Boron, Salinity, Nutrients and Dissolved Oxygen in the Irrigation Water

within

the Yolo County Flood Control and Water Conservation District

8/31/06

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Table of Contents

1. Introduction

The water quality of agricultural drainage within, and flowing out of, the Yolo County Flood Control and Water Conservation District (the District) is controlled by multiple factors; more than farming practices alone. A detailed knowledge of the source of the irrigation water (both surface and groundwater) is required to understand why some parameters, tested by the local water quality coalition, may be above water quality objectives (WQOs, either adopted or unadopted in the Basin Plan).

Both Order No. R5-2003-0826 and Order No. R5-2003-0833 state that "*If results indicate that water quality objectives are exceeded at any site, monitoring for the COCs* [constituents of concern] *shall continue and the monitoring must be expanded upstream in a systematic search for sources*." In the Yolo County area, there is a significant amount of information already available that identifies the most likely sources for high levels of salinity and boron. The farmers and resource mangers in Yolo County have been dealing with these issues for many decades. There is also significant information that explains dissolved oxygen exceedences and this information will also be discussed.

The purpose of this document is to improve communication between Regional board staff and the local water resources managers in Yolo County on issues related to water quality. We share the same goals and support efforts to improve water quality when beneficial uses are impaired.

Both surface and groundwater irrigation supplies will be discussed in this review of source water quality.

2. General Description of the YCFCWCD System

The District's boundaries cover 195,000 acres of Yolo County, of which approximately 55,000 acres receive District delivered water in any one year. This is about 40% of the irrigated farmlands in Yolo County. The District lands are within the Cache Creek and Willow Slough watersheds.

The District's surface water supply consists of water from Clear Lake, Indian Valley Reservoir and limited in-stream flows in Cache Creek. The Capay Diversion Dam, on Cache Creek, is raised 5 feet during the irrigation season so that water can be diverted into the District's 160 miles of canals. In addition to the District's canals used for water deliver, there are over 100 miles of drainage channels, informally called sloughs.

- Clear Lake – Clear Lake is the District's primary water supply. Clear Lake is a large shallow natural body of water with a maximum depth of approximately 50 feet. The maximum withdrawal for irrigation is 150,000 acre-feet. In some dry years, no water is available from Clear Lake for irrigation. Cache Creek Dam controls the irrigation releases from Clear Lake. Cache Creek Dam is located approximately 49 miles upstream from the District's Capay Diversion Dam.

- Indian Valley Dam and Reservoir -- The dam and reservoir are located on the North Fork of Cache Creek approximately 54 miles from the Capay Diversion Dam. When full, Indian Valley Reservoir has a total storage capacity of 300,600 acre-feet. Forty thousand acre-feet of the reservoir storage is dedicated to flood control. Indian Valley Reservoir was designed to provide a firm yield of approximately 55,000 acre-feet.

Because approximately 2/3 of the District's water supply comes from Clear Lake (during a typical year), water quality issues in Clear Lake will directly affect the quality of irrigation water used by District customers. Because of extensive reuse of tailwater, many additional Yolo County farmers indirectly use Clear Lake water also.

3. Nutrient TMDL for Clear Lake

Fig 1. Clear Lake Aug. 2006

Because two thirds of the District's surface water supplies come from Clear Lake, water quality conditions in Clear Lake have an impact on the quality of surface water in Yolo County.

As described in the Central Valley Regional Water Quality Control Board's proposed amendment to the Basin Plan for Control of Nutrients in Clear Lake (June 2006), the lake is "eutrophic", meaning nutrient rich. Recent improvement in water clarity in Clear Lake are encouraging, nevertheless, the relatively warm water, high nutrients, and algae blooms still can contribute to very low dissolved oxygen under certain conditions.

