August 7, 2012

State Water Resources Control Board
1001 I St.
Sacramento, CA 95814

Via email: commentletters@waterboards.ca.gov

Subject: Bay-Delta Workshop 1 – Ecosystem Changes and LSZ
FSI 064136

Dear Ms. Townsend and Members of the Board,

On behalf of the City of Antioch, Flow Science is pleased to submit comments for consideration by the State Water Resources Control Board (State Board) during its Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan.

Background. The City of Antioch (Antioch), located along the San Joaquin River in the western portion of the Sacra mento and San Joaquin River Delta (Delta), is one of the oldest towns in California. Since the 1860s, Antioch has obtained all or part of its freshwater supply directly from the San Joaquin River.[1] The City, because of its position in the western Delta, is also concerned with the ecological health of the Delta and its long-term viability as a recreational destination.

Potential Impacts of Preliminary BDCP Proposed Project. The City of Antioch and I participated in the flow criteria hearings in March 2010, and thus have included with this letter only a small portion of the materials provided to the State Board at that time. The new info rmation provided to the State Board in this submittal relates primarily to the Bay-Delta Conservation Plan (BDCP), and new data and information that have become available from the BDCP process following the 2010 flow criteria hearings.

The City of Antioch and I have participated in the BDCP process, and earlier in 2012 received a hard drive from the California Department of Water Resources (DWR) that included the results of model runs made using DWR's Delta Simulation Model II (DSM2) for various BDCP alternatives, including the "preliminary proposal" (Alternative 1, which was the proposed project at the time) and No Action model runs. The data

[1] Much of the water in the western Delta (including the City's water supply) comes from the Sacramento River. Historically, significant amounts of Sacramento River water flowed into the San Joaquin River east of Antioch at Three Mile and Georgiana Sloughs. Sacramento River water also reaches Antioch where the river merges with the San Joaquin River just west of the City. Town of Antioch v. Williams Irrigation District et al. (1922) 188 Cal. 451, 455.

provided to the City included simulated salinity levels at the City's intake for the 16-year simulation period (water years 1975-1991).

Flow Science reviewed the results of the BDCP DSM2 model runs received in 2012, which showed that under almost all modeled conditions, the water at the City's intake in the western Delta was predicted to become significantly saltier than under current conditions. For future conditions, the BDCP model runs incorporated both a no-project alternative (which incorporated varying levels of anticipated sea level rise) and with-project alternatives. These model runs generally showed that the BDCP project increased salinity significantly as compared both to the baseline (existing) condition and to future conditions without the BDCP project (i.e., with sea level rise alone).

The BDCP model runs reviewed by Flow Science indicated that the period of time that the City of Antioch could divert water at its intake (i.e., when water at the intake had a chloride level below 250 ppm, called "usable water") declined significantly with the proposed project. This effect was particularly acute in the late summer and fall months of wet years; in these time periods, model results showed that usable water would be present about 80% of the time for baseline and future-no-project model runs, but that usable water would be present less than 40% of the time for the then-preliminary proposal. Even the 6,000-cfs BDCP alternative indicated that significant salinity impacts could occur in the western Delta, indicating that it may not be the size of the diversion so much as the way in which it is operated that results in salinity impacts in the western Delta.

In addition to diverting water from the north Delta, the DSM2 model runs incorporated two features that would also result in higher salinity conditions in the western Delta and at Antioch's intake. First, the DSM2 model runs moved a point of compliance for water quality criteria. Specifically, the compliance point in the Sacramento River at Emmaton (incorporated into D-1641 and the Bay-Delta Plan) was moved upstream to Three Mile Slough in the DSM2/CALSIM II modeling performed in support of the BDCP project. (Such a change in compliance point would require a change in the water quality objectives of the Bay-Delta Water Quality Control Plan.)

Second, the then-proposed BDCP project incorporated restored habitat within the Delta. Depending on the design and location of habitat restoration, the volume of water that "sloshes" into and out of the Delta on every tidal cycle may be increased, increasing salinity intrusion within the Delta, with the most significant effects observed in the western Delta.

With respect to salinity and chloride concentrations at Antioch, the draft EIR/EIS for the BDCP Project (February 2012) concluded as follows: "Based on the additional seasonal exceedances of the municipal objective and magnitude of long-term average water quality degradation with respect to chloride at Antioch, the potential exists for <u>substantial adverse effects on the municipal and industrial water supply beneficial uses</u> through reduced opportunity for diversion of water at Antioch and Mallard Slough with acceptable salinity." (Draft EIR/EIS at p. 8-183, emphasis added).

Potential Impacts of "New" BDCP Project. On July 25, 2012, Governor Brown and the Obama administration outlined revisions to the proposed BDCP, including a change in the amount of water to be diverted from the Delta via new intakes and a new 9,000-cfs tunneled conveyance. We understand that the operating rules are currently in development, as is the environmental analysis that will assess the potential impacts of the proposed project. DWR has indicated to the City of Antioch that they do not currently know if the proposed project will resemble the alternatives already modeled.

For this reason, the City of Antioch is not providing additional quantitative information regarding the impacts of the (future) proposed BDCP project on salinity at Antioch's intake and on the western Delta. The City looks forward to receiving this information, and we will provide additional submittals, including quantitative assessments of the potential salinity impacts to the western Delta, to the State Board when information about the future proposed project becomes available.

In any case, it appears clear that impacts as a result of the proposed BDCP project at the City's intake are likely.

Historical Conditions. As detailed in our prior submittals, a small portion of which are provided with this letter as **Attachment A**, salinity in the western Delta is important not just to Antioch's drinking water supply (and to the beneficial use of these waters for municipal and domestic supply) but also to the ecological health of the Delta as a whole. The materials in **Attachment A** and others submitted previously by the City (and by others, such as CCWD) to the State Board demonstrate that the current Delta ecosystem is very different than the historical Delta – both flow and salinity are altered compared to historical conditions. For example:

- Since European settlement in the 1850s, dramatic changes to the Delta landscape have occurred, including removal of tidal marsh and building of permanent river channels.
- Water management operations (reservoir storage and diversions) since the early 1900s have increased reservoir storage in the upstream watersheds to more than 30 million acre-feet (MAF).
- Water exports from the Delta have been steadily increasing since the 1950s to the present, from about 0.5 MAF/yr to about 5 MAF/yr.

Before large-scale diversions for upstream agricultural operations began in 1918, freshwater conditions were pervasive in the western Delta. Salinity monitoring data indicate that salinity at Antioch has increased further from 1965 to present, and that the increase in salinity continues in recent years.

Salinity intrusion under current management conditions occurs earlier in the year (currently beginning in about March, as compared to June-July historically). Salinity intrusion also persists longer; currently, the period of high salinity persists for about 10 months on average, compared to about 5 months on average for unimpaired flow

conditions (i.e., without any current management operations but with the current Delta channel configuration).

It is the historical freshwater condition to which the Delta ecosystem and its native species are adapted.

Antioch's Request. As outlined above, Antioch believes that it is in the City's best interest, and in the interest of the Delta ecosystem, to maintain freshwater conditions in the western Delta. Thus, the City requests that:

- Given historical conditions, salinity should not be allowed to rise (and outflows should not be allowed to decline) beyond existing levels as required by D-1641 and X2 operations criteria.
- Compliance points (such as the compliance point currently located at Emmaton) should not be moved landward.
- The State Board should consider using the gauging station at Antioch as a point of interest for monitoring of both salinity and flow conditions in the western Delta.
- The State Board should ensure that mitigation is provided for impacts to beneficial uses that occur as a result of the BDCP project.

Please contact me at (626) 304-1134 if you have any questions regarding this submittal. We thank you for your consideration of these comments and for the opportunity to participate in the process to revise the Bay-Delta Plan.

Sincerely,

Susan C. Paulsen

Susan C. Paulsen, Ph.D., P.E.
Vice President and Senior Scientist

FLOW SCIENCE®

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February 16, 2010

Division of Water Rights
State Water Resources Control Board
Attn: Phillip Crader
P. O. Box 2000
Sacramento, CA 95812-2000

Re: Delta Flow Criteria Informational Proceeding

Dear Mr. Crader:

The City of Antioch has been diverting Sacramento River water for drinking water use from the western Delta since the 1860s, and as such, has information and data directly relevant to the SWRCB's current proceedings to establish Delta flow criteria. The City, because of its position in the western Delta, is also concerned with the ecological health of the Delta and the long-term viability of the City's historic freshwater fishing and recreational opportunities.

Please find attached the City of Antioch's exhibits and supporting documents describing the historical salinity conditions at Antioch. The City of Antioch believes that it is vitally important to consider historical salinity and flow conditions when establishing flow criteria and water quality standards that will affect the future biological and ecological integrity of the Delta, and we believe that the SWRCB should not allow flow to be reduced below, or salinity to be increased above, levels currently allowed by both D-1641 and X2 requirements. In fact, the City asks the SWRCB to establish flow and salinity standards in line with the Delta's historic fresh condition.

We appreciate your consideration in this matter. Please feel free to contact me with any questions.

