Assessment of the Leaching and On-Farm Irrigation Water Requirements of Imperial Irrigation District

A Special Report for Metropolitan Water District of Southern California

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Executive Summary

A number of assessments were undertaken to estimate the reasonably beneficial on-farm water-use requirements of the IID for the periods 1989-1996 and 2000-2002. These assessments and the key conclusions and major recommendations based on them are summarized here.

The leaching requirement (LR), which is the fraction of the infiltrated water that must leach through the crop rootzone in order to keep soil salinity within acceptable limits for full potential crop yield, was estimated using two steady-state models (which have been shown to provide very similar results to more exact transient but less practical models). Leaching requirements values were calculated using both models for the average weighted IID-wide situation for a representative mixture of crops (based on 1989-1996 and 2000-2002) for various combinations of Colorado River salinity, crop consumptive use, tailwater runoff, effective rainfall and irrigation efficiency. Based on these values, the volumes of beneficial and non-beneficial components comprising the on-farm water requirement, along with applied water, infiltrated water, tailwater, deep percolation, etc., were calculated for these various combinations. These results can be used to assess the water requirements under the different conditions of use, including those existing in the past fifteen years, at the present and those in the foreseeable future.

The IID-wide weighted values obtained for the 1989-1996 Colorado River water-use situation with the WATSUIT model (LR_W, which adjusts for the removal of salt from solution within the active rootzone by mineral precipitation) and with the conservative so-called traditional leaching requirement model (LR_T) were 0.085 and 0.125, respectively. These values were based on the weighted salt-tolerances, cropped acreages and consumptive use of each crop produced in the IID during the period 1989-1996. For 2000-2002, the analogous and corresponding values were about 0.060 and 0.106.

The IID has advocated that horizontal leaching and tailwater runoff is necessary for soil salinity control for about 87 percent of their irrigated fields and that the associated volume of tailwater should be credited as beneficial water use in the IID. The leaching requirement models do not account for the horizontal-leaching of soil salinity, as can occur in the cracking-type soils found in the IID. Therefore, I developed relationships to account for the effect of horizontal-leaching combined with tailwater drainage in the determination of the leaching requirement. These new relationships are described later. Example calculations are provided which show that horizontal-leaching does not provide an appreciable amount of benefit in the control of soil salinity, but its contribution can be assessed and included, if desired, in the determination of the leaching requirement and in the determination of associated water volumes, using the valid quantitative relationships developed and presented herein for this purpose. I did so herein, for sake of completeness.

Both LR models assume uniform conditions of irrigation, infiltration and leaching. Such conditions may not exist under actual field situations; thus, a means to adjust for non-uniformity and inefficiency of irrigation was developed for cases where such adjustment

is appropriate and is described later. A new criterion of maximum permissible non-beneficial water use was developed as a means to help determine the amount of water to be provided for non-uniformity and inefficiency compensation, for cases where such compensation is appropriate (in my opinion, such compensation is inappropriate at the prevalent levels of tailwater use in the IID and only becomes relevant when the tailwater becomes less than about 10 percent).

New equations were also developed to permit the calculations of the on-farm water requirements corresponding to the leaching requirement for different situations, i.e., for the various possible combinations of required vertical-leaching, tailwater use, horizontal-leaching and non-uniformity/inefficiency compensation. These relationships are provided in summary tables. Example calculations are provided to demonstrate the use and utility of these relationships in determining the water requirement of the IID, of the volume of tailwater that contributes to beneficial water use (i.e., provides some of the required soil salinity control) and of the effects of various irrigation options on drainage volumes and on overall beneficial and non-beneficial water use.

If tailwater use is to be reduced to low levels in the IID (about five percent or less), then some compensation for irrigation inefficiency related to non-uniformity of application, infiltration and leaching should probably be included in the assessment of the IID on-farm water requirement. The means commonly used to determine such compensation is subject to abuse; it may result in a kind of "double-accounting" and in excessive non-beneficial water use, if not used appropriately. Therefore, I advocate that the criterion of minimum non-beneficial water be used to help determine how much compensation is appropriate and reasonable. I developed practical equations to facilitate the required calculations and assessment. Example calculations are provided to illustrate the use of the procedure and to demonstrate the amounts and percentages of non-beneficial water use that can result under different possible situations.

The selection of the appropriate value of irrigation inefficiency compensation to use for the IID situation under conditions of reduced tailwater usage depends on the irrigation system, irrigation management, soil infiltration properties, tailwater percentage allowed and some decisions about how much of the irrigated field should receive optimum water application, infiltration and leaching (i.e., economic determinations are also necessary). The latter decisions must "weigh" the difference between what is beneficial and what is reasonable, which includes economic assessments of various off-site environmental considerations, as well as the in-field technical aspects of crop production and irrigation and drainage processes. The use of surface irrigation models capable of predicting water infiltration and leaching (and tailwater runoff) for various conditions of water application and soil properties facilitate the determination of the uniformity and efficiency that is potentially achievable. It also facilitates the assessment of the practicality of alternative irrigation management, especially when it is coupled with economic considerations of the fulfillment of potential crop consumption and required leaching within the field and of the potential deleterious consequences of "ponding and scalding" and of excessive deep percolation (waterlogging, salinization, increased drainage requirements, pollution, etc.) For this reason, I recommend that the approach used to compensate for non-uniformity

and inefficiency of irrigation in estimating water application requirements in IID be based on the consideration of resulting non-beneficial water use, coupled with an assessment of the feasibility and practically of achieving the corresponding non-uniformity factor (F_n) made using infiltration models calibrated for IID conditions and of the associated economic implications (covering both positive and negative effects of increasing the water application to increase the percentage of the field achieving full water requirements for crop ET and leaching).

Tailwater is not normally considered a beneficial use of irrigation water, although the IID has argued that it can provide some leaching benefit and should be credited accordingly (however, as shown herein, this benefit is very small and horizontal-leaching is very inefficient; thus, one should not intentionally advocate its use for this purpose). Thus, it may be reasonable to base the estimation of the on-farm water delivery requirement (RV_{iw}) solely on the basis of the reasonableness of beneficial water use (which only includes ET and LR related water usage) without allowance for any tailwater, considering the possible need to provide a reasonable amount of extra water to compensate for irrigation inefficiency considerations. This would permit the irrigator to determine whether he will allow tailwater use (TW), or not, within the confines of his overall "reasonable and beneficial' allotment. In other words, the total allotted water can be used in any combination of ET + LR + TW, but it must be kept within the limits of the reasonably beneficial water requirement, as defined and calculated above. Another alternative would be to credit tailwater use for the amount by which it contributes to beneficial water use (salinity control) and to include this amount (which is no more than 5 percent) in the water requirement estimate.

Various sensitivity analyses were made of the relations developed and used herein in order to assess the relative effects and importance of leaching requirement, tailwater fraction, horizontal-leaching and non-uniformity compensation, on water requirement volumes, non-beneficial water use and the volumes of required and non-required drainage. The results show, among other things, that: 1) high tailwater fraction and non-uniformity compensation greatly increase the amount of non-beneficial water use and, hence, both need to be minimized as much as practical; 2) the leaching requirement is the primary parameter, besides V_{et} of course, that affects the volume of required infiltration water, while horizontal-leaching can reduce this requirement by a small amount at high levels of tailwater fraction, its use is very inefficient and should not be advocated for this purpose; 3) the volume of total deep percolation is highly sensitive to non-uniformity compensation, much more so than to the leaching requirement and 4) non-uniformity compensation and tailwater fraction dominate and increase the volume of total water use that is non-beneficial. Hence, non-uniformity compensation should be minimized in order to minimize non-beneficial water use and the creation of water table and drainage disposal problems and costs.

The above-described relations, logic and procedures were employed to estimate a target volume for the reasonably beneficial on-farm water delivery requirement of Colorado River water in IID for the two time periods described above. The result for the 1989-1996 case where Colorado River salinity is equivalent to an EC of 1.213 dS/m, the leaching

requirement is 0.085, crop consumptive use is 1,806,000 acre feet (AF), effective rainfall is 101,000 AF and the tailwater fraction is 0.05 is about 2,005,000 AF +/- 113, 000 AF, plus another approximately 28,000 AF for duck ponds and fish farms. The corresponding volume of tailwater used beneficially in soil salinity control is about 1,800 AF compared to about 167,000 AF of required deep percolation. The non-beneficial tailwater volume is about 102,000 AF and the overall percentage of water used non-beneficially is 4.9%. This level of irrigation efficiency is deemed potentially possible and practical to achieve in the high clay content, cracking soils of the IID, based on several lines of evidence, including surface-irrigation modeling; monitoring data and demonstration field studies. For the year 2003, the estimate of the reasonable (really liberal) on-farm Colorado River water requirement for the IID service area is about 2237.6 KAF +/- 48.4 KAF. Thus, the corresponding total on-farm requirement in 2003, including duck ponds and fish farms, is about 2266.1 KAF +/- 48.4 KAF. These requirements can be reduced by about 122.7 KAF in two years and by another 110.0 KAF in about five years by reducing tailwater with relatively simple and inexpensive improvements in irrigation and cropping management to 10 percent and 5 percent, respectively.

Introduction

I was requested to provide a value for the leaching requirement (LR) of the Imperial Irrigation District (IID), as needed to estimate the reasonably beneficial on-farm irrigation water requirement of the IID. The values (they vary for different situations) that I determined, along with the logic and basic relations and approaches, are presented herein. Included are the equations that I developed to account for the effect of horizontal-leaching and tailwater drainage on the leaching requirement and to compensate for the effect of non-uniformity and inefficiency of irrigation, with consideration of beneficial water use. The latter compensation was based on a relation that I derived between non-beneficial use and an irrigation efficiency coefficient. Detailed tables of example results that were obtained using the LR-related equations to calculate irrigation and drainage water requirements are provided, as are examples of the calculation procedures and the results of a sensitivity analysis of the underlying relationships. The purpose of the sensitivity analysis was to determine the relative effects of the various involved parameters upon the leaching and water requirement values and the amounts of beneficial and reasonable non-beneficial water use, according to my logic and approach. The results of a preliminary sensitivity analysis based upon evaluations of "sensitivity-plots" of the data, which displayed the degree and extent of the effects of the various parameters on the various water volumes and benefits, are provided. The results of a more rigorous sensitivity analysis are also provided, along with additional estimates of the IID on-farm water requirement made using various estimates of practical irrigation efficiency. Leaching and irrigation water requirements are provided for two time frames, specifically for the period 1989-1996 and for the estimated year 2003 (based on the average of 2000-2002)

Estimation of the IID-Leaching Requirement

Mistakes and inconsistencies are commonly found in reports involving calculations of irrigation and drainage volumes corresponding to leaching requirement values, because of confusion about terminology and variation and inconsistency in the water-reference used to estimate LR. It is important to specify the water used as the reference of LR and to use uniform and equivalent expressions and references when comparing or calculating water volumes associated with LR values. I will now describe what I believe are the correct definitions and means of referencing, in this regard, before describing the actual LR values that I determined for two IID-wide situations.

The LR value is the estimate of the net fraction of <u>infiltrated</u> water that must pass through the rootzone over time in order to keep the level of soil salinity in the active rootzone within acceptable limits for full-potential crop production, assuming uniform conditions of water application, infiltration and leaching within the field and, traditionally, the absence of any significant removal of previously accumulated infiltrated salts by the processes of horizontal-leaching and tailwater runoff. Thus, the LR is usually referenced to the amount of infiltrated water (V_{infw}). However, it can be modified to account for horizontal-leaching and/or tailwater runoff and it can, alternatively, be referenced to the

amount of water applied to the field (V_{iw}). I will use V_{infw} as my reference for LR herein; relations are provided later for converting between these two alternative water-references.

I estimated the leaching requirement for the IID for various conditions by determining the overall "consumptive-use and leaching requirement" weighted District-wide LR_{infw} value for the mixture all crops typically grown there, as follows.

I used the data given in Table 1a, which was taken from the WST Report (1998), describing the crop and consumptive-use conditions of the IID for the eight-year period 1989-1996, as the basis for estimating the District-wide amount of water required for crop consumption and its proportional distribution among the various crops for this period. This table shows the amounts of irrigation water consumed in evapotranspiration (V_{et}) by the individual crops and their proportional use of the total irrigation water requirement for crop evapotranspiration in IID. These data show that about 50 percent of the total consumption use in the IID is typically accounted for in alfalfa production and that about 75 percent is consumed by just four crops: alfalfa, Sudan, wheat and Bermuda. I increased the average values of crop consumptive use given in Table 1a by 4 percent to obtain an increased set of ET values to use for the hypothetical situation that might apply in the future in IID, if the factors presently limiting crop consumptive use were uniformly eliminated, so as to permit the crops to consume water in an increased amount (see Table 1b). The amount of four percent (higher than present) was chosen because it is about half the amount that the present crop consumptive use is below the theoretically full potential value (about 8 percent higher than prevalent usage), which is not ever likely to be achieved (based on the recommendation of Dr R. G. Allen). I used the average crop consumptive use data for 2000-2002 to estimate the expected IID evapotranspiration requirement for 2003 (Allen, 2003b; see Table 1c).

I used the most recent tabulation of conventional threshold salt-tolerance (Maas and Grattan, 1999) to estimate the LR value for each individual crop. I calculated the corresponding leaching requirement of each crop using two steady-state models: the so-called "traditional method" (LR_T; Rhoades, 1974) and the WATSUIT model (LR_W; Rhoades, et al., 1992), respectively. The traditional method is widely used to estimate the leaching requirement, but is a relatively conservative model, since the actual amount of infiltrated salt that needs to be removed by leaching is reduced by mineral precipitation (Rhoades, et al., 1973, 1974). The WATSUIT model adjusts for the removal of soluble salts within the crop rootzone by mineral precipitation (primarily as calcite and gypsum); thus, the value of LR_W is correspondingly lower than LR_T, primarily at the levels of LR less than about 0.10 where the resulting soil water concentrations exceed the solubility of calcite and gypsum minerals in the lower depths of the plant rootzone (Oster and Rhoades, 1990). The WATSUIT model has been shown to give very similar LR results to those obtained using more rigorous and process-based transient models for a representative IID crop rotation (Rhoades, 2002). Again, the LR_T value is conservative; the LR_W value is more theoretically valid. The two values represent the range in LR values that one might reasonably apply to the IID situation. The latter value might be appropriate, if compensation for non-uniformity effects are not provided in the determination of the on-farm irrigation water requirement (as discussed later).

For the 1989-1996 dataset, I estimated leaching requirements and corresponding irrigation water requirements for four different values of EC (0.930, 1.143, 1.213 and 1.323 dS/m). These values include the average salinity levels of the Colorado River (CR) irrigation water at Imperial Dam for the period 1987-1998 (0.093 dS/m, which is the period considered in the IID EIR/EIS Report), for the period 1987-2001 (1.143 dS/m, a more recent long term average), for the period 1989-1996 (1.123 dS/m, the period used in the WST report) and for the upper limit allowed for the future salinity of the Colorado River (1.323 dS/m, equivalent to a TDS value of 879 mg/l), respectively. For 2003, I used the average salinity of the Colorado River for the three years 2000-2002 (1.091 dS/m). The average major solute compositions corresponding to these levels of CR salinity are given in Table 2.

The relations between leaching fraction (LF, the actual fraction of the deep percolation relative to the volume of infiltrated water) and average soil salinity (average rootzone soil salinity as expressed on a saturation-extract basis, EC_e, dS/m) at steady-state conditions were calculated for each of the five considered CR waters using the WATSUIT model. These relations are shown in Figures 1a-1e and were used to estimate the corresponding LR_W values for each crop, since the value of LF corresponding to the threshold level of soil salinity (average rootzone EC_e basis) of each crop is equivalent to the LR_W value of each crop. The values of LR_W were calculated for each crop and water using regression equations, such as "ln (LF) = -2.2755 ln (ave. EC_e) –0.9585", which were established (R^2 = 1.000 in each case) for the respective curves (Figures 1a-1e) relating LF and average soil salinity (EC_e basis). The LR_W values for the average CU of 1705 KAF for the period 1989-1996 and for CR salinities of 0.93, 1.143, 1.213, and 1.323 dS/m are given in Tables 3_{a-d}, as are the corresponding salinity threshold values of each crop. The LR_W values for a CU of 1774 KAF and for CR salinities of 0.93, 1.143, 1.213, and 1.323 dS/m are given in Tables 3_{e-h}, The LR_W values for a CU of 1665.2 KAF for the period of 2000-2002 and for a CR salinity level of 1.091 dS/m are given in Tables 3_i. The corresponding values of LR_T for each crop were calculated from the traditional LR model equation of Rhoades, 1974 {such as, for example, LR_T = (1.213)/[(5)(threshold salinity value)-(1.213)]}.

The District-wide LR_T and LR_W values for each considered time period were calculated as the sum of the individual crop required leaching volumes divided by the sum of the individual crop required volumes of infiltration water corresponding to the volumes of crop consumptive use and salinity level of the Colorado River water for that period (see Table 3_{a-i}). These resulting values (and the means of calculation) are given in the footnotes of Tables 3_{a-i}; they range between about 0.091 and 0.140 for LR_T and between 0.046 and 0.102 for LR_W, respectively, for the range of EC values considered.

District-wide LR_W and LR_T values for the <u>individual years</u> 1989-1996 and 2000-2002 are given in the appendix Tables A3. For the 1989-1996 period, the standard errors of the mean IID-wide LR_W and LR_T values (0.085 and 0.125, respectively; see Table 3_c) for the case of Colorado River water of average composition (EC = 1.213 dS/m) caused by yearly variation in CU volumes are 0.0026 and 0.0020, respectively. Thus, the LR_W and

LR_T values for 1989-1996 are estimated to be about 0.085 +/- 0.0052 and 0.125 +/- 0.004, respectively. The corresponding CV percentages for these mean LR values are 9 and 4 percent, respectively. The analogous standard errors and CV percentages for the 2000-2002 period, for which the mean LR_W and LR_T values are 0.058 and 0.106 (see Table 3_i), are 0.0012, 0.0007, 3% and 1%, respectively. Though a three year period is too short to establish good estimates of uncertainty, the mean IID-wide LR_W and LR_T values for 2000-2002 are determined to be about 0.058 +/- 0.002 and 0.106 +/- 0.0014, respectively. These variation data are used later to estimate the confidence intervals of the determined required volumes of Colorado River water for irrigation of the IID service area (the values are repeated in the tables associated with this discussion-Table 12).

The LR_W for the IID situation over the period of 1989-1996 is estimated to be 0.085 (see Table 3c; it does not include adjustment for the effect of horizontal-leaching (this adjustment is made when the on-farm water requirements are determined, since it varies with tailwater volume, soil type, crop type and irrigation method). This estimate is about one-half the estimate of NRCE (2002), when expressed on the basis of infiltrated water. The latter estimate includes horizontal-leaching, but does so incorrectly.

In the next section, I will describe and demonstrate how the effects of tailwater and horizontal-leaching can be accounted for in the determination of leaching requirement, when expressed in terms of either infiltrated water (LR_{infw}) or applied water (LR_{iw}) and how the volumes of water, including applied-, infiltrated-, tailwater and deep percolation waters, associated with these LR values can be calculated. I will also show how the fraction of the tailwater contributing to the fulfillment of the leaching requirement can be calculated and how the volumes and overall beneficial use of irrigation and drainage waters can be calculated. After that I will provide these calculated values.

Calculation of Volumes and Beneficial-Use of Irrigation and Drainage Waters

I derived relations to calculate both beneficial and non-beneficial volumes of various on-farm water-use categories with the leaching requirement that cover varying tailwater situations, irrigation efficiency and non-uniformity and both means of LR-referencing, assuming steady-state conditions; they are given in Table 4a (definitions of the terms used in these relations are given in Table 4b). The derivations of these relations are given elsewhere (Rhoades, 2002).

It is my opinion that it is likely appropriate to adjust for irrigation inefficiency effects in determining IID water delivery requirements when the tailwater percentage is low (but not when it is at high levels, such as greater than 15 percent, as now is most likely the case in the IID). Before, describing the on-farm water requirements that I determined for the IID service area, I will first illustrate in this section the use of the relations given in Table 4a to estimate on-farm water delivery requirements, without compensation for the effect of irrigation inefficiency. These illustrations and results will demonstrate the use of the relations of Table 4a and provide data for a sensitivity analysis that is described later. In the subsequent section, I will carry out analogous calculations, including compensation for the effect of irrigation inefficiency.

Results of some example generalized calculations made using the relations given in Tables 4a are given in Table 5. These results are based on the assumptions that V_{et} is 100 units; the fractional tailwater runoff (F_{tw}) is 0.05 and the ratio of the volume-weighted tailwater EC relative to that of the applied water (i.e., F_{ctw}) is 1.5. Additional water for non-uniformity and irrigation inefficiency compensation is not included in these examples. These results show that: 1) with tailwater runoff, LR_{iw} is less than LR_{infw}, 2) with horizontal-leaching, both LR_{infw} and LR_{iw} are reduced relative to the case of tailwater runoff without horizontal-leaching, and 3) horizontal-leaching also reduces the required amount of deep percolation (RV_{dw}), the required volume of water to apply to the field (RV_{iw}) and the corresponding volume of tailwater, although these reductions are very small. In the case of RV_{dw}, the reduction for this example is 2.88 percent [estimated as (100)(9.890-9.605)/(9.890)]. The ratio of salt removed from the soil by deep percolation relative to tailwater for this example is 33.7/1 [estimated as (9.608)/(9.890-9.605)].

Results of more extensive and inclusive calculations of water volumes and ratios are given in Table A5 (see Appendix) for various combinations of variables covering the following ranges: leaching requirement (LR; 0.07-0.15), fractional tailwater (F_{tw}; 0.00-0.20), and relative increase in tailwater salinity by horizontal-leaching (F_{ctw}; 1.0-1.6). The values of LR_{infw}, LR_{iw} and other related volumes and ratios for the various situations included in Table A5 were determined from the relations given in Table 4a. The volumes or volume-ratios presented in Table A5 are the following ones assuming uniform conditions: RV_{infw} (the volume of water that must be infiltrated to meet potential evapotranspiration and leaching requirements), RV_{iw} (the volume of irrigation water that must be delivered on-farm to supply the water required for infiltration plus tailwater, if any), RV_{dw} (the volume of deep percolation required for the control of soil salinity, as determined by the leaching requirement), V_{tw} (the volume of tailwater), BV_{tw} (the volume of tailwater that is effective in controlling soil salinity by reducing the need for vertical drainage), TBV_W (the total volume of water used beneficially; i.e., the sum of V_{et} plus RV_{dw} plus BV_{tw}), NBV_W (the volume of water used non-beneficially; i. e., the difference between the volume of applied water, RV_{iw}, and that used beneficially, TBV_W), $\%NBV_W$ (the percentage of NBV_W relative to total applied water, RV_{iw}) and 100 $(BV_{tw})/(RV_{dw})$, which is the percentage of soil salinity removal created by horizontal-leaching relative to vertical-leaching. These definitions are also given in Table 4b, in analogous terms. These calculations apply to the uniform situation (i.e., for $F_n = 1.0$; results for other values of F_n are provided later when compensation for irrigation non-uniformity/inefficiency is discussed) and are normalized assuming the potential crop evapotranspiration, V_{et}, is 100 relative units of water volume.

The results are organized in Table A5 by subsections of LR; these subsections include LR values of 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14 and 0.15, respectively. This range essentially covers most of the practical range of leaching requirement estimates that have been made for the IID. Within each subsection of LR, the results are arranged by tailwater fraction, F_{tw}: 0.00, 0.05, 0.10, 0.15 and 0.20, covering the case of no-tailwater ($F_{tw} = 0.00$) and high tailwater usage ($F_{tw} = 0.20$). The latter level probably compares to

the District-wide value of the present-day IID operation, which may be as high as 0.25. For each level of tailwater fraction, results are given for three levels of horizontal-leaching contribution, ranging from zero (F_{ctw} = 1.00) to a level that probably exceeds that mostly occurring in IID (F_{ctw} =1.6). Reported values of F_{tw} and F_{ctw} for prevalent conditions of tailwater usage in IID are reported to be about 0.17 and 1.30, respectively (Boyle, 1993; NRCE, 2002). [The average value of F_{ctw} (in my terminology) reported in the Boyle Report is 1.30, with a standard deviation of 0.3]

The data of Table A5 were used to perform a preliminary sensitivity analysis of the relative effects that LR, F_{tw} and F_{ctw} have on the water volumes and ratios of interest listed in Table A5, as is discussed later. Before the sensitivity results are discussed, examples will be given to demonstrate the manner in which the calculations used to obtain these results are made. I will now calculate each volume contained in the middle row of the first section of Table A5, to illustrate the methods of calculation. The corresponding values of LR, F_{tw} and F_{ctw} for this row are 0.07, 0.10 and 1.50, respectively. The value of V_{et} is, of course, 100 units for all cases in this table (used for purposes of normalization; for a real case, one would, of course, use the specific absolute value of V_{et}.). Correspondingly, substitution of the above parameter values into the relation given in Table 4a for LR_{infw} yields 0.0661 {= [(1-0.10 * 1.50)/(1-0.10)](0.07)}; into that for LR_{iw} yields 0.0595 {= (1-0.10*1.50)(0.07)}; into that for RV_{infw} yields 107.0791 {= 100/(1-0.0661)}; into that for RV_{iw} yields 118.9768 {= 100/(1-0.0595-0.10)}; into that for RV_{dw} yields 7.0791 {= 0.0595*118.9768}; into that for V_{tw} yields 11.8977 {= 0.10*118.9768}; into that for BV_{tw} yields 0.04478 {= [0.07*100/(1-0.07)]-[(0.0595*100)/(1-0.0595-0.10)] = (7.5268-7.07912)}; into that for TBV_W yields 107.5269 {= 100 + 7.0791 + 0.4478}; into that for NBV_W yields 11.4499 {= 118.9768-107.5269} and into that for $\%NBV_W$ yields 9.6236 {= 100(11.4499/118.9768)}. The corresponding value of $100(BV_{tw}/RV_{dw})$ is 6.3251 {= (100)(0.4478/7.0791)}.

To aid in the interpretation of these results and to determine the relative effects of the individual parameters involved in the calculations (i.e., to perform a preliminary analysis of sensitivity), some of the results of Table A5 are presented in the form of graphical relationships (see Sensitivity Plots given in the Appendix). Because we are especially interested in the effects of leaching requirement, tailwater usage and horizontal-leaching on irrigation-requirement volumes and on the amount of reasonable beneficial water use, I will mostly focus on the results of Table A5 that are pertinent to these latter factors in the following discussion of implications and partial conclusions that can be derived from these results (those in Table A5 and the associated "sensitivity plots").

The results given in Table A5 and in Figures 5a-01, 5a-02 and 5a-03 show for these cases, where F_n is 1.0 and V_{et} is 100, that: 1) with horizontal-leaching, LR_{infw} is less than LR and LR_{infw} decreases as the magnitude of horizontal-leaching (F_{ctw}) and tailwater fraction (F_{tw}) increases (the percent decrease is at most about six, for the prevalent IID situation (F_{tw} = 0.17 and F_{ctw} = 1.3); 2) with tailwater, LR_{iw} is less than LR_{infw} and like LR_{infw}, LR_{iw} decreases as the tailwater fraction (F_{tw}) increase and 3) with horizontal-leaching, both LR_{infw} and LR_{iw} are reduced relative to the case of tailwater runoff without horizontal-leaching. The results given in Table A5 and in Figure 5a-04 show that: 4)

horizontal-leaching also reduces the volume of irrigation water needed to be applied relative to ET (RV_{iw}/V_{et}), although the amount of this reduction is very small (probably insignificant at all but the very high levels of tailwater fraction). On the other hand, the delivery water multiplier-value ([N]) increases substantially (for example, by a factor of 1.23 for the LR = 0.09 case), as the tailwater fraction increases. LR has a smaller effect on this factor; the N factor increases by about 1.045 as the LR increases from 0.09 to 0.13. Figures 5a-05, 5a-06 and 5a-07 show that: 5) the percent of delivered water required to be infiltrated decreases markedly and the percent of tailwater increases markedly, of course, as the tailwater fraction increases. The results given in Table 5a and in Figure 5a-08 show that: 6) the combination of horizontal-leaching and tailwater runoff reduces the volume of required vertical-drainage, but the magnitude is not large (less than about 5 percent under the most likely conditions). Table A5 and Figures 5a-09, 5a-10, 5a-11, 5a-12 and 5a-13 show that: 7) the volume of tailwater that is beneficially used in the control of soil salinity increases with the magnitude of horizontal-leaching, with tailwater fraction and with the leaching requirement, but the amount of the benefit is relatively small (the beneficial volume of tailwater is less than about 0.8 percent of the delivered water under the most likely conditions). Table A5 and Figure 5a-14 show that: 8) the relative effectiveness of horizontal-leaching is small compared to vertical-leaching and is essentially insignificant, except at very high (and unlikely) levels of F_{tw} and F_{ctw} (no more than about six percent under prevalent IID circumstances). The results given in Table A5 and Figures 5a-15, 5a-16 and 5a-17 show that: 9) the total volume of beneficial water is not increased by horizontal-leaching, but the non-beneficial water volume increases substantially as the tailwater fraction increases.

Compensating for Non-uniformity and Irrigation Inefficiency in LR-Related Calculations of Irrigation Water Requirement

Uniformity of water application-infiltration-leaching was assumed (as is the convention) in all of the above-described determinations of the leaching requirement and in the example calculations of water volumes that were based upon it (Table 5 and Table A5 results). However, complete uniformity of leaching (or of irrigation application and infiltration) is not usually achieved in actual cropping and irrigation operations. The combined effect of non-uniformity of water application, infiltration and leaching often results in relative distributions of deep percolation like that illustrated in Figure 2. Additionally, in this figure, the various potential ultimate distributions of the total volume of applied water (RV_{iw}) are schematically represented. As I stated earlier, it is my opinion that it is likely appropriate to adjust for irrigation inefficiency effects in determining IID water delivery requirements when the tailwater percentage is low (but not when it is at high levels, such as greater than 15 percent, as now is most likely the case in the IID). I will now discuss the logic and procedures used to compensate for such inefficiency effects in determining on-farm water requirements.

If irrigation water could be applied completely uniformly to a uniform soil and unstressed uniform crop, only a volume of irrigation water equivalent to the potential crop consumptive use (RV_{et}) plus the required leaching (RV_{dw}), i.e. RV_{infw} (also = the maximum potentially-beneficial water use, MBV_{iw}), would need to be applied and

infiltrated (therefore, $RV_{iw} = MBV_{iw} = RV_{infw} = RV_{et} + RV_{dw}$, was assumed in the preceding section and in the computations of Tables 5 and A5 in the absence of tailwater). But often with surface irrigation systems, non-uniformity of irrigation results in excess irrigation water being infiltrated in the upper-end of the field (because the opportunity time for infiltration and the average water-depth are greater there) and in insufficient water being infiltrated in the lower-end of the field (because the opportunity time and the average water-depth are less there). In such typical cases of non-uniformity of application and infiltration, the actual volume of water utilized in crop ET (BRV_{et}) is usually less than maximum-potential crop ET (RV_{et}) by the unattained amount URV_{et} and the actual volume of deep percolation effectively used in leaching (BRV_{dw}) is usually less than that theoretically required volume (RV_{dw}) by the unattained amount (URV_{dw}).

To reduce these unattained amounts of required beneficial crop ET and "leaching", additional water is sometimes intentionally applied as a means to compensate for the non-uniformity induced un-attainment. With such increased application: 1) the volume of applied water exceeds RV_{infw}, 2) the volume of excess deep percolation (NRV_{dw}) may increase, especially in the upper part of the field, and leach out more salt there than is actually necessary and, hence, add unnecessarily to the total drainage requirement which often creates water table problems (crop yield reduction caused by reduced aeration and increased soil salinity), 3) the total volume of deep percolation (V_{dw}) exceeds the required deep percolation (RV_{dw}) by the amount of NRV_{dw} and 4) if tailwater is allowed, a fraction of the applied water runs off the field without being infiltrated (V_{tw}), thus not contributing to either ET or appreciably to the leaching requirement (as was shown earlier), while increasing the surface drainage requirement. The relative amount of each of the above-described potential destinations varies with the amount of tailwater, and the shape of the application-infiltration-deep percolation curves which in turn vary with irrigation management (advance rate, recession time, etc.) and soil intake properties. But in any case, for a non-uniform situation, the effectively beneficial leaching is usually less than the required leaching ($BRV_{dw} < RV_{dw}$) and total deep percolation ($V_{dw} = BRV_{dw} + NRV_{dw}$) is usually greater than the theoretical required deep percolation.

Tailwater is sometimes claimed to be necessary in order to achieve adequate uniformity and efficiency of infiltration with the use of surface irrigation systems (for example, see page 23 of Boyle Engineering Corporation, 1993 Report; also the NRCE Report, 2002). But, the results of the case examples given in Section A of Table 6 show that the percentage of applied irrigation water that is non-beneficial increases in direct proportion to the fraction of tailwater (i.e., to the F_{tw} value). The percentage of applied water that is non-beneficial exceeds 10 percent and 20 percent for F_{tw} values greater than 0.10 and 0.20, respectively. Tailwater is not needed to achieve uniform irrigation; examples will be given later to demonstrate this.

For non-uniform conditions, a means to compensate for non-uniformity when calculating the on-farm irrigation delivery requirement (RV_{iw}) is to introduce a "non-uniformity/inefficiency compensation factor" (F_n, which is analogous to distribution efficiency) to increase the volume of water to be infiltrated (and applied) relative to that determined assuming uniformity of V_{et} and LR_{infw} within the field as follows:

$$RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})(F_n)]/(1-F_{tw}). \quad [1]$$

I have argued previously (Rhoades, 1999/2002) that this means of determining the compensation amount may be excessive depending upon the value of F_n, the irrigation management being used and, especially, the amount of tailwater allowed. In fact, the volume of irrigation water calculated solely on the basis of ET considerations {i.e., determined as $RV_{iw} = [(V_{et}-V_{rw})/(F_n)/(1-F_{tw})]$}, may be sufficient to preclude the need for including the leaching requirement (salinity control component) in the compensation adjustment (i.e., using Equation [1]). This is so because the total volume of applied water determined as $[(V_{et}-V_{rw})/(F_n)/(1-F_{tw})]$ may be sufficient for salinity control itself over most of the field. If additional water is provided that exceeds this latter amount (as can result with either of the above-described methods of adjustment), then deep percolation may be far too excessive to be considered reasonably beneficial (as is implied in Figure 2 and as was discussed in the preceding paragraph). Examples are given in Table 6 to demonstrate and to support my conclusions about this possibility and the general appropriateness of the latter common practice for estimating the irrigation water delivery requirement, i.e., of first estimating ET, secondly estimating the leaching volume-requirement and then calculating RV_{iw} using Equation [1]. I will now review the salient implications that can be discerned from the results of Table 6 {primary among them is the following one: the common means described above and used to compensate for non-uniformity/inefficiency of irrigation is prone to misuse and abuse}. Subsequently, I will provide a generalized set of equations that can be used to determine appropriate values for the F_n factor for various conditions of leaching requirement and tailwater use and I will provide analogous tabular and graphical results to those already given in order to demonstrate and illustrate the utility of these new equations for estimating on farm water requirements considering irrigation inefficiency.

Relative amounts of irrigation water needed to fulfill potential ET and required leaching and the corresponding amounts of non-required (and, hence, non-beneficial) deep percolation are given in Table 6 for various combinations of tailwater fraction (F_{tw}) and the "inefficiency" compensation-factor (F_n), when the means of compensation for inefficiency is determined both solely from ET and from ET plus LR. The no-tailwater case is covered by the examples where $F_{tw} = 0$. For purposes of these examples, it was generally assumed that actual $V_{et} = RV_{et} = 100$ units, that $LR_{infw} = 0.10$ and that no significant amount of soil salinity is removed by horizontal-leaching and tailwater runoff (this phenomenon is included in a more thorough set of calculations which is provided and discussed later). When considering the results given in Table 6, keep in mind that the maximum possible amount of beneficial water use in these examples is equal to RV_{infw} (= $RV_{et} + RV_{dw}$) and that the minimum volume of non-beneficial applied irrigation water is equal to the difference ($RV_{iw} - RV_{infw}$).

Example results obtained for the case where inefficiency compensation is determined using Equation [1], with and without tailwater, are given in Section A of Table 6. These results show that tailwater adds considerably to non-beneficial water use. They also show that the application of excess irrigation water intended to compensate for non-uniformity

and inefficiency of application-infiltration-leaching can result in deep percolation amounts that substantially exceed the required amounts (RV_{dw}), especially if F_n values are less than about 0.90. These results also show that, in the absence of tailwater, the percentage of applied water that is non-beneficial exceeds 5 percent for F_n values of less than 0.95, exceeds 10 percent for F_n values of less than 0.90,exceeds 15 percent for F_n values of less than 0.85, and exceeds 20 percent for F_n values of less than 20 percent, etc. Correspondingly, the percentage of non-beneficial deep percolation increases as the F_n value is reduced; for example, % NRV_{dw} relative to V_{dw} is greater by 34, 52, 63 and 71 percent for F_n values of 0.95, 0.90, 0.85 and 0.80, respectively. These results show that the application of excess irrigation water provided to compensate for non-uniformity and inefficiency of application-infiltration-leaching can result in deep percolation amounts that substantially exceed RV_{dw}, especially if F_n values of less than about 0.90 are permitted. As mentioned earlier, such excessive volumes of deep percolation may have serious consequences on water table depths and drainage requirements and their associated costs (both on-site and off-site costs). Assessments of F_n that do not consider the consequences and costs of excessive deep percolation will likely result in the selection of inappropriately low F_n values because they only focus on the achievement of high uniformity of water application and infiltration as thought needed for ET and LR purposes. The effects of non-uniformity compensation and the consideration of <u>both beneficial and non-beneficial</u> impacts and costs should be considered when selecting the value of F_n. These negative benefits of "over-irrigation" should be considered in economic evaluations of non-uniformity/inefficiency compensation, in addition to the positive benefits of increased crop yield, when assessments are undertaken in this matter.

Example results obtained where inefficiency compensation is based solely on ET {i.e., determined as $RV_{iw} = [(V_{et}-V_{rw})/(F_n)/(1-F_{tw})]$} are given in section B of Table 6. These results show, of course, that the corresponding irrigation delivery amounts are less than those obtained when the compensation is based on both ET and LR (, i.e., compared to section A results). They also show that for the no-tailwater case, the percentages of applied water that are non-beneficial relative to RV_{iw} exceed about 5.5, 11.1 and 16.7 for F_n values of less than 0.85, 0.80 and 0.75, respectively. Correspondingly, the percentages of non-beneficial deep percolation relative to V_{dw} increase as the F_n value is reduced significantly below 0.85; for example, the % NRV_{dw} values are 37.0, 55.5 and 66.7 for F_n values of 0.85, 0.80 and 0.75, respectively. These results show that the excess application of irrigation water provided to compensate for non-uniformity of application-infiltration-leaching determined using this method of compensation will result in deep percolation amounts that substantially exceed RV_{dw}, if F_n values of less than about 0.85 are permitted. Thus, even when not intentionally applying extra irrigation water to meet the LR under non-uniform conditions, the volume of deep percolation can exceed RV_{dw} when too low a value of F_n is used in this method of inefficiency compensation.

A comparison of corresponding cases A and B given in Table 6 shows that the relative volumes of applied irrigation water are 117.65 units and 130.72 units with a F_n value of 0.85 for the case where the ET-only method of compensation is used and for the case where the "ET plus LR" method of compensation is used, respectively. Analogously, the corresponding non-beneficial drainage volumes are 6.5 units and 19.6 units, respectively.

The salient implication is that the calculated volume of irrigation water can exceed the sum of potentially beneficial ET and required deep percolation, even when based solely upon V_{et}, if too low of a value for F_n is used for inefficiency compensation. For the case where inefficiency compensation is based solely upon ET and tailwater runoff occurs, the results given in section B of Table 6 show that, assuming complete uniformity, the irrigation application would have to be sufficient to achieve tailwater runoff equivalent to a F_{tw} value of greater than 0.10, in order to meet both "ET pus LR" theoretical beneficial-use requirements. The reader should note that some portions of the field can still be "underleached" and "underirrigated", even when the application volume exceeds the required infiltration volume. The method provided by DR R. G. Allen may be used to address these deficiencies (Allen, 2003a).

While the above-presented assessment only evaluated the potentially maximum amount of beneficial water-use associated with each of the two above-described alternative means for determining the delivery water requirement needed in order to compensate for the effects of non-uniformity and inefficiency of irrigation-infiltration-leaching, it would seem that one should be able to establish appropriate values of F_n to use (when using either of these compensation methods) by considering the reasonableness of the amounts of non-beneficial water use that will result. For example, the examples provided in Table 6 show that use of a F_n value of 0.90 for the no-tailwater case applied to both ET and LR (i.e., $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})(F_n)]$) results in a water application volume (RV_{iw}) of 123.46 units, which corresponds to 10 percent non-beneficial use (% NBV_{iw}), and a volume of deep percolation (V_{dw}) of 23.46 units, of which at least 12.35 units are non-beneficial (NRV_{dw}). The corresponding minimum percentage of non-beneficial deep percolation (% NRV_{dw}) relative to V_{dw} is 52.6. The use of a F_n value of 0.80 for the no-tailwater case applied solely to ET ((i.e., $RV_{iw} = (V_{et}-V_{rw})/(F_n)$) results in a required water application amount (RV_{iw}) of 125.00 units, which corresponds to at least 11.1 percent non-beneficial use (% NBV_{iw}) relative to RV_{iw} and a volume of deep percolation (V_{dw}) of 25.00 units, of which at least 13.89 units are non-beneficial (NRV_{dw}). The corresponding minimum percentage of non-beneficial deep percolation (% NRV_{dw}) relative to RV_{dw} is 55.5. These results show that the analogous preceding non-beneficial volumes are similar for the two different methods of inefficiency compensation under no-tailwater conditions, when reasonable, but different, values of F_n are selected for each method. These results also demonstrate that, depending upon the value of F_n selected, it is not necessary to include LR in the inefficiency compensation process; compensation based only upon ET can provide enough excess water to meet the beneficial vertical-leaching requirement, provided an appropriate value of F_n is used.

The example data given in Table 6 also show that, if tailwater is permitted, a higher value of F_n is needed in order to achieve the same level of beneficial water use. For example, these example results show that when 10 percent tailwater ($F_{tw} = 0.10$) is allowed under conditions of complete uniformity ($F_n = 1.0$) the required water application volume will be 123.46 units, which corresponds to 10 percent minimum non-beneficial use (the same use as results for the no-tailwater case when determined using a F_n value of 0.90 that is applied to both ET plus LR). The amount of non-beneficial drainage is also about the

same; with tailwater, the non-beneficial drainage (12.35 units) occurs as surface runoff and, without tailwater, it occurs as excessive deep percolation (12.35 units).

The above-described results suggest that the criterion of the reasonableness of resulting non-beneficial water-use should be considered when determining appropriate F_n values, as well as for determining the corresponding water delivery requirement, for any combination of tailwater and leaching requirement. The logic can be generalized and reduced to simple equations, as will be described in the next section. Then the practical use of these equations will be demonstrated. Subsequently, the resulting equations will be used to calculate irrigation water requirements for an expanded set of situations analogous to those given in Table A5, but which include compensation for inefficiency and non-uniformity considerations.

Generalized Equations For Determining F_n and On-Farm Delivery Requirement

The minimum amount of non-beneficial irrigation water is, by definition, equal to the difference between the amount of water applied and the amount required to meet the potential ET and the LR under idealized uniform conditions ($NBV_{iw} = RV_{iw} - RV_{infw}$). Thus, the minimum percent non-beneficial water use with reference to RV_{iw} is equal to:

$$\% NBV_{iw} = 100 [(RV_{iw} - RV_{infw})/(RV_{iw})]. \quad [2]$$

The volume of infiltration water required in order to provide for ET and LR under uniform conditions, ignoring rainfall, is:

$$RV_{infw} = [(V_{et})/(1-LR_{infw})], \quad [3]$$

as shown in Table 4a. The volume of water that must be applied in order to provide both ET plus LR with compensation for inefficiency, as well as to provide for specified amounts of tailwater (i.e., RV_{iw}) is:

$$RV_{iw} = [(V_{et})/(1-LR_{infw})(F_n)]/[(1-F_{tw})], \text{ or } = [(V_{et})/(1-LR_{infw})] [1/F_n(1-F_{tw})], \quad [4a]$$

as obtained from Table 4a.

The volume of water that would have to be applied in order to solely provide ET with compensation for inefficiency (i.e., ignoring LR) and to provide for tailwater is analogously:

$$RV_{iw} = [(V_{et})/(F_n^*)]/[(1-F_{tw})] = (V_{et}) [1/(F_n^*)(1-F_{tw})], \quad [4b]$$

Equation [2] may be rearranged to solve for RV_{iw} as follows:

$$RV_{iw} = (RV_{infw})/[1-(\%NBV_W)/100]. \quad [5]$$

Substitution of Equation [5] into Equation [4a] yields the following equation, which can be used directly to determine F_n from % NBV_{iw} and F_{tw}:

$$F_n = [1-(\%NBV_W/100)]/[(1-F_{tw})]. \qquad [6a]$$

For the case where compensation for non-uniformity is determined <u>considering only V_{et}</u>, the analogous relation to use in order to calculate F_n (= F_n^*) is:

$$F_n^* = [1-(\%NBV_W/100)] = F_n(1-F_{tw}). \qquad [6b]$$

This latter relation may be derived recognizing that, for this case, $RV_{iw} = (V_{et}/F_n^*)/(1-F_{tw})$. Substitution of this relation into Equation [4a], yields Equation [6b]. Graphical representations of Equations [5] and [6a] are given in figures 3, 4 and 5, respectively.

The procedure to follow in order to determine the amount of water required to cover the volumes of ET plus LR, the volume of tailwater to be employed or allowed, and the extra volume of water to apply for the purpose of non-uniformity and inefficiency compensation using the above equations is as follows: 1) establish ET using conventional methods, 2) determine LR_{infw} using an appropriate model (I recommend that the LR value be obtained using WATSUIT), 3) decide on the amount of tailwater (F_{tw}) to be allowed or to be evaluated, 4) decide on which method of compensation is to be used ("ET plus LR" or "ET only"), 5) calculate the appropriate value of the required inefficiency factor, F_n or F_n^*, using the corresponding version of Equation [6] to meet the minimum $\%NBV_W$ objective and, finally, 6) calculate RV_{iw} using the appropriate equation given in Table [4a] and the corresponding values of V_{et}, LR_{infw}, F_{tw} and either F_n or F_n^*. For example, for the case where V_{et} is 100 units, LR_{infw} is 0.088, F_{tw} is 0.05 and %NBV is chosen to be 10.0%, F_n is determined using Equation [6a] to be 0.9474 (= [1-(10.0/100)]/[(1-0.05)]) and RV_{iw} is determined using the appropriate equation from Table 4a to be 121.828 {= [(100)/(1-0.088)(0.9474)]/[(1-0.05)]}. Alternatively, if the effects of tailwater and F_n are not of interest, RV_{iw} can be obtained directly from Equation [5].

Results of more inclusive calculations of the effects of inefficiency compensation on water volumes and ratios made using the generalized relations described above and those provided in Table 4a are given in Tables A6a and A6b (see Appendix) covering the following values or ranges: LR (0.09 and 0.13), fractional tailwater (F_{tw}; 0.00-0.20), relative increase in tailwater salinity by horizontal-leaching (F_{ctw}; 1.0, 1.3 and 1.6) and "inefficiency compensation factor" (F_n ; 0.70-1.00). These calculations were made for various combinations of the preceding variables which cover many possible situations, including uniform and non-uniform situations, and are normalized assuming the potential crop evapotranspiration, V_{et}, is 100 relative units of water volume. The results are organized in Table A6a by subsections (A and B) for the two optional means of inefficiency compensation ("ET plus LR" and "ET only"). The results within each of these subsections are further subdivided for LR (either 0.09 or 0.13 to cover the range of LR estimated by the two models corresponding to an EC_{iw} value of about 1.213 dS/m). In each subsection of LR, the results are arranged by "inefficiency factor" (F_n) covering the range 0.70 to 1.00 and then by tailwater fraction, F_{tw}, covering values of 0.00, 0.05, 0.10,

0.15 and 0.20. The latter values cover the case of no-tailwater (F_{tw} = 0.00) and high tailwater usage at a level (F_{tw} = 0.20) that is about that probably presently occurring in the IID. For each level of tailwater fraction, results are given covering horizontal-leaching contributions ranging from zero (F_{ctw} = 1.00) to a high value that probably exceeds that occurring in IID (F_{tw} =1.6), along with the reported prevalent value (F_{ctw} = 1.30). [values of F_{tw} and F_{ctw} reported by NRCE for prevalent conditions of tailwater usage in IID are about 0.17 and 1.30, respectively.] The corresponding LR_{infw} and LR_{iw} values for the various situations included in Table A6a were determined from the relations given in Table 4a. These data are presented in a modified organization in Table A6b for purposes of use in a sensitivity analysis, which is described later.

The volumes or volume-ratios calculated for the preceding combinations are presented in Table 6a in terms of: RV_{infw} (the volume of water that must be infiltrated to meet potential evapotranspiration and uniform leaching requirement), RV_{iw} (the volume of irrigation water that must be delivered on-farm to supply the water required for infiltration plus that, if any, which becomes tailwater, along with the extra for "compensation"), RV_{dw} (the minimum volume of deep percolation required for control of soil salinity, as determined by the leaching requirement), V_{tw} (the volume of tailwater), BV_{tw} (the volume of tailwater that is effective in controlling soil salinity; reducing the need for vertical leaching and drainage), TBV_W (the total volume of water used beneficially; i.e., the sum of V_{et} plus RV_{dw} plus BV_{tw}), NBV_W (the volume of water used non-beneficially; i.e., the difference between the volume of applied water, RV_{iw}, and that used beneficially, TBV_W), $\%NBV_W$ (the percentage of NBV_W relative to total applied water, RV_{iw}) and 100 $(BV_{tw})/(RV_{dw})$, which is ratio of soil salinity removal created by horizontal-leaching relative to required deep percolation leaching, expressed as a percentage. These definitions are also given in Table 4a, in analogous terms. These data will be used to perform a preliminary sensitivity analysis of the relative effect that the F_n factor, has on the water volumes and ratios of interest listed in Table A6a, as well as the effects of LR, F_{tw} and F_{ctw}, as is discussed later.

Before the implications and preliminary sensitivity analysis of the results contained in Table A6a and A6b are discussed, examples will be given to demonstrate the manner in which the relations given above and in Table 4 were used to calculate these results. The appropriate relation for each particular water item (specified by the column-heading within Table A6a) is selected from Table 4a and used to calculate the volume or ratio of the item for the particular combination of LR, F_n and F_{ctw} of interest. I will now calculate each value and volume in the middle row of the first section of Table A6a, to illustrate the calculation procedure. The corresponding values of LR, F_n, F_{tw} and F_{ctw} for these example calculations are 0.09, 0.80, 0.20 and 1.30, respectively. The value of V_{et} is, of course, 100 units for all cases in this table (used for purposes of normalization; for a real case, one would, of course, use the absolute value of V_{et}). Correspondingly, substitution of the above parameter values into the relation given in Table 4a for LR_{infw} yields 0.08325 {= [(1-0.20 * 1.30)/(1-0.20)](0.09)}; into that for LR_{iw} yields 0.06161 {= (1-0.20*1.30)(0.08325)}; into that for RV_{infw} yields 109.081 {= 100/(1-0.08325)}; into that for RV_{iw} yields 170.439 {= [(100)/(1-0.08325)(0.80)]/(1-0.20)}; into that for RV_{dw} yields 9.081 {= 0.08325*109.081}; into that for V_{tw} yields 34.0878 {= 0.20*170.439}; into that

for BV_{tw} yields 1.5463 {= [0.09*100/(1-0.09)]-[(0.06161*100)/(1-0.06161-0.20)] = (9.8901-8.3438)}; into that for TBV_W yields 110.6273 {= 100 + 9.081 + 1.5463}; into that for NBV_W yields 59.8117 {= 170.439-110.6273} and into that for $\%NBV_W$ yields 35.0927 {= 100(59.8117/170.439)}. The corresponding value of $100(BV_{tw}/RV_{dw})$ is 17.0279 {= (100)(1.5463/9.081)}. [Note: the equation given in the lower section of Table 4a is used to calculate RV_{iw} in section B of Table A6a, for cases where compensation for non-uniformity is based solely on ET.]

The results given in Table 6a and the corresponding set of figures (Figures 6a-1 through 6a-23) show, of course, the same general trends and relationships already described and discussed with reference to Tables 5 and A5 and Figures 5a-1 through 5a-17 for situations which excluded non-uniformity compensation. But they additionally include the relative effect of the inclusion of the "non-uniformity compensation factor" on the various water volumes and ratios. [Some of the trends are easier to visualize and present using the Table A5 results, others with the Table A6a results.]

The results presented in Table A6a and in Figures 6a-1a,b,c, 6a-2a,b,c and 6a-3a,b,c show that, as was the case without compensation for non-uniformity and inefficiency: 1) with horizontal-leaching, LR_{infw} is less than LR and LR_{infw} decreases as the magnitude of horizontal-leaching (F_{ctw}) and of tailwater fraction (F_{tw}) increase; 2) with tailwater, LR_{iw} is less than LR_{infw} and like LR_{infw}, LR_{iw} decreases as tailwater fraction (F_{tw}) and horizontal-leaching (F_{ctw}) increase, and 3) LR_{iw} is reduced relative to LR_{infw} and LR as the tailwater fraction increases. The results given in Table A6a and in Figure 6a-4a,b,c show that: 4) horizontal-leaching reduces the volume of irrigation water needed to be applied relative to ET (RV_{iw}/V_{et}), although the amount of reduction is very small. On the other hand this volume ratio increases substantially as the tailwater fraction increases and as extra water is provided for inefficiency compensation. For example, the latter volume must be increased by a factor of about 1.5, when the F_n factor of 0.70 is used for inefficiency compensation. Figures 6a-5a,b,c, 6a-6a,b,c and 6a-7a,b,c show that: 5) the percent of delivered water that is infiltrated decreases markedly and percent tailwater increases markedly as tailwater increases. The former percent is decreased further when extra compensation-water is provided to increase irrigation efficiency; for example, the infiltrated volume drops by about 20 percent when a F_n factor of 0.70 is used, which has about the same effect as increasing the tailwater by the same relative amount. The results given in Table A6a and in Figure 6a-8a,b,c show that: 6) horizontal-leaching reduces the volume of required vertical-drainage (leaching), but the magnitude is not large (less than about 5 percent under most likely conditions). Compensation for irrigation inefficiency, of course, has no effect on required leaching and deep percolation. Table A6a and Figures 6a-9a,b,c, 6a-10a,b,c, 6a-11a,b,c, 6a-12a,b,c and 6a-13a,b,c show that: 7) the volume of tailwater that is beneficially used in the control of soil salinity increases with the magnitude of horizontal-leaching, with tailwater fraction and with the leaching requirement, but the amount of the benefit is relatively small (the beneficial volume of tailwater is less than about 0.8 percent of the delivered water under most likely conditions). The extra water given for inefficiency compensation reduces the beneficial tailwater percentages. Table A6a and Figure 6a-14a,b,c show that: 8) the relative effectiveness of horizontal-leaching is small compared to vertical-leaching and

essentially insignificant except at very high (and unlikely) levels of F_{tw} and F_{ctw}. The results given in Table A6a and Figures 6a-15a.b.c, 6a-16a,b,c and 6a-17a,b,c show that: 9) the total volume of beneficial water is not increased by horizontal-leaching, but the non-beneficial water volume increases substantially as the tailwater fraction increases. They also show that the amount of non-beneficial water increases markedly as extra water is provided for inefficiency compensation. For example, the percent of applied water that is non-beneficial is about 30 percent and 15 percent when the F_n factor values are 0.70 and 0.85, respectively. Table A6a and Figures 6a-18a,b,c and 6a-19a,b,c show that the amount and percentage of applied water that becomes vertical-drainage increases markedly as extra water is given for inefficiency compensation. For example, the percentage of applied water that becomes vertical-drainage water increases from about 10 (for $F_n = 1.00$) to about 22 and 38 when F_n factors of 0.85 and 0.70 are used as the basis for compensation at a LR value of 0.09, respectively. Correspondingly, Figures 6a-20a,b,c and 6a-21a,b,c show that the amount and percentage of non-beneficial vertical-drainage increases as compensation water for non-uniformity is provided. Relative to the total vertical-drainage, the percentage increase in non-beneficial vertical-drainage increases by about 65 and 85 for F_n values of 0.85 and 0.70, respectively. Figures 6a-22a,b,c show that the ratio of actual deep percolation relative to the required vertical-drainage increases markedly as compensation-water is provided to improve irrigation efficiency. For example, LF_{iw} is about 3.5 to 4 times greater than LR_{infw} when F_n is 0.70 and the LR value is 0.09; the analogous range is about 2.0 to 2.5 times greater when F_n is 0.85. Figures 6a-23a,b,c show that that tailwater volume relative to deep percolation increases, of course, as the tailwater fraction increases and decreases as the compensation given for inefficiency increases, without being much affected by horizontal-leaching.

If the amounts of inefficiency-compensation water are to be limited in order to prevent the amounts of non-beneficial water use from becoming unreasonable, then the appropriate corresponding allowable value of F_n can be determined using Equation [6a], as demonstrated above, provided a means of determining reasonableness exists (this is discussed later). The values of F_n obtained with this equation for various combinations of $\%NBV_{iw}$ and F_{tw} are given in Table 7 for the example case of an LR_{infw} value of 0.088. These results clearly illustrate the interdependency that exists between these variables and they show that tailwater limits the achievement of low $\%NBV_{iw}$ values and tailwater use increases the uniformity requirements of the irrigation system (i.e., the value of F_n needs to increase as the tailwater increases), if non-beneficial water use is to be minimized. For example these results show that at a tailwater percentage of 15, it is not possible to irrigate without the non-beneficial water use exceeding 15 percent ($F_{tw} = 0.15$); furthermore, the required uniformity value of 1.00 for this situation would be nearly impossible to achieve; F_n values are not determined (ND) in Table 7 for NBV_{iw} values of less than 15 percent for the example case, because the latter lower values are not achievable under such conditions. Given more easily achievable limits of uniformity (say, $F_n = 0.9$), one could not operate an irrigation system with this amount of tailwater (15%) without causing about 25 percent of the applied water to be lost as deep percolation or tailwater (i.e., having about 25 $\%NBV_{iw}$). The corresponding values of the [N] multiplication-factor to use to multiply ET by, in order to determine the volume of

delivery water, are also provided in Table 7, in terms of allowable or desirable levels of $\%NBV_W$.

The choice of reasonable values of F_n to use in the above equations is dependent upon physical and economic considerations. The ability to enhance crop production by applying extra water for non-uniformity compensation and economic tradeoffs was estimated by the method developed by Dr R. G. Allen (Allen, 2003a). The practical ability to achieve various levels of F_n for IID conditions of soils and various optional methods of irrigation management was evaluated using the infiltration model and methods of Dr W. R. Walker (Walker, 2003c). These latter models offer the advantage of providing information that can be directly used to design and manage irrigation systems as needed to meet the determined required values of F_n. These methods were used to select practical values of F_n to use in the equations presented above, with consideration being given to crop yield reductions and the economic losses caused by insufficiency of applied water and of salinity leaching, as well as by the economic losses caused by excesses of applied water, leaching, aeration and water logging problems and increased drainage requirements.

It was concluded that the IID situation is very conducive to the achievement of uniform water infiltration and leaching because the cracking soils allow for a rapid filling of void space followed by a rapid decline in infiltration rate to very low levels. Thus, the need for additional water for irrigation non-uniformity and irrigation inefficiency is minimal for such soils. One can hardly achieve more leaching than that presently being achieved in such soils; increasing tailwater will not enhance uniformity much nor will it significantly increase leaching, but it will add to the potential to increase "ponding and scalding" problems associated with excessive water buildup in the tail-end sections of such fields (as shown by surface irrigation simulations). It is concluded that the extra water required to compensate for non-uniformity considerations in the IID is equivalent to only about the volume obtained by dividing the water requirement calculated assuming homogeneous conditions of both crop ET and LR by a factor (F_n) of about 0.95. Since the water that is lost in tailwater does not provide significant beneficial use, it should be minimized.

The selection of the latter value of 0.95 is supported by the observations that: 1) Bali and Grismer have successfully demonstrated that alfalfa and Sudan could be successfully produced in high clay content soils of the IID with tailwater runoff of less than 5 percent using simple "cutoff" irrigation systems (Grismer, 2003), 2) alfalfa, wheat, sugar beets and cantaloupes were successfully grown in high clay content soil in the IID without any tailwater runoff using level basin irrigation (Rhoades, et al., 1988), 3) Boyle Engineering concluded that it was practical to reduce tailwater to about 5 percent using tailwater recovery systems, 4) Dr Wynn (Walker, 2003a, d, d) concluded from his surface-irrigation simulations that it was practical to achieve 95 percent irrigation infiltration uniformity in the high clay content IID soils using blocked end irrigation systems, 5) Harold Payne (Payne and Brown, 2003) concluded from his field observations and evaluations of the IID situation and Arizona experience that it was practical to reduce tailwater to 5 percent with only management changes and relatively inexpensive systems

changes, and 6) the leaching fraction now being achieved in the IID is only about 0.09 (Rhoades, 2003b) and crop yields appear to be relatively good at this level of leaching (Gabrielsen, 2003). Given this evidence, I conclude that the appropriate value for the inefficiency factor (F_n) is no less than about 0.95 and that it should increase as the tailwater fraction increases. I believe that no compensation should be given (i.e., a value of 1.0 should be used for F_n) for tailwater percentages of greater than 15.

Preliminary Sensitivity Analysis of Relations Used to Estimate Irrigation Water Requirement

A preliminary sensitivity analysis of the relations given in the text and in Table 4a was undertaken to provide estimates of the relative effects of LR, F_{tw}, F_{ctw} and F_n on these relations and to acquire information to help direct the undertaking of a more rigorous and quantitative analysis of sensitivity in this regard.

To facilitate this analysis, additional calculations were made using the equations provided in the text and in Table 4a to obtain supplementary data to that given in Tables A5 and A6a for use in the preliminary sensitivity analysis; these additional results are given in Table A6b (see Appendix). The corresponding plots of the Table A6b data are given in Figures 6b-01 through 6b-04.

I performed the preliminary sensitivity analysis of these equations by plotting various water volumes and ratios of interest (using the results contained in Tables A5, A6a and A6b) obtained for the different combinations of LR, F_{tw}, F_{ctw}, F_n and examining them to infer the relative effects of these latter parameters in these equations. The various water volumes and ratios examined are listed in Table 8, along with approximate indices of the relative effects that the irrigation-related parameters (LR, F_{tw}, F_{ctw} and F_n) have on the selected water volumes and ratios of primary interest. These relative indices were determined by measuring the induced changes in the plotted results caused by each parameter using a ruler. While time was not taken to perform a more exact quantification in this regard, I believe the results given in Table 8 are adequate to identify the major effects and magnitudes of these parameters.

Some of the major conclusions obtained by this assessment are the following ones: 1) F_{tw} and F_n have the greatest potential to affect calculations of water delivery requirements (RV_{iw} and RV_{iw}-related water volumes and ratios); 2) LR is the primary parameter, besides V_{et} of course, that affects the determination of the volume of required infiltration water (RV_{infw}), but horizontal-leaching can reduce this requirement by a small amount at high levels of tailwater fraction; 3) tailwater volume and related ratios are substantially sensitive to non-uniformity compensation; 4) although beneficial tailwater is relatively small, as demonstrated earlier, its contribution is quite sensitive to the product of (F_{tw})(F_{ctw}), its importance increases slightly as the leaching requirement increases and it is not affected by irrigation inefficiency compensation (F_n); 5) the volume of total vertical-drainage (deep percolation) is highly sensitive to F_n, even more so than by LR, when extra water is provided for inefficiency compensation; 6) the required volume of vertical-drainage is dominantly controlled by LR, but it is also sensitive to and is reduced

by horizontal-leaching at high levels of tailwater fraction and F_{ctw}; 7) irrigation inefficiency compensation is the dominant factor affecting the volume of vertical-drainage water and, especially, the amount of it that is non-beneficial (it increases both); 8) inefficiency compensation and tailwater fraction dominate and increase the volume of total water use that is non-beneficial, and 9) LR_{infw} is reduced , although by a relatively small amount, in proportion to the product of $(F_{tw})(F_{ctw})$.

Formal Sensitivity Analysis

Scott M. Lesch (Lead Statistician, Environmental Statistical Services) performed a formal sensitivity analysis of the mathematical relationships provided in this report. The complete descriptions of the theory and methodology that he employed in this analysis, along with the full results, are given in the Appendix. I have summarized his results in Tables 9a and 9b.

The results of the "Basic Sensitivity" analysis are given in Table 9a in terms of the percent changes created in the response variables (LR_{iw}, LR_{infw}, RV_{iw}, RV_{infw}, RV_{dw}, BV_{tw}, TBV_W, NBV_W and [N]) as induced by sequential increases (over the ranges considered) made in the input variables (LR, F_{tw}, F_{ctw}, V_{et} and F_n). Increases in the response variables induced by increases in the input variables are indicated by a (+) sign, while analogous decreases in response variables are indicated by a (-) sign. These results essentially confirm the conclusions of the preliminary analysis. They show that LR_{iw} responds primarily and positively to LR; additionally, LR_{iw} is affected negatively to a lesser, but relatively substantial amount, by F_{tw} and to a relatively small amount by F_{ctw}. They show that LR_{infw} responds to LR and F_{ctw} to about the same degree as does LR_{iw}, but much less so to F_{tw}. The response of RV_{iw} is primarily affected by F_n, is strongly affected by V_{et} and F_{tw}, is only moderately affected by LR and is very little affected by F_{ctw}. The estimated volume of RV_{infw} is not affected by the value of F_n, it is greatly affected by V_{et}, it is only moderately affected by LR and it is very little affected by F_{tw} and F_{ctw}. The estimated volume of RV_{dw} is strongly affected by LR, it is strongly affected by V_{et} and moderately affected by F_{tw} and F_{ctw}. The calculation of NBV_W is greatly affected by F_n and it is very strongly affected by F_{tw}. The response of the irrigation multiplier term [N] is very much affected by F_n and is quite affected by F_{tw}. It should be noted that these percentages are highly affected by the values of the input variables selected for comparison.

The results of the "ANOVA" analysis are given in Table 9b, in terms of the value of the coefficient of each input variable in the multi-linear regression relation applicable to each response variable. Additionally the correlation coefficient (R^2) obtained for each multi-linear regression equation is given to indicate how good of a correlation was obtained for each response variable. All of the R^2 values were excellent, except for BV_{tw}. The latter value is less because the relationship is complex and non-linear. These results provide the best indication of the relative general effects of the input variables upon the response variables. I will not describe the value of each coefficient for each input variable, since they are more easily discerned from an examination of the table. However, I will summarize the dominant effects. LR_{iw} and LR_{infw} are both primarily affected by LR;

additionally, LR_{iw} is substantially affected by F_{tw}; neither are much affected by F_{ctw}. RV_{iw} is dominated by F_n, whereas RV_{infw} is dominated by V_{et}. RV_{infw} is also strongly affected by LR, although RV_{iw} is not. RV_{dw} is dominated, of course, by LR; it is little affected by F_{ctw}. TBV_W, of course, is dominated by V_{et} and LR. NBV_W and [N] are dominated by F_n and F_{tw}.

