# Response to Comments on *Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta*

November 4, 2009

By

Dr. Glenn J. Hoffman

# Comment Letters Received by September 14, 2009

| ENTITY: | SUBMITTED BY: | TITLE: |
|---|---|---|
| Central Valley Clean Water Association | Debbie Webster | Executive Officer |
| California Department of Water Resources | Erick Soderland | Staff Counsel |
| City of Tracy | Melissa A. Thorne | Special Counsel |
| Private Reviewer | John Letey | n/a |
| County of San Joaquin | DeeAnne Gillick | Attorney at Law |
| Sacramento Regional County Sanitation District | Linda Dorn | Environmental Program Manager |
| San Joaquin River Group Authority | Dennis Westcot; Terry L. Erlewine | Project Administrator; General Manager |
| South Delta Water Agency | John Herrick | Counsel & Manager |

# Additional Information Requested

| INFORMATION: | REQUESTED OF: | DATE RECEIVED: |
|---|---|---|
| Maps & info regarding New Jerusalem Drainage District | Dennis Westcot, SJRGA | September 30, 2009 |
| Crop acreages and irrigation methods | Jean Woods, DWR | October 6, 2009 |
| Clarification of drainage data submitted on 9/25 | Dennis Westcot, SJRGA | October 7 & 9, 2009 |
| Alfalfa harvesting and bean pre-plant irrigation practices in south Delta | Alex Hildebrand, Terry Prichard, on behalf of SDWA | October 21, 2009 |

*All comment letters and additional information above can be viewed at: http://www.waterboards.ca.gov/waterrights/*

# Salt Tolerance Data for Bean

COMMENT

Recommend that the Report advise strongly against continued use of the present salt tolerance data for bean and that a field experiment be conducted in the South Delta to establish the salt tolerance of bean. However, SWRCB should not delay potential modification of the salinity objective.

RESPONSE

The first Recommendation is that a field experiment be conducted.

# Boron Toxicity and Shallow Water Tables

COMMENT

Evaluate other factors, like boron and high water tables, that may be limiting bean yields.

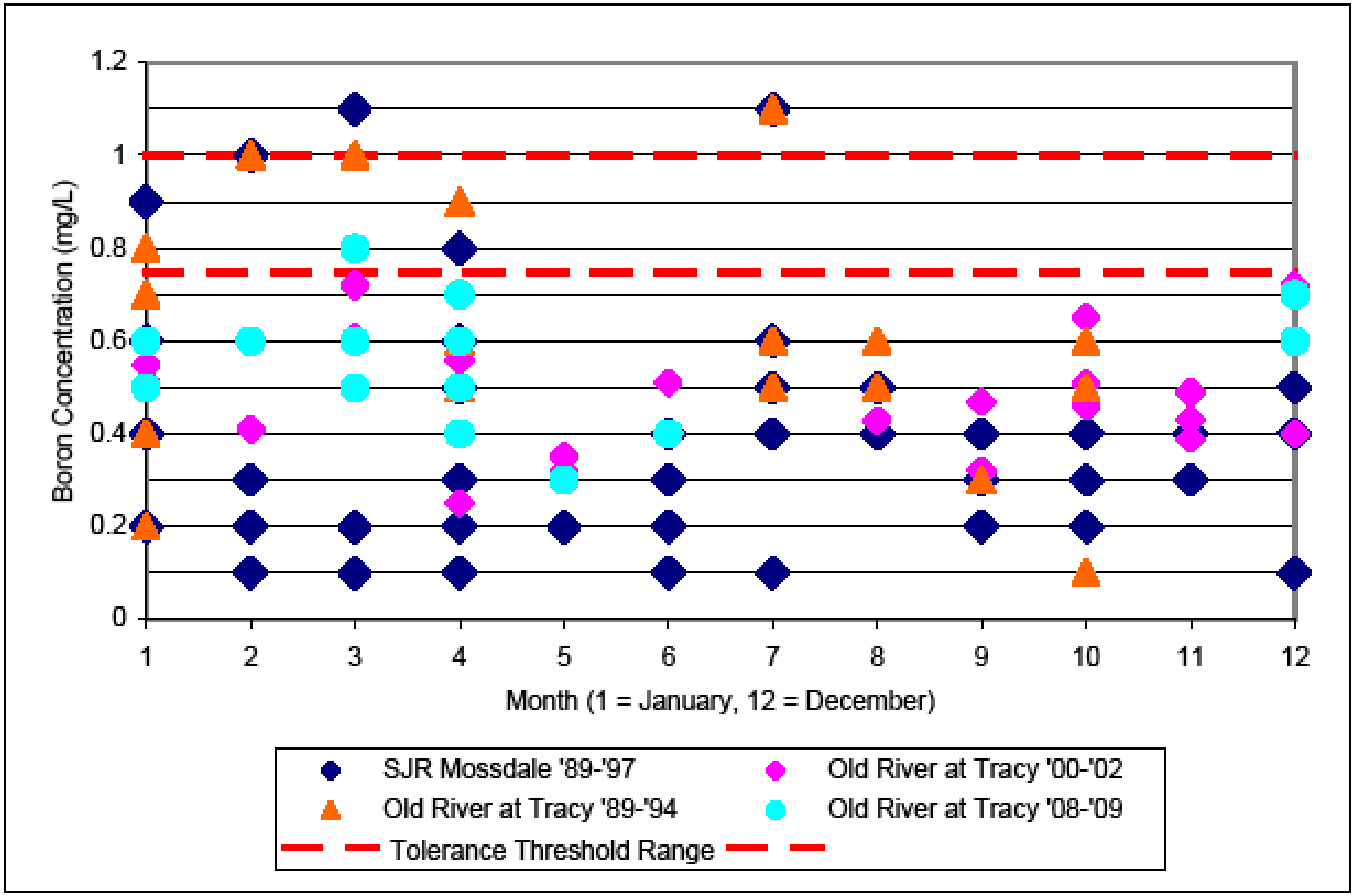
RESPONSE

*Boron Toxicity*

- Threshold for boron toxicity is 0.75 to 1.0 mg/l for beans. Boron concentrations in the effluent from New Jerusalem Drainage District average 2.6 mg/l.
- These data raise a concern about boron toxicity for beans.
- Recommend a study to determine if a boron objective is needed.

# Boron Toxicity

**Boron concentrations in two water bodies in South Delta with range of bean tolerance thresholds.**



# Shallow Water Tables

RESPONSE (con't)

<u>Shallow Water Tables</u>

The impact of high water tables on crop yields is discussed in Section 3.12 and with the subsurface drainage systems installed and the depth to the water table reported it does *not* appear that shallow water tables should be affecting a shallow rooted crop like bean.

# Crop Surveys

COMMENT

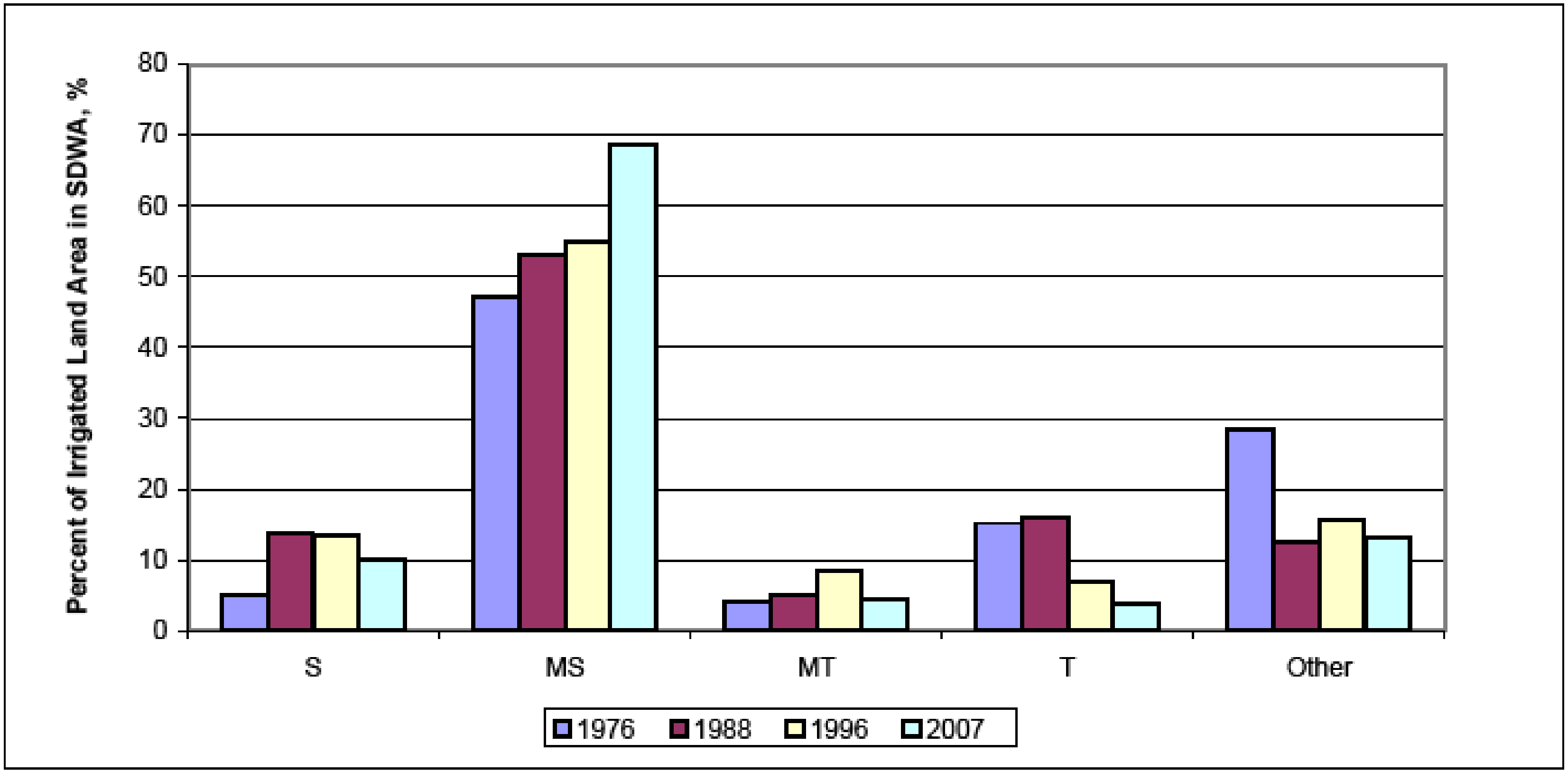
Update crop summaries based on clarified methodologies for calculating acreages.

RESPONSE

- Tables 2.2 and 2.3 have been modified to account for double cropping as suggested by DWR. Highlighted cells indicate values that changed from Draft Report.

- Slightly higher relative acreages for “sensitive” and “moderately sensitive” crops, but this does not affect conclusions of report.

**Figure 3.3: Distribution of crops based on salt tolerance relative (as a percent) to total irrigated acres in the SDWA in 1976, 1988, 1996 and 2007 (based on DWR land use surverys)**




**S = Sensitive; MS = Moderately Sensitive; MT = Moderately Tolerant; T = Tolerant**

*See revised Tables 2.2 and 2.3 in handout for complete summary*

**Acreages of crops evaluated by steady-state models.**

| Crop | 1976 | 1988 | 1996 | 2007 |
|---|---|---|---|---|
| Beans - single crop | 3,364 | 6,400 | 7,780 | 3,865 |
| *% of SDWA* | *2.4* | *4.5* | *5.5* | *2.7* |
| Beans – double crop | 2,679 | 1,022 | 931 | 553 |
| *% of SDWA* | *1.9* | *0.7* | *0.7* | *0.4* |
| Total Beans: | 6,043 | 7,422 | 8,711 | 4,418 |
| *% of SDWA* | *4.3* | *5.2* | *6.2* | *3.1* |
| Alfalfa | 26,841 | 36,581 | 30,911 | 31,342 |
| *% of SDWA* | *19.1* | *26.0* | *21.9* | *22.2* |
| Almond | 0 | 3,122 | 2,472 | 3,107 |
| *% of SDWA* | *0* | *2.2* | *1.8* | *2.2* |