Sincerely,

Phil Harrington
Director of Capital Improvements and Water Rights
City of Antioch

Attachments:

- City of Antioch's Witness List
- City of Antioch's Exhibit Identification List
- City of Antioch's Response to Key Questions
- City of Antioch's Written Summary
- City of Antioch's supporting document – a powerpoint presentation on historical salinity conditions
- City of Antioch's supporting document – A report by Thomas Means (1928): "Salt Water Problem"
- City of Antioch's supporting document – Excerpts from the DWR (1931) Report: "Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay"
- City of Antioch's supporting document – DWR (1960) Report: "Delta Water Facilities"

WITNESS IDENTIFICATION LIST (Revised January 29, 2010)
(Due 12 Noon, Tuesday, February 16, 2010)

Delta Flow Criteria Informational Proceeding

Scheduled to Commence
Monday, March 22, 2010

The City of Antioch plans to call the following witnesses: (name of individual participant or group of participants)

NAME	PROPOSES PARTICIPATION ON THE FOLLOWING PANEL(S) note panel number)	WILL THE WITNESS SUBMIT TESTIMONY (no if only responding to questions)
Susan C. Paulsen, Ph.D., P.E., Vice President, Flow Science Incorporated	Hydrology (Panel 1) and Hydrodynamics (Panel 5)	Yes
E. John List, Ph.D., P.E., Principal Consultant, Flow Science Incorporated	Hydrology (Panel 1) and Hydrodynamics (Panel 5)	No
Phil Harrington, Director of Capital Improvements and Water Rights, City of Antioch	Hydrology (Panel 1) and Hydrodynamics (Panel 5)	No
Matthew L. Emrick, Special Water Counsel to the City of Antioch	Hydrology (Panel 1) and Hydrodynamics (Panel 5)	No

EXHIBIT IDENTIFICATION LIST
(Due 12 Noon, Tuesday, February 16, 2010)

Delta Flow Criteria Informational Proceeding

Scheduled to Commence
Monday, March 22, 2010

PARTICIPANT: **The City of Antioch**

Exhibit Identification Number	Exhibit Description
Antioch Doc #1	City of Antioch's Cover Letter
Antioch Doc #2	City of Antioch's Witness Identification List
Antioch Doc #3	City of Antioch's Exhibit Identification List
Antioch Doc #4	City of Antioch's Response to Key Questions
Antioch Doc #5	City of Antioch's Written Summary
Antioch Doc #6	City of Antioch's supporting document – a powerpoint presentation on historical salinity conditions
Antioch Doc #7	City of Antioch's supporting document – A report by Thomas Means (1928): "Salt Water Problem"
Antioch Doc #8	City of Antioch's supporting document – Excerpts from the DWR (1931) Report: "Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay"
Antioch Doc #9	City of Antioch's supporting document – DWR (1960) Report: "Delta Water Facilities"

Response to Key Questions

Delta Flow Criteria Informational Proceeding
March 22, 2010

The following are brief "bullet-point style" responses to the five questions posed by the State Water Board in its original notice. The written testimony and the supporting documents submitted by the City of Antioch elaborate on these responses.

Key Question #1

What key information, in particular scientific information or portions of scientific information, should the State Water Board rely upon when determining the volume, quantity, and timing of water needed for the Delta ecosystem pursuant to the board's public trust obligations?

- The current Delta ecosystem is very different than the historical Delta – both flow and salinity are altered compared to historical conditions. For example:
  - since European settlement in the 1850s, dramatic changes to the Delta landscape have occurred, including removal of tidal marsh and building of permanent river channels
  - water management operations (reservoir storage and diversions) since the early 1900s have increased reservoir storage in the upstream watersheds to more than 30 million acre-feet (MAF)
  - water exports from the Delta have been steadily increasing since the 1950s to the present, from about 0.5 MAF/yr to about 5 MAF/yr
- Before 1918 (i.e., before large-scale diversions for upstream agricultural operations), freshwater conditions were pervasive in the western Delta as indicated by literature and technical reports (e.g., testimony from the Antioch lawsuit in 1920, DPW 1931 and DWR 1960)
- Salinity monitoring data indicate that salinity at Antioch has increased from 1965 to present; the increase in salinity continues in recent years.
- Salinity intrusion under current management conditions occurs earlier in the year (currently beginning in about March, as compared to June-July historically). Salinity intrusion also persists longer; currently, the period of high salinity persists for about 10 months on average, compared to about 5 months on average for unimpaired flow conditions (i.e., without any current management operations but with the current Delta channel configuration).

For large reports or documents, what pages or chapters should be considered?

- Specific page number references have been provided in the detailed exhibit and supporting documents.

What does this scientific information indicate regarding the minimum and maximum volume, quality, and timing of flows needed under the existing physical conditions, various hydrologic conditions, and biological conditions?

- Historic Delta was significantly fresher than the current Delta.
- Characterization of the Delta as "historically saline" is false and is not based on scientific evidence.
- Salinity intrusion under current management conditions occurs earlier (timing) and persists longer (duration) compared to unimpaired flow conditions (i.e., without any current management operations but with the current Delta channel configuration).
- Salinity has continued to increase in recent years at Antioch.
- The fraction of time that water at Antioch is suitable for use (when salinity is < 250 mg/L chlorides or 1000 µS/cm EC) has declined significantly.
- Historical fresh conditions must be considered in any effort to restore ecological conditions in the Delta.

With respect to biological conditions, what does the scientific information indicate regarding appropriateness of flow to control non native species?

- This question is not addressed in the City's submittal.

What is the level of scientific certainty regarding the foregoing information?

- Salinity and flow monitoring data were collected using scientific techniques which are universal and reliable.
- Testimony and historical evidence presented is consistent with historical literature reports, measurements made by the California & Hawaiian Sugar Refining Corporation (C&H) during the early 20th century, and also with paleo records constructed from tree rings and sediment cores (presented by others and in CCWD salinity report).

Key Question #2

What methodology should the State Water Board use to develop flow criteria for the Delta? What does that methodology indicate the needed minimum and maximum volume, quality, and timing of flows are for different hydrologic conditions under the current physical conditions of the Delta?

- The City suggests that, given historical conditions, salinity should not be allowed to rise (and flows should not be allowed to decline) beyond existing levels as required by D-1641 and X2 operations criteria.
- The City requests that compliance points should not be moved land-ward.
- The SWRCB should consider using the gauging station at Antioch as a point of interest for monitoring of both salinity and flow conditions in the western Delta.

Key Question #3

When determining Delta outflows necessary to protect public trust resources, how important is the source of those flows?

- Even though Antioch is on the San Joaquin River, the Sacramento River was historically and continues to be the main source of water at Antioch. Thus, the Sacramento River has historically been the main source of water in the western Delta, and the source of water to which Delta species have been historically exposed and to which they may have adapted.
- In the context of flushing of the South Delta, baseline residence times should be established based on current conditions, and to be used as a measure by which future actions (e.g., BDCP) can be assessed.

How should the State Water Board address this issue when developing Delta outflow criteria?

- This question is not addressed in the City's submittal.

Key Question #4

How should the State Water Board address scientific uncertainty when developing the Delta outflow criteria?

- The City of Antioch respectfully suggests, in light of the information provided, that the SWRCB should err on the side of not allowing greater salinity intrusion.

Specifically, what kind of adaptive management, monitoring, and special studies programs should the State Water Board consider as part of the Delta outflow criteria, if any?

- This question is not addressed in the City's submittal.

Key Question #5

What can the State Water Board reasonably be expected to accomplish with respect to flow criteria within the nine months following enactment of SB 1? What issues should the State Water Board focus on in order to develop meaningful criteria during this short period of time?

- This question is not addressed in the City's submittal.

State Water Resources Control Board
Delta Flow Criteria Informational Proceeding
March 22, 2010

Exhibit by City of Antioch
Summary of Historical Freshwater Availability at Antioch

Summary

The historic (pre-1918) Delta was significantly fresher than the current Delta. The characterization of the Delta as "historically saline" is false and is not based on scientific evidence. Historical salinity and flow conditions must be considered when: (i) establishing Delta outflows and inflows to protect public trust values which adapted to these conditions, (ii) establishing the criteria (volume, timing and quality) required by Senate Bill 7X 1, and (iii) establishing drinking water quality standards for the Delta.

1. Introduction

The City of Antioch (Antioch), located along the San Joaquin River in the western portion of the Sacramento and San Joaquin River Delta (Delta), is one of the oldest towns in California. Since the 1860s, Antioch has obtained all or part of its freshwater supply directly from the San Joaquin River.[1] The City, because of its position in the western Delta, is also concerned with the ecological health of the Delta and its long-term viability as a recreational destination.

As part of the informational proceeding on establishing flow criteria in the Delta, this document summarizes the historical salinity and flow conditions near Antioch and contrasts them with the largely saline conditions prevailing today. The supporting document to this summary is a "powerpoint style" document containing text and figures relevant to the material presented in this summary.

2. Systemic changes have reduced freshwater flows and increased salinity in the western Delta, including at Antioch

Salinity in the western Delta (including at Antioch) is influenced both by natural factors, including ocean tides and hydrology of the upstream watersheds, and by artificial factors, including channelization of the Delta, elimination of tidal marsh, reservoir storage and release operations, and water diversions.

Major anthropogenic modifications to the Delta that affect salinity intrusion began with the European settlement of the region around 1850. Tidal marsh acreage in the Delta decreased from over 250,000 acres in the 1870s to less than 30,000 acres in the 1920s and

[1] Much of the water in the western Delta (including the City's water supply) comes from the Sacramento River. Historically, significant amounts of Sacramento River water flowed into the San Joaquin River east of Antioch at Three Mile and Georgiana Sloughs. Sacramento River water also reaches Antioch where the river merges with the San Joaquin River just west of the City. Town of Antioch v. Williams Irrigation District et al. (1922) 188 Cal. 451, 455

has since continued to decrease (CCWD 2010), producing significant changes in the Delta landscape (Att. at pg. 7). For example, dredging of the Delta river channels to create the Stockton and Sacramento Deep Water Ship Channels affected the salt transport and distribution in the Delta (CCWD 2010). Construction of reservoirs for storage purposes started in the early 1900s and the largest reservoirs of the Central Valley Project (CVP, Lake Shasta) and the State Water Project (SWP, Lake Oroville) were completed in 1945 and 1968, respectively (CCWD 2010). Total upstream reservoir storage capacity increased from 1 million acre-feet (MAF) in 1920 to more than 30 MAF by 1979 (CCWD 2010). Water exports from the Delta have been steadily increasing since the 1950s, and the combined annual exports from CVP and SWP have increased, on average, from about 0.5 MAF/yr in the late 1950s to about 5 MAF/yr during the recent period (Att. at pg. 8).

3. Historical extent of freshwater

Testimony from the lawsuit filed by the Town of Antioch in 1920 and from various literature reports demonstrates that freshwater (low salinity conditions) prevailed in the western Delta in the late 1800s and early 1900s.