Estimation of the On-Farm Water-Requirement of IID

I calculated the volumes of water required to be delivered on-farm to meet the crop ET and leaching requirements for two time periods (1989-1996 and 1993), considering crop ET, leaching requirement and the need for additional water to compensate for non-uniformity of water application, infiltration and leaching (as affected by soil properties and irrigation management) and the percentage of non-beneficial water use, as described above.

Calculation of IID On-Farm Water Requirement for 1996-1999

The period 1989-1996 was evaluated because it is close to the period 1987-1998 used by IID to develop its EIR (IID, 2002). Reliable crop, climate and ET information was available for 1989-1996 in the WST Report (WST, 1988). It was thought that the two periods were similar enough to make reasonable comparisons. Compositions of Colorado River water were obtained for this period and used with the WATSUIT-LR model to determine the IID-wide LR value. These data were discussed earlier (see Tables 1a and 2).

As indicated by the preceding discussions, the estimation of the irrigation water requirement in the IID requires appropriate information of the crop water requirement (V_{et}), the effective rainfall (V_{rw}), the leaching requirement (LR_{infw}), the value of F_{ctw} (if tailwater is allowed), the salinity of the irrigation water, the salinity-tolerances of the crops grown, the irrigation efficiency, which varies depending upon irrigation management and the allowable amount of non-beneficial water determined to be reasonable.

I estimated the on-farm water-requirement for the 1989-1996 situation using the relations presented in this treatise, for various (for sake of comparison) estimates of Colorado River salinity (EC = 0.930, 1.143, 1.213 and 1.323 dS/m; 1.213 is the average for the period), leaching requirement (LR_W and the more conservative LR_T), tailwater fraction (5, 10, 15 and 20 percent), crop consumptive use (1806 KAF and 4% more) and effective rainfall (zero, 50.5, 101 and 151.5 KAF; 101 is the average for the period), and for four values for the inefficiency compensation factor (0.85, 0.90, 0.95, and 1.0), while including horizontal-leaching assuming the F_{ctw} factor is 1.19 for the IID-wide situation (based on a value of 1.3 for 62% and a value of 1.0 for 38% of the IID service area). These results permit the estimation of the water requirement of the prevalent situation, as well as what they are under other conditions and an evaluation of the way the IID-wide water requirement might vary as the salinity of the Colorado River changes, as the

effective rainfall varies, as crop consumptive use increases and as tailwater use is diminished. These results are given in Tables 10_{a-n}.

The results obtained for the cases where no compensation for irrigation inefficiency is provided and total crop consumptive use is 1,806 KAF (before adjustment for effective rainfall) are given in Tables 10_{a-d} for the four levels of tailwater, four levels of Colorado River salinity and two estimates of leaching requirements (essentially with and without adjustment for mineral precipitation). These results, of course, show that the irrigation requirement increases as the salinity of the Colorado River increases, the leaching requirement increases, and the tailwater increases. The amount of water required from the Colorado River, of course, decreases as the effective rainfall increases. Using the leaching requirement obtained from WATSUIT, the volume of required water for delivery on-farm is as low as about 1824 KAF, when the Colorado River salinity is 0.93 dS/m, tailwater is 5 percent and effective rainfall is 1.5 times normal. The required water requirement is as high as about 2115 KAF, when the Colorado River salinity is at its ultimate maximum permitted level of about 1.323 dS/m, tailwater is only 5 percent and effective rainfall is zero. Of course, the water requirement would be correspondingly higher, if higher percentages of tailwater were allowed and if a more conservative value of leaching requirement were used. The highest water requirement possible for all combinations (including 20 percent tailwater) considered would be 2605 KAF, when the crop consumptive use is 1806 KAF.

The results obtained for the cases where no compensation for irrigation inefficiency is provided and where crop consumptive use is increased by 4 percent to its expected potential high limit of 1878.24 KAF, are given in Tables 10_{e-h}. The minimum and maximum volumes of required delivery water for all of the combinations considered are 1904.1 KAF and 2709.2 KAF, respectively.

The results obtained for the cases where no water is provided for tailwater (tailwater is assumed zero) and extra water equivalent to F_n values of 0.90 and 0.95, are given in Tables 10_{i-j} for crop consumptive use of 1806 KAF and in Tables 10_{k-l} for crop consumptive use of 1878.24 KAF, respectively. Compared to the cases where tailwater allotments of 5 and 10 percent are provided, the irrigation delivery water requirements are about the same where compensation water equivalent to F_n values of 0.95 and 0.90 are provided without tailwater, respectively. The difference is, the excess drainage occurs as tailwater in the first case and extra deep percolation occurs in the second case.

Many more combinations are contained in Table 10 that could be discussed; they may be assessed and compared more conveniently using the data provided in the Summary Tables 10_m and 10_n. These summary results are provided to facilitate comprehension and comparison of the tailwater cases (given in Table 10_m) and of the no-tailwater cases (compensation cases, given in Table 10_n). These latter tables permit one to compare the water delivery requirements and other irrigation-related water volumes for any considered combination of Colorado River salinity, leaching requirement, tailwater fraction, effective rainfall and inefficiency compensation. For these combinations, the percentages of beneficially used water obtained for the various potential IID-wide

situations fall between about 80 and 95. They provide a suitable basis to compare with prevalent water usage to determine water conservation opportunities (compared to IID, 2002). They provide values to use to evaluate the way the IID-wide water requirement might vary as the salinity of the Colorado River changes, as the effective rainfall varies, as crop consumptive use increases and as tailwater use is diminished.

I will now use the above data to estimate the water requirement of the IID under 1989-1996 conditions (similar to 1987-1998 conditions). This estimate is based partly on the observations that: 1) Bali and Grismer have successfully demonstrated that alfalfa and Sudan could be successfully produced in high clay content soils of the IID with tailwater runoff of less than 5 percent using simple "cutoff" irrigation systems (Grismer, 2003), 2) I successfully grew alfalfa, wheat, sugar beets and cantaloupes in high clay content soil in the IID without any tailwater runoff using level basin irrigation (Rhoades, et al, 1988a and 1988b), 3) Boyle Engineering concluded that it was practical to reduce tailwater to about 5 percent using tailwater recovery systems (Boyle Engineering Inc., 1993), 4) DR Wynn Walker concluded from his simulations that it was practical to achieve 95 percent irrigation infiltration uniformity in the high clay content IID soils using blocked end irrigation systems (Walker, 2003a, b, c, d), 5) Harold Payne concluded from his field observations and evaluations of the IID situation and Arizona experience that it was practical to reduce tailwater to 5 percent with only management changes and relatively inexpensive systems changes (Payne, 2003), and 6) the leaching fraction now being achieved in the IID is only about 0.08 and crop yields are relatively good at this level of leaching (Rhoades, 2003). Given this evidence, I assume that the appropriate value for the inefficiency factor (F_n) is about 0.95 for the cracking-type soils, without tailwater. The other pertinent information is that the crop consumptive use requirement for the period is about 1806 KAF, the leaching requirement is about 0.0854, the effective rainfall is about 101 KAF and the salinity level of the Colorado River is about 1.213 dS/m. For this combination of use conditions, the on-farm target water requirement of Colorado River water on the cracking-type soils is about 1960 KAF (see Table 10_c). For the non-cracking type soils an F_n factor of about 0.90 is likely appropriate, without tailwater. The analogous volume would be about 2067 KAF. The weighted average (District-wide) requirement would be about 2001 KAF (0.62 * 1960 plus 0.38* 2067). Of course, this latter volume can be higher or lower depending mostly upon the level of the Colorado River salinity concentration and amount of effective rainfall. In the longer-term future, the water requirement may increase as ways are found to eliminate the present limits on crop consumptive use, as ways are implemented to eliminate tailwater.

I established confidence intervals for the above estimates as follows. I calculated leaching requirement values for each separate years total and distribution of crop consumptive use during 1989-1996, while keeping the Colorado River salinity constant (EC = 1.213 dS/m). The results are given in Table A3 by individual year. The LR_W values ranged between 0.079-0.097. I then calculated the on-farm irrigation water requirements for each separate year of the period 1989-1996, in two different ways, again while keeping the Colorado River salinity constant (EC = 1.213 dS/m). In one way, I kept the crop consumptive use volume constant at the rainfall adjusted crop volume of 1705 KAF; in the second way, I used the individual yearly volumes of crop consumptive use given in

Table 1_a, which are adjusted for yearly effective rainfall. The results for the first case are given in Tables $11\text{-}1_a$ through $11\text{-}1_h$. The results for the second case are given in Tables $11\text{-}2_a$ through $11\text{-}2_h$. The corresponding mean and several indices of variation in the estimates of LR, requited on-farm delivery (RV_{iw}), required deep percolation (RV_{dw}) and tailwater volume (V_{tw}) are given in Tables 12a and 12b, respectively, for different combinations of tailwater and leaching requirement. The 95% confidence interval for the mean LR_W (0.085) is about +/- 0.005 and that for the mean RV_{iw} (about 1964 KAF) with 5 percent tailwater is about 113 KAF, when both LR_W and V_{et} are varied by year. When V_{et} is held constant at 1705 KAF and only LR_W is varied, the 95% confidence volume for the RV_{iw} (about 1960 KAF) with 5 percent tailwater is about 11 KAF. Thus, the on-farm target crop water requirement of Colorado River water for 1989-1996 is estimated to be about 2005 KAF +/- about 113 KAF. The primary source of the latter uncertainty is related to variance in the crop consumptive use; the effect of leaching requirement is relatively small and insignificant. Additional water is required for the duck ponds and fish farms; these volumes total about 28,000 acre-feet (see Table 1_c).

Calculation of IID On-Farm Water Requirement for 2003

The volumes of water required to be delivered on-farm in the IID service area to meet the crop ET, leaching requirements and the need for extra water for inefficiency compensation for the estimated year 2003 are provided in this section.

As indicated by the preceding section, the estimation of the irrigation water requirement in the IID requires appropriate information of the crop water requirement (V_{et}), the effective rainfall (V_{rw}), the leaching requirement (LR_{infw}), the value of F_{ctw} (if horizontal leaching occurs and tailwater is allowed), the salinity of the Colorado River water used for irrigation, the salinity-tolerances of the crops grown, the need to compensate for irrigation distribution and leaching inefficiency, which varies depending upon irrigation management and the allowable amount of non-beneficial water determined to be reasonable. The pertinent data for the period 2000-2002 were used to estimate these parameters and, in turn, the on-farm irrigation water requirement of the IID service area for year 2003.

With these factors in mind, I estimated the on-farm water requirements for three tailwater scenarios (15%, 10% and 5% considered reasonable to achieve for 2003 and in about 2 and 5 years from now, respectively) using the relations and logic described in the preceding sections, for prevalent (average 2000-2002) combinations of crop consumptive use, leaching requirement, effective rainfall, Colorado River salinity and the value of 0.95 for F_n, while including horizontal-leaching assuming the F_{ctw} factor is 1.19 for the IID-wide situation. These results permit the estimation of the water requirement of the IID service area that can be immediately achieved in 2003 by simply adhering to IID's own 15 percent tailwater regulation (15% tailwater_F_n = 0.95 case; or simply, 15%_0.95 case), as well as the water requirement given the implementation of relatively simple inexpensive management practices that can be achieved in about two years (10%_0.95 case) and in about 5 years with somewhat more costly but still practical improvements in irrigation and cropping management (5%_0.95 case), assuming the salinity of the

Colorado River, crop ET and effective rainfall values remain similar to those of 2000-2002.

The crop consumptive use data for 2000-2002 are given in Table 1_c. The preliminary consumptive use data used to determine the leaching requirement are those summarized in Table 1c. The total consumptive use volumes that were subsequently revised and used to calculate the water requirements are also given in Table 1c. The leaching requirement values based on the earlier data are equally valid for the later data, because the changes in consumptive use are proportionately the same for all crops. The corresponding Colorado River salinity data are given in Table 2. The corresponding IID-wide leaching requirements for the period are summarized given in Table 3_i. The LR values for the individual years 2000-2002 are given in Table A3-2000, A3-2001 and A3-2002 (see Appendix). Because the salinity of the Colorado River is now lower than it was during 1989-1996, the LR_W is substantially lower for 2003 (0.058).

The estimated irrigation crop on-farm water requirements for 2003 and the two other time periods corresponding to the above data and logic are given in Table 13. For 2003, the estimated volume (15%_0.95 case) is a liberal one in my opinion (2237.6 KAF, excluding duck ponds and fish farms). The statistical estimate (see Table 14) of the mean RV_{iw} value based on the meager three years is 2243.5 KAF +/- 14.1 KAF (95% probability). However, the number of degrees of freedom is too small to justify this estimate of the mean and of the uncertainty of the mean. The uncertainty in the mean RV_{iw} is too large (about 125 KAF; see Table 12b), because the variation in crop consumptive use was large over this period compared to the past three years. Thus, this estimate is likely excessive to apply to the 2003 estimate. The likely uncertainty likely falls between the two extremes of the two described estimates. Thus, I will estimate the confidence interval to be twice the difference between the lowest and highest RV_{iw} volumes estimated for the three years, which is about 48.4 KAF (see Table 14). Thus, my estimate of the required on-farm crop water for 2003 is about 2237.6 KAF +/- 48.4 KAF. Thus, the total on-farm requirement, including duck ponds and fish farms, is about 2266.1 KAF +/- 48.4 KAF. The corresponding requirements can be reduced by reducing tailwater with irrigation and cropping management improvements by about 122.7 KAF in two years and by another 110.0 KAF in about 5 years.

Conclusions, Recommendations and Summary of Results

The above estimates of the past and present IID on-farm water requirements are believed to be conservative for the following reasons:

1. Salt tolerance threshold values used in the analyses are conservative (on the low side) causing leaching requirement (LR) calculations to be conservatively high. As an example, I believe that the varieties of alfalfa now grown in the IID are more salt tolerant than those grown in the 1960's and upon which the listed value of 2.0 dS/m is based (based on conversations with crop specialists). The tolerance is likely significantly higher. Furthermore, the salt tolerance values are generally conservative because plants are more sensitive under the more optimal growth

conditions generally used in these studies compared to actual field conditions, where other constraints limit their response to salinity. The threshold values typically are mathematically derived levels of the salinity level at which an initiation of growth reduction due to soil salinity begin, but which can't be discerned or accurately measured experimentally even under the best field test conditions. Thus, the threshold values used are conservative.

2. I believe that most of the deep percolation in IID contributes to the required leaching. This is because the IID-wide LR is low (no more than about 0.10) and so many of the soils have low permeability. This conclusion is supported by the reasoning given earlier and elsewhere (for example, p. 26, Ayers and Westcot, 1985; Mitchell and van Genuchten, 1993). For a typical irrigation of fine-textured soils, distribution of infiltration is high, and, thus, deep percolation has high uniformity and can be credited towards fulfilling leaching requirements. For typical irrigation on coarser-textured soils, the relatively larger amounts of incidental deep percolation caused by non-uniformity of infiltration are sufficient to satisfy all leaching requirements over more than 90% of the field area (Allen, 2003a). The excess deep percolation flows to other fields, where (I believe) it is partially used by deep-rooted crops. Thus, the LR is met by low amounts of relatively uniform deep percolation on fine-textured soils and by relatively large amounts of less uniform deep percolation on coarse-textured soils that are partially recaptured and used elsewhere.

3. Multiple irrigations have higher uniformity of infiltration than do individual events. Many portions of a field that are under-irrigated during a single irrigation event tend to have higher than average infiltration rates for a subsequent irrigation event (because they are more cracked and drier; Walker, 2003a,b). The resulting relatively higher infiltration rates encourage relatively greater infiltration depths for those areas during subsequent irrigation event(s), thereby resulting in more uniform infiltration across multiple events. As discussed in item 7 below, river basin-scale salt balances on IID (Alamo River basin) indicate that net, season-average irrigation uniformity within IID is high, due to physical constraints by soils (Rhoades, 2003).

4. Many fields in IID are prone to having a shallow water table develop during parts of the growing season and following large irrigation events. This shallow water can supply a portion of the ET requirement of medium and deep-rooted crops (Grismer, 2003). Therefore, some of the deep percolation losses computed by simulation models or as observed during field studies actually contribute beneficially to the overall ET requirement.

5. Because the soil profile has large capacity to accumulate salts, some build up of salts during irrigation events having low amounts of leaching can be tolerated over the short term, for example, over a single growing season. The required leaching is subsequently provided during pre-plant and early season irrigations,

especially after the soil has been dried and tilled following the harvest of the previous crop (Rhoades, 2002; Grismer, 2003).

6. The leaching requirement computed in my analyses is actually higher than indicated in some calculations, which assumed a zero or nearly zero tailwater runoff, because there would be no adjustment for horizontal-leaching and this extra water would increase the volumes of infiltrated and deep percolation substantially. For example, if the volume of water equivalent to a tailwater of 5 percent is diverted to deep percolation, it increases the leaching fraction from 0.1 to 0.145; the corresponding reduction of average soil salinity is substantial.

7. Salt balance assessments based on tilewater drainage salt concentrations in the IID strongly support the belief that there are physical limits on movement of water through soil profiles of IID on a district-wide basis. The apparent leaching fraction (LF) being achieved within IID, based on salt balances, appears to be no more than about 0.1, with reference to infiltrated water (Rhoades, 2003). That this level has not caused undue salinity problems over the long-term for the vast majority of the district indicates that this physical constraint represents an advantage to the project efficiency. Thus, the sum of ET plus LR (which is about 0.09) plus 5% extra water in addition to this sum is a realistic and conservative goal for on-farm water delivery in the IID and probably represents about as much water as can be effectively infiltrated into the soils on a district-wide average, leaving some extra water (of the 5%) for small amounts of accidental tailwater runoff and leaving some water for any increase in ET stemming from better on-farm water management. This provides a strong argument for the reasonableness of the "5% equivalent tailwater" scenario.

8. The relative "tightness" of heavy soils in IID, following the filling of cracks by water during irrigation, tends to beneficially increase uniformity of irrigation. This conclusion is clearly demonstrated by the data of Mitchell and van Genuchten, 1993 and Grismer, 2003. The leaching requirements estimated for the IID-wide situation are in keeping with this relatively low attainable leaching fraction. The provision of much more additional water for leaching than that specified would likely only result in more soil aeration, scalding and water logging problems, with little benefit to beneficial soil salinity reduction.

The leaching requirement varies from year to year as the salinity of the Colorado River changes and as the crop composition changes. For the period 1989-1996, my estimate of the LR_{infw} value is about 0.085 (or round off to 0.09); for the estimated year 2003, the corresponding estimate is about 0.060.

I conclude that horizontal-leaching and tailwater runoff contribute very little to the required control of soil salinity control and I believe that excessive tailwater enhances the harmful buildup of soil salinity that is observed in the tail-end sections of some IID

fields. Tailwater should not be encouraged for this purpose; it is too inefficient and counter-productive to be advocated for this purpose.

Valid equations are provided which can be used to properly incorporate tailwater and horizontal-leaching effects into the leaching requirement assessment. The effectiveness of horizontal-leaching in meeting the leaching requirement and tailwater contributing to the beneficial water use in the IID are minimal, as proven by the equations, data and assessments provided herein and elsewhere. Since there are inconsistencies in the various Reports about the reference water to use for the leaching requirement and errors in its use to calculate the corresponding on-farm water requirement and related volumes, I have provided a set of valid equations to use to calculate these various water volumes, as well as their beneficial and non-beneficial components.

Since the leaching requirement is also based on the assumption of a completely uniform condition of irrigation application, infiltration and leaching across the field that probably doesn't exist in most cases, the effect of non-uniformity on these amounts and irrigation inefficiency should be considered when using LR values to calculate the required volumes of irrigation water to apply on-farm, provided tailwater amounts are sufficiently low. For high tailwater situations, such as now prevail in the IID, compensation for non-uniformity is inappropriate, in my opinion.

A means to compensate for the combined effects of non-uniformity in irrigation, infiltration and leaching, when calculating the on-farm irrigation requirement, is to increase both the full potential beneficial volume of ET (V_{et}) and the full potential volume of required drainage (i.e., $RV_{dw} = [LR_{infw}/(1-LR_{infw})](V_{et})]$) using the following relation: $RV_{iw} = (V_{et})/(1-LR_{infw})(F_n)$, where F_n is often estimated to be a factor falling between 0.85-0.95, depending upon irrigation method and various hydraulic soil properties. I do not advocate the indiscriminate use of this approach, because it ignores tailwater and may lead to a form of "double-accounting" and may encourage over-irrigation and excessive amounts of non-beneficial deep percolation and tailwater runoff, especially in cracking-type soils. Whether it does or not depends on the value of F_n chosen to represent the "inefficiency compensation", the amount of tailwater and the method used to calculate the compensation. In fact, the full theoretical beneficial volume of deep percolation water (RV_{dw}) can be provided when the irrigation application volume is determined without direct inclusion of the LR in the compensation method for inefficiency, such as when it is determined using the following compensation-equation: $RV_{iw} = (V_{et})/(F_n)$ and typical values are used for F_n (0.75-0.85). Simply reducing tailwater runoff by use of blocked ends will also increase infiltration uniformity, while reducing the need for extra water applications for non-uniformity compensation. In my opinion, the value of F_n should be increased (extra water for compensation decreased) as tailwater increases to keep non-beneficial water use within reasonable limits.

A proven appropriate value of F_n to use for the IID situation has been difficult to obtain. It is made even more difficult because of the lack of a practical proven way to determine how much of the water application is actually beneficial under real field conditions. The difficulty and dilemma is that the value of F_n varies with the irrigation system, irrigation

management, soil infiltration properties, tailwater percentage allowed and some decisions about how much of the irrigated field should receive optimum water application, infiltration and leaching (i.e., economic determinations are also involved). The latter decisions must "weigh" the difference between what is beneficial, what is reasonable and what is harmful, which includes economic assessments of various off-site environmental considerations, as well as the in-field technical aspects of crop production and irrigation and drainage processes. The use of surface irrigation models capable of predicting water infiltration and leaching (and tailwater runoff) for non-uniform conditions of water application and soil properties can facilitate the F_n selection process, but such use will probably not be totally sufficient, if it does not include economic considerations associated with excessive deep percolation (i.e., non-required deep percolation). Until we have the tools and data to complete a full assessment, I recommend that the approach used to compensate for non-uniformity of irrigation in estimating water application requirements in IID include and give significant weight to considerations of minimum non-beneficial water use.

Specifically, I recommend that the amount of water to apply on-farm to meet ET plus LR requirements and to compensate for non-uniformity of infiltration and deep percolation and inefficiency of irrigation should be constrained by some criterion-value (for example, 10 %) of reasonable maximum permissible non-beneficial water use (the Bureau should be encouraged to specify such a limit). The value of total irrigation volume for delivery to IID fields can be calculated, given such a limit, using Equation [5], where RV_{iw} is obtained as $(RV_{infw})/[1-(\%NBV_W)/100]$. Alternatively, the interactions between % NBV_{iw}, tailwater usage and inefficiency compensation may be utilized to first calculate the appropriate value of F_n using Equation [6a] for the amount of tailwater and $\%NBV_{iw}$ to be permitted (such as the 10 percent criterion suggested above). Then, the corresponding amount of delivery-water is calculated using Equation [4a]. Optionally, the value of F_n^* can be determined using Equation [6b] and the associated required volume of delivery water determined using Equation [4b].

An optional approach to the above-described method that could be used to compensate for the extra water needs associated with non-uniformity and inefficiency would be to replace the LR_W value with the conservative so-called traditional model (LR_T); the latter value would result in higher volumes of applied water compared to the former LR value. This would reduce, if not eliminate, the need for the compensation for non-uniformity and irrigation inefficiency. The data presented herein demonstrate this.

Tailwater is not normally considered a beneficial use of irrigation water, although some have argued unjustifiably that it can provide substantial leaching benefit. Because this benefit is very small and because horizontal-leaching is very inefficient, tailwater use should not advocated for this purpose. Additionally, some have argued that tailwater is required to achieve high irrigation uniformity. While tailwater can enhance uniformity of infiltration, it is an inefficient method in this regard and it promotes soil salinization (rather than soil salinity control). Thus, I recommend that RV_{iw} be estimated solely on the basis of the reasonableness of beneficial water use (which only includes ET and LR usage) with minimization of tailwater; and to provide a reasonable amount of extra water

to compensate for non-uniformity and inefficiency considerations. This will permit the farmer to determine whether he will allow tailwater to occur, or not, within the confines of his overall "reasonable and beneficial' allotment. In other words the total allotted water can be used in any combination of ET + LR + TW, but it should be kept within the limits of reasonably beneficial, as defined and calculated above.

The on-farm target requirement of Colorado River water for on-farm irrigation of the IID situation during 1989-1996 is estimated to be about 2005 KAF +/- about 113 KAF, plus an additional 28 KAF for duck ponds and fish farms. For the year 2003 the estimate of the reasonable on-farm Colorado River water requirement for the IID service area is about 2237.6 KAF +/- 48.4 KAF. Thus, the corresponding total on-farm requirement, including duck ponds and fish farms, is about 2266.1 KAF +/- 48.4 KAF. These requirements can be reduced by about 122.7 KAF in two years and by another 110.0 KAF in about five years by reducing tailwater with relatively simple and inexpensive improvements in irrigation and cropping management to 10 percent and 5 percent, respectively.

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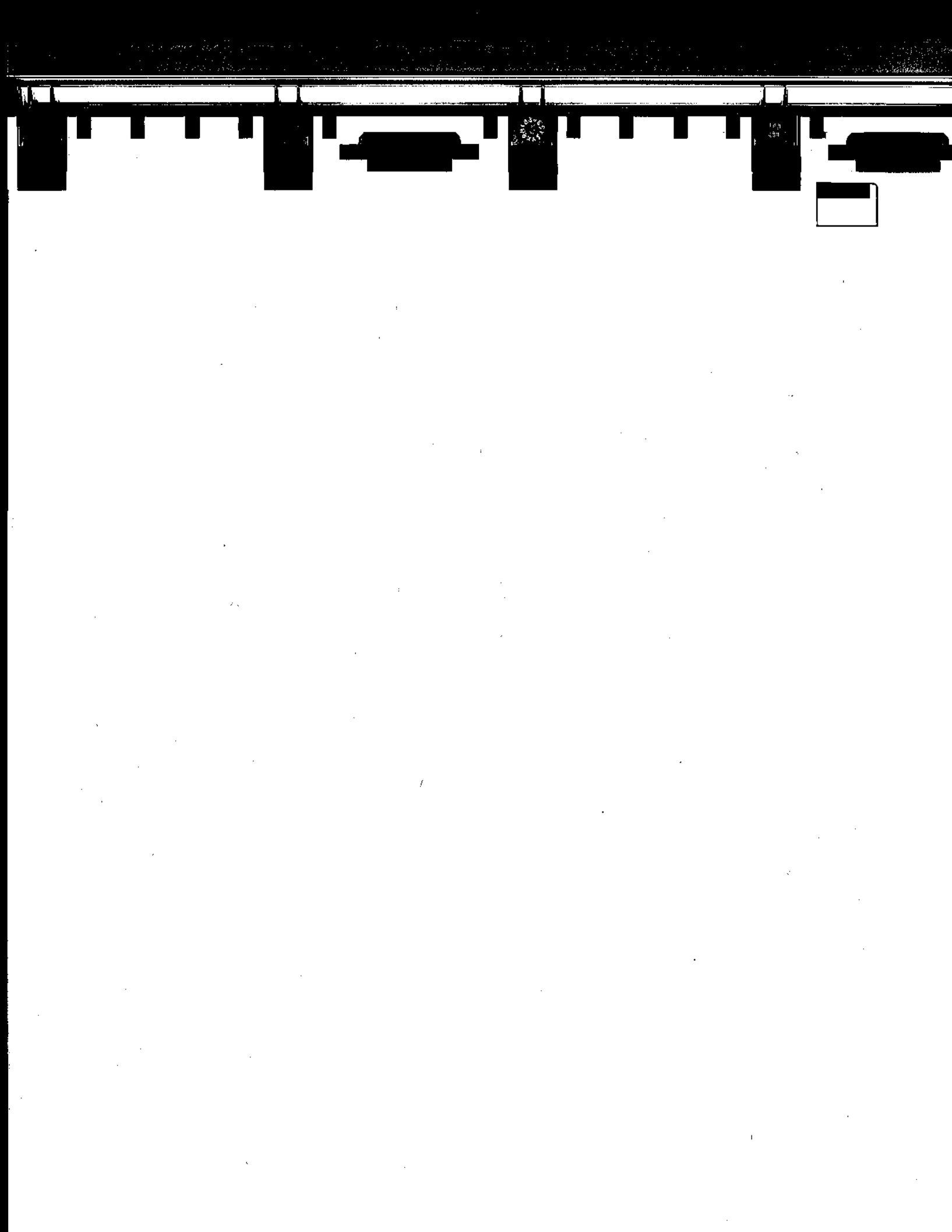


Tables

Table 1a. Evapotranspiration of irrigation water by crop and year in IID, 1989-1996

crop	1989	1990	1991	1992	1993	1994	1995	1996	sum	average	ave. %
alfalfa	906664	979698	866138	782915	779057	875215	890829	793306	6873822	859228	50.29
sudan	172646	129597	185424	149786	201999	253582	242652	227213	1562899	195362	11.43
wheat	139349	87208	61170	93957	88680	112040	126668	206057	915129	114391	6.69
bermuda	91684	81591	76701	105298	142300	149418	175906	183034	1005932	125741	7.36
sugar beets	118128	120547	119792	114420	110254	95010	115931	135040	929122	116140	6.8
lettuce-early	32545	19697	24339	18947	14944	15104	16255	20005	161836	20142	1.18
lettuce-late	18280	11744	10046	4311	4051	8159	8339	11107	76037	9505	0.56
carrots	31660	31692	25683	21010	27647	29871	25876	31795	225234	28154	1.65
cantaloupes-spring	30110	49986	36585	15631	21823	24262	25618	26244	230259	28782	1.68
cantaloupes-fall	13481	10026	11997	3600	506	920	14	1156	41700	5212	0.3
alfalfa seed	2200	5826	20436	9088	11252	8573	17431	17821	92627	11578	0.68
cotton	38333	40682	27813	12348	27310	25845	25086	19388	197417	24677	1.44
honeydew	6572	6737	5441	1410	739	1772	2474	2200	27345	3418	0.2
watermelon	8825	8926	5526	4224	6200	8532	6461	6713	55407	6926	0.4
onions	28145	29813	27832	22294	24473	29432	32064	34206	228259	28532	1.67
onion seed	9726	11352	8078	7017	7523	5786	5913	8425	63820	7977	0.47
rye-pasture	31843	23601	20757	14557	12999	14576	10229	10070	138632	17329	1.01
oats & barley	15108	6142	5764	2691	1980	3564	2670	1542	39461	4933	0.29
misc field crops	2207	2423	1881	1673	4602	4144	6793	11829	35552	4444	0.26
tomatoes	31966	37751	15431	7962	9581	6434	5696	5735	120556	15069	0.88
potatoes	417	496	761	481	1883	2123	3007	4348	13516	1689	0.1
brocolli	12101	8994	8580	5839	4979	6928	5960	6290	59671	7459	0.44
cabbage	1485	1470	1420	816	1128	1712	984	1170	10185	1273	0.07
cauliflower	9588	7867	4946	3518	3321	3518	2557	2814	38129	4766	0.28
corn-ear	3651	5925	7249	7271	6909	10582	12168	14463	68218	8527	0.5
misc garden crops	3485	4223	3707	3865	3596	3418	5121	5468	32883	4110	0.24
asparagus	25722	25816	24926	28203	29667	29044	26475	25515	215368	26921	1.58
citrus	9248	8920	9152	10667	13136	14727	15921	18712	100483	12560	0.73
jojoba	8519	8110	6553	6533	7379	7003	7164	7104	58365	7296	0.43
peach trees	2305	2002	1283	1009	907	622	47	11	8186	1023	0.06
permanent pasture	2536	2511	2248	2342	2962	3478	3242	3221	22540	2817	0.16
Total:	1808529	1771373	1627659	1463683	1573787	1755394	1825551	1842002	13667978	1708497	99.83

Table 1b. Volumes (AF) of Consumptive Use (CU) by Crop for 1989-1996 and plus 4%

crop	average CU	ave. CU plus 4%
alfalfa	859228	893597
sudan	195362	203176
wheat	114391	118967
bermuda	125741	130771
sugar beets	116140	120786
lettuce-early	20142	20948
lettuce-late	9505	9885
carrots	28154	29280
cantaloupes-spring	28782	29933
cantaloupes-fall	5212	5420
alfalfa seed	11578	12041
cotton	24677	25664
honeydew	3418	3555
watermelon	6926	7203
onions	28532	29673
onion seed	7977	8296
rye-pasture	17329	18022
oats & barley	4933	5130
misc field crops	4444	4622
tomatoes	15069	15672
potatoes	1689	1757
brocolli	7459	7757
cabbage	1273	1324
cauliflower	4766	4957
corn-ear	8527	8868
misc garden crops	4110	4274
asparagus	26921	27998
citrus	12560	13062
jojoba	7296	7588
peach trees	1023	1064
permanent pasture	2817	2930
totals:	1705981	1774220

Table 1c Crop Consumptive Use of Colorado River [1], in acre-feet per year				
	time period			
crop	2000	2001	2002	average
alfalfa	810530	823294	843827	825884
sudan	159071	149877	141792	150247
wheat	83307	69626	78146	77026
bermuda	231510	262803	280736	258350
sugar beets	101656	84401	80952	89003
lettuce-early	14141	13995	15203	14446
lettuce-late	6645	6577	7144	6789
carrots	32696	29457	31051	31068
cantaloupes-spring	15663	13392	13083	14046
cantaloupes-fall	838	1032	1762	1211
alfalfa seed	22706	10043	11051	14600
cotton	19282	44560	30515	31452
honeydew	2666	3281	2300	2749
watermelon	3652	1535	2087	2425
onions	32517	23488	21607	25871
onion seed	12998	6648	6253	8633
rye-pasture	6241	5008	2009	4419
oats & barley	1277	3898	9963	5046
misc field crops	17913	24445	24568	22309
tomatoes	2102	2099	1731	1977
potatoes	4120	3530	2133	3261
brocolli	8961	6721	5976	7219
cabbage	1063	950	868	960
cauliflower	3358	3041	2675	3025
corn-ear	14692	9515	12370	12192
misc garden crops	2634	2745	2357	2579
asparagus	23257	17273	14465	18332
citrus	27302	27161	27671	27378
jojoba	7	7	0	5
peach trees	32	33	33	33
permanent pasture	2434	2633	2781	2616
~~sub-totals:~~	~~1665271~~	~~1653068~~	~~1677109~~	~~1665149~~
~~Duck ponds~~	~~23363~~	~~23814~~	~~25005~~	~~24061~~
fish farms	4685	4283	4382	4450
~~totals:~~	~~1693319~~	~~1681165~~	~~1706496~~	~~1693660~~
~~updated totals:~~	~~1732940~~	~~1720980~~	~~1747480~~	~~1733800~~
[1] ~~excludes effective rainfall~~				

Table 2. Average Compositions of the Colorado River (at Imperial Dam), During the Period 1987-2002 [1]

period	EC, dS/m	TDS-180, mg/L	concentrations in meq/L						
			Na	K	Ca	Mg	ALK	Cl	SO_4
1987	1.001	651.6	4.15	0.12	3.74	2.36	2.88	2.33	5.10
1988	1.038	674.6	4.52	0.10	3.57	2.35	2.85	2.53	5.48
1989	1.084	693.7	4.72	0.10	3.90	2.32	2.81	2.64	5.71
1990	1.151	754.6	5.17	0.11	4.08	2.41	2.94	2.99	6.00
1991	1.217	802.7	5.47	0.12	4.35	2.77	3.01	3.30	6.17
1992	1.224	824.8	5.66	0.13	4.39	2.83	3.03	3.38	6.40
1993	1.239	824.6	6.01	0.13	4.29	2.75	2.93	3.51	6.29
1994	1.251	844.7	5.85	0.13	4.47	2.80	2.93	3.52	6.42
1995	1.267	834.2	5.94	0.13	4.32	2.74	2.98	3.59	6.44
1996	1.245	830.4	5.57	0.13	4.21	2.64	2.95	3.60	6.27
1997	1.148	752.6	5.20	0.12	4.05	2.41	2.87	2.99	5.73
1998	1.053	676.3	4.37	0.10	3.87	2.43	2.82	2.51	5.48
1999	1.080	685.7	4.72	0.11	3.97	2.31	2.94	2.63	5.75
2000	1.059	684.3	4.58	0.11	3.93	2.29	2.95	2.61	5.22
2001	1.102	713.7	4.97	0.10	3.98	2.41	2.83	2.84	5.54
2002	1.110	695.7	4.77	0.11	3.97	2.42	2.98	2.86	5.54
1989-1996	1.213	803.9	5.77	0.12	4.26	2.66	2.95	3.33	6.23
1987-2001	1.143	749.5	5.22	0.12	4.07	2.52	2.97	3.00	5.86
2000-2002	1.091	698.1	4.77	0.11	3.96	2.38	2.92	2.77	5.44

[1] USBR Yuma Desalting Plant Laboratory; average of approximately 24 samples per year

Table 3a. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for 1989-1996 CU & EC_{iw} of 0.930 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.103	0.046	859228	98167	41409	957395	900637
sudan	2.8	0.071	0.022	195362	14966	4362	210328	199724
wheat	6.0	0.032	0.004	114391	3781	465	118172	114856
bermuda	6.9	0.028	0.003	125741	3583	375	129324	126116
sugar beets	7.0	0.027	0.003	116140	3259	335	119399	116475
lettuce-early	1.3	0.167	0.119	20142	4037	2727	24179	22869
lettuce-late	1.3	0.167	0.119	9505	1905	1287	11410	10792
carrots	1.0	0.229	0.213	28154	8339	7621	36493	35775
cantaloupes-spring	1.0	0.229	0.213	28782	8525	7791	37307	36573
cantaloupes-fall	1.0	0.229	0.213	5212	1544	1411	6756	6623
alfalfa seed	2.0	0.103	0.046	11578	1323	558	12901	12136
cotton	7.7	0.025	0.002	24677	626	58	25303	24735
honeydew	1.0	0.229	0.213	3418	1012	925	4430	4343
watermelon	1.0	0.229	0.213	6926	2051	1875	8977	8801
onions	1.2	0.183	0.142	28532	6409	4735	34941	33267
onion seed	1.0	0.229	0.213	7977	2363	2159	10340	10136
rye-pasture	7.6	0.025	0.002	17329	446	42	17775	17371
oats & barley	8.0	0.024	0.002	4933	120	11	5053	4944
misc field crops	4.0	0.049	0.010	4444	228	45	4672	4489
tomatoes	2.5	0.080	0.028	15069	1317	435	16386	15504
potatoes	1.7	0.123	0.066	1689	237	119	1926	1808
brocolli	2.8	0.071	0.022	7459	571	167	8030	7626
cabbage	1.8	0.115	0.058	1273	166	78	1439	1351
cauliflower	2.8	0.071	0.022	4766	365	106	5131	4872
corn-ear	1.7	0.123	0.066	8527	1194	601	9721	9128
misc garden crops	1.8	0.115	0.058	4110	535	253	4645	4363
asparagus	4.1	0.048	0.009	26921	1343	255	28264	27176
citrus	1.3	0.167	0.119	12560	2517	1700	15077	14260
jojoba	4.0	0.049	0.010	7296	374	73	7670	7369
peach trees	1.7	0.123	0.066	1023	143	72	1166	1095
permanent pasture	5.6	0.034	0.005	2817	100	13	2917	2830
totals:				1705981	171547	82064	1877528	1788045

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (171547)/(1877528) = 0.091369

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (82064)/(1788045) = 0.045896

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 3b. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for 1989-1996 CU & EC_{iw} of 1.143 dS/m

crop	EC_e^{*} [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.129	0.067	859228	127314	61868	986542	921096
sudan	2.8	0.089	0.032	195362	19063	6396	214425	201758
wheat	6.0	0.040	0.006	114391	4718	666	119109	115057
bermuda	6.9	0.034	0.004	125741	4461	535	130202	126276
sugar beets	7.0	0.034	0.004	116140	4058	478	120198	116618
lettuce-early	1.3	0.213	0.176	20142	5463	4292	25605	24434
lettuce-late	1.3	0.213	0.176	9505	2578	2025	12083	11530
carrots	1.0	0.296	0.315	28154	11857	12973	40011	41127
cantaloupes-spring	1.0	0.296	0.315	28782	12122	13262	40904	42044
cantaloupes-fall	1.0	0.296	0.315	5212	2195	2402	7407	7614
alfalfa seed	2.0	0.129	0.067	11578	1716	834	13294	12412
cotton	7.7	0.031	0.003	24677	779	82	25456	24759
honeydew	1.0	0.296	0.315	3418	1439	1575	4857	4993
watermelon	1.0	0.296	0.315	6926	2917	3191	9843	10117
onions	1.2	0.235	0.210	28532	8781	7584	37313	36116
onion seed	1.0	0.296	0.315	7977	3360	3676	11337	11653
rye-pasture	7.6	0.031	0.003	17329	555	59	17884	17388
oats & barley	8.0	0.029	0.003	4933	150	15	5083	4948
misc field crops	4.0	0.061	0.014	4444	287	64	4731	4508
tomatoes	2.5	0.101	0.041	15069	1686	641	16755	15710
potatoes	1.7	0.155	0.097	1689	311	180	2000	1869
brocolli	2.8	0.089	0.032	7459	728	244	8187	7703
cabbage	1.8	0.145	0.085	1273	217	118	1490	1391
cauliflower	2.8	0.089	0.032	4766	465	156	5231	4922
corn-ear	1.7	0.155	0.097	8527	1568	911	10095	9438
misc garden crops	1.8	0.145	0.085	4110	700	382	4810	4492
asparagus	4.1	0.059	0.014	26921	1689	369	28610	27290
citrus	1.3	0.213	0.176	12560	3407	2676	15967	15236
jojoba	4.0	0.061	0.014	7296	471	106	7767	7402
peach trees	1.7	0.155	0.097	1023	188	109	1211	1132
permanent pasture	5.6	0.043	0.007	2817	125	19	2942	2836
totals:				1705981	225365	127891	1931346	1833872

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (225365)/(1931346) = 0.116688

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (127891)/(1833872) = 0.069738

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 3c. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for 1989-1996 CU & EC_{iw} of 1.213 dS/m

crop	EC_e^{*} [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	859228	137608	73904	996836	933132
sudan	2.8	0.095	0.037	195362	20475	7470	215837	202832
wheat	6.0	0.042	0.007	114391	5032	748	119423	115139
bermuda	6.9	0.036	0.005	125741	4755	598	130496	126339
sugar beets	7.0	0.036	0.005	116140	4325	534	120465	116674
lettuce-early	1.3	0.229	0.211	20142	5997	5389	26139	25531
lettuce-late	1.3	0.229	0.211	9505	2830	2543	12335	12048
carrots	1.0	0.320	0.383	28154	13268	17511	41422	45665
cantaloupes-spring	1.0	0.320	0.383	28782	13564	17902	42346	46684
cantaloupes-fall	1.0	0.320	0.383	5212	2456	3242	7668	8454
alfalfa seed	2.0	0.138	0.079	11578	1854	996	13432	12574
cotton	7.7	0.033	0.004	24677	830	91	25507	24768
honeydew	1.0	0.320	0.383	3418	1611	2126	5029	5544
watermelon	1	0.320	0.383	6926	3264	4308	10190	11234
onions	1.2	0.253	0.253	28532	9684	9676	38216	38208
onion seed	1.0	0.320	0.383	7977	3759	4962	11736	12939
rye-pasture	7.6	0.033	0.004	17329	591	66	17920	17395
oats & barley	8.0	0.031	0.003	4933	159	17	5092	4950
misc field crops	4	0.065	0.016	4444	307	74	4751	4518
tomatoes	2.5	0.107	0.048	15069	1814	754	16883	15823
potatoes	1.7	0.166	0.115	1689	337	219	2026	1908
brocolli	2.8	0.095	0.037	7459	782	285	8241	7744
cabbage	1.8	0.156	0.101	1273	235	142	1508	1415
cauliflower	2.8	0.095	0.037	4766	499	182	5265	4948
corn-ear	1.7	0.166	0.115	8527	1703	1104	10230	9631
misc garden crops	1.8	0.156	0.101	4110	758	460	4868	4570
asparagus	4.1	0.063	0.015	26921	1807	423	28728	27344
citrus	1.3	0.229	0.211	12560	3740	3360	16300	15920
jojoba	4	0.065	0.016	7296	504	121	7800	7417
peach trees	1.7	0.166	0.115	1023	204	132	1227	1155
permanent pasture	5.6	0.045	0.008	2817	134	22	2951	2839
totals:				1705981	244885	159363	1950866	1865344

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (244885)/(1950866) = 0.12553

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (159363)/(1865344) = 0.08543

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 3d. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for 1989-1996 CU & EC_{iw} of 1.323 dS/m

crop	EC_e^{*} [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.153	0.092	859228	154610	86538	1013838	945766
sudan	2.8	0.104	0.043	195362	22773	8778	218135	204140
wheat	6.0	0.046	0.010	114391	5516	1155	119907	115546
bermuda	6.9	0.040	0.010	125741	5239	1270	130980	127011
sugar beets	7.0	0.039	0.010	116140	4713	1173	120853	117313
lettuce-early	1.3	0.256	0.245	20142	6931	6536	27073	26678
lettuce-late	1.3	0.256	0.245	9505	3271	3084	12776	12589
carrots	1.0	0.360	0.440	28154	15837	22121	43991	50275
cantaloupes-spring	1.0	0.360	0.440	28782	16190	22614	44972	51396
cantaloupes-fall	1.0	0.360	0.440	5212	2932	4095	8144	9307
alfalfa seed	est 2.0	0.153	0.092	11578	2083	1166	13661	12744
cotton	7.7	0.036	0.010	24677	911	249	25588	24926
honeydew	est 1.0	0.360	0.440	3418	1923	2686	5341	6104
watermelon	est 1.0	0.360	0.440	6926	3896	5442	10822	12368
onions	1.2	0.283	0.290	28532	11256	11654	39788	40186
onion seed	1.0	0.360	0.440	7977	4487	6268	12464	14245
rye-pasture	7.6	0.036	0.010	17329	649	175	17978	17504
oats & barley	8.0	0.034	0.010	4933	175	50	5108	4983
misc field crops	est 4.0	0.071	0.020	4444	339	91	4783	4535
tomatoes	2.5	0.118	0.055	15069	2024	877	17093	15946
potatoes	1.7	0.184	0.135	1689	382	264	2071	1953
brocolli	2.8	0.104	0.043	7459	869	335	8328	7794
cabbage	1.8	0.172	0.120	1273	265	174	1538	1447
cauliflower	est 2.8	0.104	0.043	4766	556	214	5322	4980
corn-ear	1.7	0.184	0.135	8527	1927	1331	10454	9858
misc garden crops	est 1.8	0.172	0.120	4110	856	560	4966	4670
asparagus	4.1	0.069	0.020	26921	1995	549	28916	27470
citrus	1.3	0.256	0.245	12560	4322	4076	16882	16636
jojoba	est 4.0	0.071	0.020	7296	556	149	7852	7445
peach trees	1.7	0.184	0.135	1023	231	160	1254	1183
permanent pasture	est 5.6	0.050	0.010	2817	147	28	2964	2845
totals:				1705981	277858	193862	1983839	1899843

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (277858)/(1983839) = 0.140

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (193862)/(1899843) = 0.102

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 3e. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for 1989-1996 CU+4% & EC_{iw} of 0.930 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.103	0.046	893597	102094	43065	995691	936662
sudan	2.8	0.071	0.022	203176	15565	4537	218741	207713
wheat	6.0	0.032	0.004	118967	3932	483	122899	119450
bermuda	6.9	0.028	0.003	130771	3726	390	134497	131161
sugar beets	7.0	0.027	0.003	120786	3390	349	124176	121135
lettuce-early	1.3	0.167	0.119	20948	4199	2836	25147	23784
lettuce-late	1.3	0.167	0.119	9885	1981	1338	11866	11223
carrots	1.0	0.229	0.213	29280	8672	7926	37952	37206
cantaloupes-spring	1.0	0.229	0.213	29933	8866	8103	38799	38036
cantaloupes-fall	1.0	0.229	0.213	5420	1605	1467	7025	6887
alfalfa seed	2.0	0.103	0.046	12041	1376	580	13417	12621
cotton	7.7	0.025	0.002	25664	651	60	26315	25724
honeydew	1.0	0.229	0.213	3555	1053	962	4608	4517
watermelon	1.0	0.229	0.213	7203	2133	1950	9336	9153
onions	1.2	0.183	0.142	29673	6666	4924	36339	34597
onion seed	1.0	0.229	0.213	8296	2457	2246	10753	10542
rye-pasture	7.6	0.025	0.002	18022	464	43	18486	18065
oats & barley	8.0	0.024	0.002	5130	125	11	5255	5141
misc field crops	4.0	0.049	0.010	4622	237	46	4859	4668
tomatoes	2.5	0.080	0.028	15672	1370	453	17042	16125
potatoes	1.7	0.123	0.066	1757	246	124	2003	1881
brocolli	2.8	0.071	0.022	7757	594	173	8351	7930
cabbage	1.8	0.115	0.058	1324	172	82	1496	1406
cauliflower	2.8	0.071	0.022	4957	380	111	5337	5068
corn-ear	1.7	0.123	0.066	8868	1242	625	10110	9493
misc garden crops	1.8	0.115	0.058	4274	557	263	4831	4537
asparagus	4.1	0.048	0.009	27998	1397	266	29395	28264
citrus	1.3	0.167	0.119	13062	2618	1768	15680	14830
jojoba	4.0	0.049	0.010	7588	389	76	7977	7664
peach trees	1.7	0.123	0.066	1064	149	75	1213	1139
permanent pasture	5.6	0.034	0.005	2930	104	14	3034	2944
totals:				1774220	178409	85346	1952629	1859566

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (178409)/(1952629) = 0.091369

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (85346)/(1859566) = 0.045896

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 3f. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for 1989-1996 CU+4% & EC_{iw} of 1.143 dS/m

crop	EC_e^{*} [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.129	0.067	893597	132406	64343	1026003	957940
sudan	2.8	0.089	0.032	203176	19825	6652	223001	209828
wheat	6.0	0.040	0.006	118967	4907	692	123874	119659
bermuda	6.9	0.034	0.004	130771	4640	556	135411	131327
sugar beets	7.0	0.034	0.004	120786	4220	498	125006	121284
lettuce-early	1.3	0.213	0.176	20948	5682	4464	26630	25412
lettuce-late	1.3	0.213	0.176	9885	2681	2106	12566	11991
carrots	1.0	0.296	0.315	29280	12331	13492	41611	42772
cantaloupes-spring	1.0	0.296	0.315	29933	12606	13793	42539	43726
cantaloupes-fall	1.0	0.296	0.315	5420	2283	2497	7703	7917
alfalfa seed	2.0	0.129	0.067	12041	1784	867	13825	12908
cotton	7.7	0.031	0.003	25664	810	85	26474	25749
honeydew	1.0	0.296	0.315	3555	1497	1638	5052	5193
watermelon	1.0	0.296	0.315	7203	3034	3319	10237	10522
onions	1.2	0.235	0.210	29673	9132	7888	38805	37561
onion seed	1.0	0.296	0.315	8296	3494	3823	11790	12119
rye-pasture	7.6	0.031	0.003	18022	577	62	18599	18084
oats & barley	8.0	0.029	0.003	5130	155	16	5285	5146
misc field crops	4.0	0.061	0.014	4622	298	67	4920	4689
tomatoes	2.5	0.101	0.041	15672	1754	667	17426	16339
potatoes	1.7	0.155	0.097	1757	323	188	2080	1945
brocolli	2.8	0.089	0.032	7757	757	254	8514	8011
cabbage	1.8	0.145	0.085	1324	225	123	1549	1447
cauliflower	2.8	0.089	0.032	4957	484	162	5441	5119
corn-ear	1.7	0.155	0.097	8868	1631	947	10499	9815
misc garden crops	1.8	0.145	0.085	4274	728	397	5002	4671
asparagus	4.1	0.059	0.014	27998	1757	384	29755	28382
citrus	1.3	0.213	0.176	13062	3543	2783	16605	15845
jojoba	4.0	0.061	0.014	7588	490	110	8078	7698
peach trees	1.7	0.155	0.097	1064	196	114	1260	1178
permanent pasture	5.6	0.043	0.007	2930	130	20	3060	2950
totals:				1774220	234380	133007	2008600	1907227

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (234380)/(2008600) = 0.116688

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (133007)/(1907227) = 0.069738

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 3g. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for 1989-1996 CU+4% & EC_{iw} of 1.213 dS/m

crop	EC_e^{*} [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.1380	0.0792	893597	143112	76860	1036709	970457
sudan	2.8	0.0949	0.03683	203176	21294	7769	224470	210945
wheat	6.0	0.0421	0.0065	118967	5233	778	124200	119745
bermuda	6.9	0.0364	0.00473	130771	4946	621	135717	131392
sugar beets	7.0	0.0359	0.00458	120786	4498	556	125284	121342
lettuce-early	1.3	0.2294	0.21108	20948	6237	5605	27185	26553
lettuce-late	1.3	0.2294	0.21108	9885	2943	2645	12828	12530
carrots	1.0	0.3203	0.38347	29280	13798	18212	43078	47492
cantaloupes-spring	1.0	0.3203	0.38347	29933	14106	18618	44039	48551
cantaloupes-fall	1.0	0.3203	0.38347	5420	2554	3371	7974	8791
alfalfa seed	2.0	0.1380	0.0792	12041	1928	1036	13969	13077
cotton	7.7	0.0325	0.00369	25664	863	95	26527	25759
honeydew	1.0	0.3203	0.38347	3555	1675	2211	5230	5766
watermelon	1	0.3203	0.38347	7203	3394	4480	10597	11683
onions	1.2	0.2534	0.25325	29673	10071	10063	39744	39736
onion seed	1.0	0.3203	0.38347	8296	3909	5160	12205	13456
rye-pasture	7.6	0.0330	0.0038	18022	615	69	18637	18091
oats & barley	8.0	0.0313	0.00338	5130	166	17	5296	5147
misc field crops	4	0.0646	0.01636	4622	319	77	4941	4699
tomatoes	2.5	0.1075	0.04767	15672	1887	784	17559	16456
potatoes	1.7	0.1665	0.11464	1757	351	228	2108	1985
brocolli	2.8	0.0949	0.03683	7757	813	297	8570	8054
cabbage	1.8	0.1558	0.10066	1324	244	148	1568	1472
cauliflower	2.8	0.0949	0.03683	4957	520	190	5477	5147
corn-ear	1.7	0.1665	0.11464	8868	1771	1148	10639	10016
misc garden crops	1.8	0.1558	0.10066	4274	789	478	5063	4752
asparagus	4.1	0.0629	0.01546	27998	1879	440	29877	28438
citrus	1.3	0.2294	0.21108	13062	3889	3495	16951	16557
jojoba	4	0.0646	0.01636	7588	524	126	8112	7714
peach trees	1.7	0.1665	0.11464	1064	212	136	1276	1202
permanent pasture	5.6	0.0453	0.00761	2930	139	22	3069	2952
totals:				1774220	254680	165737	2028900	1939957

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (254680)/(2028900) = 0.12553

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (165737)/(1939957) = 0.08543

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 3h. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for 1989-1996 CU+4% & EC_{iw} of 1.323 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.1525	0.0915	893597	160795	89999	1054392	983596
sudan	2.8	0.1044	0.0430	203176	23684	9129	226860	212305
wheat	6.0	0.0460	0.0100	118967	5736	1202	124703	120169
bermuda	6.9	0.0400	0.0100	130771	5449	1321	136220	132092
sugar beets	7.0	0.0390	0.0100	120786	4902	1220	125688	122006
lettuce-early	1.3	0.2560	0.2450	20948	7208	6798	28156	27746
lettuce-late	1.3	0.2560	0.2450	9885	3401	3208	13286	13093
carrots	1.0	0.3600	0.4400	29280	16470	23006	45750	52286
cantaloupes-spring	1.0	0.3600	0.4400	29933	16837	23519	46770	53452
cantaloupes-fall	1.0	0.3600	0.4400	5420	3049	4259	8469	9679
alfalfa seed	est 2.0	0.1525	0.0915	12041	2167	1213	14208	13254
cotton	7.7	0.0356	0.0100	25664	947	259	26611	25923
honeydew	est 1.0	0.3600	0.4400	3555	2000	2793	5555	6348
watermelon	est 1.0	0.3600	0.4400	7203	4052	5660	11255	12863
onions	1.2	0.2829	0.2900	29673	11706	12120	41379	41793
onion seed	1.0	0.3600	0.4400	8296	4667	6518	12963	14814
rye-pasture	7.6	0.0361	0.0100	18022	675	182	18697	18204
oats & barley	8.0	0.0342	0.0100	5130	182	52	5312	5182
misc field crops	est 4.0	0.0708	0.0200	4622	352	94	4974	4716
tomatoes	2.5	0.1184	0.0550	15672	2105	912	17777	16584
potatoes	1.7	0.1843	0.1350	1757	397	274	2154	2031
brocolli	2.8	0.1044	0.0430	7757	904	349	8661	8106
cabbage	1.8	0.1723	0.1200	1324	276	181	1600	1505
cauliflower	est 2.8	0.1044	0.0430	4957	578	223	5535	5180
corn-ear	1.7	0.1843	0.1350	8868	2004	1384	10872	10252
misc garden crops	est 1.8	0.1723	0.1200	4274	890	583	5164	4857
asparagus	4.1	0.0690	0.0200	27998	2075	571	30073	28569
citrus	1.3	0.2560	0.2450	13062	4494	4239	17556	17301
jojoba	est 4.0	0.0708	0.0200	7588	578	155	8166	7743
peach trees	1.7	0.1843	0.1350	1064	240	166	1304	1230
permanent pasture	est 5.6	0.0496	0.0100	2930	153	30	3083	2960
totals:				1774220	288972	201616	2063192	1975836

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (288972)/(2063192) = 0.14006

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (201616)/(1975836) = 0.10204

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{Infw,T}$ and $LR_{Infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively.

