DISSERTATION

ECONOMIC ASSESSMENT OF WATER MANAGEMENT IN AGRICULTURE: MANAGING SALINITY AND WATERLOGGING IN THE ARKANSAS RIVER BASIN AND ENVIRONMENTAL WATER SHORTAGES IN THE PLATTE RIVER BASIN

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In partial fulfillment of the requirements

for the Degree of Doctor of Philosophy

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ABSTRACT OF DISSERTATION

ECONOMIC ASSESSMENT OF WATER MANAGEMENT IN AGRICULTURE: MANAGING SALINITY AND WATERLOGGING IN THE ARKANSAS RIVER BASIN AND ENVIRONMENTAL WATER SHORTAGES IN THE PLATTE RIVER BASIN

As irrigated agriculture becomes increasingly threatened by both water scarcity and degradation of land and water, the importance of appropriate water management becomes apparent. This dissertation consists of one essay examining the effects of water transfers from agriculture for improving threatened species habitat in the Platte River Basin and two essays addressing irrigation induced waterlogging and salinization in the Arkansas River Basin. Each essay integrates hydrologic modeling into the economic analysis to evaluate the effects of water management alternatives on agricultural production.

In the first essay, Discrete Sequential Stochastic Programming (DSSP) is coupled with a basin-wide hydrologic model to estimate the forgone agricultural value associated with water transfers for endangered species habitat restoration. The value of irrigation water in agriculture was estimated for five agriculturally distinct regions of the Platte River Basin. Irrigation water in the upper-most region of the basin was estimated to be of lowest value in agricultural production. Results indicate that although water transfers from agriculture that originate farther upstream result in less water yield at the habitat, they can be more cost effective.

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In the second essay, information about current agricultural practices, soil salinity levels, water table depths, and the response functions of crop yields to both waterlogging and soil salinity are used to estimate the current losses associated with waterlogging and salinization. The average forgone profit across the study area was estimated to be $4.3 million annually, or approximately $68/acre per year. This represents the potential of increasing profits by approximately 39% if the effects of waterlogging and soil salinity were removed.

The third essay evaluates several types of alternatives aimed at reducing the impact of waterlogging and soil salinization. The general approach taken is to estimate the costs of inputs required and the commensurate effects on agricultural productivity associated with the changes to soil salinity and water table depth. Each method evaluated was capable of increasing agricultural productivity; however, the associated costs were higher. Although the costs were higher than the direct benefits to agricultural production, significant reductions in salt load to the river were estimated to occur at relatively low costs to society.

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CHAPTER 1

OVERVIEW OF DISSERTATION

Introduction

As the world's population continues to increase, our dependence upon irrigated agriculture becomes more apparent. The total quantity of irrigated land worldwide has increased from approximately 99 million acres in 1900 to over 630 million in 1995 (Postel 1999). The increase in irrigated area and the ability of irrigated cropland to produce higher crop yields have been key factors in producing enough food supply for the world. Although irrigated agriculture accounts for only 17% of total cropland, it provides approximately 40% of the world's food supply (Serageldin 1995). As our dependence upon irrigated agriculture grows, it is becoming increasingly threatened by water scarcity and the degradation of land and water. Water scarcity is the single largest threat to global food production, and one out of every five acres of irrigated land is losing productivity as a result of spreading soil salinization (Postel 1999).

Irrigated agriculture in the United States is faced with the same situations as the rest of the world. In 1990, only 13.4% of the nation's cropland was irrigated, although it accounted for more than 31% of the total value of agricultural crops (Van der Leeden et al. 1990). In the western United States, water for irrigated agriculture is responsible for more than 85% of total water resource withdrawals (Frasier et al. 1999a; Taylor and

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Young 1995; Colby 1990; Gibbons 1987). As the largest water consumer, agriculture is often targeted to fulfill the needs of other competing uses.

As a result of increased urban demands, a significant amount of water is being transferred from agriculture to further urban expansion. Additionally, the desire to protect and maintain environmental water uses has exacerbated these water shortages and placed even more pressure upon irrigated agriculture. U.S. irrigated agriculture is not only faced with issues relating to water scarcity, but to degradation as well. Salt, the principal water pollutant in arid regions of the western U.S., is also threatening productivity (Tanji and Yaron 1994). Current estimates indicate that as much as 27% of the irrigated land in the United States suffers from high levels of salinity (Wichelns 1999; Ghassemi et al. 1995; Tanji 1990; Postel 1989). With the viability of irrigated agriculture in jeopardy, we must develop better methods for evaluating the impacts of both water scarcity and degradation and identify appropriate water management procedures for dealing with these problems.

Overview of Problems Addressed

Increased water scarcity and reduced productivity from degraded land and water are two of the most significant threats facing irrigated agriculture. This dissertation consists of three essays analyzing both of these quantity and quality issues as they relate to irrigation water management in the Platte and Arkansas River Basins. The first essay addresses the problem of increased water scarcity by evaluating alternatives for dealing with environmental water shortages in the Platte River Basin. The second and third

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essays address degradation of irrigated agriculture by examining irrigation induced waterlogging and soil salinization within the Arkansas River Basin.

Environmental Water Shortages in the Platte River Basin

The Platte River Basin supports four species that are listed as threatened or endangered under the Endangered Species Act (ESA) of 1973. The whooping crane (*Grus americana*), interior least tern (*Sterna antillarum athalassos*), and pallid surgeon (*Scaphirhynchus albus*) are all federally listed as endangered, while the piping plover (*Charadrius melodus*) is federally listed as threatened. Over time, habitat for each of these species has been degraded as a result of reduced river flows and altered timing of river flows. In 1978, a 56-mile long section of the Central Platte River was designated as critical habitat for the whooping crane.

To comply with the ESA mandate for species recovery, it has been estimated that approximately 373,000 acre-feet of additional water must be made available annually to augment the current flows through the critical habitat (U.S. Fish and Wildlife Service 1997). This water shortage represents approximately 10% of the total consumptive use of irrigated agriculture in the basin (U.S. Geological Survey 1995). Construction of new water storage and conveyance facilities to meet these environmental shortages is no longer feasible. Cost effective sites have already been developed (Turner and Perry 1997), and recent environmental concerns effectively prohibit new large-scale construction. In general, it would be less expensive to transfer water from agriculture than to develop new water supplies and the net value within household and industrial uses are seen to be five to ten times as high (Young 1984). As such, irrigated agriculture is likely to be targeted to meet these shortages.

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Although water transfers from current agricultural users in the Platte River Basin are expected to be a low cost alternative for meeting environmental water shortages, research is needed to quantify these costs and identify the best locations within irrigated agriculture to use. Determining the best location for a potential water transfer is critical for many reasons, two of which are as follows. First, since the value of water within agriculture will vary significantly across the basin, the cost of a potential water transfer will vary depending upon the location used. Second, the location of the water transfer will affect the timing and ability of water to make it downstream to the critical habitat when needed.

Given that the least-cost water supplies may be located in upstream irrigated agriculture, the complex hydrology (e.g. transit loss, return flows, etc.) associated with the water transfers must be considered when evaluating water being supplied to the critical habitat region. Therefore, the goal of identifying the least cost water source for improving endangered species habitat flows, takes upon two objectives: (1) estimating the foregone value of the water transferred from different regions of irrigated agriculture, and (2) a hydrologic evaluation of the water transfers, including the basin wide effects and the ability to supply water to the critical habitat reach. By combining economic and hydrologic modeling techniques to estimate the costs of effectively supplying water to offset critical habitat shortages, the least cost water source is identified.

Waterlogging and Salinization in the Arkansas River Basin

Waterlogging and salinization have threatened the sustainability of irrigated agriculture for centuries. Historical records have revealed that many ancient civilizations that relied upon irrigated agriculture have failed. The Sumerian civilization of ancient

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Mesopotamia declined as agricultural productivity began to decrease as a result of waterlogging and salinization (Hillel 2000; Tanji 1990). The same process responsible for the demise of ancient civilizations continues to plague irrigated areas today. It is estimated that worldwide crop productivity losses associated with salinity are approximately $11 billion annually and increasing (Ghassemi et al. 1995).

Farmland in the lower Arkansas River Basin of Colorado began to develop shallow saline water tables by the early part of the twentieth century (Miles 1977). Currently, the Arkansas River is one of the most saline rivers in the United States (Tanji 1990; Miles 1977). Average water table depths have risen one to four feet between 1969 and 1994 (Cain 1997) and in a recent survey of the region, 68% of producers stated that high salinity levels were a significant concern of theirs (Frasier et al. 1999b). As a result of increased salinity levels and waterlogging, agricultural productivity in the Arkansas River Basin is suffering.

Although there is anecdotal evidence identifying waterlogging and salinization as threats to the viability of irrigated agriculture in the Arkansas River Basin, no other studies have appropriately quantified the effects or evaluated potential solutions to address these problems. In this setting, two essays analyzing waterlogging and soil salinization along a study section of the lower Arkansas River Basin are presented. The objective of the first essay is to estimate the current agricultural losses that are occurring in the study area as a result of waterlogging and soil salinization. The second essay will evaluate a set of alternatives aimed at decreasing the effects of waterlogging and soil salinization. By achieving these two objectives, the effects of waterlogging and

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salinization will be revealed and the water management alternatives with the most potential will be identified.

Discussion

The overall objective of this dissertation is to develop and document the appropriate methods for combining hydrologic and economic analysis to identify solutions to water related problems. This is accomplished by examining two specific problems: environmental water shortages in the Platte River Basin, and irrigation-induced waterlogging and soil salinization in the Arkansas River Basin.

Although two different problems are addressed in this dissertation, each of the three essays presented have many common themes. First, they all integrate hydrologic modeling and economic analysis to evaluate the problems occurring in each basin. Second, each of the essays applies mathematical models developed using the General Algebraic Modeling System (GAMS) to estimate the impact of different water management alternatives upon irrigated crop production. Lastly, although the Platte and Arkansas River Basins are used as study areas to examine the two specific problems addressed, the methods developed and modeling techniques employed could be applied to other irrigated areas and related problems.

One of the primary contributions of this dissertation relates to the detailed multidisciplinary approach that was used to address the specific river basin problems. Often, when evaluating irrigation related problems that affect such large regions, the hydrologic effects associated with potential solutions are either, unknown, ignored, or simplified in order to conduct the economic evaluations. For this study, the detail of the

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hydrologic data that was available was greater than ever before as a result of sophisticated modeling efforts that have recently occurred in both the Platte and Arkansas River Basins. Given this new level of hydrologic data availability, new methods needed to be developed in order to use this detailed data to improve the economic analysis. In the two different applications presented in this dissertation, the level of detail from the hydrologic analysis has been captured in the economic models that were developed. By preserving this level of detail, the economic analysis in this dissertation is able to account for detailed aspects of both problems that have never been addressed before.

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CHAPTER 2

EVALUATING WATER TRANSFERS FROM IRRIGATED AGRICULTURE FOR IMPROVING CRITICAL HABITAT IN THE PLATTE RIVER BASIN

Introduction

As water supplies become inadequate to meet all demands, the conflicts between different uses increase. Although population growth is responsible for many of these conflicts, it is the recent emergence of environmental demands that is having the greatest impact upon current water users (Michelsen and Taylor 1999). All of the major river basin systems in the West are faced with the challenges of integrating the water requirements of plant and animal species into their current water allocation schemes.

The Platte River Basin has four species listed as threatened or endangered under the Endangered Species Act (ESA) of 1973. The whooping crane (*Grus americana*), interior least tern (*Sterna antillarum athalassos*), and pallid surgeon (*Scaphirhynchus albus*) are all classified as endangered, while the piping plover (*Charadrius melodus*) is listed as threatened. Habitat for each of these species has been degraded as a result of reduced river flows and altered timing of river flows. 1978, a 56-mile long section of the Central Platte River was designated as critical habitat for the whooping crane. To comply with the ESA mandate for species recovery, an estimated 373,000 acre-feet of additional water must be made available annually to augment the current flows through the critical habitat (U.S. Fish and Wildlife Service 1997). This represents approximately

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10% of the total consumptive use of irrigated agriculture in the basin (U.S. Geological Survey 1995).