3.1 Testimony from Antioch's lawsuit in 1920

In 1920, the Town of Antioch filed a lawsuit against upstream irrigation districts alleging that the upstream diversions were causing increased salinity intrusion at Antioch (Town of Antioch [plaintiff] v. Williams Irrigation District et al. [defendants] (1922, 188 Cal. 451)). The testimony from the Antioch lawsuit provides a perspective of the salinity conditions prevailing in the early 1900s.

3.1.1 Pre-1918: Freshwater was available at Antioch year-round

Testimony from the defendants in the Antioch lawsuit indicated that in the late 1800s, water at Antioch was known to be brackish at high tide during certain time periods, but Antioch was able to pump freshwater at low tide throughout the year, with the possible exception of the fall season during one or two dry years. Water at Antioch was fresh at low tide at least until around 1915 (when the pumping plants started pumping continuously, regardless of tidal stage) (Att. at pg. 11).

Testimony from the plaintiff in the Antioch lawsuit indicated that Antioch's freshwater supply was obtained directly from the San Joaquin River (see footnote 1 above) from about 1866 to 1918, first by private water companies and then by the municipality after 1903 (when the City acquired pre-existing water rights) (Att. at pg. 12). Plaintiff's testimony included salinity measurements taken at Antioch (1913-1917) that indicated that prior to 1918, freshwater was available at Antioch even during dry years and in the fall (Att. at pg. 12).

3.1.2 Post-1918: Increased upstream diversions drastically increased salinity intrusion

Testimony and measurements from the Delta (1918-1920) presented by the plaintiff in the Antioch lawsuit indicated that after 1918, salinity abruptly increased during the irrigation (rice cultivation) season, but returned to a potable level after irrigation ceased (Att. at pg. 13). The effect of upstream diversions was also confirmed by records in the plaintiff's testimony from California & Hawaiian Sugar Refining Corporation (C&H) (CCWD 2010). Plaintiff's testimony indicated that although Antioch is located along the San Joaquin River, the source of much of the water at Antioch was the Sacramento River, which flowed to Antioch via Georgiana and Three Mile Sloughs (Att. at pg. 14-15); this was confirmed by the California Supreme Court (Att. at p. 15).

Information from the Antioch lawsuit is consistent with literature reports (see the following discussion) and with paleo records of salinity and river flow obtained from tree rings and sediment cores (CCWD 2010).

3.2 Literature reports

Several literature reports confirm that freshwater was available year-round in the western Delta (including Antioch) and Suisun Bay during the late 1800s and early 1900s. For instance, DPW (1931), the precursor to the Department of Water Resources, indicated that the City of Antioch obtained all or most of its freshwater supplies directly from the San Joaquin River until 1917, and that salinity intrusion prevented domestic use of water at the Antioch intake in summer and fall after 1917 (Att. at pg. 9). DPW (1931) and Tolman and Poland (1935) indicated that prior to the 1920s, water near the City of Pittsburg was sufficiently fresh for that City to directly obtain all or most of its freshwater (Att. at pg. 10). Dillon (1980) and Cowell (1963) indicated that prior to the 1920s, freshwater was available in the Suisun Bay and Carquinez Straits for use by the City of Benicia (Att. at pg. 10). Means (1928) indicated that Carquinez Strait (near Martinez in the western Delta) is the approximate boundary between salt water and freshwater under natural conditions. Moreover, Means (1928) also indicated that during the wet season freshwater extended up to the Golden Gate (Att. at pg. 9).

The California Department of Water Resources (DWR, 1960) estimated that water with a chloride concentration of 350 mg/L or less would be available at San Joaquin at Antioch about 85% of the time under "natural" conditions (Att. at pg. 16). DWR (1960) also estimated that chloride concentrations at Antioch would be less than 350 mg/L about 80% of the time in 1900 and about 60% of the time by 1940, with decreasing freshwater availability due to upstream diversions; DWR also projected further deterioration of water quality in 1960 and later, but did not include the effects of reservoir releases for salinity control (Att. at pg. 16).

4. Current Salinity Conditions at Antioch

Salinity data compiled by the Interagency Ecological Program (IEP) and California Data Exchange Center (CDEC) were used to analyze the present availability of freshwater at Antioch. These quantitative measurements from the present were compared to the

testimony from the Antioch lawsuit and to observation recorded by C&H to establish how salinity at Antioch and in the western Delta has increased over time compared to historical conditions.

4.1 Freshwater availability continues to decline

Availability of freshwater at Antioch continues to decline. Antioch may take water at its intake when salinity is less than 250 mg/L chlorides (equivalent to about 1000 µS/cm EC)[2]. The number of days per year, expressed as a percentage, when daily average salinity at Antioch was below 1000 µS/cm EC declined from about 70% in the late 1960s to about 40% during the recent period (Att. at pg. 19).

Even in years with above normal runoff in the Sacramento River watershed, freshwater at Antioch is less available than historically (Att. at pg. 20). For instance, during the above normal water year 2000, water at the City of Antioch's intake was below 1000 µS/cm EC for the entire day for about four-and-a-half months (early February through mid-June) and for a portion of the day at low tide for another three-and-a-half months (mid-June through September). For the remaining four months (October-January), water at the City's intakes exceeded 1,000 µS/cm EC for the entire day, regardless of tidal stage. Testimony from the Antioch lawsuit indicates that prior to 1918, water at the City of Antioch's intake was below 1000 µS/cm EC for the entire day during above-normal years and in all but dry fall months.

Salinity at low tide at Antioch during the present is higher than historical conditions (Att. pg. 21). For instance, during the period 1985 to 2009, the tenth percentile low tide daily salinity was below 1,000 µS/cm EC for about one-and-a-half months, and the 25th percentile low tide daily salinity was below 1,000 µS/cm EC for about nine months. However, testimony from the Antioch lawsuit indicates that during the driest years prior to 1918, low tide salinity at the City of Antioch's intake was below 1000 µS/cm EC for about nine months; for all but the driest years, salinity at low tide was below 1,000 µS/cm EC throughout the year. These data establish that salinity is higher at Antioch for a wider range of hydrologic conditions and for a longer duration of the year than under historic conditions.

4.2 Salinity intrusion occurs earlier and extends farther

Since the early 1900s the California & Hawaiian Sugar Refining Corporation (C&H), located in Crockett near the western edge of Suisun Bay, obtained its freshwater supply in Crockett. When freshwater was not available at Crockett, C&H used barges that traveled upstream on the Sacramento and San Joaquin Rivers to procure freshwater. The measurements of distance to freshwater from Crockett, recorded during these barge operations, serve as a surrogate for the historical extent of freshwater in the western

[2] The freshwater salinity threshold of 250 mg/L chlorides at the San Joaquin River at Antioch is based on the 1968 agreement between the City of Antioch and DWR. This threshold is approximately equivalent to 1000 µS/cm EC, based on the site-specific empirical relationships between chloride concentration and EC (K. Guivetchi, DWR Memorandum dated June 24, 1986).

Delta. A comparison of C&H data during 1908-1917 and estimates[3] of distance to freshwater from Crockett during the post-SWP construction period (1966-1975) indicates that salinity intrusion into the Delta occurs on average about 4 months earlier (in March instead of July) during the post-SWP construction period of 1966-1975 (Att. at pg. 17). Comparison of C&H data from 1908-1917 to estimates of distance to freshwater from Crockett during the period 1995-2004 indicates that salinity intrusion during the recent period not only occurs earlier (by 4 months) but also extends farther in to the Delta (by about 5 to 20 miles) (Att. at pg. 18).

5. Conclusions

- Prior to 1918, freshwater was almost always available at Antioch at least at low tide. Only during dry years and during high tide conditions did salinity at Antioch become brackish.
- Between 1918 and the late 1930s, drought conditions, upstream water diversions, and channelization increased the salinity of water at Antioch.
- By 1940 the drought receded, but salinity at Antioch remained elevated.
- Salinity has continued to increase in recent years at Antioch.
- The fraction of time that water at Antioch is suitable for use (when salinity is < 250 mg/L chlorides or 1000 µS/cm EC) has declined significantly.
- "Historic" Delta was significantly fresher than the current Delta.

6. Request

The City of Antioch requests that the State Water Resources Control Board review and incorporate historic salinity data into its analyses when considering Delta outflow requirements to protect public trust resources in the Western Delta and the flow requirements of SB X7 1 (e. g., volume, timing and quality), and that the Board use historic data to establish and to adjust its "baseline" of water quality for both fisheries health and drinking water quality standards. In fact, the City asks the SWRCB to establish flow and salinity standards in line with the Delta's historic fresh condition. The City also requests that the SWRCB consider using the gauging station at Antioch as a point of interest to ensure that flow criteria and salinity objectives are met.

References

[CCWD] Contra Costa Water District. 2010. Report titled "Historical Freshwater and Salinity Conditions in the Western Sacramento-San Joaquin Delta and Suisun Bay".

Cowell, J. W. 1963. History of Benicia Arsenal: Benicia, California: January 1851 – December 1962. Berkeley, Howell-North Books.

[DPW] Department of Public Works. 1931. *Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay.* Bulletin No. 27. State of California, Department of Public Works, Division of Engineering and Irrigation.

[DWR] Department of Water Resources. 1960. *Delta Water Facilities.* Bulletin No. 76. State of California.

Dillon, R. 1980. Great Expectations: The Story of Benicia, California, Fresno, California. 241 pp.

Means, T. 1928. Salt Water Problem: San Francisco Bay and Delta of Sacramento and San Joaquin Rivers, San Francisco, California, April 1928. Report prepared for the Association of Industrial Water Users of Contra Costa and Solano Counties.

Tolman, C. F. and J. F. Poland. 1935. *Investigation of the Ground-Water Supply of the Columbia Steel Company Pittsburg, California*. Stanford University, California, May 30, 1935.

Town of Antioch v. Williams Irrigation District (1922, 188 Cal. 451).

[3] These estimates were made using IEP data in CCWD (2010), which will be presented by the Contra Costa Water District during this informational proceeding.

Testimony by City of Antioch

For SWRCB Delta Flow Criteria
Informational Proceeding

Submitted February 16, 2010

For hearings beginning March 22, 2010

Overview

- Antioch has taken fresh drinking water from the Delta since the 1860s
- Infrastructure and flow diversions have changed distribution and timing of freshwater flows
- Historic conditions were far fresher than current conditions
- Quality of water at Antioch has declined markedly

Why Is This Important ?

