MEMO

PLANTIERRA

From: *John Dickey*

To: *CV-SALTS, Lower San Joaquin River Committee*

Date: August 20, 2014

Subject: ***Hoffman Model Review, Initial Findings and Final Results***

As part of the technical work that will underpin development of numeric water quality standard development in the Lower San Joaquin River (LSJR), Jim Brownell/Central Valley Water Quality Control Board developed a Hoffman Model analysis for almonds irrigating with water from the Lower San Joaquin River (Reach 83). I reviewed this analysis with support from the Central Valley Salinity Coalition (CVSC), and reviewed model review comments and questions on August 5 with Jim and Mark Gowdy/State Water Resources Control Board. This memo summarizes the preliminary model review comments and questions, and the consensus, final findings based on the August 5 review meeting and subsequent discussion with Mark and Jim.

Preliminary model review comments and questions

Below is a summary of preliminary comments and questions developed by John Dickey as a result of reviewing the Hoffman Model workbook developed for the LSJR Committee (LSJRC), before consulting with Jim (who developed this workbook) and Mark (who developed the original Hoffman Model workbook from Dr. Hoffman's equations.

1. Received authorization from Daniel Cozad (CVSC) to work with LSJRC to review Hoffman model results.
2. Met with David Cory and stakeholders (General Manager of PID, WSID) to discuss thresholds relative to what is being observed in their districts this year.
3. Received recent water quality data for districts and had a preliminary look at it relative to Ag criteria for Cl, B, pH, and salinity. Brief summary of diagnostics for Almonds. PID has just provided some Almond and Walnut leaf tissue results. Main questions:
    - To what extent are salinity and specific ions (Cl, B, and pH) responsible for impacts to Almonds & Walnuts that have been observed this year?
    - How do salinity levels throughout district line up with salinity at the main diversion?
    - How do the observed impacts from salinity line up with Hoffman model predictions? This is important to know because it indicates how suitable the raw model results may be for setting protective thresholds.
4. Received and reviewed Hoffman model workbook in detail and provided comments to Jim Brownell on 7/30.
5. Evaluated sensitivity of results provided to the issues identified during review. Sensitivity is <1%, so that the results should be usable.
    - The exponential uptake model calculates root zone salinity based on two factors: a) infiltrating water (precipitation + applied water) salinity, and b) leaching fraction.
    - Potential error in applied water volume is small, but it affects salinity of infiltrating water.
    - Effects on unused scenarios are somewhat larger, so it may be worth exploring whether the identified issues are indeed errors, for the benefit of future model users.
6. Recommended that we will work through issues on a relatively separate track, since the sensitivity is so low.

Consensus summary of resolutions of questions and comments

The first two questions had to do with calculations of infiltrating irrigation water for the two main scenarios, to wit:

1. With precipitation
2. Without precipitation

It appeared to me that scenario 1 is supposed to ignore the contribution of fresh rainwater to leaching, not its influence on applied water. Thus, I_1 would seem to be the difference between ET_c and P_{eff} as a quantity would then be divided by (1-LF). The applied water depth includes both irrigation requirement and precipitation, both inflated by the leaching fraction. This exaggeration of applied water would drive EC_{sw} down due to greater dilution in the root zone, and the EC_w thresholds up.

Explanation: This scenario is intended to assess the condition in which all water demand is satisfied by applied water, not precipitation, every year. As such, the formula in I_1 calculates water that is available to dilute salinity in root zone layer 1. All of this water is applied as irrigation, carrying the salinity concentration associated with irrigation water. This is a different scenario than John had originally understood, with the following features:

- Infiltrating water depth is enough to satisfy ET_c and LF.
- The salt load applied to the land is exaggerated since the much more dilute nature of rainwater is replaced with the salinity level in applied irrigation water.

No changes are required, but the scenario 1 annotation in the workbook will be augmented to include this information.

It appeared to me that I_1 in scenario 2 should be difference between Etc and Peff as a quantity, divided by (1-LF).