**Table 2.2. Summary of irrigated crop acreage in SDWA for 1976, 1988, 1996, & 2007 from DWR land use surveys (including input received from Jean Woods at DWR on October 6, 2009), and for 2007 from San Joaquin County Agricultural Commissioner survey.**

| Crop | Salt Tolerance [1] | DWR Land Use Surveys (acres) 1976 | 1988 | 1996 | 2007 | San Joaquin County Ag Commisioner (acres) 2007 | Remarks |
|---|---|---|---|---|---|---|---|
| **Fruits & Nuts** | | | | | | | |
| Apples | S | 30 | 5 | 119 | 18 | 15 | |
| Apricots | S | 0 | 1,246 | 980 | 204 | 128 | |
| Olives | T | 0 | 0 | 0 | 77 | 132 | |
| Peaches & Nectarines | S | 0 | 0 | 94 | 0 | 0 | |
| Pears | S | 0 | 59 | 0 | 0 | 0 | |
| Plums | MS | 0 | 0 | 45 | 5 | 0 | |
| Almonds | S | 0 | 3,122 | 2,472 | 3,107 | 2,860 | |
| Walnuts | S | 76 | 3,973 | 3,693 | 2,051 | 1,699 | |
| Pistachios | MS | 0 | 40 | 30 | 18 | 18 | |
| Fruit or Nut - Misc. or <10 acres | Other | 7,207 | 231 | 95 | 56 | 35 | Pecan, Cherry, Pomegranite |
| Subtotal: | | 7,313 | 8,676 | 7,528 | 5,536 | 4,886 | |
| **Field Crops** | | | | | | | |
| Cotton | T | 0 | 0 | 0 | 34 | 0 | |
| Safflower | MT | 588 | 4,738 | 9,183 | 2,684 | 2,768 | |
| Sugar Beets | T | 14,066 | 11,594 | 1,761 | 135 | 449 | |
| Corn | MS | 13,407 | 7,632 | 15,014 | 15,481 | 14,242 | Corn, human & fodder |
| Grain Sorghum | MT | 1,072 | 8 | 0 | 0 | 86 | |
| Sudan | MT | 3,727 | 581 | 626 | 1,286 | 302 | |
| Castor Beans | S | 51 | 0 | 0 | 0 | 0 | |
| Dry Beans | S | 6,016 | 7,471 | 8,673 | 4,417 | 2,998 | |
| Sunflowers | MT | 0 | 517 | 275 | 0 | 0 | |
| Hybrid sorghum/sudan | MT | 0 | 0 | 0 | 71 | 0 | |
| Field Crops - Misc. or <10 acres | Other | 0 | 8 | 0 | 0 | 1,720 | Lima, Beans, Unspecified |
| Subtotal: | | 38,927 | 32,549 | 35,532 | 24,108 | 22,564 | |
| **Grain & Hay Crops** | | | | | | | |
| Wheat | MT | 0 | 0 | 0 | 0 | 5,806 | Wheat, human & fodder |
| Oats | T | 0 | 0 | 0 | 0 | 4,616 | Oats, human & fodder |
| Grain & Hay - Misc. | Other | 24,128 | 9,776 | 16,109 | 7,297 | 1,568 | Forage hay, barley, rye for fodder |
| Subtotal: | | 24,128 | 9,776 | 16,109 | 7,297 | 11,990 | |
| **Pasture** | | | | | | | |
| Alfalfa | MS | 26,841 | 36,581 | 30,911 | 31,342 | 33,021 | |
| Clover | MS | 0 | 31 | 0 | 0 | 0 | |
| Turf Farm | MT | 0 | 232 | 347 | 324 | 0 | |
| Pasture - Misc. | Other | 3,938 | 2,630 | 2,476 | 3,148 | 956 | |
| Subtotal: | | 30,779 | 39,474 | 33,734 | 34,814 | 33,977 | |
| **Truck & Berry Crops** | | | | | | | |
| Asparagus | T | 5,069 | 7,393 | 6,794 | 3,651 | 4,137 | |
| Green Beans | S | 58 | 164 | 39 | 24 | 458 | |
| Cole Crops | MS | 385 | 557 | 19 | 257 | 1,097 | Brocolli, Cabbage |
| Carrots | S | 0 | 0 | 219 | 197 | 247 | |
| Celery | S | 0 | 0 | 0 | 105 | 436 | |
| Melons, Squash, Cucumbers | MS | 750 | 2,210 | 4,874 | 2,628 | 2,757 | Melon, Pumpkin, Squash, Cucumber |
| Onions (Garlic) | S | 109 | 326 | 277 | 165 | 906 | Dry & green onions |
| Tomatoes | MS | 16,991 | 15,863 | 14,069 | 16,444 | 18,635 | Tomatoes & processing tomatoes |
| Strawberries | S | 0 | 0 | 41 | 4 | 0 | |
| Peppers | MS | 166 | 77 | 46 | 253 | 531 | |
| Truck Crops - Misc. or <10 acres | Other | 117 | 89 | 100 | 555 | 4,932 | Various [3] |
| Subtotal: | | 23,645 | 26,679 | 26,478 | 24,282 | 34,137 | |
| **Vineyards** | | | | | | | |
| Unspecified Varieties | MS | 755 | 521 | 2,095 | 2,902 | 2,940 | |
| **Other** | | | | | | | |
| Idle Fields | Other | 527 | 2,266 | 373 | 2,114 | 0 | |
| Other | Other | | 0 | 0 | 0 | 0 | |
| **Subtotal Irrigated Crops:** | | **126,074** | **119,942** | **121,849** | **101,053** | **110,494** | |
| **Breakdown by Salt Tolerance:** | S | 6,340 | 16,366 | 16,607 | 10,291 | 9,747 | |
| | MS | 59,295 | 63,512 | 67,103 | 69,330 | 73,241 | |
| | MT | 5,387 | 6,076 | 10,431 | 4,364 | 8,962 | |
| | T | 19,135 | 18,987 | 8,555 | 3,898 | 9,334 | |
| | Other | 35,917 | 15,000 | 19,153 | 13,170 | 9,210 | |
| **Non-Irrigated Land:** | | 14,805 | 20,937 | 19,030 | 39,826 | n/a | |
| **Total for SDWA[2]:** | | 140,879 | 140,879 | 140,879 | 140,879 | n/a | |

[1] Salt tolerance categories as follows:
S = Sensitive; MS = Moderately Sensitive; MT = Moderately Tolerant; T = Tolerant

[2] Actual area of SDWA within legal Delta (as used in this survey) is 140,879 acres. The total area of SDWA is 147,328 acres.

[3] Includes blueberry, bok choy, celeriac, christmas tree, cilantro, collard, fruit berries, herbs, kale, leek, leaf lettuce, mustard, outdoor plants, spinach, swiss chard

Yellow highlight = cells within +/- 10% or a few hundred acres of value published in July 14, 2009 draft report.
Pink highlight = cells greater than 10% or few hundred acres of value published in July 14, 2009 draft report.
Blue highlight - cells less than 10% or few hundred acres of value published in July 14, 2009 draft report.
Input cells not highlighted were not changed

**Table 2.3. Percentage of total irrigated land in SDWA for each crop grown in 1976, 1988, 1996, & 2007 from DWR land use surveys (including input received from Jean Woods at DWR on October 6, 2009), and for 2007 from San Joaquin County Agricultural Commissioner survey.**

| Crop | Salt Tolerance [1] | DWR Land Use Surveys (%) 1976 | 1988 | 1996 | 2007 | San Joaquin County Ag Commisioner (%) 2007 | Remarks |
|---|---|---|---|---|---|---|---|
| **Fruits & Nuts** | | | | | | | |
| Apples | S | 0.02 | 0.00 | 0.10 | 0.02 | 0.01 | |
| Apricots | S | 0.00 | 1.04 | 0.80 | 0.20 | 0.12 | |
| Olives | T | 0.00 | 0.00 | 0.00 | 0.08 | 0.12 | |
| Peaches & Nectarines | S | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | |
| Pears | S | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | |
| Plums | MS | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | |
| Almonds | S | 0.00 | 2.60 | 2.03 | 3.07 | 2.59 | |
| Walnuts | S | 0.06 | 3.31 | 3.03 | 2.03 | 1.54 | |
| Pistachios | MS | 0.00 | 0.03 | 0.02 | 0.02 | 0.02 | |
| Fruit or Nut - Misc. or <10 acres | Other | 5.72 | 0.19 | 0.08 | 0.06 | 0.03 | Pecan, Cherry, Pomegranite |
| Subtotal: | | 5.80 | 7.23 | 6.18 | 5.48 | 4.42 | |
| **Field Crops** | | | | | | | |
| Cotton | T | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | |
| Safflower | MT | 0.47 | 3.95 | 7.54 | 2.66 | 2.51 | |
| Sugar Beets | T | 11.16 | 9.67 | 1.45 | 0.13 | 0.41 | |
| Corn | MS | 10.63 | 6.36 | 12.32 | 15.32 | 12.89 | Corn, human & fodder |
| Grain Sorghum | MT | 0.85 | 0.01 | 0.00 | 0.00 | 0.08 | |
| Sudan | MT | 2.96 | 0.48 | 0.51 | 1.27 | 0.27 | |
| Castor Beans | S | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Dry Beans | S | 4.77 | 6.23 | 7.12 | 4.37 | 2.71 | |
| Sunflowers | MT | 0.00 | 0.43 | 0.23 | 0.00 | 0.00 | |
| Hybrid sorghum/sudan | MT | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | |
| Field Crops - Misc. or <10 acres | Other | 0.00 | 0.01 | 0.00 | 0.00 | 1.56 | Lima, Beans, Unspecified |
| Subtotal: | | 30.88 | 27.14 | 29.16 | 23.86 | 20.42 | |
| **Grain & Hay Crops** | | | | | | | |
| Wheat | MT | 0.00 | 0.00 | 0.00 | 0.00 | 5.25 | Wheat, human & fodder |
| Oats | T | 0.00 | 0.00 | 0.00 | 0.00 | 4.18 | Oats, human & fodder |
| Grain & Hay - Misc. | Other | 19.14 | 8.15 | 13.22 | 7.22 | 1.42 | Forage hay, barley, rye for fodder |
| Subtotal: | | 19.14 | 8.15 | 13.22 | 7.22 | 10.85 | |
| **Pasture** | | | | | | | |
| Alfalfa | MS | 21.29 | 30.50 | 25.37 | 31.02 | 29.88 | |
| Clover | MS | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | |
| Turf Farm | MT | 0.00 | 0.19 | 0.28 | 0.32 | 0.00 | |
| Pasture - Misc. | Other | 3.12 | 2.19 | 2.03 | 3.12 | 0.87 | |
| Subtotal: | | 24.41 | 32.91 | 27.69 | 34.45 | 30.75 | |
| **Truck & Berry Crops** | | | | | | | |
| Asparagus | T | 4.02 | 6.16 | 5.58 | 3.61 | 3.74 | |
| Green Beans | S | 0.05 | 0.14 | 0.03 | 0.02 | 0.41 | |
| Cole Crops | MS | 0.31 | 0.46 | 0.02 | 0.25 | 0.99 | Brocolli, Cabbage |
| Carrots | S | 0.00 | 0.00 | 0.18 | 0.19 | 0.22 | |
| Celery | S | 0.00 | 0.00 | 0.00 | 0.10 | 0.39 | |
| Melons, Squash, Cucumbers | MS | 0.59 | 1.84 | 4.00 | 2.60 | 2.49 | Melon, Pumpkin, Squash, Cucumber |
| Onions (Garlic) | S | 0.09 | 0.27 | 0.23 | 0.16 | 0.82 | Dry & green onions |
| Tomatoes | MS | 13.48 | 13.23 | 11.55 | 16.27 | 16.87 | Tomatoes & processing tomatoes |
| Strawberries | S | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | |
| Peppers | MS | 0.13 | 0.06 | 0.04 | 0.25 | 0.48 | |
| Truck Crops - Misc. or <10 acres | Other | 0.09 | 0.07 | 0.08 | 0.55 | 4.46 | Various [2] |
| Subtotal: | | 18.75 | 22.24 | 21.73 | 24.03 | 30.89 | |
| **Vineyards** | | | | | | | |
| Unspecified Varieties | MS | 0.60 | 0.43 | 1.72 | 2.87 | 2.66 | |
| **Other** | | | | | | | |
| Idle Fields | Other | 0.42 | 1.89 | 0.31 | 2.09 | 0.00 | |
| Other | Other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| **Subtotal Irrigated Crops:** | | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | |
| **Breakdown by Salt Tolerance:** | S | 5.03 | 13.65 | 13.63 | 10.18 | 8.82 | |
| | MS | 47.03 | 52.95 | 55.07 | 68.61 | 66.29 | |
| | MT | 4.27 | 5.07 | 8.56 | 4.32 | 8.11 | |
| | T | 15.18 | 15.83 | 7.02 | 3.86 | 8.45 | |
| | Other | 28.49 | 12.51 | 15.72 | 13.03 | 8.34 | |

[1] Salt tolerance categories as follows:
S = Sensitive; MS = Moderately Sensitive; MT = Moderately Tolerant; T = Tolerant

[2] Includes blueberry, bok choy, celeriac, christmas tree, cilantro, collard, fruit berries, herbs, kale, leek, leaf lettuce, mustard, outdoor plants, spinach, swiss chard

# Irrigation Methods Survey

COMMENT

Use DWR 2007 GIS crop survey database to compile a summary of irrigation methods used in the South Delta.

RESPONSE

Table 3.7 has been changed using summary of 2007 survey data as prepared by DWR.

**Table 3.7. Irrigation methods in the South Delta based upon the 2007 Department of Water Resources crop survey (DWR, 2008).**

| Crop Type | Crop Area (acres) | Crop Area (%) | Irrigation Method | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Furrow (%) | Border (%) | Basin (%) | Sprinkler (%) | Micro-irrigation* (%) | Unknown (%) |
| Trees & Vines | 8,438 | 9 | 22 | 10 | 3 | 17 | 48 | 0 |
| Truck Crops | 24,283 | 25 | 90 | 0 | 0 | 3 | 6 | 1 |
| Field Crops | 23,258 | 24 | 90 | 3 | 3 | 0 | 0 | 4 |
| Grain & Hay | 7,297 | 7 | 6 | 19 | 5 | 0 | 0 | 70 |
| Alfalfa, Pasture, Grass | 34,814 | 35 | 0 | 86 | 11 | 1 | 0 | 2 |
| Totals: | 98,090 | 100 | 46 | 34 | 5 | 2 | 6 | 7 |

* *Micro-irrigation includes surface and subsurface drip irrigation and mini-sprinklers.*

# Consideration of Irrigation Method

COMMENT

Link irrigation method, leaching fraction, and target crop to provide more accurate determination of irrigation water quality requirement.