Both the North and South Platte Rivers originate in the Rocky Mountains of Colorado. The North Platte River flows north from Colorado, through Wyoming and then eastward into Nebraska. The South Platte River flows northeast through Denver, Colorado and continues towards the town of North Platte, Nebraska where the two rivers converge. The critical habitat is located along the central Platte River between the towns of Lexington and Shelton, Nebraska (Figure 2.1).

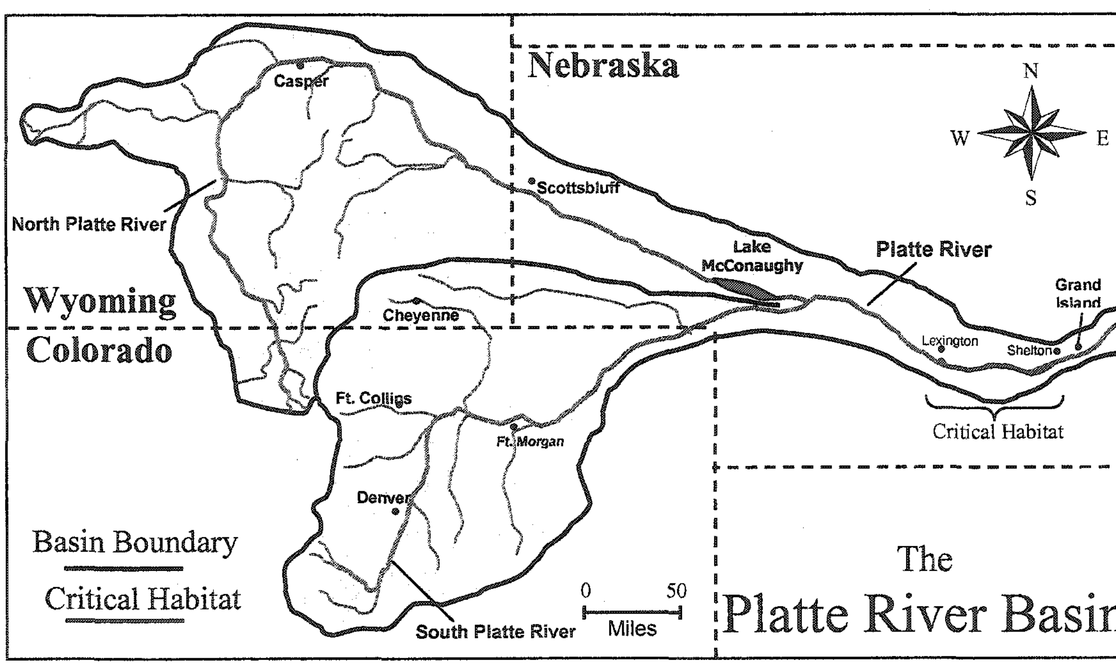

Figure 2.1: The Platte River Basin with 56-mile Critical Habitat Identified.

In 1997, Colorado, Wyoming, and Nebraska entered into a cooperative agreement with the United States Secretary of the Interior to develop and execute an incremental, adaptive management program that would increase stream flows to aid threatened and endangered species recovery. The program will be implemented in stages, with the goal of the first phase (10-13 years) to decrease water shortages by a minimum of 130,000

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acre-feet per year. 70,000 acre-feet will be provided from water projects that will not supply any additional water to the river, but will allow water to be stored and then released when additional flows are needed. The remaining quantity of water needed for this first phase has not yet been identified (Platte River Endangered Species Partnership 2003).

Construction of new water storage and conveyance facilities to meet these environmental demands is no longer feasible. Cost effective sites have already been developed (Turner and Perry 1997), and recent environmental concerns effectively prohibit new large-scale construction. Water transfers from current users appear to be the lowest cost alternative to meet these emerging higher valued water demands (Vaux and Howitt 1984; Young 1984). Irrigated agriculture, being the largest water user and relatively low-valued at the margin, is likely to be targeted first.

Water transfers from agriculture have historically been analyzed as a solution to water shortages. Over 40 years ago, Hirshleifer et al. (1960) proposed transferring low-valued water from agriculture in California's Imperial Valley, as a cost-effective alternative to constructing the Northern California Feather River Project. Cummings (1974) analyzed inter-basin water transfers from a basin with plentiful supply to a basin where irrigation was depleting ground water supplies. In the framework of a regional trade model, Vaux and Howitt (1984) linked five demand and eight supply sectors in California and showed that over a forty-year planning period reallocation of water from existing agricultural uses would cost less than development of new supplies.

These research approaches have explicitly placed water allocation in a supply and demand framework. The conventional "planning requirements" method of water

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allocation used by most governmental agencies reflects a specific example of this framework. The planning requirements approach, first forecasts future water requirements (demand), then calculates the least-cost supplies to meet those projected requirements, and lastly prices the planned supplies to recover costs (Howitt and Lund 1999). Forecasted demand is assumed to be perfectly inelastic. Similarly, government mandates to comply with the Endangered Species Act (ESA) also represent a perfectly inelastic demand in spite of the value of water. When water is required for a specific use above all other uses, the problem of meeting environmental water requirements becomes that of identifying the least cost source to be used. In this chapter, an approach similar to the planning requirements method is used to find the least cost water supply for reducing environmental shortages in the Platte River Basin.

Across the Platte River Basin, which covers approximately 90,000 square miles and supports an estimated 1.9 million surface irrigated acres (Eisel and Aiken 1997), the value of water in agriculture is vastly different. Given that the least-cost water supplies may be located in upstream irrigated agriculture, the complex hydrology (e.g. transit loss, return flows, etc.) associated with the water transfers must be considered when evaluating water being supplied to the critical habitat region. Therefore, the goal of evaluating a set of water transfers from agriculture to endangered species habitat flows, takes upon two objectives: (1) estimating the foregone value of the water transferred from irrigated agriculture, and (2) a hydrologic evaluation of the water transfers, including the basin wide effects and the ability to supply water to the critical habitat reach. By comparing the costs of effectively supplying water to offset critical habitat shortages, the least cost sources can be identified.

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Approach

The allocation of water within all river basins in the United States has developed under a system of water rights. In the western U.S. this system is dominated by the Prior Appropriation Doctrine, which allocates water according to the initial date of water use. Using an allocation system that grants priority based upon the date of water development instead of the value of water use is unlikely to have resulted in an initial allocation that achieves economic efficiency. Although the Prior Appropriation Doctrine allows for voluntary water transfers to occur, market failures and transaction costs can obstruct the flow of water from current low valued uses to higher valued uses in order to achieve economic efficiency. Specifically, it is unlikely that the current system will provide adequate water supply to maintain endangered species requirements (public good). Given that the current allocation may not achieve economic efficiency, it is useful to understand how reallocation of water from low valued uses to higher valued uses can be used to improve allocation efficiency.

An economic efficient allocation of water will occur when the distribution maximizes social welfare. An approach that is often used to approximate the maximization of social welfare is to maximize the present value of total net benefits (PVTNB). Mathematically, the problem of maximizing the PVTNB associated with water use can be seen in equation 2.1.

$$PVTNB = \sum_{u=1}^{U} \sum_{t=0}^{T} \frac{B_{ut}(w_{ut}, \theta_{ut}) - C_{ut}(w_{ut}, \delta_{ut})}{(1+r)^t} \qquad (2.1)$$

where the benefits (B) and costs (C) for each use (u) during each time period (t) is a function of the quantity of water used for that use in that time period (w_{ut}) and some

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additional set of parameters (either θ_{ut} or δ_{ut}). The net benefit in each time period for each use is then discounted using a discount rate (r).

If water supplies are limiting, equation 2.1 will be maximized when the allocation of water is such that the present value of marginal net benefits is equal across all uses for each time period (equimarginal principle). If it is not equal, then a transfer of water from a lower valued use and time period to a higher valued use and time period will increase the present value of total net benefits and should improve social welfare. This is the case when water is needed for preserving endangered species habitat.

The ESA gives federal agencies the authority to protect river flows in order to preserve endangered species habitat. A recent example of this occurred in 2001 when the U.S. Bureau of Reclamation restricted the quantity of water released for agriculture from Oregon's Klamath Project reservoirs in order to protect endangered fish. The reduction in agricultural diversions was made without regard to the value of the agricultural land that lost their water supplies and was estimated to have cost approximately $33 million (Jaeger 2003). By granting these environmental uses priority in times of shortage, the laws appear to indicate that the marginal net benefit of water is higher for protecting endangered species than for other uses. As such, any transfer of water from a lower valued use to meet these environmental requirements would be expected to increase social welfare. However, the largest gain to social welfare should occur if the required flows are met at the lowest cost possible. In the case of Oregon's Klamath Project, Jaeger (2003) estimated that the costs of preserving water for endangered species could have been reduced by approximately 71% if the least valued agricultural lands would have been targeted.

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Research examining the value of water across multiple uses has indicated that agriculture, the largest consumptive water user, is typically the lowest valued use at the margin. In general, it would be less expensive to transfer water from agriculture than to develop new water supplies and the net value within household and industrial uses are seen to be five to ten times as high (Young 1984). Although agriculture is anticipated to be the lowest valued water source at the margin, the spatial variation in values across a particular basin can be significant. Therefore, the value of water in agriculture must be estimated across different regions of a basin in order to identify the lowest valued sources.

The limited ability of water markets to provide direct price observations necessitates the valuation of water using other techniques. Since irrigation water is an intermediate good used as an input in crop production, the value of water in agriculture will reflect its contribution to the production process. The method of residual imputation can be used to estimate the value of irrigation water as an agricultural input. Assuming appropriate prices are assigned to all of the inputs except water, the remainder of the total value of product will be imputed to the residual or remaining input of water (Young 1996). In the pure case of residual imputation, the total value of an input is revealed. However, it is often more important to estimate the value associated with an incremental change in water supply. This would be the case when looking to value an increment of water being transferred from agriculture. For this situation, a change in net income approach (CINI) would be more appropriate. The CINI approach reflects a slight variation from the pure residual approach, such that the change in producer's income is associated with an incremental change in the quantity of an input. This is the general

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approach recommended by the U.S. Water Resources Council (1983) for valuing the benefits of irrigation water.

An example of a mathematical programming model that uses a change in net income approach for estimating the value of irrigation water can be seen in the equations in 2.2.

$$
\text{(2.2)} \qquad \begin{aligned} & Max\ \Pi^0 = \sum_{k=1}^{K} \left[B_k(w_k, \theta_k) - c(w_k, \delta_k) \right] \\ & s.t. \quad \sum_{k=1}^{K} w_k \leq W^0 \end{aligned}
$$

In this model, net income (Π^0) is estimated as the difference between the benefits and costs associated with crop production. Both the benefits and costs are function of the quantity of water used by each crop (w_k), and an additional set of crop parameters. The objective function is subject to a constraint which limits the total quantity of water used to be less than or equal to the total quantity of water available (W^0). Once the net income (Π^0) is estimated under the current water supply (W^0), the model can be used to estimate a new level of profits (Π^1) associated with a new level of water supply (W^1). The difference between the two net income estimates (equation 2.3) reflects the value of the change in water supply (W^0-W^1).

$$
\text{(2.3)} \qquad \Pi^0 - \Pi^1 = CINI
$$

If the new quantity of water available for crop production occurred as a result of a water transfer, the change in net income would represent the value of the water that was transferred (or the cost associated with the transfer). This approach for estimating the costs of a water transfer could then be applied to different agricultural regions of a river basin to identify how the costs would vary spatially.

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The method that is used in this chapter to identify the lowest cost source of water for reducing environmental water shortages in the Platte River Basin follows the CINI approach described above, but is much more sophisticated and accounts for the hydrologic effects of each water transfer evaluated. Due to the complex interdependency between water users in a river system, a water transfer from one region may result in indirect effects upon other regions as well. Therefore, the effect that each water transfer had upon all regions of the basin was estimated simultaneously through the use of complex hydrologic models. Once the change in water supplies was known for all regions of the basin, a set of mathematical programming models using a CINI approach were used to estimate the direct and indirect costs of each water transfer. In addition, the quantity of water expected to be lost in transit and the timing of the flows that make it to the critical habitat are accounted for. Through this process, the least cost water source for effectively improving critical habitat flows is identified. By targeting water supplies from the lowest cost sources first; reductions in critical habitat shortages will be accomplished with the largest gain to social welfare.

