CV SALTS
Central Valley Salinity Alternatives for Long-term Sustainability

CVSC
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CENTRAL VALLEY SALINITY ALTERNATIVES FOR LONG-TERM SUSTAINABILITY (CV-SALTS) TECHNICAL ADVISORY COMMITTEE RECOMMENDATIONS REGARDING CITY OF DAVIS SALINITY STUDY DRAFT WORKPLAN

On 26 August 2011, the CV-SALTS Technical Advisory Committee reviewed and discussed the City of Davis Draft EC, Boron, Sodium and Chloride Workplan (City of Davis Workplan) to conduct a salinity study in order to determine appropriate salinity water quality objectives to protect agricultural supply water. The committee focused on the applicability of data collected as part of an earlier Woodland study to the current effort; use of the Hoffman model as a check on the Grattan model; appropriateness of using either model to evaluate boron, chloride or sodium; means of determining leaching fraction; and other issues raised by committee members. Discussion points, findings and recommendations for the above issues have been documented in Attachment 1 (CV-SALTS Technical Advisory Committee City of Davis Draft EC, Boron, Sodium and Chloride Study Workplan Recommendations, September 2011).

In addition to discussing the technical issues related to the City of Davis Workplan, the committee also briefly discussed some over-arching policy issues such as the determination of the most sensitive crop to be protected in a given sub-area, the concept of a "reasonable level of protection" (i.e., acceptable range of relative crop yield), and determining appropriate adjustments for drought years. While the committee recognizes that the policy discussions will continue at the Executive Committee, some factors they agree need to be considered include:

- Evaluating seasonality of cropping and irrigation when reviewing water quality objectives to protect agricultural supply. Literature numbers developed typically provide a margin of safety for stress during different seasonal conditions (e.g., although winter grown crops may be more salt sensitive, they are also being grown in less stressful environment).
- Identifying whether economic viability, as opposed to the presence of a crop in the area, is a better consideration to determine the crops to be protected. Both the percentage of acreage devoted to a particular crop in a region and the economic return of those crops should be considered in establishing the crops that must be protected from salinity impacts.
- Providing adjustments to account for drought situations (e.g., most growers prefer, and can manage, sufficient quantities of poorer quality water as opposed to restrictions on the quantities of water provided to them.)

The Executive Committee will consider these factors and provide recommendations in a future letter. We appreciate the opportunity to comment on the City of Davis Workplan and anticipate that our recommendations will be incorporated into the final study.

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Chair, CV-SALTS Technical Advisory Committee

Parry Klassen
Chair, CV-SALTS Executive Committee

Cc: Stan Gryczko City of Davis
Pamela Creedon, Executive Officer, Central Valley Regional Water Quality Control Board

Attachment 1. CV-SALTS Technical Advisory Committee
City of Davis Draft EC, Boron, Sodium and Chloride Study Workplan Recommendations
September 2011

1) Applicability of Woodland data to the City of Davis study.

The cropping pattern identified in the City of Woodland study[1] is likely similar to the City of Davis case since the majority of agricultural use for both studies is within the Yolo Bypass. The Technical Advisory Committee concurred with initial Central Valley Water Board staff comments that the City of Davis must clearly delineate the areas that utilize the downstream receiving waters as agricultural supply, confirm the types of crops grown in these areas, investigate cropping patterns and growth cycles of crops, and identify the most salt sensitive crop(s) to be protected.

Finding: The draft City of Davis Workplan appears to adequately address the above needs.

2) Use of the Hoffman model to evaluate the results from the Grattan model.

The committee expressed concern with using a steady state model (Hoffman) to evaluate a transient model (Grattan) and noted that according to Letey et al. (2011) steady state models are more conservative than transient models.[2] Thus, the committee recognized that judgment needs to be exercised when comparing model results.

The finding that a steady state model provides more conservative results than a transient model appears to be based upon the results obtained with the steady state model developed by Ayers and Westcot.[3] The Central Valley Regional Water Quality Control Board (CVRWQCB) has traditionally used the Ayers and Westcot model to assist staff in establishing NPDES permit effluent limits.