RESPONSE

The irrigation method with various crops is relatively uniform throughout the South Delta:

- Beans are irrigated by furrows
- Alfalfa is irrigated by borders
- Almond is irrigated by a mixture of micro-irrigation, furrow, & border

Subsurface tile drain measurements suggest LF ranges from 0.2 to 0.3, but also used lower LF's in Section 5.

# Irrigation Efficiency / Uniformity

COMMENT

Irrigation efficiency and uniformity are distinctly different and should be discussed separately.

RESPONSE

Discussions added to Section 3.8:

- Efficiency is a function of system design.
- Uniformity is a function of applicator design and soil uniformity.

# Leaching Potential of Rainfall

COMMENT

Clarify the salt leaching potential of rainfall.

RESPONSE

A paragraph has been added in Section 3.5.1 describing several benefits of rainfall in mediating soil salinity:

- Substitutes for irrigation in growing season
- Off-season rain stored in soil can satisfy evaporation
- After satisfying evaporation, stored rain used by next crop
- Dilutes salinity in upper soil profile
- Sufficient rain can leach salts

# Cultural/Management Practices

COMMENT

Add discussion on cultural/management practices, like pre-plant irrigation, that limit the potential damage of soil salinity at early crop growth stages.

RESPONSE

Three management practices that minimize salt damage during germination and early growth stages have been added to Section 3.2.1.

- Pre-plant irrigation
- Over-seeding
- Planting on slope of the furrow bed

# Conservative Assumptions

COMMENT

Report is too conservative, list conservative assumptions.

RESPONSE

A number of assumptions were made in the modeling, both conservative and otherwise.

- Best management practices, including prevention of crop water stress, adequate fertility, and avoidance of insects and diseases, were assumed.
- In light of drainage data even LF = 0.20 may be conservative.
- Dissolution of salts from root zone (5 to 10% of total salinity) was ignored, which would increase the LF.

# Conservative Assumptions (con't)

- Climate is slightly conservative for salt tolerance values.
- Irrigation efficiencies are assumed to be at the upper limit for each irrigation method. If irrigation efficiencies were lower, salinity objective could be increased.
- Groundwater is not a significant source of water to satisfy shallow-rooted crop needs. If groundwater was used by crop, salinity objective could be increased.
- Irrigation applications are assumed to be uniform. In reality applications are not uniform and would need to be increased to avoid yield loss.

# Leaching Fraction Based on Subsurface Drainage Data

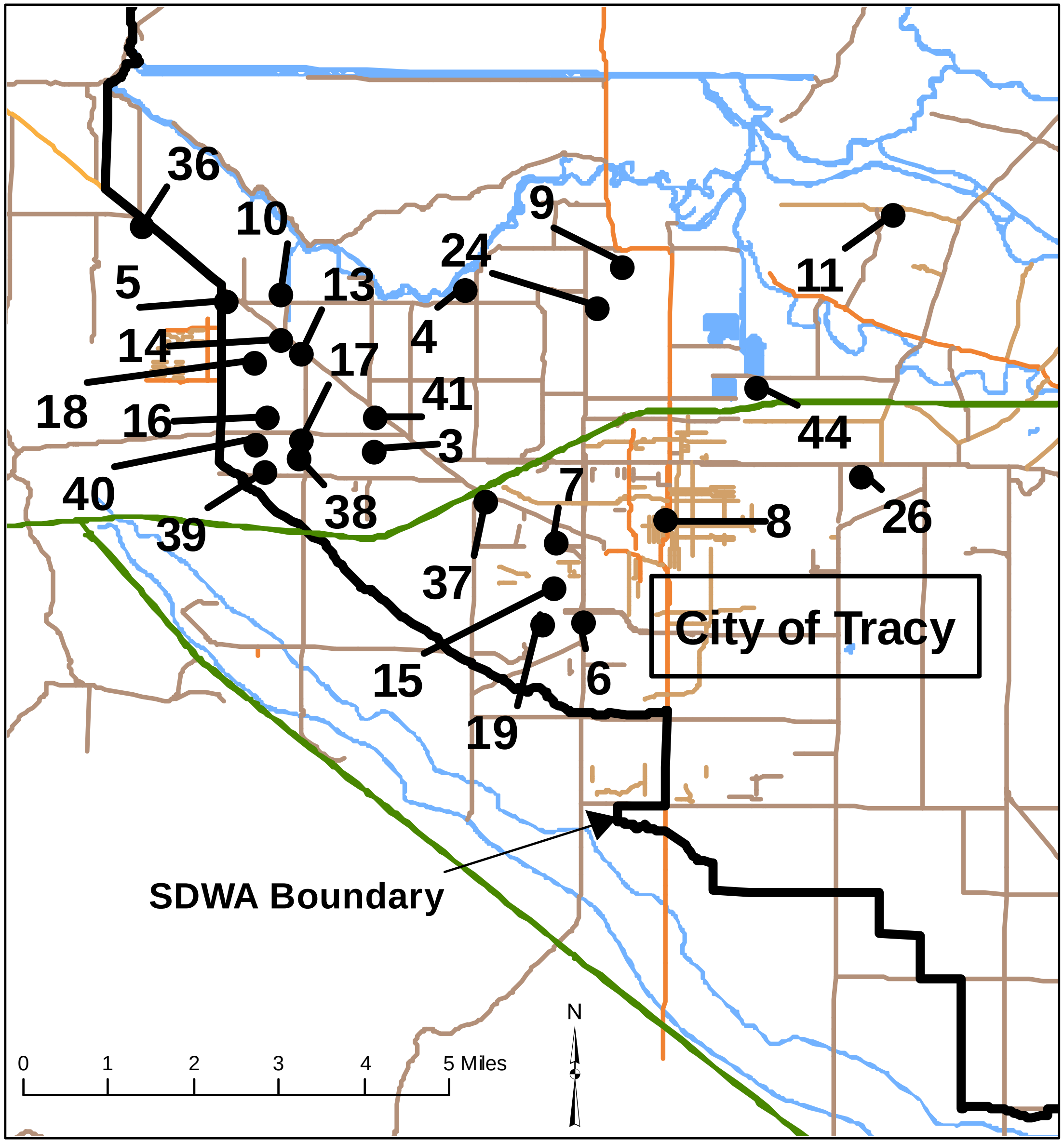
COMMENT

Expand the discussion on leaching fraction based upon data from additional subsurface drainage systems.

RESPONSE

The EC and calculated leaching fractions from the New Jerusalem Drainage District, the Tracy Boulevard Drain Sump, and 14 additional subsurface drains from the Chilcott et al. (1988) report have been added to report in Section 3.13.2.

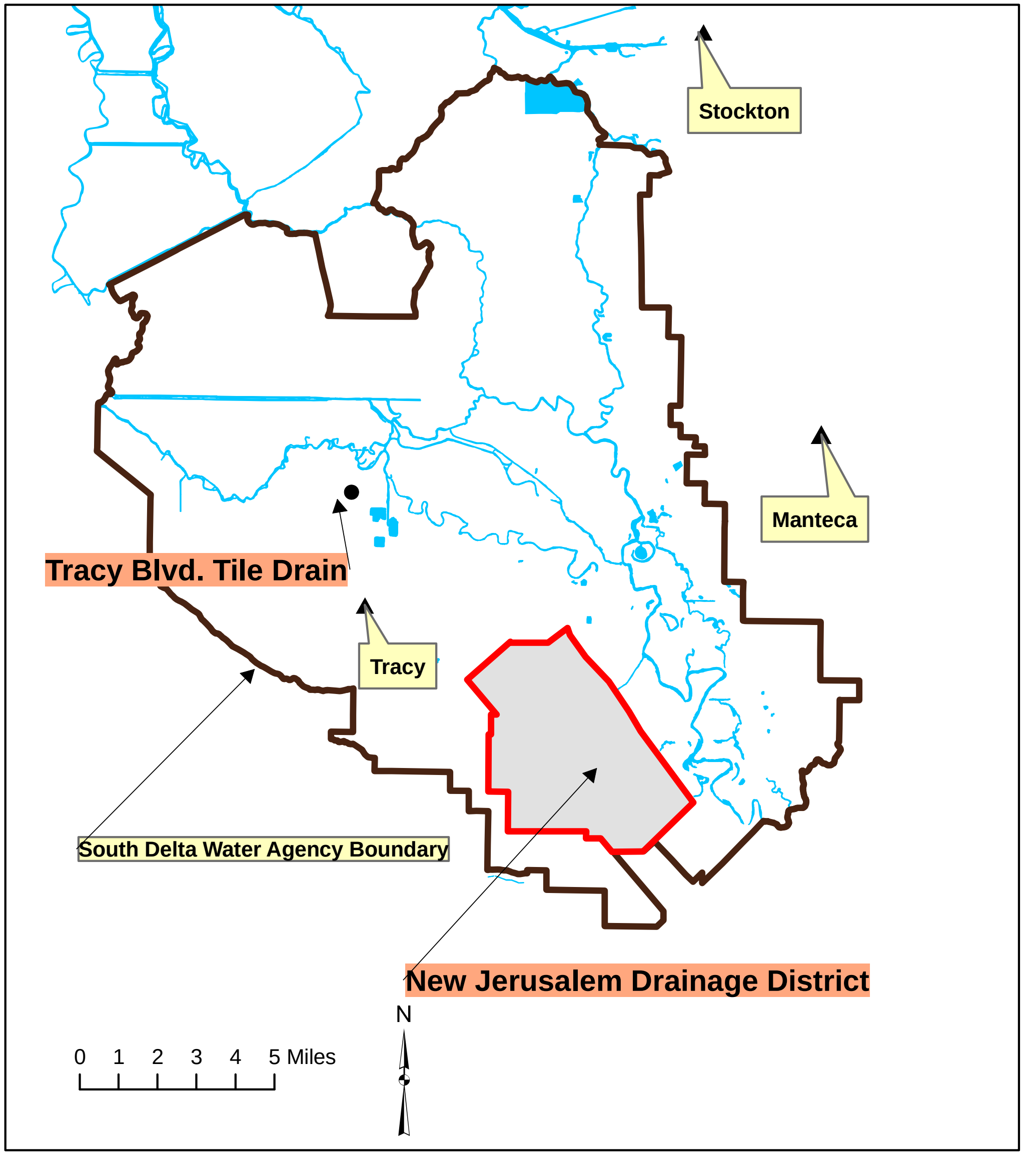
**Figure 3.18: Location of subsurface tile drains sampled on the west side of the SDWA (Chilcott, et al., 1988 and Belden et al., 1989).**



**Electrical conductivity (EC) and calculated LF assuming applied EC = 0.7 dS/m** (using Chilcott et al., 1988 & Belden et al. 1989).

| Drain Location | No. of Samples | EC (dS/m) | LF |
|---|---|---|---|
| 3, Grant Line Rd. Sump | 3 | 2.7 | .26 |
| 4, Bethany / Lammers | 3 | 2.1 | .33 |
| 5, Patterson Pass Rd. | 6 | 2.5 | .28 |
| 6, Moitose | 3 | 1.6 | .44 |
| 7, Krohn Rd. | 4 | 2.1 | .33 |
| 8, Pimentel | 2 | 2.2 | .32 |
| 9, Lammers / Corral Hollow | 4 | 4.4 | .16 |
| 11, Delta Ave. | 6 | 2.4 | .29 |
| 13, Costa Brothers East | 2 | 4.1 | .17 |
| 14, Costa Brothers West | 4 | 3.6 | .19 |
| 15, Castro | 3 | 2.4 | .29 |
| 16, Earp | 4 | 2.8 | .25 |
| 17, Freeman | 4 | 3.9 | .18 |
| 18, Costa | 5 | 3.4 | .21 |
| 19, Moitoso and Castro | 4 | 2.0 | .35 |
| 24, Corral Hollow / Bethany | 5 | 6.2 | .11 |
| 26, Chrisman Rd. | 3 | 2.0 | .35 |
| 36, Kelso Rd. / Byron Hwy. | 6 | 2.4 | .29 |
| 37, Spirow Nicholaw | 4 | 3.1 | .23 |
| 38, JM Laurence Jr. East | 4 | 3.5 | .20 |
| 39, JM Laurence Jr. West | 4 | 2.4 | .29 |
| 40, Sequeira | 3 | 3.6 | .19 |
| 41, Reeve Rd. | 3 | 3.8 | .18 |
| 44, Larch Rd. | 4 | 2.8 | .25 |
| Number of Drains Sampled: 24 | | | |
| | Average: | 3.0 | 0.23 |
| | Median: | 2.8 | 0.25 |
| | Minimum: | 1.6 | 0.11 |
| | Maximum: | 6.2 | 0.44 |