Methods

The economic models developed in this chapter estimate the forgone agricultural value associated with water transfers from different agricultural regions of the Platte River Basin. To optimize crop and water decisions across multiple stages of a crop year, a Discrete Sequential Stochastic Programming (DSSP) model was developed for each of the regions using data unique to that area. The models are first used to identify the current economic conditions using the baseline monthly estimates of each regions

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agricultural diversion over a twenty-four year time period. The models are then used to estimate the forgone agricultural value associated with the impact that each water transfer has upon all of the regions agricultural diversions. Estimates of the agricultural diversion levels were estimated using a complex hydrologic model, which accounted for the basin wide effects (e.g. transit loss, return flows, etc.) of each water transfer. In addition, the hydrologic model estimates the ability of each water transfer to reduce critical habitat shortages. By integrating economic analysis and hydrologic modeling, the cost per acre-foot of water transferred and delivered to the critical habitat can be estimated and the least cost source of water identified.

DSSP Modeling Framework

Based upon producer and irrigation district employee interviews conducted in June 1999, the basin was segmented into five regions that have similar agricultural conditions (Figure 2.2).

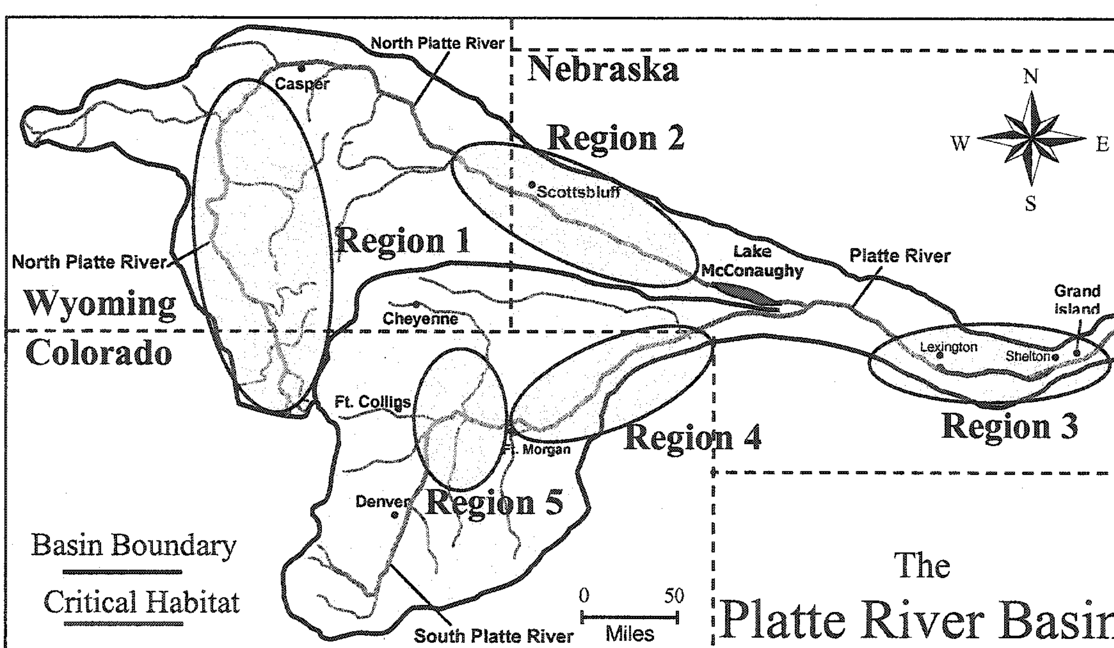

Figure 2.2: Five Agricultural Regions of the Platte River Basin.

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For each region, a 1,000 acre representative farm was constructed from survey and census farm data. The representative farm employed in each region varies in crops produced, crop yields, crop prices, cropping budgets, crop rotations, types of irrigation used, amount of irrigation water available, temporal variation of water supplies, precipitation and crop evapotranspiration requirements. Consequently, the value of water in agriculture varies across these regions due to land productivity and these other agricultural parameters.

Crop production is sequential in nature, where farm decisions are influenced by earlier decisions and information that becomes available only after earlier choices have been made (Anderson et al. 1977). Discrete Sequential Stochastic Programming (DSSP), developed by Cocks in 1968 to solve sequential decision problems under uncertainty, provides an appropriate framework to represent this problem. DSSP characterizes a situation where there is a sequence of decision making time periods, a set of decision variables for each stage, discrete probabilities for each state of nature and stage, and a structure that logically represents the flow of information through the stages of the decision process (Kaiser and Apland 1989).

The model in this study represents two sequential time periods in which irrigation water becomes available to the farm. Due to the natural variability of water supplies, the stochastic variable is identified as the quantity of irrigation water diverted in each region during these two time periods. To avoid potential dimensionality issues, Anderson et al. (1977) recommend limiting states of nature that are essentially continuous by approximating discrete distributions. Irrigation water available in the first and second

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time periods is limited to three states of nature: wet, average, or dry water conditions. Figure 2.3 illustrates the time periods and states of nature for this situation.

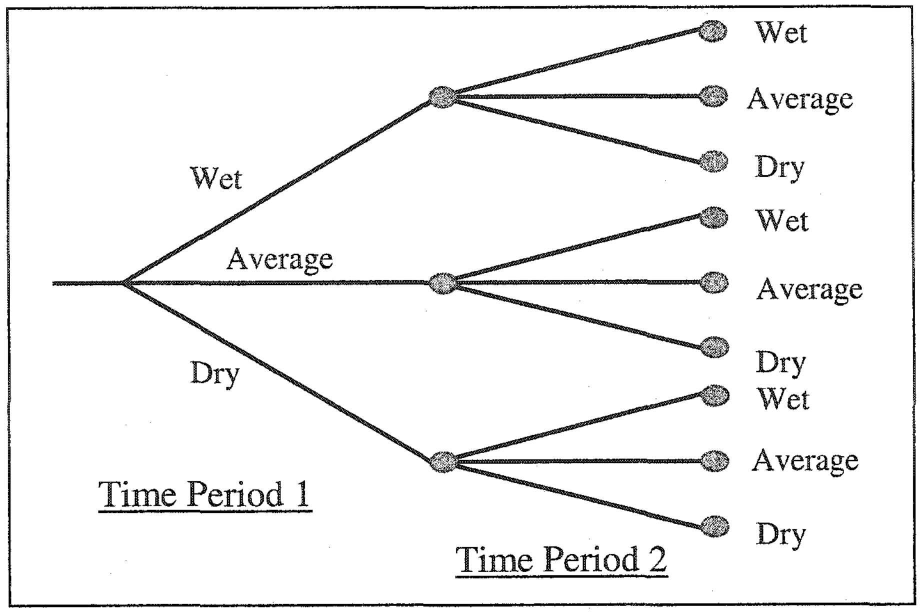

Figure 2.3: Structure of the Two Time Periods and Three States of Nature.

The first time period takes place from April 1st to June 30th. The decisions made in this stage are the allocation the farm's land planted to each crop and the optimal level of irrigation up to June 30th based upon the quantity of water diverted. The second stage decisions, begins July 1st and continues through the end of October. Irrigation water available in this period is allocated to the previously planted crops for the remainder of the growing season. The decisions made at this point will be the irrigation schedule that maximizes profits based on the crops that have been planted and the water supply available. Deficit irrigation is possible in either one or both of the time periods subject to the supply of water available.

Due to the two sequential stages in the model and the difference in crop response to water stress, crop yields will be affected differently depending upon the crop type,

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magnitude of water stress, and timing of water availability to the farm. The long run expected profitability will be determined for each representative region under the current baseline conditions and then compared to the estimated conditions after a specified water transfer alternative. Thus, allowing the foregone agricultural benefits associated with each of the water transfers from each of the five regions to be estimated.

The DSSP model identifies the optimal crop mix and optimal irrigation schedule based on the time period and state of nature by maximizing the total expected profit of the representative farm. The objective function maximizes total expected profit resulting from two sequential stages, subject to acreage, agronomic, water, and linkage constraints between the two time periods. Algebraically, the DSSP model that is estimated for each of the five regions can be represented as follows:

$$\text{Max } \Pi = \sum_{k=1}^{K}\sum_{i=1}^{I}\sum_{s1=1}^{3}\sum_{s2=1}^{3} \left[ACRE2_{k,i,s1,s2}\left(Y_{ki} * \left(P_k - HC_k\right) - NC_{ki}\right) - \left(I_{k,i,s1,s2} * Ic \right)\right] * P1_{s1} * P2_{s1,s2} \tag{2.4}$$

Subject to:

$$\begin{aligned} &\sum_{k=1}^{K}\sum_{i=1}^{I}\left[ACRE1_{k,i,s1} + I_{k,i,s1}\right] = L_{s1} \\ &\sum_{i=1}^{I} ACRE1_{k,i,s1} \le B_{k,s1} \\ &\sum_{k=1}^{K}\sum_{i=1}^{I}\left[ACRE1_{k,i,s1} * \left(Wreq1_{k,i} - R_1\right)\right] \le W1_{s1} \\ &\sum_{k=1}^{K}\sum_{i=1}^{I}\left[ACRE2_{k,i,s1,s2} * \left(Wreq2_{k,i} - R_2\right)\right] \le W2_{s1,s2} \\ &ACRE2_{k,i,s1,s2} \le ACRE1_{k,i,s1} \end{aligned} \tag{2.5}$$

where $ACRE2_{k,i,s1,s2}$ is the quantity of acres available for harvest in the second time period for each crop, *k,* across all irrigation schedules, i, and all possible states of nature *s1,s2* (*s1* = 1,2,3 ; *s2* = 1,2,3). The quantity of acres is multiplied by the crop yield (Y_{ki})

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and the difference between crop price (P_k) and the per unit cost of harvesting (HC_k) to get a per acre value of production that then has the per acre non-harvest costs subtracted (NC_{ki}). The cost of maintaining idle land reflects the quantity of idle land ($I_{k,i,s1,s2}$) multiplied by the cost of idle land (Ic) and is subtracted from the total value of all crop production. Finally, the expected returns, under each state of nature are weighted by the joint probability of its outcome ($P1_{s1} * P2_{s1,s2}$).

The objective is subject to five sets of constraints. The first set of constraints forces the total acreage planted in the first time period ($ACRE1_{k,i,s1}$) under each state of nature plus the quantity of idle land to be equal to the total land available (L_{s1}). In the second set of constraints, the parameter $B_{k,s1}$ represents the maximum rotational requirements for each of the crops under each state of nature. The third set of constraints limits the total quantity of water applied to all crops under all irrigation schedules in the first time period ($Wreq1_{k,i}$) minus the regions effective precipitation (R_1) to be less than or equal to the amount of water diverted given the state of nature ($W1_{s1}$). The fourth set of constraints require the total water applied to all crops in the second time period ($Wreq2_{k,i}$) less the regions effective precipitation (R_2) to be less than the total quantity of water available in the second time period ($W2_{s1,s2}$) under each state of nature. The last set of constraints link the acreage planted in the first period ($ACRE1_{k,i,s1}$) to the acres in the second time period ($ACRE2_{k,i,s1,s2}$). The model was developed and solved using the General Algebraic Modeling System (GAMS); an example of the written code can be seen in Appendix 2.1.

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DSSP Parameters

Most of the data was derived from secondary sources and validated through producer interviews conducted throughout the basin. Along with regional farm resource endowments the responsiveness of each crop to water stress was identified so that different levels of irrigation could be evaluated based upon water availability.

Regional Cropping Budgets

County level farm census data were used to estimate the proportion of the major irrigated crops produced on the representative farms. Crop budgets from each state's Cooperative Extension Service were used as a starting point to estimate area-specific costs of production. The accounting stance of the budgets in Nebraska and Colorado were not directly comparable and needed to be adjusted. Specifically, land costs, unpaid labor, management labor, and other fixed costs were adjusted to a comparable basis. For the Wyoming regions, cropping budgets from areas with similar characteristics in Colorado or Nebraska were adjusted to reflect the appropriate conditions (details of cropping costs in Appendix 2.2). The value used for crop sales reflects the state specific five-year average.

Irrigation and Water Demands

The constraints on water demand were constructed using the evapotranspiration (ET) requirements for each crop in each region. The quantity of water applied in each area was adjusted using region-specific average application efficiencies. In addition to irrigation water fulfilling these ET requirements, the average effective precipitation during the growing season for each region was included. Historical average rainfalls for

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each region were adjusted using effective precipitation equations to identify the portion of rainfall available for crop use.