The Ayers and Westcot model assumes a plant water use pattern of 40-30-20-10, which means the plant gets 40 percent of its evapotranspiration demand from the upper quarter of the root zone, 30 percent from the next quarter, 20 percent from the next, and 10 percent from the lowest quarter. The soil-water salinity is calculated as the linear average of these four zones. This is a primary criticism of the model. According to Letey et al. (2011), the assumption that plants respond to linear average soil-water salinity is not supported by experimental evidence.[2] Rather, most water is extracted from the upper parts of the root zone where the salt concentration is not very sensitive to the leaching fraction.

The Ayers and Westcot model also does not consider the dilution effects of rainfall. This omission is cited as another reason why the model provides conservative results. The transient model for the City of Woodland study was specifically developed by Grattan to address the fact that rainfall is not taken into account in the Ayers and Westcot model.[1] Grattan (2006) states on page 12: "The main goal of our model is to determine the extent by which rainfall will reduce the seasonal average root zone salinity, allowing the use of higher salinity water."

The Hoffman steady state model recognizes water uptake by plants does not necessarily correspond to a linear average of soil-water salinity within the root zone.[4] Consequently, the Hoffman model incorporates an exponential soil-water uptake factor. The Hoffman model also accounts for rainfall. Therefore, as noted on page 122 of Hoffman (2010), results obtained by the Hoffman model may not differ appreciably from a transient model, such as the one developed by Grattan, particularly if the leaching fraction is greater than 15 percent, and cropping patterns and irrigation water quality are relatively stable.

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[1] Grattan, S.R. and D. Isidoro-Ramirez. 2006. *An Approach to Develop Site-Specific Criteria for Electrical Conductivity, Boron and Fluoride to Protect Agricultural Beneficial Uses*.

[2] Letey, J. et al. 2011. *Evaluation of Soil Salinity Leaching Requirement Guidelines*. Agricultural Water Management.

[3] Ayers, R.S. and D.M. Westcot. 1985. *Water Quality for Agriculture*. FAO Irrigation and Drainage Paper 29.

[4] Hoffman, G.J. 5 January 2010. *Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta*. Final Report.

Transient models have shortcomings as well. On page 122, Hoffman (2010) states:

> The steady state model appears to be very reasonable at leaching fractions above 0.15. At least two groups of scientists and engineers are currently working on comparing the transient models described here and several others and attempting to resolve which model(s) should be used. One must keep in mind that transient models require a large amount of input data which are not always available. It is hoped that within a few years transient models will have been developed and field tested so that they may be used with confidence.

The City of Davis Workplan indicates the crop tolerance model for electrical conductivity (EC) will be determined in consultation with the CVRWQCB.[5]

The preference from the committee is to shift to the use of a transient model, but the group did not recommend defaulting to the Grattan model until peer review was completed through field testing. The group also noted that building in water management (e.g. method of application and seasonality of use) may alleviate some salinity concerns.

Recommendation: Use of the Hoffman model as an initial check on Grattan model results can be tried as long as some of the basic differences between the models are understood. If the two model results are "considerably" different (e.g., greater than 100 mg/L TDS difference), conduct further review to determine why.

The Hoffman and Grattan models will provide estimates of soil salinity that will result from the conditions simulated by the models. The modeled soil salinity will be compared to a response curve that relates the relative yield of a particular crop to soil salinity.[6] If this comparison indicates the modeled soil salinity will not result in an unacceptable crop yield then the agricultural (AGR) beneficial use of waters from the Willow Slough Bypass, Conaway Ranch Toe Drain, and/or Yolo Bypass, which receive treated effluent from the City of Davis, has been protected.

The available response curves for many crops are based on data obtained from experiments that were conducted 20 to 30 years ago. The salt tolerances of these crops may be higher today than when the experiments were performed because new and improved varieties are now probably being grown. For this reason, Hoffman (2010) on page 102 recommended that a field experiment be conducted to ensure the salt tolerance of beans is established for local conditions before setting the salinity water quality standard for the South Delta. Consideration should be given to performing similar field experiments if available response curves do not pertain to the crop varieties being grown in the City of Davis study area.