# Location of New Jerusalem Drainage District and Tracy Blvd. Tile Drain Sump



**Electrical conductivity (EC) and calculated LF assuming applied EC = 0.7 dS/m for the New Jerusalem Drainage District.**

| Year Sampled | No. of Samples | EC of Effluent (dS/m) | LF w/ ECi = 0.7 dS/m |
|---|---|---|---|
| 1977 | 1 | 2.6 | 0.27 |
| 1978 | 1 | 3.2 | 0.22 |
| 1979 | 1 | 3.0 | 0.23 |
| 1980 | 1 | 2.6 | 0.27 |
| 1982 | 5 | 2.5 | 0.28 |
| 1983 | 11 | 3.0 | 0.23 |
| 1984 | 13 | 2.6 | 0.27 |
| 1985 | 11 | 2.5 | 0.28 |
| 1986 | 5 | 2.5 | 0.28 |
| 1987 | 2 | 2.4 | 0.29 |
| 1988 | 4 | 2.5 | 0.28 |
| 2000 | 3 | 2.4 | 0.29 |
| 2001 | 12 | 2.5 | 0.28 |
| 2002 | 13 | 2.4 | 0.29 |
| 2003 | 9 | 2.4 | 0.29 |
| 2004 | 6 | 2.4 | 0.29 |
| 2005 | 11 | 2.4 | 0.29 |
| Number of Years Sampled: 17 | | | |
| Number of Samples: 109 | | | |
| | Average: | 2.6 | 0.27 |
| | Median: | 2.5 | 0.28 |
| | Minimum: | 2.4 | 0.22 |
| | Maximum: | 3.2 | 0.29 |

**Electrical conductivity (EC) and calculated LF assuming applied EC = 0.7 dS/m for the Tracy Boulevard Tile Drain Sump.**

| Year Sampled | No. of Samples | EC of Effluent (dS/m) | LF w/ ECi = 0.7 dS/m |
|---|---|---|---|
| 1982 | 3 | 3.5 | 0.20 |
| 1983 | 10 | 3.6 | 0.19 |
| 1984 | 10 | 3.4 | 0.21 |
| 1985 | 12 | 3.4 | 0.21 |
| 1986 | 7 | 3.1 | 0.23 |
| 1987 | 2 | 3.1 | 0.23 |
| Number of Years Sampled: 6 | | | |
| Number of Samples: 44 | | | |
| | Average: | 3.4 | 0.21 |
| | Median: | 3.4 | 0.21 |
| | Minimum: | 3.1 | 0.19 |
| | Maximum: | 3.6 | 0.23 |

# Modeling Different Bean Planting Dates

COMMENT

Report the steady-state computer results for different planting dates for bean.

RESPONSE

Three planting dates were modeled from Goldhamer & Snyder (1989), with no significant difference in estimated soil water salinity.

### April 1st Planting Date

| Growth Stage | Kc | Dates |
|---|---|---|
| Initial Growth | 0.14 | April 1 thru 30th |
| Rapid Growth | 0.14 to 1.15 | April 30 to May 25 |
| Mid-Season | 1.15 | May 25 to June 29 |
| Late Season | 1.15 to 0.30 | June 29 to July 31 |
| | | 121 Days Total |

**Median $EC_{SWb-2}$**

| | LF = 0.15 | LF = 0.20 | LF = 0.25 |
|---|---|---|---|
| $EC_i$ = 0.7 dS/m | 1.38 | 0.97 | 0.68 |
| $EC_i$ =1.0 dS/m | 1.98 | 1.38 | 0.98 |

### May 1st Planting Date

| Growth Stage | Kc | Dates |
|---|---|---|
| Initial Growth | 0.14 | May 1 to 18th |
| Rapid Growth | 0.14 to 1.12 | May 18 to June 8 |
| Mid-Season | 1.12 | June 8 to July 12 |
| Late Season | 1.12 to 0.35 | July 12 to August 15 |
| | | 106 Days Total |

**Median $EC_{SWb-2}$**

| | LF = 0.15 | LF = 0.20 | LF = 0.25 |
|---|---|---|---|
| $EC_i$ = 0.7 dS/m | 1.40 | 0.98 | 0.69 |
| $EC_i$ =1.0 dS/m | 2.00 | 1.40 | 0.99 |

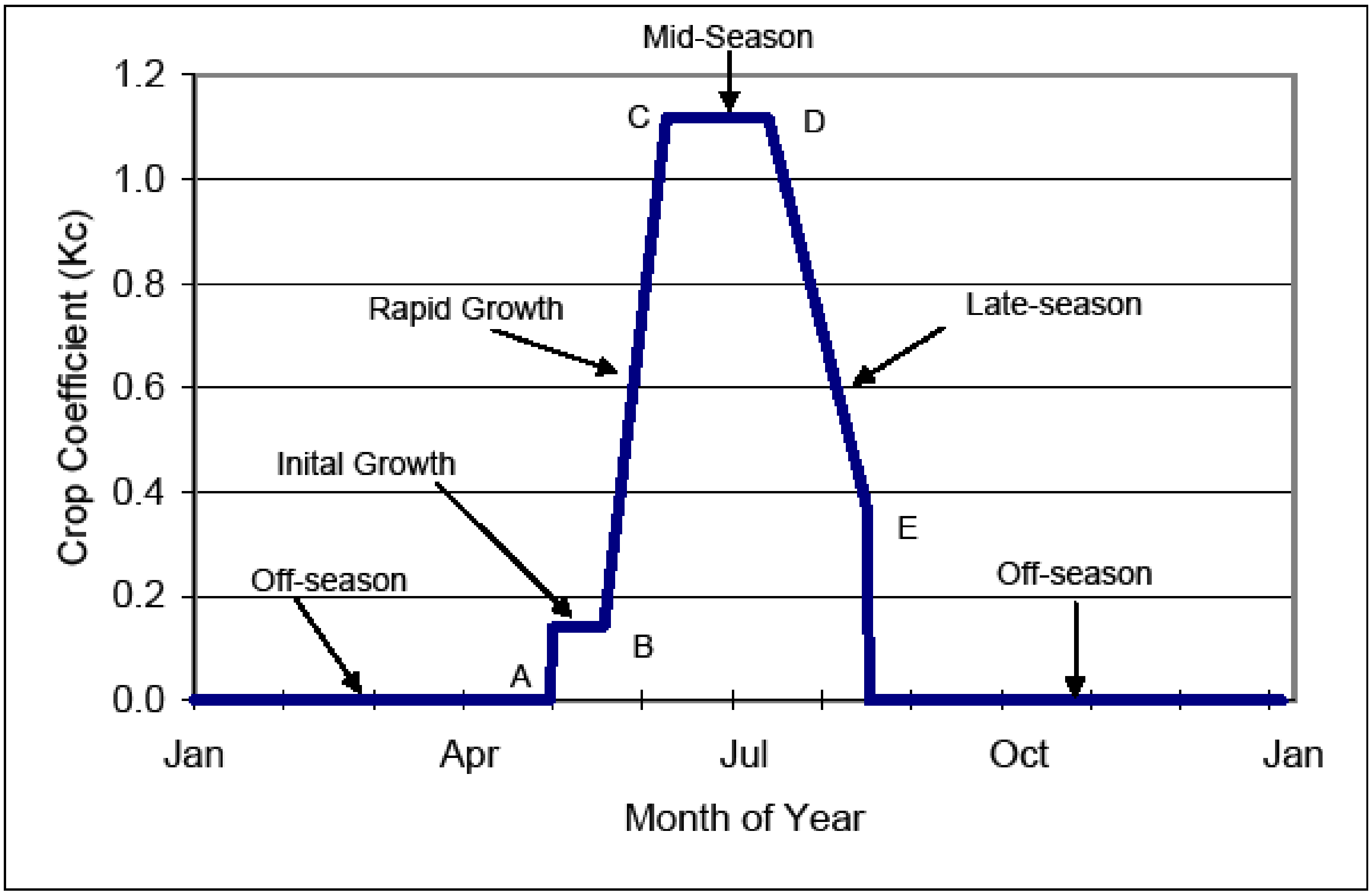
### June 16th Planting Date

| Growth Stage | Kc | Dates |
|---|---|---|
| Initial Growth | 0.13 | June 16 to July 1 |
| Rapid Growth | 0.13 to 1.07 | July 1 to July 26 |
| Mid-Season | 1.07 | July 26 to Sept. 2 |
| Late Season | 1.07 to 0.20 | Sept. 2 to Sept. 30 |
| | | 106 Days Total |

**Median $EC_{SWb-2}$**

| | LF = 0.15 | LF = 0.20 | LF = 0.25 |
|---|---|---|---|
| $EC_i$ = 0.7 dS/m | 1.36 | 0.95 | 0.67 |
| $EC_i$ =1.0 dS/m | 1.95 | 1.36 | 0.96 |

**Figure 5.3. Relationship between crop coefficients (Kc) and growth and development periods for dry bean with May 1st planting date (Goldhamer and Snyder, 1989)**



# Yield Impact Probabilities

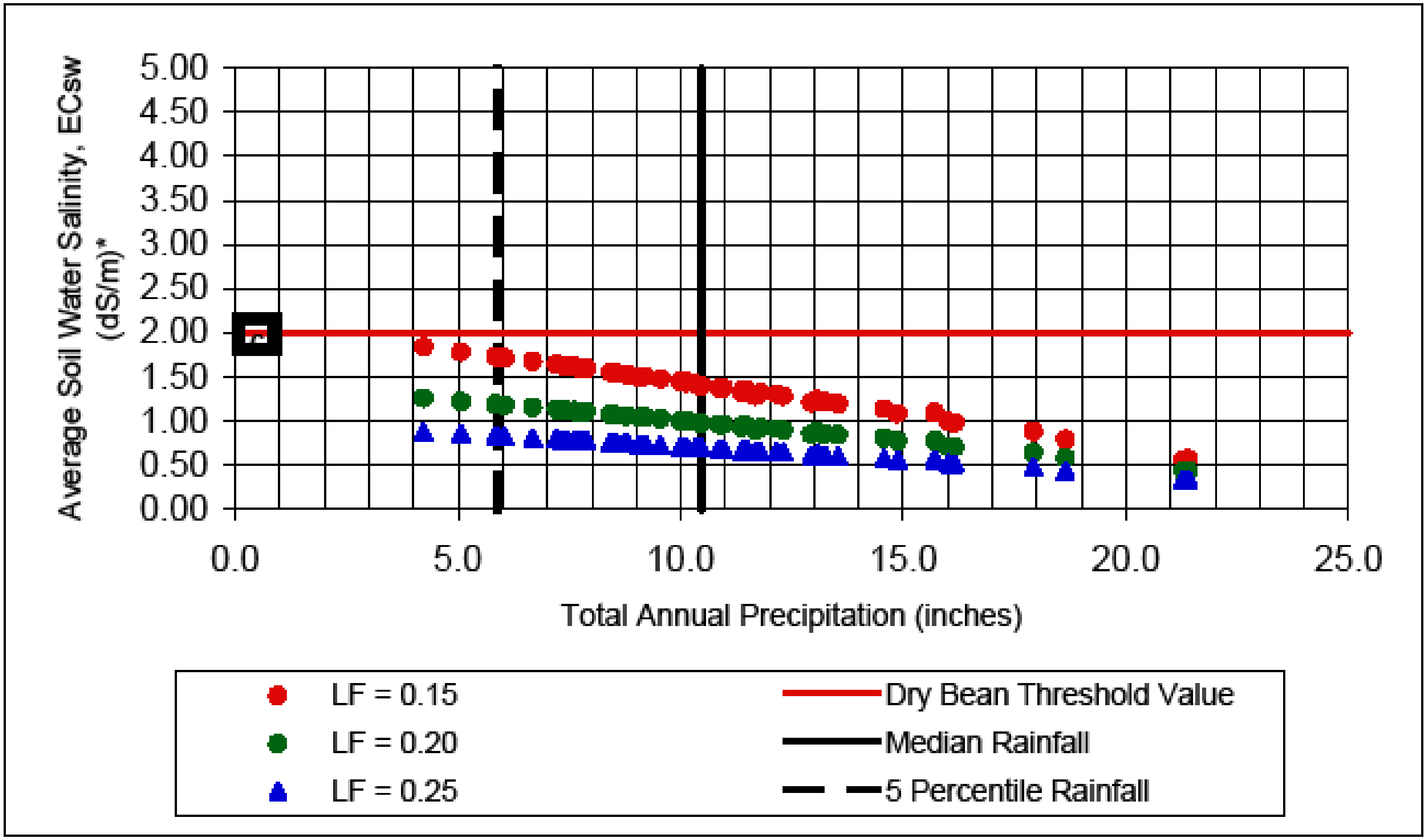
COMMENT

Provide reasonable yield targets that reflect some risk like the 95 percentile or 1 in 3 year exceedance of salinity objective.