The distribution of water availability was developed based upon historic agricultural diversions for each region. Due to the lack of metered agricultural diversions in Region 1, the distribution of water supply was based upon historic river flows. This region is characterized by lack of water storage, therefore, variability of river flows will drive the variability of agricultural diversions for the region.

Agricultural diversions and stream flows were estimated under baseline conditions and for each of the water transfer alternatives using a hydrologic model formulated in MODSIM. MODSIM is a generalized river basin network model that uses advanced network optimization algorithms for simultaneously assuring that water is allocated according to physical, hydrological, and institutional aspects of river basin management, including water rights and interstate compact agreements. The hydrologic model estimates the timing and magnitude of impacts on river flows and agricultural diversions associated with water transfers from each region. (For a complete description of MODSIM see Labadie 1994). The diversion estimates from MODSIM are used to develop the states of nature distribution in each time period that is incorporated into the DSSP model.

Crop-Water Production Functions and Crop Yield

The relationship between relative crop yield and relative evapotranspiration (ET) deficit can be described by a piecewise linear function for each growth stage of a crop (Doorenbos and Kassam 1979; Vaux and Pruitt 1983). Mathematically, the relationship can be stated as follows.

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$$1-\frac{Y_a}{Y_m}=K_y\left(1-\frac{ET_a}{ET_m}\right) \quad (2.6)$$

where one minus the ratio of actual yield (Y_a) to maximum yield (Y_m) reflects the relative yield decrease, and one minus the ratio of actual crop evapotranspiration (ET_a) to maximum evapotranspiration (ET_m) reflects the relative ET deficit. The magnitude of the crop yield response to water stress is quantified through the yield response factor (K_y). This factor can vary greatly depending upon the timing of the water stress, the general relationship for each growth period can be seen in Figure 2.4.

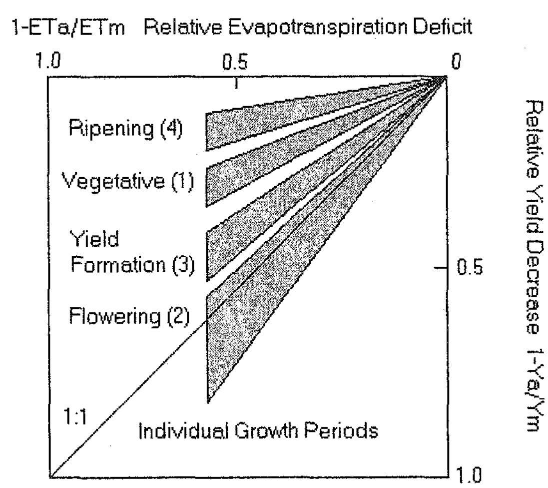

Figure 2.4: Relative Crop Yield as a Function of Relative Evapotranspiration Deficit.

Yield response factors below 1.0 indicate that the percentage of crop yield decrease will be less than the percentage of ET deficit. For example, an ET deficit of 40% for a crop with a yield response factor of .60 would only decrease crop yield by 24% (.4*.6=.24). The larger the value of the yield response factor the more sensitive to water stress.

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From the yield response factors identified by Doorenbos and Kassam (1979) for each growth-stage, average yield response factors that correspond to the first and second time periods being modeled were estimated (Table 2.1).

Table 2.1: Estimated Yield Response Factors (K_y) for the Early and Late Time Periods.

	Time Period 1 (April 1-June 30)	Time Period 2 (July 1-October 31)
Corn	0.40	0.64
Alfalfa	0.70	0.70
Sugarbeets	0.60	0.60
Drybeans	0.20	0.69
Wheat	0.20	0.54
Other Hay	0.70	0.70
Soybean	0.20	0.76

* Crop yield reduction equals the Ky value multiplied by the evapotranspiration deficit for each time period, estimated from Doorenbos and Kassam (1979).

Using these estimated yield response factors, the model allows for deficit irrigation of crops using seven different levels in the two time periods: 0% (no deficit), 10%, 20%, 30%, 40%, 50%, and 100% (total deficit); resulting in 49 (7^2=49) possible irrigation schedules for each crop in each region. Each of the irrigation schedules corresponds to a unique crop yield, irrigation cost, and water requirement. The forty-nine irrigation schedules for each crop were embedded into the model so that the most profitable activity could be selected based upon the quantity and timing of available water.

Hydrologic Model Parameters

The output from the hydrologic model was compiled into total monthly agriculture diversions over a twenty-four year time period for each of the five regions. This data set was then used to create the specific baseline water level conditions for each region and the conditions that resulted from each of the water transfer alternatives.

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The estimated monthly diversion levels were aggregated into early and late time periods so it would conform to the two time period economic model. Once the total early and total late diversion levels were estimated for all twenty-four years, the data set was used to estimate the temporal distribution of each region's water supply. The early and late time periods were broken up into three equally likely states of nature, identified as wet, average, or dry. The eight observations within each of the categories were then averaged to find an area specific quantity of water that was associated with each of the conditions. Once these thresholds were developed, the joint probabilities of all the possible outcomes were estimated.

The estimated total water diversions were then scaled to represent the average diversion associated with a representative 1,000 acres of farmland within each of the five regions. It was posited that a representative farm would receive "full water" when the year was wet in both time periods. After the wet water quantities were identified, the other states of nature were estimated based upon the percentage of total water that was diverted under each condition for the region.

Using the estimated water diversion levels associated with each water transfer alternative, the economic model estimated the producers' responses and the ultimate impact on expected profits. The individual farm impacts were then scaled up to represent the total impact on the region by calculating how many representative farms would be serviced by the total agricultural diversions in each of the regions.

Baseline Economic Conditions

Using the estimated baseline water diversions (Appendix 2.3), the expected economic condition for each region's 1,000-acre representative farm was estimated. The

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expected profit, crop acreage, average crop yields, and water availability was estimated for each region (detailed results reported in Appendix 2.4). The average expected return above operating costs ranged from approximately $25/acre in Region 1 to a high of $176/acre in Region 3.

Region 1 begins in the Rocky Mountains of northern Colorado and extends down river to south central Wyoming near Casper. The area is characterized by high elevation and short growing season, with crop production limited to low yielding flood irrigated alfalfa, mountain hays, and pasture. As a result of these characteristics it was expected to have relatively low returns. Region 3 is located along the Central Platte River along the critical habitat reach and is characterized by producing high yielding corn and soybean.

Given the estimated returns per acre, it may be anticipated that the marginal impacts associated with a water transfer from Region 1 would be lowest. However, since Region 1 is located farthest from the critical habitat reach and Region 3 is located closest, it is necessary to account for the ability of water acquired upstream to make its way to the critical habitat in order to offset shortages. These issues were addressed with the use of MODSIM, which estimated the effects of each alternative on all regions simultaneously, therefore accounting for the percentage of water transferred from agriculture to the amount actually received in the critical habitat to offset shortages.

Water Transfer Alternatives

A set of water transfer alternatives was selected to represent a range of institutional characteristics and locations of potential agricultural sources. By examining the quantitative impacts of this range of alternatives, the significance of location,

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alternative flow protection policies, use of an environmental storage account, and changes in consumptive use and diversion patterns can be explored.

While a range of alternatives for increasing instream flows are examined, no attempt is made to identify the globally optimal alternative for meeting specific flow, or target flow shortage reduction levels. Here the focus is on hydrologic and economic impacts of a discrete set of specified alternatives. In particular, water transfers are uniformly defined in terms of application changes totaling 10,000 acre-feet per year in each region. To provide for appropriate comparison between alternatives, hydrologic impacts at the critical habitat are used directly. Alternatives are ultimately evaluated in terms of the cost per unit reduction in target flow shortages at the critical habitat.

Overview of Alternatives

A total of 20 water transfer alternatives are considered, covering transfers from each of the five regions of the basin. For each region, a water rights transfer of 10,000 acre-feet annually is considered. A set of the most senior flow rights in each region is chosen because in virtually all conditions these water rights will be in priority. Transfers of up to 20% of these flow rights from any given ditch is allowed, and transfers are distributed as needed amongst several ditches to achieve the total annual reduction of 10,000 acre-feet. The timing of the water transfer is made in proportion to the historical pattern of irrigation diversions. For example, if May through September diversions have typically been in the ratio of 1:2:4:2:1, respectively, then water transfers would range from 4,000 acre-feet in July to only 1,000 acre-feet in both May and September.

The reduction in flow rights reduces diversions by a full 10,000 acre-feet in the target region, but results in a much smaller reduction in consumptive use. The typical

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ratio of the consumptive use reduction to the change in diversion is about 50%, resulting in an annual increase in available instream flow (some of which is diverted and used by junior appropriators) of about 5,000 acre-feet. The timing and availability of these flows at the critical habitat is not only a function of use by junior appropriators, but also of river losses, and the timing of return flows at both the original senior, and new junior uses.

In the representative alternatives considered for this study, water rights from existing consumptive uses may be protected to the downstream state line using an instream flow right, to storage in an environmental account in Lake McConaughy, to both, or may be left entirely unprotected. Use of the instream flow right reflects the re-assignment of the original priority date associated with the water being transferred to an enforceable instream flow right. By assigning the priority date to the instream flow, it effectively protects the water from junior appropriators to the downstream state line. Water can also be protected and retimed using basin storage facilities. The Central Nebraska Public Power District (Central) and the Nebraska Public Power District (NPPD) have five hydropower plants in the Platte River basin. In order to obtain new licenses for these hydropower plants in 1998, the Federal Energy Regulatory Commission (FERC) required the establishment of an environmental account in Lake McConaughy to address threatened and endangered species issues related to Central and NPPD operations. Lake McConaughy is located in Nebraska just upstream from the critical habitat area and can be used to store and retime river flows so they correspond to environmental demands. For each of the water transfer alternatives, the impact upon target flow shortages at the critical reach is quantified. The foregone economic benefits

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resulting from the reductions in consumptive water use are quantified for only the most favorable institutional conditions.

Hydrologic Evaluation of Alternatives

The hydrologic impacts of all 20 water transfer alternatives were quantified through the use of the hydrologic model. The most promising alternatives were identified by analyzing the ability of each to reduce instream flow shortages at the critical region (Grand Island, NE). For each water transfer alternative, the resulting instream flows at Grand Island, NE were compared to the baseline flow levels. In each case however, we are not only concerned with increased river flows, but also with the timing of those flows, and their availability to decrease critical habitat shortages. The "yield" of water in terms of the proportion of water transferred that is available to reduce critical habitat flow shortages is thus an essential component of the analysis. The yield per unit of water transferred from agriculture upstream was calculated by comparing the identified shortage with and without each alternative (Appendix 2.5 contains baseline flows, target flows, and estimated flows for all alternatives at Grand Island, NE). This process was repeated for all 24 years and averaged for each of the 20 alternatives. Table 2.2 describes the characteristics of each alternative examined and the average water yield that resulted, the alternative within each region that resulted in the largest yield per unit of water transferred was selected for continued economic analysis.

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Table 2.2: Characteristics and Average Water Yield for each Water Transfer Alternative Evaluated with the Hydrologic Model.

Region	State	Alternative Name	Instream Flow?[1]	Environ. Account?[2]	Avg. Yield Grand Island[3]	Alternative for Econ. Analysis[4]
1	WY	Region 1 WY Transfer A	n	n	0.0611	no
		Region 1 WY Transfer B	n	y	0.2898	no
		Region 1 WY Transfer C	y	n	0.0610	no
		Region 1 WY Transfer D	y	y	0.2898	**yes**
2	WY	Region 2 WY Transfer A	n	n	0.0506	no
		Region 2 WY Transfer B	n	y	0.4782	no
		Region 2 WY Transfer C	y	n	0.0492	no
		Region 2 WY Transfer D	y	y	0.4788	**yes**
2	NE	Region 2 NE Transfer A	n	n	0.0739	no
		Region 2 NE Transfer B	n	y	0.4146	**yes**
3	NE	Region 3 NE Transfer A	n	n	0.0500	no
		Region 3 NE Transfer B	n	y	0.4929	**yes**
4	CO	Region 4 CO Transfer A	n	n	-0.0364	no
		Region 4 CO Transfer B	n	y	0.4286	no
		Region 4 CO Transfer C	y	n	-0.0153	no
		Region 4 CO Transfer D	y	y	0.4293	**yes**
5	CO	Region 5 CO Transfer A	n	n	-0.0217	no
		Region 5 CO Transfer B	n	y	0.4083	no
		Region 5 CO Transfer C	y	n	-0.0029	no
		Region 5 CO Transfer D	y	y	0.4088	**yes**

1. State instream flow protects transferred water to state line for CO and WY.
2. Environ. account retimes water flows and protects water to Grand Island, NE.
3. Avg. yield at Grand Island reflects the average reduction in target flow shortages per unit of water diverted.
4. Indicates whether the alternative will be evaluated with the economic model.