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 3_i. Salt-Tolerances, Volumes (in AF) of Crop ET, of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for Year 2000-2002; EC_{iw} of 1.0909 dS/m

crop	EC_e^{*} [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.122	0.060	825884	115238	53025	941122	878909
sudan	2.8	0.085	0.028	150247	13869	4348	164116	154595
wheat	6.0	0.038	0.005	77026	3021	386	80047	77412
bermuda	6.9	0.033	0.004	258350	8721	943	267071	259293
sugar beets	7.0	0.032	0.004	89003	2959	314	91962	89317
lettuce-early	1.3	0.202	0.160	14446	3649	2758	18095	17204
lettuce-late	1.3	0.202	0.160	6789	1715	1296	8504	8085
carrots	1.0	0.279	0.291	31068	12026	12732	43094	43800
cantaloupes-spring	1.0	0.279	0.291	14046	5437	5756	19483	19802
cantaloupes-fall	1.0	0.279	0.291	1211	469	496	1680	1707
alfalfa seed	2.0	0.122	0.060	14600	2037	937	16637	15537
cotton	7.7	0.029	0.003	31452	945	89	32397	31541
honeydew	1.0	0.279	0.291	2749	1064	1127	3813	3876
watermelon	1.0	0.279	0.291	2425	939	994	3364	3419
onions	1.2	0.222	0.192	25871	7392	6156	33263	32027
onion seed	1.0	0.279	0.291	8633	3342	3538	11975	12171
rye-pasture	7.6	0.030	0.003	4419	135	13	4554	4432
oats & barley	8.0	0.028	0.003	5046	146	13	5192	5059
misc field crops	4.0	0.058	0.013	22309	1366	283	23675	22592
tomatoes	2.5	0.096	0.036	1977	209	75	2186	2052
potatoes	1.7	0.147	0.087	3261	563	312	3824	3573
brocolli	2.8	0.085	0.028	7219	666	209	7885	7428
cabbage	1.8	0.138	0.077	960	154	80	1114	1040
cauliflower	2.8	0.085	0.028	3025	279	88	3304	3113
corn-ear	1.7	0.147	0.087	12192	2105	1165	14297	13357
misc garden crops	1.8	0.138	0.077	2579	413	214	2992	2793
asparagus	4.1	0.056	0.012	18332	1092	220	19424	18552
citrus	1.3	0.202	0.160	27378	6916	5227	34294	32605
jojoba	4.0	0.058	0.013	5	0	0	5	5
peach trees	1.7	0.147	0.087	33	6	3	39	36
permanent pasture	5.6	0.041	0.006	2616	111	15	2727	2631
totals:				1665151	196981	102812	1862132	1767963

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (196981)/(1862132) = 0.105783

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (102812)/(1767963) = 0.058153

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table 4a. Summary of Some of the LR-Related Relationships of J. D. Rhoades

Symbol[a]	Mathematical Relationships[b]
	use when including LR in calculations
LR	$LR = LR_T$, or LR_W
LR_{infw}	$LR_{infw} = [(1 - F_{tw}{}^{c}F_{ctw}{}^{d})/(1 - F_{tw})](LR)$; or $LR_{infw} = LR_{iw}/(1-F_{tw})$, if $F_n = 1$
LR_{iw}	$LR_{iw} = (1-F_{tw}F_{ctw})(F_n)(LR)$; or $LR_{iw} = (1-F_{tw})(F_n)(LR_{infw})$, if $F_n < 1$
TLR_{iw}	$TLR_{iw} = LR_{iw} + (BV_{tw} / RV_{iw})$
RV_{infw}	$RV_{infw} = (V_{et}-V_{rw})/(1 - LR_{infw})$
F_n	$F_n = [1-(\%NBV_W/100)]/(1-F_{tw})$
F_n	$F_n = (RV_{et} + RV_{dw})/(RV_{et} + RV_{dw}$ + additional deep percolation), or
F_n	$F_n = (RV_{infw})/(RV_{iw})$, when $F_{tw} = 0.0$
RV_{iw}	$RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})(F_n)]/(1-F_{tw})$, or
RV_{iw}	$RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})][1/(F_n)(1-F_{tw})]$, or
RV_{iw}	$RV_{iw} = (V_{et}-V_{rw})/[(1-LR_{infw})(1-F_{tw})(F_n)]$, or
RV_{iw}	$RV_{iw} = RV_{infw} + V_{tw}$
RV_{iw}/RV_{infw}	$RV_{iw}/RV_{infw} = [1/F_n(1-F_{tw})]$
$[N]$	$[N] = (RV_{iw}/V_{et}) = [((1/(1-LR_{infw})(F_n))/(1-F_{tw})]$
RV_{dw}	$RV_{dw} = (LR_{infw})(RV_{infw})$, or
RV_{dw}	$RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$, or
RV_{dw}	$RV_{dw} = (LR_{iw})(RV_{iw})$
V_{tw}	$V_{tw} = (F_{tw})(RV_{iw})$
TDV	$TDV = RV_{dw} + V_{tw}$, or
TDV	$TDV = (LR_{iw})(RV_{iw}) + (F_{tw})(RV_{iw})$, or
TDV	$TDV = (LR_{iw} + F_{tw})(RV_{iw})$, or
TDV	$TDV = (LR_{infw})(RV_{infw}) + (F_{tw})(RV_{iw})$
BV_{tw}	$BV_{tw} = [(LR)((V_{et})/(1-LR))]-[(LR_{infw})((V_{et})/(1-LR_{infw}))]$, or
BV_{tw}	$BV_{tw} = [(LR)((V_{et})/(1-LR))]-[(LR_{iw})((V_{et})/(1-LR_{iw}-F_{tw}))]$, or
TBV_w	$TBV_w = V_{et} + RV_{dw} + BV_{tw}$
NBV_W	$NBV_W = RV_{iw} - TBV_W$
C_{infw}	$C_{infw} = [(V_{iw}C_{iw})(1-F_{tw}F_{ctw})]/(V_{infw})$
	use when ignoring LR in calculations; based solely on V_{et}
F_n^*	$F_n^* = [1-(\%NBV_W/100)]/(1-F_{tw})$, or $= (F_n)(1-F_{tw})$
RV^*_{iw}	$RV_{iw} = [(V_{et})/(F_n^*)]/(1-F_{tw})$, or $= (V_{et})[1/(F_n^*)(1-F_{tw})]$

[a] symbols are defined in Table 4a; [b] the general assumption in LR models;
[c] $F_{tw} = (V_{tw})/(V_{iw})$; [d] $F_{ctw} = (EC^{\wedge}_{tw})/(EC_{iw})$

Table 4b. Definitions of Symbols Used in Table 4 Relations	
Symbol	Definitions
LR	the required leaching fraction, as estimated using either the Traditional LR-model or WATSUIT-model
LR_{infw}	the required leaching fraction, with reference to the volume of infiltration water
LR_{iw}	the required leaching fraction, with reference to the volume of irrigation water
TLR_{iw}	the total required leaching fraction, including vertical- & horizontal-leaching
RV_{infw}	the required volume of infiltration water, based on LR_{infw}
F_n	factor for increasing water requirement to provide compensation for non-uniformity and irrigation inefficiency
RV_{iw}	the required volume of irrigation water, based on LR_{iw}
V_{et}	the volume of water required for crop consumption
V_{rw}	the effective rainfall used in crop consumption
$[N]$	a multiplier factor to calcultae the required volume of irrigation water from crop consumptive use (ET_c)
RV_{dw}	the required volume of vertical-drainage water (deep perclation)
V_{tw}	the volume of tailwater
TDV_W	the total volume of drainage water; deep percolation plus tailwater
BV_{tw}	the volume of the tailwater that effectively contributes to the required leaching of soil salinitty
TBV_w	the total beneficial volume of water used for crop consumption and required leaching
NBV_W	the total non-beneficial volume of water used without direct benefit to crop consumption or required leaching
C_{infw}	weighted average concentration of infiltrated water, when horizontal-leaching occurs
F^*_n	compensation factor for non-uniformity and irrigation inefficiency, based solely on crop consumptive use
RV^*_{iw}	the required volume of irrigation water, based solely on crop consumptive use
F_{tw}	the fraction of tailwater relative to applied irrigation water,
F_{ctw}	the ratio of salinity concentration in the tailwater relative to the applied irrigation water

Table 5. Example Calculations of Water Volumes Associated With LR and Tailwater Under Uniform Conditions[a]

case	LR_{infw}	LR_{iw}	RV_{infw}	RV_{iw}	RV_{dw}	V_{tw}	BV_{tw}	TBV_W	NBV_W	$\%NBV_W$	$100(BV_{tw})/(RV_{dw})$	$V_{et} + RV_{dw} + V_{tw}$
no TW	0.090	0.090	109.890	109.890	9.890	0.000	0.000	109.890	0.000	0.000	0.000	109.890
TW - H-L	0.090	0.086	109.890	115.674	9.890	5.784	0.000	109.890	5.784	5.000	0.00	115.674
TW + H-L	0.088	0.083	109.601	115.374	9.605	5.769	0.285	109.890	5.484	4.753	2.967	115.374

[a] assuming $V_{et} = 100$; LR = 0.09; $F_{tw} = 0.05$; $F_{ctw} = 1.5$

Table 6. Effects of Non-Uniformity Compensation on Minimum Non-Beneficial Irrigation and Drainage Volumes[a]

A) Compensation Applied to Both V_{et} and RV_{dw}; $RV_{iw} = [(V_{et})/(1-LR_{infw})(F_n)]/(1-F_{tw})$

F_n[b]	F_{tw}	V_{et}	RV_{infw}[c]	RV_{dw}[c]	RV_{iw}[d]	NBV_W[e]	% NBV_W[e]	V_{tw}[f]	V_{dw}[g]	LF_{iw}[h]	NRV_{dw}[i]	% NRV_{dw}[j]
0.70	0.00	100.000	111.111	11.111	158.730	47.619	30.000	0.000	58.730	0.370	47.620	81.083
0.75	0.00	100.000	111.111	11.111	148.148	37.037	25.000	0.000	48.148	0.325	37.038	76.925
0.80	0.00	100.000	111.111	11.111	138.889	27.778	20.000	0.000	38.889	0.280	27.779	71.431
0.85	0.00	100.000	111.111	11.111	130.719	19.608	15.000	0.000	30.719	0.235	19.608	63.830
0.90	0.00	100.000	111.111	11.111	123.457	12.346	10.000	0.000	23.457	0.190	12.347	52.637
0.95	0.00	100.000	111.111	11.111	116.959	5.848	5.000	0.000	16.959	0.145	5.849	34.489
1.00	0.00	100.000	111.111	11.111	111.111	0.000	0.000	0.000	11.111	0.100	0.000	0.000
1.00	0.05	100.000	111.111	11.111	116.959	5.848	5.000	5.848	11.111	0.095	0.000	0.000
1.00	0.10	100.000	111.111	11.111	123.457	12.346	10.000	12.346	11.111	0.090	0.000	0.000
1.00	0.15	100.000	111.111	11.111	130.719	19.608	15.000	19.608	11.111	0.085	0.000	0.000
1.00	0.20	100.000	111.111	11.111	138.889	27.778	20.000	27.778	11.111	0.080	0.000	0.000

B) Compensation Applied Only to V_{et}; $RV_{iw} = [(V_{et})/(F_n^*)]/(1-F_{tw})$

F_n^*[b]	F_{tw}	V_{et}	RV_{inf}[c]	RV_{dw}[c]	RV_{iw}[d]	NBV_W[e]	% NBV_W[e]	V_{tw}[f]	V_{dw}[g]	LF_{iw}[h]	NRV_{dw}[i]	% NRV_{dw}[j]
0.70	0.00	100.000	111.111	11.111	142.857	31.746	22.222	0.000	42.857	0.298	31.746	74.074
0.75	0.00	100.000	111.111	11.111	133.333	22.222	16.666	0.000	33.333	0.250	22.222	66.667
0.80	0.00	100.000	111.111	11.111	125.000	13.889	11.111	0.000	25.000	0.200	13.889	55.556
0.85	0.00	100.000	111.111	11.111	117.647	6.536	5.556	0.000	17.647	0.150	6.536	37.037
0.90	0.00	100.000	111.111	11.111	111.111	0.000	0.000	0.000	11.111	0.100	0.000	0.000
0.95	0.00	100.000	111.111	11.111	105.263	-5.848	-5.556	0.000	5.263	0.050	-0.5848	-11.111
1.00	0.00	100.000	111.111	11.111	100.000	-11.111	-11.111	0.000	0.000	0.000	0.000	0.000
1.00	0.05	100.000	111.111	11.111	105.263	-5.848	-5.556	5.263	0.000	0.000	0.000	0.000
1.00	0.10	100.000	111.111	11.111	111.111	0.000	0.000	11.111	0.000	0.000	0.000	0.000
1.00	0.15	100.000	111.111	11.111	117.647	6.536	5.556	17.647	0.000	0.000	0.000	0.000
1.00	0.20	100.000	111.111	11.111	125.000	13.889	11.111	25.000	0.000	0.000	0.000	0.000

[a] $LR_{infw} = 0.1$ and tailwater fraction $F_{tw} = 0.00 - 0.20$; [b] F_n and F_n^* are the non-uniformity compensation factors;

[c] $RV_{infw} = (V_{et})/(1-LR_{infw})$, $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})]$, assuming complete uniformity ($F_n = 1.0$);

[d] for A) $RV_{iw} = [V_{et}/(1-LR_{infw})(F_n)]/(1-F_{tw})$, for B) $RV_{iw} = [(V_{et})/(F_n^*)]/(1-F_{tw})$;

[e] $NBV_{iw} = (RV_{iw} - TBV_W)$ = minimum non-beneficial irrigation water, % $NBV_{iw} = (100)(NBV_{iw})/(RV_{iw})$; [f] $V_{tw} = (F_{tw})(RV_{iw})$; [g] $V_{dw} = RV_{iw} - V_{et} - V_{tw}$;

[h] $LF_{iw} = V_{dw}/RV_{iw}$; [i] NRV_{dw} = minimum non-beneficial deep percolation = $V_{dw} - RV_{dw}$; [j] % $NRV_{dw} = (100)(NRV_{dw})/(V_{dw})$

Table 7. Effect of F_{tw} and $\%NBV_{iw}$ on F_n and RV_{iw}[a]			
$\%\ NBV_{iw}$	F_{tw}	F_n	[N][b]
5	0.00	0.950	1.154
10	0.00	0.900	1.218
15	0.00	0.850	1.290
20	0.00	0.800	1.371
25	0.00	0.750	1.462
5	0.05	0.947	1.154
10	0.05	0.895	1.218
15	0.05	0.868	1.290
20	0.05	0.842	1.371
25	0.05	0.790	1.462
5	0.10	ND	ND
10	0.10	1.000	1.218
15	0.10	0.944	1.290
20	0.10	0.889	1.371
25	0.10	0.833	1.462
5	0.15	ND	ND
10	0.15	ND	ND
15	0.15	1.000	1.290
20	0.15	0.941	1.371
25	0.15	0.882	1.462
5	0.20	ND	ND
10	0.20	ND	ND
15	0.20	ND	ND
20	0.20	1.000	1.371
25	0.20	0.938	1.462

[a] for case of $LR_{infw} = 0.088$ and $V_{et} = 100$; [b] $RV_{iw} = [N]\ (V_{et})$, where, $[N] = [(1/(1-LR_{infw})(F_n))/(1-F_{tw})]$

Table 8. Preliminary Graphical Sensitivity Analysis of Irrigation Parameters				
	Relative Effects of Irrigation Parameters			
Water Voume or Ratio	LR	F_{tw}	F_{ctw}	F_n
RV_{iw}	<0.1	2	<0.1	6
RV_{iw}/RV_{infw}	0	4	0	8
$[N] = RV_{iw}/V_{et}$	1	3	<0.1	5
$100(RV_{iw}/RV_{infw})$	0	3	0	6
RV_{infw}	7	2	2	0
V_{tw}	<0.1	6	<0.1	3
V_{tw}/RV_{iw}	0	8	0	0
BV_{tw}	1	3	3	0
$100(BV_{tw}/RV_{iw})$	1	3	3	0
$100(BV_{tw}/\text{Total drainage})$	0.5	7	<0.1	<0.1
$100(BV_{tw}/RV_{dw})$	<0.1	4	4	0
V_{tw}/V_{dw}	<0.1	3	<0.1	6
V_{dw}	0.1	0	<0.1	6
RV_{dw}	6	2	2	0
$100(V_{dw}/RV_{iw})$	0.1	1	<0.1	5
NRV_{dw}	<0.1	0	0	9
$100(NRV_{dw}/V_{dw})$	1	0	<0.1	9
NBV_W	0	3	<0.1	6
$100(NBV_W/RV_{iw})$	0	4	<0.1	4
$100(TBV_W/RV_{iw})$	0	4	<0.1	4
LR_{infw}	3	1	1	0
LR_{iw}/LR_{infw}	0.1	1	<0.1	4

Table 9a. Percent changes in response variables caused by sequential changes in input variables.

response variables	input variables[a]				
	LR	F_{tw}	F_{ctw}	V_{et}	F_n
LR_{iw}	66.67 (+)	23.91 (-)	6.90 (-)		
LR_{infw}	66.67 (+)	6.18 (-)	6.90 (-)		
RV_{iw}	8.76 (+)	17.10 (+)	0.90 (-)	20.00 (+)	36.43 (-)
RV_{infw}	8.76 (+)	0.81 (-)	0.90 (-)	20.00 (+)	
RV_{dw}	75.56 (+)	6.99 (-)	7.80 (-)	20.00 (+)	
BV_{tw}	84.98 (+)	178.26 (+)	199.10 (+)	20.00 (+)	
TBV_W	9.11 (+)			20.00 (+)	
NBV_W	7.62 (+)	73.84 (+)	3.91 (-)	20.00 (+)	157.34 (-)
[N]	8.76 (+)	17.10 (+)	0.90 (-)		36.43 (-)

[a] minimum, median and maximum vaues used are as follows:
LR (0.08, 0.12, 0.16); F_{tw} (0.02, 0.10, 0.18); F_{ctw} (1.00, 1.30, 1.60);
V_{et} (90, 100, 110); F_n (0.70, 0.85, 1.00)

Table 9b. Percent of variation and correlation explained by ANOVA model						
response variable	input variables					R^2
	LR	F_{tw}	F_{ctw}	V_{et}	F_n	
LR_{tw}	86.62	11.14	0.92			0.9868
LR_{infw}	97.25	0.84	1.16			0.9925
RV_{iw}	3.76	13.99	0.05	19.31	62.03	0.9904
RV_{infw}	15.95	0.14	0.20	83.46		0.9975
RV_{dw}	90.21	0.80	1.11	6.46		0.9858
BV_{tw}[a]	6.48	27.27	37.78	0.38		0.7191
TBV_W	17.14			82.75		0.9989
BNV_W	0.22	17.84	0.07	1.55	79.13	0.9881
[N]	4.58	17.45	0.06		77.38	0.9947

[a] highly non-linear and complex interactions involving input variables

Table 10_a. Calculation of Water Duty of IID, for 1989-1996 Crop Consumptive Use [a], and for EC_{iw} = 0.930 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.045896				LR_T[b] = 0.091369			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0454	0.0449	0.0444	0.0437	0.0905	0.0894	0.0883	0.0870
LR_{iw}[c]	0.0432	0.0404	0.0377	0.0350	0.0859	0.0805	0.0751	0.0696
RV_{infw}[d]	1892.0	1891.0	1889.8	1888.6	1985.6	1983.4	1980.9	1978.2
RV_{iw}[d]	1991.8	2101.1	2223.3	2360.7	2090.1	2203.8	2330.5	2472.7
RV_{dw}[e]	86.0	85.0	83.8	82.6	179.6	177.4	174.9	172.2
V_{dw}[f]	86.0	85.0	83.8	82.6	179.6	177.4	174.9	172.2
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	99.6	210.1	333.5	472.1	104.5	220.4	349.6	494.5
BV_{tw}[i]	0.9	1.9	3.0	4.3	2.0	4.2	6.7	9.4
NBV_{tw}[j]	98.7	208.2	330.5	467.8	102.5	216.2	342.9	485.1
$BV_{tw} + RV_{dw}$[l]	86.9	86.9	86.9	86.9	181.6	181.6	181.6	181.6
$V_{tw} + V_{dw}$[k]	185.5	295.1	417.3	554.7	284.1	397.8	524.5	666.7
BV_W[l]	1892.9	1892.9	1892.9	1892.9	1987.6	1987.6	1987.6	1987.6
NBV_W[m]	98.7	208.2	330.5	467.8	102.5	216.2	342.9	485.1
$\%NBV_W$[n]	5.0	9.9	14.9	19.8	4.9	9.8	14.7	19.6
RV_{CR}[o]	1935.8	2042.3	2161.3	2294.7	2031.8	2142.1	2265.3	2403.5
RV_{CR}[p]	1880.1	1983.5	2099.1	2228.6	1973.3	2080.4	2200.2	2334.3
RV_{CR}[q]	1824.4	1924.8	2036.9	2162.6	1914.9	2018.8	2135.0	2265.2

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] %NBV = 100 $(NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_b. Calculation of Water Duty of IID, for 1989-1996 Crop Consumptive Use [a], and EC_{iw} = 1.143 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.069738				LR_T[b] = 0.116688			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0690	0.0683	0.0674	0.0664	0.1155	0.1142	0.1128	0.1111
LR_{iw}[c]	0.0656	0.0614	0.0573	0.0531	0.1097	0.1028	0.0959	0.0889
RV_{infw}[d]	1939.9	1938.3	1936.5	1934.5	2041.9	2038.9	2035.6	2031.8
RV_{iw}[d]	2042.0	2153.7	2278.3	2418.1	2149.3	2265.4	2394.8	2539.8
RV_{dw}[e]	133.9	132.3	130.5	128.5	235.9	232.9	229.6	225.8
V_{dw}[f]	133.9	132.3	130.5	128.5	235.9	232.9	229.6	225.8
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	102.1	215.4	341.7	483.6	107.5	226.5	359.2	508.0
BV_{tw}[i]	1.5	3.1	4.9	6.9	2.7	5.7	9.0	12.7
NBV_{tw}[j]	100.6	212.3	336.9	476.7	104.8	220.9	350.2	495.2
$BV_{tw} + RV_{dw}$[i]	135.4	135.4	135.4	135.4	238.6	238.6	238.6	238.6
$V_{tw} + V_{dw}$[k]	236.0	347.7	472.3	612.1	343.3	459.4	588.8	733.8
BV_W[l]	1941.4	1941.4	1941.4	1941.4	2044.6	2044.6	2044.6	2044.6
NBV_W[m]	100.6	212.3	336.9	476.7	104.8	220.9	350.2	495.2
$\%NBV_W$[n]	4.9	9.9	14.8	19.7	4.9	9.7	14.6	19.5
RV_{CR}[o]	1984.8	2093.5	2214.6	2350.4	2089.2	2202.0	2327.9	2468.6
RV_{CR}[p]	1927.8	2033.3	2150.9	2282.9	2029.1	2138.7	2260.9	2397.6
RV_{CR}[q]	1870.7	1973.1	2087.1	2215.2	1969.0	2075.3	2193.9	2326.6

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_c. Calculation of Water Duty of IID, for 1989-1996 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.0854				LR_T[b] = 0.1255			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0845	0.0836	0.0825	0.0813	0.1242	0.1229	0.1213	0.1195
LR_{iw}[c]	0.0803	0.0752	0.0702	0.0651	0.1180	0.1106	0.1031	0.0956
RV_{infw}[d]	1972.8	1970.7	1968.5	1965.9	2062.2	2058.9	2055.3	2051.2
RV_{iw}	2076.6	2183.7	2315.8	2457.4	2170.8	2287.2	2418.0	2564.0
RV_{dw}[e]	166.8	164.7	162.5	159.9	256.2	252.9	249.3	245.2
V_{dw}[f]	166.8	164.7	162.5	159.9	256.2	252.9	249.3	245.2
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	103.8	219.0	347.4	491.5	108.5	228.8	362.7	512.8
BV_{tw}[i]	1.8	3.9	6.2	8.7	3.0	6.2	9.9	14.0
NBV_{tw}[j]	102.0	215.1	341.2	482.8	105.6	222.5	352.8	498.8
$BV_{tw} + RV_{dw}$[i]	168.6	168.6	168.6	168.6	259.2	259.2	259.2	259.2
$V_{tw} + V_{dw}$[k]	270.6	383.7	509.8	651.4	364.8	481.7	612.0	758.0
BV_W[l]	1974.6	1974.6	1974.6	1974.6	2065.2	2065.2	2065.2	2065.2
NBV_W[m]	102.0	215.1	341.2	482.8	105.6	222.5	352.8	498.8
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.9	9.7	14.6	19.5
RV_{CR}[o]	2018.5	2128.5	2251.0	2388.6	2110.0	2223.9	2350.4	2492.2
RV_{CR}[p]	1960.4	2067.3	2186.2	2319.9	2049.3	2159.9	2425.5	2420.5
RV_{CR}[q]	1902.3	2006.0	2121.5	2251.1	1988.6	2095.9	2215.2	2348.8

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[i] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_d. Calculation of Water Duty of IID, for 1989-1996 Crop Consumptive Use [a], and EC_{iw} = 1.323 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.10204				LR_T[b] = 0.14006			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.1010	0.0999	0.0986	0.0972	0.1387	0.1371	0.1354	0.1334
LR_{iw}[c]	0.0960	0.0899	0.0838	0.0778	0.1317	0.1234	0.1151	0.1067
RV_{infw}[d]	2008.9	2006.4	2003.6	2000.4	2096.7	2093.0	2088.7	2084.0
RV_{iw}[d]	2214.8	2229.3	2357.2	2500.5	2207.1	2232.6	2457.3	2605.0
RV_{dw}[e]	202.9	200.4	197.6	194.4	290.7	287.0	282.7	278.0
V_{dw}[f]	202.9	200.4	197.6	194.4	290.7	287.0	282.7	278.0
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	105.7	222.9	353.6	500.1	110.4	232.6	368.6	521.0
BV_{tw}[i]	2.3	4.8	7.6	10.8	3.4	7.2	11.4	16.1
NBV_{tw}[j]	103.5	218.1	345.9	489.3	106.9	225.4	357.2	504.9
$BV_{tw} + RV_{dw}$[i]	205.2	205.2	205.2	205.2	294.1	294.1	294.1	294.1
$V_{tw} + V_{dw}$[k]	308.7	423.3	551.2	694.5	401.1	519.5	651.3	799.0
BV_W[l]	2011.2	2011.2	2011.2	2011.2	2100.1	2100.1	2100.1	2100.1
NBV_W[m]	103.5	218.1	345.9	489.3	106.9	225.4	357.2	504.9
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.8	9.7	14.5	19.4
RV_{CR}[o]	2055.5	2167.0	2291.2	2430.6	2146.5	2260.5	2388.7	2530.2
RV_{CR}[p]	1996.4	2104.7	2225.3	2360.7	2083.8	2195.4	2320.0	2459.3
RV_{CR}[q]	1937.2	2042.4	2159.4	2290.8	2022.0	2130.4	2251.3	2386.5

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [l] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_e. Calculation of Water Duty of IID, for 1989-1996 Crop Consumptive Use plus 4% [a], and EC_{iw} = 0.930 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.045896				LR_T[b] = 0.091369			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0454	0.0449	0.0444	0.0437	0.0905	0.0894	0.0883	0.0870
LR_{iw}[c]	0.0432	0.0404	0.0377	0.0350	0.0859	0.0805	0.0751	0.0696
RV_{infw}[d]	1967.6	1966.6	1965.4	1964.1	2065.0	2062.7	2060.2	2057.3
RV_{iw}[d]	2071.2	2186.1	2312.3	2456.1	2173.7	2291.9	2423.7	2571.6
RV_{dw}[e]	89.4	88.4	87.2	85.9	186.8	184.5	181.9	179.0
V_{dw}[f]	89.4	88.4	87.2	85.9	186.8	184.5	181.9	179.0
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	103.6	218.5	346.8	491.0	108.7	229.2	363.6	514.3
BV_{tw}[i]	0.9	2.0	3.2	4.5	2.1	4.4	6.9	9.8
NBV_{tw}[j]	102.6	216.5	343.7	486.5	106.6	224.8	356.6	504.5
$BV_{tw} + RV_{dw}$[l]	90.4	90.4	90.4	90.4	188.9	188.9	188.9	188.9
$V_{tw} + V_{dw}$[k]	193.0	306.9	434.0	576.9	295.5	413.7	545.5	693.4
BV_W[l]	1968.6	1968.6	1968.6	1968.6	2067.1	2067.1	2067.1	2067.1
NBV_W[m]	102.6	216.5	343.7	486.5	106.6	224.8	356.6	504.5
$\%NBV_W$[n]	5.0	9.9	14.9	19.8	4.9	9.8	14.7	19.6
RV_{CR}[o]	2015.4	2126.3	2250.2	2389.1	2115.4	2230.2	2358.5	2502.4
RV_{CR}[p]	1959.8	2067.5	2188.0	2323.1	2056.9	2168.6	2293.4	2433.2
RV_{CR}[q]	1904.1	2008.8	2125.8	2257.1	1998.5	2107.0	2228.2	2364.1

[a] for total crop consumptive use of 1878.24 K acre-feet;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] %NBV = 100 $(NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10$_f$. Calculation of Water Duty of IID, for 1989-1996 Crop Consumptive Use plus 4% [a], and EC_{iw} = 1.143 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.069738				LR_T[b] = 0.116688			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0690	0.0683	0.0674	0.0664	0.1155	0.1142	0.1128	0.1111
LR_{tw}[c]	0.0656	0.0614	0.0573	0.0531	0.1097	0.1028	0.0959	0.0889
RV_{infw}[d]	2017.5	2015.9	2014.0	2011.9	2123.6	2120.4	2117.0	2113.1
RV_{tw}[d]	2123.7	2236.8	2369.4	2514.9	2235.3	2356.1	2490.5	2641.3
RV_{dw}[e]	139.3	137.6	135.7	133.6	245.3	242.2	238.7	234.9
V_{dw}[f]	139.3	137.6	135.7	133.6	245.3	242.2	238.7	234.9
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	106.2	224.0	355.4	503.0	111.8	235.6	373.6	528.3
BV_{tw}[i]	1.5	3.2	5.1	7.2	2.8	5.9	9.4	13.3
NBV_{tw}[j]	104.7	220.8	350.3	495.8	109.0	229.7	364.2	515.0
$BV_{tw} + RV_{dw}$[i]	140.8	140.8	140.8	140.8	248.1	248.1	248.1	248.1
$V_{tw} + V_{dw}$[k]	245.5	361.6	491.2	636.6	357.1	477.8	612.3	763.1
BV_W[l]	2019.0	2019.0	2019.0	2019.0	2126.4	2126.4	2126.4	2126.4
NBV_W[m]	104.7	220.8	350.3	495.8	109.0	229.7	364.2	515.0
$\%NBV_W$[n]	4.9	9.9	14.8	19.7	4.9	9.7	14.6	19.5
RV_{CR}[o]	2066.5	2179.7	2305.7	2447.2	2175.2	2292.6	2423.7	2570.2
RV_{CR}[p]	2009.4	2119.5	2242.0	2379.6	2115.1	2229.3	2356.7	2499.2
RV_{CR}[q]	1952.3	2059.2	2178.3	2311.9	2055.0	2166.0	2289.7	2428.2

[a] for total crop consumptive use of 1878.24 K acre-feet;

[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{tw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = \{(V_{et})/(1-LR_{infw})\}$; $RV_{tw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{tw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{tw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{tw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{tw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[i] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] %NBV = 100 $(NBV_W)/RV_{tw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_g. Calculation of Water Duty of IID, for 1989-1996 Crop Consumptive Use plus 4% [a], and EC_{tw} = 1.213 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.0854				LR_T[b] = 0.1255			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0845	0.0836	0.0825	0.0813	0.1242	0.1229	0.1213	0.1195
LR_{tw}[c]	0.0803	0.0752	0.0702	0.0651	0.1180	0.1106	0.1031	0.0956
RV_{infw}[d]	2051.7	2049.6	2047.2	2044.6	2144.7	2141.3	2137.5	2133.2
RV_{tw}[d]	2169.7	2277.3	2408.5	2565.7	2257.6	2379.2	2514.7	2666.5
RV_{dw}[e]	173.5	171.3	169.0	166.3	266.5	263.1	259.3	255.0
V_{dw}[f]	173.5	171.3	169.0	166.3	266.5	263.1	259.3	255.0
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	108.0	227.7	361.3	511.1	112.9	237.9	377.2	533.3
BV_{tw}[i]	1.9	4.0	6.4	9.1	3.1	6.5	10.3	14.5
NBV_{tw}[j]	106.1	223.7	354.9	502.1	109.8	231.4	366.9	518.8
$BV_{tw} + RV_{dw}$[i]	175.4	175.4	175.4	175.4	269.5	269.5	269.5	269.5
$V_{tw} + V_{dw}$[k]	281.4	399.1	530.2	677.4	379.3	501.0	636.5	788.3
BV_W[l]	2053.6	2053.6	2053.6	2053.6	2147.8	2147.8	2147.8	2147.8
NBV_W[m]	106.1	223.7	354.9	502.1	109.8	231.4	366.9	518.8
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.9	9.7	14.6	19.5
RV_{CR}[o]	2101.5	2216.1	2343.9	2486.9	2196.8	2315.4	2447.1	2594.7
RV_{CR}[p]	2043.5	2154.9	2278.9	2418.1	2136.1	2251.4	2379.5	2523.1
RV_{CR}[q]	1985.4	2093.6	2214.1	2349.4	2075.4	2187.4	2311.9	2451.4

[a] for total crop consumptive use of 1878.24 K acre-feet;

[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{tw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{tw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{tw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{tw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{tw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{tw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{tw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_h. Calculation of Water Duty of IID, for 1989-1996 Crop Consumptive Use plus 4% [a], and EC_{iw} = 1.323 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.10204				LR_T[b] = 0.14006			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.1010	0.0999	0.0986	0.0972	0.1387	0.1371	0.1354	0.1334
LR_{iw}[c]	0.0960	0.0899	0.0838	0.0778	0.1317	0.1234	0.1151	0.1067
RV_{infw}[d]	2089.3	2086.7	2083.7	2080.4	2180.6	2176.7	2172.3	2167.4
RV_{iw}[e]	2199.3	2318.5	2445.1	2580.6	2295.4	2410.9	2535.6	2709.2
RV_{dw}[e]	211.1	208.4	205.5	202.2	302.4	298.4	294.0	289.1
V_{dw}[f]	211.1	208.4	205.5	202.2	302.4	298.4	294.0	289.1
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	110.0	231.9	367.7	520.1	114.8	241.9	383.3	541.8
BV_{tw}[i]	2.4	5.0	7.9	11.2	3.6	7.5	11.9	16.8
NBV_{tw}[j]	107.6	226.8	359.8	508.9	111.2	234.4	371.5	525.1
$BV_{tw} + RV_{dw}$[l]	213.4	213.4	213.4	213.4	305.9	305.9	305.9	305.9
$V_{tw} + V_{dw}$[k]	321.0	440.3	573.2	722.3	417.1	540.3	677.4	831.0
BV_W[l]	2091.7	2091.7	2091.7	2091.7	2184.2	2184.2	2184.2	2184.2
NBV_W[m]	107.6	226.8	359.8	508.9	111.2	234.4	371.5	525.1
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.8	9.7	14.5	19.4
RV_{CR}[o]	2140.1	2256.2	2385.5	2530.7	2233.8	2353.5	2487.0	2636.4
RV_{CR}[p]	2081.0	2193.9	2319.6	2460.7	2172.0	2288.5	2418.3	2563.5
RV_{CR}[q]	2021.8	2131.5	2253.7	2390.8	2110.3	2223.4	2349.6	2490.7

[a] for total crop consumptive use of 1878.24 K acre-feet;
[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;
[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;
[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;
[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;
[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});
[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;
[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;
[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;
[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/(RV_{iw})$;
[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 50.5 K ac.ft.)
[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 101 K ac.ft.)
[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_I. Calculation of Water Duty, for 1989-1996 Crop Consumptive Use, and $F_n = 0.90$

	$EC_{iw} = 0.930$		$EC_{iw} = 1.143$		$EC_{iw} = 1.213$		$EC_{iw} = 1.323$	
	LR_W	LR_T	LR_W	LR_T	LR_W	LR_T	LR_W	LR_T
item	0.04590	0.09137	0.06974	0.11669	0.08540	0.12550	0.10204	0.14006
LR_{infw}[c]	0.0459	0.0914	0.0697	0.1167	0.0854	0.1255	0.1020	0.1401
LR_{iw}[c]	0.0413	0.0822	0.0628	0.1050	0.0769	0.1130	0.0918	0.1261
RV_{infw}[d]	1892.9	1987.6	1941.4	2044.6	1974.6	2065.2	2011.2	2100.1
RV_{iw}[a]	2103.2	2208.6	2157.1	2271.8	2194.0	2294.6	2234.7	2333.5
RV_{dw}[e]	86.9	181.6	135.4	238.6	168.6	259.2	205.2	294.1
V_{dw}[f]	297.2	402.5	351.1	465.8	388.0	488.6	428.7	527.5
NBV_{dw}[g]	210.3	220.8	215.7	227.2	219.4	229.5	223.5	233.3
V_{tw}[h]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BV_{tw}[i]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NBV_{tw}[j]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$BV_{tw} + RV_{dw}$[l]	86.9	181.6	135.4	238.6	168.6	259.2	205.2	294.1
$V_{tw} + V_{dw}$[k]	297.2	402.5	351.1	465.8	388.0	488.6	428.7	527.5
BV_W[l]	1892.9	1987.6	1941.4	2044.6	1974.6	2065.2	2011.2	2100.1
NBV_W[m]	210.3	220.8	215.7	227.2	219.4	229.5	223.5	233.3
$\%NBV_W$[n]	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
RV_{CR}[o]	2044.4	2146.8	2096.7	2208.3	2132.7	2230.5	2172.1	2268.4
RV_{CR}[p]	1985.6	2085.0	2036.4	2144.7	2071.3	2166.3	2109.6	2203.1
RV_{CR}[q]	1926.8	2023.3	1976.1	2081.2	2010.0	2102.2	2047.1	2137.8

[a] for total crop consumptive use of 1806 K acre-feet;

[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(F_n)(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})(F_n)]$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K a

Table 10_j . Calculation of Water Duty, for 1989-1996 Crop Consumptive Use, and F_n = 0.95								
	EC_{iw} = 0.930		EC_{iw} = 1.143		EC_{iw} = 1.213		EC_{iw} = 1.323	
	LR_W	LR_T	LR_W	LR_T	LR_W	LR_T	LR_W	LR_T
item	0.045896	0.091369	0.069738	0.116688	0.0854	0.1255	0.10204	0.14006
LR_{infw}[c]	0.0459	0.0914	0.0697	0.1167	0.0854	0.1255	0.1020	0.1401
LR_{iw}[c]	0.0436	0.0868	0.0663	0.1109	0.0811	0.1192	0.0969	0.1331
RV_{infw}[d]	1892.9	1987.6	1941.4	2044.6	1974.6	2065.2	2011.2	2100.1
RV_{iw}	1992.5	2089.2	2040.6	2162.2	2078.6	2173.1	2117.1	2210.7
RV_{dw}[e]	86.9	181.6	135.4	238.6	168.6	259.2	205.2	294.1
V_{dw}[f]	186.5	286.2	237.6	346.2	272.6	367.9	311.1	404.7
NBV_{dw}[g]	99.6	104.6	102.2	107.6	103.9	108.7	105.9	110.5
V_{tw}[h]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BV_{tw}[i]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NBV_{tw}[j]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$BV_{tw} + RV_{dw}$[l]	86.9	181.6	135.4	238.6	168.6	259.2	205.2	294.1
$V_{tw} + V_{dw}$[k]	186.5	286.2	237.6	346.2	272.6	367.9	311.1	404.7
BV_W[l]	1892.9	1987.6	1941.4	2044.6	1974.6	2065.2	2011.2	2100.1
NBV_W[m]	99.6	104.6	102.2	107.6	103.9	108.7	105.9	110.5
$\%NBV_W$[n]	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RV_{CR}[o]	1936.8	2033.8	1986.3	2092.0	2020.4	2113.1	2067.8	2149.0
RV_{CR}[p]	1881.1	1975.3	1929.2	2031.9	1962.3	2052.3	1998.6	2087.1
RV_{CR}[q]	1825.4	1916.8	1872.1	1971.7	1904.2	1991.5	1939.4	2025.3

[a] for total crop consumptive use of 1806 K acre-feet;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(F_n)(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})(F_n)]$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{tw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [l] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_k . Calculation of Water Duty, for 1989-1996 Crop Consumptive Use plus 4%, and F_n = 0.90								
	EC_{iw} = 0.930		EC_{iw} = 1.143		EC_{iw} = 1.213		EC_{iw} = 1.323	
	LR_W	LR_T	LR_W	LR_T	LR_W	LR_T	LR_W	LR_T
item	0.045896	0.091369	0.069738	0.116688	0.0854	0.1255	0.10204	0.14006
LR_{infw}[c]	0.0459	0.0914	0.0697	0.1167	0.0854	0.1255	0.1020	0.1401
LR_{iw}[c]	0.0413	0.0822	0.0628	0.1050	0.0769	0.1130	0.0918	0.1261
RV_{infw}[d]	1968.6	2067.1	2019.0	2126.4	2053.6	2147.8	2091.7	2184.2
RV_{iw}[a]	2187.3	2296.8	2243.4	2362.6	2281.8	2386.4	2324.1	2426.8
RV_{dw}[e]	90.4	188.9	140.8	248.1	175.4	269.5	213.4	305.9
V_{dw}[f]	309.1	418.5	365.1	484.4	403.6	508.2	445.8	548.6
NBV_{dw}[g]	218.7	229.7	224.3	236.3	228.2	238.6	232.4	242.7
V_{tw}[h]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BV_{tw}[i]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NBV_{tw}[j]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$BV_{tw} + RV_{dw}$[l]	86.9	181.6	135.4	238.6	168.6	259.2	205.2	294.1
$V_{tw} + V_{dw}$[k]	309.1	418.5	365.1	484.4	403.6	508.2	445.8	548.6
BV_W[l]	1968.6	2067.1	2019.0	2126.4	2053.6	2147.8	2091.7	2184.2
NBV_W[m]	218.7	229.7	224.3	236.3	228.2	238.6	232.4	242.7
$\%NBV_W$[n]	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
RV_{CR}[o]	2128.5	2235.1	2183.0	2299.1	2220.4	2322.3	2261.5	2361.7
RV_{CR}[p]	2069.7	2173.4	2122.7	2235.6	2159.1	2258.1	2199.0	2296.4
RV_{CR}[q]	2010.9	2111.6	2062.3	2172.1	2097.7	2193.9	2136.5	2231.2

[a] for total crop consumptive use of 1878.24 K acre-feet;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(F_n)(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})(F_n)]$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_I . Calculation of Water Duty, for 1989-1996 Crop Consumptive Use plus 4%, and $F_n = 0.95$								
	$EC_{iw} = 0.930$		$EC_{iw} = 1.143$		$EC_{iw} = 1.213$		$EC_{iw} = 1.323$	
	LR_W	LR_T	LR_W	LR_T	LR_W	LR_T	LR_W	LR_T
item	0.045896	0.091369	0.069738	0.116688	0.0854	0.1255	0.10204	0.14006
LR_{infw}[c]	0.0459	0.0914	0.0697	0.1167	0.0854	0.1255	0.1020	0.1401
LR_{iw}[c]	0.0436	0.0868	0.0663	0.1109	0.0811	0.1192	0.0969	0.1331
RV_{infw}[d]	1968.6	2067.1	2019.0	2126.4	2053.6	2147.8	2091.7	2184.2
RV_{iw}[a]	2072.2	2175.08	2125.3	2238.3	2161.7	2260.8	2200.[illegible]	2299.1
RV_{dw}[e]	90.4	188.9	140.8	248.1	175.4	269.5	213.4	305.9
V_{dw}[f]	194.0	297.7	247.1	360.0	283.5	382.6	323.5	420.9
NBV_{dw}[g]	103.6	108.8	106.3	111.9	108.1	113.0	110.1	115.0
V_{tw}[h]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BV_{tw}[i]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NBV_{tw}[j]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$BV_{tw} + RV_{dw}$[i]	86.9	181.6	135.4	238.6	168.6	259.2	205.2	294.1
$V_{tw} + V_{dw}$[k]	194.0	297.7	247.1	360.0	283.5	382.6	323.5	420.9
BV_W[l]	1968.6	2067.1	2019.0	2126.4	2053.6	2147.8	2091.7	2184.2
NBV_W[m]	103.6	108.8	106.3	111.9	108.1	113.0	110.1	115.0
$\%NBV_W$[n]	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RV_{CR}[o]	2016.5	2117.5	2068.1	2178.1	2103.6	2200.0	2142.5	2237.4
RV_{CR}[p]	1960.8	2059.0	2010.9	2117.9	2045.5	2139.3	2083.3	2175.6
RV_{CR}[q]	1905.1	2000.5	1953.8	2057.8	1987.3	2078.5	2024.1	2113.8

[a] for total crop consumptive use of 1878.24 K acre-feet;
[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;
[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(F_n)(LR)$; assuming $F_{ctw} = 1.19$;
[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})(F_n)]$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;
[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;
[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});
[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;
[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;
[i] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;
[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;
[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 50.5 K ac.ft.)
[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 101 K ac.ft.)
[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1878.24 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 10_m. Comparison of Water Volumes for IID Situation as Affected by Colorado River Salinity, Crop CU, Tailwater Without Non-Uniformity Compensation														
EC_{iw}	LR^a	F_{tw}	F_{ctw}	F_n	V_{et}^b	LR_{infw}^c	RV_{iw}^d	RV_{dw}^e	V_{tw}^f	BV_{tw}^g	BV_w^h	NBV_w^i	$\%NBV_w^j$	$100(BV_w/RV_{iw})^k$
0.930	0.0459	0.05	1.19	1.0	1806.00	0.0454	1991.5	86.0	99.6	0.9	1892.9	98.7	5.0	95.0
		0.10	1.19	1.0	1806.00	0.0449	2101.1	85.0	210.1	1.9	1892.9	208.2	9.9	90.1
		0.15	1.19	1.0	1806.00	0.0444	2223.1	83.8	333.5	3.0	1892.9	330.5	14.9	85.1
		0.20	1.19	1.0	1806.00	0.0437	2360.7	82.6	472.1	4.3	1892.9	467.8	19.8	80.2
	0.0459	0.05	1.19	1.0	1878.24	0.0454	2071.2	89.4	103.6	0.9	1968.6	102.6	5.0	95.0
		0.10	1.19	1.0	1878.24	0.0449	2185.1	88.4	218.5	2.0	1968.6	216.5	9.9	90.1
		0.15	1.19	1.0	1878.24	0.0444	2312.3	87.2	346.8	3.2	1968.6	343.7	14.9	85.1
		0.20	1.19	1.0	1878.24	0.0437	2455.1	85.9	491.0	4.5	1968.6	486.5	19.8	80.2
0.930	0.0914	0.05	1.19	1.0	1806.00	0.0905	2090.1	179.6	104.5	2.0	1987.6	102.5	4.9	95.1
		0.10	1.19	1.0	1806.00	0.0894	2203.8	177.4	220.4	4.2	1987.6	216.2	9.8	90.2
		0.15	1.19	1.0	1806.00	0.0883	2330.5	174.9	349.6	6.7	1987.6	342.9	14.7	85.3
		0.20	1.19	1.0	1806.00	0.0870	2472.7	172.2	494.5	9.4	1987.6	485.1	19.6	80.4
	0.0914	0.05	1.19	1.0	1878.24	0.0905	2173.7	186.8	108.7	2.1	2067.1	106.6	4.9	95.1
		0.10	1.19	1.0	1878.24	0.0894	2291.9	184.5	229.2	4.4	2067.1	224.8	9.8	90.2
		0.15	1.19	1.0	1878.24	0.0883	2423.7	181.9	363.6	6.9	2067.1	356.6	14.7	85.3
		0.20	1.19	1.0	1878.24	0.0870	2571.6	179.0	514.3	9.8	2067.1	504.5	19.6	80.4
1.143	0.0697	0.05	1.19	1.0	1806.00	0.0690	2042.0	133.9	102.1	1.5	1941.4	100.6	4.9	95.1
		0.10	1.19	1.0	1806.00	0.0683	2153.7	132.3	215.4	3.1	1941.4	212.3	9.9	90.1
		0.15	1.19	1.0	1806.00	0.0674	2278.3	130.5	341.7	4.9	1941.4	336.9	14.8	85.2
		0.20	1.19	1.0	1806.00	0.6640	2418.1	128.5	483.6	6.9	1941.4	476.7	19.7	80.3
	0.0697	0.05	1.19	1.0	1878.24	0.0690	2123.7	139.3	106.2	1.5	2019.0	104.7	4.9	95.1
		0.10	1.19	1.0	1878.24	0.0683	2239.8	137.6	224.0	3.2	2019.0	220.8	9.9	90.1
		0.15	1.19	1.0	1878.24	0.0674	2369.4	135.7	355.4	5.1	2019.0	350.3	14.8	85.2
		0.20	1.19	1.0	1878.24	0.6640	2514.9	133.6	503.0	7.2	2019.0	495.8	19.7	80.3
1.143	0.1167	0.05	1.19	1.0	1806.00	0.1155	2149.3	235.9	107.5	2.7	2044.6	104.8	4.9	95.1
		0.10	1.19	1.0	1806.00	0.1142	2265.4	232.9	226.5	5.7	2044.6	220.9	9.7	90.3
		0.15	1.19	1.0	1806.00	0.1128	2394.8	229.6	359.2	9.0	2044.6	350.2	14.6	85.4
		0.20	1.19	1.0	1806.00	0.1111	2539.8	225.8	508.0	12.7	2044.6	495.2	19.5	80.5
	0.1167	0.05	1.19	1.0	1878.24	0.1155	2235.3	245.3	111.8	2.8	2126.4	109.0	4.9	95.1
		0.10	1.19	1.0	1878.24	0.1142	2356.1	242.2	235.6	5.9	2126.4	229.7	9.7	90.3
		0.15	1.19	1.0	1878.24	0.1128	2490.6	238.7	373.6	9.4	2126.4	364.2	14.6	85.4
		0.20	1.19	1.0	1878.24	0.1111	2641.4	234.9	528.3	13.3	2126.4	515.0	19.5	80.5

EC_{iw}	LR[a]	F_{tw}	F_{ctw}	F_n	V_{et}[b]	LR_{infw}[c]	RV_{iw}[d]	RV_{dw}[e]	V_{tw}[f]	BV_{tw}[g]	BV_W[h]	NBV_W[i]	$\%NBV_W$[j]	$100(BV_W/RV_{iw})$[k]
1.213	0.0854	0.05	1.19	1.0	1806.00	0.0845	2076.6	166.8	103.8	1.8	1974.6	102.0	4.9	95.1
		0.10	1.19	1.0	1806.00	0.0836	2189.7	164.7	219.0	3.9	1974.6	215.1	9.8	90.2
		0.15	1.19	1.0	1806.00	0.0825	2315.8	162.5	347.4	6.2	1974.6	341.2	14.7	85.3
		0.20	1.19	1.0	1806.00	0.0813	2457.4	159.9	491.5	8.7	1974.6	482.8	19.6	80.4
	0.0854	0.05	1.19	1.0	1878.24	0.0845	2159.7	173.5	108.0	1.9	2053.6	106.1	4.9	95.1
		0.10	1.19	1.0	1878.24	0.0836	2277.3	171.3	227.7	4.0	2053.6	223.7	9.8	90.2
		0.15	1.19	1.0	1878.24	0.0825	2408.5	169.0	361.3	6.4	2053.6	354.9	14.7	85.3
		0.20	1.19	1.0	1878.24	0.0813	2555.7	166.3	511.1	9.1	2053.6	502.1	19.6	80.4
1.213	0.1255	0.05	1.19	1.0	1806.00	0.1242	2170.8	256.2	108.5	3.0	2065.2	105.6	4.9	95.1
		0.10	1.19	1.0	1806.00	0.1229	2287.7	252.9	228.8	6.2	2065.2	222.5	9.7	90.3
		0.15	1.19	1.0	1806.00	0.1213	2418.0	249.3	362.7	9.9	2065.2	352.8	14.6	85.4
		0.20	1.19	1.0	1806.00	0.1195	2564.0	245.2	512.8	14.0	2065.2	498.8	19.5	80.5
	0.1255	0.05	1.19	1.0	1878.24	0.1242	2257.6	266.5	112.9	3.1	2147.8	109.8	4.9	95.1
		0.10	1.19	1.0	1878.24	0.1229	2379.2	263.1	237.9	6.5	2147.8	231.4	9.7	90.3
		0.15	1.19	1.0	1878.24	0.1213	2514.7	259.3	377.2	10.3	2147.8	366.9	14.6	85.4
		0.20	1.19	1.0	1878.24	0.1195	2666.6	255.0	533.3	14.5	2147.8	518.8	19.5	80.5
1.323	0.1020	0.05	1.19	1.0	1806.00	0.1010	2114.7	202.9	105.7	2.3	2011.2	103.5	4.9	95.1
		0.10	1.19	1.0	1806.00	0.0999	2229.3	200.4	222.9	4.8	2011.2	218.1	9.8	90.2
		0.15	1.19	1.0	1806.00	0.0986	2357.2	197.6	353.6	7.6	2011.2	345.9	14.7	85.3
		0.20	1.19	1.0	1806.00	0.0972	2500.5	194.4	500.1	10.8	2011.2	489.3	19.6	80.4
	0.1020	0.05	1.19	1.0	1878.24	0.1010	2199.3	211.1	110.0	2.4	2091.7	107.6	4.9	95.1
		0.10	1.19	1.0	1878.24	0.0999	2318.5	208.4	231.9	5.0	2091.7	226.8	9.8	90.2
		0.15	1.19	1.0	1878.24	0.0986	2451.5	205.5	367.7	7.9	2091.7	359.8	14.7	85.3
		0.20	1.19	1.0	1878.24	0.0972	2600.6	202.2	520.1	11.2	2091.7	508.9	19.6	80.4
1.323	0.1401	0.05	1.19	1.0	1806.00	0.1387	2207.1	290.7	110.4	3.4	2100.1	106.9	4.8	95.2
		0.10	1.19	1.0	1806.00	0.1371	2325.5	287.0	232.6	7.2	2100.1	225.4	9.7	90.3
		0.15	1.19	1.0	1806.00	0.1354	2457.3	282.7	368.6	11.4	2100.1	357.2	14.5	85.5
		0.20	1.19	1.0	1806.00	0.1334	2605.0	278.0	521.0	16.1	2100.1	504.9	19.4	80.6
	0.1401	0.05	1.19	1.0	1878.24	0.1387	2295.4	302.4	114.8	3.6	2184.2	111.2	4.8	95.2
		0.10	1.19	1.0	1878.24	0.1371	2418.5	298.4	241.9	7.5	2184.2	234.4	9.7	90.3
		0.15	1.19	1.0	1878.24	0.1354	2555.6	294.0	383.3	11.9	2184.2	371.5	14.5	85.5
		0.20	1.19	1.0	1878.24	0.1334	2709.2	289.1	541.8	16.8	2184.2	525.1	19.4	80.6

[a] LR_W is the lower LR value; LR_T is the higher LR value; [b] V_{et} is the estimated crop consumptive use and 4% higher, [c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$;

[d] $RV_{iw} = [(V_{et})/(1-LR_{infw})(F_n)]/(1-F_{tw})$; [e] $RV_{dw} = (LR_{infw})/(1-LR_{infw})](V_{et})$; [f] $V_{tw} = (F_{tw})(RV_{iw})$; [g] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[h] BV_W = total volume of beneficial water = crop CU plus required leaching = $V_{et} + RV_{dw} + BV_{tw}$; [i] $NBV_W = RV_{iw} - BV_W$; [j] $\%NBV_W = 100(NBV_W/RV_{iw})$; [k] % efficiency

Table 10_n. Comparison of Water Volumes for IID as Affected by Colorado River Salinity[a], LR[b], Non-Uniformity Compensation[c] and Crop CU[d]

EC_{iw}[a]	LR[b]	F_n[c]	V_{et}[d]	LR_{irdw}[e]	RV_{iw}[f]	RV_{dw}[g]	V_{dw}[h]	NBV_{dw}[i]	BV_W[j]	NBV_W[k]	$\%NBV_W$[l]	$100(BV_W/RV_{iw})$[m]
0.930	0.0459	0.85	1806.00	0.0459	2226.9	86.9	420.9	334.0	1892.9	334.0	15.0	85.0
		0.90	1806.00	0.0459	2103.2	86.9	297.2	210.3	1892.9	210.3	10.0	90.0
		0.95	1806.00	0.0459	1992.5	86.9	186.5	99.6	1892.9	99.6	5.0	95.0
		0.85	1878.24	0.0459	2316.0	90.4	437.8	347.4	1968.6	347.4	15.0	85.0
		0.90	1878.24	0.0459	2187.3	90.4	309.1	218.7	1968.6	218.7	10.0	90.0
		0.95	1878.24	0.0459	2072.2	90.4	194.0	103.6	1968.6	103.6	5.0	95.0
0.930	0.0914	0.85	1806.00	0.0914	2338.4	181.6	532.4	350.8	1987.6	350.8	15.0	85.0
		0.90	1806.00	0.0914	2208.5	181.6	402.5	220.9	1987.6	220.9	10.0	90.0
		0.95	1806.00	0.0914	2092.2	181.6	286.2	104.6	1987.6	104.6	5.0	95.0
		0.85	1878.24	0.0914	2432.0	188.9	553.7	364.8	2067.1	364.8	15.0	85.0
		0.90	1878.24	0.0914	2296.8	188.9	418.6	229.7	2067.1	229.7	10.0	90.0
		0.95	1878.24	0.0914	2175.9	188.9	297.7	108.8	2067.1	108.8	5.0	95.0
1.143	0.0697	0.85	1806.00	0.0697	2283.9	135.4	477.9	342.5	1941.4	342.5	15.0	85.0
		0.90	1806.00	0.0697	2157.1	135.4	351.1	215.7	1941.4	215.7	10.0	90.0
		0.95	1806.00	0.0697	2043.6	135.4	237.6	102.2	1941.4	102.2	5.0	95.0
		0.85	1878.24	0.0697	2375.2	140.8	497.0	356.2	2019.0	356.2	15.0	85.0
		0.90	1878.24	0.0697	2243.4	140.8	365.2	224.4	2019.0	224.4	10.0	90.0
		0.95	1878.24	0.0697	2125.3	140.8	247.1	106.3	2019.0	106.3	5.0	95.0
1.143	0.1167	0.85	1806.00	0.1167	2405.4	238.6	599.4	360.8	2044.6	360.8	15.0	85.0
		0.90	1806.00	0.1167	2271.8	238.6	465.8	227.2	2044.6	227.2	10.0	90.0
		0.95	1806.00	0.1167	2152.2	238.6	346.2	107.6	2044.6	107.6	5.0	95.0
		0.85	1878.24	0.1167	2501.6	248.1	623.4	375.3	2126.3	375.3	15.0	85.0
		0.90	1878.24	0.1167	2362.6	248.1	484.4	236.3	2126.3	236.3	10.0	90.0
		0.95	1878.24	0.1167	2238.3	248.1	360.1	112.0	2126.3	112.0	5.0	95.0
1.213	0.0854	0.85	1806.00	0.0854	2323.1	168.6	517.1	348.5	1974.6	348.5	15.0	85.0
		0.90	1806.00	0.0854	2194.0	168.6	388.0	219.4	1974.6	219.4	10.0	90.0
		0.95	1806.00	0.0854	2078.6	168.6	272.6	104.0	1974.6	104.0	5.0	95.0
		0.85	1878.24	0.0854	2416.0	175.4	537.8	362.4	2053.6	362.4	15.0	85.0
		0.90	1878.24	0.0854	2281.8	175.4	403.6	228.2	2053.6	228.2	10.0	90.0
		0.95	1878.24	0.0854	2161.7	175.4	283.5	108.1	2053.6	108.1	5.0	95.0
1.213	0.1255	0.85	1806.00	0.1255	2429.6	259.2	623.6	364.4	2065.2	364.4	15.0	85.0
		0.90	1806.00	0.1255	2294.6	259.2	488.6	229.4	2065.2	229.4	10.0	90.0
		0.95	1806.00	0.1255	2173.9	259.2	367.9	108.7	2065.2	108.7	5.0	95.0
		0.85	1878.24	0.1255	2526.8	269.5	648.6	379.1	2147.7	379.1	15.0	85.0
		0.90	1878.24	0.1255	2386.4	269.5	508.2	238.7	2147.7	238.7	10.0	90.0
		0.95	1878.24	0.1255	2260.8	269.5	382.6	113.1	2147.7	113.1	5.0	95.0
1.323	0.1020	0.85	1806.00	0.1020	2366.0	205.2	560.0	354.8	2011.2	354.8	15.0	85.0
		0.90	1806.00	0.1020	2234.7	205.2	428.7	223.5	2011.2	223.5	10.0	90.0
		0.95	1806.00	0.1020	2117.1	205.2	311.1	105.9	2011.2	105.9	5.0	95.0
		0.85	1878.24	0.1020	2460.7	213.4	582.4	369.0	2091.6	369.0	15.0	85.0
		0.90	1878.24	0.1020	2324.1	213.4	445.9	232.5	2091.6	232.5	10.0	90.0
		0.95	1878.24	0.1020	2201.8	213.4	323.6	110.2	2091.6	110.2	5.0	95.0
1.323	0.1401	0.85	1806.00	0.1401	2470.9	294.1	664.9	370.8	2100.1	370.8	15.0	85.0
		0.90	1806.00	0.1401	2333.5	294.1	527.5	233.4	2100.1	233.4	10.0	90.0
		0.95	1806.00	0.1401	2210.7	294.1	404.7	110.6	2100.1	110.6	5.0	95.0
		0.85	1878.24	0.1401	2569.7	305.9	691.5	385.6	2184.1	385.6	15.0	85.0
		0.90	1878.24	0.1401	2426.8	305.9	548.6	242.7	2184.1	242.7	10.0	90.0
		0.95	1878.24	0.1401	2299.1	305.9	420.9	115.0	2184.1	115.0	5.0	95.0

[a] the EC of the irrigation water, dS/m; [b] LR_W is the lower LR value, LR_T is the higher LR value; [c] the compensation factor for non-uniformity/inefficiency;

[d] V_{et} is the estimated crop consumptive use and 4% higher, [e] $LR_{irdw} = [(1-F_{iw}F_{cdw})/(1-F_{iw})](LR)$;

[f] $RV_{iw} = [(V_{et})/(1-LR_{irdw})(F_n)]/(1-F_{iw})$; [g] $RV_{dw} = (LR_{irdw})/(1-LR_{irdw})](V_{et})$; [h] $V_{dw} = (RV_{iw} - V_{et})$; [i] $NBV_{dw} = (RV_{iw} - V_{et} - RV_{dw})$;

[j] BV_W = total volume of beneficial water = crop CU plus required leaching = $V_{et} + RV_{dw} + BV_{tw}$; [k] $NBV_W = RV_{iw} - BV_W$; [l] $\%NBV_W = 100(NBV_W/RV_{iw})$;

[m] % efficiency

Table 11-1a. Calculation of Water Duty of IID, for 1989 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.090264				LR_T[b] = 0.128284			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0894	0.0884	0.0872	0.0860	0.1270	0.1256	0.1240	0.1222
LR_{iw}[c]	0.0849	0.0795	0.0742	0.0688	0.1207	0.1130	0.1054	0.0978
RV_{infw}[d]	1983.2	1981.0	1978.6	1975.9	2068.7	2065.4	2061.6	2057.4
RV_{iw}[1]	2087.6	2201.2	2327.8	2469.8	2177.6	2294.8	2425.4	2571.4
RV_{dw}[e]	177.2	175.0	172.6	169.9	262.7	259.4	255.6	251.4
V_{dw}[f]	177.2	175.0	172.6	169.9	262.7	259.4	255.6	251.4
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	104.4	220.1	349.2	494.0	108.9	229.5	363.8	514.3
BV_{tw}[i]	2.0	4.1	6.6	9.3	3.0	6.4	10.2	14.4
NBV_{tw}[j]	102.4	216.0	342.6	484.7	105.8	223.1	353.6	500.0
$BV_{tw} + RV_{dw}$[i]	179.2	179.2	179.2	179.2	265.8	265.8	265.8	265.8
$V_{tw} + V_{dw}$[k]	281.6	395.2	521.8	663.8	371.6	488.8	619.4	765.7
BV_W[l]	1985.2	1985.2	1985.2	1985.2	2071.8	2071.8	2071.8	2071.8
NBV_W[m]	102.4	216.0	342.6	484.7	105.8	223.1	353.6	500.0
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.9	9.7	14.6	19.4
RV_{CR}[o]	2029.3	2139.7	2262.6	2400.8	2116.7	2230.7	2357.6	2499.9
RV_{CR}[p]	1970.9	2078.2	2197.5	2331.8	2055.8	2166.6	2289.8	2427.9
RV_{CR}[q]	1911.5	2016.6	2132.4	2262.7	1994.9	2102.4	2222.0	2356.0

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 11-1b. Calculation of Water Duty of IID, for 1990 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.097382				LR_T[b] = 0.134344			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0964	0.0953	0.0941	0.0928	0.1330	0.1315	0.1298	0.1280
LR_{iw}[c]	0.0916	0.0858	0.0800	0.0742	0.1264	0.1184	0.1104	0.1024
RV_{infw}[d]	1998.7	1996.3	1993.6	1990.6	2083.0	2079.5	2075.5	2071.0
RV_{iw}[d]	2103.9	2218.1	2345.5	2488.3	2192.7	2310.5	2441.7	2586.8
RV_{dw}[e]	192.7	190.3	187.6	184.6	277.0	273.5	269.5	265.0
V_{dw}[f]	192.7	190.3	187.6	184.6	277.0	273.5	269.5	265.0
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	105.2	221.8	351.8	497.7	109.6	231.1	366.3	517.8
BV_{tw}[i]	2.2	4.5	7.2	10.2	3.2	6.8	10.8	15.3
NBV_{tw}[j]	103.0	217.3	344.6	487.5	106.4	224.2	355.5	502.5
$BV_{tw} + RV_{dw}$[l]	194.8	194.8	194.8	194.8	280.3	280.3	280.3	280.3
$V_{tw} + V_{dw}$[k]	297.9	412.1	539.5	682.3	386.7	504.5	635.7	782.8
BV_W[l]	2000.8	2000.8	2000.8	2000.8	2086.3	2086.3	2086.3	2086.3
NBV_W[m]	103.0	217.3	344.6	487.5	106.4	224.2	355.5	502.5
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.9	9.7	14.6	19.4
RV_{CR}[o]	2045.0	2156.0	2279.8	2418.8	2131.4	2245.9	2373.4	2516.5
RV_{CR}[p]	1986.2	2094.0	2214.2	2349.3	2070.1	2181.3	2305.1	2444.1
RV_{CR}[q]	1927.4	2032.0	2148.7	2279.7	2008.7	2116.7	2236.8	2371.7

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] %NBV = 100 $(NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 11-1c. Calculation of Water Duty of IID, for 1991 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.093359				LR_T[b] = 0.132277			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0924	0.0914	0.0902	0.0889	0.1310	0.1295	0.1278	0.1260
LR_{iw}[c]	0.0878	0.0822	0.0767	0.0711	0.1244	0.1165	0.1087	0.1008
RV_{infw}[d]	1989.9	1987.6	1985.1	1982.3	2078.1	2074.6	2070.7	2066.3
RV_{iw}[a]	2084.7	2208.5	2335.4	2477.8	2187.5	2305.1	2436.1	2582.9
RV_{dw}[e]	183.9	181.6	179.1	176.3	272.1	268.6	264.7	260.3
V_{dw}[f]	183.9	181.6	179.1	176.3	272.1	268.6	264.7	260.3
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	104.7	220.8	350.3	495.6	109.4	230.5	365.4	516.6
BV_{tw}[i]	2.0	4.3	6.9	9.7	3.2	6.7	10.6	15.0
NBV_{tw}[j]	102.7	216.5	343.5	485.9	106.2	223.8	354.8	501.6
$BV_{tw} + RV_{dw}$[l]	186.0	186.0	186.0	186.0	275.3	275.3	275.3	275.3
$V_{tw} + V_{dw}$[k]	288.7	402.5	529.4	671.8	381.5	499.1	630.1	776.9
BV_W[l]	1992.0	1992.0	1992.0	1992.0	2081.3	2081.3	2081.3	2081.3
NBV_W[m]	102.7	216.5	343.5	485.9	106.2	223.8	354.8	501.6
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.9	9.7	14.6	19.4
RV_{CR}[o]	2036.0	2146.8	2270.1	2408.5	2126.5	2240.7	2367.9	2510.7
RV_{CR}[p]	1977.5	2085.0	2204.8	2339.2	2065.3	2176.3	2299.8	2438.5
RV_{CR}[q]	1918.9	2023.3	2139.4	2269.9	2004.1	2111.8	2231.7	2366.3

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 11-1d. Calculation of Water Duty of IID, for 1992 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.080504				LR_T[b] = 0.123182			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0797	0.0788	0.0778	0.0767	0.1220	0.1206	0.1191	0.1173
LR_{iw}[c]	0.0757	0.0709	0.0661	0.0613	0.1159	0.1085	0.1012	0.0939
RV_{infw}[d]	1962.4	1960.5	1958.4	1956.0	2056.8	2053.6	2050.1	2046.1
RV_{iw}	2065.7	2178.3	2304.0	2445.0	2305.0	2251.8	2411.5	2557.6
RV_{dw}[e]	156.4	154.5	152.4	150.0	250.8	247.6	244.1	240.1
V_{dw}[f]	156.4	154.5	152.4	150.0	250.8	247.6	244.1	240.1
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	103.3	217.8	345.6	489.0	108.3	228.2	361.8	511.5
BV_{tw}[i]	1.7	3.6	5.7	8.1	2.9	6.1	9.7	13.7
NBV_{tw}[j]	101.6	214.2	339.8	480.9	105.4	222.1	352.1	497.9
$BV_{tw} + RV_{dw}$[j]	158.1	158.1	158.1	158.1	253.7	253.7	253.7	253.7
$V_{tw} + V_{dw}$[k]	259.7	372.3	498.0	639.0	359.1	475.8	605.8	751.6
BV_W[l]	1964.1	1964.1	1964.1	1964.1	2059.7	2059.7	2059.7	2059.7
NBV_W[m]	101.6	214.2	339.8	480.9	105.4	222.1	352.1	497.9
$\%NBV_W$[n]	4.9	9.8	14.8	19.7	4.9	9.7	14.6	19.5
RV_{CR}[o]	2007.9	2117.4	2239.5	2376.7	2104.7	2218.1	2344.5	2486.0
RV_{CR}[p]	1950.2	2056.5	2175.1	2308.3	2044.1	2154.2	2277.1	2414.5
RV_{CR}[q]	1892.4	1995.6	2110.7	2239.9	1983.6	2090.4	2209.6	2343.0

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + RV_{dw} + BV_{tw};

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 11-1e. Calculation of Water Duty of IID, for 1993 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m

item	volumes in thousands of acre-feet							
	LR_W[b] = 0.080546				LR_T[b] = 0.121952			
	tailwater percentages				tailwater percentages			
	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0797	0.0788	0.0778	0.0767	0.1207	0.1194	0.1179	0.1162
LR_{iw}[c]	0.0758	0.0710	0.0662	0.0614	0.1147	0.1074	0.1002	0.0929
RV_{infw}[d]	1962.5	1960.6	1958.5	1956.1	2054.0	2050.8	2047.3	2043.4
RV_{iw}[e]	2066.8	2178.4	2304.1	2445.1	2162.1	2278.7	2408.6	2564.2
RV_{dw}[e]	156.5	154.6	152.5	150.1	248.0	244.8	241.3	237.4
V_{dw}[f]	156.5	154.6	152.5	150.1	248.0	244.8	241.3	237.4
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	103.3	217.8	345.6	489.0	108.1	227.9	361.3	510.8
BV_{tw}[i]	1.7	3.6	5.8	8.1	2.9	6.0	9.5	13.5
NBV_{tw}[j]	101.6	214.2	339.9	480.9	105.3	221.9	351.8	497.4
$BV_{tw} + RV_{dw}$[i]	158.2	158.2	158.2	158.2	250.8	250.8	250.8	250.8
$V_{tw} + V_{dw}$[k]	259.8	372.4	498.1	639.1	356.1	472.7	602.6	748.2
BV_W[l]	1964.2	1964.2	1964.2	1964.2	2056.8	2056.8	2056.8	2056.8
NBV_W[m]	101.6	214.2	339.9	480.9	105.3	221.9	351.8	497.4
$\%NBV_W$[n]	4.9	9.8	14.8	19.7	4.9	9.7	14.6	19.5
RV_{CR}[o]	2007.9	2117.4	2239.5	2376.7	2101.6	2215.0	2341.3	2482.9
RV_{CR}[p]	1950.2	2054.3	2175.1	2308.3	2041.1	2151.3	2274.0	2411.5
RV_{CR}[q]	1892.4	1995.6	2110.7	2239.9	1980.6	2087.6	2206.6	2340.0

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[i] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 11-1f. Calculation of Water Duty of IID, for 1994 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.08154				LR_T[b] = 0.12331			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0807	0.0798	0.0788	0.0777	0.1221	0.1207	0.1192	0.1175
LR_{iw}[c]	0.0767	0.0718	0.0670	0.0621	0.1160	0.1086	0.1013	0.0940
RV_{infw}[d]	1964.6	1962.7	1960.5	1958.1	2057.1	2053.9	2050.4	2046.3
RV_{iw}[e]	2068.0	2180.7	2306.5	2447.6	2185.4	2282.1	2412.2	2557.9
RV_{dw}[e]	158.6	156.7	154.5	152.1	251.1	247.9	244.4	240.3
V_{dw}[f]	158.6	156.7	154.5	152.1	251.1	247.9	244.4	240.3
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	103.4	218.1	346.0	489.5	108.3	228.2	361.8	511.6
BV_{tw}[i]	1.7	3.7	5.8	8.3	2.9	6.1	9.7	13.7
NBV_{tw}[j]	101.7	214.4	340.1	481.3	105.4	222.1	352.2	497.9
$BV_{tw} + RV_{dw}$[i]	160.3	160.3	160.3	160.3	254.0	254.0	254.0	254.0
$V_{tw} + V_{dw}$[k]	262.0	374.7	500.5	641.6	359.4	476.1	606.2	751.9
BV_W[l]	1966.3	1966.3	1966.3	1966.3	2060.0	2060.0	2060.0	2060.0
NBV_W[m]	101.7	214.4	340.1	481.3	105.4	222.1	352.2	497.9
$\%NBV_W$[n]	4.9	9.8	14.7	19.7	4.9	9.7	14.6	19.5
RV_{CR}[o]	2010.1	2119.7	2242.0	2379.2	2104.9	2218.3	2344.8	2486.5
RV_{CR}[p]	1952.3	2058.7	2177.5	2310.8	2044.4	2154.5	2277.3	2415.0
RV_{CR}[q]	1894.5	1997.8	2113.0	2242.4	1983.8	2090.7	2209.9	2343.5

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 11-1g. Calculation of Water Duty of IID, for 1995 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.079034				LR_T[b] = 0.121113			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0782	0.0774	0.0764	0.0753	0.1199	0.1186	0.1171	0.1154
LR_{iw}[c]	0.0743	0.0696	0.0649	0.0602	0.1139	0.1067	0.0995	0.0923
RV_{infw}[d]	1959.3	1957.4	1955.4	1953.0	2052.0	2048.9	2045.4	2041.5
RV_{iw}	2062.4	2172.9	2300.4	2441.3	2150.0	2278.6	2406.4	2555.9
RV_{dw}[e]	153.3	151.4	149.4	147.0	246.0	242.9	239.4	235.5
V_{dw}[f]	153.3	151.4	149.4	147.0	246.0	242.9	239.4	235.5
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	103.1	217.5	345.1	488.3	108.0	227.7	361.0	510.4
BV_{tw}[i]	1.7	3.5	5.6	8.0	2.8	6.0	9.5	13.4
NBV_{tw}[j]	101.4	213.9	339.4	480.3	105.2	221.7	351.5	497.0
$BV_{tw} + RV_{dw}$[i]	155.0	155.0	155.0	155.0	248.9	248.9	248.9	248.9
$V_{tw} + V_{dw}$[k]	256.4	368.9	494.4	635.3	354.0	470.6	600.4	745.9
BV_W[l]	1961.0	1961.0	1961.0	1961.0	2054.9	2054.9	2054.9	2054.9
NBV_W[m]	101.4	213.9	339.4	480.3	105.2	221.7	351.5	497.0
$\%NBV_W$[n]	4.9	9.8	14.8	19.7	4.9	9.7	14.6	19.5
RV_{CR}[o]	2004.7	2114.2	2236.1	2373.1	2099.6	2213.0	2339.2	2480.6
RV_{CR}[p]	1947.0	2053.4	2171.8	2304.8	2039.2	2149.4	2271.9	2409.3
RV_{CR}[q]	1889.3	1992.6	2107.5	2236.5	1978.8	2085.7	2204.6	2337.9

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{Infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + RV_{dw} + BV_{tw};

[i] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] %NBV = 100 $(NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 11-1h. Calculation of Water Duty of IID, for 1996 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.079230				LR_T[b] = 0.118697			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0784	0.0776	0.0766	0.0755	0.1175	0.1162	0.1147	0.1131
LR_{iw}[c]	0.0745	0.0698	0.0651	0.0604	0.1116	0.1046	0.0975	0.0904
RV_{infw}[d]	1959.7	1957.8	1955.8	1953.4	2046.5	2043.4	2040.0	2036.2
RV_{iw}	2062.9	2175.4	2300.9	2441.8	2164.2	2270.5	2400.0	2545.3
RV_{dw}[e]	153.7	151.8	149.8	147.4	240.5	237.4	234.0	230.2
V_{dw}[f]	153.7	151.8	149.8	147.4	240.5	237.4	234.0	230.2
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	103.1	217.5	345.1	488.4	107.7	227.0	360.0	509.1
BV_{tw}[i]	1.7	3.6	5.6	8.0	2.8	5.8	9.2	13.0
NBV_{tw}[j]	101.5	214.0	339.5	480.4	105.0	221.2	350.8	496.0
$BV_{tw} + RV_{dw}$[l]	155.4	155.4	155.4	155.4	243.2	243.2	243.2	243.2
$V_{tw} + V_{dw}$[k]	256.9	369.4	494.9	635.8	348.2	464.5	594.0	739.3
BV_W[l]	1961.4	1961.4	1961.4	1961.4	2049.2	2049.2	2049.2	2049.2
NBV_W[m]	101.5	214.0	339.5	480.4	105.0	221.2	350.8	496.0
$\%NBV_W$[n]	4.9	9.8	14.8	19.7	4.9	9.7	14.6	19.5
RV_{CR}[o]	2005.1	2114.7	2236.6	2373.6	2093.9	2207.0	2332.9	2474.2
RV_{CR}[p]	1947.4	2053.8	2172.3	2305.3	2033.7	2143.5	2265.8	2403.0
RV_{CR}[q]	1889.7	1993.0	2107.9	2237.0	1973.5	2080.0	2198.7	2331.9

[a] for total crop consumptive use of 1806K acre-feet ;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

[o] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 50.5 K ac.ft.)