RESPONSE

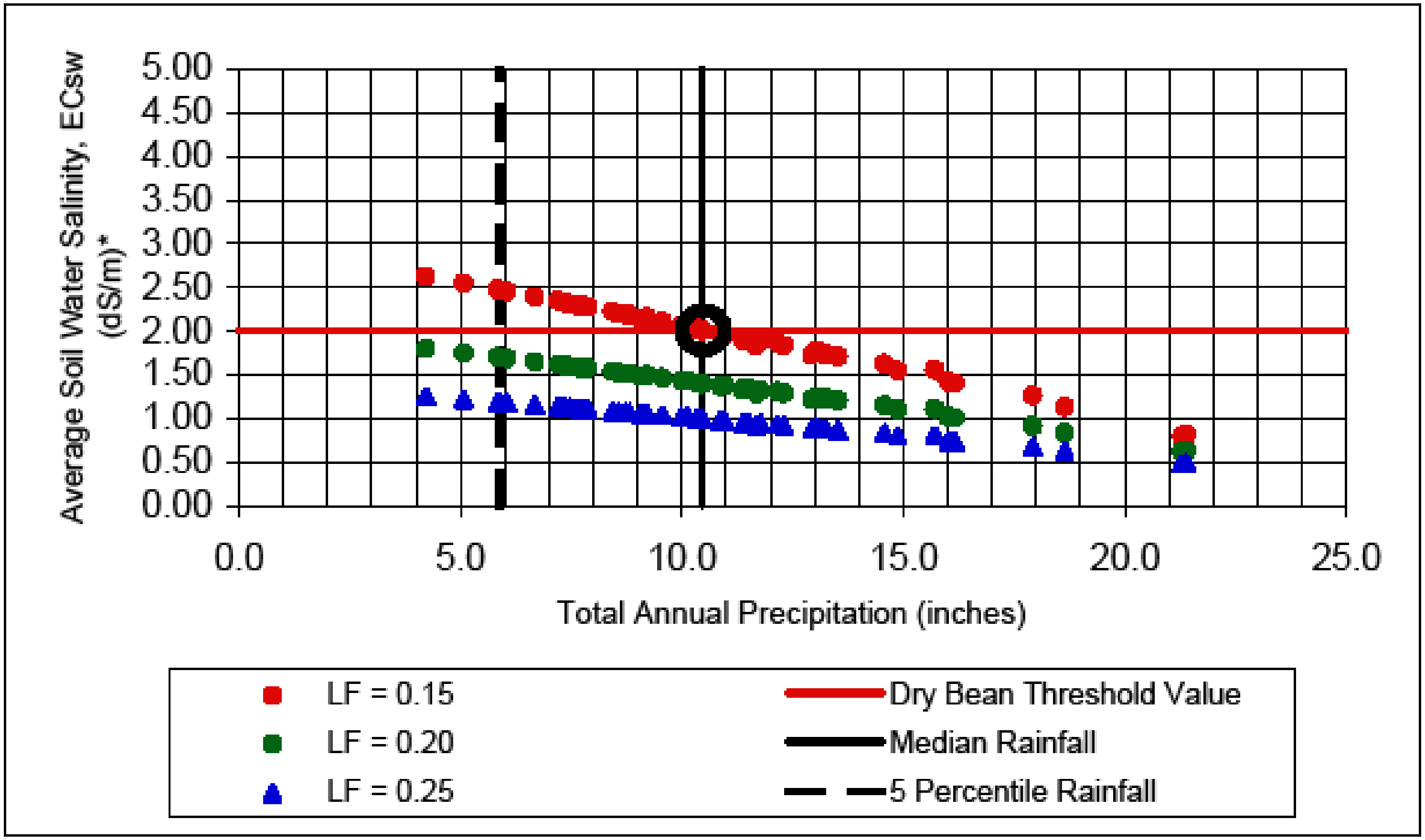
In Section 5 the impact of winter rainfall on bean yield and the number of years when yields might be expected to be below 100% is presented. The yield curves of (the new) Figure 5.10 can also show crop yield reductions when the salinity objective is exceeded. Similar information is presented for alfalfa and almond.

**<u>Bean w/ May 1st planting date:</u>** **average soil water salinity (ECsw)* vs. total precipitation assuming <u>ECi = 0.7 dS/m</u> and using exponential water uptake functions.**



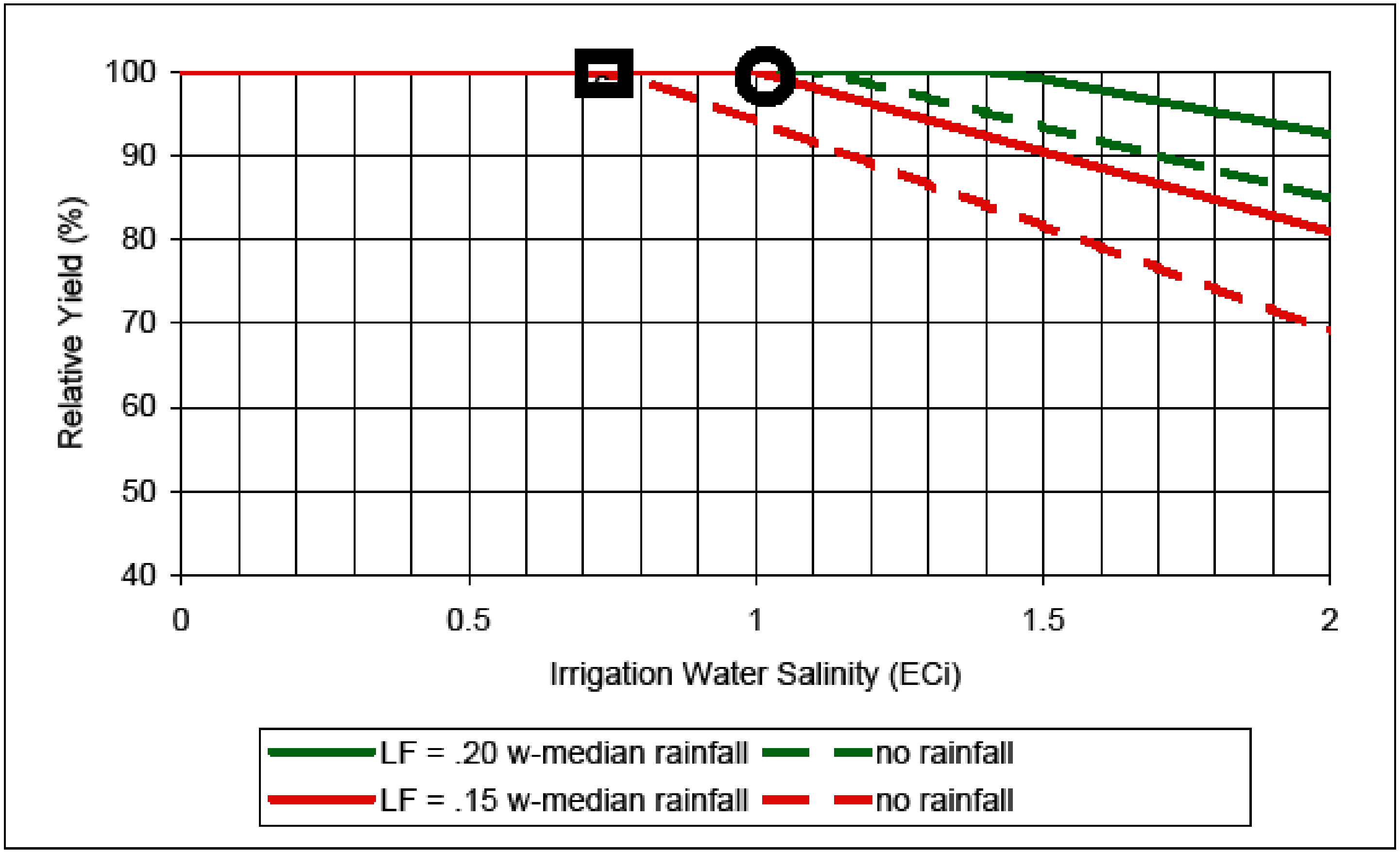

** As discussed in Section 4.1, the average soil water salinity was reduced by the soil salinity at 50% leaching for the exponential model.*

**<u>Bean w/ May 1st planting date:</u>** **average soil water salinity (ECsw)* vs. total precipitation assuming <u>ECi = 1.0 dS/m</u> and using exponential water uptake functions.**




** As discussed in Section 4.1, the average soil water salinity was reduced by the soil salinity at 50% leaching for the exponential model.*

**Relative bean yield as a function of irrigation water salinity (ECi) for median annual rainfall and no rainfall.**



# Modeling Alfalfa and Almond

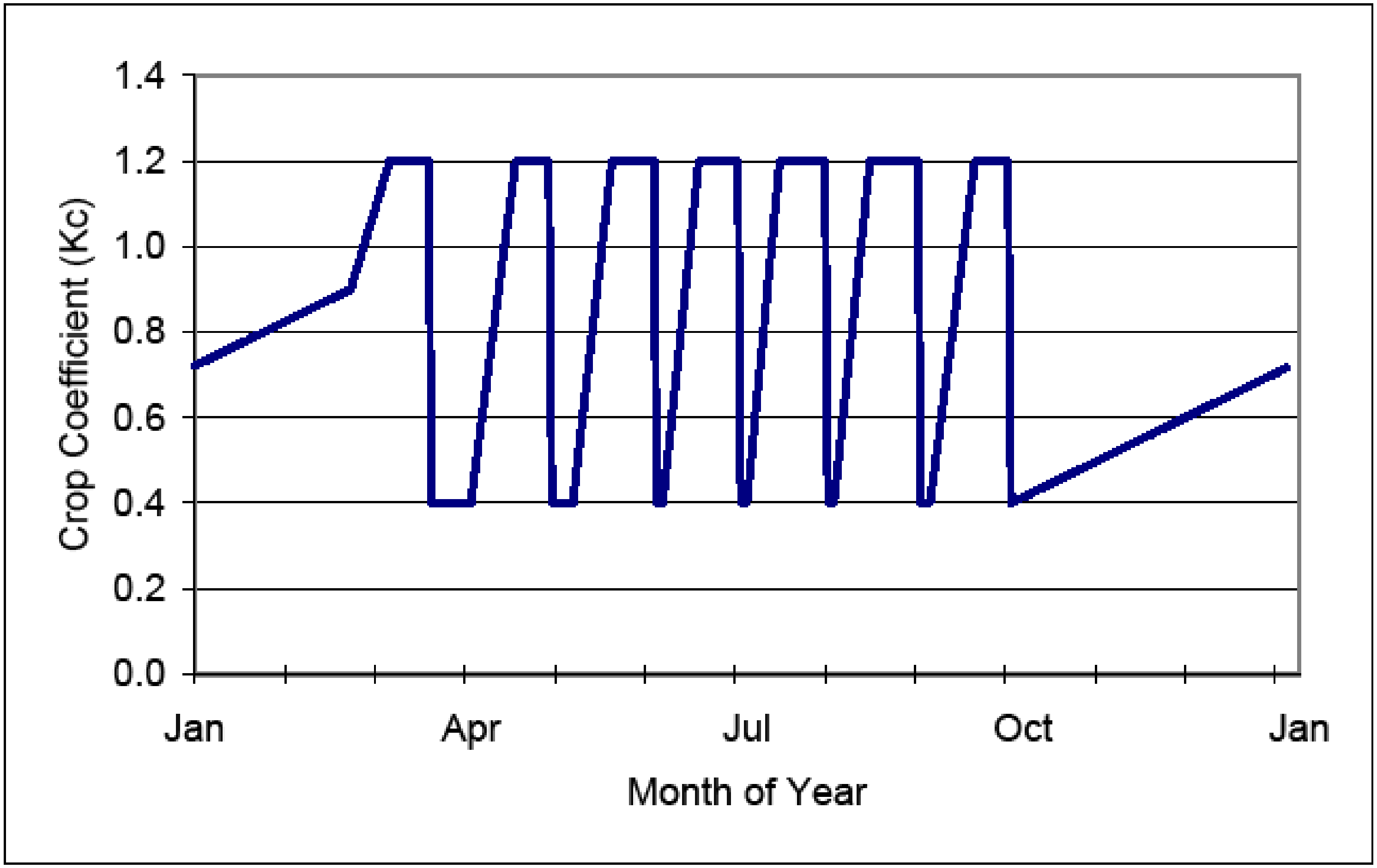
COMMENT

Report the steady-state computer results for alfalfa and almond.