- Characterizations of the Delta as “historically saline” are false
- Native species are adapted to historical conditions, so historic salinity and flow patterns must be considered in establishing appropriate flow and salinity standards

What Should Happen ?

- SWRCB should review and incorporate historic salinity data into its analyses
- SWRCB should use historic data to establish an historic baseline of water quality and flows for both fisheries and drinking water quality standards

What Should Happen ?

- SWRCB should ensure that flows are not reduced, nor salinity increased, beyond levels assured by D-1641 and current X2 requirements
- In fact, the City of Antioch asks the SWRCB to establish flow and salinity standards in line with the Delta's historic fresh condition
- SWRCB should state that characterizations of the Delta as "historically saline" are false
- SWRCB should consider using Antioch's gauging station as a 'point of interest' to gauge flow and salinity conditions

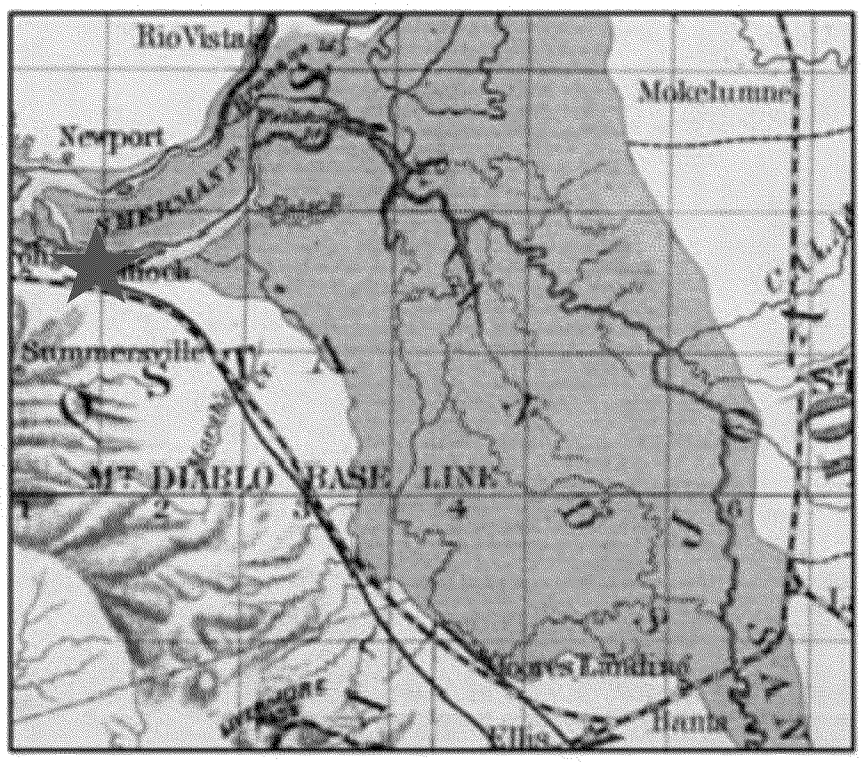
Systemic Changes Have Influenced Flows and Salinity

Factors Influencing Salinity

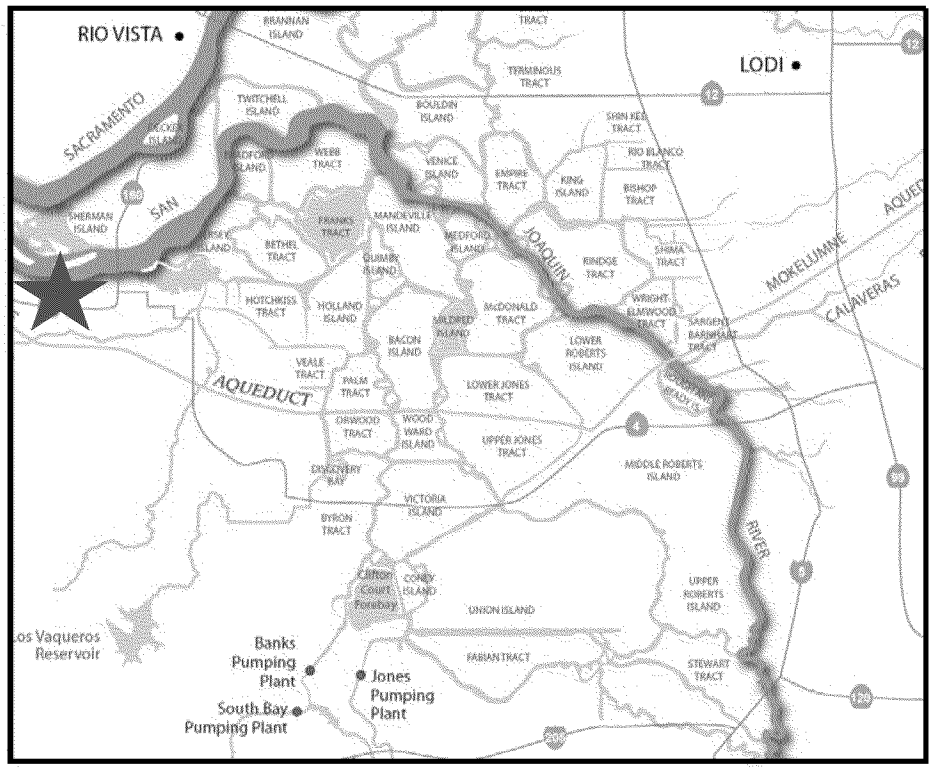
- Hydrology
- Changes to the Delta landscape
- Water Management
  - Exports
  - Diversions
  - Reservoir Storage

The Delta Landscape is Dramatically Different

1873



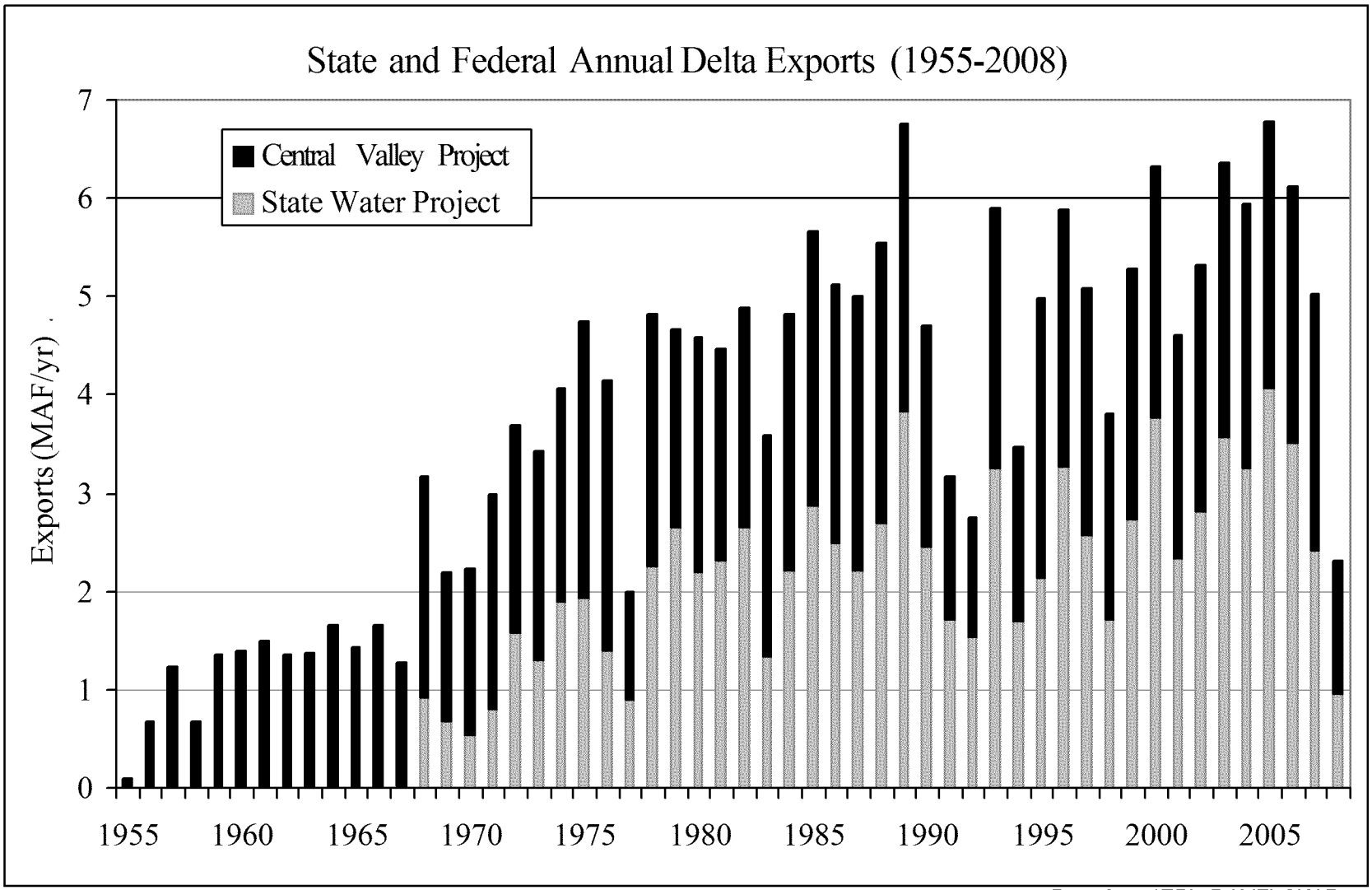
2010



★ Approximate location of City of Antioch's water intake

Source: left panel: DWR archives presented to Delta Vision (2008) final report; right panel: Delta Vision (2008)