[p] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 101 K ac.ft.)

[q] RV_{CR} is the required volume of Colorado River water, where $V_{et} - V_{rw}$ = 1806 KAF - (effective rainfall of 151.5 K ac.ft.)

Table 11-2a. Calculation of Water Duty of IID, for 1989 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.090264				LR_T[b] = 0.128284			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0894	0.0884	0.0872	0.0860	0.1270	0.1256	0.1240	0.1222
LR_{iw}[c]	0.0849	0.0795	0.0742	0.0688	0.1207	0.1130	0.1054	0.0978
RV_{infw}[d]	1986.0	1983.8	1981.3	1978.6	2071.6	2068.2	2064.5	2060.2
RV_{iw}[d]	2080.0	2220.2	2331.0	2472.3	2340.6	2298.0	2428.9	2575.6
RV_{dw}[e]	177.5	175.3	172.8	170.1	263.1	259.7	256.0	251.7
V_{dw}[f]	177.5	175.3	172.8	170.1	263.1	259.7	256.0	251.7
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
V_{tw}[h]	104.5	220.4	349.6	494.7	109.0	229.8	364.3	515.1
BV_{tw}[i]	2.0	4.2	6.6	9.3	3.0	6.4	10.2	14.4
NBV_{tw}[j]	102.6	216.3	343.1	485.3	106.0	223.4	354.1	500.7
$BV_{tw} + RV_{dw}$[i]	179.4	179.4	179.4	179.4	266.1	266.1	266.1	266.1
$V_{tw} + V_{dw}$[k]	282.0	395.7	522.5	664.8	372.1	489.5	620.4	766.8
BV_W[l]	1987.9	1987.9	1987.9	1987.9	2074.6	2074.6	2074.6	2074.6
NBV_W[m]	102.6	216.3	343.1	485.3	106.0	223.4	354.2	500.7
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.9	9.7	14.6	19.4

[a] for total net crop consumptive use of 1808.5 K acre-feet;

[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

Table 11-2b. Calculation of Water Duty of IID, for 1990 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m

	volumes in thousands of acre-feet							
	LR_W[b] = 0.097382				LR_T[b] = 0.134344			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0964	0.0953	0.0941	0.0928	0.1330	0.1315	0.1298	0.1280
LR_{iw}[c]	0.0916	0.0858	0.0800	0.0742	0.1264	0.1184	0.1104	0.1024
RV_{infw}[d]	1960.4	1958.1	1955.4	1952.5	2043.1	2039.6	2035.7	2031.3
RV_{iw}[d]	2083.6	2175.6	2300.5	2440.6	2180.7	2266.3	2395.0	2539.1
RV_{dw}[e]	189.0	186.7	184.0	181.1	271.7	268.2	264.3	259.9
V_{dw}[f]	189.0	186.7	184.0	181.1	271.7	268.2	264.3	259.9
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	103.2	217.6	345.1	488.1	107.5	226.6	359.2	507.8
BV_{tw}[i]	2.1	4.5	7.1	10.0	3.2	6.7	10.6	15.0
NBV_{tw}[j]	101.1	213.1	338.0	478.1	104.4	219.9	348.7	492.9
$BV_{tw} + RV_{dw}$[i]	191.1	191.1	191.1	191.1	274.9	274.9	274.9	274.9
$V_{tw} + V_{dw}$[k]	292.2	404.2	529.1	669.2	379.3	494.9	623.6	767.8
BV_W[l]	1962.5	1962.5	1962.5	1962.5	2046.3	2046.3	2046.3	2046.3
NBV_W[m]	101.1	213.1	338.0	478.1	104.4	219.9	348.7	492.9
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.9	9.7	14.6	19.4

[a] for total net crop consumptive use of 1771.4 K acre-feet;
[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;
[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;
[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;
[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;
[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});
[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;
[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;
[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [i] $V_{tw} + V_{dw}$ = total volume of drainage water;
[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] %NBV = 100 (NBV_W)/RV_{iw};

Table 11-2c. Calculation of Water Duty of IID, for 1991 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.093359				LR_T[b] = 0.132277			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0924	0.0914	0.0902	0.0889	0.1310	0.1295	0.1278	0.1260
LR_{iw}[c]	0.0878	0.0822	0.0767	0.0711	0.1244	0.1165	0.1087	0.1008
RV_{infw}[d]	1793.5	1791.4	1789.1	1786.6	1873.0	1869.8	1866.3	1862.3
RV_{iw}[d]	1887.9	1990.5	2104.9	2233.2	1971.6	2077.6	2195.6	2327.9
RV_{dw}[e]	165.8	163.7	161.4	158.9	245.3	242.1	238.6	234.6
V_{dw}[f]	165.8	163.7	161.4	158.9	245.3	242.1	238.6	234.6
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	94.4	199.0	315.7	446.6	98.6	207.8	329.3	465.6
BV_{tw}[i]	1.8	3.9	6.2	8.7	2.9	6.0	9.5	13.5
NBV_{tw}[j]	92.5	195.2	309.6	437.9	95.7	201.7	319.8	452.1
$BV_{tw} + RV_{dw}$[l]	167.6	167.6	167.6	167.6	248.1	248.1	248.1	248.1
$V_{tw} + V_{dw}$[k]	260.2	362.8	477.2	605.5	343.9	449.9	567.9	700.2
BV_W[l]	1795.3	1795.3	1795.3	1795.3	1875.8	1875.8	1875.8	1875.8
NBV_W[m]	92.5	195.2	309.6	437.9	95.7	201.7	319.8	452.1
$\%NBV_W$[n]	4.9	9.8	14.7	19.6	4.9	9.7	14.6	19.4

[a] for total net crop consumptive use of 1627.7 K acre-feet;

[b] $LR = LR_W$ or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

Table 11-2d. Calculation of Water Duty of IID, for 1992 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m

item	volumes in thousands of acre-feet							
	LR_W[b] = 0.080504				LR_T[b] = 0.123182			
	tailwater percentages				tailwater percentages			
	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0797	0.0788	0.0778	0.0767	0.1220	0.1206	0.1191	0.1173
LR_{iw}[c]	0.0757	0.0709	0.0661	0.0613	0.1159	0.1085	0.1012	0.0939
RV_{infw}[d]	1590.5	1588.9	1587.2	1585.3	1667.0	1664.4	1661.5	1658.3
RV_{iw}[d]	1674.2	1765.5	1867.0	1981.6	1754.7	1849.3	1954.7	2072.8
RV_{dw}[e]	126.8	125.2	123.5	121.6	203.3	200.7	197.8	194.6
V_{dw}[f]	126.8	125.2	123.5	121.6	203.3	200.7	197.8	194.6
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	83.7	176.5	280.1	396.3	87.7	184.9	293.2	414.6
BV_{tw}[i]	1.4	2.9	4.7	6.6	2.3	4.9	7.8	11.1
NBV_{tw}[j]	82.3	173.6	275.4	389.7	85.4	180.0	285.4	403.5
$BV_{tw} + RV_{dw}$[j]	128.2	128.2	128.2	128.2	205.6	205.6	205.6	205.6
$V_{tw} + V_{dw}$[k]	210.5	301.8	403.6	517.9	291.0	385.6	491.0	609.1
BV_W[l]	1591.9	1591.9	1591.9	1591.9	1669.3	1669.3	1669.3	1669.3
NBV_W[m]	82.3	173.6	275.4	389.7	85.4	180.0	285.4	403.5
$\%NBV_W$[n]	4.9	9.8	14.8	19.7	4.9	9.7	14.6	19.5

[a] for total net crop consumptive use of 1463.7 K acre-feet;

[b] LR = LR_W or LR_T , the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

Table 11-2e. Calculation of Water Duty of IID, for 1993 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m

item	volumes in thousands of acre-feet							
	LR_W[b] = 0.080546				LR_T[b] = 0.121952			
	tailwater percentages				tailwater percentages			
	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0797	0.0788	0.0778	0.0767	0.1207	0.1194	0.1179	0.1162
LR_{iw}[c]	0.0758	0.0710	0.0662	0.0614	0.1147	0.1074	0.1002	0.0929
RV_{infw}[d]	1710.2	1708.5	1706.7	1704.6	1789.9	1787.1	1784.1	1780.6
RV_{iw}[d]	1800.2	1899.3	2007.8	2130.7	1884.1	1985.7	2098.9	2222.8
RV_{dw}[e]	136.4	134.7	132.9	130.8	216.1	213.3	210.3	206.8
V_{dw}[f]	136.4	134.7	132.9	130.8	216.1	213.3	210.3	206.8
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	90.0	189.8	301.2	426.1	94.2	198.6	314.8	445.2
BV_{tw}[i]	1.5	3.2	5.0	7.1	2.5	5.2	8.3	11.7
NBV_{tw}[j]	88.5	186.7	296.2	419.1	91.7	193.3	306.5	433.4
$BV_{tw} + RV_{dw}$[i]	137.9	137.9	137.9	137.9	218.6	218.6	218.6	218.6
$V_{tw} + V_{dw}$[k]	226.4	324.5	434.0	556.9	310.3	411.9	525.1	652.0
BV_W[l]	1711.7	1711.7	1711.7	1711.7	1792.4	1792.4	1792.4	1792.4
NBV_W[m]	88.5	186.7	296.2	419.1	91.7	193.3	306.5	433.4
$\%NBV_W$[n]	4.9	9.8	14.8	19.7	4.9	9.7	14.6	19.5

[a] for total net crop consumptive use of 1573.8 K acre-feet;

[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[i] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [l] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

Table 11-2f. Calculation of Water Duty of IID, for 1994 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m								
	volumes in thousands of acre-feet							
	LR_W[b] = 0.08154				LR_T[b] = 0.12331			
	tailwater percentages				tailwater percentages			
item	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0807	0.0798	0.0788	0.0777	0.1221	0.1207	0.1192	0.1175
LR_{iw}[c]	0.0767	0.0718	0.0670	0.0621	0.1160	0.1086	0.1013	0.0940
RV_{infw}[d]	1909.5	1907.7	1905.6	1903.2	1999.5	1996.4	1992.9	1989.0
RV_{iw}[d]	2010.0	2119.6	2241.8	2379.0	2104.7	2219.2	2344.8	2486.3
RV_{dw}[e]	154.1	152.3	150.2	147.8	244.1	241.0	237.5	233.6
V_{dw}[f]	154.1	152.3	150.2	147.8	244.1	241.0	237.5	233.6
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	100.5	212.0	336.3	475.8	105.2	221.8	351.7	497.3
BV_{tw}[i]	1.7	3.6	5.7	8.0	2.8	5.9	9.4	13.3
NBV_{tw}[j]	98.8	208.4	330.6	467.8	102.4	215.9	342.3	484.0
$BV_{tw} + RV_{dw}$[l]	155.8	155.8	155.8	155.8	246.9	246.9	246.9	246.9
$V_{tw} + V_{dw}$[k]	254.6	364.2	486.4	623.6	349.3	462.8	589.2	730.9
BV_W[l]	1911.2	1911.2	1911.2	1911.2	2002.3	2002.3	2002.3	2002.3
NBV_W[m]	98.8	208.4	330.6	467.8	102.4	215.9	342.3	484.0
$\%NBV_W$[n]	4.9	9.8	14.7	19.7	4.9	9.7	14.6	19.5

[a] for total net crop consumptive use of 1755.4 K acre-feet;
[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;
[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;
[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;
[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;
[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});
[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;
[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;
[i] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;
[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

Table 11-2g. Calculation of Water Duty of IID, for 1995 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m

item	volumes in thousands of acre-feet							
	LR_W[b] = 0.079034				LR_T[b] = 0.121113			
	tailwater percentages				tailwater percentages			
	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0782	0.0774	0.0764	0.0753	0.1199	0.1186	0.1171	0.1154
LR_{iw}[c]	0.0743	0.0696	0.0649	0.0602	0.1139	0.1067	0.0995	0.0923
RV_{Infw}[d]	1980.5	1978.6	1976.5	1974.1	2074.2	2071.0	2067.5	2063.6
RV_{iw}	2088.7	2186.4	2285.3	2467.6	2183.4	2301.1	2432.4	2579.4
RV_{dw}[e]	155.0	153.1	151.0	148.6	248.7	245.5	242.0	238.1
V_{dw}[f]	155.0	153.1	151.0	148.6	248.7	245.5	242.0	238.1
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	104.2	219.8	348.8	493.5	109.2	230.1	364.9	515.9
BV_{tw}[i]	1.7	3.6	5.7	8.0	2.9	6.1	9.6	13.5
NBV_{tw}[j]	102.5	216.3	343.1	485.5	106.3	224.0	355.3	502.3
$BV_{tw} + RV_{dw}$[i]	156.7	156.7	156.7	156.7	251.6	251.6	251.6	251.6
$V_{tw} + V_{dw}$[k]	259.2	372.9	499.8	642.1	357.9	475.6	606.9	753.9
BV_W[l]	1982.2	1982.2	1982.2	1982.2	2077.1	2077.1	2077.1	2077.1
NBV_W[m]	102.5	216.3	343.1	485.5	106.3	224.0	355.3	502.3
$\%NBV_W$[n]	4.9	9.8	14.8	19.7	4.9	9.7	14.6	19.5

[a] for total net crop consumptive use of 1825.5 K acre-feet;

[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming $F_{ctw} = 1.19$;

[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{Infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] %NBV = 100 $(NBV_W)/RV_{iw}$;

Table 11-2h. Calculation of Water Duty of IID, for 1996 Crop Consumptive Use [a], and EC_{iw} = 1.213 dS/m

item	volumes in thousands of acre-feet							
	LR_W[b] = 0.079230				LR_T[b] = 0.118697			
	tailwater percentages				tailwater percentages			
	5%	10%	15%	20%	5%	10%	15%	20%
LR_{infw}[c]	0.0784	0.0776	0.0766	0.0755	0.1175	0.1162	0.1147	0.1131
LR_{iw}[c]	0.0745	0.0698	0.0651	0.0604	0.1116	0.1046	0.0975	0.0904
RV_{infw}[d]	1998.8	1996.9	1994.7	1992.4	2087.3	2084.2	2080.7	2076.8
RV_{iw}	2104.0	2218.7	2346.8	2490.4	2197.1	2315.7	2447.9	2598.0
RV_{dw}[e]	156.8	154.9	152.7	150.4	245.3	242.2	238.7	234.8
V_{dw}[f]	156.8	154.9	152.7	150.4	245.3	242.2	238.7	234.8
NBV_{dw}[g]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V_{tw}[h]	105.2	221.9	352.0	498.1	109.9	231.6	367.2	519.2
BV_{tw}[i]	1.7	3.6	5.8	8.1	2.8	5.9	9.4	13.3
NBV_{tw}[j]	103.5	218.2	346.3	489.9	107.0	225.6	357.8	505.9
$BV_{tw} + RV_{dw}$[l]	158.5	158.5	158.5	158.5	248.1	248.1	248.1	248.1
$V_{tw} + V_{dw}$[k]	262.0	376.7	504.8	648.4	355.1	473.7	605.9	754.0
BV_W[l]	2000.5	2000.5	2000.5	2000.5	2090.1	2090.1	2090.1	2090.1
NBV_W[m]	103.5	218.2	346.3	489.9	107.0	225.6	357.8	505.9
$\%NBV_W$[n]	4.9	9.8	14.8	19.7	4.9	9.7	14.6	19.5

[a] for total net crop consumptive use of 1842.0 K acre-feet;

[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw}F_{ctw})(LR)$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})]/(1-F_{tw})$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1806K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [l] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

Table 12a. Variation in Required Leaching (LR_{intw}) and Irrigation Requirement (RV_{iw})[1], 1989-1996

Required Volumes of Irrigation Water, RV_{iw}, in thousands of acre-feet

year	LR_W	tailwater percentages				LR_T	tailwater percentages			
		5%	10%	15%	20%		5%	10%	15%	20%
1989	0.0903	1970.9	2078.2	2197.5	2331.8	0.1283	2055.8	2166.6	2289.8	2427.9
1990	0.0974	1986.2	2094.0	2214.0	2349.3	0.1343	2070.1	2181.3	2305.1	2444.1
1991	0.0934	1977.5	2085.0	2204.8	2339.2	0.1323	2065.3	2176.3	2299.8	2438.5
1992	0.0805	1950.2	2056.5	2175.1	2308.3	0.1232	2044.1	2154.2	2277.1	2414.5
1993	0.0805	1950.2	2054.3	2175.1	2308.3	0.1220	2041.1	2151.3	2274.0	2411.5
1994	0.0815	1952.3	2058.7	2177.5	2310.8	0.1233	2044.4	2154.5	2277.3	2415.0
1995	0.0790	1947.0	2053.4	2171.8	2304.8	0.1211	2039.2	2149.4	2271.9	2409.3
1996	0.0792	1947.4	2053.8	2172.3	2305.3	0.1187	2033.7	2143.5	2265.8	2403.0
mean	0.08523	1960.2	2066.7	2186	2319.7	0.12539	2049.2	2159.6	2282.6	2420.5
variance	0.000053	241.5	268.2	281.3	310.2	0.000031	170.6	183.7	197.6	216.4
SD	0.007284	15.5	16.4	16.8	17.6	0.005607	13.1	13.6	14.1	14.7
SE	0.002575	5.5	5.8	5.9	6.2	0.001982	4.6	4.8	5	5.2
CV	9%	1%	1%	1%	1%	4%	1%	1%	1%	1%

[1] assuming an effective annual rainfall of 101 thousand acre-feet, V_{el} = 1806 thousand acre-feet; EC_{iw} = 1.213 dS/m.

Table 12b. Variation in Required Leaching (LR_{infw}) and Irrigation Requirement (RV_{iw})[1], 1989-1996

Required Volumes of Irrigation Water, RV_{iw}, in thousands of acre-feet

year	LR_W	tailwater percentages				LR_T	tailwater percentages			
		5%	10%	15%	20%		5%	10%	15%	20%
1989	0.0903	2090.5	2204.2	2331.0	2473.3	0.1283	2180.6	2298.0	2428.9	2575.3
1990	0.0974	2063.6	2175.6	2300.5	2440.6	0.1343	2150.7	2266.3	2395.0	2539.2
1991	0.0934	1887.9	1990.5	2104.9	2233.2	0.1323	1971.6	2077.6	2195.6	2327.9
1992	0.0805	1674.2	1765.5	1867.3	1981.6	0.1232	1754.7	1849.3	1954.7	2072.8
1993	0.0805	1800.2	1898.3	2007.8	2130.7	0.1220	1884.1	1985.7	2098.9	2225.8
1994	0.0815	2010.0	2119.6	2241.8	2379.0	0.1233	2104.7	2218.2	2344.6	2486.3
1995	0.0790	2084.7	2198.4	2325.3	2467.6	0.1211	2183.4	2301.1	2342.4	2579.4
1996	0.0792	2104.0	2218.7	2346.8	2490.4	0.1187	2197.1	2315.7	2447.9	2596.0
mean	0.08523	1964.4	2071.3	2190.7	2324.5	0.12539	2053.4	2164.0	2276.0	2425.3
variance	0.000053	25544.5	28389.5	31748.2	35723.7	0.000031	27200.6	30208.6	31038.0	37946.1
SD	0.007284	159.8	168.5	178.2	189.0	0.005607	164.9	173.8	176.2	194.8
SE	0.002575	56.5	59.6	63.0	66.8	0.001982	58.3	61.4	62.3	68.9
CV	9%	8%	8%	8%	8%	4%	8%	8%	8%	8%

[1] assuming an effective annual rainfall of 101 thousand acre-feet, V_{et} = variable with year; EC_{iw} = 1.213 dS/m.

Table 13a. IID Water Requirement for 2000-2002 Crop Consumptive Use [a] and EC_{iw} = 1.0909 dS/m						
	volumes in thousands of acre-feet					
	LR_W [b] = 0.058153			LR_T [b] = 0.105783		
	tailwater percentages_F_n			tailwater percentages_F_n		
item	5%_0.95	10%_0.95	15%_0.95	5%_1.0	10%_1.0	15%_1.0
LR_{infw} [c]	0.0576	0.0569	0.0562	0.1047	0.1035	0.1022
LR_{iw} [c]	0.0520	0.0487	0.0454	0.0995	0.0932	0.0869
RV_{infw} [d]	1809.5	1808.2	1806.8	1904.8	1902.3	1899.5
RV_{iw} [d]	2004.9	2114.9	2227.6	2006.0	2115.6	2234.7
RV_{dw} [e]	104.2	102.9	101.6	199.5	197.0	194.2
V_{dw} [f]	199.4	198.1	196.6	199.5	197.0	194.2
NBV_{dw} [g]	95.2	95.2	95.1	0.0	0.0	0.0
V_{tw} [h]	100.2	211.5	335.6	100.3	211.4	335.2
BV_{tw} [i]	1.1	2.4	3.7	2.3	4.8	7.5
NBV_{tw} [j]	99.1	209.1	331.9	98.0	206.6	327.7
$BV_{tw} + RV_{dw}$ [l]	105.3	105.3	105.3	201.7	201.7	201.7
$V_{tw} + V_{dw}$ [k]	299.7	409.6	532.3	299.7	408.3	529.4
BV_W [l]	1810.6	1810.6	1810.6	1907.0	1907.0	1907.0
NBV_W [m]	194.4	304.3	427.0	98.0	206.6	327.7
$\%NBV_W$ [n]	9.7	14.4	19.1	4.9	9.8	14.7

[a] for total crop consumptive use of 1,705,289 acre-feet (= $V_{et} - V_{rw}$), where V_{rw} = effective rain = $E_P + T_P$;
[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;
[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw})(F_n)(LR_{infw})$; assuming $F_{ctw} = 1.19$;
[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})][1/(F_n)(1-F_{tw})]$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;
[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;
[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});
[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;
[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1654.293 K acre-feet + $RV_{dw} + BV_{tw}$;
[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;
[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

Table 13b. Calculation of IID Water Requirement for 2000 Crop Consumptive Use [a] and EC_{iw} = 1.059 dS/m

	volumes in thousands of acre-feet					
	LR_W[b] = 0.060004			LR_T[b] = 0.104388		
	tailwater percentages_F_n			tailwater percentages_F_n		
item	5%_0.95	10%_0.95	15%_0.95	5%_1.0	10%_1.0	15%_1.0
LR_{infw}[c]	0.0594	0.0587	0.0580	0.1033	0.1022	0.1009
LR_{iw}[c]	0.0536	0.0502	0.0468	0.0982	0.0920	0.0858
RV_{infw}[d]	1812.6	1811.3	1809.9	1901.4	1898.9	1896.2
RV_{iw}[e]	2008.4	2118.6	2241.3	2001.5	2109.9	2230.8
RV_{dw}[e]	107.7	106.4	105.0	196.5	194.0	191.3
V_{dw}[f]	203.1	201.7	200.2	196.5	194.0	191.3
NBV_{dw}[g]	95.4	95.3	95.3	0.0	0.0	0.0
V_{tw}[h]	100.4	211.8	336.2	100.1	211.0	334.6
BV_{tw}[i]	1.2	2.4	3.9	2.2	4.7	7.4
NBV_{tw}[j]	99.3	209.4	332.3	97.9	206.3	327.2
$BV_{tw} + RV_{dw}$[i]	108.8	108.8	108.8	198.7	198.7	198.7
$V_{tw} + V_{dw}$[k]	303.5	413.6	536.4	296.6	405.0	525.9
BV_W[l]	1813.7	1813.7	1813.7	1903.6	1903.6	1903.6
NBV_W[m]	194.7	304.7	427.6	97.9	206.3	327.2
$\%NBV_W$[n]	9.7	14.4	19.1	4.9	9.8	14.7

[a] for total crop consumptive use of 1,704,892 acre-feet (= $V_{et} - V_{rw}$), where V_{rw} = effective rain = $E_P + T_P$;
[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;
[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw})(F_n)(LR_{infw})$; assuming F_{ctw} = 1.19;
[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})][1/(F_n)(1-F_{tw})]$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;
[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;
[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});
[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;
[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1654.293 K acre-feet + $RV_{dw} + BV_{tw}$;
[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;
[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\ (NBV_W)/RV_{iw}$;

Table 13c. Calculation of IID Water Requirement for 2001 Crop Consumptive Use [a] and EC_{iw} = 1.102 dS/m						
	volumes in thousands of acre-feet					
	LR_W [b] = 0.063043			LR_T [b] = 0.105872		
	tailwater percentages_F_n			tailwater percentages_F_n		
item	5%_0.95	10%_0.95	15%_0.95	5%_1.0	10%_1.0	15%_1.0
LR_{infw} [c]	0.0624	0.0617	0.0609	0.1047	0.1035	0.1023
LR_{iw} [c]	0.0563	0.0528	0.0492	0.0995	0.0932	0.0870
RV_{infw} [d]	1805.6	1804.2	1802.7	1890.9	1888.4	1885.8
RV_{iw} [e]	2000.6	2110.2	2232.5	1990.9	2098.3	2218.6
RV_{dw} [e]	112.7	111.3	109.8	198.0	195.5	193.0
V_{dw} [f]	207.7	206.3	204.7	198.0	195.5	193.0
NBV_{dw} [g]	95.0	95.0	94.9	0.0	0.0	0.0
V_{tw} [h]	100.0	211.0	334.9	99.5	209.8	332.8
BV_{tw} [i]	1.2	2.6	4.1	2.4	4.9	7.5
NBV_{tw} [j]	98.8	208.5	330.8	97.1	204.9	325.3
$BV_{tw} + RV_{dw}$ [i]	113.9	113.9	113.9	200.5	200.5	200.5
$V_{tw} + V_{dw}$ [k]	307.8	417.3	539.6	297.5	405.4	525.8
BV_W [l]	1806.8	1806.8	1806.8	1893.3	1893.3	1893.3
NBV_W [m]	193.8	303.4	425.7	97.1	204.9	325.3
$\%NBV_W$ [n]	9.7	14.4	19.1	4.9	9.8	14.7

[a] for total crop consumptive use of 1,692,883 acre-feet (= $V_{et} - V_{rw}$), where V_{rw} = effective rain = $E_P + T_P$;
[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;
[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw})(F_n)(LR_{infw})$; assuming F_{ctw} = 1.19;
[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})][1/(F_n)(1-F_{tw})]$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;
[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;
[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});
[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;
[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;
[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1654.293 K acre-feet + $RV_{dw} + BV_{tw}$;
[i] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;
[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] $\%NBV = 100\,(NBV_W)/RV_{iw}$;

Table 13d. Calculation of IID Water Requirement for 2002 Crop Consumptive Use [a] and EC_{iw} = 1.110 dS/m

	volumes in thousands of acre-feet					
	LR_W [b] = 0.059162			LR_T [b] = 0.106859		
	tailwater percentages_F_n			tailwater percentages_F_n		
item	5%_0.95	10%_0.95	15%_0.95	5%_1.0	10%_1.0	15%_1.0
LR_{infw} [c]	0.0586	0.0579	0.0572	0.1058	0.1046	0.1033
LR_{iw} [c]	0.0529	0.0495	0.0462	0.1005	0.0941	0.0878
RV_{infw} [d]	1825.0	1823.7	1822.3	1921.4	1918.8	1916.0
RV_{iw} [e]	2022.1	2133.0	2256.7	2022.5	2132.0	2254.1
RV_{dw} [e]	106.9	105.6	104.2	203.3	200.7	197.9
V_{dw} [f]	202.9	201.6	200.1	203.3	200.7	197.9
NBV_{dw} [g]	96.1	96.0	95.9	0.0	0.0	0.0
V_{tw} [h]	101.1	213.3	338.5	101.1	213.2	338.1
BV_{tw} [i]	1.1	2.4	3.8	2.3	4.8	7.7
NBV_{tw} [j]	100.0	210.9	334.7	98.8	208.4	330.4
$BV_{tw} + RV_{dw}$ [l]	108.0	108.0	108.0	205.6	205.6	205.6
$V_{tw} + V_{dw}$ [k]	304.0	414.9	538.6	304.4	413.9	536.0
BV_W [l]	1826.1	1826.1	1826.1	1923.7	1923.7	1923.7
NBV_W [m]	196.0	306.9	430.6	98.8	208.4	330.4
$\%NBV_W$ [n]	9.7	14.4	19.1	4.9	9.8	14.7

[a] for total crop consumptive use of 1,718,093 acre-feet (= $V_{et} - V_{rw}$), where V_{rw} = effective rain = $E_P + T_P$;

[b] LR = LR_W or LR_T, the IID crop-weighted WATSUIT- and Traditional- LR values, respectively;

[c] $LR_{infw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$; $LR_{iw} = (1-F_{tw})(F_n)(LR_{infw})$; assuming F_{ctw} = 1.19;

[d] $RV_{infw} = [(V_{et}-V_{rw})/(1-LR_{infw})]$; $RV_{iw} = [(V_{et}-V_{rw})/(1-LR_{infw})][1/(F_n)(1-F_{tw})]$; [e] $RV_{dw} = [(LR_{infw})/(1-LR_{infw})](V_{et})$;

[f] $V_{dw} = V_{iw} - V_{et} - V_{tw}$; [h] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[g] $NBV_{dw} = RV_{iw} - V_{et} - V_{tw} - RV_{dw}$;

[h] $V_{tw} = (F_{tw})(RV_{iw})$, where F_{tw} is the fraction of tailwater relative to applied irrigation water (RV_{iw});

[i] $BV_{tw} = \{[(LR)/(1-LR)](V_{et})\} - \{[(LR_{infw})/(1-LR_{infw})](V_{et})\}$;

[j] $NBV_{tw} = V_{tw} - BV_{tw}$; [k] $V_{tw} + V_{dw}$ = total volume of drainage water;

[l] BV_W = total volume of beneficial water = crop ET plus required leaching = 1654.293 K acre-feet + $RV_{dw} + BV_{tw}$;

[l] $BV_{tw} + RV_{dw}$ = total beneficial leaching water; [j] $V_{tw} + V_{dw}$ = total volume of drainage water;

[m] NBV_W = total volume of non-beneficial water = $NBV_{tw} + NBV_{dw}$; [n] %NBV = 100 $(NBV_W)/RV_{iw}$;

Table 14. On-Farm Irrigation-Related Volumes by Year and Average for 2000, 2001, 2002 and 2000-2002

year	ET	LR_W	LR_T	5%_0.95					10%_0.95					15%_0.95				
				RV_{iw}	RV_{dw}	V_{tw}	NBV_{dw}	LF	RV_{iw}	RV_{dw}	V_{tw}	NBV_{dw}	LF	RV_{iw}	RV_{dw}	V_{tw}	NBV_{dw}	LF
2000	1704892	0.060004	0.104388	2008.4	107.7	100.4	95.4	0.112	2118.5	106.4	211.8	95.3	0.111	2241.3	105.0	336.2	95.3	0.111
2001	1692883	0.063043	0.105782	2000.6	112.7	100.0	95.0	0.115	2110.2	111.3	211.0	95.0	0.114	2232.5	109.8	334.9	94.9	0.113
2002	1718093	0.059162	0.106859	2022.1	106.9	101.1	96.1	0.111	2133	105.6	213.3	96.0	0.111	2256.7	104.2	338.5	95.9	0.110
2000-20002	1705289	0.058153	0.105783	2004.9	104.2	100.2	95.2	0.110	2114.9	102.9	211.5	95.2	0.110	2237.6	101.6	335.6	95.1	0.109
mean; 3 years	1705289	0.061	0.106	2010.4	109.1	100.5	95.5	0.113	2120.6	107.8	212.0	95.4	0.112	2243.5	106.3	336.5	95.4	0.111
SD; 3 years	12610	0.002	0.0012	10.88	3.14	0.56	0.56	0.0021	11.54	3.09	1.17	0.51	0.0019	12.25	3.03	1.82	0.50	0.0016
SE; 3 years	7280	0.0012	0.0007	6.28	1.81	0.32	0.32	0.0012	6.66	1.78	0.67	0.30	0.0011	7.07	1.75	1.05	0.29	0.0009
CV; 3 years	1%	3%	1%	1%	3%	1%	1%	2%	1%	3%	1%	1%	2%	1%	3%	1%	1%	1%

Figures

Figure 1a. WATSUIT Results (EC = 0.930 dS/m)

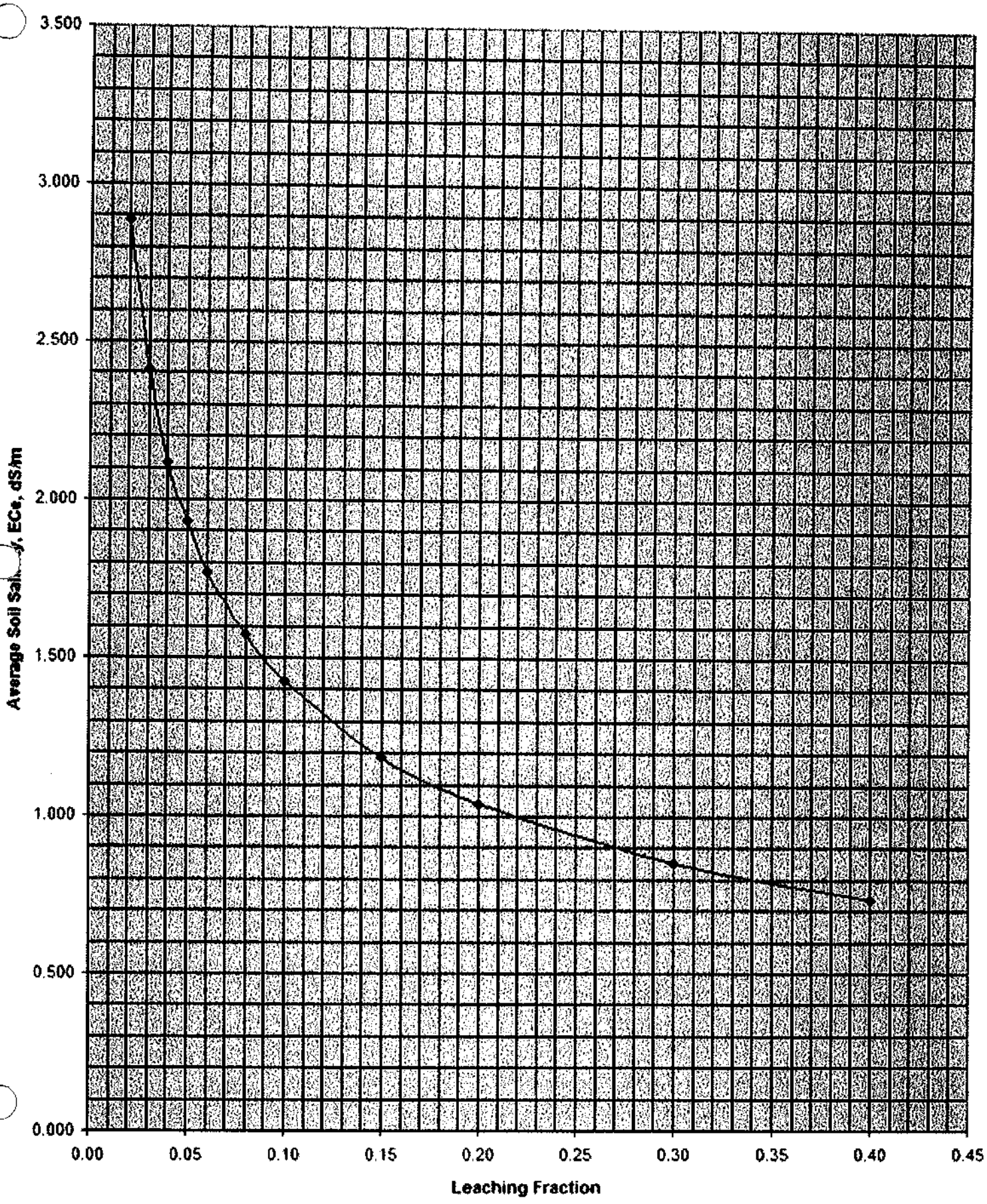


Figure 1b. WATSUIT Results (EC = 1.143 dS/m)

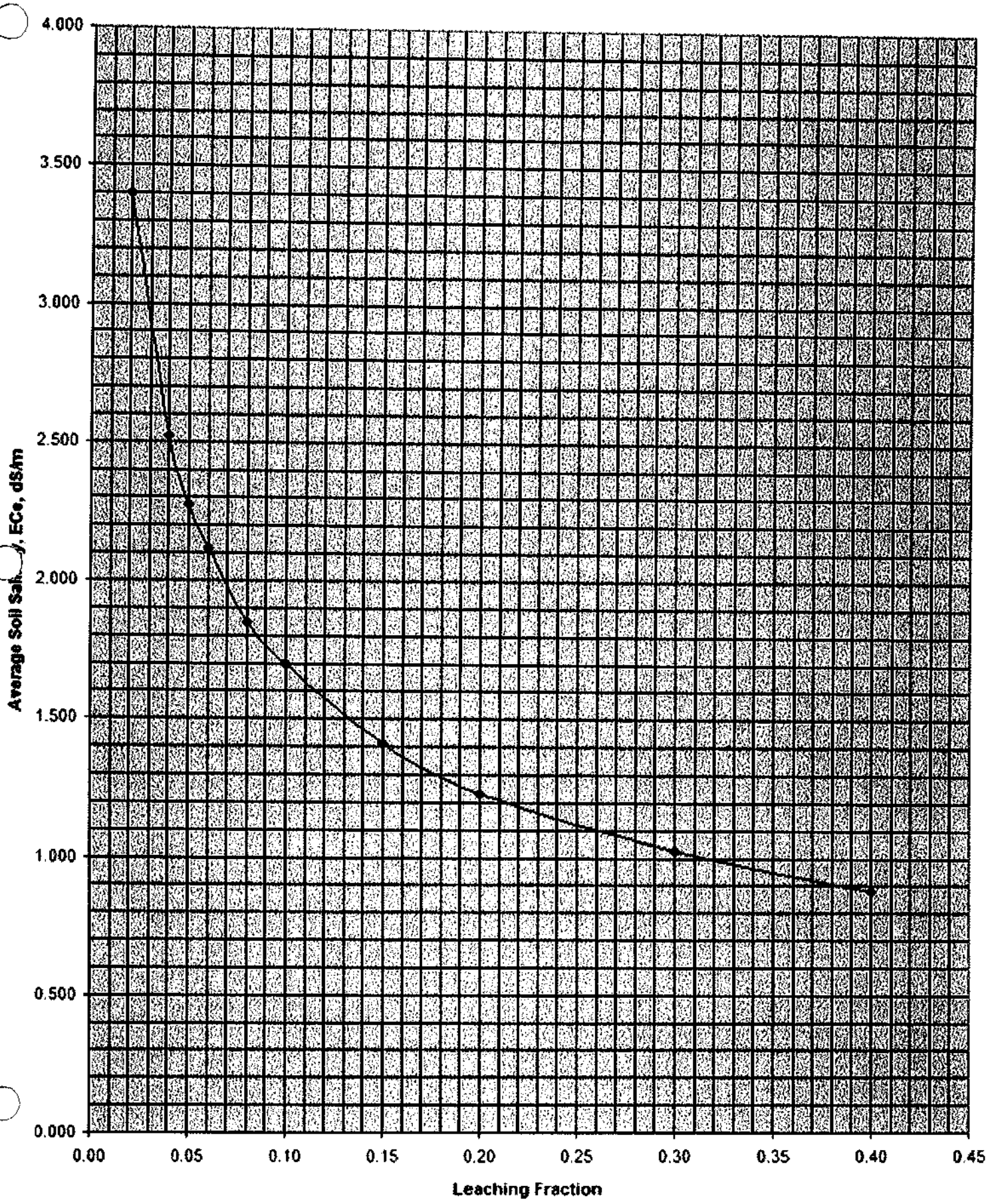


Figure 1c. Watsuit Results (EC = 1.213 dS/m)

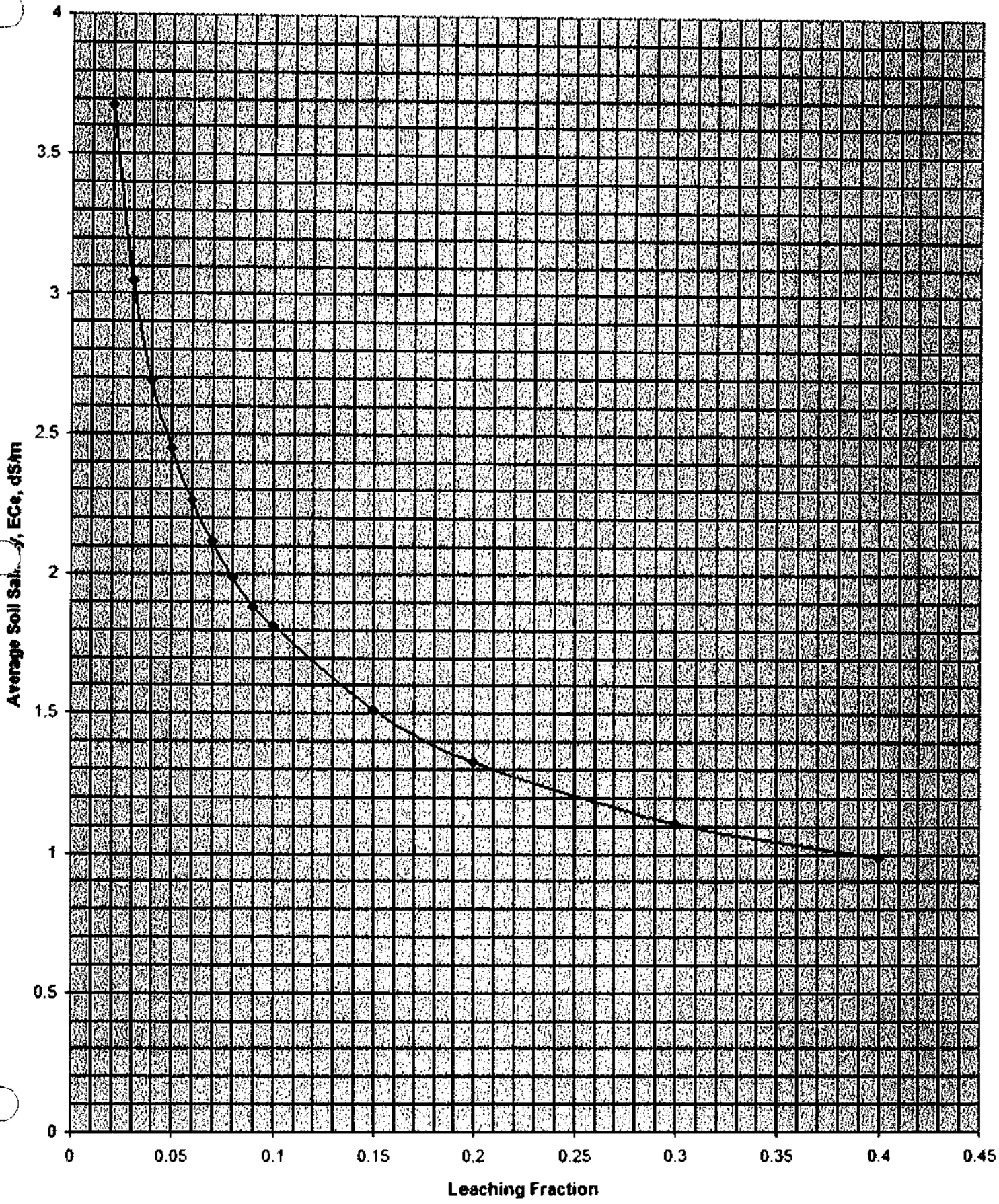


Figure 1d. Watsuit Results (EC = 1.323 dS/m)

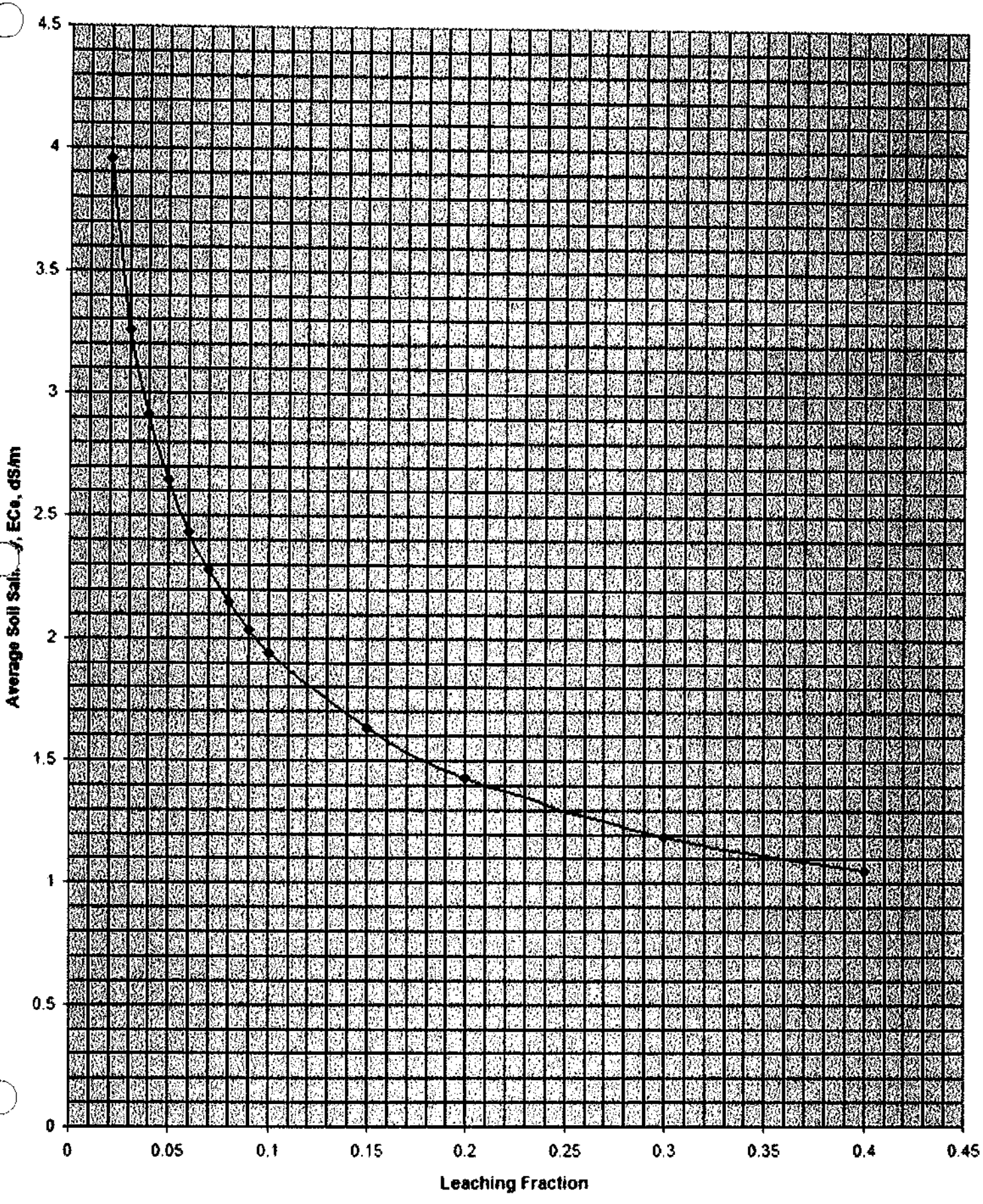


Figure 1e. WATSUIT Results (EC= 1.091 dS/m)

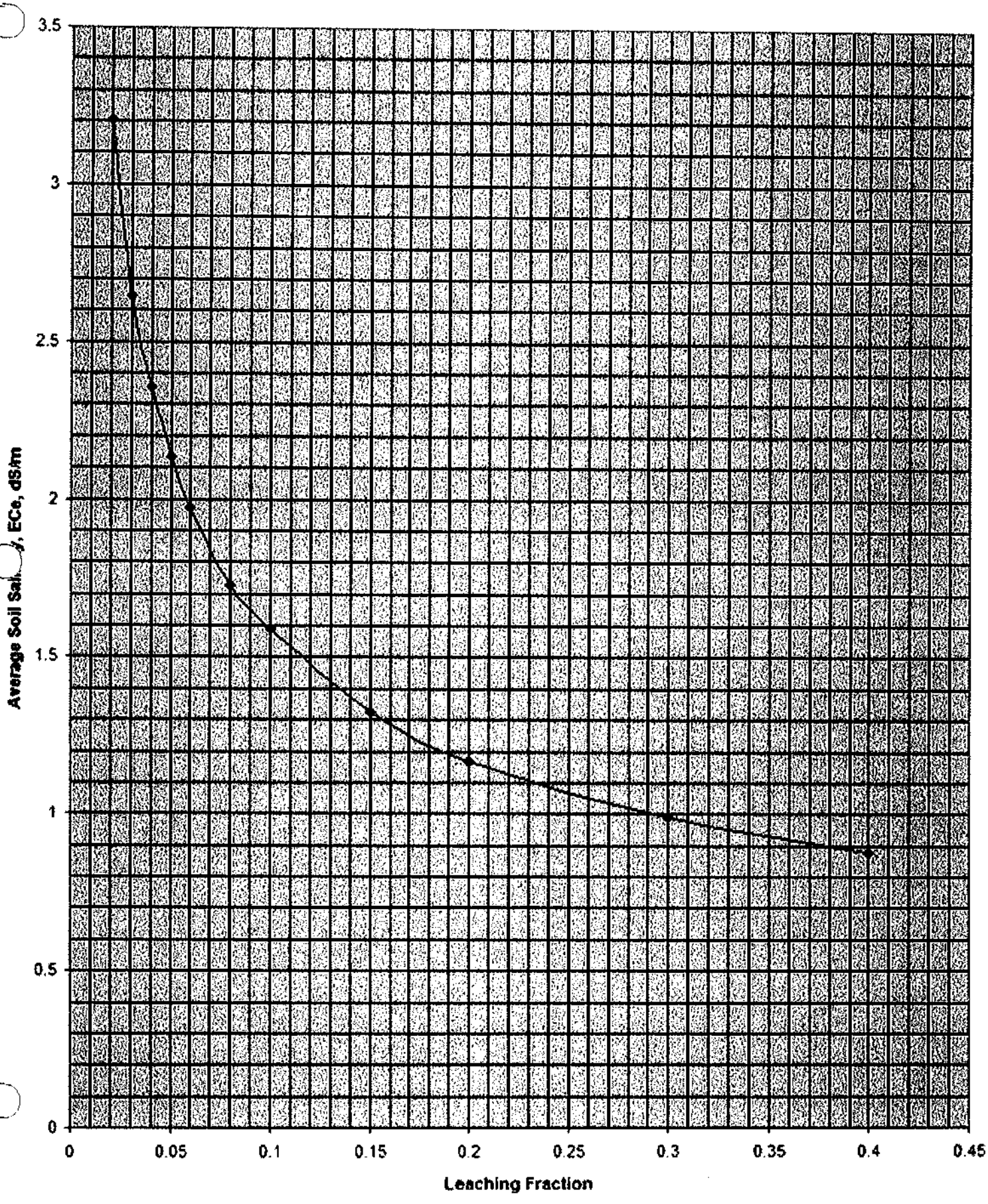
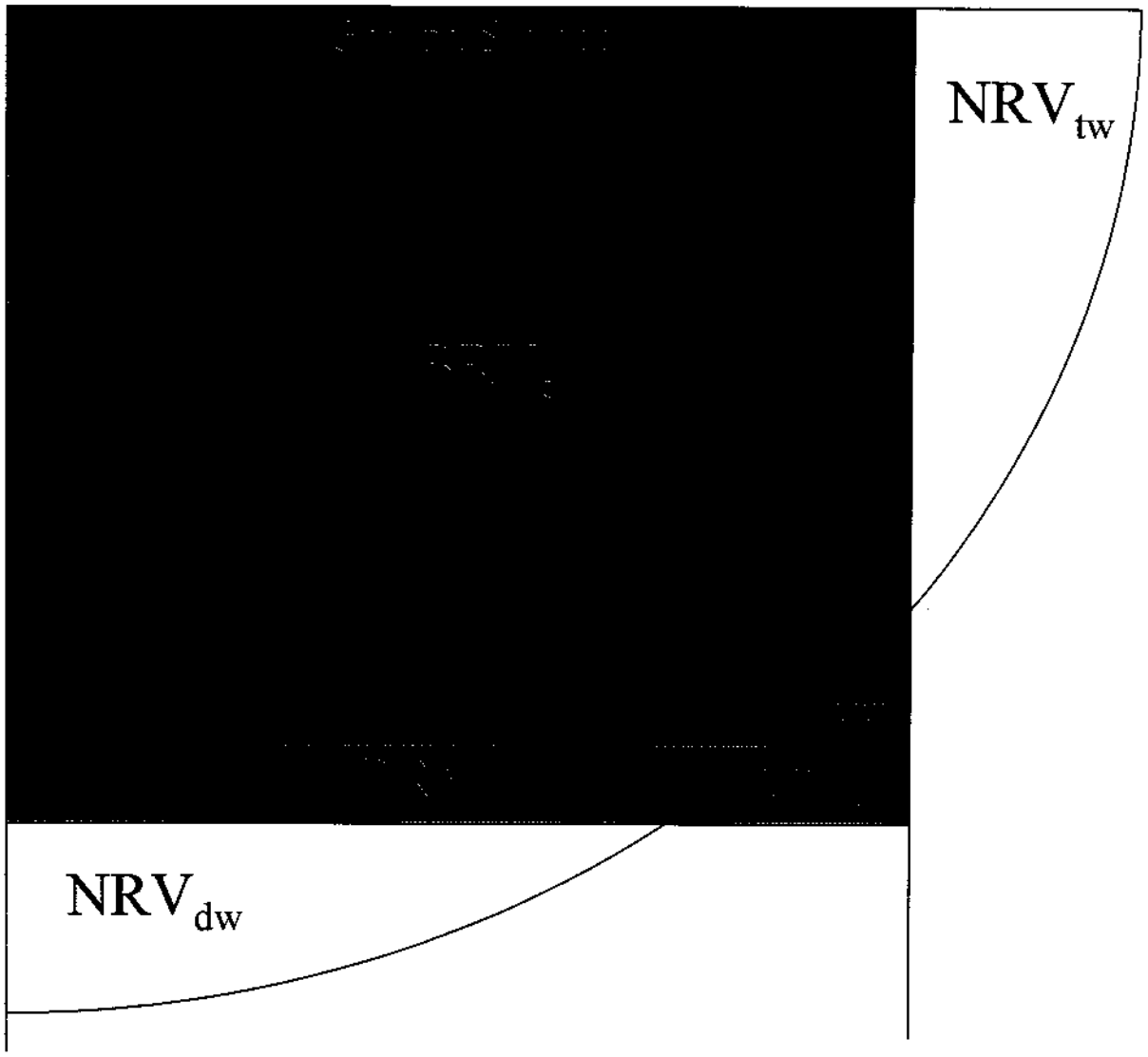


Figure 2. Schematic of Potential Destinations of Applied Irrigation Water



$$RV_{et} = BRV_{et} + URV_{et}; \; RV_{dw} = BRV_{dw} + URV_{dw}$$

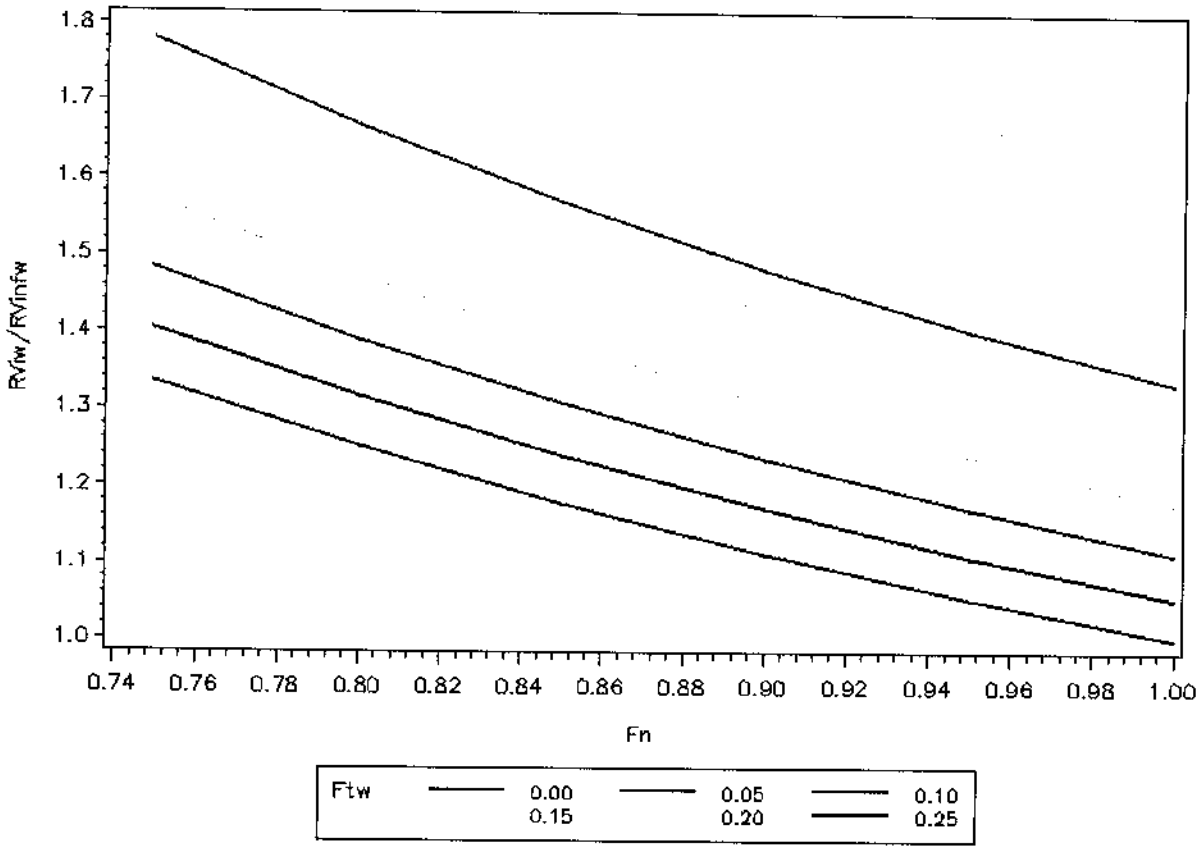


Figure 3. Graphical Representation of Equation [4].

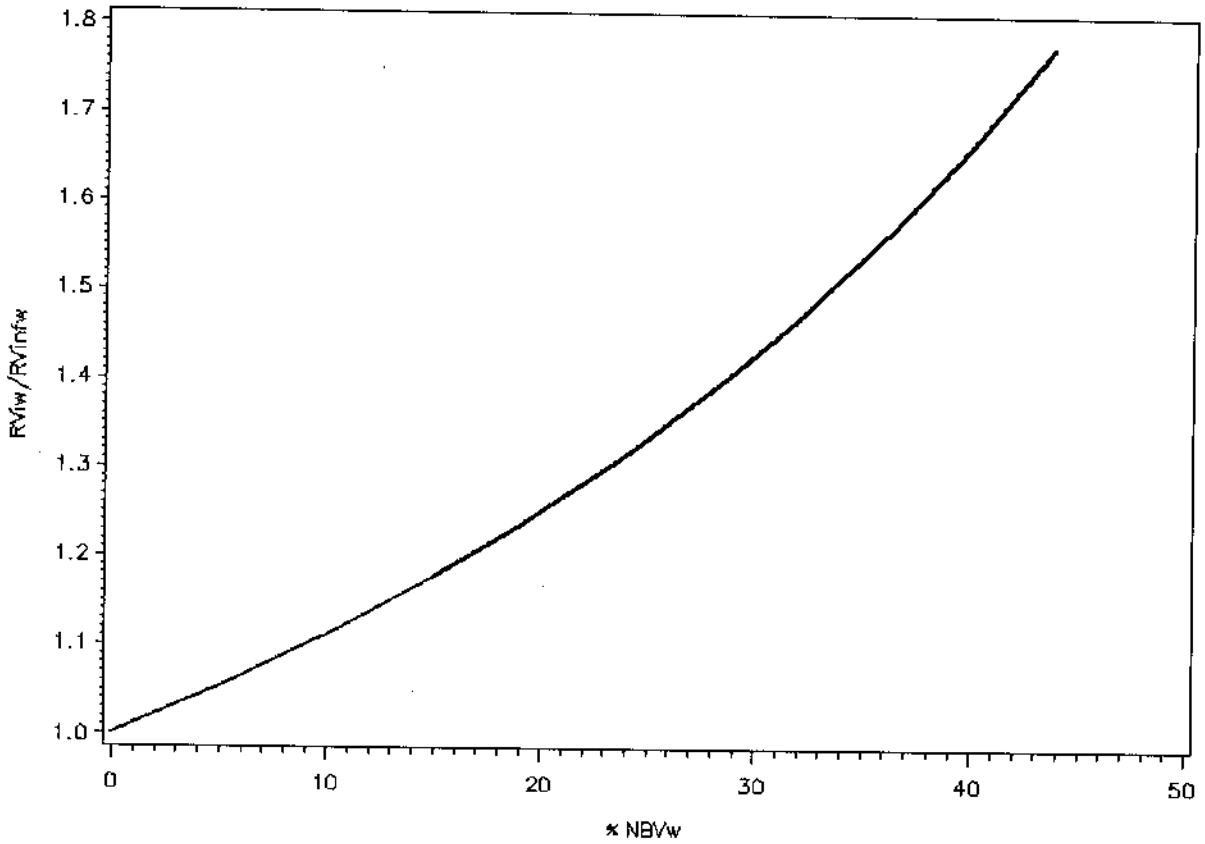


Figure 4. Graphical Representaion of Equation [5].

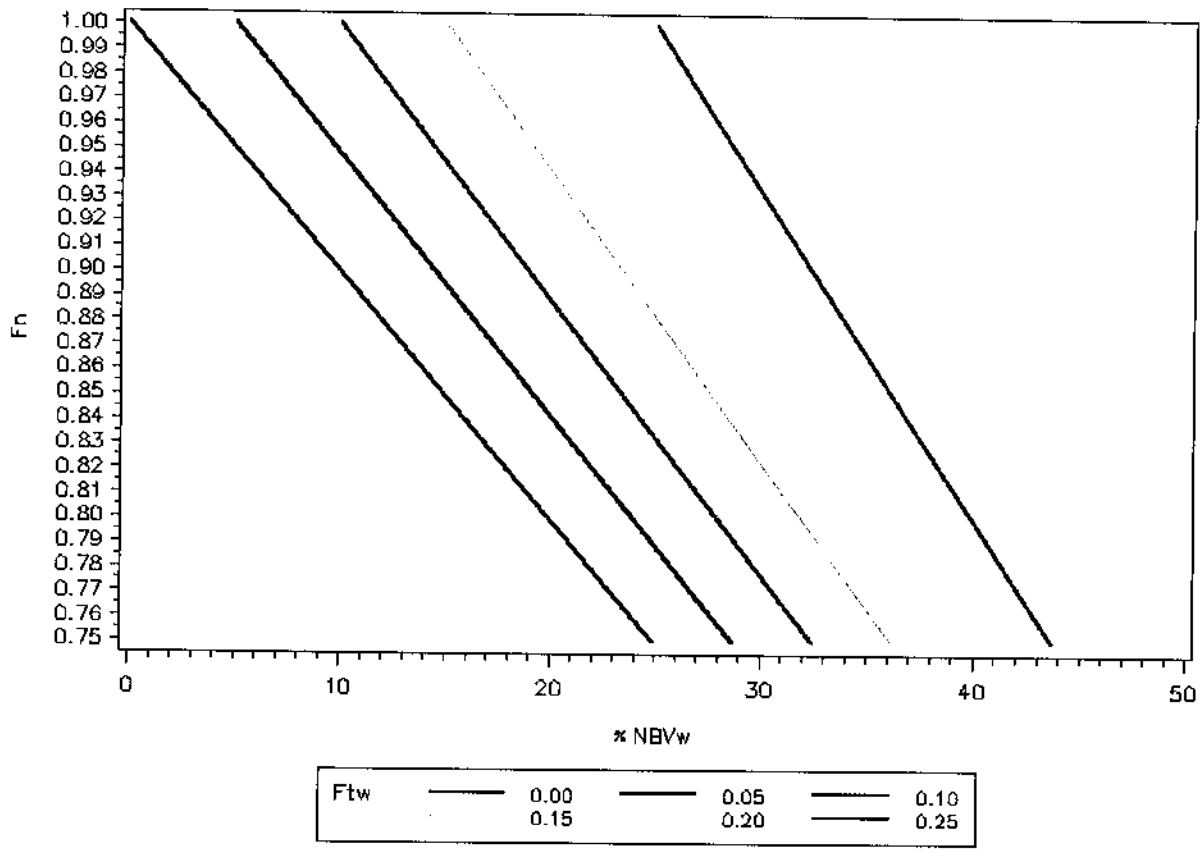


Figure 5. Graphical Representation of Equation [6].