Explanation: This formula calculates leaching volume as a percentage of the ETc component of water demand that is satisfied by applied water, ignoring the ETc component that is satisfied by effective precipitation. Hoffman did not intend to apply the leaching fraction to effective precipitation. This equation correctly reflects this intent. This approach results in a leaching fraction that is purely a fraction of applied water, which is then supplemented by precipitation. The effects of both applied water and precipitation are correctly reflected in the EC_{sw} calculations.

No changes are required, but the scenario 1 annotation in the workbook will be augmented to include this information.

The P_{ng} and P_{gs} calculations (columns D and F on the "scenarios" sheet) ignore total infiltrating precipitation calculation (in column G on data sheet). This (rather than total precipitation) should be referenced if the infiltrating water (NRCS curve number, or CN calculation) is going to be taken into account.

To achieve this, change column F on the "data" worksheet (Precip. - Growing Season) to reference column G rather than column E to account for runoff, where it occurs. Re-title this column "Infiltr. - Growing Season".

Explanation: The infiltrating water calculation is new, as it was not needed for the South Delta region for which the workbook was originally developed. The calculation appears to be correct, but needs to be referenced as described. The effect of the error on the current results is minor, since only a bit over an inch of precipitation was calculated to have run off the land during the entire data period. Were another CN used, the effect might be greater. These changes will be incorporated.

Cell R3 on the "data" tab should be an equation, not a hand-entered result. If not, when the CN is changed, infiltrating precipitation would remain unaffected, which is not intended or correct.

Explanation: The result of the equation for the current curve number is entered where this equation should go. The equation needs to be used instead. The result for the current analysis is nil, but the error needs to be corrected, since it would result in problems as soon as a different CN were entered.

Since the analysis actually relates ETc to AW with a leaching fraction (LF) calculation, the irrigation efficiency (IE) can be calculated (if irrigation runoff is ignored). To do this, change cell x10 on the "data" tab from its current value to 1/(1+LF), where "LF" is actually a reference to cell N4 on the "scenarios" tab. A comment should probably be added to the effect that, while irrigation runoff is not mentioned or acknowledged in calculations, it could be

<0% of applied water. This would affect this IE, but no other result. The IE is mainly an informational, reference item, and does not influence the Hoffman Model results relative to irrigation water quality criteria.

Explanation: As stated, the IE figure does not affect any of the Model results employed to help identify water quality criteria, and was therefore not a focus of previous discussion. It can and should be modified, as described, as a matter of clarification, and to show a meaningful value.

The amount of runoff for the entire data period (62 years), is estimated at a bit over an inch, or less than a percent of precipitation. Is this credible? The draft report argues that it is.

In the model's current form, the effect of precipitation on leaching is largely ignored, so that this issue currently has no effect. Were the preceding corrections made, and runoff assumed to be somewhat greater, it would diminish the amount of precipitation that leaches, and lower the threshold salinity value.

Explanation: The CN employed in this analysis merits a reality check with land managers in the LSJR area. If the results of this check indicate that the CN should be altered, then it will be.

Other joint observations:

There are some outstanding questions of how Hoffman model results look relative to stakeholder sensitivity, particularly in a dry year like 2013-14. This may require some additional work on their part to evaluate their own, drought-year situations.

Most of the almonds in the valley (and soon virtually all) are irrigated by drip or microspray. Sensitivity of these systems is less than for surface irrigated almonds. This may not be fully reflected in the modeling, and is a source of some conservatism. That is, the thresholds provided by the model may be a little low relative to what they might be if low-volume, high-efficiency irrigation methods were represented.

The effects of specific ions are not captured in the Hoffman Model, which deals exclusively with salinity. However, many of the drought-year effects on almonds and walnuts that are being observed are caused by specific ions (B, Cl, Na, and pH). The relationship of these constituents to bulk salinity needs to be considered in considering salinity thresholds.

It is generally acknowledged that steady-state models with annual-average calculations contain approximations that can be overcome by using more complex (e.g., augmented steady-state) models. Such limitations pertain to every modeling effort, and should be recognized. If greater resolution is required, then one solution is to model the system in a more detailed manner. However, with the preceding stipulations, the current Hoffman analysis is an appropriate starting point for the LSJR setting, and may be sufficient, in conjunction with other considerations and information, to provide crop sensitivity thresholds that can be referenced when setting a numeric standard.