Water Exports Have Increased and Remove Fresh Water from Delta



Data from IEP's DAYFLOW Program

Pre-1918, Fresh Water was Available in Western Delta Nearly Year-round

Location	Quotation
Antioch, CA	"*From early days, Antioch has obtained all or most of its domestic and municipal water supply from the San Joaquin River immediately offshore from the city… However, conditions were fairly satisfactory in this respect until 1917, when the increased degree and duration of saline invasion began to result in the water becoming too brackish for domestic use during considerable periods in the summer and fall.*" (DPW, 1931, pg. 60)
Western Delta	"*The dry years of 1917 to 1919, combined with increased upstream irrigation diversions, especially for rice culture in the Sacramento Valley, had already given rise to invasions of salinity into the upper bay and lower delta channels of greater extent and magnitude than had ever been known before.*" (DPW, 1931, pg. 22) "*It is particularly important to note that the period 1917-1929 has been one of unusual dryness and subnormal stream flow and that this condition has been a most important contributing factor to the abnormal extent of saline invasion which has occurred during this same time.*" (DPW, 1931, pg. 66)
Carquinez Strait (Western Delta)	"*Under natural conditions, Carquinez Straits marked, approximately, the boundary between salt and fresh water in the upper San Francisco Bay and delta region…*" (Means, 1928, pg. 9) "*For short intervals in late summer of years of minimum flow, salt water penetrated at lower river and delta region, and in wet seasons the upper bay was fresh, part of the time, to the Golden Gate.*" (Means, 1928, pg. 9 & pg. 57)

DPW (1931). Bulletin No. 27. State of California, Department of Public Works, See http://www.archive.org/details/variationcontrol27calirich
Means, T. (1928). Salt Water Problem: San Francisco Bay and Delta of Sacramento and San Joaquin Rivers, San Francisco, California, April 1928. A report prepared for the Association of Industrial Water Users of Contra Costa and Solano Counties.

Pre-1918, Fresh Water was Available in Western Delta Nearly Year-round

Location	Quotation
Benicia, CA (Suisun Bay)	"*In 1889, an artificial lake was constructed. This reservoir, filled with fresh water from Suisun Bay during the spring runoff of the Sierra snow melt water …*" (Dillon, 1980, pg. 131) "*…in 1889, construction began on an artificial lake for the* [Benicia] *arsenal which would serve throughout its remaining history as a reservoir, being filled with fresh water pumped from Suisun Bay during spring runoffs of the Sacramento and San Joaquin Rivers which emptied into the bay a short distance north of the installation.*" (Cowell, 1963, pg. 31)
Pittsburg, CA	"*From 1880 to 1920, Pittsburg (formerly Black Diamond) obtained all or most of its domestic and municipal water supply from New York Slough [near Pittsburg at the confluence of the Sacramento and San Joaquin Rivers] offshore.*" (DPW, 1931, pg. 60) "*There was an inexhaustible supply of river water available in the New York Slough* [near Pittsburg at the confluence of the Sacramento and San Joaquin Rivers]*, but in the summer of 1924 this river water showed a startling rise in salinity to 1,400 ppm of chlorine, the first time in many years that it had grown very brackish during the dry summer months.*" (Tolman and Poland, 1935, pg. 27)

Cowell, J. W. 1963. History of Benicia Arsenal: Benicia, California: January 1851 – December 1962. Berkeley, Howell-North Books
Dillon, R. 1980. Great Expectations: The Story of Benicia, California, Fresno, California. 241 pp.
Tolman, C. F. and J. F. Poland. 1935. *Investigation of the Ground-Water Supply of the Columbia Steel Company Pittsburg, California*. Stanford University, California, May 30, 1935

Testimony from Antioch Lawsuit: Pre-1918, Fresh Water was Available at Antioch Year-round

- Antioch lawsuit in 1920: Town of Antioch [plaintiff] v. Williams Irrigation District et al. [defendants] (1922, 188 Cal. 451)

- Plaintiff alleged that the upstream diversions were causing increased salinity intrusion at Antioch

- Testimony from defendants in the Antioch lawsuit (from the supporting Supreme Court record on file at the State Archives) (CCWD, 2010)
  - In the late 1800s, water at Antioch was known to be brackish at high tide during certain time periods.
  - Antioch was able to pump fresh water at low tide throughout the year, with the possible exception of the fall season during one or two dry years.
  - Water at Antioch was apparently fresh at low tide at least until around 1915 (when the pumping plants started pumping continuously, regardless of tidal stage).

Testimony from Antioch Lawsuit: Pre-1918, Fresh Water was Available at Antioch in Fall

Testimony from plaintiff in the Antioch lawsuit (from the supporting Supreme Court record on file at the State Archives)

- Antioch's freshwater supply was obtained directly from the western Delta from about 1866 to 1918 (pg. 47-48).

- Prior to 1918, freshwater was available at Antioch even during dry years and in the fall (pg. 23-24).

Date	Location	Salinity (ppm)
1913 (Sept; a dry year)	Antioch	66
1916 (Aug. 5th; wet year)	Antioch	22.3
1916 (Aug. 9th; wet year)	Antioch	12.3
1916 (Sept. 19th; wet year)	Antioch	101.3
1917 (Sept. 14th; wet year)	Antioch	141.6

Testimony from Antioch Lawsuit: Post-1918, Upstream Diversions Drastically Increased Salinity Intrusion

Testimony from plaintiff in the Antioch lawsuit (continued)

- After 1918, salinity abruptly increased during irrigation (rice cultivation) season, and returned to a potable level after irrigation ceased (pg. 18-20)

Date	Location	Salinity (ppm)
1918 (Sept. 25th; dry year)	Antioch	1360
1920 (mid-July; critical year)	Pittsburg, CA	4500
1920 (end-July; critical year)	Pittsburg, CA	6000
1920 (mid-Aug.; critical year)	Pittsburg, CA	9500
1920 (end-Sept.; critical year)	Pittsburg, CA	2500
1920 (during rice irrigation; critical year)	Antioch	12,500
1920 (end-Oct, after irrigation; critical year)	Pittsburg, CA	fresh

Measurements at Pittsburg, CA, are from the Great Western Electro Chemical Co.

- Information on the effect of upstream diversions is also confirmed by records in the plaintiff's testimony from C&H Sugar (see CCWD 2010).

Testimony from Antioch Lawsuit: Water at Antioch is from Sacramento River

- Testimony from plaintiff in the Antioch lawsuit (continued)
  - Plaintiff testimony asserted that in 1920 "the amount of water which the San Joaquin carried was dependent entirely upon the amount of water in the Sacramento," and that "the San Joaquin itself carried practically no water at all. In other words, it was demonstrated that the amount of fresh water which came into the San Joaquin and down as far as the Town of Antioch was practically all Sacramento River water." (pg. 15)
  - Water was delivered to the San Joaquin River from the Sacramento River via two main conduits: Georgiana Slough and Three Mile Slough. 1920 flow rates in these sloughs were the basis of the assertion quoted above.

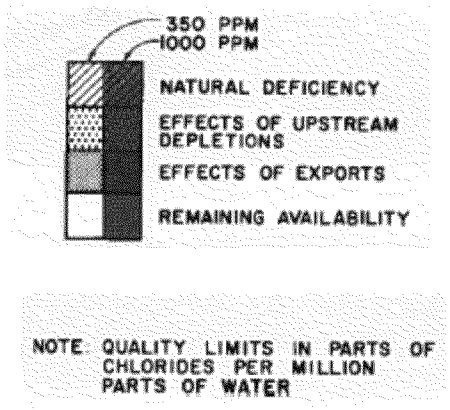
Testimony from Antioch Lawsuit: Water at Antioch is from Sacramento River

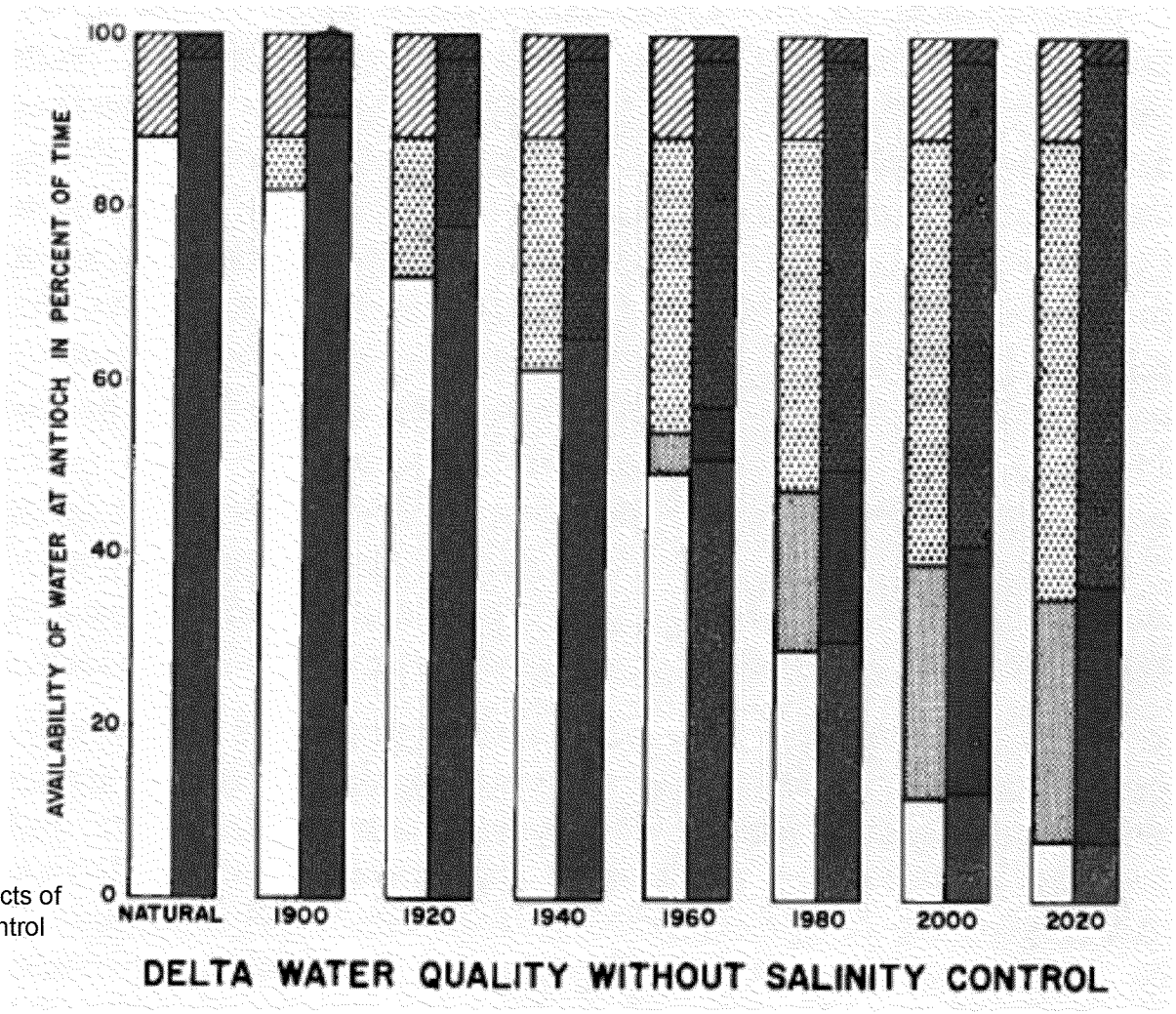
- "It is necessary here to state some additional facts to explain how this pollution comes about and why diversions from the Sacramento River may or do affect the volume and quality of the water flowing down the San Joaquin River . . . From the Sacramento River at two points, one about eight [Three Mile] and the other about twenty - three miles [Georgiana] above its mouth, sloughs diverge, into which parts of its waters escape and flow through the said sloughs and into the San Joaquin River at points several miles above the place of the diversion by the city of Antioch." Town of Antioch v. Williams Irrigation District et al. (1922) 188 Cal. 451, 455