Appendix of Tables

Table A3-1989. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for CU of 1706 KAF & EC_{iw} of 1.213 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	906664	145205	77984	1051869	984648
sudan	2.8	0.095	0.037	172646	18094	6602	190740	179248
wheat	6.0	0.042	0.007	139349	6130	912	145479	140261
bermuda	6.9	0.036	0.005	91684	3467	436	95151	92120
sugar beets	7.0	0.036	0.005	118128	4399	544	122527	118672
lettuce-early	1.3	0.229	0.211	32545	9690	8708	42235	41253
lettuce-late	1.3	0.229	0.211	18280	5443	4891	23723	23171
carrots	1.0	0.320	0.383	31660	14920	19692	46580	51352
cantaloupes-spring	1.0	0.320	0.383	30110	14189	18728	44299	48838
cantaloupes-fall	1.0	0.320	0.383	13481	6353	8385	19834	21866
alfalfa seed	2.0	0.138	0.079	2200	352	189	2552	2389
cotton	7.7	0.033	0.004	38333	1289	142	39622	38475
honeydew	1.0	0.320	0.383	6572	3097	4088	9669	10660
watermelon	1	0.320	0.383	8825	4159	5489	12984	14314
onions	1.2	0.253	0.253	28145	9552	9545	37697	37690
onion seed	1.0	0.320	0.383	9726	4583	6049	14309	15775
rye-pasture	7.6	0.033	0.004	31843	1086	121	32929	31964
oats & barley	8.0	0.031	0.003	15108	488	51	15596	15159
misc field crops	4	0.065	0.016	2207	152	37	2359	2244
tomatoes	2.5	0.107	0.048	31966	3849	1600	35815	33566
potatoes	1.7	0.166	0.115	417	83	54	500	471
brocolli	2.8	0.095	0.037	12101	1268	463	13369	12564
cabbage	1.8	0.156	0.101	1485	274	166	1759	1651
cauliflower	2.8	0.095	0.037	9588	1005	367	10593	9955
corn-ear	1.7	0.166	0.115	3651	729	473	4380	4124
misc garden crops	1.8	0.156	0.101	3485	643	390	4128	3875
asparagus	4.1	0.063	0.015	25722	1726	404	27448	26126
citrus	1.3	0.229	0.211	9248	2754	2474	12002	11722
jojoba	4	0.065	0.016	8519	588	142	9107	8661
peach trees	1.7	0.166	0.115	2305	460	298	2765	2603
permanent pasture	5.6	0.045	0.008	2536	120	19	2656	2555
totals:				1808529	266149	179442	2074678	1987971

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (266149)/(2074678) = 0.128284

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (179442)/(1987971) = 0.090264

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively.

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-1990. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for CU of 1706 KAF & EC_{iw} of 1.213 dS/m

crop	EC_e^{*} [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	979698	156902	84266	1136600	1063964
sudan	2.8	0.095	0.037	129597	13582	4956	143179	134553
wheat	6.0	0.042	0.007	87208	3836	571	91044	87779
bermuda	6.9	0.036	0.005	81591	3086	388	84677	81979
sugar beets	7.0	0.036	0.005	120547	4489	555	125036	121102
lettuce-early	1.3	0.229	0.211	19697	5865	5270	25562	24967
lettuce-late	1.3	0.229	0.211	11744	3497	3142	15241	14886
carrots	1.0	0.320	0.383	31692	14935	19712	46627	51404
cantaloupes-spring	1.0	0.320	0.383	49986	23556	31090	73542	81076
cantaloupes-fall	1.0	0.320	0.383	10026	4725	6236	14751	16262
alfalfa seed	2.0	0.138	0.079	5826	933	501	6759	6327
cotton	7.7	0.033	0.004	40682	1368	151	42050	40833
honeydew	1.0	0.320	0.383	6737	3175	4190	9912	10927
watermelon	1	0.320	0.383	8926	4206	5552	13132	14478
onions	1.2	0.253	0.253	29813	10118	10111	39931	39924
onion seed	1.0	0.320	0.383	11352	5350	7061	16702	18413
rye-pasture	7.6	0.033	0.004	23601	805	90	24406	23691
oats & barley	8.0	0.031	0.003	6142	198	21	6340	6163
misc field crops	4	0.065	0.016	2423	167	40	2590	2463
tomatoes	2.5	0.107	0.048	37751	4546	1890	42297	39641
potatoes	1.7	0.166	0.115	496	99	64	595	560
brocolli	2.8	0.095	0.037	8994	943	344	9937	9338
cabbage	1.8	0.156	0.101	1470	271	165	1741	1635
cauliflower	2.8	0.095	0.037	7867	824	301	8691	8168
corn-ear	1.7	0.166	0.115	5925	1183	767	7108	6692
misc garden crops	1.8	0.156	0.101	4223	779	473	5002	4696
asparagus	4.1	0.063	0.015	25816	1733	405	27549	26221
citrus	1.3	0.229	0.211	8920	2656	2387	11576	11307
jojoba	4	0.065	0.016	8110	560	135	8670	8245
peach trees	1.7	0.166	0.115	2002	400	259	2402	2261
permanent pasture	5.6	0.045	0.008	2511	119	19	2630	2530
totals:				1771373	274905	191110	2046278	1962483

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (274905)/(2046278) = 0.134344

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (191110)/(1962483) = 0.097382

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-1991. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for CU of 1706 KAF & EC_{iw} of 1.213 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	866138	138715	74498	1004853	940636
sudan	2.8	0.095	0.037	185424	19433	7090	204857	192514
wheat	6.0	0.042	0.007	61170	2691	400	63861	61570
bermuda	6.9	0.036	0.005	76701	2901	365	79602	77066
sugar beets	7.0	0.036	0.005	119792	4461	551	124253	120343
lettuce-early	1.3	0.229	0.211	24339	7247	6512	31586	30851
lettuce-late	1.3	0.229	0.211	10046	2991	2688	13037	12734
carrots	1.0	0.320	0.383	25683	12103	15974	37786	41657
cantaloupes-spring	1.0	0.320	0.383	36585	17241	22755	53826	59340
cantaloupes-fall	1.0	0.320	0.383	11997	5654	7462	17651	19459
alfalfa seed	2.0	0.138	0.079	20436	3273	1758	23709	22194
cotton	7.7	0.033	0.004	27813	935	103	28748	27916
honeydew	1.0	0.320	0.383	5441	2564	3384	8005	8825
watermelon	1	0.320	0.383	5526	2604	3437	8130	8963
onions	1.2	0.253	0.253	27832	9446	9439	37278	37271
onion seed	1.0	0.320	0.383	8078	3807	5024	11885	13102
rye-pasture	7.6	0.033	0.004	20757	708	79	21465	20836
oats & barley	8.0	0.031	0.003	5764	186	20	5950	5784
misc field crops	4	0.065	0.016	1881	130	31	2011	1912
tomatoes	2.5	0.107	0.048	15431	1858	772	17289	16203
potatoes	1.7	0.166	0.115	761	152	99	913	860
brocolli	2.8	0.095	0.037	8580	899	328	9479	8908
cabbage	1.8	0.156	0.101	1420	262	159	1682	1579
cauliflower	2.8	0.095	0.037	4946	518	189	5464	5135
corn-ear	1.7	0.166	0.115	7249	1448	939	8697	8188
misc garden crops	1.8	0.156	0.101	3707	684	415	4391	4122
asparagus	4.1	0.063	0.015	24926	1673	391	26599	25317
citrus	1.3	0.229	0.211	9152	2725	2449	11877	11601
jojoba	4	0.065	0.016	6553	452	109	7005	6662
peach trees	1.7	0.166	0.115	1283	256	166	1539	1449
permanent pasture	5.6	0.045	0.008	2248	107	17	2355	2265
totals:				1627659	248123	167604	1875782	1795263

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (248123)/(1875782) = 0.132277

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (167604)/(1795263) = 0.093359

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-1992. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for CU of 1706 KAF & EC_{iw} of 1.213 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	782915	125386	67340	908301	850255
sudan	2.8	0.095	0.037	149786	15698	5728	165484	155514
wheat	6.0	0.042	0.007	93957	4133	615	98090	94572
bermuda	6.9	0.036	0.005	105298	3982	500	109280	105798
sugar beets	7.0	0.036	0.005	114420	4261	526	118681	114946
lettuce-early	1.3	0.229	0.211	18947	5641	5069	24588	24016
lettuce-late	1.3	0.229	0.211	4311	1284	1153	5595	5464
carrots	1.0	0.320	0.383	21010	9901	13068	30911	34078
cantaloupes-spring	1.0	0.320	0.383	15631	7366	9722	22997	25353
cantaloupes-fall	1.0	0.320	0.383	3600	1697	2239	5297	5839
alfalfa seed	2.0	0.138	0.079	9088	1455	782	10543	9870
cotton	7.7	0.033	0.004	12348	415	46	12763	12394
honeydew	1.0	0.320	0.383	1410	664	877	2074	2287
watermelon	1	0.320	0.383	4224	1991	2627	6215	6851
onions	1.2	0.253	0.253	22294	7566	7561	29860	29855
onion seed	1.0	0.320	0.383	7017	3307	4364	10324	11381
rye-pasture	7.6	0.033	0.004	14557	496	56	15053	14613
oats & barley	8.0	0.031	0.003	2691	87	9	2778	2700
misc field crops	4	0.065	0.016	1673	115	28	1788	1701
tomatoes	2.5	0.107	0.048	7962	959	399	8921	8361
potatoes	1.7	0.166	0.115	481	96	62	577	543
brocolli	2.8	0.095	0.037	5839	612	223	6451	6062
cabbage	1.8	0.156	0.101	816	151	91	967	907
cauliflower	2.8	0.095	0.037	3518	369	135	3887	3653
corn-ear	1.7	0.166	0.115	7271	1452	941	8723	8212
misc garden crops	1.8	0.156	0.101	3865	713	433	4578	4298
asparagus	4.1	0.063	0.015	28203	1893	443	30096	28646
citrus	1.3	0.229	0.211	10667	3176	2854	13843	13521
jojoba	4	0.065	0.016	6533	451	109	6984	6642
peach trees	1.7	0.166	0.115	1009	202	131	1211	1140
permanent pasture	5.6	0.045	0.008	2342	111	18	2453	2360
totals:				1463683	205630	128149	1669313	1591832

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (205630)/(1669313) = 0.123182

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (128149)/(1591832) = 0.080504

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-1993. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for CU of 1706 KAF & EC_{iw} of 1.213 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	779057	124768	67008	903825	846065
sudan	2.8	0.095	0.037	201999	21170	7724	223169	209723
wheat	6.0	0.042	0.007	88680	3901	580	92581	89260
bermuda	6.9	0.036	0.005	142300	5382	676	147682	142976
sugar beets	7.0	0.036	0.005	110254	4106	507	114360	110761
lettuce-early	1.3	0.229	0.211	14944	4449	3998	19393	18942
lettuce-late	1.3	0.229	0.211	4051	1206	1084	5257	5135
carrots	1.0	0.320	0.383	27647	13029	17196	40676	44843
cantaloupes-spring	1.0	0.320	0.383	21823	10284	13573	32107	35396
cantaloupes-fall	1.0	0.320	0.383	506	238	315	744	821
alfalfa seed	2.0	0.138	0.079	11252	1802	968	13054	12220
cotton	7.7	0.033	0.004	27310	918	101	28228	27411
honeydew	1.0	0.320	0.383	739	348	460	1087	1199
watermelon	1	0.320	0.383	6200	2922	3856	9122	10056
onions	1.2	0.253	0.253	24473	8306	8300	32779	32773
onion seed	1.0	0.320	0.383	7523	3545	4679	11068	12202
rye-pasture	7.6	0.033	0.004	12999	443	50	13442	13049
oats & barley	8.0	0.031	0.003	1980	64	7	2044	1987
misc field crops	4	0.065	0.016	4602	318	77	4920	4679
tomatoes	2.5	0.107	0.048	9581	1154	480	10735	10061
potatoes	1.7	0.166	0.115	1883	376	244	2259	2127
brocolli	2.8	0.095	0.037	4979	522	190	5501	5169
cabbage	1.8	0.156	0.101	1128	208	126	1336	1254
cauliflower	2.8	0.095	0.037	3321	348	127	3669	3448
corn-ear	1.7	0.166	0.115	6909	1380	895	8289	7804
misc garden crops	1.8	0.156	0.101	3596	664	402	4260	3998
asparagus	4.1	0.063	0.015	29667	1991	466	31658	30133
citrus	1.3	0.229	0.211	13136	3911	3515	17047	16651
jojoba	4	0.065	0.016	7379	509	123	7888	7502
peach trees	1.7	0.166	0.115	907	181	117	1088	1024
permanent pasture	5.6	0.045	0.008	2962	140	23	3102	2985
totals:				1573787	218584	137867	1792371	1711654

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (218584)/(1792371) = 0.121952

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (137867)/(1711654) = 0.080546

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-1994. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for CU of 1706 KAF & EC_{iw} of 1.213 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	875215	140168	75279	1015383	950494
sudan	2.8	0.095	0.037	253582	26576	9697	280158	263279
wheat	6.0	0.042	0.007	112040	4929	733	116969	112773
bermuda	6.9	0.036	0.005	149418	5651	710	155069	150128
sugar beets	7.0	0.036	0.005	95010	3538	437	98548	95447
lettuce-early	1.3	0.229	0.211	15104	4497	4041	19601	19145
lettuce-late	1.3	0.229	0.211	8159	2429	2183	10588	10342
carrots	1.0	0.320	0.383	29871	14077	18579	43948	48450
cantaloupes-spring	1.0	0.320	0.383	24262	11433	15091	35695	39353
cantaloupes-fall	1.0	0.320	0.383	920	434	572	1354	1492
alfalfa seed	2.0	0.138	0.079	8573	1373	737	9946	9310
cotton	7.7	0.033	0.004	25845	869	96	26714	25941
honeydew	1.0	0.320	0.383	1772	835	1102	2607	2874
watermelon	1	0.320	0.383	8532	4021	5307	12553	13839
onions	1.2	0.253	0.253	29432	9989	9981	39421	39413
onion seed	1.0	0.320	0.383	5786	2727	3599	8513	9385
rye-pasture	7.6	0.033	0.004	14576	497	56	15073	14632
oats & barley	8.0	0.031	0.003	3564	115	12	3679	3576
misc field crops	4	0.065	0.016	4144	286	69	4430	4213
tomatoes	2.5	0.107	0.048	6434	775	322	7209	6756
potatoes	1.7	0.166	0.115	2123	424	275	2547	2398
brocolli	2.8	0.095	0.037	6928	726	265	7654	7193
cabbage	1.8	0.156	0.101	1712	316	192	2028	1904
cauliflower	2.8	0.095	0.037	3518	369	135	3887	3653
corn-ear	1.7	0.166	0.115	10582	2113	1370	12695	11952
misc garden crops	1.8	0.156	0.101	3418	631	383	4049	3801
asparagus	4.1	0.063	0.015	29044	1949	456	30993	29500
citrus	1.3	0.229	0.211	14727	4385	3940	19112	18667
jojoba	4	0.065	0.016	7003	483	116	7486	7119
peach trees	1.7	0.166	0.115	622	124	81	746	703
permanent pasture	5.6	0.045	0.008	3478	165	27	3643	3505
totals:				1755394	246904	155842	2002298	1911236

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (246904)/(2002298) = 0.123310

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (155842)/(1911236) = 0.081540

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-1995. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for CU of 1706 KAF & EC_{iw} of 1.213 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	890829	142669	76622	1033498	967451
sudan	2.8	0.095	0.037	242652	25431	9279	268083	251931
wheat	6.0	0.042	0.007	126668	5572	829	132240	127497
bermuda	6.9	0.036	0.005	175906	6653	836	182559	176742
sugar beets	7.0	0.036	0.005	115931	4317	533	120248	116464
lettuce-early	1.3	0.229	0.211	16255	4840	4349	21095	20604
lettuce-late	1.3	0.229	0.211	8339	2483	2231	10822	10570
carrots	1.0	0.320	0.383	25876	12194	16094	38070	41970
cantaloupes-spring	1.0	0.320	0.383	25618	12073	15934	37691	41552
cantaloupes-fall	1.0	0.320	0.383	14	7	9	21	23
alfalfa seed	2.0	0.138	0.079	17431	2792	1499	20223	18930
cotton	7.7	0.033	0.004	25086	844	93	25930	25179
honeydew	1.0	0.320	0.383	2474	1166	1539	3640	4013
watermelon	1	0.320	0.383	6461	3045	4019	9506	10480
onions	1.2	0.253	0.253	32064	10882	10874	42946	42938
onion seed	1.0	0.320	0.383	5913	2787	3678	8700	9591
rye-pasture	7.6	0.033	0.004	10229	349	39	10578	10268
oats & barley	8.0	0.031	0.003	2670	86	9	2756	2679
misc field crops	4	0.065	0.016	6793	469	113	7262	6906
tomatoes	2.5	0.107	0.048	5696	686	285	6382	5981
potatoes	1.7	0.166	0.115	3007	601	389	3608	3396
brocolli	2.8	0.095	0.037	5960	625	228	6585	6188
cabbage	1.8	0.156	0.101	984	182	110	1166	1094
cauliflower	2.8	0.095	0.037	2557	268	98	2825	2655
corn-ear	1.7	0.166	0.115	12168	2430	1576	14598	13744
misc garden crops	1.8	0.156	0.101	5121	945	573	6066	5694
asparagus	4.1	0.063	0.015	26475	1777	416	28252	26891
citrus	1.3	0.229	0.211	15921	4740	4260	20661	20181
jojoba	4	0.065	0.016	7164	494	119	7658	7283
peach trees	1.7	0.166	0.115	47	9	6	56	53
permanent pasture	5.6	0.045	0.008	3242	154	25	3396	3267
totals:				1825551	251566	156663	2077117	1982214

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (251566)/(2077117) = 0.121113

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (156663)/(1982214) = 0.079034

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-1996. Salt-Tolerances, Volumes (in AF) of Consumptive Use (CU), of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for CU of 1706 KAF & EC_{iw} of 1.213 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.138	0.079	793306	127050	68234	920356	861540
sudan	2.8	0.095	0.037	227213	23813	8688	251026	235901
wheat	6.0	0.042	0.007	206057	9065	1348	215122	207405
bermuda	6.9	0.036	0.005	183034	6922	870	189956	183904
sugar beets	7.0	0.036	0.005	135040	5029	621	140069	135661
lettuce-early	1.3	0.229	0.211	20005	5956	5352	25961	25357
lettuce-late	1.3	0.229	0.211	11107	3307	2972	14414	14079
carrots	1.0	0.320	0.383	31795	14983	19776	46778	51571
cantaloupes-spring	1.0	0.320	0.383	26244	12368	16323	38612	42567
cantaloupes-fall	1.0	0.320	0.383	1156	545	719	1701	1875
alfalfa seed	2.0	0.138	0.079	17821	2854	1533	20675	19354
cotton	7.7	0.033	0.004	19388	652	72	20040	19460
honeydew	1.0	0.320	0.383	2200	1037	1368	3237	3568
watermelon	1	0.320	0.383	6713	3164	4175	9877	10888
onions	1.2	0.253	0.253	34206	11609	11600	45815	45806
onion seed	1.0	0.320	0.383	8425	3970	5240	12395	13665
rye-pasture	7.6	0.033	0.004	10070	343	38	10413	10108
oats & barley	8.0	0.031	0.003	1542	50	5	1592	1547
misc field crops	4	0.065	0.016	11829	816	197	12645	12026
tomatoes	2.5	0.107	0.048	5735	691	287	6426	6022
potatoes	1.7	0.166	0.115	4348	868	563	5216	4911
brocolli	2.8	0.095	0.037	6290	659	241	6949	6531
cabbage	1.8	0.156	0.101	1170	216	131	1386	1301
cauliflower	2.8	0.095	0.037	2814	295	108	3109	2922
corn-ear	1.7	0.166	0.115	14463	2888	1873	17351	16336
misc garden crops	1.8	0.156	0.101	5468	1009	612	6477	6080
asparagus	4.1	0.063	0.015	25515	1712	401	27227	25916
citrus	1.3	0.229	0.211	18712	5571	5007	24283	23719
jojoba	4	0.065	0.016	7104	490	118	7594	7222
peach trees	1.7	0.166	0.115	11	2	1	13	12
permanent pasture	5.6	0.045	0.008	3221	153	25	3374	3246
totals:				1842002	248088	158499	2090090	2000501

IID-wide $LR_{Infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (248088)/(2090090) = 0.118697

IID-wide $LR_{Infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (158499)/(2000501) = 0.079230

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{Infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{Infw,W}$ are the required drainage volumes corresponding to $LR_{Infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-2000. Salt-Tolerances, Volumes (in AF) of Crop ET, of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for Year 2000; EC_{iw} of 1.059 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.118	0.059	810530	108900	50408	919430	860938
sudan	2.8	0.082	0.027	159071	14177	4363	173248	163434
wheat	6.0	0.037	0.005	83307	3164	377	86471	83684
bermuda	6.9	0.032	0.003	231510	7571	755	239081	232265
sugar beets	7.0	0.031	0.003	101656	3274	321	104930	101977
lettuce-early	1.3	0.195	0.160	14141	3417	2694	17558	16835
lettuce-late	1.3	0.195	0.160	6645	1606	1266	8251	7911
carrots	1.0	0.269	0.295	32696	12014	13698	44710	46394
cantaloupes-spring	1.0	0.269	0.295	15663	5755	6562	21418	22225
cantaloupes-fall	1.0	0.269	0.295	838	308	351	1146	1189
alfalfa seed	2.0	0.118	0.059	22706	3051	1412	25757	24118
cotton	7.7	0.028	0.003	19282	561	49	19843	19331
honeydew	1.0	0.269	0.295	2666	980	1117	3646	3783
watermelon	1.0	0.269	0.295	3652	1342	1530	4994	5182
onions	1.2	0.214	0.193	32517	8871	7773	41388	40290
onion seed	1.0	0.269	0.295	12998	4776	5446	17774	18444
rye-pasture	7.6	0.029	0.003	6241	184	16	6425	6257
oats & barley	8.0	0.027	0.002	1277	36	3	1313	1280
misc field crops	4.0	0.056	0.012	17913	1061	210	18974	18123
tomatoes	2.5	0.093	0.035	2102	214	76	2316	2178
potatoes	1.7	0.142	0.086	4120	684	386	4804	4506
brocolli	2.8	0.082	0.027	8961	799	246	9760	9207
cabbage	1.8	0.133	0.075	1063	164	86	1227	1149
cauliflower	2.8	0.082	0.027	3358	299	92	3657	3450
corn-ear	1.7	0.142	0.086	14692	2438	1375	17130	16067
misc garden crops	1.8	0.133	0.075	2634	405	213	3039	2847
asparagus	4.1	0.054	0.011	23257	1340	258	24597	23515
citrus	1.3	0.195	0.160	27302	6598	5202	33900	32504
jojoba	4.0	0.056	0.012	7	0	0	7	7
peach trees	1.7	0.142	0.086	32	5	3	37	35
permanent pasture	5.6	0.039	0.005	2434	100	13	2534	2447
totals:				1665271	194095	106301	1859366	1771572

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (194095)/(1859366) = 0.104388

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (106301)/(1771572) = 0.060004

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-2001. Salt-Tolerances, Volumes (in AF) of Crop ET, of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for Year 2001; EC_{iw} of 1.102 dS/m

crop	EC_e^{*a}	LR_T^b	LR_W^b	average CU	$RV_{dw,T}^c$	$RV_{dw,W}^c$	$RV_{infw,T}^d$	$RV_{infw,W}^d$
alfalfa	2.0	0.124	0.064	823294	116376	56497	939670	879791
sudan	2.8	0.085	0.030	149877	14002	4576	163879	154453
wheat	6.0	0.038	0.005	69626	2760	360	72386	69986
bermuda	6.9	0.033	0.004	262803	8967	983	271770	263786
sugar beets	7.0	0.033	0.004	84401	2836	305	87237	84706
lettuce-early	1.3	0.204	0.173	13995	3590	2925	17585	16920
lettuce-late	1.3	0.204	0.173	6577	1687	1375	8264	7952
carrots	1.0	0.283	0.316	29457	11610	13607	41067	43064
cantaloupes-spring	1.0	0.283	0.316	13392	5278	6186	18670	19578
cantaloupes-fall	1.0	0.283	0.316	1032	407	477	1439	1509
alfalfa seed	2.0	0.124	0.064	10043	1420	689	11463	10732
cotton	7.7	0.029	0.003	44560	1353	129	45913	44689
honeydew	1.0	0.283	0.316	3281	1293	1516	4574	4797
watermelon	1.0	0.283	0.316	1535	605	709	2140	2244
onions	1.2	0.225	0.208	23488	6819	6161	30307	29649
onion seed	1.0	0.283	0.316	6648	2620	3071	9268	9719
rye-pasture	7.6	0.030	0.003	5008	154	15	5162	5023
oats & barley	8.0	0.028	0.003	3898	114	10	4012	3908
misc field crops	4.0	0.058	0.131	24445	1514	3669	25959	28114
tomatoes	2.5	0.097	0.038	2099	225	84	2324	2183
potatoes	1.7	0.149	0.093	3530	618	363	4148	3893
brocolli	2.8	0.085	0.030	6721	628	205	7349	6926
cabbage	1.8	0.140	0.082	950	154	85	1104	1035
cauliflower	2.8	0.085	0.030	3041	284	93	3325	3134
corn-ear	1.7	0.149	0.093	9515	1665	979	11180	10494
misc garden crops	1.8	0.140	0.082	2745	445	245	3190	2990
asparagus	4.1	0.057	0.012	17273	1040	216	18313	17489
citrus	1.3	0.204	0.173	27161	6967	5677	34128	32838
jojoba	4.0	0.058	0.131	7	0	1	7	8
peach trees	1.7	0.149	0.093	33	6	3	39	36
permanent pasture	5.6	0.041	0.006	2633	112	16	2745	2649
totals:				1653068	195550	111226	1848618	1764294

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (195550)/(1848619) = 0.105782

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (111226)/(1764294) = 0.063043

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-2002. Salt-Tolerances, Volumes (in AF) of Crop ET, of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for Year 2002; EC_{iw} of 1.110 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.125	0.060	843827	120392	54290	964219	898117
sudan	2.8	0.086	0.028	141792	13361	4062	155153	145854
wheat	6.0	0.038	0.005	78146	3122	378	81268	78524
bermuda	6.9	0.033	0.003	280736	9654	983	290390	281719
sugar beets	7.0	0.033	0.003	80952	2741	274	83693	81226
lettuce-early	1.3	0.206	0.163	15203	3943	2961	19146	18164
lettuce-late	1.3	0.206	0.163	7144	1853	1392	8997	8536
carrots	1.0	0.285	0.298	31051	12398	13203	43449	44254
cantaloupes-spring	1.0	0.285	0.298	13083	5224	5563	18307	18646
cantaloupes-fall	1.0	0.285	0.298	1762	704	749	2466	2511
alfalfa seed	2.0	0.125	0.060	11051	1577	711	12628	11762
cotton	7.7	0.030	0.003	30515	934	83	31449	30598
honeydew	1.0	0.285	0.298	2300	918	978	3218	3278
watermelon	1.0	0.285	0.298	2087	833	887	2920	2974
onions	1.2	0.227	0.196	21607	6345	5269	27952	26876
onion seed	1.0	0.285	0.298	6253	2497	2659	8750	8912
rye-pasture	7.6	0.030	0.003	2009	62	6	2071	2015
oats & barley	8.0	0.029	0.002	9963	293	25	10256	9988
misc field crops	4.0	0.059	0.122	24568	1534	3429	26102	27997
tomatoes	2.5	0.097	0.036	1731	187	65	1918	1796
potatoes	1.7	0.150	0.088	2133	377	206	2510	2339
brocolli	2.8	0.086	0.028	5976	563	171	6539	6147
cabbage	1.8	0.141	0.077	868	142	72	1010	940
cauliflower	2.8	0.086	0.028	2675	252	77	2927	2752
corn-ear	1.7	0.150	0.088	12370	2186	1192	14556	13562
misc garden crops	1.8	0.141	0.077	2357	386	197	2743	2554
asparagus	4.1	0.057	0.012	14465	878	169	15343	14634
citrus	1.3	0.206	0.163	27671	7176	5390	34847	33061
jojoba	4.0	0.059	0.122	0	0	0	0	0
peach trees	1.7	0.150	0.088	33	6	3	39	36
permanent pasture	5.6	0.041	0.006	2781	120	16	2901	2797
totals:				1677109	200657	105460	1877766	1782569

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (200657)/(1877766) = 0.106859

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (105460)/(1782569) = 0.059162

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A3-2000-2002. Salt-Tolerances, Volumes (in AF) of Crop ET, of Required Deep Percolation (RV_{dw}) and of Required Infiltration Water (RV_{infw}) and Individual and IID-wide Leaching Requirements (LR_{infw}), for Year 2000-2002; EC_{iw} of 1.0909 dS/m

crop	EC_e [a]	LR_T [b]	LR_W [b]	average CU	$RV_{dw,T}$ [c]	$RV_{dw,W}$ [c]	$RV_{infw,T}$ [d]	$RV_{infw,W}$ [d]
alfalfa	2.0	0.122	0.060	825884	115238	53025	941122	878909
sudan	2.8	0.085	0.028	150247	13869	4348	164116	154595
wheat	6.0	0.038	0.005	77026	3021	366	80047	77412
bermuda	6.9	0.033	0.004	258350	8721	943	267071	259293
sugar beets	7.0	0.032	0.004	89003	2959	314	91962	89317
lettuce-early	1.3	0.202	0.160	14446	3649	2758	18095	17204
lettuce-late	1.3	0.202	0.160	6789	1715	1296	8504	8085
carrots	1.0	0.279	0.291	31068	12026	12732	43094	43800
cantaloupes-spring	1.0	0.279	0.291	14046	5437	5756	19483	19802
cantaloupes-fall	1.0	0.279	0.291	1211	469	496	1680	1707
alfalfa seed	2.0	0.122	0.060	14600	2037	937	16637	15537
cotton	7.7	0.029	0.003	31452	945	89	32397	31541
honeydew	1.0	0.279	0.291	2749	1064	1127	3813	3876
watermelon	1.0	0.279	0.291	2425	939	994	3364	3419
onions	1.2	0.222	0.192	25871	7392	6156	33263	32027
onion seed	1.0	0.279	0.291	8633	3342	3538	11975	12171
rye-pasture	7.6	0.030	0.003	4419	135	13	4554	4432
oats & barley	8.0	0.028	0.003	5046	146	13	5192	5059
misc field crops	4.0	0.058	0.013	22309	1366	283	23675	22592
tomatoes	2.5	0.096	0.036	1977	209	75	2186	2052
potatoes	1.7	0.147	0.087	3261	563	312	3824	3573
brocolli	2.8	0.085	0.028	7219	666	209	7885	7428
cabbage	1.8	0.138	0.077	960	154	80	1114	1040
cauliflower	2.8	0.085	0.028	3025	279	88	3304	3113
corn-ear	1.7	0.147	0.087	12192	2105	1165	14297	13357
misc garden crops	1.8	0.138	0.077	2579	413	214	2992	2793
asparagus	4.1	0.056	0.012	18332	1092	220	19424	18552
citrus	1.3	0.202	0.160	27378	6916	5227	34294	32605
jojoba	4.0	0.058	0.013	5	0	0	5	5
peach trees	1.7	0.147	0.087	33	6	3	39	36
permanent pasture	5.6	0.041	0.006	2616	111	15	2727	2631
totals:				1665151	196981	102812	1862132	1767963

IID-wide $LR_{infw,T}$ = total $RV_{dw,T}$ / total $RV_{infw,T}$ = (196981)/(1862132) = 0.105783

IID-wide $LR_{infw,W}$ = total $RV_{dw,T}$ / total $RV_{infw,W}$ = (102812)/(1767963) = 0.058153

[a] obtained from Maas and Grattan (1999) in dS/m

[b] $LR_{infw,T}$ and $LR_{infw,W}$ are the individual crop LR_{infw} values for the Traditional (T) and WATSUIT (W) models, respectively .

[c] $RV_{dw,T}$ and $RV_{dw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively.

[d] $RV_{infw,T}$ and $RV_{infw,W}$ are the required drainage volumes corresponding to $LR_{infw,T}$ and $LR_{infw,W}$ values, respectively

Table A5. Effects of Variation in Leaching Requitement, Tailwater Fraction and Horizontal-Leaching on Water Volumes and Ratios Under Uniform Conditions [a]

LR^b	F_{tw}	F_{ctw}	LR_{intw}	LR_{tw}	RV_{intw}	RV_{tw}	RV_{dw}	V_{tw}	BV_{tw}	TBV_W	NBV_W	$\%NBV_W$	$100(BV_{tw}/RV_{dw})$
0.07	0.00	1.00	0.0700	0.0700	107.5269	107.5269	7.5269	0.0000	0.0000	107.5269	0.0000	0.0000	0.0000
0.07	0.05	1.00	0.0700	0.0665	107.5269	113.1862	7.5269	5.6593	0.0000	107.5269	5.6593	5.0000	0.0000
0.07	0.05	1.10	0.0696	0.0661	107.4843	113.1414	7.4843	5.6571	0.0426	107.5269	5.6145	4.9624	0.5689
0.07	0.05	1.20	0.0693	0.0658	107.4418	113.0966	7.4418	5.6548	0.0851	107.5269	5.5697	4.9247	1.1439
0.07	0.05	1.30	0.0689	0.0655	107.3992	113.0518	7.3992	5.6526	0.1276	107.5269	5.5250	4.8871	1.7250
0.07	0.05	1.40	0.0685	0.0651	107.3568	113.0071	7.3568	5.6504	0.1701	107.5269	5.4802	4.8494	2.3124
0.07	0.05	1.50	0.0682	0.0647	107.3143	112.9624	7.3143	5.6481	0.2126	107.5269	5.4356	4.8119	2.9061
0.07	0.05	1.60	0.0678	0.0644	107.2719	112.9178	7.2719	5.6459	0.2550	107.5269	5.3909	4.7742	3.5063
0.07	0.10	1.00	0.0700	0.0630	107.5269	119.4743	7.5269	11.9474	0.0000	107.5269	11.9474	10.0000	0.0000
0.07	0.10	1.10	0.0692	0.0623	107.4370	119.3745	7.4370	11.9374	0.0899	107.5269	11.8476	9.9247	1.2082
0.07	0.10	1.20	0.0684	0.0616	107.3473	119.2748	7.3473	11.9275	0.1796	107.5269	11.7479	9.8494	2.4438
0.07	0.10	1.30	0.0677	0.0609	107.2578	119.1753	7.2578	11.9175	0.2691	107.5269	11.6484	9.7742	3.7078
0.07	0.10	1.40	0.0669	0.0602	107.1684	119.0760	7.1684	11.9076	0.3585	107.5269	11.5491	9.6989	5.0013
0.07	0.10	1.50	0.0661	0.0595	107.0791	118.9768	7.0791	11.8977	0.4478	107.5269	11.4499	9.6236	6.3251
0.07	0.10	1.60	0.0653	0.0588	106.9900	118.8778	6.9900	11.8878	0.5369	107.5269	11.3509	9.5484	7.6805
0.07	0.15	1.00	0.0700	0.0595	107.5269	126.5022	7.5269	18.9753	0.0000	107.5269	18.9753	15.0000	0.0000
0.07	0.15	1.10	0.0688	0.0585	107.3842	126.3344	7.3842	18.9502	0.1426	107.5269	18.8075	14.8871	1.9316
0.07	0.15	1.20	0.0675	0.0574	107.2420	126.1670	7.2420	18.9251	0.2849	107.5269	18.6402	14.7742	3.9339
0.07	0.15	1.30	0.0663	0.0564	107.1001	126.0001	7.1001	18.9000	0.4268	107.5269	18.4732	14.6613	6.0108
0.07	0.15	1.40	0.0651	0.0553	106.9586	125.8336	6.9586	18.8750	0.5683	107.5269	18.3068	14.5484	8.1666
0.07	0.15	1.50	0.0638	0.0543	106.8175	125.6676	6.8175	18.8501	0.7094	107.5269	18.1407	14.4355	10.4058
0.07	0.15	1.60	0.0626	0.0532	106.6767	125.5020	6.6767	18.8253	0.8502	107.5269	17.9751	14.3226	12.7334
0.07	0.20	1.00	0.0700	0.0560	107.5269	134.4086	7.5269	26.8817	0.0000	107.5269	26.8817	20.0000	0.0000
0.07	0.20	1.10	0.0682	0.0546	107.3249	134.1562	7.3249	26.8312	0.2020	107.5269	26.6293	19.8495	2.7571
0.07	0.20	1.20	0.0665	0.0532	107.1237	133.9047	7.1237	26.7809	0.4032	107.5269	26.3778	19.6989	5.6593
0.07	0.20	1.30	0.0647	0.0518	106.9233	133.6541	6.9233	26.7308	0.6036	107.5269	26.1272	19.5484	8.7184
0.07	0.20	1.40	0.0630	0.0504	106.7236	133.4045	6.7236	26.6809	0.8033	107.5269	25.8776	19.3978	11.9474
0.07	0.20	1.50	0.0613	0.0490	106.5246	133.1558	6.5246	26.6312	1.0022	107.5269	25.6289	19.2473	15.3610
0.07	0.20	1.60	0.0595	0.0476	106.3264	132.9080	6.3264	26.5816	1.2005	107.5269	25.3811	19.0968	18.9753
0.08	0.00	1.00	0.0800	0.0800	108.6957	108.6957	8.6957	0.0000	0.0000	108.6957	0.0000	0.0000	0.0000
0.08	0.05	1.00	0.0800	0.0760	108.6957	114.4165	8.6957	5.7208	0.0000	108.6957	5.7208	5.0000	0.0000
0.08	0.05	1.10	0.0796	0.0756	108.6459	114.3641	8.6459	5.7182	0.0497	108.6957	5.6685	4.9565	0.5751
0.08	0.05	1.20	0.0792	0.0752	108.5963	114.3118	8.5963	5.7156	0.0994	108.6957	5.6162	4.9131	1.1563
0.08	0.05	1.30	0.0787	0.0748	108.5466	114.2596	8.5466	5.7130	0.1490	108.6957	5.5639	4.8695	1.7438
0.08	0.05	1.40	0.0783	0.0744	108.4970	114.2074	8.4970	5.7104	0.1986	108.6957	5.5117	4.8260	2.3375
0.08	0.05	1.50	0.0779	0.0740	108.4475	114.1553	8.4475	5.7078	0.2482	108.6957	5.4596	4.7826	2.9377
0.08	0.05	1.60	0.0775	0.0736	108.3980	114.1031	8.3980	5.7052	0.2977	108.6957	5.4075	4.7391	3.5444
0.08	0.10	1.00	0.0800	0.0720	108.6957	120.7729	8.6957	12.0773	0.0000	108.6957	12.0773	10.0000	0.0000
0.08	0.10	1.10	0.0791	0.0712	108.5907	120.6564	8.5907	12.0656	0.1049	108.6957	11.9607	9.9130	1.2213
0.08	0.10	1.20	0.0782	0.0704	108.4860	120.5400	8.4860	12.0540	0.2096	108.6957	11.8444	9.8261	2.4704
0.08	0.10	1.30	0.0773	0.0696	108.3815	120.4239	8.3815	12.0424	0.3141	108.6957	11.7282	9.7391	3.7481
0.08	0.10	1.40	0.0764	0.0688	108.2772	120.3080	8.2772	12.0308	0.4185	108.6957	11.6123	9.6521	5.0556
0.08	0.10	1.50	0.0756	0.0680	108.1731	120.1923	8.1731	12.0192	0.5226	108.6957	11.4967	9.5653	6.3939
0.08	0.10	1.60	0.0747	0.0672	108.0692	120.0768	8.0692	12.0077	0.6265	108.6957	11.3812	9.4783	7.7640
0.08	0.15	1.00	0.0800	0.0680	108.6957	127.8772	8.6957	19.1816	0.0000	108.6957	19.1816	15.0000	0.0000
0.08	0.15	1.10	0.0786	0.0668	108.5291	127.6813	8.5291	19.1522	0.1665	108.6957	18.9857	14.8696	1.9526
0.08	0.15	1.20	0.0772	0.0656	108.3631	127.4860	8.3631	19.1229	0.3326	108.6957	18.7903	14.7391	3.9767
0.08	0.15	1.30	0.0758	0.0644	108.1976	127.2912	8.1976	19.0937	0.4981	108.6957	18.5956	14.6087	6.0762
0.08	0.15	1.40	0.0744	0.0632	108.0325	127.0971	8.0325	19.0646	0.6631	108.6957	18.4015	14.4783	8.2554
0.08	0.15	1.50	0.0729	0.0620	107.8680	126.9036	7.8680	19.0355	0.8276	108.6957	18.2079	14.3478	10.5189
0.08	0.15	1.60	0.0715	0.0608	107.7040	126.7106	7.7040	19.0066	0.9916	108.6957	18.0149	14.2174	12.8719
0.08	0.20	1.00	0.0800	0.0640	108.6957	135.8696	8.6957	27.1739	0.0000	108.6957	27.1739	20.0000	0.0000
0.08	0.20	1.10	0.0780	0.0624	108.4599	135.5748	8.4599	27.1150	0.2358	108.6957	26.8792	19.8261	2.7871
0.08	0.20	1.20	0.0760	0.0608	108.2251	135.2814	8.2251	27.0563	0.4705	108.6957	26.5857	19.6521	5.7208
0.08	0.20	1.30	0.0740	0.0592	107.9914	134.9892	7.9914	26.9978	0.7043	108.6957	26.2935	19.4782	8.8132
0.08	0.20	1.40	0.0720	0.0576	107.7586	134.6983	7.7586	26.9397	0.9370	108.6957	26.0026	19.3043	12.0773
0.08	0.20	1.50	0.0700	0.0560	107.5269	134.4086	7.5269	26.8817	1.1688	108.6957	25.7129	19.1304	15.5280
0.08	0.20	1.60	0.0680	0.0544	107.2961	134.1202	7.2961	26.8240	1.3995	108.6957	25.4245	18.9565	19.1816

LR	F_{tw}	F_{ctw}	LR_{trdw}	LR_{tw}	RV_{trdw}	RV_{tw}	RV_{dw}	V_{tw}	BV_{tw}	TBV_W	NBV_W	$\%NBV_W$	$100(BV_{tw}/RV_{dw})$
0.09	0.00	1.00	0.0900	0.0900	109.8901	109.8901	9.8901	0.0000	0.0000	109.8901	0.0000	0.0000	0.0000
0.09	0.05	1.00	0.0900	0.0855	109.8901	115.6738	9.8901	5.7837	0.0000	109.8901	5.7837	5.0000	0.0000
0.09	0.05	1.10	0.0895	0.0851	109.8329	115.6136	9.8329	5.7807	0.0572	109.8901	5.7235	4.9505	0.5814
0.09	0.05	1.20	0.0891	0.0846	109.7758	115.5535	9.7758	5.7777	0.1143	109.8901	5.6634	4.9011	1.1690
0.09	0.05	1.30	0.0886	0.0842	109.7188	115.4934	9.7188	5.7747	0.1713	109.8901	5.6033	4.8516	1.7629
0.09	0.05	1.40	0.0881	0.0837	109.6618	115.4335	9.6618	5.7717	0.2283	109.8901	5.5433	4.8022	2.3632
0.09	0.05	1.50	0.0876	0.0833	109.6048	115.3735	9.6048	5.7687	0.2853	109.8901	5.4834	4.7527	2.9700
0.09	0.05	1.60	0.0872	0.0828	109.5480	115.3137	9.5480	5.7657	0.3421	109.8901	5.4235	4.7033	3.5834
0.09	0.10	1.00	0.0900	0.0810	109.8901	122.1001	9.8901	12.2100	0.0000	109.8901	12.2100	10.0000	0.0000
0.09	0.10	1.10	0.0890	0.0801	109.7695	121.9661	9.7695	12.1966	0.1206	109.8901	12.0760	9.9011	1.2347
0.09	0.10	1.20	0.0880	0.0792	109.6491	121.8324	9.6491	12.1832	0.2410	109.8901	11.9422	9.8022	2.4975
0.09	0.10	1.30	0.0870	0.0783	109.5290	121.6989	9.5290	12.1699	0.3611	109.8901	11.8088	9.7033	3.7893
0.09	0.10	1.40	0.0860	0.0774	109.4092	121.5658	9.4092	12.1566	0.4809	109.8901	11.6757	9.6044	5.1112
0.09	0.10	1.50	0.0850	0.0765	109.2896	121.4329	9.2896	12.1433	0.6005	109.8901	11.5428	9.5055	6.4641
0.09	0.10	1.60	0.0840	0.0756	109.1703	121.3003	9.1703	12.1300	0.7198	109.8901	11.4102	9.4066	7.8493
0.09	0.15	1.00	0.0900	0.0765	109.8901	129.2825	9.8901	19.3924	0.0000	109.8901	19.3924	15.0000	0.0000
0.09	0.15	1.10	0.0884	0.0752	109.6987	129.0572	9.6987	19.3586	0.1915	109.8901	19.1671	14.8516	1.9741
0.09	0.15	1.20	0.0868	0.0738	109.5079	128.8328	9.5079	19.3249	0.3823	109.8901	18.9427	14.7033	4.0204
0.09	0.15	1.30	0.0852	0.0725	109.3177	128.6091	9.3177	19.2914	0.5724	109.8901	18.7190	14.5550	6.1429
0.09	0.15	1.40	0.0836	0.0711	109.1283	128.3862	9.1283	19.2579	0.7619	109.8901	18.4961	14.4066	8.3461
0.09	0.15	1.50	0.0821	0.0698	108.9394	128.1640	8.9394	19.2246	0.9507	109.8901	18.2739	14.2582	10.6345
0.09	0.15	1.60	0.0805	0.0684	108.7513	127.9427	8.7513	19.1914	1.1388	109.8901	18.0526	14.1099	13.0133
0.09	0.20	1.00	0.0900	0.0720	109.8901	137.3626	9.8901	27.4725	0.0000	109.8901	27.4725	20.0000	0.0000
0.09	0.20	1.10	0.0878	0.0702	109.6191	137.0238	9.6191	27.4048	0.2710	109.8901	27.1337	19.8022	2.8177
0.09	0.20	1.20	0.0855	0.0684	109.3494	136.6867	9.3494	27.3373	0.5407	109.8901	26.7966	19.6044	5.7837
0.09	0.20	1.30	0.0833	0.0666	109.0810	136.3512	9.0810	27.2702	0.8091	109.8901	26.4611	19.4066	8.9100
0.09	0.20	1.40	0.0810	0.0648	108.8139	136.0174	8.8139	27.2035	1.0762	109.8901	26.1273	19.2088	12.2100
0.09	0.20	1.50	0.0788	0.0630	108.5482	135.6852	8.5482	27.1370	1.3419	109.8901	25.7951	19.0110	15.6986
0.09	0.20	1.60	0.0765	0.0612	108.2837	135.3546	8.2837	27.0709	1.6064	109.8901	25.4645	18.8132	19.3924
0.10	0.00	1.00	0.1000	0.1000	111.1111	111.1111	11.1111	0.0000	0.0000	111.1111	0.0000	0.0000	0.0000
0.10	0.05	1.00	0.1000	0.0950	111.1111	116.9591	11.1111	5.8480	0.0000	111.1111	5.8480	5.0000	0.0000
0.10	0.05	1.10	0.0995	0.0945	111.0462	116.8907	11.0462	5.8445	0.0649	111.1111	5.7796	4.9444	0.5879
0.10	0.05	1.20	0.0989	0.0940	110.9813	116.8224	10.9813	5.8411	0.1298	111.1111	5.7113	4.8889	1.1820
0.10	0.05	1.30	0.0984	0.0935	110.9165	116.7542	10.9165	5.8377	0.1946	111.1111	5.6431	4.8333	1.7825
0.10	0.05	1.40	0.0979	0.0930	110.8518	116.6861	10.8518	5.8343	0.2593	111.1111	5.5750	4.7778	2.3895
0.10	0.05	1.50	0.0974	0.0925	110.7872	116.6181	10.7872	5.8309	0.3239	111.1111	5.5070	4.7223	3.0030
0.10	0.05	1.60	0.0968	0.0920	110.7226	116.5501	10.7226	5.8275	0.3885	111.1111	5.4390	4.6667	3.6232
0.10	0.10	1.00	0.1000	0.0900	111.1111	123.4568	11.1111	12.3457	0.0000	111.1111	12.3457	10.0000	0.0000
0.10	0.10	1.10	0.0989	0.0890	110.9741	123.3046	10.9741	12.3305	0.1370	111.1111	12.1935	9.8889	1.2484
0.10	0.10	1.20	0.0978	0.0880	110.8374	123.1527	10.8374	12.3153	0.2737	111.1111	12.0416	9.7778	2.5253
0.10	0.10	1.30	0.0967	0.0870	110.7011	123.0012	10.7011	12.3001	0.4100	111.1111	11.8901	9.6667	3.8314
0.10	0.10	1.40	0.0956	0.0860	110.5651	122.8501	10.5651	12.2850	0.5460	111.1111	11.7390	9.5555	5.1680
0.10	0.10	1.50	0.0944	0.0850	110.4294	122.6994	10.4294	12.2699	0.6817	111.1111	11.5883	9.4445	6.5359
0.10	0.10	1.60	0.0933	0.0840	110.2941	122.5490	10.2941	12.2549	0.8170	111.1111	11.4379	9.3333	7.9365
0.10	0.15	1.00	0.1000	0.0850	111.1111	130.7190	11.1111	19.6078	0.0000	111.1111	19.6078	15.0000	0.0000
0.10	0.15	1.10	0.0982	0.0835	110.8937	130.4631	10.8937	19.5695	0.2174	111.1111	19.3520	14.8333	1.9960
0.10	0.15	1.20	0.0965	0.0820	110.6771	130.2083	10.6771	19.5313	0.4340	111.1111	19.0972	14.6667	4.0650
0.10	0.15	1.30	0.0947	0.0805	110.4613	129.9545	10.4613	19.4932	0.6498	111.1111	18.8434	14.5000	6.2112
0.10	0.15	1.40	0.0929	0.0790	110.2464	129.7017	10.2464	19.4553	0.8647	111.1111	18.5906	14.3334	8.4388
0.10	0.15	1.50	0.0912	0.0775	110.0324	129.4498	10.0324	19.4175	1.0787	111.1111	18.3387	14.1666	10.7527
0.10	0.15	1.60	0.0894	0.0760	109.8191	129.1990	9.8191	19.3798	1.2920	111.1111	18.0879	14.0000	13.1579
0.10	0.20	1.00	0.1000	0.0800	111.1111	138.8889	11.1111	27.7778	0.0000	111.1111	27.7778	20.0000	0.0000
0.10	0.20	1.10	0.0975	0.0780	110.8033	138.5042	10.8033	27.7008	0.3078	111.1111	27.3930	19.7777	2.8490
0.10	0.20	1.20	0.0950	0.0760	110.4972	138.1215	10.4972	27.6243	0.6139	111.1111	27.0104	19.5555	5.8480
0.10	0.20	1.30	0.0925	0.0740	110.1928	137.7410	10.1928	27.5482	0.9183	111.1111	26.6299	19.3333	9.0090
0.10	0.20	1.40	0.0900	0.0720	109.8901	137.3626	9.8901	27.4725	1.2210	111.1111	26.2515	19.1111	12.3457
0.10	0.20	1.50	0.0875	0.0700	109.5890	136.9863	9.5890	27.3973	1.5221	111.1111	25.8752	18.8889	15.8730
0.10	0.20	1.60	0.0850	0.0680	109.2896	136.6120	9.2896	27.3224	1.8215	111.1111	25.5009	18.6667	19.6078

LR	F_{tw}	F_{ctw}	LR_{trtw}	LR_{tw}	RV_{trtw}	RV_{tw}	RV_{dw}	V_{tw}	BV_{tw}	TBV_W	NBV_W	%NBV_W	$100(BV_{tw}/RV_{dw})$
0.11	0.00	1.00	0.1100	0.1100	112.3596	112.3596	12.3596	0.0000	0.0000	112.3596	0.0000	0.0000	0.0000
0.11	0.05	1.00	0.1100	0.1045	112.3596	118.2732	12.3596	5.9137	0.0000	112.3596	5.9137	5.0000	0.0000
0.11	0.05	1.10	0.1094	0.1040	112.2865	118.1963	12.2865	5.9098	0.0730	112.3596	5.8368	4.9382	0.5945
0.11	0.05	1.20	0.1088	0.1034	112.2136	118.1195	12.2136	5.9060	0.1460	112.3596	5.7600	4.8764	1.1953
0.11	0.05	1.30	0.1083	0.1029	112.1407	118.0428	12.1407	5.9021	0.2188	112.3596	5.6833	4.8146	1.8026
0.11	0.05	1.40	0.1077	0.1023	112.0679	117.9663	12.0679	5.8983	0.2916	112.3596	5.6067	4.7528	2.4163
0.11	0.05	1.50	0.1071	0.1018	111.9953	117.8898	11.9953	5.8945	0.3643	112.3596	5.5302	4.6910	3.0367
0.11	0.05	1.60	0.1065	0.1012	111.9227	117.8134	11.9227	5.8907	0.4368	112.3596	5.4538	4.6292	3.6639
0.11	0.10	1.00	0.1100	0.0990	112.3596	124.8439	12.3596	12.4844	0.0000	112.3596	12.4844	10.0000	0.0000
0.11	0.10	1.10	0.1088	0.0979	112.2055	124.6727	12.2055	12.4673	0.1541	112.3596	12.3132	9.8764	1.2625
0.11	0.10	1.20	0.1076	0.0968	112.0518	124.5020	12.0518	12.4502	0.3078	112.3596	12.1424	9.7528	2.5536
0.11	0.10	1.30	0.1063	0.0957	111.8985	124.3317	11.8985	12.4332	0.4610	112.3596	11.9722	9.6292	3.8745
0.11	0.10	1.40	0.1051	0.0946	111.7457	124.1619	11.7457	12.4162	0.6138	112.3596	11.8024	9.5057	5.2260
0.11	0.10	1.50	0.1039	0.0935	111.5933	123.9926	11.5933	12.3993	0.7662	112.3596	11.6330	9.3820	6.6094
0.11	0.10	1.60	0.1027	0.0924	111.4413	123.8237	11.4413	12.3824	0.9182	112.3596	11.4641	9.2584	8.0257
0.11	0.15	1.00	0.1100	0.0935	112.3596	132.1877	12.3596	19.8282	0.0000	112.3596	19.8282	15.0000	0.0000
0.11	0.15	1.10	0.1081	0.0919	112.1150	131.9000	12.1150	19.7850	0.2445	112.3596	19.5405	14.8146	2.0184
0.11	0.15	1.20	0.1061	0.0902	111.8715	131.6136	11.8715	19.7420	0.4880	112.3596	19.2540	14.6292	4.1107
0.11	0.15	1.30	0.1042	0.0886	111.6291	131.3284	11.6291	19.6993	0.7304	112.3596	18.9688	14.4438	6.2810
0.11	0.15	1.40	0.1022	0.0869	111.3878	131.0444	11.3878	19.6567	0.9718	112.3596	18.6849	14.2584	8.5336
0.11	0.15	1.50	0.1003	0.0853	111.1474	130.7617	11.1474	19.6143	1.2121	112.3596	18.4021	14.0730	10.8735
0.11	0.15	1.60	0.0984	0.0836	110.9081	130.4802	10.9081	19.5720	1.4514	112.3596	18.1206	13.8876	13.3057
0.11	0.20	1.00	0.1100	0.0880	112.3596	140.4494	12.3596	28.0899	0.0000	112.3596	28.0899	20.0000	0.0000
0.11	0.20	1.10	0.1073	0.0858	112.0134	140.0168	12.0134	28.0034	0.3461	112.3596	27.6573	19.7528	2.8810
0.11	0.20	1.20	0.1045	0.0836	111.6695	139.5868	11.6695	27.9174	0.6901	112.3596	27.2273	19.5056	5.9137
0.11	0.20	1.30	0.1018	0.0814	111.3276	139.1595	11.3276	27.8319	1.0320	112.3596	26.7999	19.2584	9.1102
0.11	0.20	1.40	0.0990	0.0792	110.9878	138.7347	10.9878	27.7469	1.3718	112.3596	26.3752	19.0112	12.4844
0.11	0.20	1.50	0.0963	0.0770	110.6501	138.3126	10.6501	27.6625	1.7095	112.3596	25.9530	18.7640	16.0514
0.11	0.20	1.60	0.0935	0.0748	110.3144	137.8930	10.3144	27.5786	2.0452	112.3596	25.5334	18.5169	19.8282
0.12	0.00	1.00	0.1200	0.1200	113.6364	113.6364	13.6364	0.0000	0.0000	113.6364	0.0000	0.0000	0.0000
0.12	0.05	1.00	0.1200	0.1140	113.6364	119.6172	13.6364	5.9809	0.0000	113.6364	5.9809	5.0000	0.0000
0.12	0.05	1.10	0.1194	0.1134	113.5549	119.5314	13.5549	5.9766	0.0815	113.6364	5.8951	4.9318	0.6013
0.12	0.05	1.20	0.1187	0.1128	113.4735	119.4458	13.4735	5.9723	0.1629	113.6364	5.8094	4.8636	1.2089
0.12	0.05	1.30	0.1181	0.1122	113.3922	119.3602	13.3922	5.9680	0.2441	113.6364	5.7239	4.7955	1.8230
0.12	0.05	1.40	0.1175	0.1116	113.3111	119.2748	13.3111	5.9637	0.3253	113.6364	5.6384	4.7272	2.4438
0.12	0.05	1.50	0.1168	0.1110	113.2300	119.1895	13.2300	5.9595	0.4063	113.6364	5.5531	4.6591	3.0713
0.12	0.05	1.60	0.1162	0.1104	113.1491	119.1043	13.1491	5.9552	0.4872	113.6364	5.4680	4.5909	3.7055
0.12	0.10	1.00	0.1200	0.1080	113.6364	126.2626	13.6364	12.6263	0.0000	113.6364	12.6263	10.0000	0.0000
0.12	0.10	1.10	0.1187	0.1068	113.4644	126.0716	13.4644	12.6072	0.1719	113.6364	12.4352	9.8636	1.2768
0.12	0.10	1.20	0.1173	0.1056	113.2931	125.8812	13.2931	12.5881	0.3433	113.6364	12.2448	9.7273	2.5826
0.12	0.10	1.30	0.1160	0.1044	113.1222	125.6913	13.1222	12.5691	0.5142	113.6364	12.0549	9.5909	3.9185
0.12	0.10	1.40	0.1147	0.1032	112.9518	125.5020	12.9518	12.5502	0.6846	113.6364	11.8656	9.4545	5.2854
0.12	0.10	1.50	0.1133	0.1020	112.7820	125.3133	12.7820	12.5313	0.8544	113.6364	11.6769	9.3182	6.6845
0.12	0.10	1.60	0.1120	0.1008	112.6126	125.1251	12.6126	12.5125	1.0238	113.6364	11.4888	9.1818	8.1169
0.12	0.15	1.00	0.1200	0.1020	113.6364	133.6898	13.6364	20.0535	0.0000	113.6364	20.0535	15.0000	0.0000
0.12	0.15	1.10	0.1179	0.1002	113.3636	133.3689	13.3636	20.0053	0.2728	113.6364	19.7325	14.7954	2.0414
0.12	0.15	1.20	0.1158	0.0984	113.0921	133.0495	13.0921	19.9574	0.5443	113.6364	19.4131	14.5909	4.1574
0.12	0.15	1.30	0.1136	0.0966	112.8219	132.7316	12.8219	19.9097	0.8145	113.6364	19.0953	14.3864	6.3523
0.12	0.15	1.40	0.1115	0.0948	112.5530	132.4153	12.5530	19.8623	1.0834	113.6364	18.7789	14.1818	8.6306
0.12	0.15	1.50	0.1094	0.0930	112.2853	132.1004	12.2853	19.8151	1.3510	113.6364	18.4640	13.9772	10.9971
0.12	0.15	1.60	0.1073	0.0912	112.0190	131.7870	12.0190	19.7681	1.6174	113.6364	18.1507	13.7727	13.4569
0.12	0.20	1.00	0.1200	0.0960	113.6364	142.0455	13.6364	28.4091	0.0000	113.6364	28.4091	20.0000	0.0000
0.12	0.20	1.10	0.1170	0.0936	113.2503	141.5629	13.2503	28.3126	0.3861	113.6364	27.9265	19.7273	2.9138
0.12	0.20	1.20	0.1140	0.0912	112.8668	141.0835	12.8668	28.2167	0.7695	113.6364	27.4472	19.4546	5.9809
0.12	0.20	1.30	0.1110	0.0888	112.4859	140.6074	12.4859	28.1215	1.1504	113.6364	26.9711	19.1818	9.2138
0.12	0.20	1.40	0.1080	0.0864	112.1076	140.1345	12.1076	28.0269	1.5287	113.6364	26.4982	18.9091	12.6263
0.12	0.20	1.50	0.1050	0.0840	111.7318	139.6648	11.7318	27.9330	1.9045	113.6364	26.0284	18.6363	16.2338
0.12	0.20	1.60	0.1020	0.0816	111.3586	139.1982	11.3586	27.8396	2.2778	113.6364	25.5619	18.3636	20.0535

LR	F_{tw}	F_{ctw}	LR_{intw}	LR_{tw}	RV_{intw}	RV_{tw}	RV_{dw}	V_{tw}	BV_{tw}	TBV_W	NBV_W	$\%NBV_W$	$100(BV_{tw}/RV_{dw})$
0.13	0.00	1.00	0.1300	0.1300	114.9425	114.9425	14.9425	0.0000	0.0000	114.9425	0.0000	0.0000	0.0000
0.13	0.05	1.00	0.1300	0.1235	114.9425	120.9921	14.9425	6.0496	0.0000	114.9425	6.0496	5.0000	0.0000
0.13	0.05	1.10	0.1293	0.1229	114.8522	120.8971	14.8522	6.0449	0.0903	114.9425	5.9545	4.9253	0.6082
0.13	0.05	1.20	0.1286	0.1222	114.7620	120.8021	14.7620	6.0401	0.1805	114.9425	5.8596	4.8506	1.2228
0.13	0.05	1.30	0.1279	0.1216	114.6720	120.7073	14.6720	6.0354	0.2706	114.9425	5.7648	4.7759	1.8440
0.13	0.05	1.40	0.1273	0.1209	114.5821	120.6127	14.5821	6.0306	0.3605	114.9425	5.6702	4.7012	2.4719
0.13	0.05	1.50	0.1266	0.1203	114.4923	120.5182	14.4923	6.0259	0.4502	114.9425	5.5757	4.6264	3.1066
0.13	0.05	1.60	0.1259	0.1196	114.4027	120.4239	14.4027	6.0212	0.5398	114.9425	5.4814	4.5517	3.7481
0.13	0.10	1.00	0.1300	0.1170	114.9425	127.7139	14.9425	12.7714	0.0000	114.9425	12.7714	10.0000	0.0000
0.13	0.10	1.10	0.1286	0.1157	114.7520	127.5022	14.7520	12.7502	0.1905	114.9425	12.5597	9.8506	1.2915
0.13	0.10	1.20	0.1271	0.1144	114.5621	127.2912	14.5621	12.7291	0.3804	114.9425	12.3487	9.7011	2.6123
0.13	0.10	1.30	0.1257	0.1131	114.3729	127.0810	14.3729	12.7081	0.5697	114.9425	12.1384	9.5517	3.9635
0.13	0.10	1.40	0.1242	0.1118	114.1842	126.8714	14.1842	12.6871	0.7583	114.9425	11.9288	9.4023	5.3462
0.13	0.10	1.50	0.1228	0.1105	113.9962	126.6624	13.9962	12.6662	0.9463	114.9425	11.7199	9.2529	6.7613
0.13	0.10	1.60	0.1213	0.1092	113.8088	126.4542	13.8088	12.6454	1.1337	114.9425	11.5117	9.1034	8.2102
0.13	0.15	1.00	0.1300	0.1105	114.9425	135.2265	14.9425	20.2840	0.0000	114.9425	20.2840	15.0000	0.0000
0.13	0.15	1.10	0.1277	0.1086	114.6402	134.8709	14.6402	20.2306	0.3023	114.9425	19.9283	14.7758	2.0648
0.13	0.15	1.20	0.1254	0.1066	114.3395	134.5171	14.3395	20.1776	0.6030	114.9425	19.5746	14.5518	4.2052
0.13	0.15	1.30	0.1231	0.1047	114.0404	134.1652	14.0404	20.1248	0.9021	114.9425	19.2226	14.3276	6.4254
0.13	0.15	1.40	0.1208	0.1027	113.7428	133.8151	13.7428	20.0723	1.1997	114.9425	18.8725	14.1034	8.7298
0.13	0.15	1.50	0.1185	0.1008	113.4468	133.4668	13.4468	20.0200	1.4957	114.9425	18.5243	13.8793	11.1235
0.13	0.15	1.60	0.1162	0.0988	113.1523	133.1203	13.1523	19.9681	1.7902	114.9425	18.1778	13.6552	13.6116
0.13	0.20	1.00	0.1300	0.1040	114.9425	143.6782	14.9425	28.7356	0.0000	114.9425	28.7356	20.0000	0.0000
0.13	0.20	1.10	0.1268	0.1014	114.5147	143.1434	14.5147	28.6287	0.4278	114.9425	28.2009	19.7012	2.9472
0.13	0.20	1.20	0.1235	0.0988	114.0901	142.6127	14.0901	28.5225	0.8524	114.9425	27.6701	19.4023	6.0496
0.13	0.20	1.30	0.1203	0.0962	113.6687	142.0858	13.6687	28.4172	1.2739	114.9425	27.1433	19.1035	9.3197
0.13	0.20	1.40	0.1170	0.0936	113.2503	141.5629	13.2503	28.3126	1.6922	114.9425	26.6203	18.8046	12.7714
0.13	0.20	1.50	0.1138	0.0910	112.8350	141.0437	12.8350	28.2087	2.1075	114.9425	26.1012	18.5058	16.4204
0.13	0.20	1.60	0.1105	0.0884	112.4227	140.5284	12.4227	28.1057	2.5198	114.9425	25.5859	18.2069	20.2840
0.14	0.00	1.00	0.1400	0.1400	116.2791	116.2791	16.2791	0.0000	0.0000	116.2791	0.0000	0.0000	0.0000
0.14	0.05	1.00	0.1400	0.1330	116.2791	122.3990	16.2791	6.1200	0.0000	116.2791	6.1200	5.0000	0.0000
0.14	0.05	1.10	0.1393	0.1323	116.1795	122.2942	16.1795	6.1147	0.0995	116.2791	6.0152	4.9186	0.6152
0.14	0.05	1.20	0.1385	0.1316	116.0802	122.1896	16.0802	6.1095	0.1989	116.2791	5.9106	4.8372	1.2370
0.14	0.05	1.30	0.1378	0.1309	115.9810	122.0852	15.9810	6.1043	0.2981	116.2791	5.8061	4.7558	1.8654
0.14	0.05	1.40	0.1371	0.1302	115.8819	121.9810	15.8819	6.0990	0.3971	116.2791	5.7019	4.6744	2.5006
0.14	0.05	1.50	0.1363	0.1295	115.7831	121.8769	15.7831	6.0938	0.4960	116.2791	5.5978	4.5930	3.1427
0.14	0.05	1.60	0.1356	0.1288	115.6844	121.7730	15.6844	6.0887	0.5947	116.2791	5.4939	4.5116	3.7917
0.14	0.10	1.00	0.1400	0.1260	116.2791	129.1990	16.2791	12.9199	0.0000	116.2791	12.9199	10.0000	0.0000
0.14	0.10	1.10	0.1384	0.1246	116.0691	128.9657	16.0691	12.8966	0.2099	116.2791	12.6866	9.8372	1.3065
0.14	0.10	1.20	0.1369	0.1232	115.8599	128.7333	15.8599	12.8733	0.4191	116.2791	12.4542	9.6744	2.6427
0.14	0.10	1.30	0.1353	0.1218	115.6515	128.5017	15.6515	12.8502	0.6276	116.2791	12.2226	9.5116	4.0096
0.14	0.10	1.40	0.1338	0.1204	115.4438	128.2709	15.4438	12.8271	0.8353	116.2791	11.9918	9.3488	5.4083
0.14	0.10	1.50	0.1322	0.1190	115.2369	128.0410	15.2369	12.8041	1.0422	116.2791	11.7619	9.1860	6.8399
0.14	0.10	1.60	0.1307	0.1176	115.0307	127.8119	15.0307	12.7812	1.2484	116.2791	11.5328	9.0233	8.3056
0.14	0.15	1.00	0.1400	0.1190	116.2791	136.7989	16.2791	20.5198	0.0000	116.2791	20.5198	15.0000	0.0000
0.14	0.15	1.10	0.1375	0.1169	115.9460	136.4070	15.9460	20.4611	0.3331	116.2791	20.1280	14.7558	2.0888
0.14	0.15	1.20	0.1351	0.1148	115.6148	136.0174	15.6148	20.4026	0.6643	116.2791	19.7383	14.5116	4.2541
0.14	0.15	1.30	0.1326	0.1127	115.2855	135.6300	15.2855	20.3445	0.9936	116.2791	19.3509	14.2674	6.5001
0.14	0.15	1.40	0.1301	0.1106	114.9581	135.2448	14.9581	20.2867	1.3210	116.2791	18.9657	14.0232	8.8313
0.14	0.15	1.50	0.1276	0.1085	114.6325	134.8618	14.6325	20.2293	1.6466	116.2791	18.5827	13.7791	11.2528
0.14	0.15	1.60	0.1252	0.1064	114.3088	134.4809	14.3088	20.1721	1.9703	116.2791	18.2018	13.5349	13.7699
0.14	0.20	1.00	0.1400	0.1120	116.2791	145.3488	16.2791	29.0698	0.0000	116.2791	29.0698	20.0000	0.0000
0.14	0.20	1.10	0.1365	0.1092	115.8078	144.7597	15.8078	28.9519	0.4713	116.2791	28.4806	19.6744	2.9815
0.14	0.20	1.20	0.1330	0.1064	115.3403	144.1753	15.3403	28.8351	0.9388	116.2791	27.8962	19.3488	6.1200
0.14	0.20	1.30	0.1295	0.1036	114.8765	143.5956	14.8765	28.7191	1.4026	116.2791	27.3166	19.0233	9.4280
0.14	0.20	1.40	0.1260	0.1008	114.4165	143.0206	14.4165	28.6041	1.8626	116.2791	26.7415	18.6977	12.9199
0.14	0.20	1.50	0.1225	0.0980	113.9601	142.4501	13.9601	28.4900	2.3190	116.2791	26.1711	18.3721	16.6113
0.14	0.20	1.60	0.1190	0.0952	113.5074	141.8842	13.5074	28.3768	2.7717	116.2791	25.6052	18.0465	20.5198