The most recent significant fish kill, which occurred during the first week in August 2006 was caused by the high water temperatures in Clear Lake. Thousands of threadfin shad, pictured above in figure 1, were found along the North shore of Clear Lake. (Photo by Bob Myskey, Lake County Record-Bee.) According to Rick Macedo, Fisheries Biologist with the California Department of Fish and Game, the threadfin shad in this picture died because of acute temperature changes, not necessarily low dissolved oxygen.

When water is released from Clear Lake for irrigation purposes, the same water quality conditions that contribute to eutrophication, high water temperatures, and low dissolved oxygen in Clear Lake are carried downstream into Yolo County.

Yolo County agriculture may additionally impact nutrient and dissolved oxygen levels in irrigation return flows as well, but how and to what extent is undetermined at this time. A detailed analysis will need to be made comparing drainage to source water. An excellent starting place for the quality of source water is from the data used to develop the Clear Lake TMDL. We ask the Regional Board staff for assistance in this effort, as the current published Clear Lake TMDL reports were not written with this comparison in mind, and the published reports appear to be inadequate for the proposed analysis.

5. Ground versus Surface Water

Within the District, and Yolo County in general, ground and surface water resources are vitally important for agriculture, urban, and environmental uses. The use patterns between ground and surface water, and differences in water quality between ground and surface water, are critical to understanding patterns of water quality in agricultural drainage.

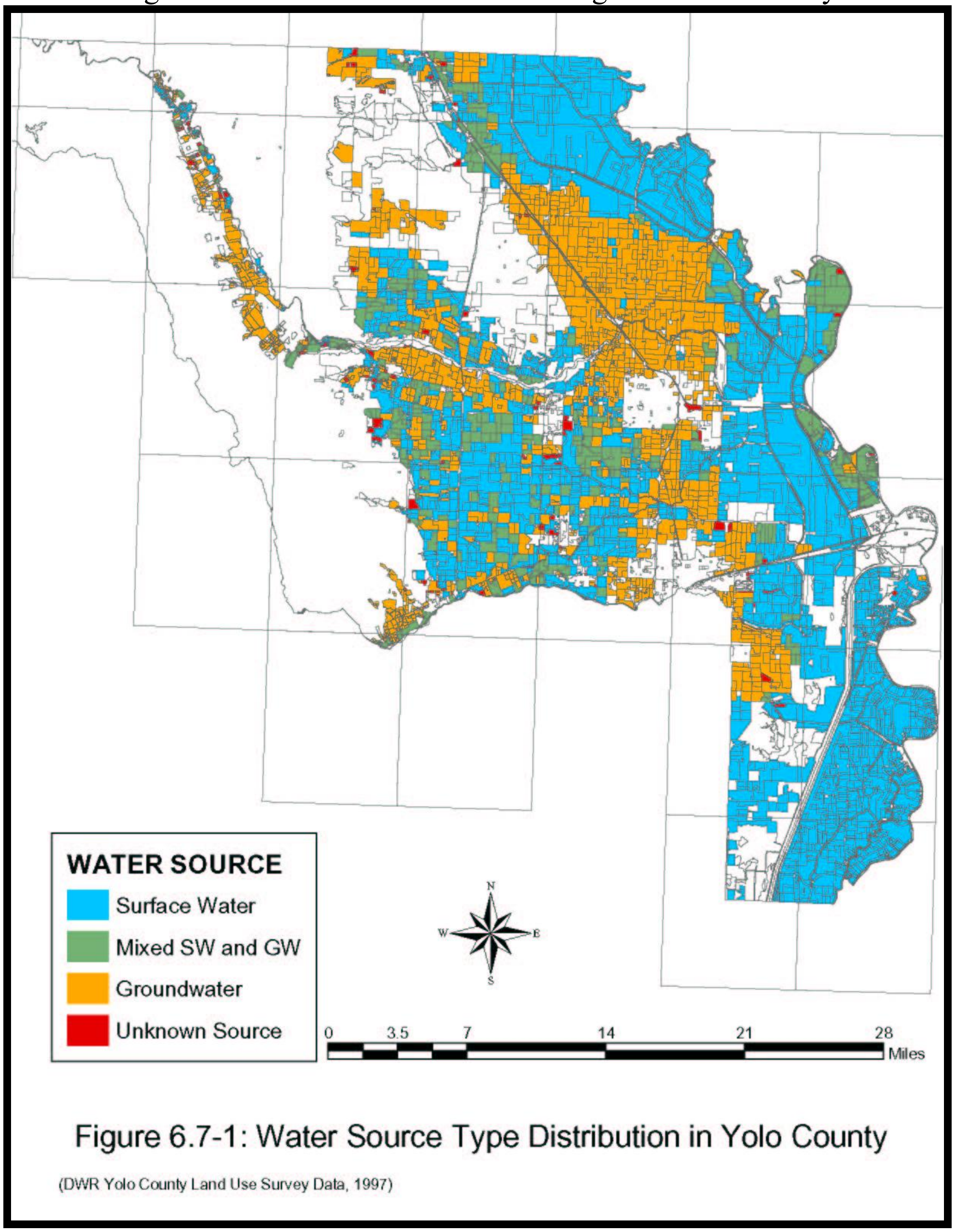
During normal water years, groundwater supplies approximately 36% of irrigation water in all of Yolo County and 50% of irrigation water in the YCFCWCD service area. During drought years, groundwater supplies almost 100% of the irrigation water.