Freshwater Availability has Declined

DWR (1960, pg. 13) found that freshwater was available at San Joaquin River at Antioch:

- 85% of the time under "natural" conditions
- 80% of the time in 1900
- 60% of the time by 1940
- 50% of the time by 1960



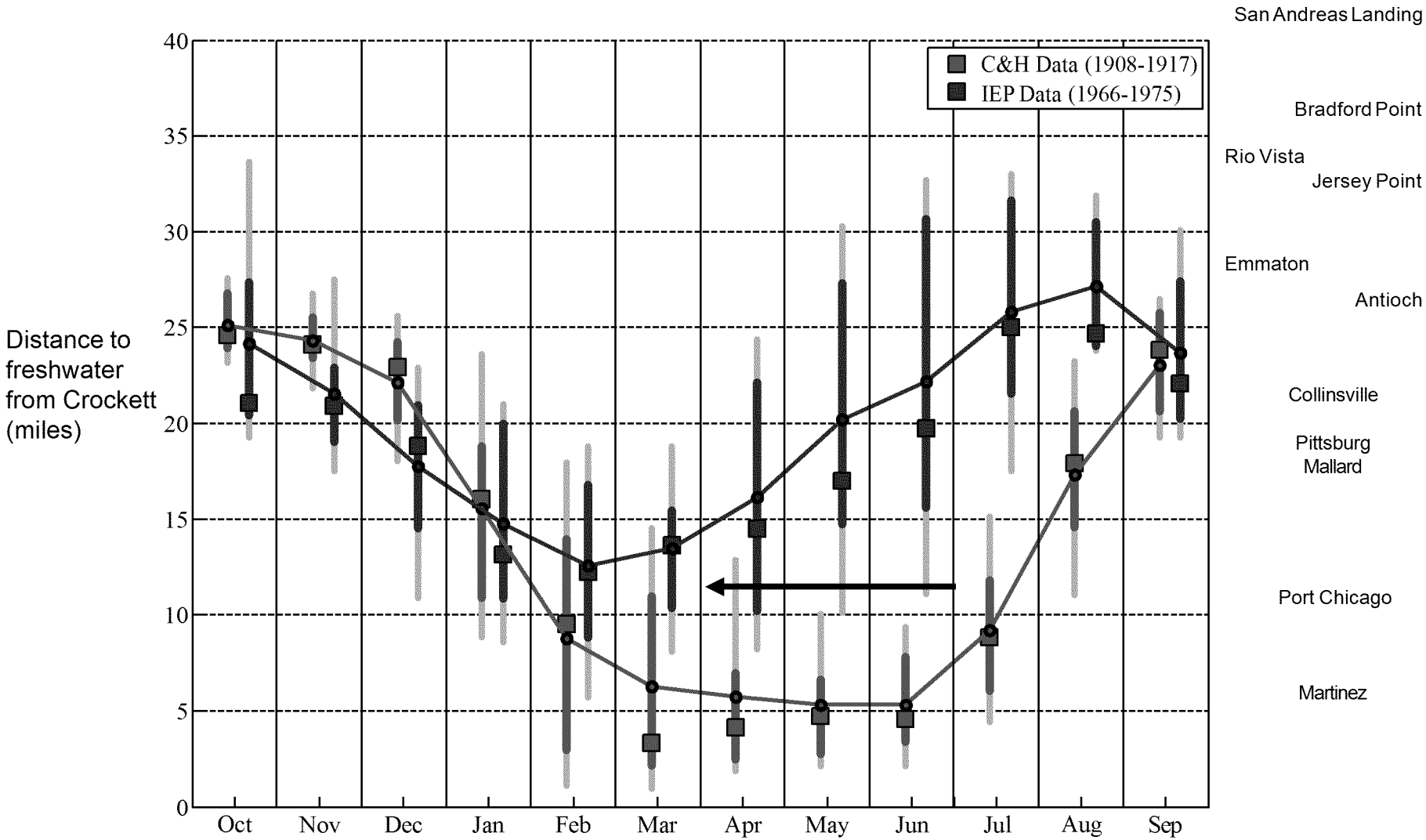


Note:- report did not include effects of reservoir releases for salinity control

DWR (1960). Bulletin No. 76. State of California. See http://www.deltacorridors.com/uploads/Bulletin_No._76_Delta_Water_Facilities-Color.pdf

Salinity Intrusion Occurred Earlier by 1975

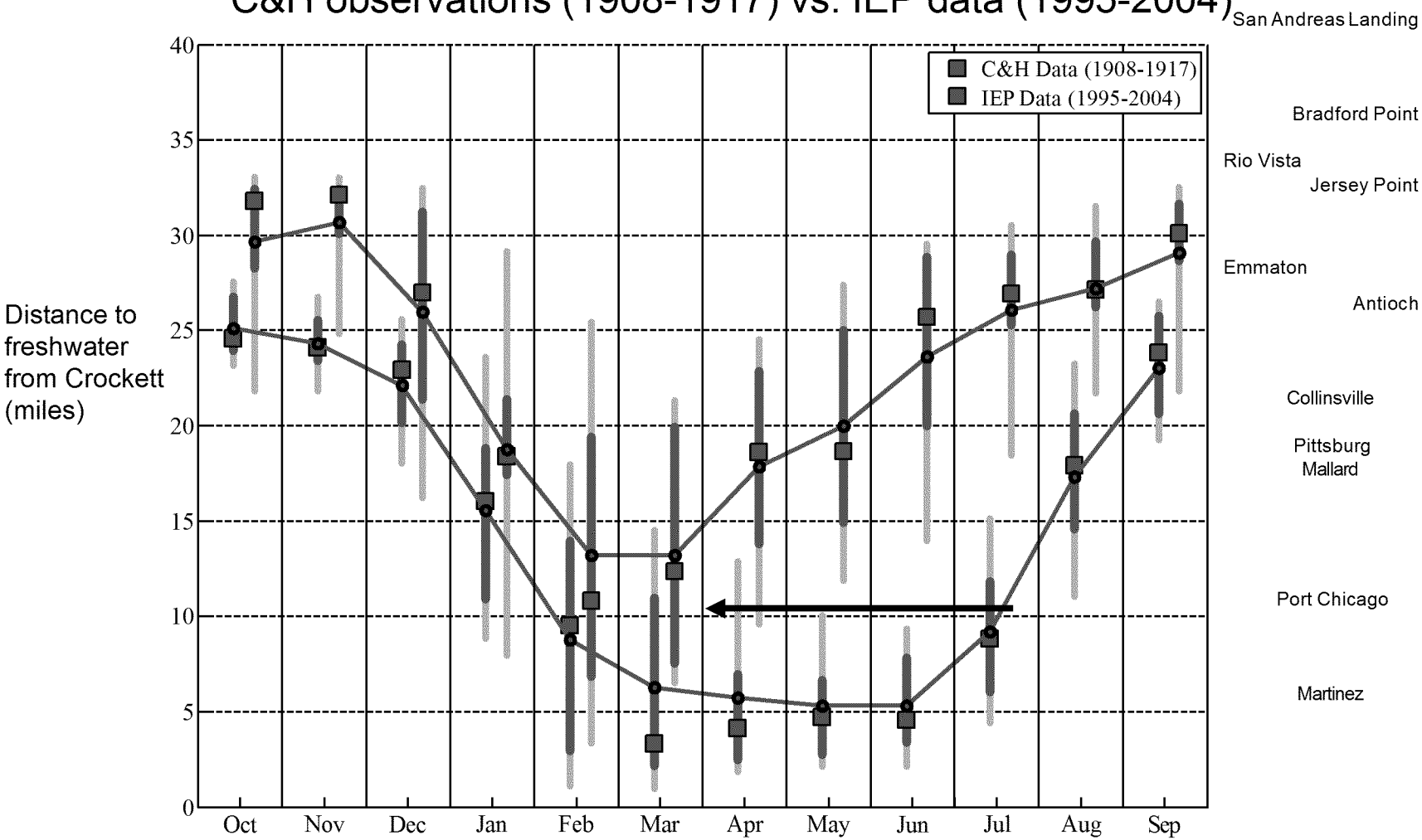
Distance to freshwater from Crockett (~25 miles west of Antioch)
C&H observations (1908-1917) vs. IEP data (1966-1975)



Source: CCWD Salinity Report (2010)