LR	F_{tw}	F_{ctw}	LR_{intw}	LR_{tw}	RV_{intw}	RV_{tw}	RV_{ctw}	V_{tw}	BV_{tw}	TBV_W	NBV_W	$\%NBV_W$	$100(BV_{tw}/RV_{ctw})$
0.15	0.00	1.00	0.1500	0.1500	117.6471	117.6471	17.6471	0.0000	0.0000	117.6471	0.0000	0.0000	0.0000
0.15	0.05	1.00	0.1500	0.1425	117.6471	123.8390	17.6471	6.1920	0.0000	117.6471	6.1920	5.0000	0.0000
0.15	0.05	1.10	0.1492	0.1418	117.5379	123.7241	17.5379	6.1862	0.1092	117.6471	6.0770	4.9117	0.6225
0.15	0.05	1.20	0.1484	0.1410	117.4289	123.6094	17.4289	6.1805	0.2181	117.6471	5.9623	4.8235	1.2516
0.15	0.05	1.30	0.1476	0.1403	117.3202	123.4949	17.3202	6.1747	0.3269	117.6471	5.8478	4.7353	1.8874
0.15	0.05	1.40	0.1468	0.1395	117.2116	123.3806	17.2116	6.1690	0.4355	117.6471	5.7336	4.6471	2.5300
0.15	0.05	1.50	0.1461	0.1388	117.1032	123.2666	17.1032	6.1633	0.5438	117.6471	5.6195	4.5588	3.1797
0.15	0.05	1.60	0.1453	0.1380	116.9951	123.1527	16.9951	6.1576	0.6520	117.6471	5.5057	4.4706	3.8363
0.15	0.10	1.00	0.1500	0.1350	117.6471	130.7190	17.6471	13.0719	0.0000	117.6471	13.0719	10.0000	0.0000
0.15	0.10	1.10	0.1483	0.1335	117.4168	130.4631	17.4168	13.0463	0.2302	117.6471	12.8161	9.8235	1.3219
0.15	0.10	1.20	0.1467	0.1320	117.1875	130.2083	17.1875	13.0208	0.4596	117.6471	12.5613	9.6471	2.6738
0.15	0.10	1.30	0.1450	0.1305	116.9591	129.9545	16.9591	12.9955	0.6880	117.6471	12.3075	9.4706	4.0568
0.15	0.10	1.40	0.1433	0.1290	116.7315	129.7017	16.7315	12.9702	0.9155	117.6471	12.0546	9.2941	5.4720
0.15	0.10	1.50	0.1417	0.1275	116.5049	129.4498	16.5049	12.9450	1.1422	117.6471	11.8028	9.1177	6.9204
0.15	0.10	1.60	0.1400	0.1260	116.2791	129.1990	16.2791	12.9199	1.3680	117.6471	11.5519	8.9412	8.4034
0.15	0.15	1.00	0.1500	0.1275	117.6471	138.4083	17.6471	20.7612	0.0000	117.6471	20.7612	15.0000	0.0000
0.15	0.15	1.10	0.1474	0.1253	117.2818	137.9786	17.2818	20.6968	0.3652	117.6471	20.3316	14.7353	2.1134
0.15	0.15	1.20	0.1447	0.1230	116.9188	137.5516	16.9188	20.6327	0.7282	117.6471	19.9045	14.4706	4.3042
0.15	0.15	1.30	0.1421	0.1208	116.5581	137.1272	16.5581	20.5691	1.0890	117.6471	19.4801	14.2059	6.5765
0.15	0.15	1.40	0.1394	0.1185	116.1996	136.7054	16.1996	20.5058	1.4475	117.6471	19.0583	13.9411	8.9352
0.15	0.15	1.50	0.1368	0.1163	115.8433	136.2862	15.8433	20.4429	1.8038	117.6471	18.6391	13.6764	11.3852
0.15	0.15	1.60	0.1341	0.1140	115.4891	135.8696	15.4891	20.3804	2.1579	117.6471	18.2225	13.4118	13.9319
0.15	0.20	1.00	0.1500	0.1200	117.6471	147.0588	17.6471	29.4118	0.0000	117.6471	29.4118	20.0000	0.0000
0.15	0.20	1.10	0.1463	0.1170	117.1303	146.4129	17.1303	29.2826	0.5168	117.6471	28.7658	19.6470	3.0166
0.15	0.20	1.20	0.1425	0.1140	116.6181	145.7726	16.6181	29.1545	1.0290	117.6471	28.1255	19.2941	6.1920
0.15	0.20	1.30	0.1388	0.1110	116.1103	145.1379	16.1103	29.0276	1.5368	117.6471	27.4908	18.9412	9.5390
0.15	0.20	1.40	0.1350	0.1080	115.6069	144.5087	15.6069	28.9017	2.0401	117.6471	26.8616	18.5882	13.0719
0.15	0.20	1.50	0.1313	0.1050	115.1079	143.8849	15.1079	28.7770	2.5391	117.6471	26.2378	18.2353	16.8067
0.15	0.20	1.60	0.1275	0.1020	114.6132	143.2665	14.6132	28.6533	3.0339	117.6471	25.6194	17.8824	20.7612

[a] assuming V_{et} = 100; [b] the leaching requirement determined by either either LR_T or LR_W

Table 6a: Effects of Non-Uniformity Compensation on Irrigation and Drainage Volumes and Ratios [a]

A) Compensation Applied to Both V_{et} and RV_{dw}: $RV_{iw} = [(V_{et})/(1-LR_{iw})(F_n)]/(1-F_{iw})$

LR	F_n	F_{iw}	F_{etw}	RV_{iwW} [b]	RV_{dw} [c]	RV_{iw} [d]	BV_{iw} [e]	NBV_W [f]	$\%NBV_W$ [f]	V_{iw} [g]	V_{dw} [h]	LF_{iw} [i]	NRV_{dw} [j]	$\%NRV_{dw}$ [j]
0.09	0.70	0.00	1.0	109.890	9.890	156.986	0.0000	47.0958	30.0000	0.000	56.986	0.363	47.096	82.645
0.09	0.70	0.05	1.0	109.890	9.890	165.248	0.0000	55.3582	33.5000	8.262	56.986	0.345	47.096	82.645
0.09	0.70	0.05	1.3	109.719	9.719	164.991	0.1713	55.1005	33.3962	8.250	56.741	0.344	47.022	82.872
0.09	0.70	0.05	1.6	109.548	9.548	164.734	0.3421	54.8437	33.2923	8.237	56.497	0.343	46.949	83.100
0.09	0.70	0.10	1.0	109.890	9.890	174.429	0.0000	64.5386	37.0000	17.443	56.986	0.327	47.096	82.645
0.09	0.70	0.10	1.3	109.529	9.529	173.856	0.3611	63.9655	36.7923	17.386	56.470	0.325	46.941	83.126
0.09	0.70	0.10	1.6	109.170	9.170	173.286	0.7198	63.3961	36.5846	17.329	55.958	0.323	46.787	83.612
0.09	0.70	0.15	1.0	109.890	9.890	184.689	0.0000	74.7992	40.5000	27.703	56.986	0.309	47.096	82.645
0.09	0.70	0.15	1.3	109.318	9.318	183.727	0.5724	73.8372	40.1885	27.559	56.168	0.306	46.851	83.411
0.09	0.70	0.15	1.6	108.751	8.751	182.775	1.1388	72.8851	39.8769	27.416	55.359	0.303	46.608	84.192
0.09	0.70	0.20	1.0	109.890	9.890	196.232	0.0000	86.3422	44.0000	39.247	56.986	0.290	47.096	82.645
0.09	0.70	0.20	1.3	109.081	9.081	194.788	0.8091	84.8974	43.5846	38.958	55.830	0.287	46.749	83.735
0.09	0.70	0.20	1.6	108.284	8.284	193.364	1.6064	83.4736	43.1692	38.673	54.691	0.283	46.407	84.854
0.09	0.80	0.00	1.0	109.890	9.890	137.363	0.0000	27.4725	20.0000	0.000	37.363	0.272	27.473	73.529
0.09	0.80	0.05	1.0	109.890	9.890	144.592	0.0000	34.7021	24.0000	7.230	37.363	0.258	27.473	73.529
0.09	0.80	0.05	1.3	109.719	9.719	144.367	0.1713	34.4767	23.8813	7.218	37.149	0.257	27.430	73.838
0.09	0.80	0.05	1.6	109.548	9.548	144.142	0.3421	34.2520	23.7626	7.207	36.935	0.256	27.387	74.149
0.09	0.80	0.10	1.0	109.890	9.890	152.625	0.0000	42.7350	28.0000	15.263	37.363	0.245	27.473	73.529
0.09	0.80	0.10	1.3	109.529	9.529	152.124	0.3611	42.2335	27.7626	15.212	36.911	0.243	27.382	74.184
0.09	0.80	0.10	1.6	109.170	9.170	151.625	0.7198	41.7353	27.5253	15.163	36.463	0.241	27.293	74.850
0.09	0.80	0.15	1.0	109.890	9.890	161.603	0.0000	51.7130	32.0000	24.241	37.363	0.231	27.473	73.529
0.09	0.80	0.15	1.3	109.318	9.318	160.761	0.5724	50.8713	31.6440	24.114	36.647	0.228	27.329	74.575
0.09	0.80	0.15	1.6	108.751	8.751	159.928	1.1388	50.0382	31.2879	23.989	35.939	0.225	27.188	75.650
0.09	0.80	0.20	1.0	109.890	9.890	171.703	0.0000	61.8132	36.0000	34.341	37.363	0.218	27.473	73.529
0.09	0.80	0.20	1.3	109.081	9.081	170.439	0.8091	60.5489	35.5253	34.088	36.351	0.213	27.270	75.019
0.09	0.80	0.20	1.6	108.284	8.284	169.193	1.6064	59.3032	35.0505	33.839	35.355	0.209	27.071	76.570
0.09	0.90	0.00	1.0	109.890	9.890	122.100	0.0000	12.2100	10.0000	0.000	22.100	0.181	12.210	55.249
0.09	0.90	0.05	1.0	109.890	9.890	128.526	0.0000	18.6363	14.5000	6.426	22.100	0.172	12.210	55.249
0.09	0.90	0.05	1.3	109.719	9.719	128.326	0.1713	18.4359	14.3665	6.416	21.910	0.171	12.191	55.642
0.09	0.90	0.05	1.6	109.548	9.548	128.126	0.3421	18.2362	14.2330	6.406	21.720	0.170	12.172	56.041
0.09	0.90	0.10	1.0	109.890	9.890	135.667	0.0000	25.7767	19.0000	13.567	22.100	0.163	12.210	55.249
0.09	0.90	0.10	1.3	109.529	9.529	135.221	0.3611	25.3309	18.7330	13.522	21.699	0.161	12.170	56.085
0.09	0.90	0.10	1.6	109.170	9.170	134.778	0.7198	24.8880	18.4659	13.478	21.300	0.158	12.130	56.948
0.09	0.90	0.15	1.0	109.890	9.890	143.647	0.0000	33.7571	23.5000	21.547	22.100	0.154	12.210	55.249
0.09	0.90	0.15	1.3	109.318	9.318	142.899	0.5724	33.0089	23.0995	21.435	21.464	0.150	12.146	56.589
0.09	0.90	0.15	1.6	108.751	8.751	142.159	1.1388	32.2684	22.6989	21.324	20.835	0.147	12.084	57.997
0.09	0.90	0.20	1.0	109.890	9.890	152.625	0.0000	42.7350	28.0000	30.525	22.100	0.145	12.210	55.249
0.09	0.90	0.20	1.3	109.081	9.081	151.501	0.8091	41.6113	27.4659	30.300	21.201	0.140	12.120	57.167
0.09	0.90	0.20	1.6	108.284	8.284	150.394	1.6064	40.5039	26.9319	30.079	20.315	0.135	12.032	59.224
0.09	1.00	0.00	1.0	109.890	9.890	109.890	0.0000	0.0000	0.0000	0.000	9.890	0.090	0.000	0.000
0.09	1.00	0.05	1.0	109.890	9.890	115.674	0.0000	5.7837	5.0000	5.784	9.890	0.086	0.000	0.000
0.09	1.00	0.05	1.3	109.719	9.719	115.493	0.1713	5.6033	4.8516	5.775	9.719	0.084	0.000	0.000
0.09	1.00	0.05	1.6	109.548	9.548	115.314	0.3421	5.4235	4.7033	5.766	9.548	0.083	0.000	0.000
0.09	1.00	0.10	1.0	109.890	9.890	122.100	0.0000	12.2100	10.0000	12.210	9.890	0.081	0.000	0.000
0.09	1.00	0.10	1.3	109.529	9.529	121.699	0.3611	11.8088	9.7033	12.170	9.529	0.078	0.000	0.000
0.09	1.00	0.10	1.6	109.170	9.170	121.300	0.7198	11.4102	9.4066	12.130	9.170	0.076	0.000	0.000
0.09	1.00	0.15	1.0	109.890	9.890	129.283	0.0000	19.3924	15.0000	19.392	9.890	0.077	0.000	0.000
0.09	1.00	0.15	1.3	109.318	9.318	128.609	0.5724	18.7190	14.5549	19.291	9.318	0.072	0.000	0.000
0.09	1.00	0.15	1.6	108.751	8.751	127.943	1.1388	18.0526	14.1099	19.191	8.751	0.068	0.000	0.000
0.09	1.00	0.20	1.0	109.890	9.890	137.363	0.0000	27.4725	20.0000	27.473	9.890	0.072	0.000	0.000
0.09	1.00	0.20	1.3	109.081	9.081	136.351	0.8091	26.4611	19.4066	27.270	9.081	0.067	0.000	0.000
0.09	1.00	0.20	1.6	108.284	8.284	135.355	1.6064	25.4645	18.8132	27.071	8.284	0.061	0.000	0.000

LR	F_s	F_{bw}	F_{ctw}	RV_{bstw}[b]	RV_{dw}[c]	RV_{tw}[d]	BV_{tw}[e]	NBV_{tw}[f]	$\%NBV_{tw}$[f]	V_{bw}[g]	V_{dw}[h]	LF_{tw}[i]	NRV_{dw}[j]	$\%NRV_{dw}$[j]
0.13	0.70	0.00	1.0	114.943	14.943	164.204	0.0000	49.2611	30.0000	0.000	64.204	0.391	49.261	76.726
0.13	0.70	0.05	1.0	114.943	14.943	172.846	0.0000	57.9034	33.5000	8.642	64.204	0.372	49.261	76.726
0.13	0.70	0.05	1.3	114.672	14.672	172.439	0.2706	57.4965	33.3431	8.622	63.817	0.370	49.145	77.009
0.13	0.70	0.05	1.6	114.403	14.403	172.034	0.5398	57.0916	33.1862	8.602	63.432	0.369	49.030	77.294
0.13	0.70	0.10	1.0	114.943	14.943	182.449	0.0000	67.5059	37.0000	18.245	64.204	0.352	49.261	76.726
0.13	0.70	0.10	1.3	114.373	14.373	181.544	0.5697	66.6017	36.6862	18.154	63.390	0.349	49.017	77.326
0.13	0.70	0.10	1.6	113.809	13.809	180.649	1.1337	65.7064	36.3724	18.065	62.584	0.346	48.775	77.936
0.13	0.70	0.15	1.0	114.943	14.943	193.181	0.0000	78.2382	40.5000	28.977	64.204	0.332	49.261	76.726
0.13	0.70	0.15	1.3	114.040	14.040	191.665	0.9021	76.7220	40.0293	28.750	62.915	0.328	48.875	77.684
0.13	0.70	0.15	1.6	113.152	13.152	190.172	1.7902	75.2294	39.5586	28.526	61.646	0.324	48.494	78.665
0.13	0.70	0.20	1.0	114.943	14.943	205.255	0.0000	90.3120	44.0000	41.051	64.204	0.313	49.261	76.726
0.13	0.70	0.20	1.3	113.669	13.669	202.980	1.2739	88.0372	43.3724	40.596	62.384	0.307	48.715	78.089
0.13	0.70	0.20	1.6	112.423	12.423	200.755	2.5198	85.8123	42.7448	40.151	60.604	0.302	48.181	79.502
0.13	0.80	0.00	1.0	114.943	14.943	143.678	0.0000	28.7356	20.0000	0.000	43.678	0.304	28.736	65.790
0.13	0.80	0.05	1.0	114.943	14.943	151.240	0.0000	36.2976	24.0000	7.562	43.678	0.289	28.736	65.790
0.13	0.80	0.05	1.3	114.672	14.672	150.884	0.2706	35.9417	23.8207	7.544	43.340	0.287	28.668	66.147
0.13	0.80	0.05	1.6	114.403	14.403	150.530	0.5398	35.5873	23.6414	7.527	43.003	0.286	28.601	66.508
0.13	0.80	0.10	1.0	114.943	14.943	159.642	0.0000	44.6999	28.0000	15.964	43.678	0.274	28.736	65.790
0.13	0.80	0.10	1.3	114.373	14.373	158.851	0.5697	43.9087	27.6414	15.885	42.966	0.271	28.593	66.548
0.13	0.80	0.10	1.6	113.809	13.809	158.068	1.1337	43.1253	27.2828	15.807	42.261	0.267	28.452	67.325
0.13	0.80	0.15	1.0	114.943	14.943	169.083	0.0000	54.0906	32.0000	25.355	43.678	0.258	28.736	65.790
0.13	0.80	0.15	1.3	114.040	14.040	167.706	0.9021	52.7639	31.4621	25.156	42.551	0.254	28.510	67.003
0.13	0.80	0.15	1.6	113.152	13.152	166.400	1.7902	51.4579	30.9241	24.960	41.440	0.249	28.288	68.262
0.13	0.80	0.20	1.0	114.943	14.943	179.598	0.0000	64.6552	36.0000	35.920	43.678	0.243	28.736	65.790
0.13	0.80	0.20	1.3	113.669	13.669	177.607	1.2739	62.6647	35.2828	35.522	42.086	0.237	28.417	67.522
0.13	0.80	0.20	1.6	112.423	12.423	175.661	2.5198	60.7180	34.5655	35.132	40.528	0.231	28.106	69.348
0.13	0.90	0.00	1.0	114.943	14.943	127.714	0.0000	12.7714	10.0000	0.000	27.714	0.217	12.771	46.083
0.13	0.90	0.05	1.0	114.943	14.943	134.436	0.0000	19.4932	14.5000	6.722	27.714	0.206	12.771	46.083
0.13	0.90	0.05	1.3	114.672	14.672	134.119	0.2706	19.1767	14.2983	6.706	27.413	0.204	12.741	46.479
0.13	0.90	0.05	1.6	114.403	14.403	133.804	0.5398	18.8618	14.0966	6.690	27.114	0.203	12.711	46.881
0.13	0.90	0.10	1.0	114.943	14.943	141.904	0.0000	26.9618	19.0000	14.190	27.714	0.195	12.771	46.083
0.13	0.90	0.10	1.3	114.373	14.373	141.201	0.5697	26.2585	18.5966	14.120	27.081	0.192	12.708	46.926
0.13	0.90	0.10	1.6	113.809	13.809	140.505	1.1337	25.5622	18.1931	14.051	26.454	0.188	12.645	47.801
0.13	0.90	0.15	1.0	114.943	14.943	150.252	0.0000	35.3091	23.5000	22.538	27.714	0.185	12.771	46.083
0.13	0.90	0.15	1.3	114.040	14.040	149.072	0.9021	34.1299	22.8948	22.361	26.712	0.179	12.671	47.437
0.13	0.90	0.15	1.6	113.152	13.152	147.912	1.7902	32.9690	22.2897	22.187	25.725	0.174	12.573	48.873
0.13	0.90	0.20	1.0	114.943	14.943	159.642	0.0000	44.6999	28.0000	31.929	27.714	0.174	12.771	46.083
0.13	0.90	0.20	1.3	113.669	13.669	157.873	1.2739	42.9306	27.1931	31.575	26.299	0.167	12.630	48.025
0.13	0.90	0.20	1.6	112.423	12.423	156.143	2.5198	41.2001	26.3862	31.229	24.914	0.160	12.491	50.138
0.13	1.00	0.00	1.0	114.943	14.943	114.943	0.0000	0.0000	0.0000	0.000	14.943	0.130	0.000	0.000
0.13	1.00	0.05	1.0	114.943	14.943	120.992	0.0000	6.0496	5.0000	6.050	14.943	0.124	0.000	0.000
0.13	1.00	0.05	1.3	114.672	14.672	120.707	0.2706	5.7548	4.7759	6.035	14.672	0.122	0.000	0.000
0.13	1.00	0.05	1.6	114.403	14.403	120.424	0.5398	5.4814	4.5517	6.021	14.403	0.120	0.000	0.000
0.13	1.00	0.10	1.0	114.943	14.943	127.714	0.0000	12.7714	10.0000	12.771	14.943	0.117	0.000	0.000
0.13	1.00	0.10	1.3	114.373	14.373	127.081	0.5697	12.1384	9.5517	12.708	14.373	0.113	0.000	0.000
0.13	1.00	0.10	1.6	113.809	13.809	126.454	1.1337	11.5117	9.1034	12.645	13.809	0.109	0.000	0.000
0.13	1.00	0.15	1.0	114.943	14.943	135.227	0.0000	20.2840	15.0000	20.284	14.943	0.111	0.000	0.000
0.13	1.00	0.15	1.3	114.040	14.040	134.165	0.9021	19.2226	14.3276	20.125	14.040	0.105	0.000	0.000
0.13	1.00	0.15	1.6	113.152	13.152	133.120	1.7902	18.1778	13.6552	19.968	13.152	0.099	0.000	0.000
0.13	1.00	0.20	1.0	114.943	14.943	143.678	0.0000	28.7356	20.0000	28.736	14.943	0.104	0.000	0.000
0.13	1.00	0.20	1.3	113.669	13.669	142.086	1.2739	27.1433	19.1034	28.417	13.669	0.096	0.000	0.000
0.13	1.00	0.20	1.6	112.423	12.423	140.528	2.5198	25.5859	18.2069	28.106	12.423	0.088	0.000	0.000

B) Compensation Applied Only to V_{ob}: $RV_{hw} = [(V_{ob})/(F_n^*)]/(1-F_{hw})$

LR	F_n	F_{hw}	F_{obw}	RV_{inhw} [b]	RV_{dw} [c]	RV_{hw} [d]	BV_{hw} [e]	NBV_{hw} [f]	$\%NBV_{hw}$ [f]	V_{hw} [g]	V_{dw} [h]	LF_{hw} [i]	NRV_{dw} [j]	$\%NRV_{dw}$ [j]
0.09	0.70	0.00	1.0	109.890	9.890	142.857	0.0000	32.9670	23.0769	0.000	42.857	0.300	32.967	76.923
0.09	0.70	0.05	1.0	109.890	9.890	150.376	0.0000	40.4858	26.9231	7.519	42.857	0.285	32.967	76.923
0.09	0.70	0.05	1.3	109.719	9.719	150.376	0.1713	40.4858	26.9231	7.519	42.857	0.285	33.138	77.323
0.09	0.70	0.05	1.6	109.548	9.548	150.376	0.3421	40.4858	26.9231	7.519	42.857	0.285	33.309	77.721
0.09	0.70	0.10	1.0	109.890	9.890	158.730	0.0000	48.8400	30.7692	15.873	42.857	0.270	32.967	76.923
0.09	0.70	0.10	1.3	109.529	9.529	158.730	0.3611	48.8400	30.7692	15.873	42.857	0.270	33.328	77.766
0.09	0.70	0.10	1.6	109.170	9.170	158.730	0.7198	48.8400	30.7692	15.873	42.857	0.270	33.687	78.603
0.09	0.70	0.15	1.0	109.890	9.890	168.067	0.0000	58.1771	34.6154	25.210	42.857	0.255	32.967	76.923
0.09	0.70	0.15	1.3	109.318	9.318	168.067	0.5724	58.1771	34.6154	25.210	42.857	0.255	33.539	78.259
0.09	0.70	0.15	1.6	108.751	8.751	168.067	1.1388	58.1771	34.6154	25.210	42.857	0.255	34.106	79.580
0.09	0.70	0.20	1.0	109.890	9.890	178.571	0.0000	68.6813	38.4615	35.714	42.857	0.240	32.967	76.923
0.09	0.70	0.20	1.3	109.081	9.081	178.571	0.8091	68.6813	38.4615	35.714	42.857	0.240	33.776	78.811
0.09	0.70	0.20	1.6	108.284	8.284	178.571	1.6064	68.6813	38.4615	35.714	42.857	0.240	34.573	80.671
0.09	0.80	0.00	1.0	109.890	9.890	125.000	0.0000	15.1099	12.0879	0.000	25.000	0.200	15.110	60.440
0.09	0.80	0.05	1.0	109.890	9.890	131.579	0.0000	21.6888	16.4835	6.579	25.000	0.190	15.110	60.440
0.09	0.80	0.05	1.3	109.719	9.719	131.579	0.1713	21.6888	16.4835	6.579	25.000	0.190	15.281	61.125
0.09	0.80	0.05	1.6	109.548	9.548	131.579	0.3421	21.6888	16.4835	6.579	25.000	0.190	15.452	61.808
0.09	0.80	0.10	1.0	109.890	9.890	138.889	0.0000	28.9988	20.8791	13.889	25.000	0.180	15.110	60.440
0.09	0.80	0.10	1.3	109.529	9.529	138.889	0.3611	28.9988	20.8791	13.889	25.000	0.180	15.471	61.884
0.09	0.80	0.10	1.6	109.170	9.170	138.889	0.7198	28.9988	20.8791	13.889	25.000	0.180	15.830	63.319
0.09	0.80	0.15	1.0	109.890	9.890	147.059	0.0000	37.1687	25.2747	22.059	25.000	0.170	15.110	60.440
0.09	0.80	0.15	1.3	109.318	9.318	147.059	0.5724	37.1687	25.2747	22.059	25.000	0.170	15.682	62.729
0.09	0.80	0.15	1.6	108.751	8.751	147.059	1.1388	37.1687	25.2747	22.059	25.000	0.170	16.249	64.995
0.09	0.80	0.20	1.0	109.890	9.890	156.250	0.0000	46.3599	29.6703	31.250	25.000	0.160	15.110	60.440
0.09	0.80	0.20	1.3	109.081	9.081	156.250	0.8091	46.3599	29.6703	31.250	25.000	0.160	15.919	63.676
0.09	0.80	0.20	1.6	108.284	8.284	156.250	1.6064	46.3599	29.6703	31.250	25.000	0.160	16.716	66.865
0.09	0.90	0.00	1.0	109.890	9.890	111.111	0.0000	1.2210	1.0989	0.000	11.111	0.100	1.221	10.989
0.09	0.90	0.05	1.0	109.890	9.890	116.959	0.0000	7.0690	6.0440	5.848	11.111	0.095	1.221	10.989
0.09	0.90	0.05	1.3	109.719	9.719	116.959	0.1713	7.0690	6.0440	5.848	11.111	0.095	1.392	12.531
0.09	0.90	0.05	1.6	109.548	9.548	116.959	0.3421	7.0690	6.0440	5.848	11.111	0.095	1.563	14.068
0.09	0.90	0.10	1.0	109.890	9.890	123.457	0.0000	13.5667	10.9890	12.346	11.111	0.090	1.221	10.989
0.09	0.90	0.10	1.3	109.529	9.529	123.457	0.3611	13.5667	10.9890	12.346	11.111	0.090	1.582	14.239
0.09	0.90	0.10	1.6	109.170	9.170	123.457	0.7198	13.5667	10.9890	12.346	11.111	0.090	1.941	17.467
0.09	0.90	0.15	1.0	109.890	9.890	130.719	0.0000	20.8288	15.9341	19.608	11.111	0.085	1.221	10.989
0.09	0.90	0.15	1.3	109.318	9.318	130.719	0.5724	20.8288	15.9341	19.608	11.111	0.085	1.793	16.140
0.09	0.90	0.15	1.6	108.751	8.751	130.719	1.1388	20.8288	15.9341	19.608	11.111	0.085	2.360	21.239
0.09	0.90	0.20	1.0	109.890	9.890	138.889	0.0000	28.9988	20.8791	27.778	11.111	0.080	1.221	10.989
0.09	0.90	0.20	1.3	109.081	9.081	138.889	0.8091	28.9988	20.8791	27.778	11.111	0.080	2.030	18.271
0.09	0.90	0.20	1.6	108.284	8.284	138.889	1.6064	28.9988	20.8791	27.778	11.111	0.080	2.827	25.447
0.09	1.00	0.00	1.0	109.890	9.890	100.000	0.0000	-9.8901	0.0000	0.000	0.000	0.000	0.000	0.000
0.09	1.00	0.05	1.0	109.890	9.890	105.263	0.0000	-4.6270	0.0000	5.263	0.000	0.000	0.000	0.000
0.09	1.00	0.05	1.3	109.719	9.719	105.263	0.1713	-4.6270	0.0000	5.263	0.000	0.000	0.000	0.000
0.09	1.00	0.05	1.6	109.548	9.548	105.263	0.3421	-4.6270	0.0000	5.263	0.000	0.000	0.000	0.000
0.09	1.00	0.10	1.0	109.890	9.890	111.111	0.0000	1.2210	1.0989	11.111	0.000	0.000	0.000	0.000
0.09	1.00	0.10	1.3	109.529	9.529	111.111	0.3611	1.2210	1.0989	11.111	0.000	0.000	0.000	0.000
0.09	1.00	0.10	1.6	109.170	9.170	111.111	0.7198	1.2210	1.0989	11.111	0.000	0.000	0.000	0.000
0.09	1.00	0.15	1.0	109.890	9.890	117.647	0.0000	7.7569	6.5934	17.647	0.000	0.000	0.000	0.000
0.09	1.00	0.15	1.3	109.318	9.318	117.647	0.5724	7.7569	6.5934	17.647	0.000	0.000	0.000	0.000
0.09	1.00	0.15	1.6	108.751	8.751	117.647	1.1388	7.7569	6.5934	17.647	0.000	0.000	0.000	0.000
0.09	1.00	0.20	1.0	109.890	9.890	125.000	0.0000	15.1099	12.0879	25.000	0.000	0.000	0.000	0.000
0.09	1.00	0.20	1.3	109.081	9.081	125.000	0.8091	15.1099	12.0879	25.000	0.000	0.000	0.000	0.000
0.09	1.00	0.20	1.6	108.284	8.284	125.000	1.6064	15.1099	12.0879	25.000	0.000	0.000	0.000	0.000

LR	F_n	F_{tw}	F_{ctw}	RV_{intw} [b]	RV_{dw} [c]	RV_{tw} [d]	BV_{tw} [e]	NBV_w [f]	$\%NBV_w$ [f]	V_{tw} [g]	V_{dw} [h]	LF_{tw} [i]	NRV_{dw} [j]	$\%NRV_{dw}$ [j]
0.13	0.70	0.00	1.0	114.943	14.943	142.857	0.0000	27.9146	19.5402	0.000	42.857	0.300	27.915	65.134
0.13	0.70	0.05	1.0	114.943	14.943	150.376	0.0000	35.4334	23.5632	7.519	42.857	0.285	27.915	65.134
0.13	0.70	0.05	1.3	114.672	14.672	150.376	0.2706	35.4334	23.5632	7.519	42.857	0.285	28.185	65.765
0.13	0.70	0.05	1.6	114.403	14.403	150.376	0.5398	35.4334	23.5632	7.519	42.857	0.285	28.454	66.394
0.13	0.70	0.10	1.0	114.943	14.943	158.730	0.0000	43.7876	27.5862	15.873	42.857	0.270	27.915	65.134
0.13	0.70	0.10	1.3	114.373	14.373	158.730	0.5697	43.7876	27.5862	15.873	42.857	0.270	28.484	66.463
0.13	0.70	0.10	1.6	113.809	13.809	158.730	1.1337	43.7876	27.5862	15.873	42.857	0.270	29.048	67.780
0.13	0.70	0.15	1.0	114.943	14.943	168.067	0.0000	53.1247	31.6092	25.210	42.857	0.255	27.915	65.134
0.13	0.70	0.15	1.3	114.040	14.040	168.067	0.9021	53.1247	31.6092	25.210	42.857	0.255	28.817	67.239
0.13	0.70	0.15	1.6	113.152	13.152	168.067	1.7902	53.1247	31.6092	25.210	42.857	0.255	29.705	69.311
0.13	0.70	0.20	1.0	114.943	14.943	178.571	0.0000	63.6289	35.6322	35.714	42.857	0.240	27.915	65.134
0.13	0.70	0.20	1.3	113.669	13.669	178.571	1.2739	63.6289	35.6322	35.714	42.857	0.240	29.189	68.107
0.13	0.70	0.20	1.6	112.423	12.423	178.571	2.5198	63.6289	35.6322	35.714	42.857	0.240	30.434	71.014
0.13	0.80	0.00	1.0	114.943	14.943	125.000	0.0000	10.0575	8.0460	0.000	25.000	0.200	10.058	40.230
0.13	0.80	0.05	1.0	114.943	14.943	131.579	0.0000	16.6364	12.6437	6.579	25.000	0.190	10.058	40.230
0.13	0.80	0.05	1.3	114.672	14.672	131.579	0.2706	16.6364	12.6437	6.579	25.000	0.190	10.328	41.312
0.13	0.80	0.05	1.6	114.403	14.403	131.579	0.5398	16.6364	12.6437	6.579	25.000	0.190	10.597	42.389
0.13	0.80	0.10	1.0	114.943	14.943	138.889	0.0000	23.9464	17.2414	13.889	25.000	0.180	10.058	40.230
0.13	0.80	0.10	1.3	114.373	14.373	138.889	0.5697	23.9464	17.2414	13.889	25.000	0.180	10.627	42.509
0.13	0.80	0.10	1.6	113.809	13.809	138.889	1.1337	23.9464	17.2414	13.889	25.000	0.180	11.191	44.765
0.13	0.80	0.15	1.0	114.943	14.943	147.059	0.0000	32.1163	21.8391	22.059	25.000	0.170	10.058	40.230
0.13	0.80	0.15	1.3	114.040	14.040	147.059	0.9021	32.1163	21.8391	22.059	25.000	0.170	10.960	43.839
0.13	0.80	0.15	1.6	113.152	13.152	147.059	1.7902	32.1163	21.8391	22.059	25.000	0.170	11.848	47.391
0.13	0.80	0.20	1.0	114.943	14.943	156.250	0.0000	41.3075	26.4368	31.250	25.000	0.160	10.058	40.230
0.13	0.80	0.20	1.3	113.669	13.669	156.250	1.2739	41.3075	26.4368	31.250	25.000	0.160	11.331	45.325
0.13	0.80	0.20	1.6	112.423	12.423	156.250	2.5198	41.3075	26.4368	31.250	25.000	0.160	12.577	50.309
0.13	0.90	0.00	1.0	114.943	14.943	111.111	0.0000	-3.8314	0.0000	0.000	11.111	0.100	0.000	0.000
0.13	0.90	0.05	1.0	114.943	14.943	116.959	0.0000	2.0165	1.7241	5.848	11.111	0.095	0.000	0.000
0.13	0.90	0.05	1.3	114.672	14.672	116.959	0.2706	2.0165	1.7241	5.848	11.111	0.095	0.000	0.000
0.13	0.90	0.05	1.6	114.403	14.403	116.959	0.5398	2.0165	1.7241	5.848	11.111	0.095	0.000	0.000
0.13	0.90	0.10	1.0	114.943	14.943	123.457	0.0000	8.5143	6.8966	12.346	11.111	0.090	0.000	0.000
0.13	0.90	0.10	1.3	114.373	14.373	123.457	0.5697	8.5143	6.8966	12.346	11.111	0.090	0.000	0.000
0.13	0.90	0.10	1.6	113.809	13.809	123.457	1.1337	8.5143	6.8966	12.346	11.111	0.090	0.000	0.000
0.13	0.90	0.15	1.0	114.943	14.943	130.719	0.0000	15.7764	12.0690	19.608	11.111	0.085	0.000	0.000
0.13	0.90	0.15	1.3	114.040	14.040	130.719	0.9021	15.7764	12.0690	19.608	11.111	0.085	0.000	0.000
0.13	0.90	0.15	1.6	113.152	13.152	130.719	1.7902	15.7764	12.0690	19.608	11.111	0.085	0.000	0.000
0.13	0.90	0.20	1.0	114.943	14.943	138.889	0.0000	23.9464	17.2414	27.778	11.111	0.080	0.000	0.000
0.13	0.90	0.20	1.3	113.669	13.669	138.889	1.2739	23.9464	17.2414	27.778	11.111	0.080	0.000	0.000
0.13	0.90	0.20	1.6	112.423	12.423	138.889	2.5198	23.9464	17.2414	27.778	11.111	0.080	0.000	0.000
0.13	1.00	0.00	1.0	114.943	14.943	100.000	0.0000	-14.9425	0.0000	0.000	0.000	0.000	0.000	0.000
0.13	1.00	0.05	1.0	114.943	14.943	105.263	0.0000	-9.6794	0.0000	5.263	0.000	0.000	0.000	0.000
0.13	1.00	0.05	1.3	114.672	14.672	105.263	0.2706	-9.6794	0.0000	5.263	0.000	0.000	0.000	0.000
0.13	1.00	0.05	1.6	114.403	14.403	105.263	0.5398	-9.6794	0.0000	5.263	0.000	0.000	0.000	0.000
0.13	1.00	0.10	1.0	114.943	14.943	111.111	0.0000	-3.8314	0.0000	11.111	0.000	0.000	0.000	0.000
0.13	1.00	0.10	1.3	114.373	14.373	111.111	0.5697	-3.8314	0.0000	11.111	0.000	0.000	0.000	0.000
0.13	1.00	0.10	1.6	113.809	13.809	111.111	1.1337	-3.8314	0.0000	11.111	0.000	0.000	0.000	0.000
0.13	1.00	0.15	1.0	114.943	14.943	117.647	0.0000	2.7045	2.2989	17.647	0.000	0.000	0.000	0.000
0.13	1.00	0.15	1.3	114.040	14.040	117.647	0.9021	2.7045	2.2989	17.647	0.000	0.000	0.000	0.000
0.13	1.00	0.15	1.6	113.152	13.152	117.647	1.7902	2.7045	2.2989	17.647	0.000	0.000	0.000	0.000
0.13	1.00	0.20	1.0	114.943	14.943	125.000	0.0000	10.0575	8.0460	25.000	0.000	0.000	0.000	0.000
0.13	1.00	0.20	1.3	113.669	13.669	125.000	1.2739	10.0575	8.0460	25.000	0.000	0.000	0.000	0.000
0.13	1.00	0.20	1.6	112.423	12.423	125.000	2.5198	10.0575	8.0460	25.000	0.000	0.000	0.000	0.000

[a] for LR = 0.09 and 0.13, F_{tw} = 0.00 - 0.20, F_{ctw} = 1.0, 1.3 and 1.6 and F_n and F_n^* = 0.7, 0.8, 0.9 and 1.0; [b] $RV_{intw} = [(1-F_{tw}F_{ctw})/(1-F_{tw})](LR)$;

[c] $RV_{dw} = [(LR_{intw})/(1-LR_{intw})](V_{st})$; [d] for A) $RV_{tw} = [V_{st}/(1-LR_{intw})(F_n)]/(1-F_{tw})$, for B) $RV_{tw} = [(V_{st})/(F_n^*)]/(1-F_{tw})$; [e] $BV_{tw} = [(LR)((V_{st})/(1-LR)] - [(LR_{tw})(V_{st})/(1-LR_{tw}-F_{tw}))]$;

[f] $NBV_W = (RV_{tw} - TBV_W)$ = minimum non-beneficial irrigation water, $\%NBV_W = (100)(NBV_W)/(RV_{tw})$; [g] $V_{tw} = (F_{tw})(RV_{tw})$; [h] $V_{dw} = RV_{tw} - V_{st} - V_{tw}$;

[i] $LF_{tw} = V_{dw}/RV_{tw}$; [j] NRV_{dw} = minimum non-beneficial deep percolation = $V_{dw} - RV_{dw}$, $\%NRV_{dw} = (100)(NRV_{dw})/(V_{dw})$

Table 6b. Relationships Between RV_{infw}, RV_{iw}, LR^a, LR_{infw}, F_{tw}, F_{ctw} and F_n for the Case Where V_{et} is Fixed at the Normalized Value of 100.

LR	F_{tw}	F_{ctw}	F_n	$1/F_n(1-F_{tw})$	$(1-F_{tw}F_{ctw})$	$(1-F_{tw})$	$(1-F_{tw}F_{ctw})/(1-F_{tw})$	LR_{infw}	$1-LR_{infw}$	V_{et}	RV_{infw}	RV_{iw}	RV_{iw}/RV_{infw}
0.09	0.00	1.00	1.00	1.0000	1.000	1.000	1.0000	0.090	0.910	100	109.89011	109.8901	1.0000
0.09	0.00	1.00	0.85	1.1765	1.000	1.000	1.0000	0.090	0.910	100	109.89011	129.2825	1.1765
0.09	0.00	1.00	0.70	1.4286	1.000	1.000	1.0000	0.090	0.910	100	109.89011	156.9859	1.4286
0.09	0.05	1.00	1.00	1.0526	0.950	0.950	1.0000	0.090	0.910	100	109.89011	115.6738	1.0526
0.09	0.05	1.00	0.85	1.2384	0.950	0.950	1.0000	0.090	0.910	100	109.89011	136.0868	1.2384
0.09	0.05	1.00	0.70	1.5038	0.950	0.950	1.0000	0.090	0.910	100	109.89011	165.2483	1.5038
0.09	0.05	1.10	1.00	1.0526	0.945	0.950	0.9947	0.090	0.910	100	109.83294	115.6136	1.0526
0.09	0.05	1.10	0.85	1.2384	0.945	0.950	0.9947	0.090	0.910	100	109.83294	136.0160	1.2384
0.09	0.05	1.10	0.70	1.5038	0.945	0.950	0.9947	0.090	0.910	100	109.83294	165.1623	1.5038
0.09	0.05	1.20	1.00	1.0526	0.940	0.950	0.9895	0.089	0.911	100	109.77583	115.5535	1.0526
0.09	0.05	1.20	0.85	1.2384	0.940	0.950	0.9895	0.089	0.911	100	109.77583	135.9453	1.2384
0.09	0.05	1.20	0.70	1.5038	0.940	0.950	0.9895	0.089	0.911	100	109.77583	165.0764	1.5038
0.09	0.05	1.30	1.00	1.0526	0.935	0.950	0.9842	0.089	0.911	100	109.71877	115.4934	1.0526
0.09	0.05	1.30	0.85	1.2384	0.935	0.950	0.9842	0.089	0.911	100	109.71877	135.8746	1.2384
0.09	0.05	1.30	0.70	1.5038	0.935	0.950	0.9842	0.089	0.911	100	109.71877	164.9906	1.5038
0.09	0.05	1.40	1.00	1.0526	0.930	0.950	0.9789	0.088	0.912	100	109.66178	115.4335	1.0526
0.09	0.05	1.40	0.85	1.2384	0.930	0.950	0.9789	0.088	0.912	100	109.66178	135.8041	1.2384
0.09	0.05	1.40	0.70	1.5038	0.930	0.950	0.9789	0.088	0.912	100	109.66178	164.9049	1.5038
0.09	0.05	1.50	1.00	1.0526	0.925	0.950	0.9737	0.088	0.912	100	109.60485	115.3735	1.0526
0.09	0.05	1.50	0.85	1.2384	0.925	0.950	0.9737	0.088	0.912	100	109.60485	135.7336	1.2384
0.09	0.05	1.50	0.70	1.5038	0.925	0.950	0.9737	0.088	0.912	100	109.60485	164.8193	1.5038
0.09	0.05	1.60	1.00	1.0526	0.920	0.950	0.9684	0.087	0.913	100	109.5480	115.3137	1.0526
0.09	0.05	1.60	0.85	1.2384	0.920	0.950	0.9684	0.087	0.913	100	109.5480	135.6631	1.2384
0.09	0.05	1.60	0.70	1.5038	0.920	0.950	0.9684	0.087	0.913	100	109.5480	164.7338	1.5038
0.09	0.10	1.00	1.00	1.1111	0.900	0.900	1.0000	0.090	0.910	100	109.8901	122.1001	1.1111
0.09	0.10	1.00	0.85	1.3072	0.900	0.900	1.0000	0.090	0.910	100	109.8901	143.6472	1.3072
0.09	0.10	1.00	0.70	1.5873	0.900	0.900	1.0000	0.090	0.910	100	109.8901	174.4287	1.5873
0.09	0.10	1.10	1.00	1.1111	0.890	0.900	0.9889	0.089	0.911	100	109.7695	121.9661	1.1111
0.09	0.10	1.10	0.85	1.3072	0.890	0.900	0.9889	0.089	0.911	100	109.7695	143.4895	1.3072
0.09	0.10	1.10	0.70	1.5873	0.890	0.900	0.9889	0.089	0.911	100	109.7695	174.2373	1.5873
0.09	0.10	1.20	1.00	1.1111	0.880	0.900	0.9778	0.088	0.912	100	109.6491	121.8324	1.1111
0.09	0.10	1.20	0.85	1.3072	0.880	0.900	0.9778	0.088	0.912	100	109.6491	143.3322	1.3072
0.09	0.10	1.20	0.70	1.5873	0.880	0.900	0.9778	0.088	0.912	100	109.6491	174.0462	1.5873
0.09	0.10	1.30	1.00	1.1111	0.870	0.900	0.9667	0.087	0.913	100	109.5290	121.6989	1.1111
0.09	0.10	1.30	0.85	1.3072	0.870	0.900	0.9667	0.087	0.913	100	109.5290	143.1752	1.3072
0.09	0.10	1.30	0.70	1.5873	0.870	0.900	0.9667	0.087	0.913	100	109.5290	173.8556	1.5873
0.09	0.10	1.40	1.00	1.1111	0.860	0.900	0.9556	0.086	0.914	100	109.4092	121.5658	1.1111
0.09	0.10	1.40	0.85	1.3072	0.860	0.900	0.9556	0.086	0.914	100	109.4092	143.0185	1.3072
0.09	0.10	1.40	0.70	1.5873	0.860	0.900	0.9556	0.086	0.914	100	109.4092	173.6654	1.5873
0.09	0.10	1.50	1.00	1.1111	0.850	0.900	0.9444	0.085	0.915	100	109.2896	121.4329	1.1111
0.09	0.10	1.50	0.85	1.3072	0.850	0.900	0.9444	0.085	0.915	100	109.2896	142.8622	1.3072
0.09	0.10	1.50	0.70	1.5873	0.850	0.900	0.9444	0.085	0.915	100	109.2896	173.4756	1.5873
0.09	0.10	1.60	1.00	1.1111	0.840	0.900	0.9333	0.084	0.916	100	109.1703	121.3003	1.1111
0.09	0.10	1.60	0.85	1.3072	0.840	0.900	0.9333	0.084	0.916	100	109.1703	142.7063	1.3072
0.09	0.10	1.60	0.70	1.5873	0.840	0.900	0.9333	0.084	0.916	100	109.1703	173.2862	1.5873

LR_T	F_{bw}	F_{ctw}	F_n	$1/F_n(1-F_{bw})$	$(1-F_{bw}F_{ctw})$	$(1-F_{bw})$	$(1-F_{bw}F_{ctw})/(1-F_{bw})$	LR_{infw}	$1-LR_{infw}$	V_{et}	RV_{infw}	RV_{iw}	RV_{iw}/RV_{infw}
0.09	0.15	1.00	1.00	1.1765	0.850	0.850	1.0000	0.090	0.910	100	109.8901	129.2825	1.1765
0.09	0.15	1.00	0.85	1.3841	0.850	0.850	1.0000	0.090	0.910	100	109.8901	152.0970	1.3841
0.09	0.15	1.00	0.70	1.6807	0.850	0.850	1.0000	0.090	0.910	100	109.8901	184.6893	1.6807
0.09	0.15	1.10	1.00	1.1765	0.835	0.850	0.9824	0.088	0.912	100	109.6987	129.0572	1.1765
0.09	0.15	1.10	0.85	1.3841	0.835	0.850	0.9824	0.088	0.912	100	109.6987	151.8320	1.3841
0.09	0.15	1.10	0.70	1.6807	0.835	0.850	0.9824	0.088	0.912	100	109.6987	184.3675	1.6807
0.09	0.15	1.20	1.00	1.1765	0.820	0.850	0.9647	0.087	0.913	100	109.5079	128.8328	1.1765
0.09	0.15	1.20	0.85	1.3841	0.820	0.850	0.9647	0.087	0.913	100	109.5079	151.5680	1.3841
0.09	0.15	1.20	0.70	1.6807	0.820	0.850	0.9647	0.087	0.913	100	109.5079	184.0468	1.6807
0.09	0.15	1.30	1.00	1.1765	0.805	0.850	0.9471	0.085	0.915	100	109.3177	128.6091	1.1765
0.09	0.15	1.30	0.85	1.3841	0.805	0.850	0.9471	0.085	0.915	100	109.3177	151.3048	1.3841
0.09	0.15	1.30	0.70	1.6807	0.805	0.850	0.9471	0.085	0.915	100	109.3177	183.7273	1.6807
0.09	0.15	1.40	1.00	1.1765	0.790	0.850	0.9294	0.084	0.916	100	109.1283	128.3862	1.1765
0.09	0.15	1.40	0.85	1.3841	0.790	0.850	0.9294	0.084	0.916	100	109.1283	151.0426	1.3841
0.09	0.15	1.40	0.70	1.6807	0.790	0.850	0.9294	0.084	0.916	100	109.1283	183.4088	1.6807
0.09	0.15	1.50	1.00	1.1765	0.775	0.850	0.9118	0.082	0.918	100	108.9394	128.1640	1.1765
0.09	0.15	1.50	0.85	1.3841	0.775	0.850	0.9118	0.082	0.918	100	108.9394	150.7812	1.3841
0.09	0.15	1.50	0.70	1.6807	0.775	0.850	0.9118	0.082	0.918	100	108.9394	183.0915	1.6807
0.09	0.15	1.60	1.00	1.1765	0.760	0.850	0.8941	0.080	0.920	100	108.7513	127.9427	1.1765
0.09	0.15	1.60	0.85	1.3841	0.760	0.850	0.8941	0.080	0.920	100	108.7513	150.5208	1.3841
0.09	0.15	1.60	0.70	1.6807	0.760	0.850	0.8941	0.080	0.920	100	108.7513	182.7753	1.6807
0.09	0.20	1.00	1.00	1.2500	0.800	0.800	1.0000	0.090	0.910	100	109.8901	137.3626	1.2500
0.09	0.20	1.00	0.85	1.4706	0.800	0.800	1.0000	0.090	0.910	100	109.8901	161.6031	1.4706
0.09	0.20	1.00	0.70	1.7857	0.800	0.800	1.0000	0.090	0.910	100	109.8901	196.2323	1.7857
0.09	0.20	1.10	1.00	1.2500	0.780	0.800	0.9750	0.088	0.912	100	109.6191	137.0238	1.2500
0.09	0.20	1.10	0.85	1.4706	0.780	0.800	0.9750	0.088	0.912	100	109.6191	161.2045	1.4706
0.09	0.20	1.10	0.70	1.7857	0.780	0.800	0.9750	0.088	0.912	100	109.6191	195.7483	1.7857
0.09	0.20	1.20	1.00	1.2500	0.760	0.800	0.9500	0.086	0.915	100	109.3494	136.6867	1.2500
0.09	0.20	1.20	0.85	1.4706	0.760	0.800	0.9500	0.086	0.915	100	109.3494	160.8079	1.4706
0.09	0.20	1.20	0.70	1.7857	0.760	0.800	0.9500	0.086	0.915	100	109.3494	195.2667	1.7857
0.09	0.20	1.30	1.00	1.2500	0.740	0.800	0.9250	0.083	0.917	100	109.0810	136.3512	1.2500
0.09	0.20	1.30	0.85	1.4706	0.740	0.800	0.9250	0.083	0.917	100	109.0810	160.4132	1.4706
0.09	0.20	1.30	0.70	1.7857	0.740	0.800	0.9250	0.083	0.917	100	109.0810	194.7875	1.7857
0.09	0.20	1.40	1.00	1.2500	0.720	0.800	0.9000	0.081	0.919	100	108.8139	136.0174	1.2500
0.09	0.20	1.40	0.85	1.4706	0.720	0.800	0.9000	0.081	0.919	100	108.8139	160.0205	1.4706
0.09	0.20	1.40	0.70	1.7857	0.720	0.800	0.9000	0.081	0.919	100	108.8139	194.3106	1.7857
0.09	0.20	1.50	1.00	1.2500	0.700	0.800	0.8750	0.079	0.921	100	108.5482	135.6852	1.2500
0.09	0.20	1.50	0.85	1.4706	0.700	0.800	0.8750	0.079	0.921	100	108.5482	159.6297	1.4706
0.09	0.20	1.50	0.70	1.7857	0.700	0.800	0.8750	0.079	0.921	100	108.5482	193.8360	1.7857
0.09	0.20	1.60	1.00	1.2500	0.680	0.800	0.8500	0.077	0.924	100	108.2837	135.3546	1.2500
0.09	0.20	1.60	0.85	1.4706	0.680	0.800	0.8500	0.077	0.924	100	108.2837	159.2407	1.4706
0.09	0.20	1.60	0.70	1.7857	0.680	0.800	0.8500	0.077	0.924	100	108.2837	193.3638	1.7857

LR_T	F_{tw}	F_{ctw}	F_n	$1/F_n(1-F_{tw})$	$(1-F_{tw}F_{ctw})$	$(1-F_{tw})$	$(1-F_{tw}F_{ctw})/(1-F_{tw})$	LR_{infw}	$1-LR_{infw}$	V_{et}	RV_{infw}	RV_{iw}	RV_{iw}/RV_{infw}
0.13	0.00	1.00	1.00	1.0000	1.000	1.000	1.0000	0.130	0.870	100	114.9425	114.9425	1.0000
0.13	0.00	1.00	0.85	1.1765	1.000	1.000	1.0000	0.130	0.870	100	114.9425	135.2265	1.1765
0.13	0.00	1.00	0.70	1.4286	1.000	1.000	1.0000	0.130	0.870	100	114.9425	164.2036	1.4286
0.13	0.05	1.00	1.00	1.0526	0.950	0.950	1.0000	0.130	0.870	100	114.9425	120.9921	1.0526
0.13	0.05	1.00	0.85	1.2384	0.950	0.950	1.0000	0.130	0.870	100	114.9425	142.3437	1.2384
0.13	0.05	1.00	0.70	1.5038	0.950	0.950	1.0000	0.130	0.870	100	114.9425	172.8459	1.5038
0.13	0.05	1.10	1.00	1.0526	0.945	0.950	0.9947	0.129	0.871	100	114.8522	120.8971	1.0526
0.13	0.05	1.10	0.85	1.2384	0.945	0.950	0.9947	0.129	0.871	100	114.8522	142.2318	1.2384
0.13	0.05	1.10	0.70	1.5038	0.945	0.950	0.9947	0.129	0.871	100	114.8522	172.7101	1.5038
0.13	0.05	1.20	1.00	1.0526	0.940	0.950	0.9895	0.129	0.871	100	114.7620	120.8021	1.0526
0.13	0.05	1.20	0.85	1.2384	0.940	0.950	0.9895	0.129	0.871	100	114.7620	142.1201	1.2384
0.13	0.05	1.20	0.70	1.5038	0.940	0.950	0.9895	0.129	0.871	100	114.7620	172.5745	1.5038
0.13	0.05	1.30	1.00	1.0526	0.935	0.950	0.9842	0.128	0.872	100	114.6720	120.7073	1.0526
0.13	0.05	1.30	0.85	1.2384	0.935	0.950	0.9842	0.128	0.872	100	114.6720	142.0086	1.2384
0.13	0.05	1.30	0.70	1.5038	0.935	0.950	0.9842	0.128	0.872	100	114.6720	172.4391	1.5038
0.13	0.05	1.40	1.00	1.0526	0.930	0.950	0.9789	0.127	0.873	100	114.5821	120.6127	1.0526
0.13	0.05	1.40	0.85	1.2384	0.930	0.950	0.9789	0.127	0.873	100	114.5821	141.8973	1.2384
0.13	0.05	1.40	0.70	1.5038	0.930	0.950	0.9789	0.127	0.873	100	114.5821	172.3039	1.5038
0.13	0.05	1.50	1.00	1.0526	0.925	0.950	0.9737	0.127	0.873	100	114.4923	120.5182	1.0526
0.13	0.05	1.50	0.85	1.2384	0.925	0.950	0.9737	0.127	0.873	100	114.4923	141.7862	1.2384
0.13	0.05	1.50	0.70	1.5038	0.925	0.950	0.9737	0.127	0.873	100	114.4923	172.1689	1.5038
0.13	0.05	1.60	1.00	1.0526	0.920	0.950	0.9684	0.126	0.874	100	114.4027	120.4239	1.0526
0.13	0.05	1.60	0.85	1.2384	0.920	0.950	0.9684	0.126	0.874	100	114.4027	141.6752	1.2384
0.13	0.05	1.60	0.70	1.5038	0.920	0.950	0.9684	0.126	0.874	100	114.4027	172.0341	1.5038
0.13	0.10	1.00	1.00	1.1111	0.900	0.900	1.0000	0.130	0.870	100	114.9425	127.7139	1.1111
0.13	0.10	1.00	0.85	1.3072	0.900	0.900	1.0000	0.130	0.870	100	114.9425	150.2517	1.3072
0.13	0.10	1.00	0.70	1.5873	0.900	0.900	1.0000	0.130	0.870	100	114.9425	182.4485	1.5873
0.13	0.10	1.10	1.00	1.1111	0.890	0.900	0.9889	0.129	0.871	100	114.7520	127.5022	1.1111
0.13	0.10	1.10	0.85	1.3072	0.890	0.900	0.9889	0.129	0.871	100	114.7520	150.0026	1.3072
0.13	0.10	1.10	0.70	1.5873	0.890	0.900	0.9889	0.129	0.871	100	114.7520	182.1460	1.5873
0.13	0.10	1.20	1.00	1.1111	0.880	0.900	0.9778	0.127	0.873	100	114.5621	127.2912	1.1111
0.13	0.10	1.20	0.85	1.3072	0.880	0.900	0.9778	0.127	0.873	100	114.5621	149.7544	1.3072
0.13	0.10	1.20	0.70	1.5873	0.880	0.900	0.9778	0.127	0.873	100	114.5621	181.8446	1.5873
0.13	0.10	1.30	1.00	1.1111	0.870	0.900	0.9667	0.126	0.874	100	114.3729	127.0810	1.1111
0.13	0.10	1.30	0.85	1.3072	0.870	0.900	0.9667	0.126	0.874	100	114.3729	149.5070	1.3072
0.13	0.10	1.30	0.70	1.5873	0.870	0.900	0.9667	0.126	0.874	100	114.3729	181.5442	1.5873
0.13	0.10	1.40	1.00	1.1111	0.860	0.900	0.9556	0.124	0.876	100	114.1842	126.8714	1.1111
0.13	0.10	1.40	0.85	1.3072	0.860	0.900	0.9556	0.124	0.876	100	114.1842	149.2604	1.3072
0.13	0.10	1.40	0.70	1.5873	0.860	0.900	0.9556	0.124	0.876	100	114.1842	181.2448	1.5873
0.13	0.10	1.50	1.00	1.1111	0.850	0.900	0.9444	0.123	0.877	100	113.9962	126.6624	1.1111
0.13	0.10	1.50	0.85	1.3072	0.850	0.900	0.9444	0.123	0.877	100	113.9962	149.0146	1.3072
0.13	0.10	1.50	0.70	1.5873	0.850	0.900	0.9444	0.123	0.877	100	113.9962	180.9463	1.5873
0.13	0.10	1.60	1.00	1.1111	0.840	0.900	0.9333	0.121	0.879	100	113.8088	126.4542	1.1111
0.13	0.10	1.60	0.85	1.3072	0.840	0.900	0.9333	0.121	0.879	100	113.8088	148.7697	1.3072
0.13	0.10	1.60	0.70	1.5873	0.840	0.900	0.9333	0.121	0.879	100	113.8088	180.6489	1.5873