Groundwater in Yolo County, especially the shallow aquifer that agricultural pumps tap, tends to have high levels of Boron and Electrical Conductivity (EC). In fact, the Boron and EC levels in most shallow (0-220 feet) and intermediate (220-600 feet) groundwater aquifers in the County exceed the most conservative recommended goals for salt sensitive crops for Boron and EC.[1] Most likely, ***all*** of the shallow groundwater supplies in the eastern part of the County exceed 700 uS/cm for EC. (YCWCWCD Groundwater Management Plan 2006).

In normal water year types, groundwater is an important water source for agriculture in Yolo County. During drought, groundwater is our ‘backup’ water supply and is a critical resource. Because of the importance and quantity of groundwater used for irrigation, it must be recognized that agricultural runoff for Boron and EC will have elevated levels of Boron and EC regardless of the agricultural practices used by area farmers.

[1] The Water Quality Control Plan for the Sacramento and San Joaquin River Basins does not contain adopted water quality objectives for Electrical Conductivity and Boron. In the absence of adopted objectives, Regional Board staff has interpreted the narrative chemical objective with various available water quality criteria. The water quality criteria available for Boron and EC, as used by the Regional Board, are from the United Nations Recommended Goals for Agriculture (FAO, Irrigation and Drainage Paper #29, 1985). It has not been determined if these goals are applicable to agricultural as it exists within Yolo County and specifically within the District. In a precedential Water Quality Order, the State Water Resources Control required the Regional Board to consider site-specific conditions in determining the appropriate level of EC in the irrigation water. (WQO 2004-0010, June 17, 2004, at page 7.) Thus, the water quality goals are used within this report for comparison purposes only and are not intended to imply that these goals are the appropriate water quality criteria that apply to agriculture in this area.