RESPONSE

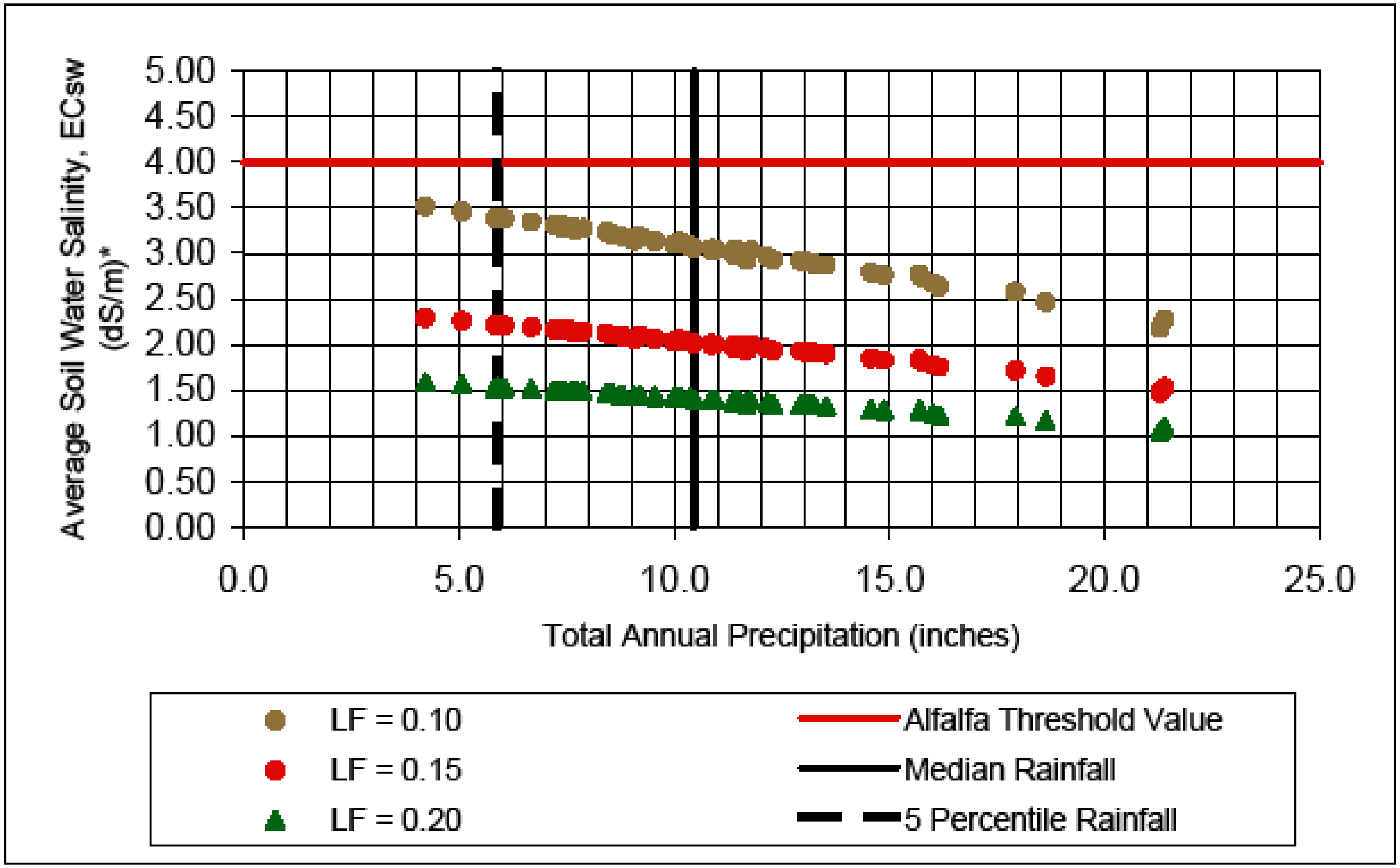
The results for alfalfa and almond are presented in Section 5. Estimated average soil water salinity did not exceed threshold values for $EC_i$ = 1.0 and LF = .15

**Crop coefficients (Kc) used for steady-state modeling of alfalfa (adapted from Goldhamer and Snyder, 1989 and input from the SDWA)**




*See table in handout for corresponding model output for alfalfa*

**Alfalfa:** average soil water salinity (ECsw)* vs. total annual rainfall assuming **ECi = 1.0 dS/m** and using exponential water uptake function.

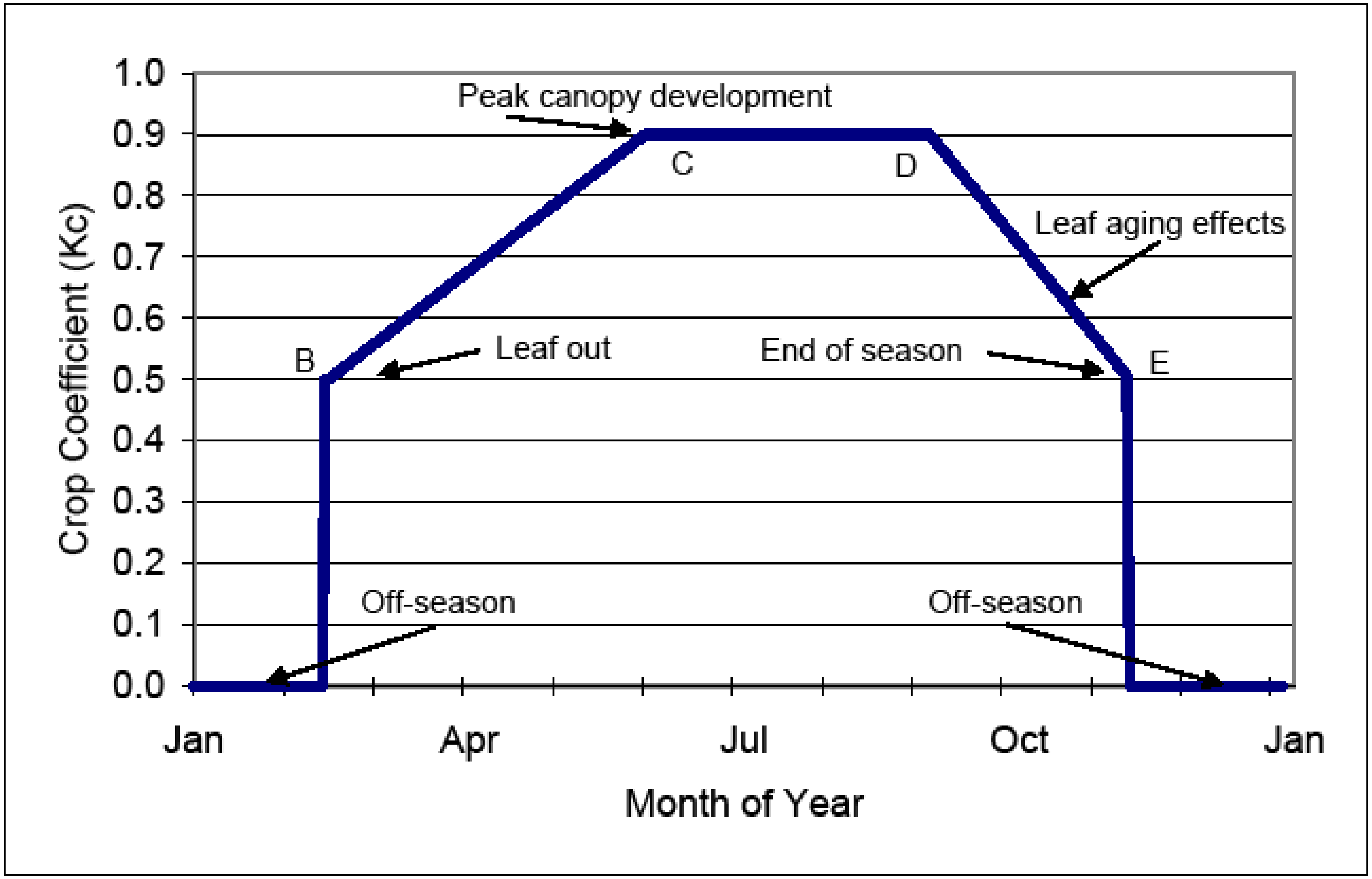



** As discussed in Section 4.1, the average soil water salinity was reduced by the soil salinity at 50% leaching for the exponential model.*

**Alfalfa:** output from the steady-state model both 1) without precipitation and 2) including precipitation (all equations defined in Table 5.2) with precipitation data from NCDC Tracy-Carbona Station #8999 and alfalfa crop evapotranspiration coefficients (modified Goldhamer & Snyder, 1989).