3) Is it appropriate to run the Grattan or other model to evaluate boron, chloride and/or sodium water quality objectives?

No known models were identified for sodium or chloride. Grattan tried to adapt his model to account for the behavior of boron in soil. However, after consulting with soil chemists at the U.S. Salinity Laboratory, Grattan (2006) states on page iv that boron "adsorption/desorption processes are highly dependent upon soil mineralogy, clay content, surface area, organic matter content and pH." On page 31, Grattan (2006) concluded that his model is "not appropriate to predict soil boron behavior nor could it be readily adapted to account for complex soil boron chemistry." There was some speculation that the UC Salinity Laboratory may have a boron model, but that the model would be calibrated for boron concentrations at a much higher level than those seen in the City of Davis treated effluent.

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[5] Larry Walker Associates. February 2011. *EC, Boron, Sodium and Chloride Study Workplan*. p. 4.

[6] According to University of California, Davis, University of California Irrigation Program publication titled *Agricultural Salinity and Drainage*, revised 2006, the most common method of experimentally determining soil salinity is to measure the EC of the solution extracted from a saturated soil paste sample. This measurement is frequently called the salinity of the saturation extract (EC_e).

Recommendations: Rather than attempting to model boron, chloride, or sodium, the Committee recommends reviewing literature values to identify any potential concerns and to follow up on those concerns by reviewing current management practices. In particular, chloride impairment can be related to how the water is applied (sprinkler vs. furrow) and infiltration issues associated with sodium (dispersion of surface soils in the presence of higher sodium concentration water) may be offset by higher overall salinity concentrations. The Committee also recommended evaluating current sodium concentrations in groundwater and current management practices utilized by growers irrigating with groundwater to determine whether current practices already account for and mitigate elevated sodium concentrations.

4) Leaching fractions

Both steady state and transient models rely upon water and salt mass balances. According to Letey and Feng, steady state models require the constant flow of water.[7] Under these conditions, the mass balance dictates the salinity of the drainage water leaving the root zone (EC_{dw}) is equal to the irrigation water salinity (EC_w) divided by the leaching fraction (LF). The salinity of the drainage water is given by the following equation under steady state conditions:

$$EC_{dw} = \frac{EC_w}{LF}$$

In contrast, transient models use the Darcy-Richards equation to estimate water flow and the advection-dispersion equation for a non-reactive, non-interacting solute to estimate salt transport. Information on soil properties is needed for a transient model. Besides soil properties, transient models are required to account for all of the time dependent variables encountered in the field. Letey and Feng (2007) indicate these variables include "switching crops with different salinity tolerance, variable irrigation water salinity including rainfall that is pure, timing and amount of irrigation, initial soil salinity conditions, etc."

The Hoffman model (steady state) has typically utilized 15 to 20 percent as the leaching fraction. This fraction has been calculated in the San Joaquin Valley through a mass balance approach using tile drainage and applied water data. While the methodology is adequate, the same data set is not currently available for the Yolo Bypass. The Grattan model utilizes the Darcy-Richards and advection-dispersion equations rather than the assumption of a specific leaching fraction input. In other words, the Grattan model simulates leaching rather than assuming a fixed leaching fraction value.

Recommendation: For the Hoffman model, utilize a range of 15 to 20 percent for the leaching fraction input to represent conditions in the Yolo Bypass. If utilizing rice as the most limiting crop, recognize that the current management practice of ponding irrigation water alleviates some salt impact since salt does not accumulate in the soil profile during the growing season.

5) Other technical considerations

The Committee discussed in detail the importance of irrigation water management in mitigating anticipated impacts from suboptimal water quality and provided two additional recommendations.

Recommendation: Initial study results should be discussed with the local agricultural commissioner, UC Cooperative Extension, and local growers to determine if the actual users of the water have any specific concerns with the study assumptions, findings, or the numbers being developed.

Recommendation: Should consider the potential to have different objectives during different growing seasons (e.g. winter cropping).

[7] Letey, J. and G.L. Feng. 2007. *Dynamic Versus Steady-State Approaches to Evaluate Irrigation Management of Saline Waters*. Agricultural Water Management.