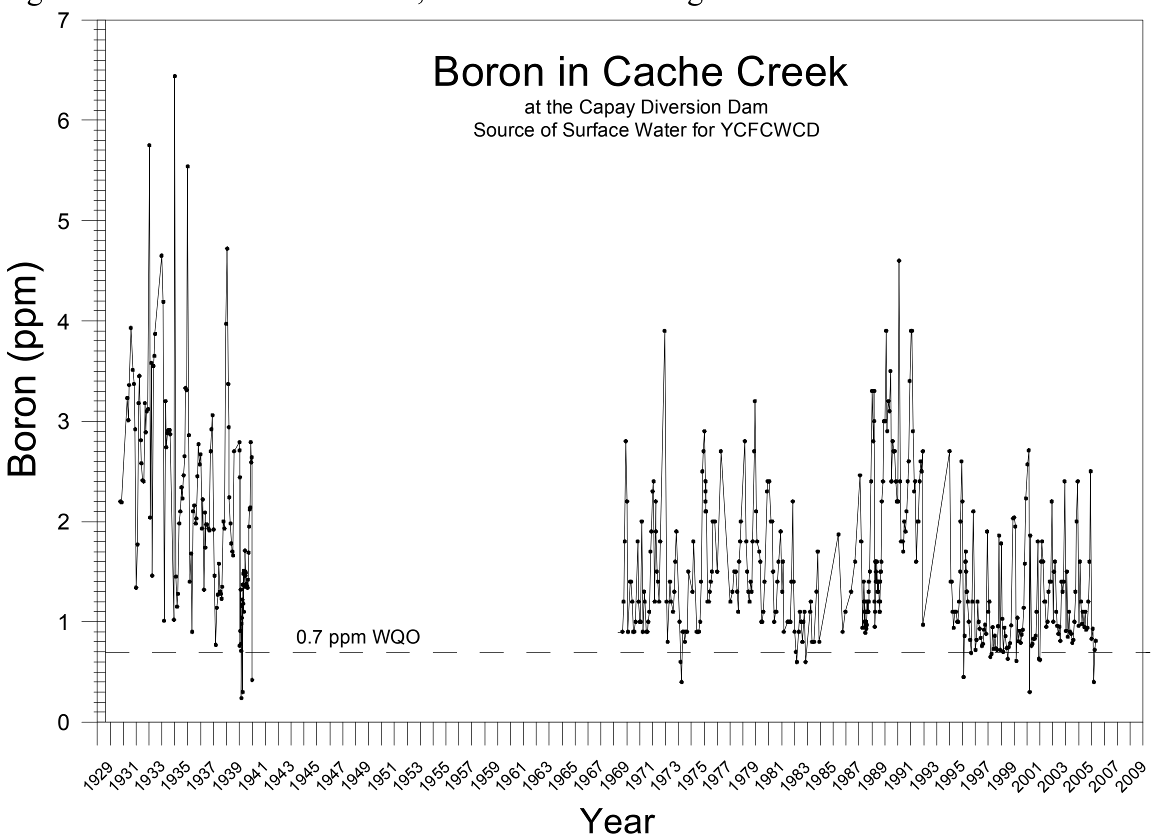
Fig 2. Patterns of ground and surface water use for irrigation Yolo County.



6.a. Boron - surface water

High levels of Boron occur naturally in the Cache Creek watershed. Since 1930, the District and its predecessors have been monitoring background levels of Boron in Cache Creek at the Capay Diversion Dam. Although there are some gaps in the data, it is clear that the main source of surface supplied irrigation water for the District, at its main diversion point at Capay, nearly always exceeds the most conservative water quality criteria available that could be used to interpret narrative WQO that applies to Boron (0.7ppm). The Boron levels in this watershed have been documented for the past 75 years and have probably been high for much longer. (Many other studies and datasets can supply greater detail about Boron in the Cache Creek watershed, and are needed for a full analysis, but they will not be discussed here for sake of simplicity and clarity.)

Figure 3. Boron in Cache Creek, source water for irrigation.



6.b. Boron - groundwater

The District's Groundwater Management Plan (2006) contains an extensive discussion of Boron in groundwater, along with data from 267 recent samples (years 2000 to 2004) from various depth zones and sub-basins. In the sixteen combinations of sub-basin and depth zone, all, except one, had **average** values for Boron at or above the interpreted narrative WQO for Boron.

High levels of Boron can be a problem for some types of crops in Yolo County, especially young tree crops. The farmers in Yolo County are aware of the high levels of Boron and have successfully managed their irrigation practices and water supplies to minimize the potential negative effects that could be caused by high levels of Boron.