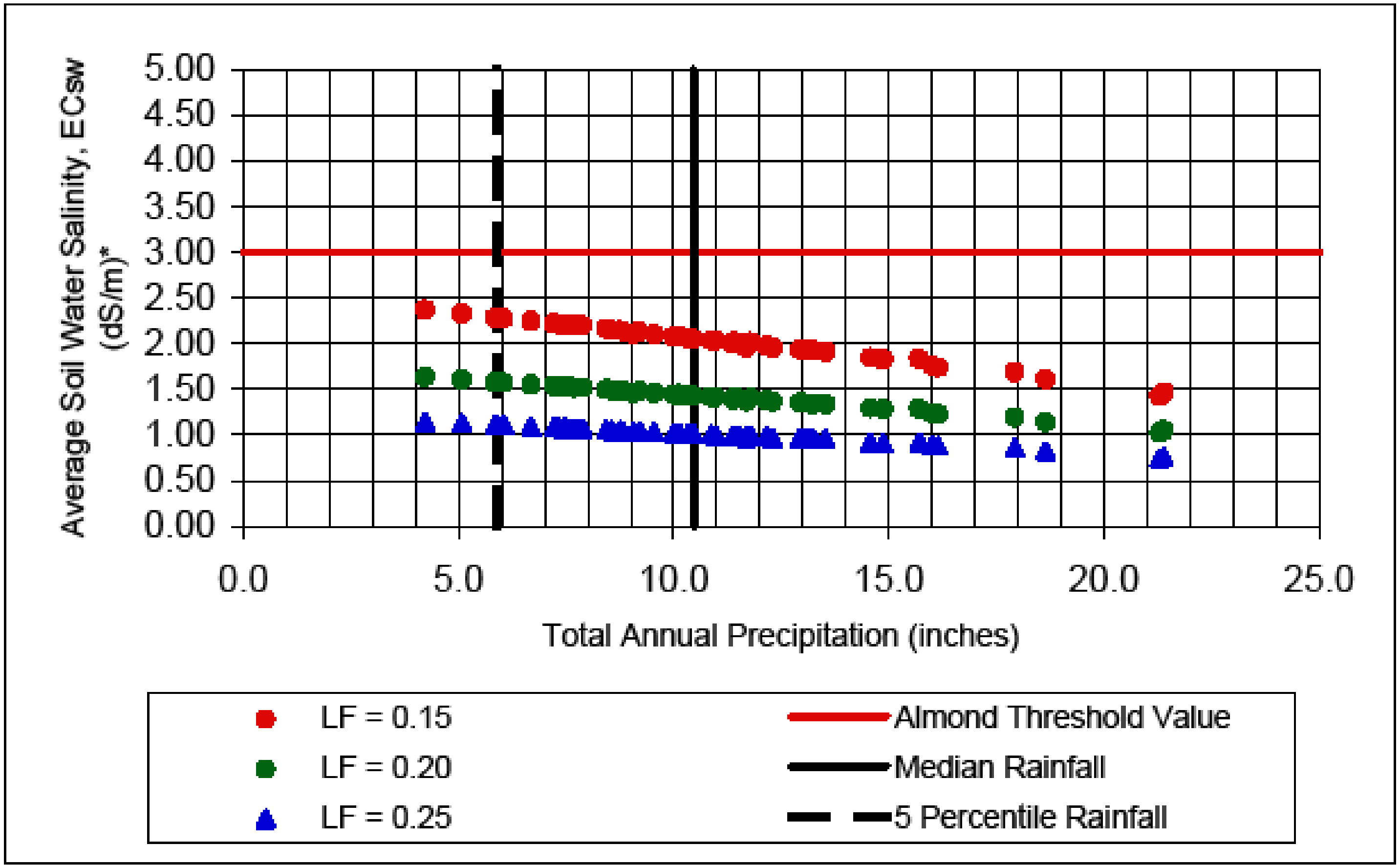
| | Input Variables | | | | | | Model Output | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | $EC_i$ = 1.0 | | | LF = 0.10 | | | |
| | | | | | | | 1) without precipitation | | | 2) with precipitation | | | |
| Water Year | $P_T$ (in.) | $P_{NG}$ (in.) | $E_S$ (in.) | $P_{GS}$ (in.) | $P_{EFF}$ (in.) | $ET_C$ (in.) | $I_1$ (in.) | $EC_{SWa-1}$ (dS/m) | $EC_{SWb-1}$ (dS/m) | $I_2$ (in.) | $EC_{AW-2}$ (dS/m) | $EC_{SWa-2}$ (dS/m) | $EC_{SWb-2}$ (dS/m) |
| 1952 | 13.5 | 0.0 | 0.0 | 13.5 | 13.5 | 50.6 | 56.2 | 4.11 | 3.79 | 42.7 | 0.76 | 3.12 | 2.88 |
| 1953 | 7.6 | 0.0 | 0.0 | 7.6 | 7.6 | 50.2 | 55.7 | 4.11 | 3.79 | 48.1 | 0.86 | 3.55 | 3.27 |
| 1954 | 6.1 | 0.0 | 0.0 | 6.1 | 6.1 | 50.8 | 56.4 | 4.11 | 3.79 | 50.4 | 0.89 | 3.67 | 3.38 |
| 1955 | 10.9 | 0.0 | 0.0 | 10.9 | 10.9 | 49.4 | 54.9 | 4.11 | 3.79 | 44.0 | 0.80 | 3.29 | 3.04 |
| 1956 | 13.2 | 0.0 | 0.0 | 13.2 | 13.2 | 50.2 | 55.8 | 4.11 | 3.79 | 42.6 | 0.76 | 3.14 | 2.89 |
| 1957 | 8.8 | 0.0 | 0.0 | 8.8 | 8.8 | 49.7 | 55.2 | 4.11 | 3.79 | 46.4 | 0.84 | 3.45 | 3.18 |
| 1958 | 16.0 | 0.0 | 0.0 | 16.0 | 16.0 | 49.0 | 54.4 | 4.11 | 3.79 | 38.4 | 0.71 | 2.90 | 2.67 |
| 1959 | 7.9 | 0.0 | 0.0 | 7.9 | 7.9 | 52.3 | 58.1 | 4.11 | 3.79 | 50.2 | 0.86 | 3.55 | 3.27 |
| 1960 | 5.1 | 0.0 | 0.0 | 5.1 | 5.1 | 52.8 | 58.7 | 4.11 | 3.79 | 53.6 | 0.91 | 3.75 | 3.46 |
| 1961 | 7.8 | 0.0 | 0.0 | 7.8 | 7.8 | 51.0 | 56.6 | 4.11 | 3.79 | 48.9 | 0.86 | 3.54 | 3.27 |
| 1962 | 8.7 | 0.0 | 0.0 | 8.7 | 8.7 | 50.2 | 55.8 | 4.11 | 3.79 | 47.1 | 0.84 | 3.46 | 3.19 |
| 1963 | 9.1 | 0.0 | 0.0 | 9.1 | 9.1 | 47.8 | 53.1 | 4.11 | 3.79 | 44.0 | 0.83 | 3.40 | 3.14 |
| 1964 | 5.9 | 0.0 | 0.0 | 5.9 | 5.9 | 50.5 | 56.2 | 4.11 | 3.79 | 50.3 | 0.90 | 3.68 | 3.39 |
| 1965 | 10.5 | 0.0 | 0.0 | 10.5 | 10.5 | 49.0 | 54.4 | 4.11 | 3.79 | 44.0 | 0.81 | 3.32 | 3.06 |
| 1966 | 7.5 | 0.0 | 0.0 | 7.5 | 7.5 | 52.3 | 58.1 | 4.11 | 3.79 | 50.7 | 0.87 | 3.58 | 3.30 |
| 1967 | 12.2 | 0.0 | 0.0 | 12.2 | 12.2 | 50.4 | 56.0 | 4.11 | 3.79 | 43.9 | 0.78 | 3.21 | 2.97 |
| 1968 | 11.5 | 0.0 | 0.0 | 11.5 | 11.5 | 51.5 | 57.2 | 4.11 | 3.79 | 45.7 | 0.80 | 3.28 | 3.03 |
| 1969 | 13.2 | 0.0 | 0.0 | 13.2 | 13.2 | 50.4 | 56.0 | 4.11 | 3.79 | 42.7 | 0.76 | 3.13 | 2.89 |
| 1970 | 7.6 | 0.0 | 0.0 | 7.6 | 7.6 | 52.3 | 58.1 | 4.11 | 3.79 | 50.5 | 0.87 | 3.57 | 3.29 |
| 1971 | 11.4 | 0.0 | 0.0 | 11.4 | 11.4 | 50.1 | 55.6 | 4.11 | 3.79 | 44.2 | 0.80 | 3.26 | 3.01 |
| 1972 | 4.2 | 0.0 | 0.0 | 4.2 | 4.2 | 53.0 | 58.8 | 4.11 | 3.79 | 54.6 | 0.93 | 3.81 | 3.52 |
| 1973 | 15.7 | 0.0 | 0.0 | 15.7 | 15.7 | 51.4 | 57.1 | 4.11 | 3.79 | 41.4 | 0.72 | 2.97 | 2.74 |
| 1974 | 11.4 | 0.0 | 0.0 | 11.4 | 11.4 | 51.8 | 57.5 | 4.11 | 3.79 | 46.1 | 0.80 | 3.29 | 3.04 |
| 1975 | 10.0 | 0.0 | 0.0 | 10.0 | 10.0 | 49.5 | 55.0 | 4.11 | 3.79 | 45.1 | 0.82 | 3.36 | 3.10 |
| 1976 | 5.8 | 0.0 | 0.0 | 5.8 | 5.8 | 49.6 | 55.2 | 4.11 | 3.79 | 49.3 | 0.89 | 3.67 | 3.39 |
| 1977 | 7.4 | 0.0 | 0.0 | 7.4 | 7.4 | 50.1 | 55.7 | 4.11 | 3.79 | 48.3 | 0.87 | 3.56 | 3.28 |
| 1978 | 12.3 | 0.0 | 0.0 | 12.3 | 12.3 | 48.9 | 54.3 | 4.11 | 3.79 | 42.0 | 0.77 | 3.18 | 2.93 |
| 1979 | 9.6 | 0.0 | 0.0 | 9.6 | 9.6 | 50.2 | 55.7 | 4.11 | 3.79 | 46.2 | 0.83 | 3.40 | 3.14 |
| 1980 | 11.4 | 0.0 | 0.0 | 11.4 | 11.4 | 48.5 | 53.8 | 4.11 | 3.79 | 42.5 | 0.79 | 3.24 | 2.99 |
| 1981 | 7.2 | 0.0 | 0.0 | 7.2 | 7.2 | 51.9 | 57.7 | 4.11 | 3.79 | 50.5 | 0.88 | 3.59 | 3.31 |
| 1982 | 16.2 | 0.0 | 0.0 | 16.2 | 16.2 | 47.8 | 53.1 | 4.11 | 3.79 | 36.9 | 0.70 | 2.86 | 2.63 |
| 1983 | 21.3 | 0.0 | 0.0 | 21.3 | 21.3 | 45.2 | 50.2 | 4.11 | 3.79 | 28.9 | 0.58 | 2.36 | 2.18 |
| 1984 | 9.2 | 0.0 | 0.0 | 9.2 | 9.2 | 52.4 | 58.2 | 4.11 | 3.79 | 49.0 | 0.84 | 3.46 | 3.19 |
| 1985 | 13.1 | 0.0 | 0.0 | 13.1 | 13.1 | 50.5 | 56.1 | 4.11 | 3.79 | 43.0 | 0.77 | 3.15 | 2.91 |
| 1986 | 13.3 | 0.0 | 0.0 | 13.3 | 13.3 | 50.0 | 55.6 | 4.11 | 3.79 | 42.3 | 0.76 | 3.13 | 2.88 |
| 1987 | 6.7 | 0.0 | 0.0 | 6.7 | 6.7 | 51.5 | 57.2 | 4.11 | 3.79 | 50.6 | 0.88 | 3.63 | 3.35 |
| 1988 | 8.4 | 0.0 | 0.0 | 8.4 | 8.4 | 52.4 | 58.2 | 4.11 | 3.79 | 49.7 | 0.86 | 3.51 | 3.24 |
| 1989 | 7.7 | 0.0 | 0.0 | 7.7 | 7.7 | 50.2 | 55.7 | 4.11 | 3.79 | 48.1 | 0.86 | 3.54 | 3.27 |
| 1990 | 7.3 | 0.0 | 0.0 | 7.3 | 7.3 | 50.6 | 56.2 | 4.11 | 3.79 | 48.9 | 0.87 | 3.57 | 3.29 |
| 1991 | 7.7 | 0.0 | 0.0 | 7.7 | 7.7 | 50.8 | 56.4 | 4.11 | 3.79 | 48.7 | 0.86 | 3.55 | 3.27 |
| 1992 | 11.8 | 0.0 | 0.0 | 11.8 | 11.8 | 53.3 | 59.2 | 4.11 | 3.79 | 47.4 | 0.80 | 3.29 | 3.03 |
| 1993 | 17.9 | 0.0 | 0.0 | 17.9 | 17.9 | 50.6 | 56.2 | 4.11 | 3.79 | 38.3 | 0.68 | 2.80 | 2.58 |
| 1994 | 10.1 | 0.0 | 0.0 | 10.1 | 10.1 | 52.4 | 58.2 | 4.11 | 3.79 | 48.1 | 0.83 | 3.39 | 3.13 |
| 1995 | 14.9 | 0.0 | 0.0 | 14.9 | 14.9 | 49.2 | 54.7 | 4.11 | 3.79 | 39.8 | 0.73 | 2.99 | 2.76 |
| 1996 | 15.7 | 0.0 | 0.0 | 15.7 | 15.7 | 52.5 | 58.3 | 4.11 | 3.79 | 42.6 | 0.73 | 3.00 | 2.77 |
| 1997 | 12.9 | 0.0 | 0.0 | 12.9 | 12.9 | 50.6 | 56.3 | 4.11 | 3.79 | 43.3 | 0.77 | 3.16 | 2.92 |
| 1998 | 21.4 | 0.0 | 0.0 | 21.4 | 21.4 | 48.3 | 53.6 | 4.11 | 3.79 | 32.2 | 0.60 | 2.47 | 2.28 |
| 1999 | 11.7 | 0.0 | 0.0 | 11.7 | 11.7 | 49.3 | 54.8 | 4.11 | 3.79 | 43.1 | 0.79 | 3.23 | 2.98 |
| 2000 | 10.4 | 0.0 | 0.0 | 10.4 | 10.4 | 50.0 | 55.5 | 4.11 | 3.79 | 45.1 | 0.81 | 3.34 | 3.08 |
| 2001 | 10.1 | 0.0 | 0.0 | 10.1 | 10.1 | 50.9 | 56.6 | 4.11 | 3.79 | 46.4 | 0.82 | 3.37 | 3.11 |
| 2002 | 11.0 | 0.0 | 0.0 | 11.0 | 11.0 | 50.0 | 55.5 | 4.11 | 3.79 | 44.6 | 0.80 | 3.30 | 3.04 |
| 2003 | 10.3 | 0.0 | 0.0 | 10.3 | 10.3 | 50.1 | 55.6 | 4.11 | 3.79 | 45.3 | 0.81 | 3.34 | 3.08 |
| 2004 | 10.9 | 0.0 | 0.0 | 10.9 | 10.9 | 50.3 | 55.8 | 4.11 | 3.79 | 45.0 | 0.81 | 3.31 | 3.05 |
| 2005 | 18.6 | 0.0 | 0.0 | 18.6 | 18.6 | 48.1 | 53.4 | 4.11 | 3.79 | 34.7 | 0.65 | 2.67 | 2.46 |
| 2006 | 14.6 | 0.0 | 0.0 | 14.6 | 14.6 | 49.9 | 55.4 | 4.11 | 3.79 | 40.9 | 0.74 | 3.03 | 2.79 |
| 2007 | 8.6 | 0,0 | 0.0 | 8.6 | 8.6 | 50.2 | 55.7 | 4.11 | 3.79 | 47.2 | 0.85 | 3.48 | 3.21 |
| 2008 | 11.7 | 0.0 | 0.0 | 11.7 | 11.7 | 46.6 | 51.7 | 4.11 | 3.79 | 40.1 | 0.77 | 3.18 | 2.93 |
| Median: | 10.5 | 0.0 | 0.0 | 10.5 | 10.5 | 50.2 | 55.8 | 4.11 | 3.79 | 45.1 | 0.81 | 3.32 | 3.06 |
| Max: | 21.4 | 0.0 | 0.0 | 21.4 | 21.4 | 53.3 | 59.2 | 4.11 | 3.79 | 54.6 | 0.93 | 3.81 | 3.52 |
| Min: | 4.2 | 0.0 | 0.0 | 4.2 | 4.2 | 45.2 | 50.2 | 4.11 | 3.79 | 28.9 | 0.58 | 2.36 | 2.18 |

**Relationship between crop coefficients (Kc) and growth and development periods <u>for almond</u> (Goldhamer and Snyder, 1989)**




*See table in handout for corresponding model output for almond*

**Almond:** **average soil water salinity (ECsw)* vs. total annual rainfall assuming ECi = 1.0 dS/m and using exponential water uptake function.**




** As discussed in Section 4.1, the average soil water salinity was reduced by the soil salinity at 50% leaching for the exponential model.*