The importance of utilizing an "environmental account" in storage facilities becomes apparent when evaluating the potential water yields. Without the use of an environmental account it is estimated that less than 8% of each acre-foot transferred would be available for offsetting shortages, regardless of the transfer location. This significance relates directly to the timing needs identified for habitat restoration. For transfers originating in Wyoming and Colorado, an instream flow right protecting the water to the Nebraska state line was found to increase the yield of water transfers and was also included for these regions.

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Results

The basin-wide agricultural impacts associated with the six water transfer alternatives identified above were estimated. The foregone agricultural benefits that occurred in each region reflect the basin wide changes in agricultural diversions that were estimated to occur as a result of each 10,000 acre-feet water transfer (detailed summary of estimated diversion levels in Appendix 2.3). Once the on farm impact associated with each water transfer is identified, the ability of the transfer to reduce critical habitat shortages is addressed. Ultimately, the average cost of reducing critical habitat shortages by one acre-foot is presented for each 10,000 acre-foot water transfer alternative and the least cost location is identified.

<u>Forgone Benefits of Water Transferred</u>

This section indicates how the value of water in agriculture varies across the five regions and the basin-wide effects of each water transfer alternative. At this point, the ability of the each water transfer to offset shortages in the critical habitat is not addressed. Regional and total foregone benefits in irrigated agriculture per acre-foot of water transferred as a result of each 10,000 acre-foot water transfer is shown in Table 2.3 (detailed economic output for each alternative in Appendix 2.4).

Table 2.3: Average Foregone Benefit in Each Region and in Total per acre-foot Transferred Under each 10,000 acre-foot Water Transfer.

	Region					
Alternative	1	2	3	4	5	Total
Region 1 WY Transfer D	6.01	0.00	3.71	0.00	0.00	$ 9.71
Region 2 WY Transfer D	0.00	16.16	9.93	0.00	0.00	$ 26.10
Region 2 NE Transfer B	0.00	16.80	4.00	0.00	0.00	$ 20.80
Region 3 NE Transfer B	0.00	0.00	87.26	0.00	0.00	$ 87.26
Region 4 CO Transfer D	0.00	0.00	15.26	42.79	-1.51	$ 56.54
Region 5 CO Transfer D	0.00	0.00	14.62	-5.74	26.72	$ 35.61

*Shaded values reflect the direct impacts occurring within the region specified for the alternative.

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As a result of the institutional characteristics and the inability to completely protect transferred water from other diverters, each water transfer alternative can result in a decrease or increase in agricultural diversions in other regions. This translates into negative or positive externality effects occurring within regions not specifically being targeted for a water transfer. Since each of the water transfer alternatives evaluated use an environmental account in Lake McConaughy to control the timing of flows and protect water to the habitat, all of the alternatives negatively impacted Region 3 (this region is downstream from Lake McConaughy). These negative impacts result from the inability of users within Nebraska to divert water that is now protected in an environmental account in Lake McConaughy. Transfers originating from Region 4 and Region 5 reflect the situation where the transferred water is not completely protected. In these cases, senior water right holders in each region were able to slightly increase their diversions due to the additional water in the river as a result of the other regions water transfer.

The total average foregone benefit per acre-foot transferred associated with each alternative ranges from $9.71 to $87.26/AF transferred. Transfers from Region 1 had the lowest total impacts of $9.71/AF. Therefore, transferring 10,000 acre-feet of water from Region 1, establishing an instream right to protect this water, and retiming and protecting the flows in Nebraska with an environmental account in Lake McConaughy resulted in an average direct loss of $6.01/AF within Region 1 and an external cost of $3.71/AF within Region 3. The direct losses in Region 1 are comparably smaller than those for all other regions. Crop production in Region 1 is limited to low yielding flood irrigated alfalfa, mountain hays, and pasture. Since these crops are relatively tolerant to water stress, the

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region only loses marginal quantities of hay production in order to reduce annual diversions. At $87.26/AF, the water transfer originating from Region 3 had the largest average foregone benefit. These impacts were relatively large due to the fact that Region 3 primarily produces high yielding corn and soybean instead lower valued crops like alfalfa. Thus, Region 3 was unable to sacrifice low valued crops and is faced with large yield losses of corn and soybean.

Foregone Benefits of Water Received at Habitat

It is the impact in terms of water received at the critical habitat to offset shortages that is of most concern. Using the average annual percentage yield in the critical reach, the costs imposed on each region and in total as a result of one additional acre-foot of water offsetting shortages in the critical reach was computed (Table 2.4).

Table 2.4: Average Foregone Benefit in each Region and in Total per acre-foot Reduction in Critical Habitat Shortages for each 10,000 acre-foot Water Transfer.

Alternative	Average % Yield in Critical Area	Region 1	2	3	4	5	Total
Region 1 WY Transfer D	0.2898	20.72	0.00	12.80	0.00	0.00	$ 33.52
Region 2 WY Transfer D	0.4788	0.00	33.76	20.75	0.00	0.00	$ 54.50
Region 2 NE Transfer B	0.4146	0.00	40.53	9.65	0.00	0.00	$ 50.18
Region 3 NE Transfer B	0.4929	0.00	0.00	177.03	0.00	0.00	$ 177.03
Region 4 CO Transfer D	0.4293	0.00	0.00	35.55	99.68	-3.52	$ 131.71
Region 5 CO Transfer D	0.4088	0.00	0.00	35.77	-14.03	65.37	$ 87.11

*Shaded values reflect the direct impacts occurring within the region specified for the alternative.

The total estimated losses associated with decreasing annual shortages by one acre-foot range from a low of $33.52 for a transfer from Region 1 to a high of $177.03 for a transfer originating within Region 3. Region 1 foregoes $20.72 of direct crop production to obtain one acre-foot of water to offset shortages at the critical habitat. This occurs because Region 1 diversions must be reduced by approximately three acre-feet to

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reduce shortages along the critical reach by one acre-foot. Total crop losses associated with a transfer from Region 1 must also account for the impacts that this alternative has within Region 3. Region 3 foregoes approximately $12.80 in crop production due to the Region 1 transfer for a total loss of $33.52 per acre-foot reduction in critical habitat shortages.

Conclusions

Water transfers from current agricultural users have the ability to increase instream flows for habitat restoration. Such water transfers are most beneficial when they are accompanied by an instream flow water right and managed through the use of an environmental account in a basin storage facility. Without the use of an environmental account, less than 8% of each acre-foot transferred would be available to offset shortages, regardless of the transfer location. Using an environmental account within the state of Nebraska resulted in all of the water transfer alternatives examined to negatively impact crop production within Region 3 (Central Nebraska).

Although water transfers that originate closer to the critical habitat yield a larger percentage of water to alleviate habitat shortages, these options do not have the lowest costs. A transfer from Region 3 had the highest water yield, but the increased water yield was not offset by the high costs on agriculture from this region. Even though a larger quantity of water would need to be transferred from upstream in Region 1 to accomplish the same reduction in shortages, this study shows that transfers from Region 1 will have lower costs.

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If a compensated water transfer originating from Region 1 with both an instream flow right and environmental account was to be used, it would require producers from Region 1to be compensated for their water losses. However, it has been shown that the use of an environmental account in Lake McConaughy would impose additional external costs on producers in Region 3. Even if the external costs on Region 3 producers was internalized into the Region 1 water transfer costs, targeting Region 1 remains the most cost effective location for a 10,000 acre-foot water transfer for critical habitat preservation.

Findings of this study indicate that the location of water sources and the resulting hydrology is essential for evaluating the economic impacts of water transfers. Sensitivity of the results to the presence or absence of an environmental account indicate that further research is warranted to evaluate alternative institutional arrangements to assure conveyance of transferred water. In addition, the costs associated with managing these institutional arrangements should be identified.

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CHAPTER 3

ASSESSING THE AGRICULTURAL IMPACTS OF IRRIGATION INDUCED WATERLOGGING AND SOIL SALINITY IN THE ARKANSAS BASIN

Introduction

As lands are continually used in irrigated crop production the salinity levels in the soil and water table tend to increase. Over time, if there is inadequate drainage, the depth to the water table will decrease and a saline shallow water table is likely to develop. When a saline shallow water table exists, crop production can suffer as a result of waterlogging and/or excess soil salinity. The primary effect of waterlogging on crop growth is from reduced soil aeration as a result of excess water. Reduced soil aeration around a crop's root zone results in decreased respiration and therefore reduces crop growth and yield (Evans and Fausey 1999; Wesseling 1974). In the presence of a saline shallow water table, salts often accumulate as a result of saline water that rises to the soil surface through capillary action (Wichelns 1999). Soil salinity negatively affects crop growth by increasing the osmotic potential of the soil solution (Jones and Marshall 1992). In general, increased osmotic potential in the soil solution decreases a crops ability to extract water and results in suppressed plant growth and decreased yield (Ayers and Westcot 1985).

Approximately 25-30% of irrigated lands in the United States have crop yields that are negatively affected by high soil salinity levels (Tanji 1990; Postel 1989;

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Ghassemi et al. 1995; Wichelns 1999). Estimates suggest that the worldwide crop production losses associated with salinity on irrigated lands are around $11 billion annually and increasing (Ghassemi et al. 1995). Although general estimates of the large-scale impacts associated with waterlogging and soil salinization have been examined, further research is necessary to better understand the extent of the problems within individual basins.

The lower Arkansas River Basin of Colorado has been continuously irrigated since the 1870's and began to develop high saline water tables by the early part of the twentieth century (Miles 1977). Currently, the Arkansas River is one of the most saline rivers in the United States (Tanji 1990; Miles 1977). In a recent survey of the region, 68% of producers stated that high salinity levels were a significant concern (Frasier et al. 1999). Although there is subjective evidence identifying waterlogging and soil salinity as threats to the viability of agriculture in the Arkansas River Basin, until recently there has not been adequate field data to appropriately quantify the phenomena. The objective of this paper is to estimate the economic impacts associated with waterlogging and soil salinization on irrigated agriculture along a section of the Lower Arkansas River of Colorado.

Since the magnitude of salinity and waterlogging effects are likely to vary across seasonal conditions, this research will present estimates of these impacts across a three year time period for which the physical conditions of the study area have been modeled. The general approach taken is to link a detailed hydrologic model, calibrated from extensive field data, to an economic model that evaluates productivity losses within the study region. The first step is to identify the relationships between crop yield and both

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soil salinity and waterlogging. Then, the current cropping patterns and costs within the region are specified. Ultimately the current field conditions will be identified from the hydrologic model, and a mathematical model will be used to estimate the associated economic impacts to agricultural production.

Review of Literature

Several studies have been published within the crop sciences literature examining the effects of either waterlogging or soil salinity on crop growth, however there is little research available describing the combined effects. In addition, few studies are available concerning the specific methods and techniques for quantifying the overall economic costs of salinity and waterlogging on agricultural production. Ghassemi et al. (1995) estimated the worldwide loss to farm income due to soil salinization in irrigated areas to exceed $11 billion a year. This figure was found by multiplying the estimated worldwide quantity of salt-affected land within irrigated agriculture of 112 million acres by a constant estimate of income loss of $101/acre, as identified by Dregne et al. (1991). Although this figure is often referenced, it does little more than indicate that significant losses are occurring. Additional research estimating the losses within specific regions of the world is limited, no other study identified has captured the total costs of both salinity and waterlogging in as much detail as this study.