LR_T	F_{tw}	F_{ctw}	F_n	$1/F_n(1-F_{tw})$	$(1-F_{tw}F_{ctw})$	$(1-F_{tw})$	$(1-F_{tw}F_{ctw})/(1-F_{tw})$	LR_{infw}	$1-LR_{infw}$	V_{et}	RV_{infw}	RV_{tw}	RV_{tw}/RV_{infw}
0.13	0.15	1.00	1.00	1.1765	0.850	0.850	1.0000	0.130	0.870	100	114.9425	135.2265	1.1765
0.13	0.15	1.00	0.85	1.3841	0.850	0.850	1.0000	0.130	0.870	100	114.9425	159.0900	1.3841
0.13	0.15	1.00	0.70	1.6807	0.850	0.850	1.0000	0.130	0.870	100	114.9425	193.1807	1.6807
0.13	0.15	1.10	1.00	1.1765	0.835	0.850	0.9824	0.128	0.872	100	114.6402	134.8709	1.1765
0.13	0.15	1.10	0.85	1.3841	0.835	0.850	0.9824	0.128	0.872	100	114.6402	158.6716	1.3841
0.13	0.15	1.10	0.70	1.6807	0.835	0.850	0.9824	0.128	0.872	100	114.6402	192.6727	1.6807
0.13	0.15	1.20	1.00	1.1765	0.820	0.850	0.9647	0.125	0.875	100	114.3395	134.5171	1.1765
0.13	0.15	1.20	0.85	1.3841	0.820	0.850	0.9647	0.125	0.875	100	114.3395	158.2554	1.3841
0.13	0.15	1.20	0.70	1.6807	0.820	0.850	0.9647	0.125	0.875	100	114.3395	192.1673	1.6807
0.13	0.15	1.30	1.00	1.1765	0.805	0.850	0.9471	0.123	0.877	100	114.0404	134.1652	1.1765
0.13	0.15	1.30	0.85	1.3841	0.805	0.850	0.9471	0.123	0.877	100	114.0404	157.8414	1.3841
0.13	0.15	1.30	0.70	1.6807	0.805	0.850	0.9471	0.123	0.877	100	114.0404	191.6645	1.6807
0.13	0.15	1.40	1.00	1.1765	0.790	0.850	0.9294	0.121	0.879	100	113.7428	133.8151	1.1765
0.13	0.15	1.40	0.85	1.3841	0.790	0.850	0.9294	0.121	0.879	100	113.7428	157.4295	1.3841
0.13	0.15	1.40	0.70	1.6807	0.790	0.850	0.9294	0.121	0.879	100	113.7428	191.1644	1.6807
0.13	0.15	1.50	1.00	1.1765	0.775	0.850	0.9118	0.119	0.881	100	113.4468	133.4668	1.1765
0.13	0.15	1.50	0.85	1.3841	0.775	0.850	0.9118	0.119	0.881	100	113.4468	157.0198	1.3841
0.13	0.15	1.50	0.70	1.6807	0.775	0.850	0.9118	0.119	0.881	100	113.4468	190.6669	1.6807
0.13	0.15	1.60	1.00	1.1765	0.760	0.850	0.8941	0.116	0.884	100	113.1523	133.1203	1.1765
0.13	0.15	1.60	0.85	1.3841	0.760	0.850	0.8941	0.116	0.884	100	113.1523	156.6122	1.3841
0.13	0.15	1.60	0.70	1.6807	0.760	0.850	0.8941	0.116	0.884	100	113.1523	190.1719	1.6807
0.13	0.20	1.00	1.00	1.2500	0.800	0.800	1.0000	0.130	0.870	100	114.9425	143.6782	1.2500
0.13	0.20	1.00	0.85	1.4706	0.800	0.800	1.0000	0.130	0.870	100	114.9425	169.0331	1.4706
0.13	0.20	1.00	0.70	1.7857	0.800	0.800	1.0000	0.130	0.870	100	114.9425	205.2545	1.7857
0.13	0.20	1.10	1.00	1.2500	0.780	0.800	0.9750	0.127	0.873	100	114.5147	143.1434	1.2500
0.13	0.20	1.10	0.85	1.4706	0.780	0.800	0.9750	0.127	0.873	100	114.5147	168.4040	1.4706
0.13	0.20	1.10	0.70	1.7857	0.780	0.800	0.9750	0.127	0.873	100	114.5147	204.4906	1.7857
0.13	0.20	1.20	1.00	1.2500	0.760	0.800	0.9500	0.124	0.877	100	114.0901	142.6127	1.2500
0.13	0.20	1.20	0.85	1.4706	0.760	0.800	0.9500	0.124	0.877	100	114.0901	167.7796	1.4706
0.13	0.20	1.20	0.70	1.7857	0.760	0.800	0.9500	0.124	0.877	100	114.0901	203.7324	1.7857
0.13	0.20	1.30	1.00	1.2500	0.740	0.800	0.9250	0.120	0.880	100	113.6687	142.0858	1.2500
0.13	0.20	1.30	0.85	1.4706	0.740	0.800	0.9250	0.120	0.880	100	113.6687	167.1598	1.4706
0.13	0.20	1.30	0.70	1.7857	0.740	0.800	0.9250	0.120	0.880	100	113.6687	202.9797	1.7857
0.13	0.20	1.40	1.00	1.2500	0.720	0.800	0.9000	0.117	0.883	100	113.2503	141.5629	1.2500
0.13	0.20	1.40	0.85	1.4706	0.720	0.800	0.9000	0.117	0.883	100	113.2503	166.5445	1.4706
0.13	0.20	1.40	0.70	1.7857	0.720	0.800	0.9000	0.117	0.883	100	113.2503	202.2326	1.7857
0.13	0.20	1.50	1.00	1.2500	0.700	0.800	0.8750	0.114	0.886	100	112.8350	141.0437	1.2500
0.13	0.20	1.50	0.85	1.4706	0.700	0.800	0.8750	0.114	0.886	100	112.8350	165.9338	1.4706
0.13	0.20	1.50	0.70	1.7857	0.700	0.800	0.8750	0.114	0.886	100	112.8350	201.4910	1.7857
0.13	0.20	1.60	1.00	1.2500	0.680	0.800	0.8500	0.111	0.890	100	112.4227	140.5284	1.2500
0.13	0.20	1.60	0.85	1.4706	0.680	0.800	0.8500	0.111	0.890	100	112.4227	165.3275	1.4706
0.13	0.20	1.60	0.70	1.7857	0.680	0.800	0.8500	0.111	0.890	100	112.4227	200.7548	1.7857

[a] either LR_W (= 0.090 or LR_T (= 0.13)

Appendix of Figures

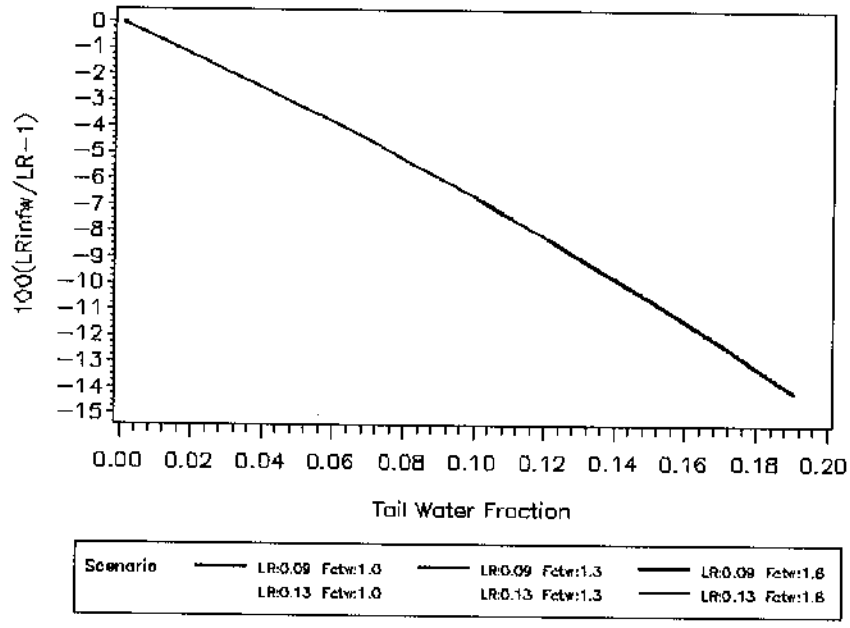


Figure 5a- 1. Percent decrease in infiltrated water leaching requirement relative to model leaching requirement, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

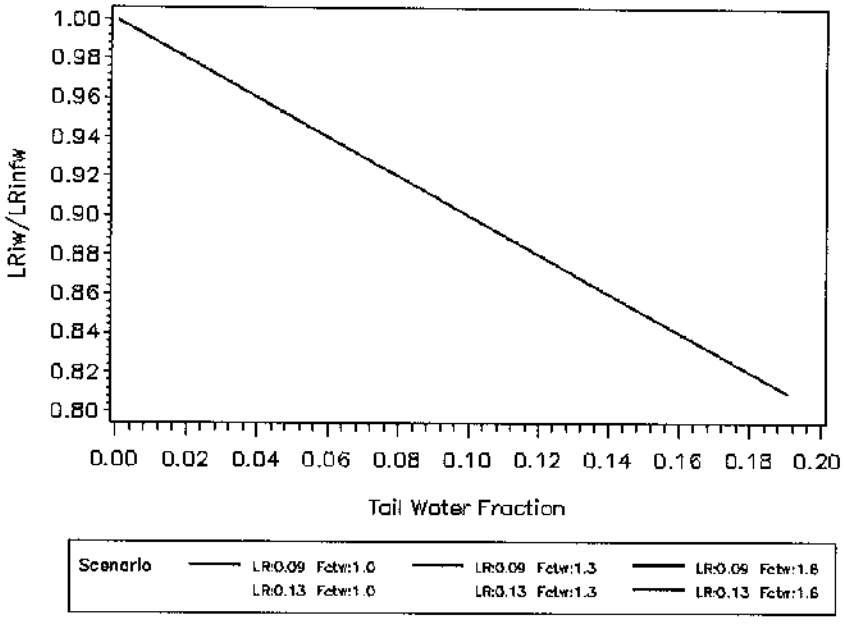


Figure 5a- 2. Ratio of leaching requirements relative to irrigation water and infiltrated water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

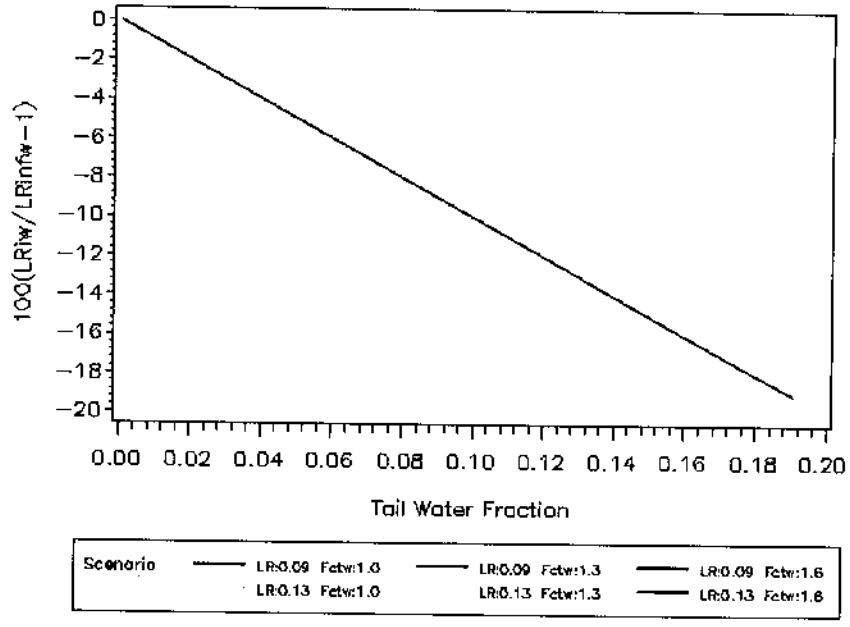


Figure 5a- 3. Percent decrease in irrigation water leaching requirement relative to infiltration water leaching requirement, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

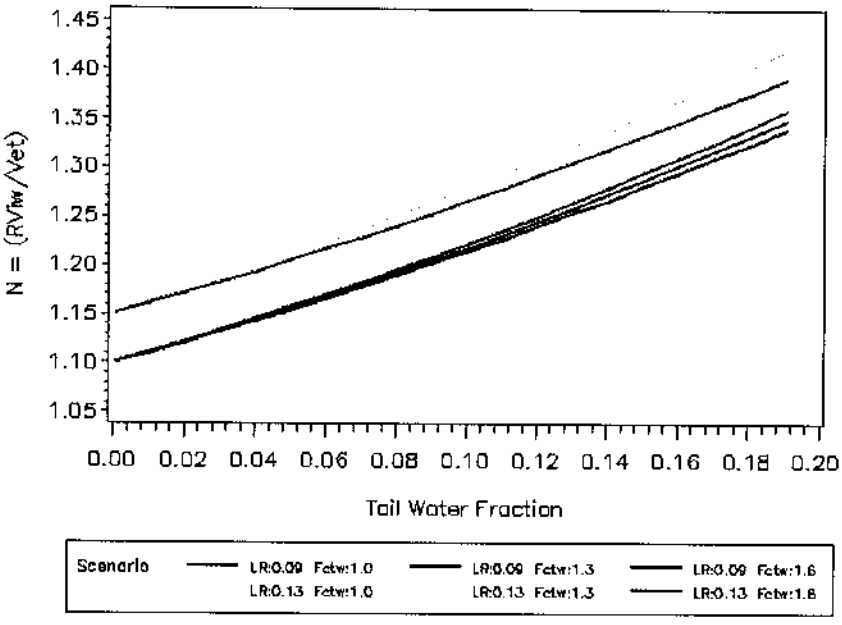


Figure 5a- 4. Delivery water multiplier [N], in relation to tailwater fraction, tailwater EC-ratio and model reaching requirement value.

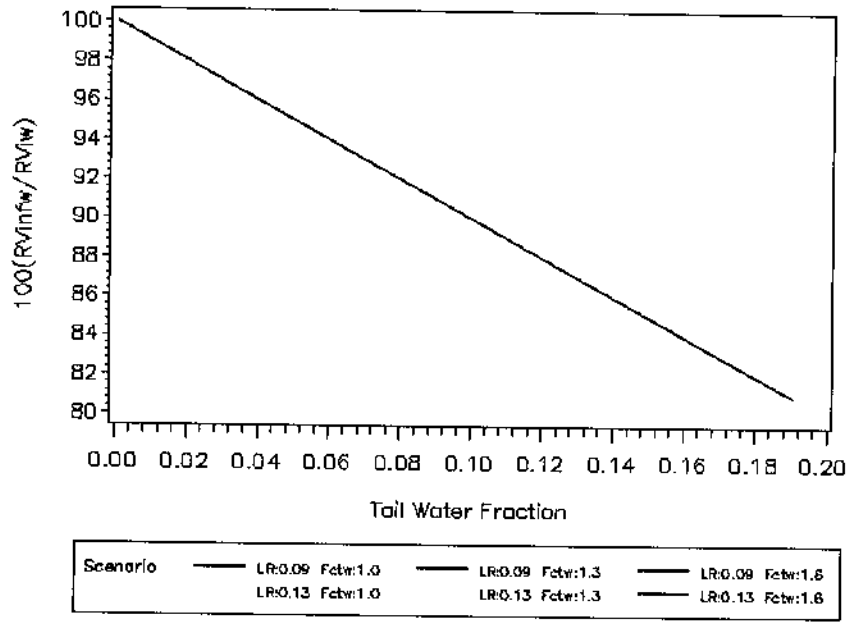


Figure 5a- 5. Percent of required infiltrated water relative to irrigation water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

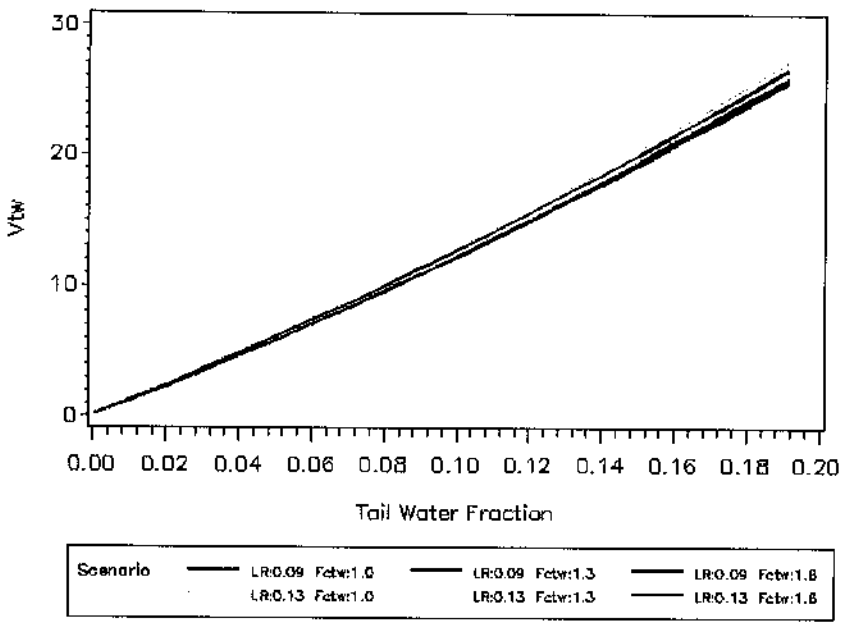


Figure 5a- 6. Tailwater volume, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

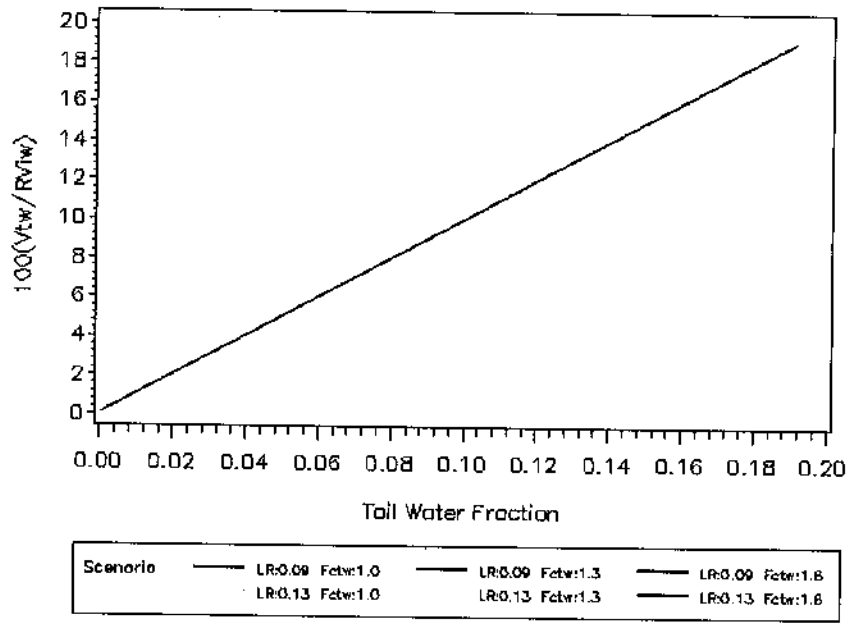


Figure 5a- 7. Percent tailwater relative to irrigation water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

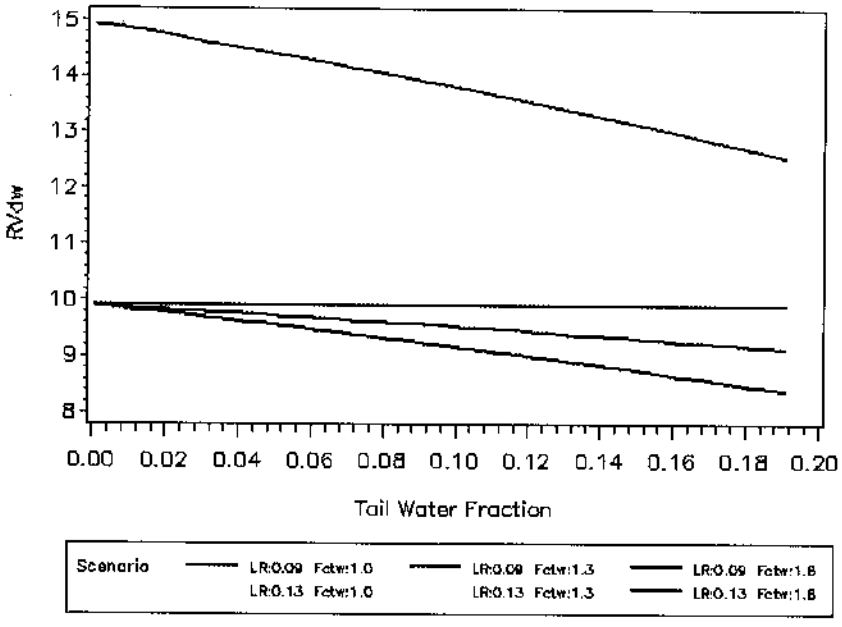


Figure 5a- 8. Required volume of deep percolation, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

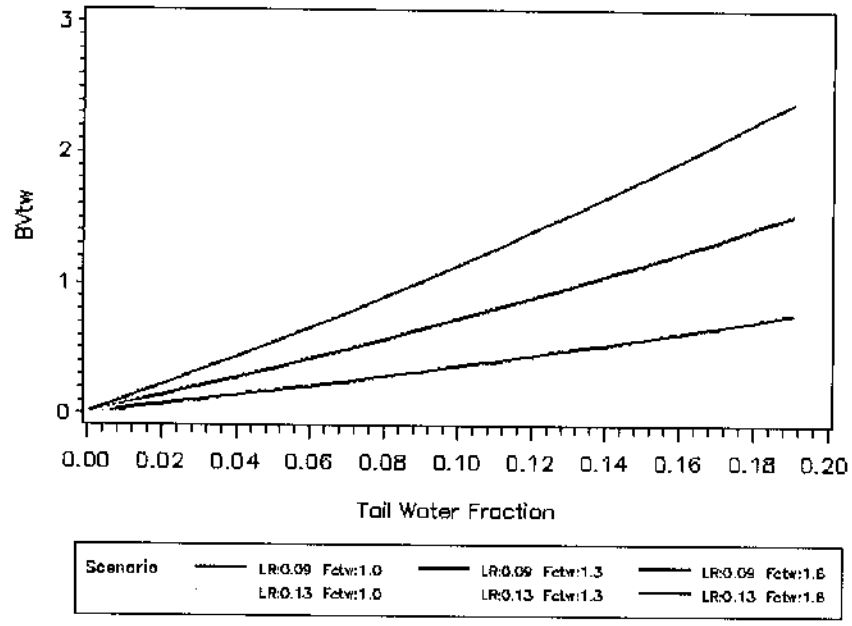


Figure 5a- 9. Beneficial volume of tailwater, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

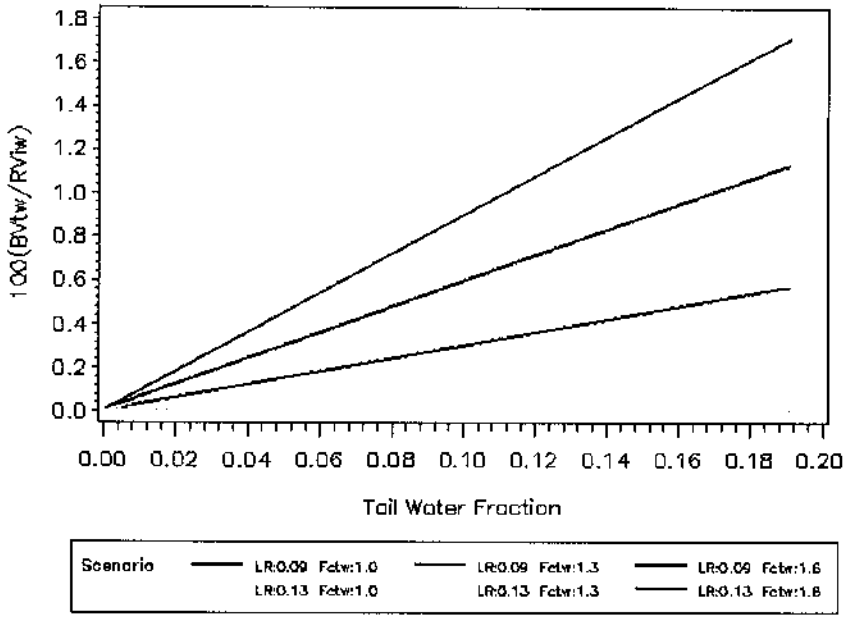


Figure 5a- 10. Percent of beneficial tailwater relative to irrigation water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

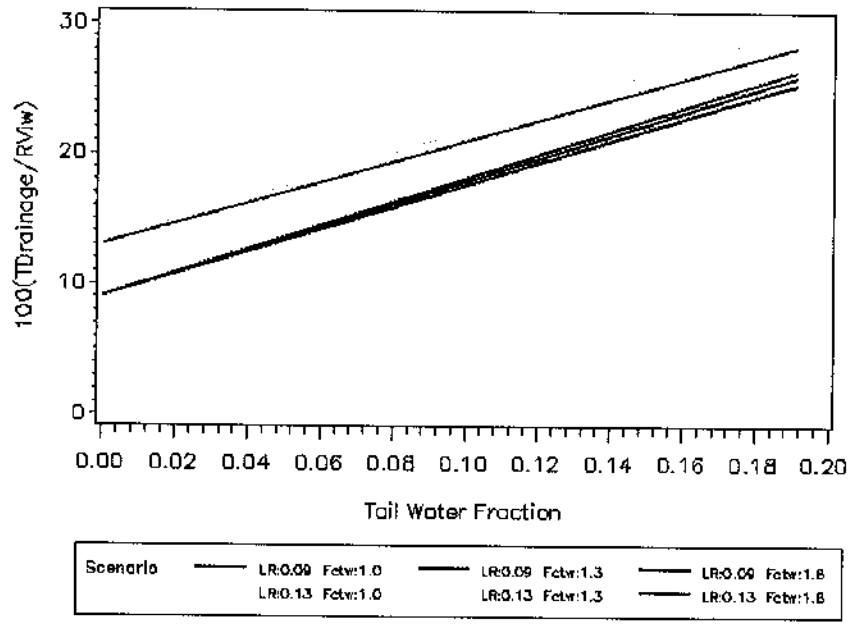


Figure 5a- 11. Percent of total drainage water relative to irrigation water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

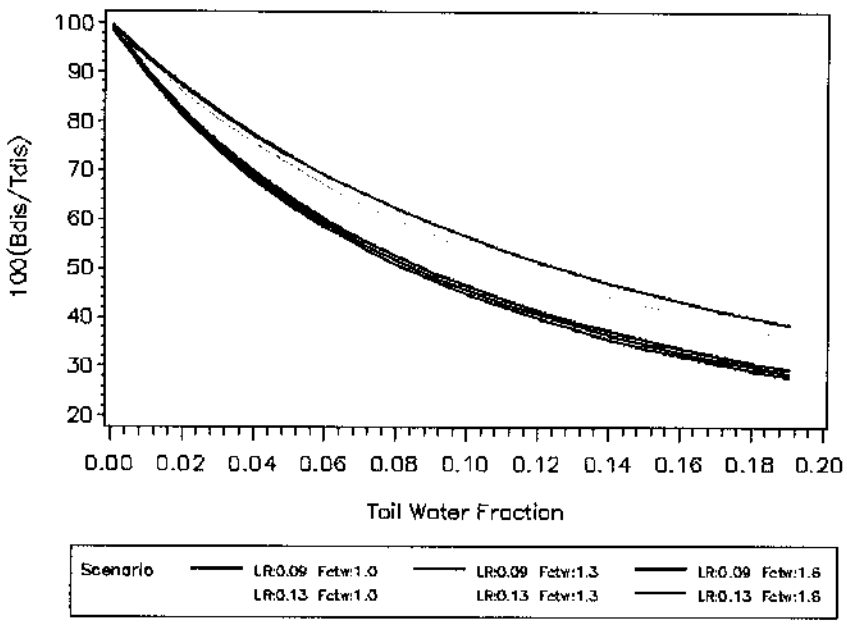


Figure 5a- 12. Percent of beneficially used drainage water relative to total drainage water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

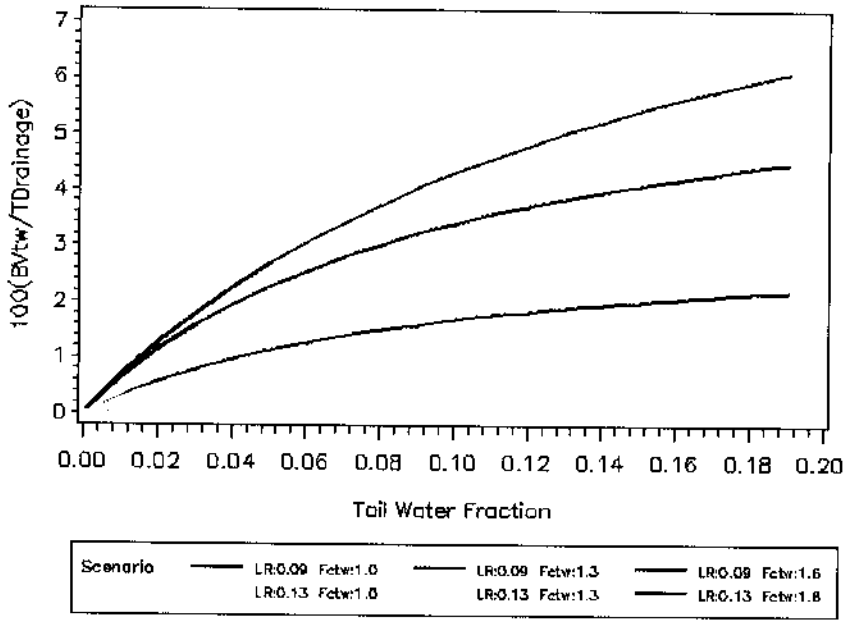


Figure 5a- 13. Percent of beneficial tailwater relative to total drainage water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

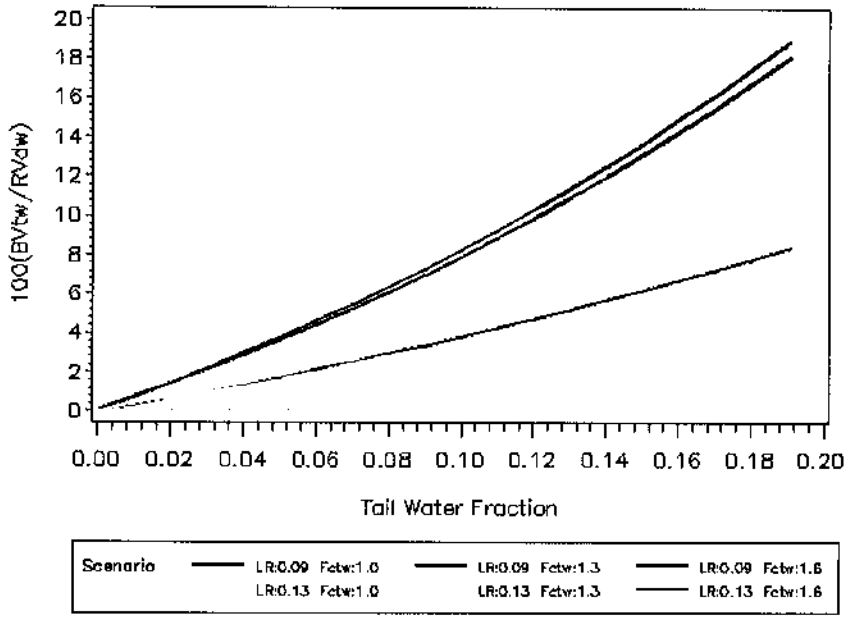


Figure 5a- 14. Percent of beneficial tailwater relative to required deep percolation, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

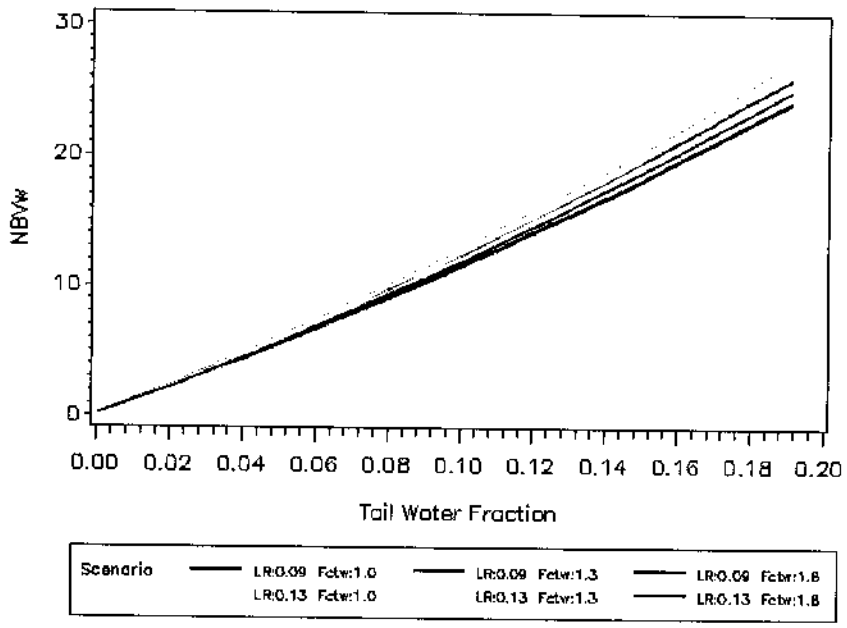


Figure 5a- 15. Volume of non-beneficial water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

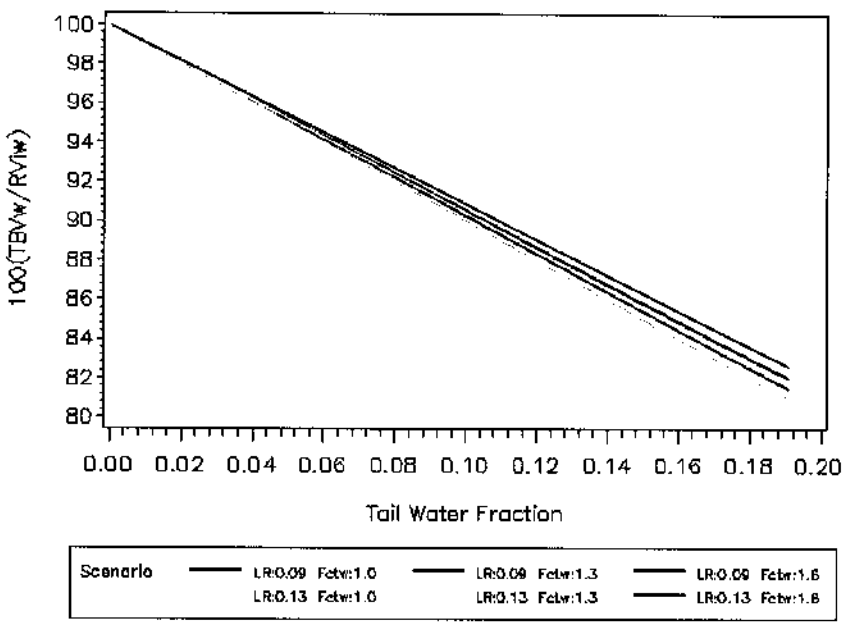


Figure 5a- 16. Percent of beneficial water relative to required volume of irrigation water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

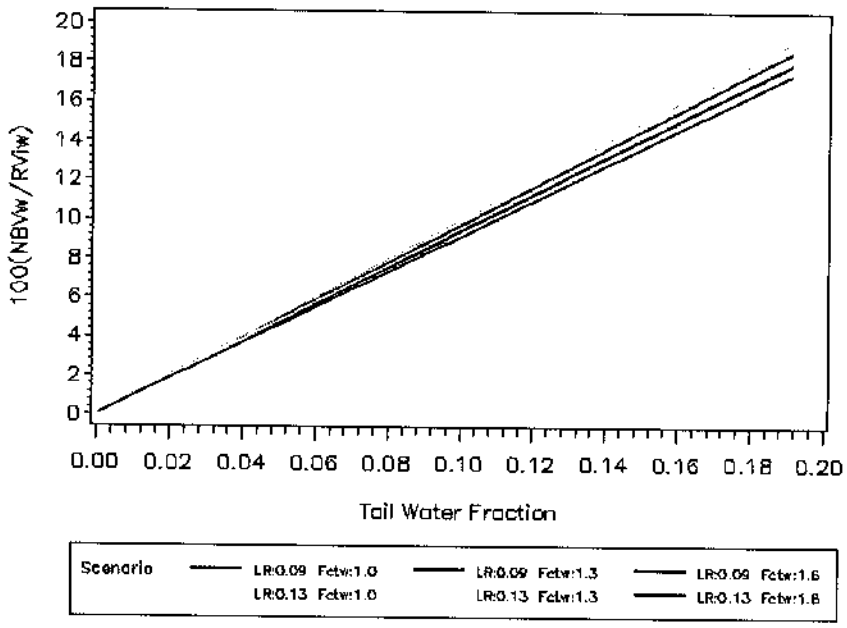


Figure 5a- 17. Percent of irrigation water that is not used beneficially relative to the required volume of irrigation water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement value.

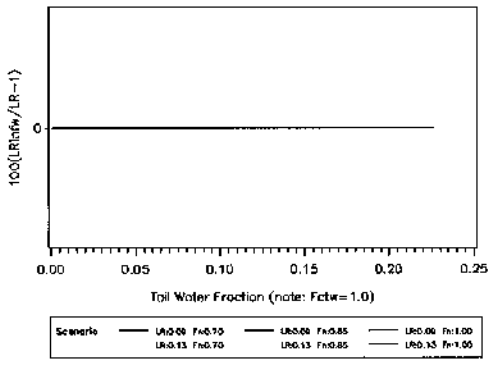


Figure 6a- 1a. Percent decrease in infiltrated leaching requirement relative to model leaching requirement value, in relation to tailwater fraction and model leaching requirement value for ta tailwater EC-ratio of 1.0.

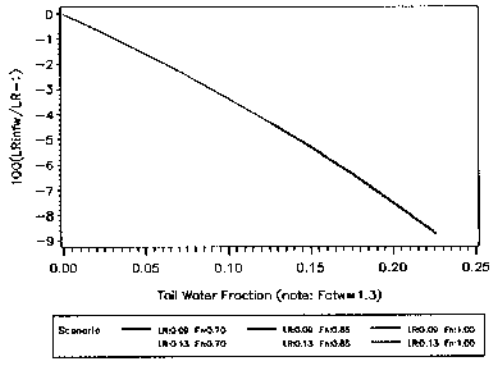


Figure 6a- 1b. Percent decrease in infiltrated leaching requirement relative to model leaching requirement value, in relation to tailwater fraction and model leaching requirement value for ta tailwater EC-ratio of 1.3.

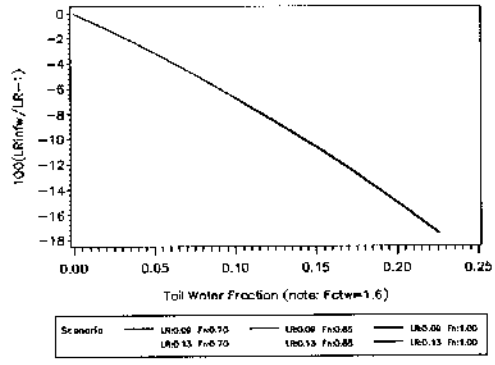


Figure 6a- 1c. Percent decrease in infiltrated leaching requirement relative to model leaching requirement value, in relation to tailwater fraction and model leaching requirement value for ta tailwater EC-ratio of 1.6.

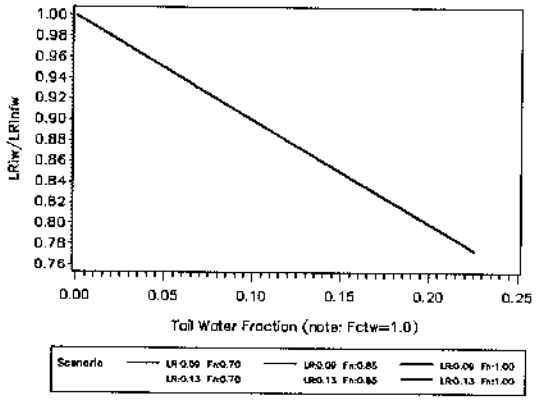


Figure 6a- 2b. Ratio of irrigation water and infiltration water leaching requirements, in relation to tailwater fraction and model leaching requirement value for tailwater EC-ratio of 1.0.

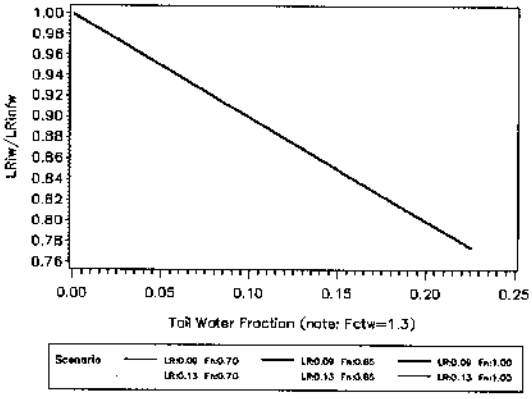


Figure 6a- 2b. Ratio of irrigation water and infiltration water leaching requirements, in relation to tailwater fraction and model leaching requirement value for tailwater EC-ratio of 1.3.

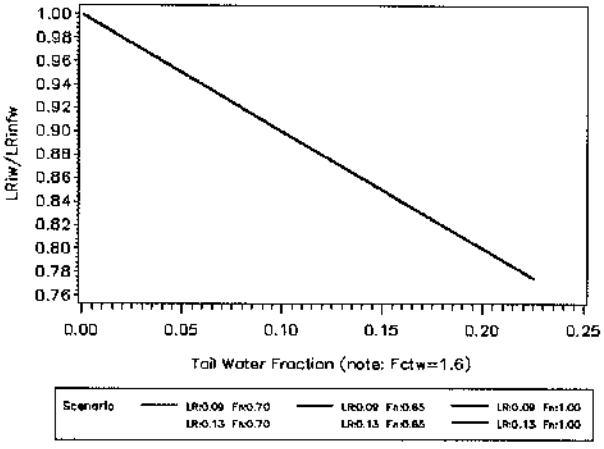


Figure 6a- 2c. Ratio of irrigation water and infiltration water leaching requirements, in relation to tailwater fraction and model leaching requirement value for tailwater EC-ratio of 1.6.

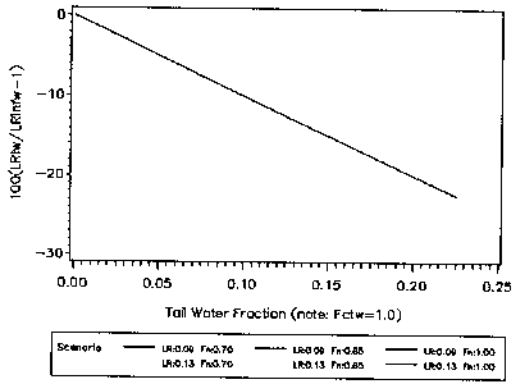


Figure 6a- 3a. Percent decrease in irrigation water leaching requirement relative to infiltration water leaching requirement, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

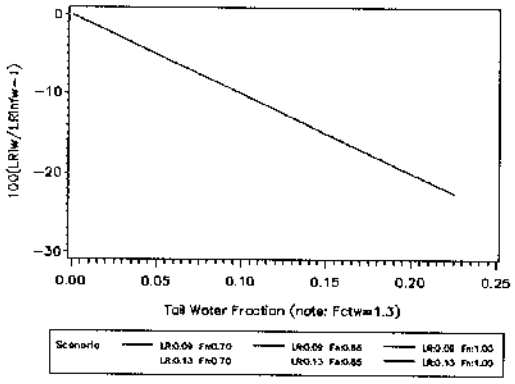


Figure 6a- 3b. Percent decrease in irrigation water leaching requirement relative to infiltration water leaching requirement, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

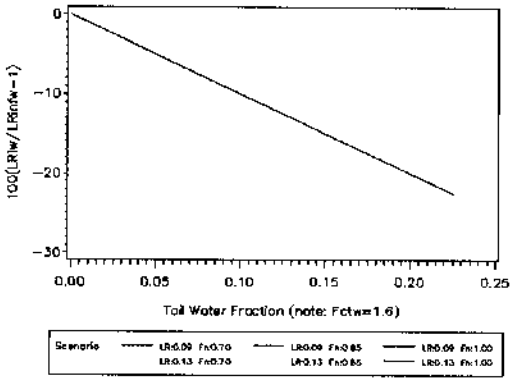


Figure 6a-3c. Percent decrease in irrigation water leaching requirement relative to infiltration water leaching requirement, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

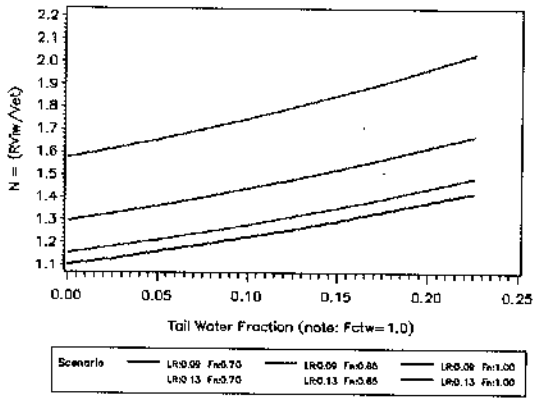


Figure 6a- 4a. Delivery water multiplier [N], in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

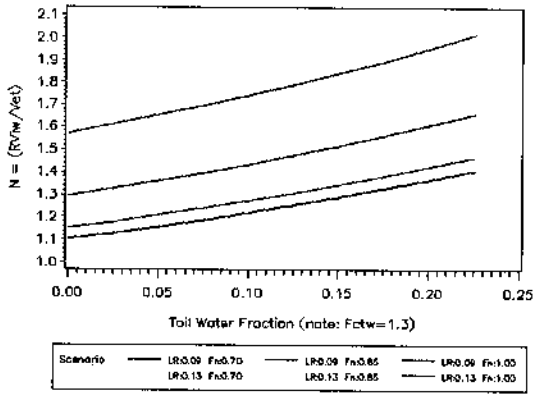


Figure 6a- 4b. Delivery water multiplier [N], in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

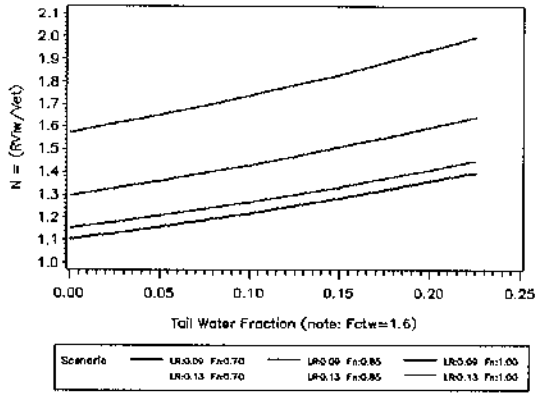


Figure 6a- 4c. Delivery water multiplier [N], in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

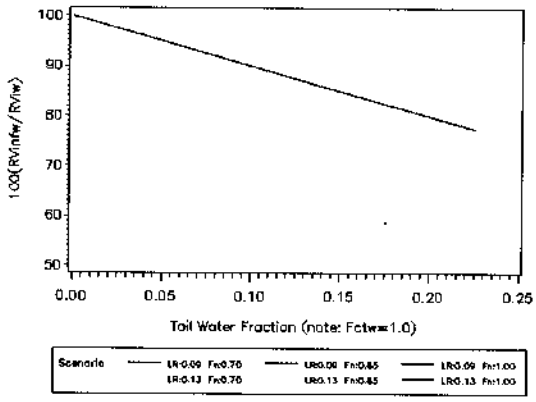


Figure 6a- 5a. Percent of infiltrated water relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

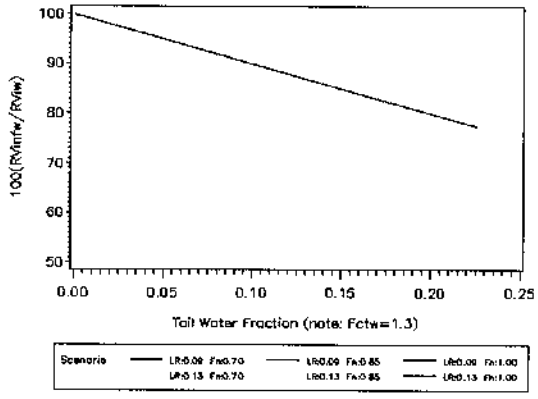


Figure 6a- 5b. Percent of infiltrated water relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

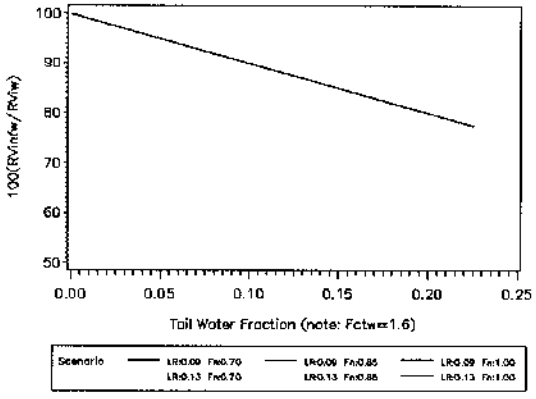


Figure 6a- 5c. Percent of infiltrated water relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6

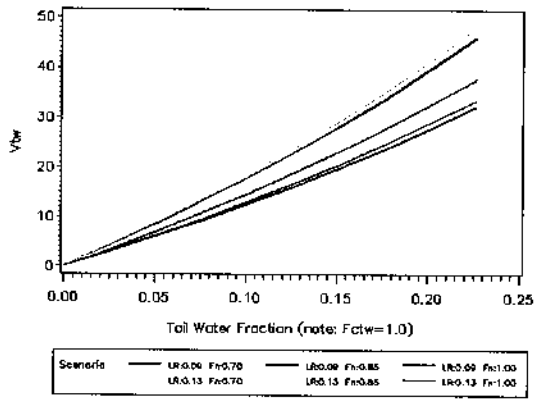


Figure 6a- 6a. Tailwater volume, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0

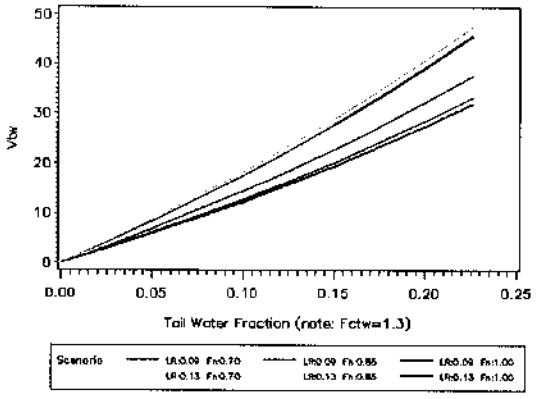


Figure 6a- 6b. Tailwater volume, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

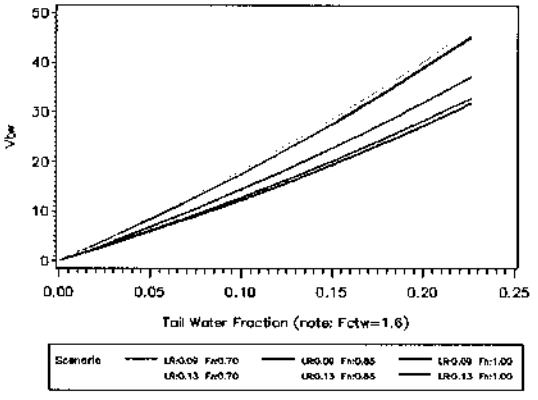


Figure 6a- 6c. Tailwater volume, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

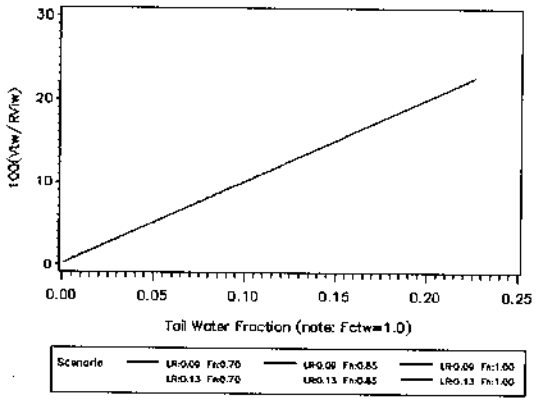


Figure 6a- 7a. Percent of tailwater relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

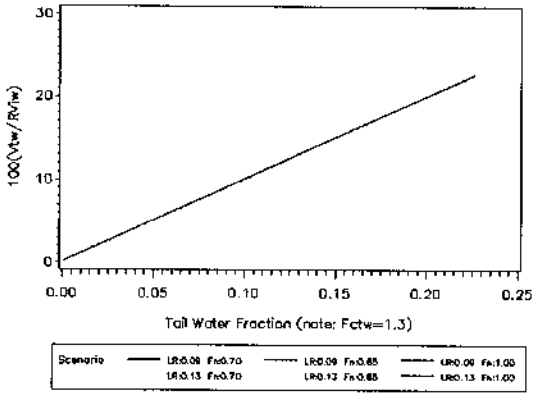


Figure 6a- 7b. Percent of tailwater relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

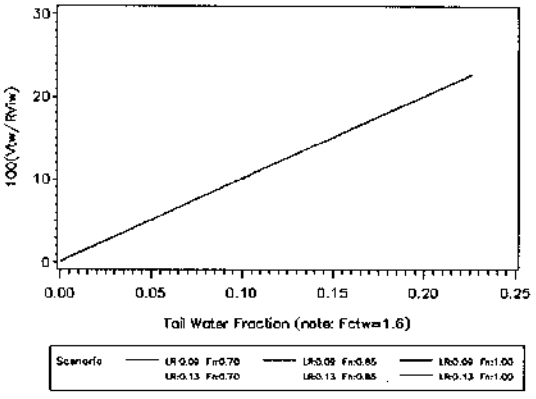


Figure 6a- 7c. Percent of tailwater relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

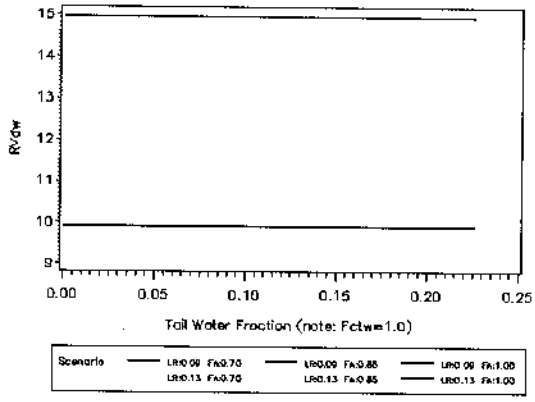


Figure 6a- 8a. Volume of required deep percolation, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

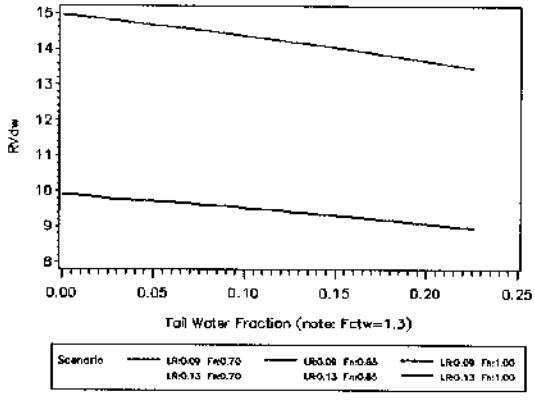


Figure 6a- 8b. Volume of required deep percolation, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

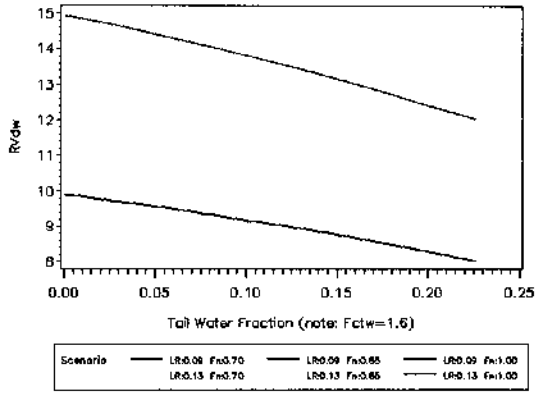


Figure 6a- 8c. Volume of required deep percolation, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

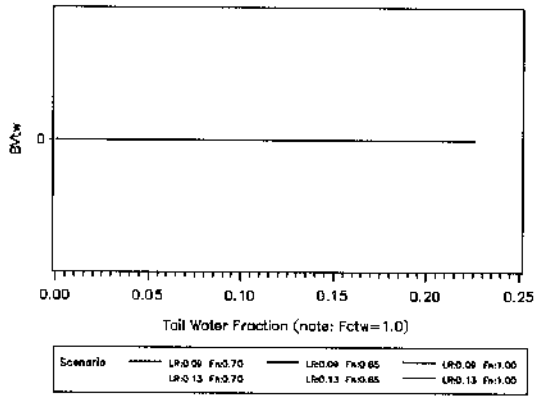


Figure 6a- 9a. Beneficial tailwater volume, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

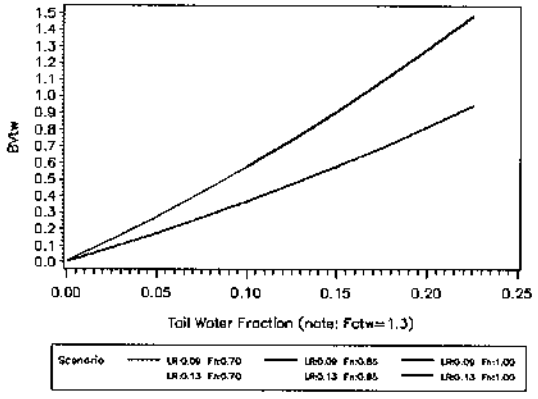


Figure 6a- 9b. Beneficial tailwater volume, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

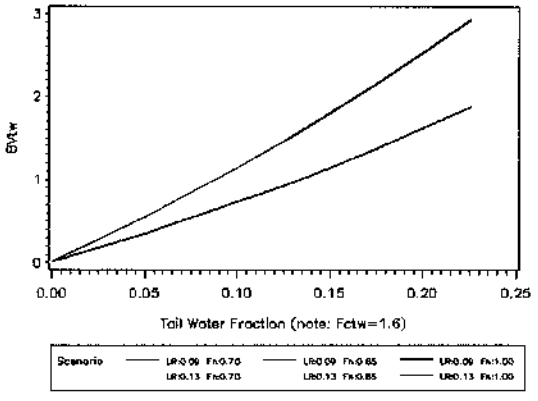


Figure 6a- 9c. Beneficial tailwater volume, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

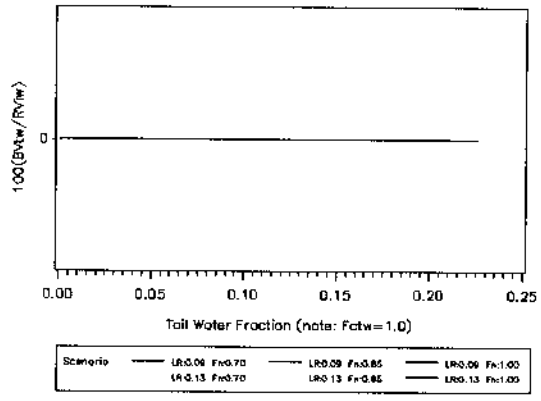


Figure 6a- 10a. Percent beneficial tailwater relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

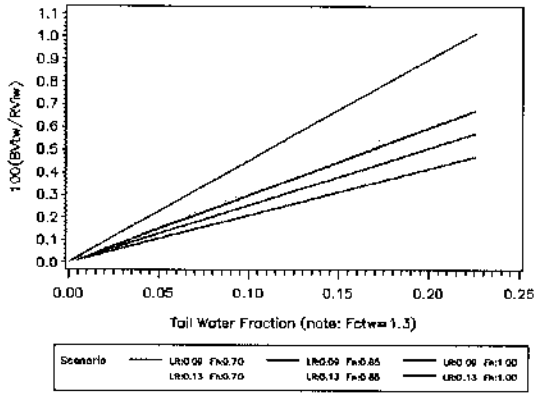


Figure 6a- 10b. Percent beneficial tailwater relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

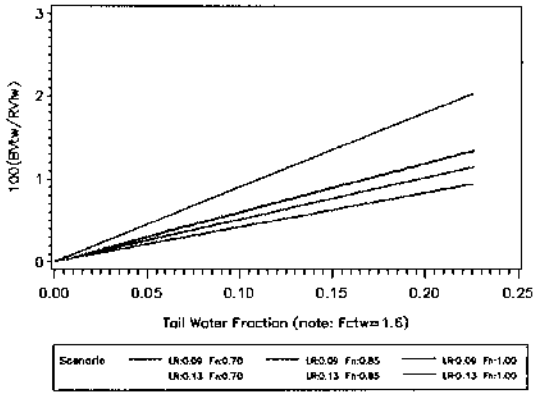


Figure 6a- 10c. Percent beneficial tailwater relative to irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

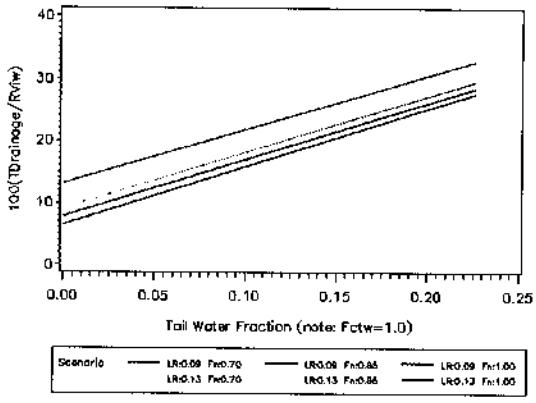


Figure 6a- 11a. Percent total drainage water relative to required irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

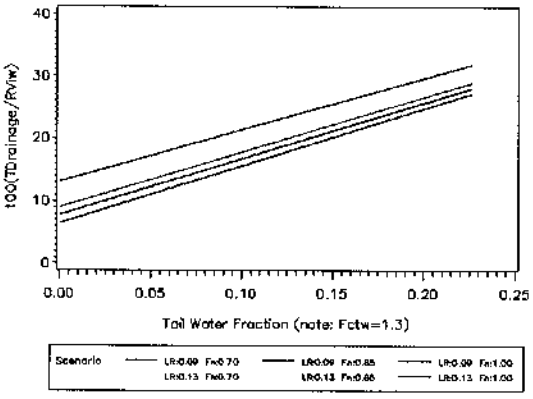


Figure 6a- 11b. Percent total drainage water relative to required irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

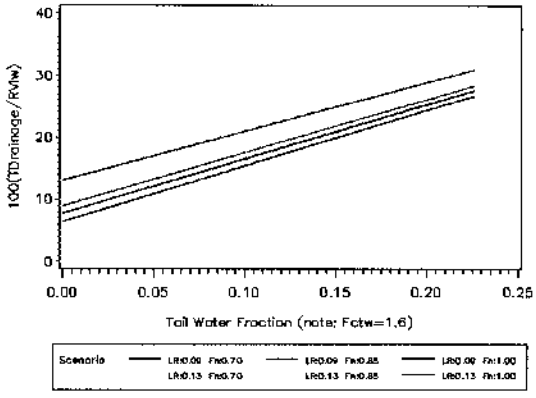


Figure 6a- 11c. Percent total drainage water relative to required irrigation water, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

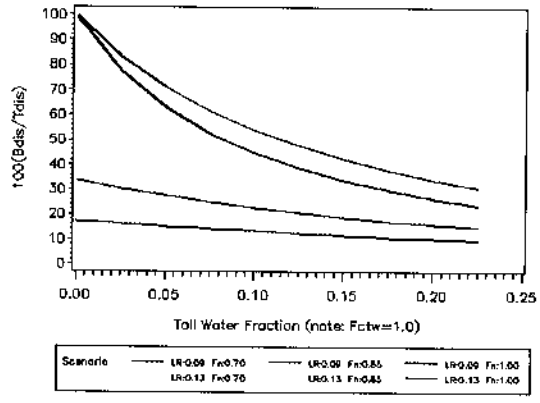


Figure 6a- 12a. Percent beneficial drainage relative to total drainage, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.0.

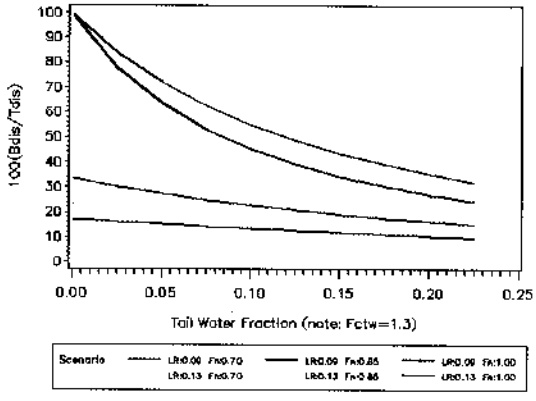


Figure 6a- 12b. Percent beneficial drainage relative to total drainage, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.3.

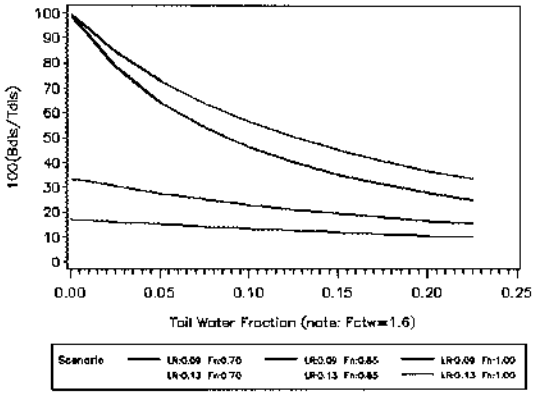


Figure 6a- 12c. Percent beneficial drainage relative to total drainage, in relation to tailwater fraction and model leaching requirement value for a tailwater EC-ratio of 1.6.