**Almond:** **output from the steady-state model both 1) without precipitation and 2) including precipitation (all equations defined in Table 5.2) with precipitation data from NCDC Tracy-Carbona Station #8999 and crop evapotranspiration coefficients from Goldhamer & Snyder (1989).**

| | Input Variables | | | | | | Model Output | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | $EC_i$ = 1.0 | | | LF = 0.15 | | | |
| | | | | | | | 1) without precipitation | | | 2) with precipitation | | | |
| Water Year | $P_T$ (in.) | $P_{NG}$ (in.) | $E_S$ (in.) | $P_{GS}$ (in.) | $P_{EFF}$ (in.) | $ET_C$ (in.) | $I_1$ (in.) | $EC_{SWa\text{-}1}$ (dS/m) | $EC_{SWb\text{-}1}$ (dS/m) | $I_2$ (in.) | $EC_{AW\text{-}2}$ (dS/m) | $EC_{SWa\text{-}2}$ (dS/m) | $EC_{SWb\text{-}2}$ (dS/m) |
| 1952 | 13.5 | 8.4 | 2.2 | 5.2 | 11.3 | 43.1 | 50.7 | 3.18 | 2.46 | 39.4 | 0.78 | 2.47 | 1.91 |
| 1953 | 7.6 | 5.0 | 2.2 | 2.6 | 5.4 | 42.3 | 49.7 | 3.18 | 2.46 | 44.4 | 0.89 | 2.84 | 2.20 |
| 1954 | 6.1 | 2.1 | 2.2 | 4.0 | 3.8 | 42.9 | 50.4 | 3.18 | 2.46 | 46.6 | 0.92 | 2.94 | 2.27 |
| 1955 | 10.9 | 5.6 | 2.2 | 5.2 | 8.7 | 42.4 | 49.9 | 3.18 | 2.46 | 41.2 | 0.83 | 2.63 | 2.03 |
| 1956 | 13.2 | 9.6 | 2.2 | 3.6 | 10.9 | 42.5 | 50.0 | 3.18 | 2.46 | 39.0 | 0.78 | 2.48 | 1.92 |
| 1957 | 8.8 | 2.4 | 2.2 | 6.5 | 6.6 | 42.1 | 49.6 | 3.18 | 2.46 | 43.0 | 0.87 | 2.76 | 2.14 |
| 1958 | 16.0 | 5.9 | 2.2 | 10.1 | 13.8 | 41.3 | 48.6 | 3.18 | 2.46 | 34.8 | 0.72 | 2.28 | 1.76 |
| 1959 | 7.9 | 2.8 | 2.2 | 5.1 | 5.7 | 44.2 | 52.0 | 3.18 | 2.46 | 46.3 | 0.89 | 2.83 | 2.19 |
| 1960 | 5.1 | 4.0 | 2.2 | 1.0 | 2.9 | 44.7 | 52.6 | 3.18 | 2.46 | 49.8 | 0.95 | 3.01 | 2.33 |
| 1961 | 7.8 | 4.6 | 2.2 | 3.1 | 5.5 | 43.2 | 50.8 | 3.18 | 2.46 | 45.3 | 0.89 | 2.84 | 2.19 |
| 1962 | 8.7 | 6.4 | 2.2 | 2.3 | 6.5 | 43.0 | 50.5 | 3.18 | 2.46 | 44.0 | 0.87 | 2.77 | 2.14 |
| 1963 | 9.1 | 4.4 | 2.2 | 4.6 | 6.9 | 40.0 | 47.1 | 3.18 | 2.46 | 40.2 | 0.85 | 2.72 | 2.10 |
| 1964 | 5.9 | 3.1 | 2.2 | 2.8 | 3.7 | 42.2 | 49.7 | 3.18 | 2.46 | 46.0 | 0.93 | 2.95 | 2.28 |
| 1965 | 10.5 | 5.3 | 2.2 | 5.1 | 8.2 | 41.5 | 48.8 | 3.18 | 2.46 | 40.5 | 0.83 | 2.64 | 2.05 |
| 1966 | 7.5 | 6.2 | 2.2 | 1.3 | 5.3 | 44.5 | 52.4 | 3.18 | 2.46 | 47.1 | 0.90 | 2.86 | 2.21 |
| 1967 | 12.2 | 6.8 | 2.2 | 5.4 | 10.0 | 42.7 | 50.3 | 3.18 | 2.46 | 40.3 | 0.80 | 2.55 | 1.97 |
| 1968 | 11.5 | 5.2 | 2.2 | 6.3 | 9.3 | 43.5 | 51.1 | 3.18 | 2.46 | 41.8 | 0.82 | 2.60 | 2.01 |
| 1969 | 13.2 | 7.4 | 2.2 | 5.9 | 11.0 | 42.9 | 50.5 | 3.18 | 2.46 | 39.5 | 0.78 | 2.49 | 1.93 |
| 1970 | 7.6 | 4.5 | 2.2 | 3.1 | 5.4 | 44.1 | 51.8 | 3.18 | 2.46 | 46.4 | 0.90 | 2.85 | 2.21 |
| 1971 | 11.4 | 7.0 | 2.2 | 4.4 | 9.2 | 42.7 | 50.2 | 3.18 | 2.46 | 41.0 | 0.82 | 2.60 | 2.01 |
| 1972 | 4.2 | 2.9 | 2.2 | 1.4 | 2.0 | 45.1 | 53.1 | 3.18 | 2.46 | 51.0 | 0.96 | 3.06 | 2.37 |
| 1973 | 15.7 | 10.2 | 2.2 | 5.5 | 13.5 | 44.1 | 51.9 | 3.18 | 2.46 | 38.4 | 0.74 | 2.35 | 1.82 |
| 1974 | 11.4 | 5.1 | 2.2 | 6.3 | 9.2 | 43.8 | 51.5 | 3.18 | 2.46 | 42.3 | 0.82 | 2.61 | 2.02 |
| 1975 | 10.0 | 4.0 | 2.2 | 6.0 | 7.8 | 42.0 | 49.4 | 3.18 | 2.46 | 41.6 | 0.84 | 2.68 | 2.07 |
| 1976 | 5.8 | 1.3 | 2.2 | 4.6 | 3.6 | 41.2 | 48.4 | 3.18 | 2.46 | 44.8 | 0.93 | 2.94 | 2.28 |
| 1977 | 7.4 | 2.2 | 2.2 | 5.2 | 5.2 | 42.0 | 49.4 | 3.18 | 2.46 | 44.2 | 0.90 | 2.85 | 2.20 |
| 1978 | 12.3 | 7.2 | 2.2 | 5.1 | 10.1 | 41.6 | 48.9 | 3.18 | 2.46 | 38.8 | 0.79 | 2.52 | 1.95 |
| 1979 | 9.6 | 5.1 | 2.2 | 4.5 | 7.3 | 42.7 | 50.2 | 3.18 | 2.46 | 42.9 | 0.85 | 2.72 | 2.10 |
| 1980 | 11.4 | 4.8 | 2.2 | 6.6 | 9.2 | 40.7 | 47.8 | 3.18 | 2.46 | 38.7 | 0.81 | 2.57 | 1.99 |
| 1981 | 7.2 | 3.4 | 2.2 | 3.8 | 5.0 | 44.0 | 51.8 | 3.18 | 2.46 | 46.8 | 0.90 | 2.88 | 2.23 |
| 1982 | 16.2 | 5.8 | 2.2 | 10.3 | 13.9 | 40.4 | 47.5 | 3.18 | 2.46 | 33.6 | 0.71 | 2.25 | 1.74 |
| 1983 | 21.3 | 10.8 | 2.2 | 10.5 | 19.1 | 38.5 | 45.2 | 3.18 | 2.46 | 26.2 | 0.58 | 1.84 | 1.42 |
| 1984 | 9.2 | 6.7 | 2.2 | 2.5 | 7.0 | 44.2 | 51.9 | 3.18 | 2.46 | 45.0 | 0.87 | 2.75 | 2.13 |
| 1985 | 13.1 | 7.1 | 2.2 | 6.0 | 10.8 | 42.3 | 49.8 | 3.18 | 2.46 | 39.0 | 0.78 | 2.49 | 1.93 |
| 1986 | 13.3 | 5.8 | 2.2 | 7.5 | 11.0 | 42.5 | 50.0 | 3.18 | 2.46 | 39.0 | 0.78 | 2.48 | 1.92 |
| 1987 | 6.7 | 4.6 | 2.2 | 2.1 | 4.5 | 43.6 | 51.3 | 3.18 | 2.46 | 46.8 | 0.91 | 2.90 | 2.25 |
| 1988 | 8.4 | 4.8 | 2.2 | 3.6 | 6.2 | 43.7 | 51.4 | 3.18 | 2.46 | 45.2 | 0.88 | 2.80 | 2.16 |
| 1989 | 7.7 | 4.0 | 2.2 | 3.6 | 5.4 | 42.6 | 50.1 | 3.18 | 2.46 | 44.7 | 0.89 | 2.84 | 2.20 |
| 1990 | 7.3 | 2.4 | 2.2 | 5.0 | 5.1 | 43.0 | 50.6 | 3.18 | 2.46 | 45.5 | 0.90 | 2.86 | 2.21 |
| 1991 | 7.7 | 3.1 | 2.2 | 4.6 | 5.5 | 42.6 | 50.2 | 3.18 | 2.46 | 44.7 | 0.89 | 2.83 | 2.19 |
| 1992 | 11.8 | 6.3 | 2.2 | 5.5 | 9.6 | 45.1 | 53.0 | 3.18 | 2.46 | 43.5 | 0.82 | 2.61 | 2.02 |
| 1993 | 17.9 | 10.3 | 2.2 | 7.6 | 15.7 | 42.3 | 49.8 | 3.18 | 2.46 | 34.1 | 0.69 | 2.18 | 1.69 |
| 1994 | 10.1 | 5.0 | 2.2 | 5.2 | 7.9 | 43.9 | 51.7 | 3.18 | 2.46 | 43.8 | 0.85 | 2.69 | 2.09 |
| 1995 | 14.9 | 8.8 | 2.2 | 6.1 | 12.7 | 41.5 | 48.8 | 3.18 | 2.46 | 36.1 | 0.74 | 2.36 | 1.82 |
| 1996 | 15.7 | 9.3 | 2.2 | 6.4 | 13.5 | 44.9 | 52.8 | 3.18 | 2.46 | 39.4 | 0.74 | 2.37 | 1.83 |
| 1997 | 12.9 | 10.6 | 2.2 | 2.4 | 10.7 | 42.5 | 50.0 | 3.18 | 2.46 | 39.3 | 0.79 | 2.50 | 1.93 |
| 1998 | 21.4 | 12.9 | 2.2 | 8.5 | 19.2 | 40.4 | 47.5 | 3.18 | 2.46 | 28.4 | 0.60 | 1.90 | 1.47 |
| 1999 | 11.7 | 5.8 | 2.2 | 5.8 | 9.5 | 41.0 | 48.2 | 3.18 | 2.46 | 38.8 | 0.80 | 2.56 | 1.98 |
| 2000 | 10.4 | 4.9 | 2.2 | 5.5 | 8.2 | 41.6 | 49.0 | 3.18 | 2.46 | 40.8 | 0.83 | 2.65 | 2.05 |
| 2001 | 10.1 | 3.4 | 2.2 | 6.7 | 7.9 | 42.8 | 50.3 | 3.18 | 2.46 | 42.4 | 0.84 | 2.68 | 2.08 |
| 2002 | 11.0 | 7.6 | 2.2 | 3.3 | 8.8 | 42.4 | 49.8 | 3.18 | 2.46 | 41.1 | 0.82 | 2.62 | 2.03 |
| 2003 | 10.3 | 5.6 | 2.2 | 4.7 | 8.1 | 41.7 | 49.1 | 3.18 | 2.46 | 41.0 | 0.83 | 2.65 | 2.05 |
| 2004 | 10.9 | 5.1 | 2.2 | 5.8 | 8.7 | 42.8 | 50.3 | 3.18 | 2.46 | 41.7 | 0.83 | 2.63 | 2.04 |
| 2005 | 18.6 | 8.9 | 2.2 | 9.7 | 16.4 | 40.3 | 47.4 | 3.18 | 2.46 | 31.0 | 0.65 | 2.08 | 1.61 |
| 2006 | 14.6 | 6.3 | 2.2 | 8.3 | 12.4 | 41.8 | 49.2 | 3.18 | 2.46 | 36.8 | 0.75 | 2.38 | 1.84 |
| 2007 | 8.6 | 5.7 | 2.2 | 2.9 | 6.4 | 42.1 | 49.5 | 3.18 | 2.46 | 43.2 | 0.87 | 2.77 | 2.15 |
| 2008 | 11.7 | 9.8 | 2.2 | 1.9 | 9.5 | 39.3 | 46.3 | 3.18 | 2.46 | 36.8 | 0.80 | 2.53 | 1.96 |
| Median: | 10.5 | 5.6 | 2.2 | 5.1 | 8.2 | 42.5 | 50.0 | 3.18 | 2.46 | 41.6 | 0.83 | 2.64 | 2.05 |
| Max: | 21.4 | 12.9 | 2.2 | 10.5 | 19.2 | 45.1 | 53.1 | 3.18 | 2.46 | 51.0 | 0.96 | 3.06 | 2.37 |
| Min: | 4.2 | 1.3 | 2.2 | 1.0 | 2.0 | 38.5 | 45.2 | 3.18 | 2.46 | 26.2 | 0.58 | 1.84 | 1.42 |

# Transient Model Recommendation

COMMENT

Expand Recommendation on additional studies necessary for consideration of transient models.

RESPONSE

- Evaluation of transient models is currently being conducted by a California group and an international group of scientists.
- This evaluation process will probably require several years.
- Recommend California group be supported to test transient models on South Delta data.

# Remaining Comments

- All comments will be addressed in the final report as an appendix, which will be available on the Division of Water Rights website.
- Do you have any additional comments that need to be addressed today?

# Recommendations

- A field experiment should be conducted to establish the salt tolerance of bean under local conditions using current varieties.
- If water quality standard is changed throughout the year, knowing salt sensitivity of bean at different growth stages would be beneficial.
- If a steady-state model is to be used, include effective rainfall, and employ either the exponential or the 40-30-20-10 model.
- Support should be given to test one or more transient models using South Delta data.
- It is recommended that the source of drain discharge be determined.
- Boron is a potential concern and further study is recommended