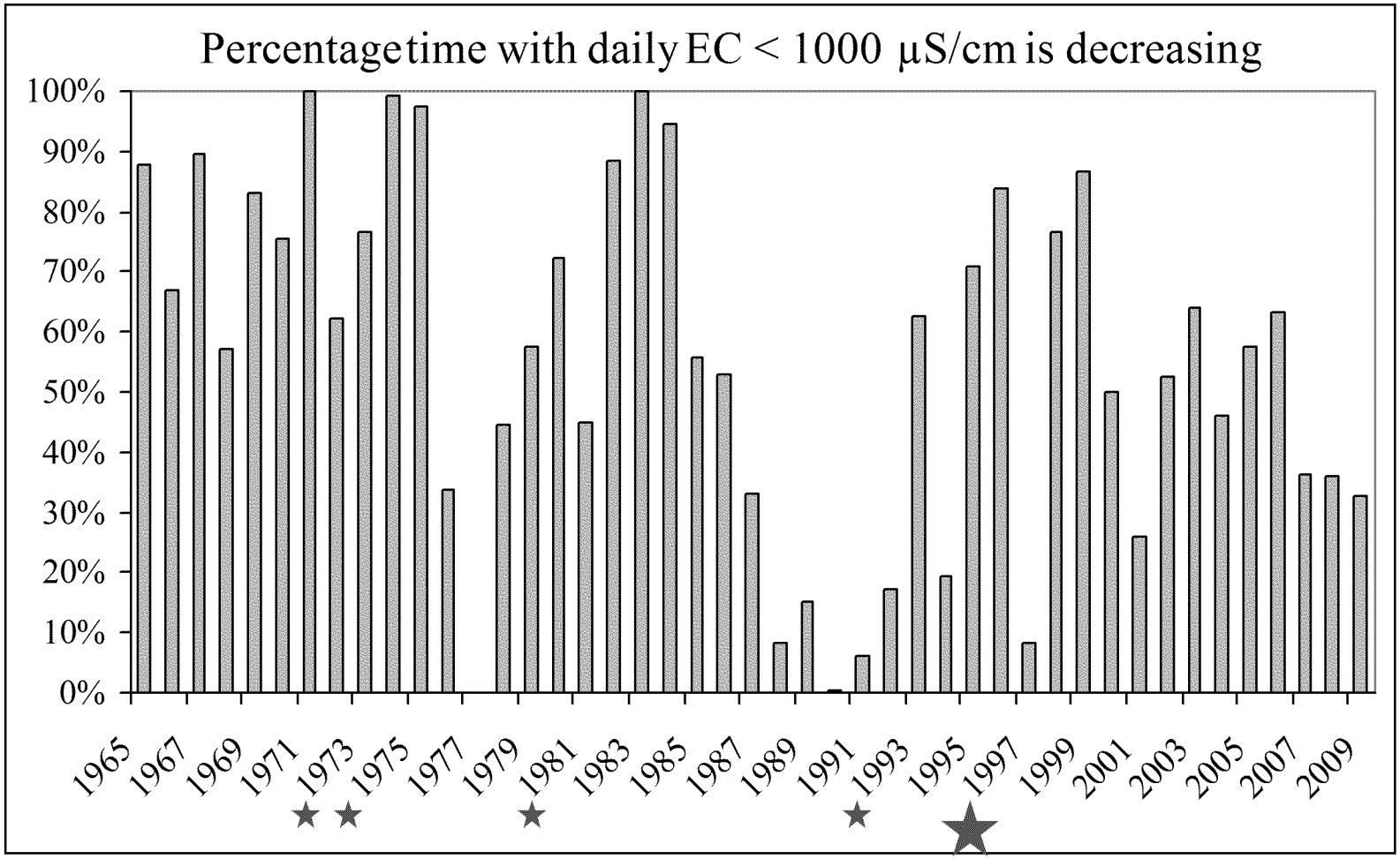
Salinity Intrusion Occurred Even Earlier and Extended Farther by 2004

Distance to freshwater from Crockett (~25 miles west of Antioch)
C&H observations (1908-1917) vs. IEP data (1995-2004)



Source: CCWD Salinity Report (2010)