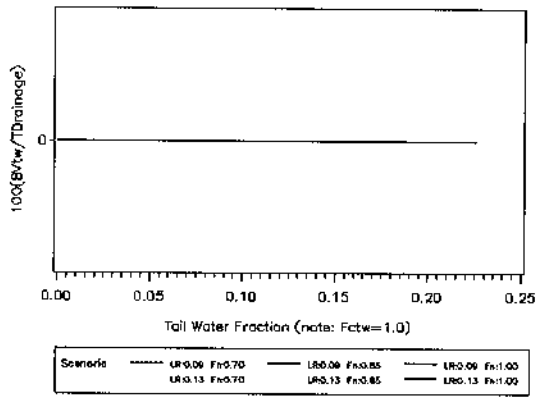


Figure 6a- 13a. Percent beneficial tailwater relative to total drainage, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

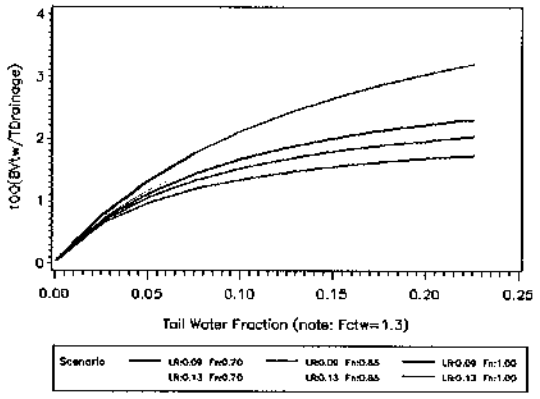


Figure 6a- 13b. Percent beneficial tailwater relative to total drainage, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

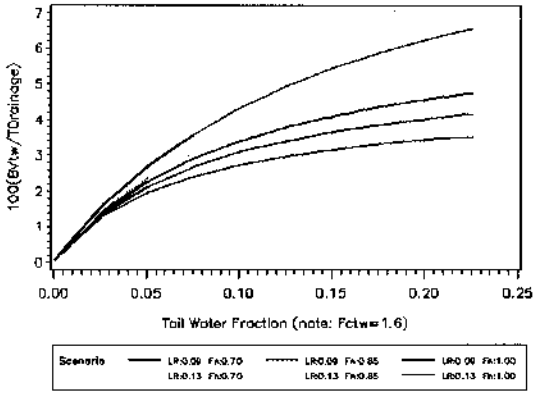


Figure 6a- 13c. Percent beneficial tailwater relative to total drainage, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

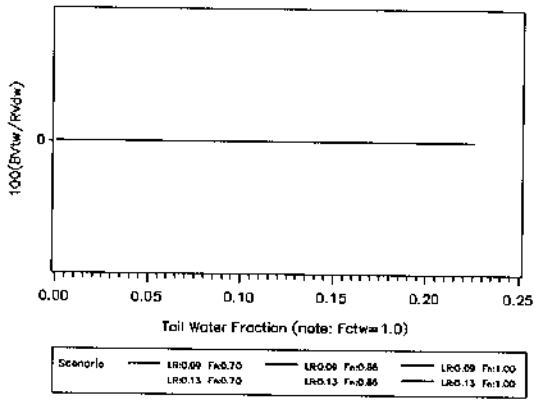


Figure 6a- 14a. Percent beneficial tailwater relative to required deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

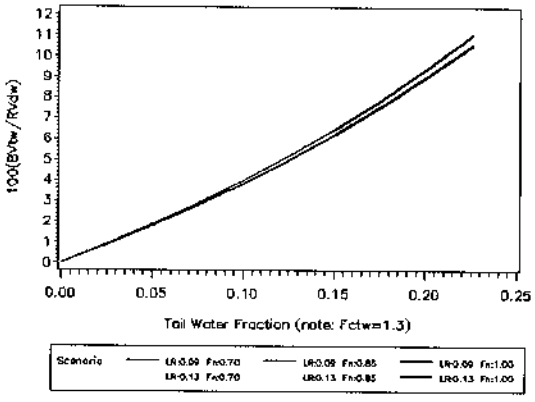


Figure 6a- 14b. Percent beneficial tailwater relative to required deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

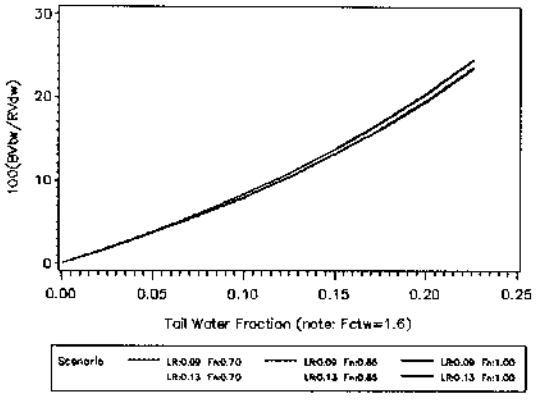


Figure 6a- 14c. Percent beneficial tailwater relative to required deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

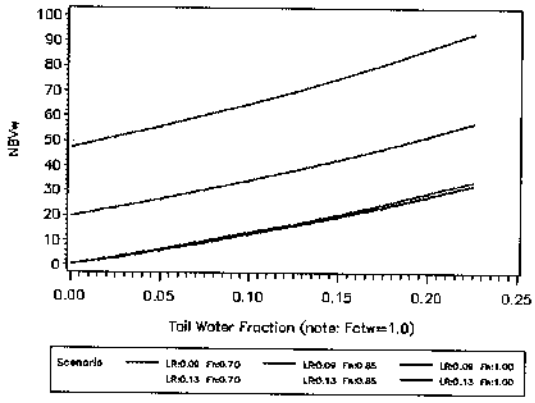


Figure 6a- 15a. Volume of non-beneficial water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

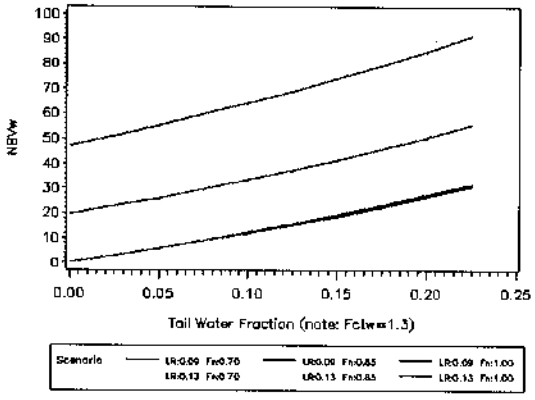


Figure 6a- 15b. Volume of non-beneficial water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

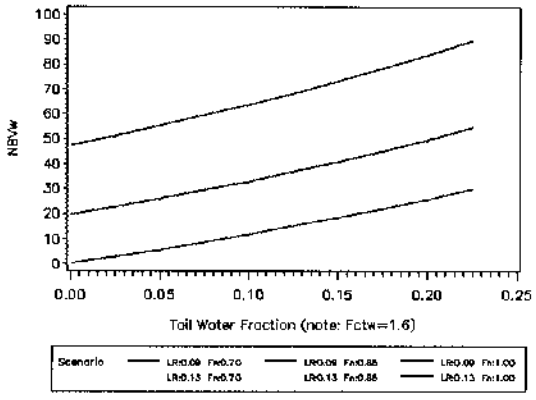


Figure 6a- 15c. Volume of non-beneficial water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

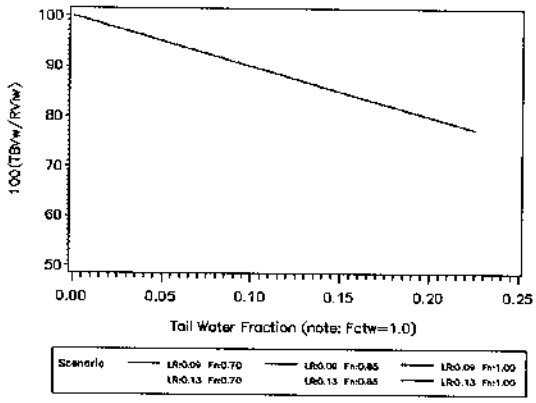


Figure 6a- 16a. Percent beneficial water relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

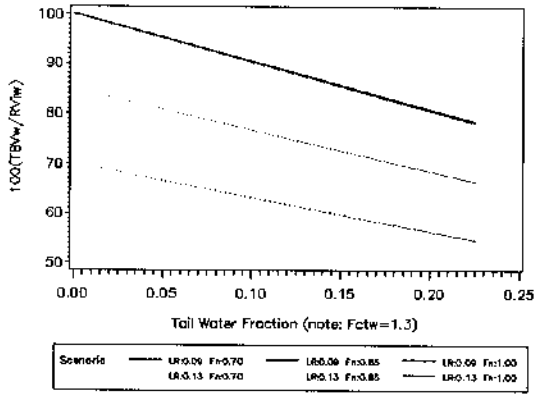


Figure 6a- 16b. Percent beneficial water relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

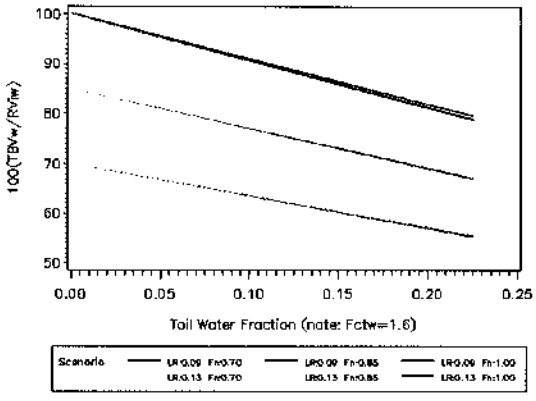


Figure 6a- 16c. Percent beneficial water relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

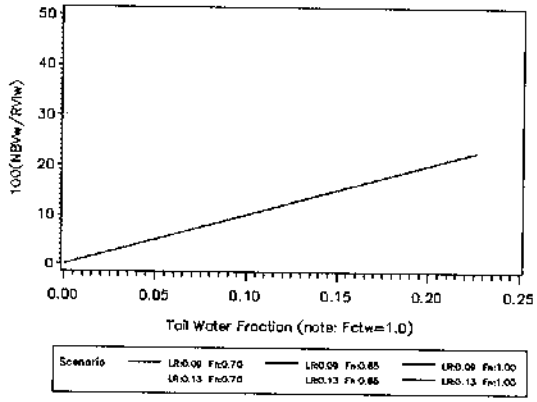


Figure 6a- 17a. Percent of beneficial water relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

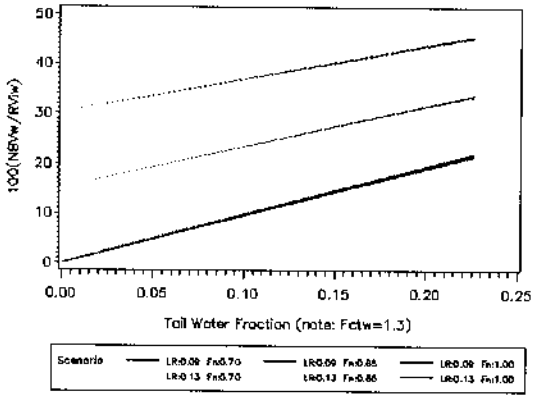


Figure 6a- 17b. Percent of beneficial water relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

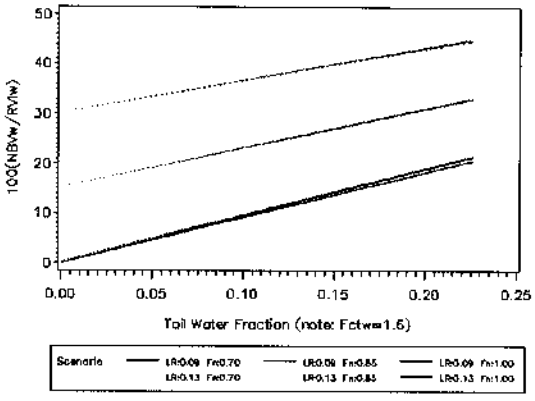


Figure 6a- 17c. Percent of beneficial water relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

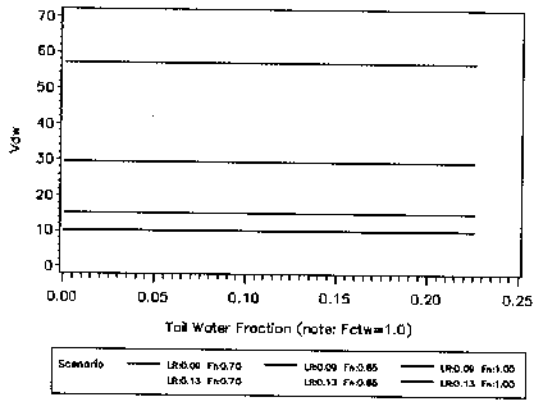


Figure 6a- 18a. Volume of deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

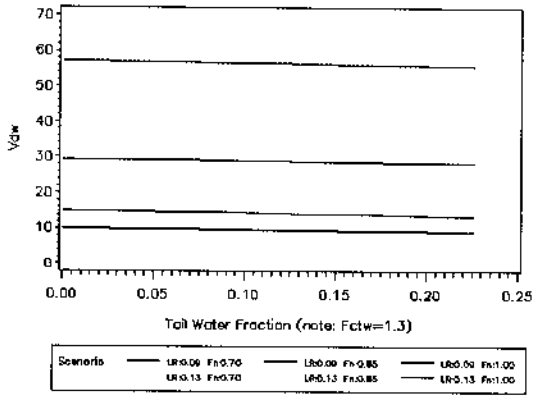


Figure 6a- 18b. Volume of deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

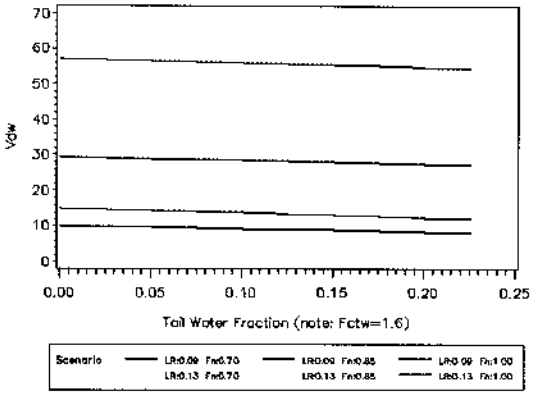


Figure 6a- 18c. Volume of deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

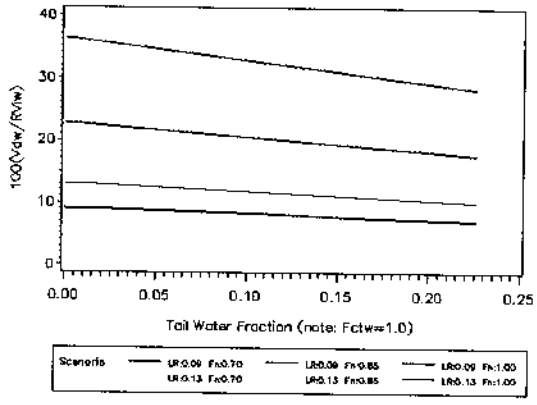


Figure 6a- 19a. Percent of total drainage relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

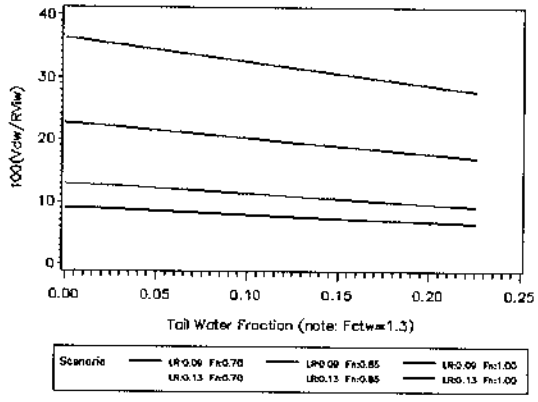


Figure 6a- 19b. Percent of total drainage relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

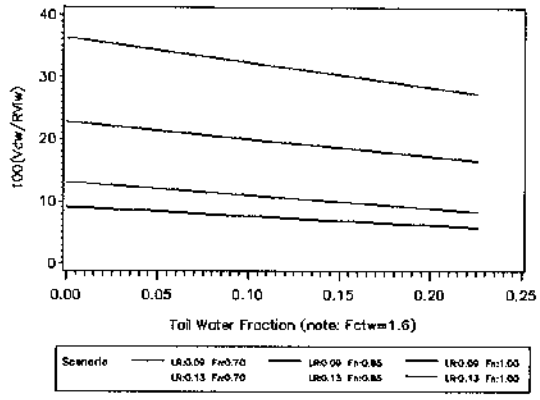


Figure 6a- 19c. Percent of total drainage relative to required irrigation water, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

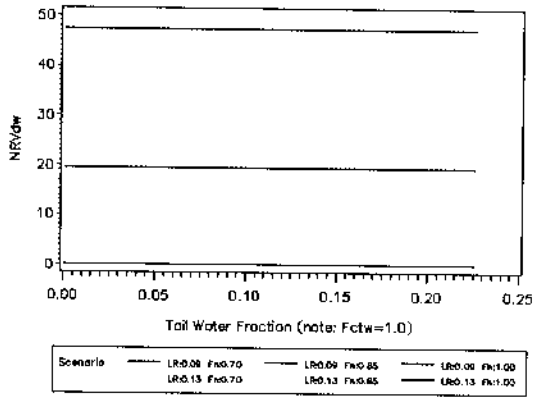


Figure 6a- 20a. Volume of non-required deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

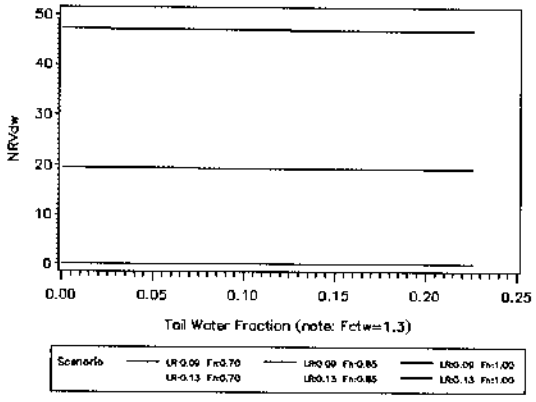


Figure 6a- 20b. Volume of non-required deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

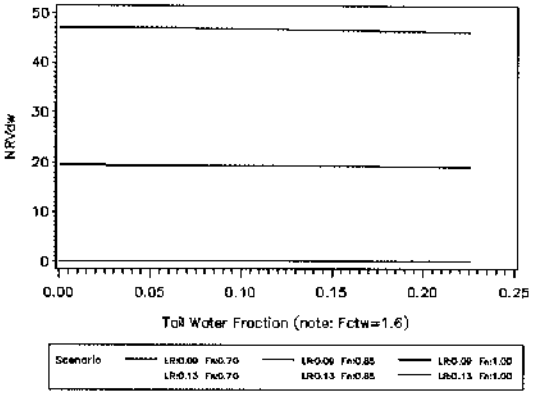


Figure 6a- 20c. Volume of non-required deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

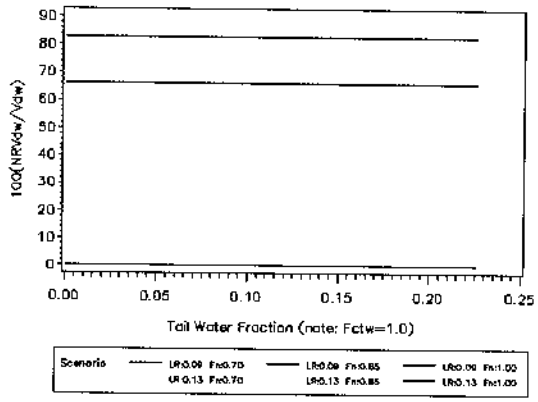


Figure 6a- 21a. Percent non-required deep percolation relative to total deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

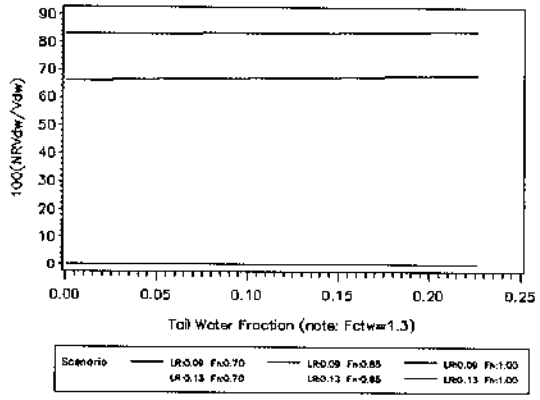


Figure 6a- 21b. Percent non-required deep percolation relative to total deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

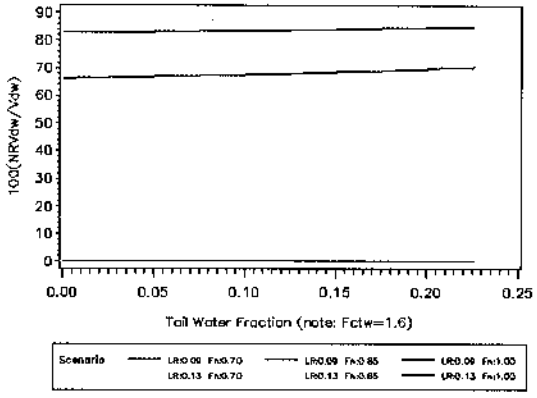


Figure 6a- 21c. Percent non-required deep percolation relative to total deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

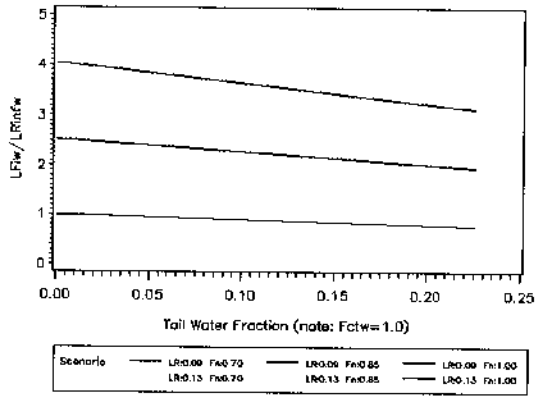


Figure 6a- 22a. Actual leaching fraction relative to required leaching fraction, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

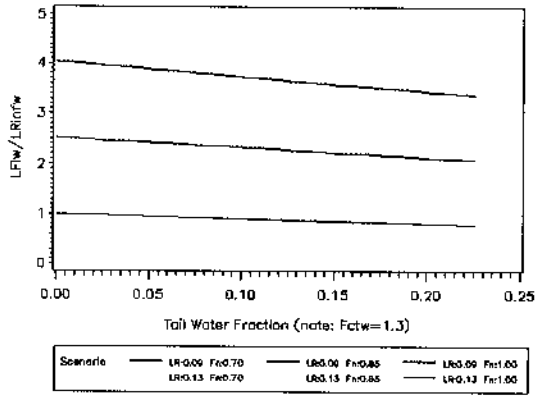


Figure 6a- 22b. Actual leaching fraction relative to required leaching fraction, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

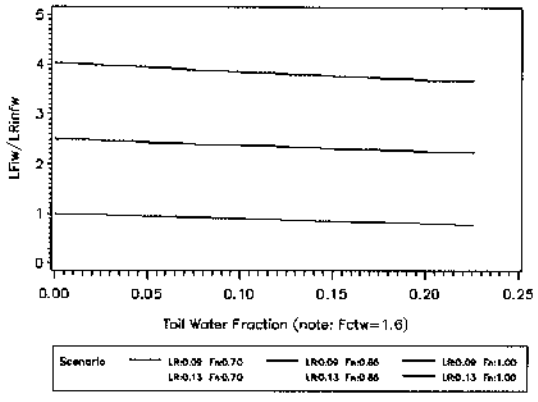


Figure 6a- 22c. Actual leaching fraction relative to required leaching fraction, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

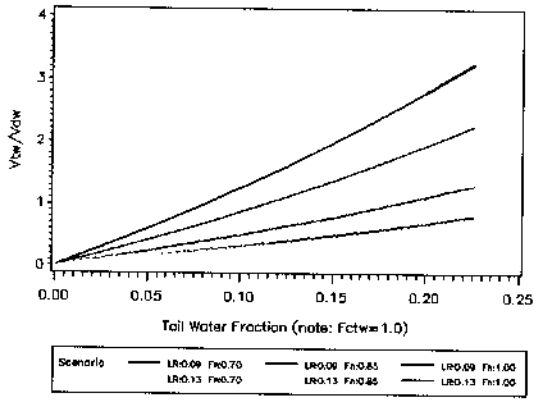


Figure 6a- 23a Ratio of tailwater to total deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.0.

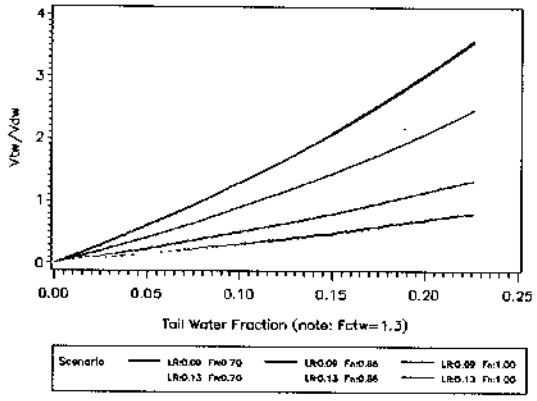


Figure 6a- 23b. Ratio of tailwater to total deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.3.

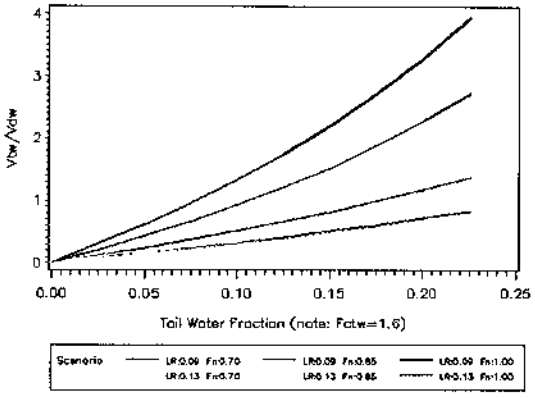


Figure 6a-23c. Ratio of tailwater to total deep percolation, in relation to tailwater fraction model leaching requirement value for a tailwater EC-ratio of 1.6.

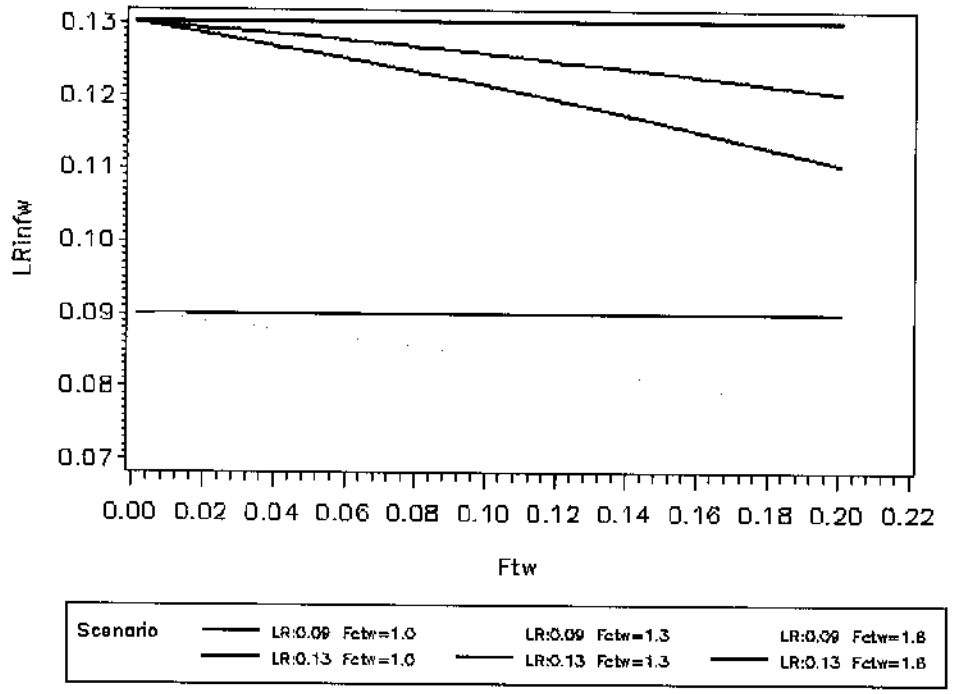


Figure 6b-1. Leaching requirement referenced to infiltrated water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement values.

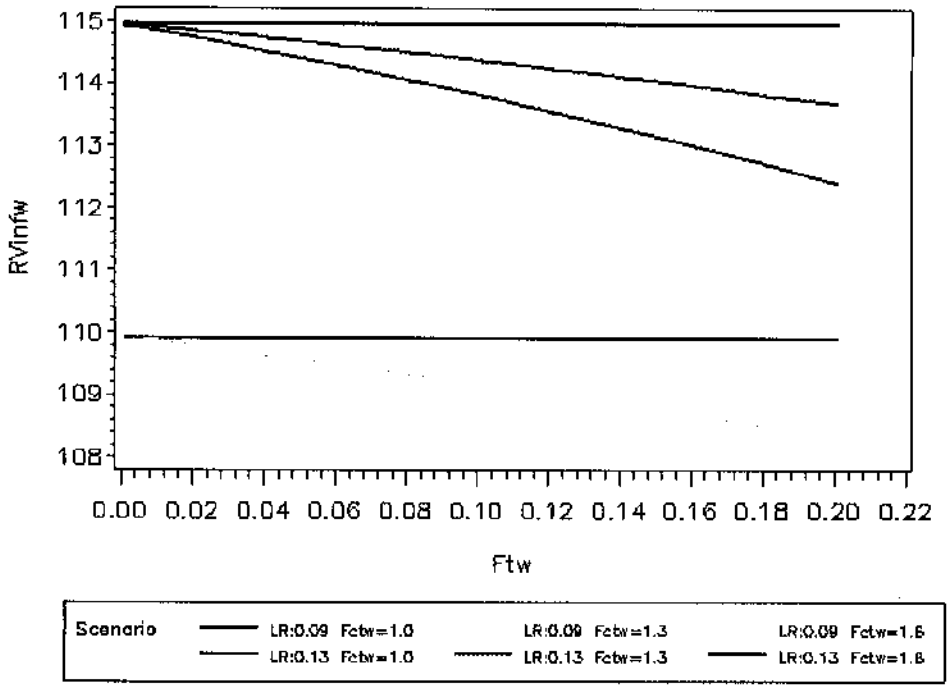


Figure 6b-2. Required volume of water to be infiltrated, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement values.

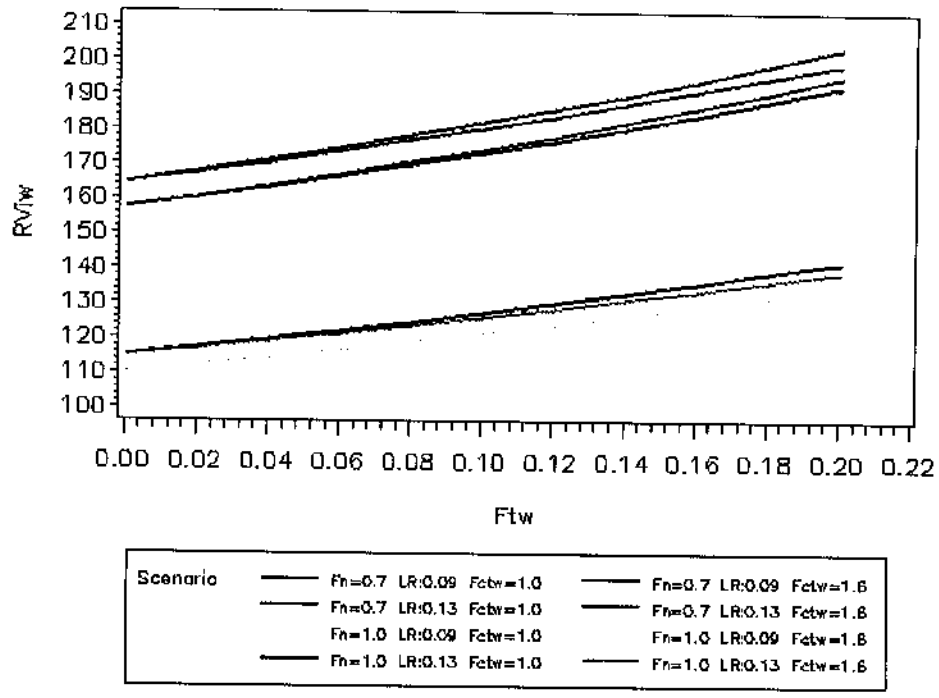


Figure 6b-3. Required volume of irrigation water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement values.

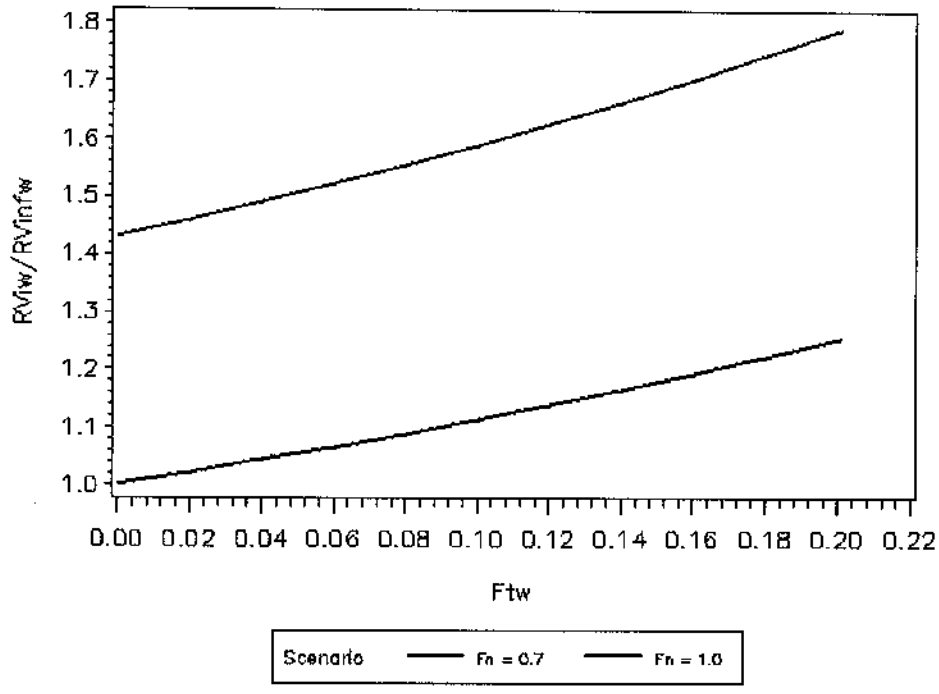


Figure 6b-4. Ratio of required volume of irrigation water relative to the required volume of infiltrated water, in relation to tailwater fraction, tailwater EC-ratio and model leaching requirement values.

Appendix of Sensitivity Analyses

To: **Jim Rhoades**
From: **Scott Lesch**

Subject: **Performing a more rigorous Sensitivity Analysis**

In general, a sensitivity analysis of a specific model (or equation) attempts to quantify precisely how much each model parameter influences the response variable. This "influence" can be measured in several ways, and the model parameters can be examined either independently or simultaneously.

The simplest way to perform a sensitivity analysis is via the "1 parameter at a time (*1PT*)" approach. For example, suppose our model response (Z) is a function of 3 parameters (A, B, and C). We can write this relationship mathematically as

$$Z = g(A,B,C)$$

where "g" represents some type of linear or nonlinear equation, etc. Suppose also that we can agree on reasonable ranges for the three input parameters; i.e., we can specify the minimum, typical (mean), and maximum values that each parameter might possibly assume. In the *1PT* approach, we sequentially set one parameter to its minimum and maximum values, while holding all other parameters fixed at their mean levels. The change in the Z response level is then quantified (usually on a percent basis). This process is repeated for each parameter (while all other parameters are held fixed at their respective mean levels), and hence the "sensitivity" of Z to each parameter (A, B, C) is quantified.

An Analysis of Variance (*ANOVA*) model represents another effective technique for quantifying the effects of parameter (input) variation on the model response (output) variation. In the *ANOVA* analysis, we approximate the exact equation (g(A,B,C)) using a first-order analysis of variance equation. This technique allows us to partition the response variation according to specific input parameters. For example, we might find that 80% of the observed variation in Z is explained by (changes in) parameter A, 15% of the observed variation is due to parameter B, and only 5% is associated with parameter C, etc.

The *ANOVA* results can be used to compliment and enhance the *1PT* results. (For linear equations, there is actually a mathematical relationship between these two approaches, but I will not explain the relationship here.)

I've included an actual example on the next page (for RV_{div}) showing how both approaches would be employed.

Example 1: Formula for Calculating RV_{dw}

$$RV_{dw} = LR_{iw} \cdot RV_{iw}$$

$$RV_{dw} = \frac{LR_{iw} \cdot V_{et}}{1 - LR_{iw} - F_{tw}}$$

$$RV_{dw} = \frac{LR \cdot (1 - F_{tw} \cdot F_{ctw}) \cdot V_{et}}{1 - LR \cdot (1 - F_{tw} \cdot F_{ctw}) - F_{tw}}$$

$$RV_{dw} = V_{et}\left[\frac{LR \cdot (1 - F_{tw} \cdot F_{ctw})}{1 - LR \cdot (1 - F_{tw} \cdot F_{ctw}) - F_{tw}}\right]$$

A nonlinear equation, dependent on V_{et}, LR, F_{tw}, and F_{ctw}.

Conditional on a V_{et} value of 100 (considered fixed), a simple sensitivity analysis can be performed on the remaining 3 parameters, using the following ranges:

	LR	F_{tw}	F_{ctw}
Minimum	0.07	0.01	1.0
Mean	0.11	0.12	1.3
Maximum	0.15	0.23	1.6

Likewise, a first order variance partitioning can be performed via use of an ANOVA model, conditional on a fixed value of V_{et}, i.e.,

$$RV_{dw} \approx \mu + \alpha_i(LR) + \delta_j(F_{tw}) + \lambda_k(F_{ctw})$$

for i= 1, 2, 3; j = 1, 2, 3; and k = 1, 2, 3 and where the 3 levels of each input variable are set to the minimum, mean (typical), and maximum expected values shown above.

The sensitivity analysis allows one to determine the average % change in the RV_{dw} as each parameter changes from its minimum to maximum levels. Likewise the ANOVA model allows one to partition the variability of the RV_{dw} response into 4 effects:

1. Variability due to changes in the LR,
2. Variability due to changes in the F_{tw},
3. Variability due to changes in the F_{ctw}, and
4. Variability due to higher order interaction between the 3 input variables.

Thus, both of these techniques help us to quantify the "sensitivity" of the RV_{dw} response to each

input parameter, etc...

Sensitivity Results:

1. Calculated Sensitivity: (typical RV_{dw} value: 11.794)

Parameter	Minimum	Maximum	% Change
LR	7.197	16.804	81.5 %
F_{tw}	12.318	11.129	10.1 %
F_{ctw}	12.360	11.235	9.5 %

Variability Results:

2. Calculated % Variation in the RV_{dw} associated with each model parameter (Note: R^2 value is 0.984, thus model explains 98.4 % of observed variability)

Parameter	% Variation
LR	95.3 %
F_{tw}	1.5 %
F_{ctw}	1.6 %
Higher order interaction	1.6 %

General Results:

The dominate variable influencing the required volume of drainage water is the leaching rate. Changing the *LR* over its full range results in an 82% change in the volume of drainage water. Additionally, over 95% of the projected variation in drainage water volumes is explained by variation in the *LR*, etc.

To: **Jim Rhoades**
Agsalt

From: **Scott Lesch**
EnvStatSrvcs

Date: **January 6, 2003**

Subject: **Requested Sensitivity Analysis**

1.0 Introduction

This report describes and documents the results from a formal sensitivity analysis performed on nine mathematical equations derived from your composite tail-water leaching model. Each of these nine equations describes a specific response variable of interest, as defined by one or more of the following five input parameters:

LR: the theoretical leaching rate
Ftw: the fraction of applied water that constitutes tail-water run-off
Fctw: the proportional increase in salinity (ECe) in the tail-water component
Vet: the assumed ET volume, expressed on a percent basis
Fu: the uniformity coefficient, expressed as a fraction of the applied water

In this report, these five input parameters have been defined to have the following minimum, median (mid-point), and maximum values, respectively:

Parameter	Minimum	Median	Maximum
LR	0.08	0.12	0.16
Ftw	0.02	0.10	0.18
Fctw	1.00	1.30	1.60
Vet	90	100	110
Fu	0.70	0.85	1.00

The nine response variables of interest (subject to the sensitivity analysis) are as follows:

LRiw: the irrigation water leaching rate
LRinfw: the infiltration water leaching rate
RViw: the required volume of irrigation water
RVinfw: the required volume of infiltration water
RVdw: the required volume of deep percolation water
BVtw: the beneficial volume of tail-water
TBVw: the total beneficial volume of water (applied to the field)

NBVw:	the non-beneficial volume of water (applied to the field)
N:	the ratio of total water applied referenced to Vet

The mathematical equations defining these nine response variables are:

$$LRiw = LR \cdot (1 - Ftw \cdot Fctw)$$
$$LRinfw = LRiw / (1 - Ftw)$$
$$RViw = Vet / [(1 - LRinfw) \cdot (1 - Ftw) \cdot Fu]$$
$$RVinfw = Vet / (1 - LRinfw)$$
$$RVdw = LRinfw \cdot RVinfw$$
$$BVtw = [LR \cdot (Vet / (1 - LR))] - [LRiw \cdot (Vet / (1 - LRiw - Ftw))]$$
$$TBVw = Vet + RVdw + BVtw$$
$$NBVw = RViw - TBVw$$
$$N = RViw / Vet$$

Note that these nine equations do not all depend on all five input parameters, although each of the five input parameters effect multiple equations.

The remainder of this report is organized as follows. Section 2 describes the statistical techniques used to perform the basic sensitivity and variability analysis. Section 3 presents the results of these analyses for each response variable of interest. Finally, section 4 contains some brief discussion and comments pertaining to these results.

2.0 Sensitivity Analysis: Basic Theory

This section described the mathematical and statistical techniques used to perform the basic sensitivity analyses. This includes the techniques used to (1) determine the percent change in the response variables due to one-at-a-time (sequential) changes in the individual input parameters, and (2) calculate and partition the percent variability in the response variable induced by sequential changes across all relevant input variables.

2.1 Determining the % change in the response variable due to sequential changes in (individual) input parameters.

In general, a basic sensitivity analysis can be used to determine the percent change in the response variables due to one-at-a-time (sequential) changes in the individual input parameters. To determine such changes, a set of minimum, typical (mid-point), and maximum levels are first defined for all of the relevant input parameters. The mid-point input levels are then used to calculate "reference" values for the response variables of interest. Next, each input parameter is sequentially set to its minimum and maximum level (while all other input parameters are held fixed at their respective mid-point levels) and the changes in a specific response variable are recorded. The difference in the response output (maximum - minimum) is then used in conjunction with the reference output level to define the percent change. Formally, this is defined as

$$\% \text{ change} = 100 \cdot (\text{abs} [Y_{max} - Y_{min}] / Y_{reference})$$

where *abs* stands for "absolute value" and Y_{min}, Y_{max}, and $Y_{reference}$ refer to the minimum, maximum, and reference response variable output values.

The following example should help clarify this technique. Consider the equation used to define the irrigation water leaching rate (LRiw):

$$LRiw = LR \cdot (1 - Ftw \cdot Fctw)$$

This equation contains three input parameters (LR, Ftw, and Fctw), and thus the LRiw response variable is clearly a function of these three parameters. First, each input parameter is set to its defined mid-point level (0.12, 0.10, and 1.3, respectively) and then these mid-point values are used to calculate the LRiw reference output value (0.1044). Next, the LRiw responses at LR = 0.08 and LR = 0.16 are calculated, while holding the Ftw and Fctw input levels fixed at 0.1 and 1.3. In this example, these values turn out to be 0.0696 and 0.1392, respectively. Finally, the percent change in LRiw is calculated as

$$\begin{aligned} \% \text{ change} &= 100 \cdot (0.1392 - 0.0696) / 0.1044 \\ &= 66.67 \% \end{aligned}$$

Hence, the observed percent change in the LRiw response variable due to the maximum expected variation in the LR input parameter is about 67 %.

When this process is repeated for the Ftw and Fctw input parameters, we find that the corresponding percent changes in the LRiw response variable are 23.91 % and 6.90 %, respectively. Taken together, these calculations imply that the LRiw response variable exhibits the greatest degree of sensitivity to the LR input parameter, and the least degree of sensitivity to the Fctw input parameter, etc.

In general, a basic sensitivity analysis can be used to formally address three issues. First, it ranks the degree of sensitivity (of the response variable) to each input variable. Second, it quantifies the percent change in the response variable output value to the expected full range of deviation in each input parameter. Third, the response variable output values can additionally be used to determine if an *increase* in the input parameter level results in a corresponding *increase* or *decrease* in the response output. (In the LR input parameter example, an increase in this parameter resulted in a corresponding increase in the LRiw response output.) Note that the sensitivity analyses presented in this report are used to address all three of these issues.

2.2 Calculating the % variability in the response variable induced by sequential changes across all input parameters.

The basic sensitivity analysis technique described above supplies important information. However, in addition to quantifying the sensitivity (of the response

variable), it is also generally desirable to quantify the percent variation in the response variable induced by sequential changes across all relevant input variables. The most direct way to estimate such variation is via use of a statistical modeling technique referred to as an Analysis of Variance (ANOVA) model.

This modeling process works as follows. First, all possible combinations of the five input parameters are generated and used to calculate a data set of response variable output levels. In this study, note that there are 243 (3^5) possible combinations of minimum, mid-point, and maximum input parameter levels, respectively. Next, the output data associated with each response variable is modeled using the following first-order ANOVA model:

$$y = \mu + \alpha_i + \gamma_j + \delta_k + \lambda_s + \pi_t + \varepsilon$$

where y represents the calculated response variable data, μ represents the overall mean response variable level, ε represents an error term, and α_i, γ_j, δ_k, λ_s, and π_t represent empirical (model) parameters that quantify the effects of the five theoretical input parameters at levels $i, j, k, s, t = 1$, 2, and 3 (i.e., the minimum, mid-point, and maximum input levels, respectively). Provided the theoretical input levels used in the analysis are orthogonal (i.e., jointly uncorrelated, which they are in this study), the results from this ANOVA model can be used to quantify the observed variation in the response variable and partition it across the various input parameters.

More specifically, the above ANOVA model represents an additive, first-order approximation to the true (typically non-linear) mathematical equations that define each response variable. As such, the partial sum of squares associated with each fitted ANOVA model parameter represent the proportion of response variation explained by each theoretical input parameter (for example, refer to Myers, 1986, section 3.4 for an equivalent example using a linear regression model). Of course, since the ANOVA model is only an approximation to the true non-linear equation, less than a perfect 100 % of the response variation will be explained (the unexplained portion of variation is, by default, associated with the ε error term). However, if the ANOVA model provides for a good approximation then this unexplained (error) component will be minimal. In such a situation, the estimated proportion of response variation explained by each theoretical input parameter will represent an accurate approximation to the true amount of variation attributable to each input parameter.

An example will help clarify this technique. Consider the LRiw response variable once again. The ANOVA model fit to all 243 LRiw response variable output values produces the following sum of squares (SS) estimates:

Total SS (corrected for mean):	0.22651
SS explained by the ANOVA model:	0.22352

Partial SS attributed to each input parameter:	LR:	0.19619
	Ftw:	0.02523
	Fctw:	0.00210
	Vet:	0.00000
	Fu:	0.00000

First, note that the proportion of explained variability (i.e., the model R^2 value) is defined as the ratio of the SS explained by the model to the total SS. In the above example this value is (0.22352 / 0.22651) = 0.9868. Hence, the ANOVA model explains about 98.7 % of the total observed variability in the LRiw response data, and thus the approximation is highly accurate. Second, note that the sum of the partial SS (attributed to each theoretical input parameter) add up to the SS explained by the model. Thus, these partial SS estimates "partition" the explained variation; i.e., they can be used to determine exactly how much variation (in the response output) is caused by each input parameter. For example, since 100(0.19619 / 0.22651) = 86.6 %, we can infer that 86.6 % of the observed variation in the LRiw response data is due to (i.e., caused by) changing the LR input parameter (from 0.08 to 0.16). Likewise, a little over 11 % of the observed variation in the LRiw response data is due to (i.e., caused by) changing the Ftw input parameter (from 0.02 to 0.18). Hence, we can conclude that (1) the LR parameter "dominates" the LRiw equation (since about 87 % of the observed LRiw variation can be attributed to this input parameter), (2) the Ftw input parameter exhibits significantly less influence (about 11 %, etc.), and (3) the Fctw input parameter is associated with only a trivial amount of explained variation.

In this report, the above mentioned ANOVA modeling technique is used to compliment the sensitivity analysis results. Specifically, the amount of observed variation in the calculated response variable data that is attributable to each input parameter has been determined using the partial sum of squares estimates (produced by each ANOVA model). These SS calculations estimate the amount of *explainable variation* in the response variable *associated with* each theoretical input parameter. In turn, such estimates are used to directly quantify how important each input parameter is with respect to inducing variation in the response variable output data.

3.0 Sensitivity Analysis: Results

The pertinent sensitivity analysis details associated with each of the nine response variables are presented in this section.

3.1 LRiw

The sensitivity analysis results for the LRiw response variable are shown in Table 1. As indicated in Table 1, LRiw is a function of three input parameters: LR, Ftw, and Fctw. The sequential parameter results show that the largest change in LRiw (66.67 %) is caused by changing the LR input parameter from 0.08 to 0.16. A 23.91 % change is

caused when the Ftw input parameter is varied from 0.02 to 0.18, and a 6.90 % change occurs when the Fctw input parameter is varied from 1.0 to 1.6. Note that the LRiw response variable decreases as the values of the latter two tail-water input parameters (Ftw and Fctw) increase. In contrast, the LRiw response variable increases as the value of the LR input parameter increases.

The associated ANOVA results suggest that the bulk of the observed variation in the LRiw response (86.62 %) can be attributed to changes in the LR input parameter. Nearly all of the remaining explained variation (11.14 %) can be attributed to changes in the Ftw input parameter. Note that changes in the Fctw parameter induce only a trivial amount of variation in the LRiw response. The overall R^2 value of 0.9868 suggests that the approximation of this first order ANOVA model (to the true nonlinear response function) is highly accurate.

3.2 LRinfw

The sensitivity analysis results for the LRinfw response variable are shown in Table 2. As indicated in Table 2, LRiw is a function of three input parameters: LR, Ftw, and Fctw. The sequential parameter results show that the largest change in LRinfw (66.67 %) is caused by changing the LR input parameter from 0.08 to 0.16. A 6.18 % change is caused when the Ftw input parameter is varied from 0.02 to 0.18, and a 6.90 % change occurs when the Fctw input parameter is varied from 1.0 to 1.6. Note that the LRinfw response variable decreases as the values of the latter two tail-water input parameters (Ftw and Fctw) increase. In contrast, the LRiw response variable increases as the value of the LR input parameter increases.

The associated ANOVA results suggest that almost all of the explained variation in the LRinfw response (97.25 %) can be attributed to changes in the LR input parameter. Note that changes in either the Ftw and/or Fctw parameters induce only trivial amounts of variation in the LRiw response. The overall R^2 value of 0.9925 suggests that the approximation of this first order ANOVA model is highly accurate.

3.3 RViw

The sensitivity analysis results for the RViw response variable are shown in Table 3. As indicated in Table 3, RViw is a function of all five input parameters: LR, Ftw, Fctw, Vet, and Fu. The sequential parameter results show that the largest change in RViw (36.43 %) is caused by changing the Fu input parameter from 0.70 to 1.00. The next two largest changes are induced by changing the Vet and Ftw parameters (20.00 % and 17.10 %), respectively. Additionally, a 8.76 % change occurs from varying the LR input parameter. Varying the Fctw input parameter results in only a trivial % change in the RViw response variable. Note that the RViw response variable decreases as the Fu input parameter value increases. In contrast, the RViw response variable increases as the values of the LR, Ftw, and Vet input parameters increase.

The associated ANOVA results suggest that the majority of the observed variation in the RViw response (62.03 %) can be attributed to changes in the Fu input parameter. Most of the remaining explained variation can be attributed to changes in the Ftw and Vet input parameters (13.99 % and 19.31 %, respectively). Note that changes in the LR input parameter induce only a minimal amount of variation in the RViw response (3.76 %), and that changes in the Fctw input parameter are barely even detectable. The overall R^2 value of 0.9904 again suggests that the approximation of this first order ANOVA model is highly accurate.

3.4 RVinfw

The sensitivity analysis results for the RVinfw response variable are shown in Table 4. As indicated in Table 4, RVinfw is a function of four input parameters: LR, Ftw, Fctw, and Vet. The sequential parameter results show that the largest change in RVinfw (20.00 %) is caused by changing the Vet input parameter from 90 to 110 %. The next largest change is induced by changing the LR parameter (8.76 %). Varying either the Ftw or Fctw input parameters results in only a trivial % change in the RVinfw response variable. Note that the RVinfw response variable increases as the values of the LR and Vet input parameters increase.

The associated ANOVA results suggest that the bulk of the observed variation in the RVinfw response (83.46 %) can be attributed to changes in the Vet input parameter. Nearly all of the remaining explained variation (15.95 %) can be attributed to changes in the LR input parameter. Note that changes in either the Ftw or Fctw parameters induce virtually no variation in the LRiw response. The overall R^2 value of 0.9975 again suggests that the approximation of this first order ANOVA model is highly accurate.

3.5 RVdw

The sensitivity analysis results for the RVdw response variable are shown in Table 5. As indicated in Table 5, RVinfw is a function of four input parameters: LR, Ftw, Fctw, and Vet. The sequential parameter results show that the largest change in RVdw (75.56 %) is caused by changing the LR input parameter from 0.08 to 0.16. The next largest change is induced by changing the Vet parameter (20.00 %). Varying either the Ftw or Fctw input parameters results in smaller % changes in the RVinfw response variable (6.99 % and 7.80 %, respectively). Note that the RVinfw response variable increases as the values of the LR and Vet input parameters increase, and decreases as the Ftw and Fctw input parameters increase.

The associated ANOVA results suggest that the dominant amount of observed variation in the RVinfw response (90.21 %) can be attributed to changes in the LR input parameter. The majority of the remaining explained variation (6.46 %) can be attributed to changes in the Vet input parameter. Note that changes in either the Ftw or Fctw parameters induce only trivial variation in the LRiw response (about 1% each). The overall R^2 value of 0.9858 once again suggests that the approximation of this first order ANOVA model is highly accurate.

3.6 BVtw

The sensitivity analysis results for the BVtw response variable are shown in Table 6. As indicated in Table 6, BVtw is a function of four input parameters: LR, Ftw, Fctw, and Vet. The sequential parameter results show that very large changes in BVtw are induced by varying the Fctw, Ftw, and LR input parameters. The largest change in BVtw (199.10 %) is caused by changing the Fctw input parameter from 1.0 to 1.6. Almost as large a change (178.26 %) is caused by changing the Ftw input parameter from 0.02 to 0.18. Changing the LR input parameter (from 0.08 to 0.16) also induces a large change (84.98 %) in the BVtw response variable. Changing the Vet input parameter by 20 % (from 90 % to 110 %) induces an equivalent 20% change in the BVtw response. Note that the BVtw response variable increases as all four of the input parameters increase.

The associated ANOVA results for this response variable need to be interpreted with caution. Note that the majority of the observed variation in the BVtw response is attributed to changes in the Ftw and Fctw input parameters (27.27 % and 37.78 %, respectively). Another 6.48 % can be attributed to changes in the LR input parameter, while only a trivial change is associated with the Vet input parameter. However, the overall R^2 value for this ANOVA model is only 0.7191. This implies that the ANOVA approximation (of this functional relationship) is not very good, since over 28 % of the observed variation is unexplained. This high amount of unexplained variation is a direct result of the highly nonlinear and complex (i.e., interactive) relationship between the BVtw response variable and LR, Ftw, and Fctw input parameters. Hence, these estimated % explained variation amounts may be unreliable.

3.7 TBVw

The sensitivity analysis results for the TBVw response variable are shown in Table 7. Although the TBVw equation appears rather complex, this variable actually reduces to a function of just two input parameters: LR and Vet. The sequential parameter results show that the largest change in TBVw (20.00 %) is caused by changing the Vet input parameter from 90 to 110 %. A corresponding 9.11 % change is caused when the LR input parameter is varied from 0.08 to 0.16. Note that the TBVw response variable increases as both of these input parameter increase.

The associated ANOVA results suggest that the bulk of the observed variation in the LRiw response (82.75 %) can be attributed to changes in the Vet input parameter. All of the remaining explained variation (17.14 %) can be attributed to changes in the LR input parameter. The overall R^2 value of 0.9989 suggests that the approximation of this first order ANOVA model to the true nonlinear response function is almost perfect.

3.8 NBVw

The sensitivity analysis results for the NBVw response variable are shown in Table 8. As indicated in Table 8, NBVw is a function of all five input parameters: LR, Ftw, Fctw, Vet, and Fu. The sequential parameter results show that by far the largest change in NBVw (157.34 %) is caused by changing the Fu input parameter from 0.70 to 1.00. The next two largest changes are induced by changing the Ftw and Vet parameters (73.84 % and 20.00 %, respectively). Additionally, a 7.62 % change occurs from varying the LR input parameter, and a 3.91 % change occurs from varying the Fctw input parameter. Note that the NBVw response variable decreases as the Fu and Fctw input parameters value increase. In contrast, the NBVw response variable increases as the values of the LR, Ftw, and Vet input parameters increase.

The associated ANOVA results suggest that the bulk of the observed variation in the NBVw response (79.13 %) can be attributed to changes in the Fu input parameter. Most of the remaining explained variation can be attributed to changes in the Ftw input parameter (17.84 %). Note that changes in the Vet input parameter induce only a minimal amount of variation in the NBVw response (1.55 %), and that changes in the LR and Fctw input parameters are barely even detectable. The overall R^2 value of 0.9881 again suggests that the approximation of this first order ANOVA model is highly accurate.

3.9 N

The sensitivity analysis results for the N response variable are shown in Table 9. As indicated in Table 9, N is a function of four input parameters: LR, Ftw, Fctw, and Fu. The sequential parameter results show that the largest change in N (36.43 %) is caused by changing the Fu input parameter from 0.70 to 1.00. The next largest changes are induced by changing the Ftw and LR parameters (17.10 % and 8.76 %, respectively). Varying the Fctw input parameter results in only a trivial % change in the RVinfw response variable. Note that the N response variable increases as the values of the LR and Ftw input parameters increase, and decreases as the Fu (and Fctw) input parameters increase.

The associated ANOVA results suggest that the bulk of the observed variation in the N response (77.38 %) can be attributed to changes in the Fu input parameter. Nearly all of the remaining explained variation (17.45 % and 4.58 %) can be attributed to changes in either the Ftw or LR input parameters, respectively. Note that changes in the Fctw parameter induce almost no detectable variation in the N response. The overall R^2 value of 0.9947 yet again suggests that the approximation of this first order ANOVA model is highly accurate.

4.0 Sensitivity Analysis: Discussion and Comments

Some brief comments that summarize the main statistical results discussed in section 3 are given below.

4.1 Leaching Rate Response Variables (LRiw and LRinfw)

Not surprisingly, the two leaching rate response variables are predominantly influenced by the input LR (theoretical leaching rate) parameter values. Note that the input LR values appear to have a stronger effect on the LRinfw response variable, since the effect of the Ftw parameter is less pronounced on this latter variable.

4.2 Required Volume Response Variables (RViw, RVinfw, and RVdw)

These three response variables exhibit dissimilar relationships to the five input parameters. The RViw variable is primarily influenced by the Fu input parameter, and exhibits secondary sensitivity to the Vet and Ftw input parameters. In contrast, the Fu input parameter has no effect at all on either the RVinfw or RVdw response variables (since it does not enter into either functional relationship). The RVinfw variable seems to be mostly influenced by the Vet input parameter, and to a lesser extent the LR parameter. However, the RVdw response variable shows by far the greatest sensitivity to the LR input parameter, and (proportionally) far less sensitivity to Vet.

4.3 Beneficial Volume Response Variables (BVtw and TBVw)

Perhaps not surprisingly, the BVtw and TBVw response variables also exhibit dissimilar relationships to the five input parameters. The BVtw variable is extremely sensitive to the Fctw and Ftw input values, and also very sensitive to changing LR input levels. In contrast, the TBVw response variable is mostly influenced by the input Vet parameter values.

It is interesting to note that the Ftw and Fctw input parameters apparently cancel out of the TBVw functional relationship. (I would expect that this can be shown algebraically, although I have not tried to do so.)

4.4 Excess Water Load Variables (NBVw and N)

Although the NBVw response variable exhibits far more sensitivity to the various input parameters in an absolute sense (than the N variable), on a relative (i.e., proportional) scale both variables exhibit distinctively similar patterns. Both variables exhibit the greatest sensitivity to the Fu input parameter, and to a lesser extent, Ftw. Additionally, both variables respond to these two input parameters in the same way; i.e., inversely to increasing Fu values and proportionately to increasing Ftw values.

4.5 Additional Comments concerning the Vet Input Parameter

Overall, the Vet input parameter enters into six of the nine functional response variable relationships; RViw, RVinfw, RVdw, BVtw, TBVw, and NBVw. In all six cases, a 20 % change in the Vet input parameter results in an equivalent 20 % change in the output response parameter. Hence, there is a direct (one-to-one) correspondence with respect to the induced sensitivity. However, there is *not* a corresponding consistent degree of induced variation in these respective response variables, since the changes in the remaining input parameters tend to induce proportionately dissimilar amounts of variation (into each variable). This is why the Vet parameter appears to explain the dominant amount of variation in the RVinfw, TBVw, and NBVw response variables, but not the RViw, RVdw, or BVtw variables.

4.6 Additional Comments concerning the BVtw Response Variable

As stated previously, the low ANOVA model R^2 value for the BVtw response data suggests that the calculated % explained variation amounts (associated with the input parameters for this variable) may be unreliable. In contrast, all of the other calculations appear to be highly reliable, since the R^2 values associated with the remaining eight ANOVA models always exceeded 0.98.

5.0 References

Myers, R. H. 1986. Classical and modern regression with applications. Duxbury press, Boston, MA.

Table 1. Sensitivity analysis results for the LRiw response variable.

Response Variable: LRiw

Basic Sensitivity Analysis

Controlling Input Variables: LR Ftw Fctw

Parameter Levels	Range	LRiw	% Change	
Midpoint	n/a	0.10440		
flux:LR	0.08	0.06960		
	0.16	0.13920	66.67 %	(+)
flux:Ftw	0.02	0.11688		
	0.18	0.09192	23.91 %	(-)
flux:Fctw	1.00	0.10800		
	1.60	0.10080	6.90 %	(-)
flux:Vet	90.00	0.10440		
	110.00	0.10440	0.00 %	
flux:Fu	0.70	0.10440		
	1.00	0.10440	0.00 %	

ANOVA Analysis: % Explained Variation

Model R-square: 0.9868

Parameter	% Explained Variation
LR	86.62 %
Ftw	11.14 %
Fctw	0.92 %
Unexplained	1.32 %

Table 2. Sensitivity analysis results for the LRinfw response variable.

Response Variable: LRinfw

Basic Sensitivity Analysis

Controlling Input Variables: LR Ftw Fctw

Parameter Levels	Range	LRinfw	% Change	
Midpoint	n/a	0.11600		
flux:LR	0.08	0.07733		
	0.16	0.15467	66.67 %	(+)
flux:Ftw	0.02	0.11927		
	0.18	0.11210	6.18 %	(-)
flux:Fctw	1.00	0.12000		
	1.60	0.11200	6.90 %	(-)
flux:Vet	90.00	0.11600		
	110.00	0.11600	0.00 %	
flux:Fu	0.70	0.11600		
	1.00	0.11600	0.00 %	

ANOVA Analysis: % Explained Variation

Model R-square: 0.9925

Parameter	% Explained Variation
LR	97.25 %
Ftw	0.84 %
Fctw	1.16 %
Unexplained	0.75 %

Table 3. Sensitivity analysis results for the RViw response variable.

Response Variable: RViw

Basic Sensitivity Analysis

Controlling Input Variables: LR Ftw Fctw Vet Fu

Parameter Levels	Range	RViw	% Change	
Midpoint	n/a	147.872		
flux:LR	0.08	141.675		
	0.16	154.636	8.76 %	(+)
flux:Ftw	0.02	136.304		
	0.18	161.585	17.10 %	(+)
flux:Fctw	1.00	148.544		
	1.60	147.206	0.90 %	(-)
flux:Vet	90.00	133.085		
	110.00	162.659	20.00 %	(+)
flux:Fu	0.70	179.559		
	1.00	125.691	36.43 %	(-)

ANOVA Analysis: % Explained Variation

Model R-square: 0.9904

Parameter	% Explained Variation
LR	3.76 %
Ftw	13.99 %
Fctw	0.05 %
Vet	19.31 %
Fu	62.03 %
Unexplained	0.96 %

Table 4. Sensitivity analysis results for the RVinfw response variable.

Response Variable: RVinfw

Basic Sensitivity Analysis

Controlling Input Variables: LR Ftw Fctw Vet

Parameter Levels	Range	RVinfw	% Change	
Midpoint	n/a	113.122		
flux:LR	0.08	108.382		
	0.16	118.297	8.76 %	(+)
flux:Ftw	0.02	113.542		
	0.18	112.625	0.81 %	(-)
flux:Fctw	1.00	113.636		
	1.60	112.613	0.90 %	(-)
flux:Vet	90.00	101.810		
	110.00	124.434	20.00 %	(+)
flux:Fu	0.70	113.122		
	1.00	113.122	0.00 %	

ANOVA Analysis: % Explained Variation

Model R-square: 0.9975

Parameter	% Explained Variation
LR	15.95 %
Ftw	0.14 %
Fctw	0.20 %
Vet	83.46 %
Unexplained	0.25 %

Table 5. Sensitivity analysis results for the RVdw response variable.

Response Variable: RVdw

Basic Sensitivity Analysis

Controlling Input Variables: LR Ftw Fctw Vet

Parameter Levels	Range	RVdw	% Change	
Midpoint	n/a	13.1222		
flux:LR	0.08	8.3815		
	0.16	18.2965	75.56 %	(+)
flux:Ftw	0.02	13.5416		
	0.18	12.6250	6.99 %	(-)
flux:Fctw	1.00	13.6364		
	1.60	12.6126	7.80 %	(-)
flux:Vet	90.00	11.8100		
	110.00	14.4344	20.00 %	(+)
flux:Fu	0.70	13.1222		
	1.00	13.1222	0.00 %	

ANOVA Analysis: % Explained Variation

Model R-square: 0.9858

Parameter	% Explained Variation
LR	90.21 %
Ftw	0.80 %
Fctw	1.11 %
Vet	6.46 %
Unexplained	1.42 %

Table 6. Sensitivity analysis results for the BVtw response variable.

Response Variable: BVtw

Basic Sensitivity Analysis

Controlling Input Variables: LR Ftw Fctw Vet

Parameter Levels	Range	BVtw	% Change	
Midpoint	n/a	0.51419		
flux:LR	0.08	0.31415		
	0.16	0.75109	84.98 %	(+)
flux:Ftw	0.02	0.09479		
	0.18	1.01138	178.26 %	(+)
flux:Fctw	1.00	0.00000		
	1.60	1.02375	199.10 %	(+)
flux:Vet	90.00	0.46277		
	110.00	0.56561	20.00 %	(+)
flux:Fu	0.70	0.51419		
	1.00	0.51419	0.00 %	

ANOVA Analysis: % Explained Variation

Model R-square: 0.7191

Parameter	% Explained Variation
LR	6.48 %
Ftw	27.27 %
Fctw	37.78 %
Vet	0.38 %
Unexplained	28.09 %

Note: BVtw response is highly non-linear and exhibits significant interaction between the LR, Ftw, and Fctw input variables.

Table 7. Sensitivity analysis results for the TBVw response variable.

Response Variable: TBVw

Basic Sensitivity Analysis

Controlling Input Variables: LR Vet

Parameter Levels	Range	TBVw	% Change	
Midpoint	n/a	113.636		
flux:LR	0.08	108.696		
	0.16	119.048	9.11 %	(+)
flux:Ftw	0.02	113.636		
	0.18	113.636	0.00 %	
flux:Fctw	1.00	113.636		
	1.60	113.636	0.00 %	
flux:Vet	90.00	102.273		
	110.00	125.000	20.00 %	(+)
flux:Fu	0.70	113.636		
	1.00	113.636	0.00 %	

ANOVA Analysis: % Explained Variation

Model R-square: 0.9989

Parameter	% Explained Variation
LR	17.14 %
Vet	82.75 %
Unexplained	0.11 %

Table 8. Sensitivity analysis results for the NBVw response variable.

Response Variable: NBVw

Basic Sensitivity Analysis

Controlling Input Variables: LR Ftw Fctw Vet Fu

Parameter Levels	Range	NBVw	% Change	
Midpoint	n/a	34.2358		
flux:LR	0.08	32.9795		
	0.16	35.5884	7.62 %	(+)
flux:Ftw	0.02	22.6680		
	0.18	47.9490	73.84 %	(+)
flux:Fctw	1.00	34.9079		
	1.60	33.5697	3.91 %	(-)
flux:Vet	90.00	30.8122		
	110.00	37.6593	20.00 %	(+)
flux:Fu	0.70	65.9226		
	1.00	12.0549	157.34 %	(-)

ANOVA Analysis: % Explained Variation

Model R-square: 0.9881

Parameter	% Explained Variation
LR	0.22 %
Ftw	17.84 %
Fctw	0.07 %
Vet	1.55 %
Fu	79.13 %
Unexplained	1.19 %

Table 9. Sensitivity analysis results for the N response variable.

Response Variable: N

Basic Sensitivity Analysis

Controlling Input Variables: LR Ftw Fctw Fu

Parameter Levels	Range	N	% Change	
Midpoint	n/a	1.47872		
flux:LR	0.08	1.41675		
	0.16	1.54636	8.76 %	(+)
flux:Ftw	0.02	1.36304		
	0.18	1.61585	17.10 %	(+)
flux:Fctw	1.00	1.48544		
	1.60	1.47206	0.90 %	(-)
flux:Vet	90.00	1.47872		
	110.00	1.47872	0.00 %	
flux:Fu	0.70	1.79559		
	1.00	1.25691	36.43 %	(-)

ANOVA Analysis: % Explained Variation

Model R-square: 0.9947

Parameter	% Explained Variation
LR	4.58 %
Ftw	17.45 %
Fctw	0.06 %
Fu	77.38 %
Unexplained	0.53 %