Miles (1977) estimated the total losses associated with 200,000 acres of cropland within the Arkansas Basin that was being irrigated with highly saline water. These lands were identified as croplands being irrigated with Class C4 water, the U.S. Salinity Laboratory's highest classification for salinity hazard. The study identified a different

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crop distribution to occur within these highly saline areas. It was found that only 25% as much of these lands were planted in corn as compared to higher quality areas and that sorghum and alfalfa acreages were higher. It was estimated that the value lost associated with these altered crop distributions is approximately $10 million per year. In addition, when the potential increase in crop yield was accounted for, the total losses increased to approximately $30 million per year (~$150/acre). However, it was noted that these estimates may be higher than actual, given field observations and a review of regional crop production statistics.

Grieve et al. (1986) estimated the total economic losses resulting from waterlogging and soil salinization of lands used for dairying and winter cereal production within two irrigated areas of New South Wales, Australia. They found the total losses on approximately 161,000 acres of land used for winter cereals and dairy pasture to be approximately $9.2 million dollars, or approximately $57/acre. This study simply accounted for the estimated percentage of each district that was classified as waterlogged and applied a constant yield deficit to these areas to estimate the losses. One of the main limitations of this approach was that it failed to account for the degree of waterlogging on crop yield. The total quantity of land affected by soil salinity was estimated by extrapolation of survey data collected from the study area. Production loss coefficients were calculated by summing the various crop yield functions over the respective soil salinity frequency distributions. The study then utilized an additive relationship between the waterlogging and soil salinity impacts. They found that the losses from waterlogging significantly outweighed the losses from soil salinity. This research did not attempt to estimate the total agricultural impacts, instead it only focused upon the dairying and

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winter cereal industries. An additional limitation of the study is the disregard of how these losses would change from year to year.

Jones and Marshall (1992) used a similar approach to that of Grieve et al. (1986) to estimate the costs associated with waterlogging and soil salinization in the Benerembah irrigation district of New South Wales, Australia. In this study they also applied a constant yield reduction factor for all waterlogged soils, ignoring the magnitude of the phenomena. The quantity of waterlogged soils was again identified subjectively as a percentage of the total area. This approach also ignores how different crops will vary in their thresholds and responsiveness to waterlogging (land considered waterlogged for one crop may not be for another). Jones and Marshall expanded upon the work of Grieve et al. by including all of the primary crops produced, analyzed the problem over time, and allowed crop mixes to vary over time. They modeled the impacts over a thirty-year time period assuming that soil salinity levels would continue to increase at an average annual rate of .05 dS/m. This assumption oversimplifies the soil salinization process, ignoring distributional changes and other annual fluctuations. The study concluded that the annual reduction in net farm income associated with waterlogging and soil salinity across the region of approximately 84,720 acres to be $1.7 million (approx. $20/acre). Along with Grieve et al. (1986), both studies showed the losses from waterlogging to be significantly higher than those from soil salinity.

The research presented in this chapter will build upon these studies as a reflection of the extensive data collection and hydrologic modeling that is in underway in the Arkansas Valley. The approach that will be taken will not only allow for the combined effects of waterlogging and soil salinity, but will evaluate the magnitude of these effects

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upon every irrigated field within the study area. No other study identified has analyzed these types of regional problems by identifying the specific soil salinity and waterlogging effects occurring upon every irrigated field within the study area. Additionally, the impacts upon agricultural profitability will be analyzed across a three-year time period for which field data has been collected so that year-dependent variations will be revealed.

Description of Study Area

The Arkansas River originates in the Rocky Mountains near Leadville, Colorado at an elevation of over 14,000 feet. The river flows south and east through Colorado for approximately 360 miles, then enters the state of Kansas at an elevation of less than 3,400 feet (Miles 1977). The Arkansas River drains approximately 25,000 square miles of Colorado (approx. 25% of the state) and is the states largest river basin.

This research focuses upon a 38.5-mile reach of the lower Arkansas River consisting of approximately 65,000 acres of irrigated land. This section of the Arkansas Valley is located within Otero and Bent counties beginning at the town of Manzanola and extending down river past the city of La Junta. (Figure 3.1). The major irrigated crops that are produced in this region consist of alfalfa, beans, corn, grass, melons, onions, sorghum, and wheat (Farm Service Agency 1999-2001). Six major canal companies service the study area: Holbrook (1), Rocky Ford (2), Catlin (3), Otero (4), Rocky Ford Highline (5), and Fort Lyon (6). Although, the effects of waterlogging and soil salinity will be estimated for every irrigated field in the study area, they will be presented as summarized for the total acreage serviced by each canal and in total for each of the three years.

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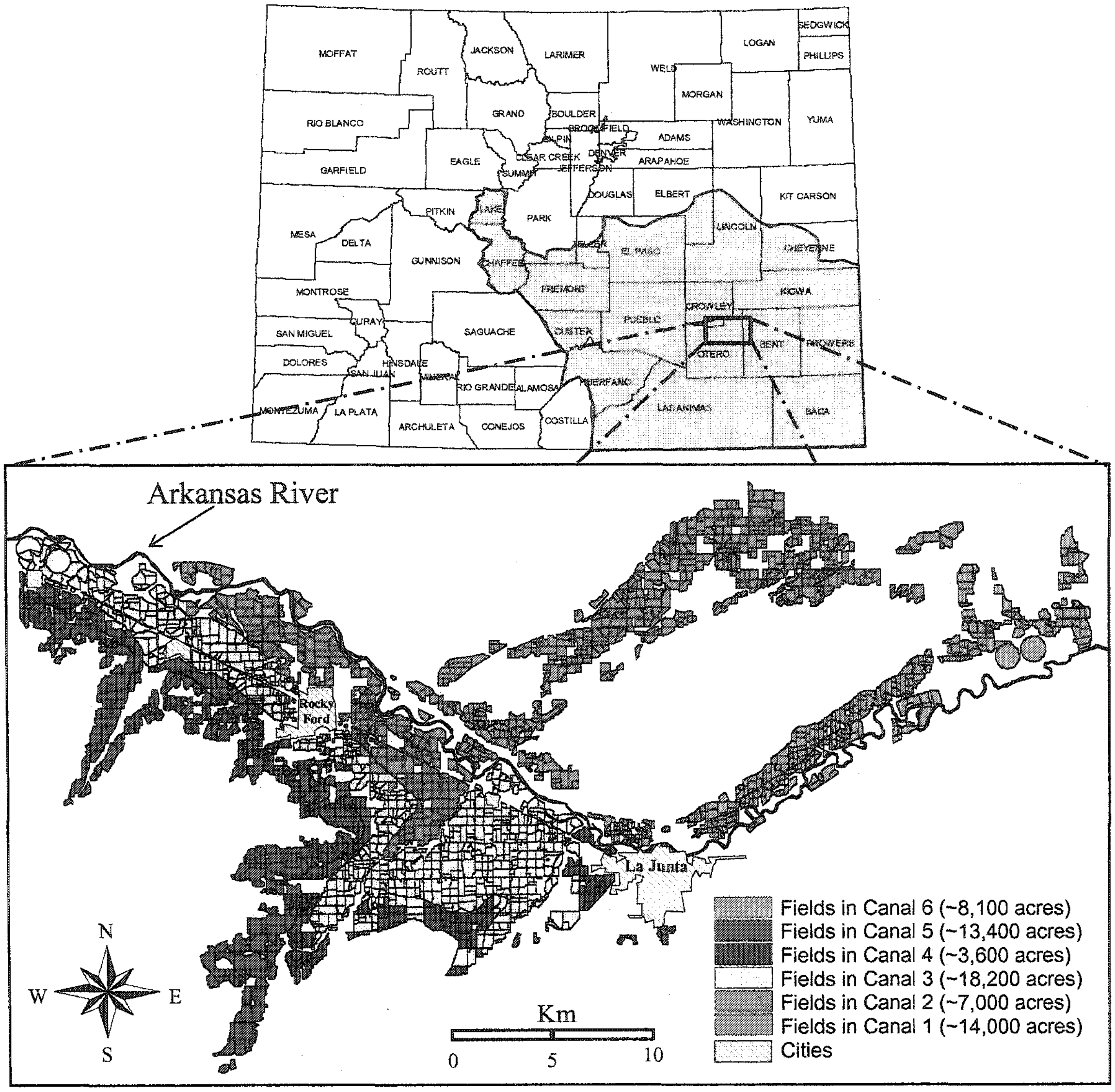

Figure 3.1: Map of Colorado Counties with Arkansas Basin Highlighted and Study Area Enlarged with Cities, River, and Irrigated Fields in each Canal Area Identified.

Soil Salinity Effects

The negative effect associated with soil salinization has been an issue of irrigated agriculture for centuries. A soil salinity problem exists when the build up of salts in a crops root zone is significant enough that a loss in crop yield results (Ayers and Westcot 1985). Although, waterlogged and saline soils are found naturally, in irrigated areas

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these salts typically originate from either a saline high water table or from salts in the applied water. The four primary reasons that irrigation causes salinization include seepage from poorly lined canals and reservoirs, excessive water application, inadequate provision of drainage, and inadequate application of water to leach away salts (Barrow 1991). As a result of excessive seepage and deep percolation from over irrigation, water enters the aquifer, typically saline, and decreases the water table depth. In general, when a water table is within approximately 2 meters of the soil surface, salts can rise to the surface through capillary action and render the land unsuitable for agricultural production (Wichelns 1999). In 1999, the study area had an average water table depth of only 2.1 meters below the surface, with approximately 25% of the region's water table depth to be less than 1.5 meters (Gates et al. 2002). These shallow water table depths are likely to be the significant cause of high soil salinity levels in the study area.

One of the most important relationships that must be understood to estimate the economic cost of salinity is the relationship between soil salinity levels and crop yield. The agricultural impacts associated with excess soil salinity levels will be derived from the corresponding decrease in crop yield. Additional plant symptoms associated with high salinity levels are similar in appearance to those of drought, such as wilting (Ayers and Westcot 1985). Many studies have been conducted to estimate the relationship between soil salinity levels and crop yield. Maas and Hoffman (1977) published an extensive review of the research examining these relationships. They concluded that in general crops will be unaffected by salinity up to a threshold at which time yield will begin to decrease linearly as soil salinity levels increase. Soil salinity is typically measured using the electrical conductivity of the soil extract (EC_e) and is reported in

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decisiemens per meter (dS/m). Maas (1986) presents a list of 84 crops identified into four qualitative groups according to their sensitivity to soil salinity (Figure 3.2).

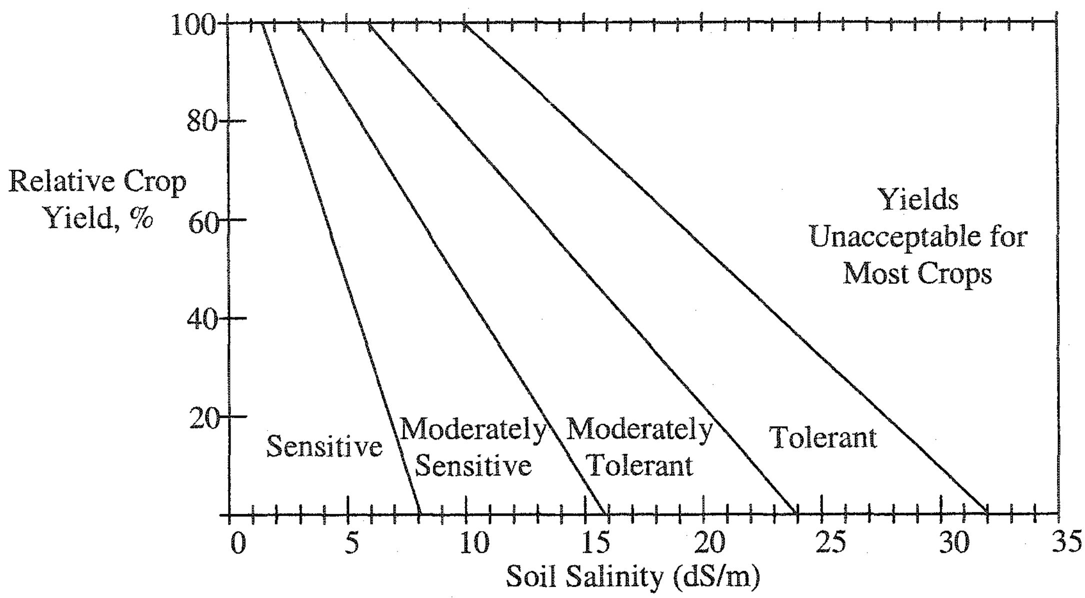

Figure 3.2: General Relationship Between Relative Crop Yield and Soil Salinity with Four Qualitative Divisions Identified for Classifying Crop Tolerance to Soil Salinity.