Freshwater Availability at Antioch Continues to Decline

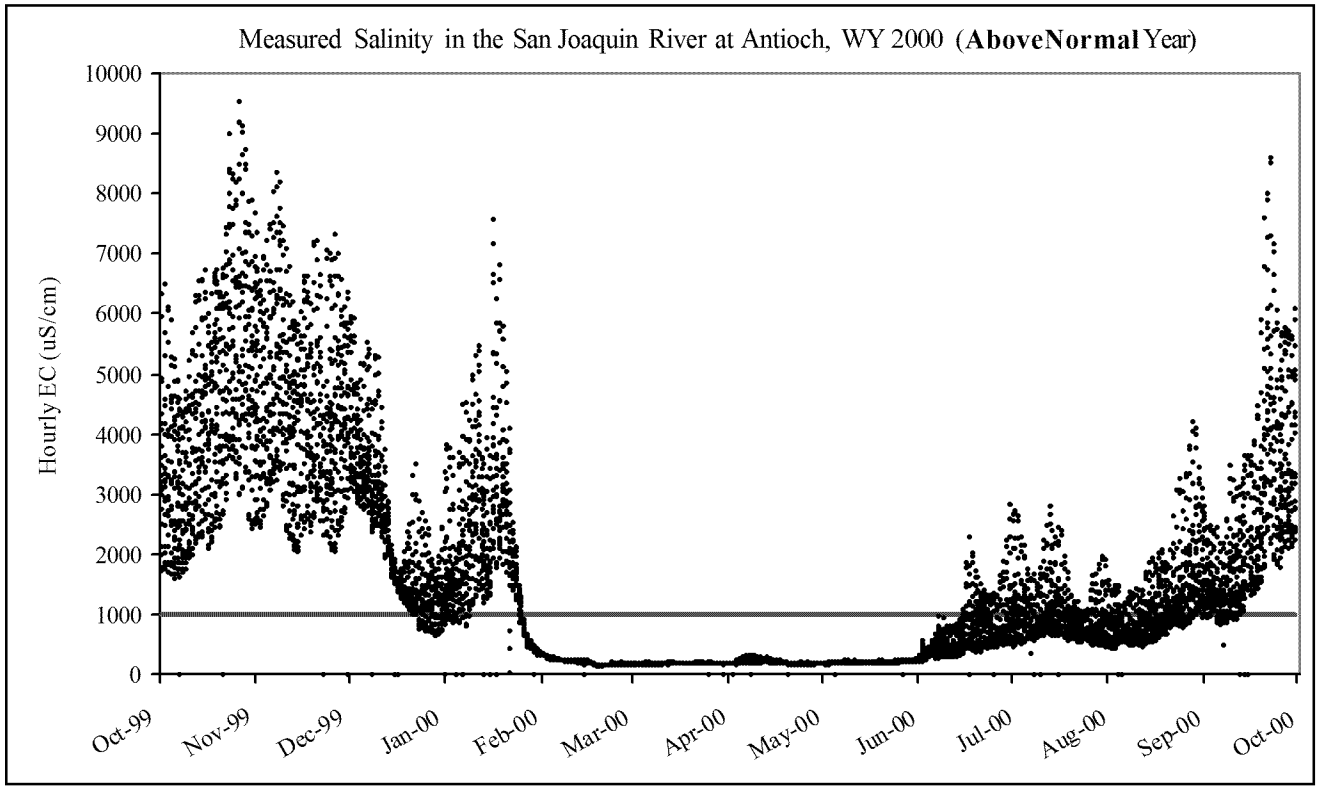


★ 10%-20% data missing

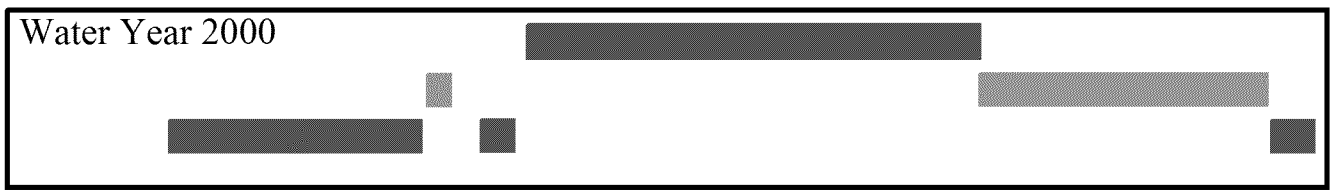
★ 80% data missing

Data from IEP & CDEC

Even in Above Normal Years, Freshwater is Now Unavailable in Summer/Fall



Freshwater Criterion
< 1000 EC

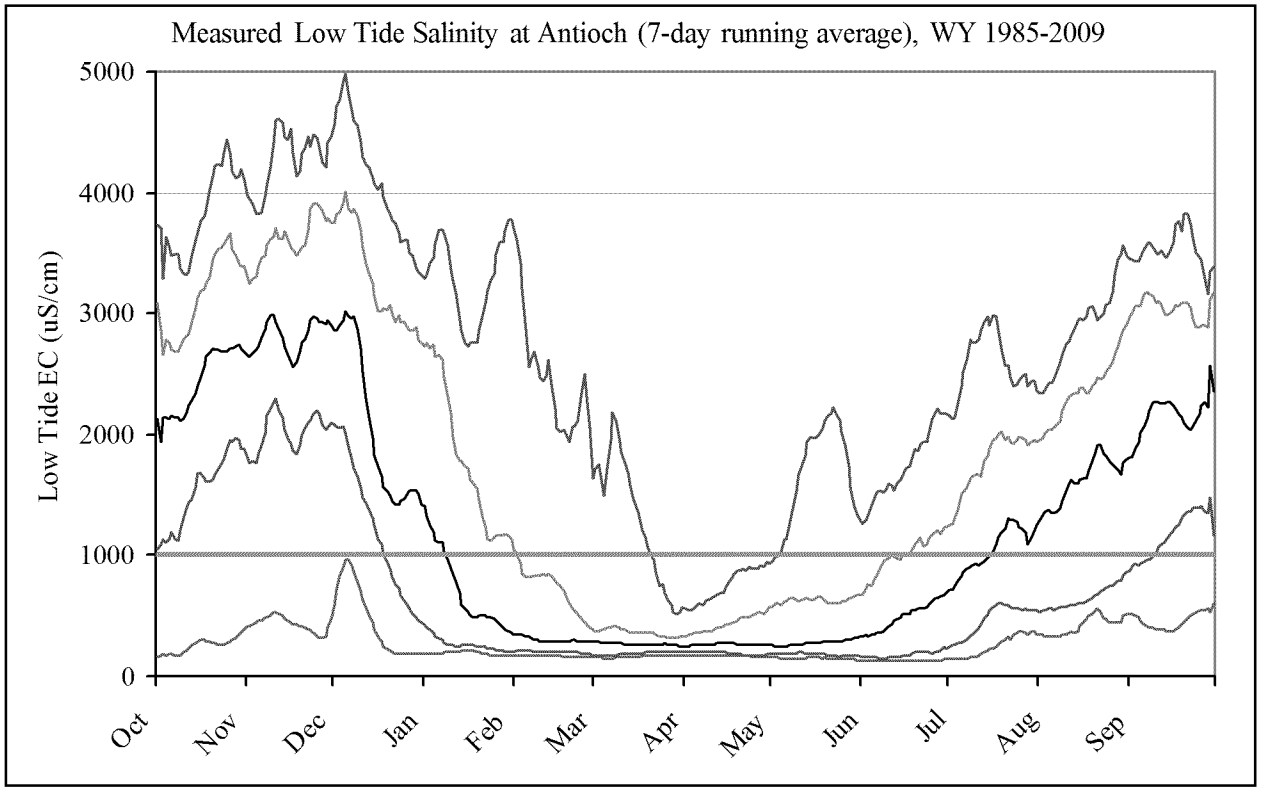


< 1000 EC all day
< 1000 EC low tide only
> 1000 EC all day

Pre-1918,
freshwater was
available year-round

Data from CDEC

Freshwater is Now Available at Antioch Far Less Often



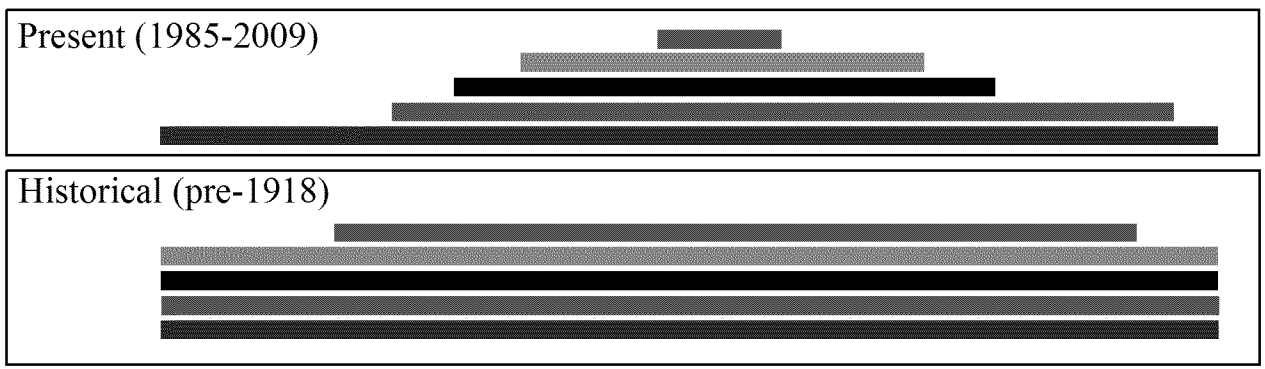
Driest 10%

Driest 25%

Median

Wettest 25%

Wettest 10%



Pre-1918, freshwater was available year-round at low tide in all but driest years

Data from CDEC

Summary: The Western Delta was Historically Fresher

- Pre-1918, freshwater was almost always available at least at low tide.
- Between 1918 and the late 1930s, drought conditions, upstream water diversions, and channelization increased the salinity of water at Antioch.
- By 1940 the drought receded, but salinity at Antioch remained elevated.
- Salinity continues to increase in recent years at Antioch.
- The fraction of time that water at Antioch is suitable for use (when salinity is < 250 mg/L chlorides or 1000 µS/cm EC) has declined significantly.
- “Historic” Delta was significantly fresher than the current Delta.

Conclusions

Consider historic fresh conditions to:

Establish Delta outflows and inflows to protect species adapted to these conditions.

Establish the criteria (volume, timing, quality) required by SB 7X 1.

Establish drinking water quality standards for the Delta.

Flow Science Incorporated
723 E Green St., Pasadena, CA 91101
(626) 304-1134 y **FAX (626) 304-9427**

April 14, 2010

Division of Water Rights
State Water Resources Control Board
Attention: Phillip Crader
P.O. Box 2000
Sacramento, CA 95812-2000

Re: Delta Flow Criteria Closing Comments

Dear Mr. Crader:

Flow Science, on behalf of the City of Antioch, appreciates this opportunity to submit closing comments to the SWRCB regarding its development of Delta Flow criteria for the purpose of informing planning decisions for the Delta Plan and the Bay Delta Conservation Plan.

Our closing comments include key points and recommendations for SWRCB consideration, supported by our written testimony and exhibits and the oral testimony provided at the hearings on March 22-24, 2010. Because we do not have the biological expertise to recommend specific flow rates and flow volumes, we are not providing specific quantitative recommendations with this submittal.

At the March 2010 hearing, we suggested that it may be useful for the SWRCB to consider a process of simultaneously working from the "bottom up"—identifying the flow needs of fish—and working from the "top down"—analyzing flows that can be provided by the current system and systems operations, in the context of other beneficial uses, including upstream flow and temperature requirements, and water supply needs. On behalf of the City of Antioch, I would be happy to work with SWRCB Staff to explore the advantages of such a process and to participate in such a process.

Key Points for SWRCB consideration

As discussed in our February 16, 2010, written submittal, the City of Antioch has been diverting water for drinking water use from the western Delta since the 1860s. In its written testimony, the City of Antioch has provided the SWRCB with information and data on historical flows and salinity conditions in the western Delta (testimony submitted by the City of Antioch on February 16, 2010, and incorporated here by reference in its entirety; see http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/antioch.shtml). Key points in the City's oral and written testimony include the following:

1. Historical fresh conditions must be considered in any effort to restore ecological conditions in the Delta.

We believe that it is essential for the SWRCB and its Independent Science Team to consider the historical salinity and flow conditions within which the Delta fisheries thrived, to ensure that the Delta flow criteria and other standards will ensure the protection of public trust resources, i.e. the future biological and ecological integrity of the Delta.

Systemic changes in the Delta over the years have reduced freshwater flows and dramatically increased salinity (Antioch testimony, Document #5, p. 1). Infrastructure and flow diversions have changed distribution and timing of freshwater flows, and historic conditions were far fresher than current conditions (Antioch testimony, Document #5, p. 2-4 & Document #6, p. 16-21).

It has sometimes been contended that the Delta was historically saline. As mentioned in our oral testimony (and as documented in the City's written testimony at p. 4-5 of Document #5), while the system experienced variability in flows and salinity in the past, the variability existed in a significantly fresher Delta, especially in the fall, spring and early summer months. As shown in Contra Costa Water District's submittal "Historical Freshwater and Salinity Conditions in the Western Sacramento-San Joaquin Delta and Suisun Bay" (at p. v and p. 47), while variability occurred historically, the levels of salinity were much lower than current conditions.

2. Native species are adapted to historical conditions, so historic salinity and flow patterns must be considered in establishing appropriate flow and salinity standards.

Our oral testimony during the March 2010 Informational Proceeding outlined the changes that have occurred to alter the flow and salinity environment in the Delta. This testimony on such changes was supported by other panelists. These changes include, in approximate chronological order:

- Alterations to Delta channels and loss of marshlands (Antioch testimony, Document #5, p. 1-2 & Document #6, p. 7)
- Alterations to sedimentation and transport patterns (Antioch testimony, Document #6, p. 7)
- Diversions of flows upstream of the Delta including the dewatering of significant portions of the San Joaquin River (Antioch testimony, Document #5, p. 2 & Document #6, p. 14-15)
- Diversions/exports of flows from the Delta and from Delta channels themselves (Antioch testimony, Document #6, p. 8 & p. 16)

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3. Because of these changes to the Delta, flow now plays a more crucial role than in the past, in order to maintain or improve physical habitat and water quality in the Delta.

We encourage the SWRCB to explore and document the biological significance of the historical changes in flow and salinity regimes, and to consider this information in its recommendations. It is critical to keep in mind the significance of Sacramento River flows on the health of the public trust resources in the Delta.

Closing Recommendations

1. SWRCB should review, consider, and incorporate historic salinity data into its Flow Criteria analyses. The City of Antioch and Contra Costa Water District have provided valuable data regarding historic Delta flow and lower salinity conditions.
2. SWRCB should use historic flow and salinity data to establish a baseline of water quality and flows sufficient to restore public trust resources in the Delta.
3. SWRCB should ensure that flows are not reduced, nor salinity increased, beyond levels assured by D-1641 and current X2 requirements. Ideally, the SWRCB should increase flows to more proximate historic conditions of outflow and low salinity. The City is not recommending that historic flows be completely restored as this is not practical and could potentially impact other beneficial uses. However, historic flows and historic low salinity levels supported native species and must be considered in making any determinations on restoring Delta flows.
4. Compliance points for outflow and salinity should <u>not</u> be moved land-ward (easterly) and should likely be established more westerly than present as supported by the historical data.
5. Due to the loss of historic San Joaquin River flows, it is critical that Sacramento River flows be maintained in and through the Delta – and that the SWRCB recognizes that such Sacramento River flows included significant flows into the Central and Western Delta through Georgiana and Three Mile Sloughs.
6. SWRCB should consider using Antioch's gauging station as a 'point of interest' to gauge flow and salinity conditions, given Antioch's historical diversion of fresh drinking water dating back to the 1860s.

Please feel free to contact me or Phil Harrington with any questions.

Sincerely,

Susan C. Paulsen

Susan C. Paulsen, Ph.D., P.E.
Vice President and Senior Scientist

cc: Phil Harrington