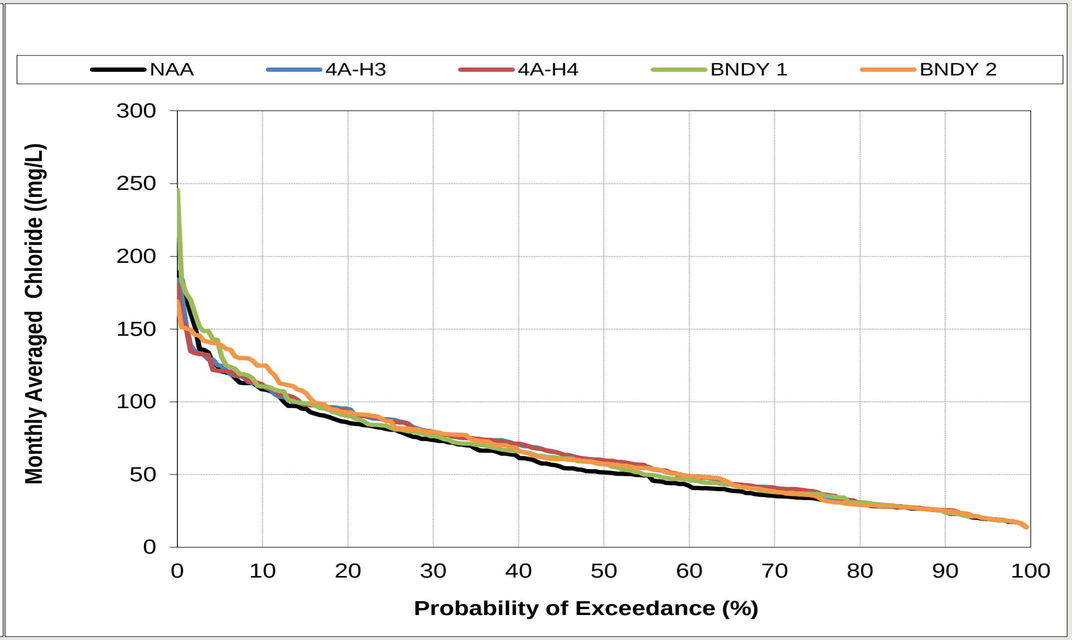




Box-and-whisker and probability of exceedance plots for monthly average bromide concentrations in the San Joaquin River at the City of Stockton's drinking water diversion location for all water years (1976–1991)

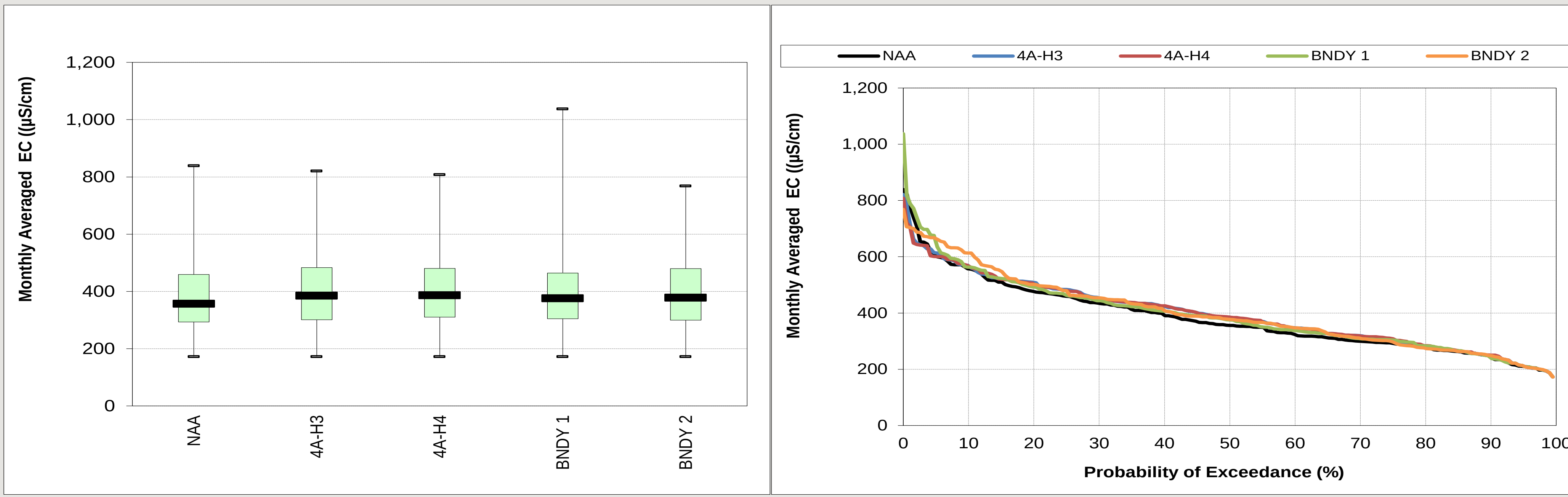
CWF EFFECTS ON CHLORIDE AT STOCKTON INTAKE





Box-and-whisker and probability of exceedance plots for monthly average chloride concentrations in the San Joaquin River at the City of Stockton's drinking water diversion location for all water years (1976–1991)

CWF EFFECTS ON EC AT STOCKTON INTAKE



Box-and-whisker and probability of exceedance plots for monthly average EC levels in the San Joaquin River at the City of Stockton's drinking water diversion location for all water years (1976–1991)

CWF EFFECTS AT CITY OF STOCKTON WTP INTAKE

- **The CWF would not substantially degrade water quality in the San Joaquin River for any of the constituents assessed, relative to the NAA**
  - Bromide
  - Chloride
  - Electrical Conductivity
  - Organic Carbon
  - Nitrate / Nitrite
  - Pesticides
  - Other Toxins
  - Water Temperature
  - Cyanobacteria (e.g., *Microcystis*)

Questions