This type of two-piece linear relationship between relative crop yield (RY^S) and EC_e has provided reasonable good fits for crop yields (Tanji 1990). The estimated percentage of potential yields under soil salinities exceeding the threshold for each crop can be described mathematically as follows:

$$RY^S = 100 - b(EC - a) \qquad \text{for } EC \geq a \tag{3.1}$$

where, b is the slope of the yield salinity curve, EC is the electrical conductivity of the soil extract at root depth, and a is the salinity threshold level at which crop yields begin to be effected. The thresholds and slope parameters presented by Maas and Grattan (1999) are used in this study to reflect the responsiveness of the relevant crops to salinity stressing (Table 3.1).

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Table 3.1: Soil Salinity Ratings, Thresholds, and Slope Response Parameters.

	Rating	Threshold (*a*)	Slope (*b*)
ALFALFA	Moderately Sensitive	2.0	7.3
BEANS	Sensitive	1.0	19.0
CORN	Moderately Sensitive	1.7	12.0
GRASS	Moderately Sensitive	3.9	5.3
MELONS	Moderately Sensitive	1.0	8.4
ONION	Moderately Sensitive	1.0	8.0
SORGHUM	Moderately Tolerant	6.8	16.0
WHEAT	Moderately Tolerant	6.0	7.1

As can be seen in the table above, the response of different crops to soil salinity varies greatly. The most salinity sensitive crop in the study area is bean production, which is consistent with information collected from area producers who referred to beans as being the "indicator crop" for soil salinity.

Waterlogging Effects

Waterlogging of agricultural lands occurs when there is inadequate oxygen available in the crops root zone as a result of excess water. Reduced oxygen supplies to a crops root as a result of a shallow water table reduces nutrient uptake, crop growth, and yield (Wesseling 1974). In general, when a shallow water tables exists the yields of most crops can be related to the depth of the water table. For most crops there exists an "optimum" water table depth, at which aeration, moisture, and nutrients are such that crop yields can be maximized. When the water table rises above this threshold, crop yields begin to decline (Evans and Fausey 1999). The optimum water table depth will not only be a function of crop type, but will also be a function of other soil and climatic properties. Many studies have documented the negative effects of waterlogged soils on crop growth and yield. Williamson and Kriz (1970) presented a comprehensive review of

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the literature relating static (constant) non-saline water table depths to crop yield and included additional results from their own studies. Wesseling (1974) later compiled these findings and more recently Evans and Fausey (1999) have expanded upon these earlier studies. Table 3.2 reflects a summary of research results concerning the relevant crops in the study area, as presented by Evans and Fausey (1999) and adapted from Williamson and Kriz (1970). Although no data was available for the response of melons, personal communication with a local crop scientist suggested that the data for squash be used in its place since they are both in the *Cucurbitaceae* family. In addition, the table includes data on onion production from Harris, et al. (1962).

Table 3.2: Relative Crop Yield (%) at Varying Water Table Depths.

		Water Table Depth, cm								
Crop	Code*	15-20	30	40-50	60	75	80-90	100	120	150
Alfalfa	1 5	37	63	100	-	-	-	-	-	-
	2 5	-	-	49	-	-	-	90	-	100
Beans	3 1	-	-	79	84	-	90	-	94	100
Corn	4 3	45	55	67	70	-	100	-	-	-
	5 3	-	-	-	59	-	87	-	100	-
	6 3	20	31	-	67	-	67	-	100	-
Grass	7 4	51	100	-	-	-	-	-	-	-
Melon(Squash)	8 4	21	48	58	65	78	90	100	-	-
Onion	9 6	-	-	63	109	-	-	-	-	-
Sorghum	10 2	-	34	-	48	-	100	-	-	-
Wheat	11 3	-	-	-	91	-	100	-	-	-

*Code numbers refer to author and soil type respectively.
First Number: 1 = Rai, S.D., D.A. Miller, and C.N. Hittle (1971), 2 = Benz, L.C., E.J. Doering, and G.A. Reichman (1985), 3 = Van Hoorn, J.W. (1958), 4 = Goins, T.J. Lunin, and H.L. Worley (1966), 5 = Chaudhary, T.N., V.K. Bhatnagar, and S.S. Prihar (1975), 6 = Kalita, P.K., and R.S. Kanwar (1992), 7 = Gilbert, W.B., and D.S. Shamblee (1959), 8 = Williamson, R.E., and G.J.. Kriz (1970), 9 = Harris, C.R., H.T. Erickson, N.K. Ellis, and J.E. Larson (1962), 10 = Hiler, E.A., R.N. Clark, and L.J. Glass (1971), 11 = Chaudhary, T.N., V.K. Bhatnagar, and S.S. Prihar (1974).
Second Number: 1 = Clay, 2 = Clay Loam, 3 = Silty Clay Loam, 4 = Loam, 5 = Sandy Loam, 6 = Muck.

The soils within the study are primarily made up of silty clay loam surface layers and loam to sandy loam substrata (USDA 1972a, 1972b). For some crops there was no information available for the relevant soil type, in this case the next closest soil type was used. It can be seen that crops vary widely in their "optimum" water table depth and

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sensitivity. In addition, Table 3.2 only includes information concerning crop yield response under non-saline water table depths. It would not be appropriate to reflect the yield response to a saline shallow water table since the effects of salinization are already accounted for in the soil salinity responses.

In order to include estimates of the losses associated with waterlogging in this study, it was necessary to estimate the functional form explaining the relationship between crop yield and water table depth. After analyzing the data, it was found that a segmented linear relationship identifying a water table depth threshold and response coefficient for each crop would be appropriate. Gates and Grismer (1989) used a similar approach to explain the variation in cotton yield as a function of water table depth. To identify the crop specific thresholds and slope parameters, data from Table 3.2 was plotted and ordinary least squares regressions were estimated (Figure 3.3).

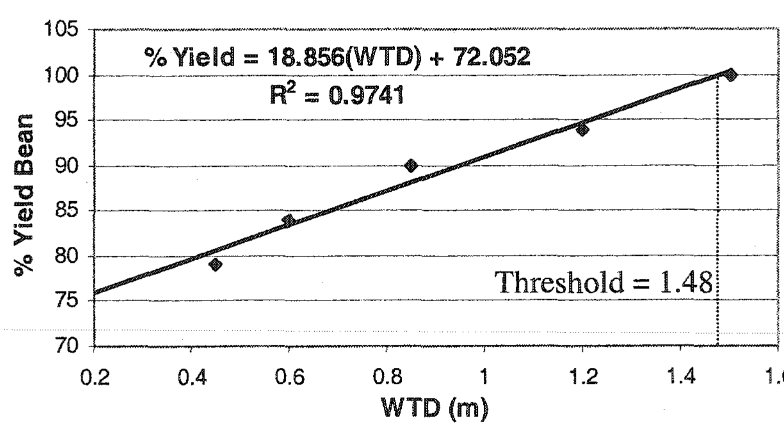

Figure 3.3: Relationship Between Relative Bean Yield and Depth of Water Table.

For some crops, there was more than one study available that identified the relationship between crop yield and water table depth. In these cases, the data sets were combined and the same regression techniques were used. This can be seen for corn in Figure 3.4, which uses the data from three separate studies.

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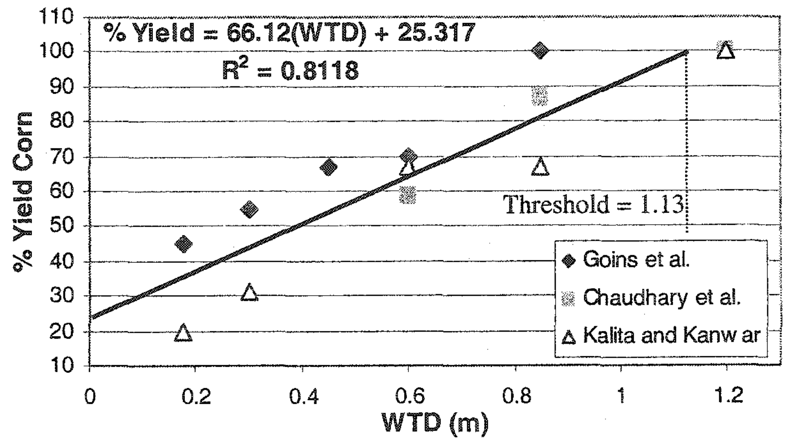

Figure 3.4: Relationship Between Relative Corn Yield and Depth of Water Table.

This segmented linear relationship can be shown mathematically in a similar manner as the relative yield concept for soil salinity. Where the relative yield as a result of water table depth (RY^{WTD}) can be shown as follows:

(3.2) $$RY^{WTD} = 100 - d(c - WT) \qquad \text{for } 0 \leq WT \leq c$$

Where, d is the slope of the waterlogging response curve, WT is the depth to water table, and c is the water table depth threshold level at which crop yields begin to be affected. The estimated thresholds and slope parameters for all of the relevant crops can be seen in Table 3.3.

Table 3.3: Estimated Values of Waterlogging Thresholds and Slope Parameters.

	Threshold (m)	Slope	P-Value of Slope Coefficient	R^2
ALFALFA	1.34	38	0.11339	0.505
BEANS	1.48	19	0.00178	0.974
CORN	1.13	66	0.00003	0.812
GRASS	0.30	392	0.00000	1.000
MELONS	1.00	84	0.00006	0.970
ONION	0.56	230	0.00000	1.000
SORGHUM	0.96	110	0.20431	0.901
WHEAT	0.85	36	0.00000	1.000

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Combined Effects of Soil Salinity and Waterlogging

Little or no field data has been analyzed in order to better understand the combined effects of both soil salinity and waterlogging on crop yields (Christopher and TeKrony 1982). However, most field observations describe the effects of soil salinity on crop production to be increased when waterlogging conditions are present (West and Taylor 1980). Kahlown and Azam (2002) also observed the combined effect of waterlogging and soil salinity to be more harmful to crop yields than the individual effect of waterlogging. Due to the complexity associated with these interactions only a few studies have tried to account for the relationship between these impacts, typically assuming the interaction to be additive (Grieve et al 1986) or multiplicative (Christopher and TeKrony 1982; Gates and Grismer 1989). This study will follow the method developed by Christopher and TeKrony (1982) and later applied by Gates and Grismer (1989). These studies related the total relative yield factor (*RY*) for each crop to be the product of the relative yield associated with soil salinity (RY^S) and the relative yield associated with waterlogging (RY^{WTD}) as follows:

$$RY = RY^S * RY^{WTD} \tag{3.3}$$

This multiplicative relationship of the combined effects of waterlogging and soil salinity can also be seen graphically in Figure 3.5, where the response of corn yield is depicted as a function of soil salinity at varying depths to water table.

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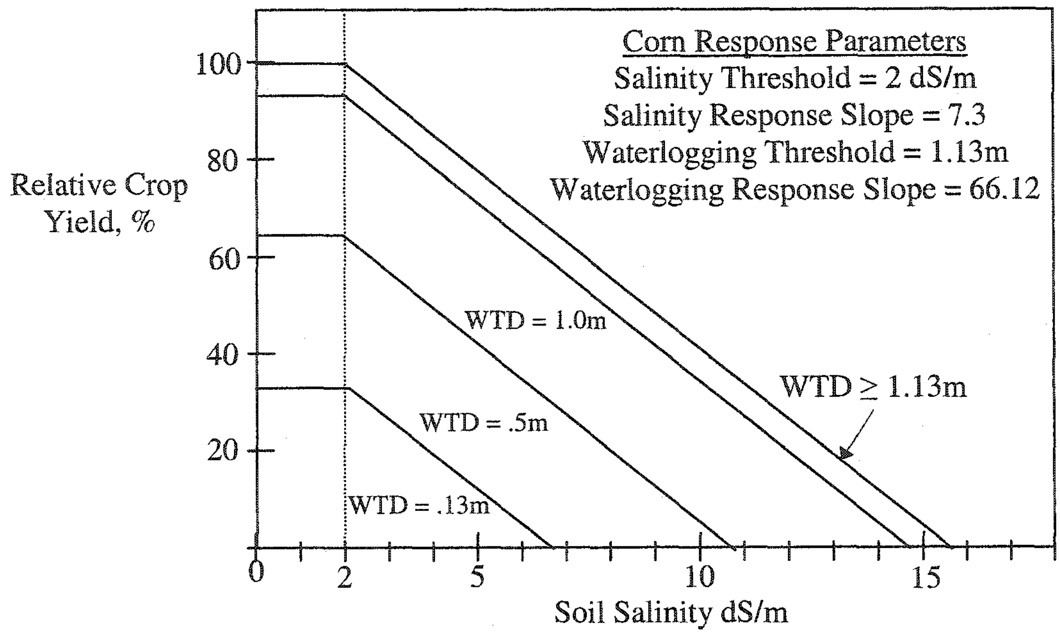

Figure 3.5: Corn Yield Response to Soil Salinity at Different Water Table Depths.