The District welcomes ideas and creative efforts to address the Boron issue, however, it appears unlikely that changes in agricultural practices will reduce Boron in agricultural drainage. It also unnecessary to expand upstream drainage monitoring for Boron sources, since the sources are well known and have been monitored and documented for many years. We hope to continue to share information and knowledge we have gained about Boron with the Regional Board, so that we can work on this issue together.

7. EC/Salinity

The CVRWQCB has recently completed an excellent report on EC and salinity in the Central Valley entitled: <u>Salinity in the Central Valley: an Overview</u> (Cismowski, et al. 2006). To quote:

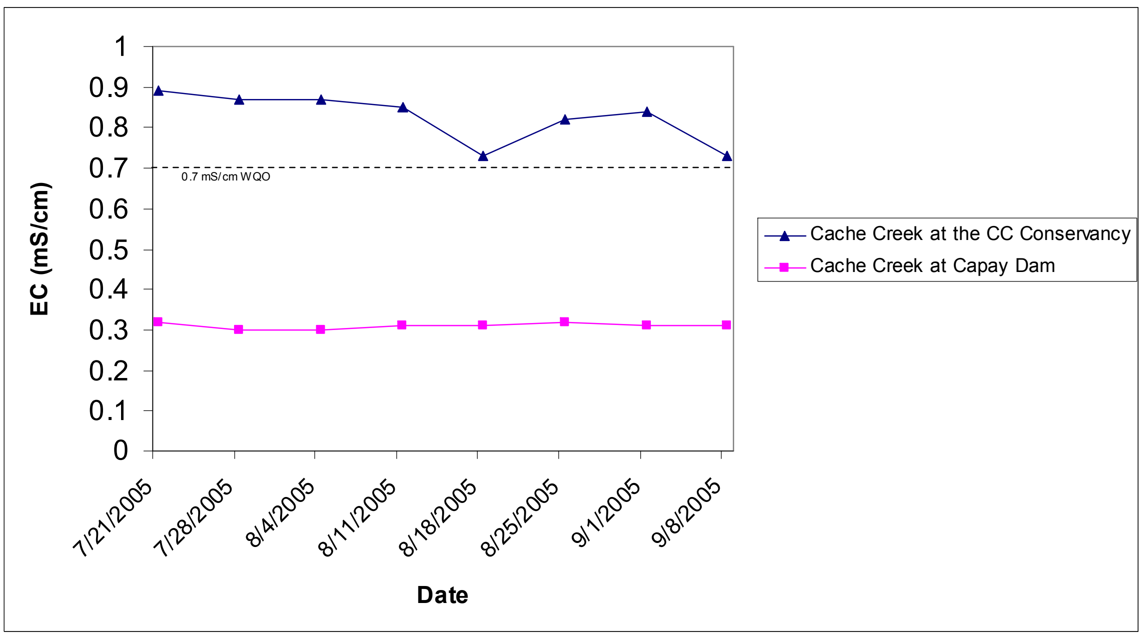
> "The salinity impairment of surface and groundwater in the Central Valley is a subset of a more far-reaching problem shared by most of California, other arid western states, and much of the developed world. As surface and groundwater supplies become scarcer, and as wastewater streams become more concentrated, salinity impairments are occurring with greater frequency and magnitude. Such impairments in the past have led to the fall of civilizations. These impairments will not be resolved by purely technical solutions. Solution of the salinity impairment in the Central Valley will depend upon development and successful implementation of effective land use, water supply, and water quality policies, in conjunction with overcoming institutional barriers…

This salinity report essentially describes salinity problems in water as requiring major statewide efforts and coordination over the next many decades. A long term salinity management plan for the Central Valley is needed.
To quote the report's explanation of how agriculture contributes salt:

> "Surface runoff from agricultural lands usually contains salt levels similar to the water supply… For the most part, it is drainage from the shallow groundwater beneath agricultural lands that is saline as a result of evapoconcentration of the salt and dissolution of salts in the soil profile. This groundwater can be collected by drainage systems or move laterally into surface waters…

Many of the sloughs and creeks in Yolo County are "gaining reaches", meaning that at least some of the water found flowing in them comes from shallow groundwater. This process is well documented in Cache Creek. In the gaining reaches of Cache Creek, EC is high. See Figure 4.

Figure 4. Electrical Conductivity in Cache Creek during the summer of 2005. The Conservancy reach (blue line) is exclusively groundwater, there is no surface water coming from the upper reach at Capay Dam (pink line) nor any drainage flows into the Creek above this point (pers. obs during a walk of the entire creek bed from Capay Dam to CC Conservancy).



In 1975, Scott and Scalmanini predicted increased salinity in shallow Yolo County groundwater of 400 uS/cm by 1990. The current data support this projection (GWMP 2006). This means that the process of salinization of groundwater is generally well understood in Yolo County. This understanding can be used to start addressing salinity issues. Which means there is no need to move monitoring upstream in a systematic search for the source of high EC. The high EC values measured by the Ag Water Quality Coalition monitoring program are from the use of high EC groundwater for irrigation and the drainage of shallow groundwater into waterways in gaining reaches.

Over the long term, the salinity in shallow groundwater will probably continue to increase due to a number of different factors. (See Cismowski, et al. 2006 for details).

This salinity problem must be addressed aggressively, methodically, and holistically by considering both surface and groundwater together.

7. Differences in Source Water versus Tail Water

The impact of an agricultural practice on water quality can be determined by comparing water quality of irrigation source water to the water quality of the tail water. This is especially true on an individual field basis. On a watershed basis this becomes more difficult, but it is still a straightforward analysis for certain agricultural practices. For example, when an ag chemical is added to unknown fields upstream of a tail water monitoring station, and that ag chemical is not in the source water already, and the ag chemical shows up in the tail water, one can safely assume that the ag chemical has runoff from the fields where it was applied.

Sometimes there are issues with pesticides and fertilizer runoff from farms into waterways. This is a well known fact that the Conditional Waiver Program is addressing. However, some water quality issues do not follow this pattern. Some water quality issues involve constituents that are not ag chemicals and are not applied to fields as part of an ag management practice. A good example of this is the issue of high EC/salinity. Although farmer's add fertilizer, which is a component of salt, this amount is very small compared to the amount of salt that comes in the with the source water itself. The issue of high EC in shallow groundwater is from the natural process of evapotranspiration and poor soil drainage and is a cumulative process taking decades or centuries (as explained in Cismowski, et al. 2006). Depending on the water year type, source of irrigation water used, amount of shallow groundwater entering gaining reaches of waterways, and other factors, the tail water EC may be higher or lower than the source water. A comparison of source versus tail water quality is not very useful for issues with EC. Boron is a similar issue.

Nutrients are applied to the land for farming. Although there are other sources of nutrients that may cause water quality issues, fertilizer application can sometimes be a cause. In Yolo County, it will be useful to do a source versus tail water analysis for nutrients.

8. Conclusion

The brief overview of Boron, salinity, and nutrient water quality issues in Yolo County provided in this report is a very simplified description of these three issues in the irrigation water in our area. The primary purpose of this report is to promote communication between local resource managers and the Regional Board technical staff. A lot of information has been collected over many decades regarding water quality issues related to salinity, Boron and nutrients. Because these are primarily source water issues, the District believed it was important to explain how the surface and groundwater irrigation supply impacts water quality monitoring results for ag drainage.

Overall, the District is looking forward to creating a closer working relationship between our local experts and the Regional Board technical staff to address these issues and work towards improved water quality for all identified beneficial uses. In this spirit, we ask the Regional Board staff to assist us with an appropriate analysis of Clear Lake nutrient TMDL data, as it relates to source water quality issues in Yolo County.

9. References

G. Cismowski, et al. 2006 Salinity in the Central Valley:An Overview
Central Valley Regional Water Quality Control Board
http://www.swrcb.ca.gov/~rwqcb5/available_documents/basin_plans/salinity-overview-rpt.pdf

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