Once the total relative yield factor is calculated for each crop on each of the fields it can be multiplied by each crops potential yield to estimate the actual crop yield. Identification of the appropriate potential yield is critical; other studies have used the maximum achievable yield (Grieve et al. 1986) or average yield (Gutteridge et al. 1985). Maximum achievable yield is likely to overstate the impact on yields. This approach implies that the entire yield deficit is associated with waterlogging and soil salinization and ignores other factors that influence yield reductions (poor management, climate, etc.). Thus, in the absence of waterlogging and soil salinity it would estimate maximum achievable yields to occur, although other factors would still cause reduced yields.

Using current average yield as the base (or 100% yield) against which yield deficits are calculated is likely to underestimate yield impacts since current average yields already include observations from fields with high levels of salinity and waterlogging. Thus, a total reduction in waterlogging and soil salinity would only result

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in yield estimates that were equal to the current averages instead of above current averages as expected.

The appropriate potential yield to use is one that represents the achievable yield given no waterlogging and soil salinity, yet still accounts for other sources of yield reductions. This study will identify a set of potential crop yields for each year such that the estimated yields given current waterlogging and soil salinity levels calibrate to the average yield reported in the region each year. These yields will correctly reflect the potential yield that could have been obtained given no waterlogging or salinization effects, thus isolating only the modeled effects. The change in the potential yields from year to year will reflect all other factors that may have affected yields that year but were not directly modeled. This approach will correctly predict above current average yields when waterlogging and salinity are reduced and below current averages if the conditions were to worsen.

Analytical Framework

The economic approach that is used in this study is to estimate the profitability within the study section of the Lower Arkansas Basin given the current distribution of water table depths and soil salinity levels. Since the primary benefits that we are concerned about are producer returns, regional profits will be calculated. Once the current conditions are estimated, the net effect of waterlogging and soil salinization can be determined. Many studies have developed mathematical programming models to estimate profits from production under different conditions. McCarl and Spreen (2002) have summarized and explained many of these applied mathematical programming

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methods. The set of equations identified in (3.4) represents how total profits are estimated across all crops (*k=1,..,8*), irrigated fields (*I, avg.= 470/canal*), and canal areas (*c=1,...,6*) for each of the years.

$$\Pi = \sum_{c=1}^{C} \sum_{i=1}^{I} \sum_{k=1}^{K} \left[(P_k - HC_k) * Y_{cik} * A_{cik} - NHC_k \right]$$

(3.4) Where:

$$Y_{cik} = Y_k^P * RY_{cik}^S * RY_{cik}^{WTD}$$

$$RY_{cik}^S = 100 - b_k (EC_{ci} - a_k) \quad \text{for } EC_{ci} \geq a_k$$

$$RY_{cik}^{WTD} = 100 - d_k (c_k - WT_{ci}) \quad \text{for } WT_{ci} \leq c_k$$

Total profits (Π) are calculated by first identifying the difference between crop price (P_k) and per unit harvest costs (HC_k) which are multiplied by the estimated yield on each canal area field for each crop (Y_{cik}). This per unit crop return is then multiplied by the quantity of acres of each crop on each canal area field (A_{cik}). Finally, the per acre non-harvest costs for each crop (NHC_k) are subtracted. As mentioned above, the estimated yield of each crop on each canal area field represents the multiplicative effect of both salinity (RY^S_{cik}) and waterlogging (RY^{WTD}_{cik}) which is multiplied by the potential yield for each crop (Y_k^P). The model was written and solved using the General Algebraic Modeling System (GAMS), the model can be seen in Appendix 3.1.

The above model will be estimated under current conditions and then again assuming a total reduction in soil salinity and waterlogging effects, thus identifying the total impact of the two effects. In addition, the model will be solved for incremental changes in soil salinity and water table depths. Through this process, a surface relating the responsiveness of profits to both of these effects will be produced.

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Data Requirements

Along with the collection of waterlogging and soil salinity response data for each crop, data was also collected concerning the area specific cropping parameters and the current distribution of water table depths and soil salinity

Cropping Parameters

The area specific cropping parameters that needed to be identified are as follows: field acreage, field crop type, field location, current crop yields, regional crop prices, regional costs, irrigation technologies, and typical management practices. Information concerning the size, crop type, and location of each field within the study area was identified using Farm Service Agency records for each of the three years (FSA 1999-2001). Average crop yields for Otero County and ten-year average crop prices were collected from Colorado Agricultural Statistics (Appendix 3.2). Crop budgets from Colorado State Universities Cooperative Extension were used as a reference point from which to develop a complete set of area specific cropping budgets (Appendix 3.3). All of the budgets reflect the costs of an open-ditch gravity irrigation system, which was identified as the typical water application method used in the region.

Soil Salinity and Water Table Depths

The current magnitude and distribution of soil salinity and water table depths over the three-year period were estimated by the Department of Civil Engineering at Colorado State University through the use of sophisticated hydrologic modeling. This hydrologic model has been calibrated through the use of extensive field data that was collected between 1999 and 2001. During these years, data was collected across the study region concerning water table depth and salinity levels, soil salinity levels, and surface water

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salinity levels. The hydrologic model applies a numerical finite-difference technique to simulate groundwater flow and salinity transport throughout the study area using a three dimensional grid containing 16,188 active cells. The active cells have a uniform X-Y dimension of 250 meters and vary in depth as a result of aquifer thickness (for a complete description see Burkhalter 2003, Gates et al. 2002). To estimate the on field impact associated with waterlogging and soil salinity, the hydrologic grid output was used to estimate the weighted average condition on each field within the study area.

To convert the hydrologic grid data, the coverage was imported into ArcView GIS 3.2 and combined with a polygon layer identifying the borders of all irrigated fields within the study area. The software was then used to calculate the weighted average value for both soil salinity and water table depth on each field for each year[1]. (Figure 3.6)

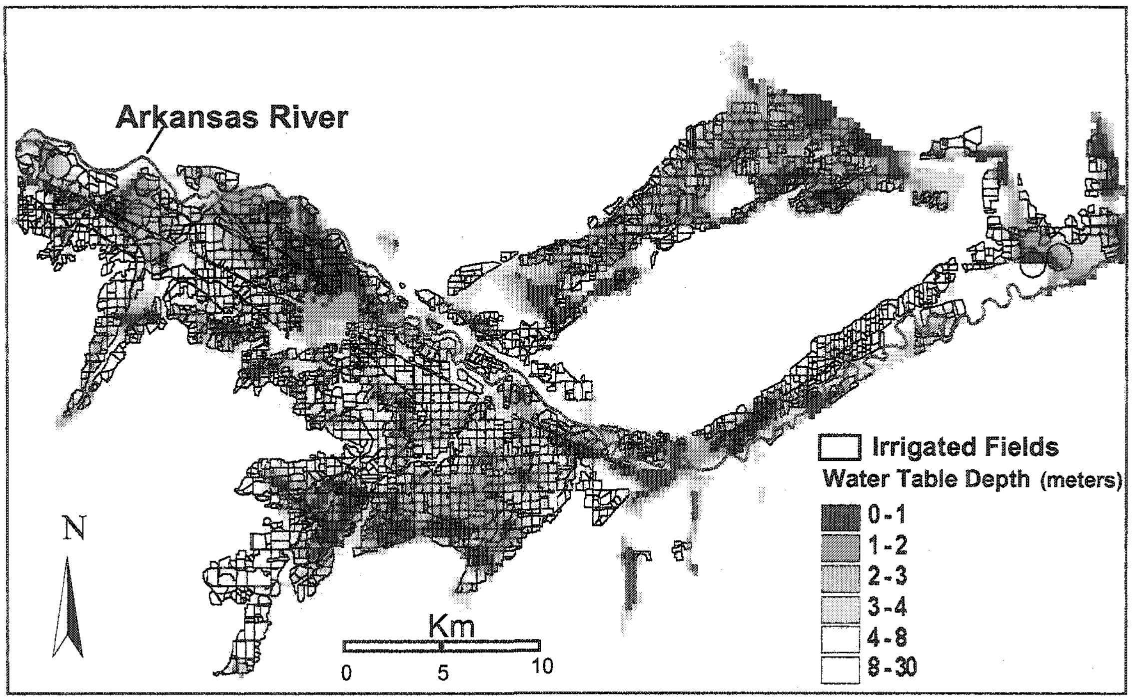

Figure 3.6: Image of Irrigated Fields Over Water Table Depth Grid Output (1999).

[1] The hydrologic model was found to over predict soil salinity levels in the last two time periods. The average overestimate was calculated by comparing the modeled levels on approx. 67 fields for which field data had been collected. This average over prediction was then subtracted from all observations.

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Once the information concerning the regional cropping parameters, soil salinity levels, and water table depths were compiled for each field and each year the model presented in equation 3.4 was used to estimate the crop yields and current profitability.

Results

Summarized estimates of the average soil salinity levels and water table depths that occurred during the growing seasons (April-October) of 1999-2001 can be seen in Tables 3.4 and 3.5.

Table 3.4: Average Growing Season Soil Salinity Levels (dS/m) for each Canal Area and in Total.

	Canal Area						
	1	2	3	4	5	6	Total Area
1999	3.39	3.23	3.42	4.62	3.37	3.54	3.47
2000	2.55	2.69	2.73	3.74	2.57	3.15	2.76
2001	3.68	3.79	3.30	3.88	2.66	3.83	3.41
Average	3.21	3.24	3.15	4.08	2.87	3.51	3.21

Table 3.5: Average Growing Season Water Table Depth (m) for each Canal Area and in Total.

	Canal Area						
	1	2	3	4	5	6	Total Area
1999	2.80	2.65	2.89	3.75	5.46	4.38	3.62
2000	3.25	3.06	4.04	5.99	8.76	6.41	5.17
2001	3.51	3.29	4.43	6.59	9.24	6.55	5.50
Average	3.19	3.00	3.79	5.44	7.82	5.78	4.76

Both soil salinity and average water table depth estimates vary greatly across canal areas and years. One reason explaining the annual variation is due to how unique the climate was under each of the three years modeled. The main difference between these years was the amount of precipitation that occurred and the amount of snowmelt supplying the headwaters. This difference can be seen by examining the total growing

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season precipitation levels as monitored at the Rocky Ford weather station (#057167), which reported 18.36 inches in 1999, 6.71 inches in 2000, and 9.61 inches in 2001 (WRCC 2003). The average level of precipitation at the Rocky Ford weather station during the growing season is 9.73 inches, which is comparable to the conditions that occurred in 2001. These precipitation levels along with an increased supply of irrigation water likely influenced the average depth of the water table across the three-year time period. The water table depth was the shallowest in 1999 (wet year) and increased in depth significantly by 2000 (dry year) and then continued to increase only slightly by 2001 (average year).

Using the estimated water table depth and soil salinity level for each field within the study area, the economic model is used to estimate the relative crop yield (*RY*) on each field for each year under the current conditions (Table 3.6).

Table 3.6: Average Relative Crop Yield (*RY*) for each Crop and Year as a Result of Both Waterlogging and Soil Salinity.

	1999	2000	2001	Average
ALFALFA	0.86	0.91	0.86	0.88
BEANS	0.53	0.63	0.57	0.58
CORN	0.80	0.88	0.82	0.83
GRASS	0.97	0.99	0.98	0.98
MELONS	0.80	0.88	0.82	0.83
ONION	0.83	0.89	0.84	0.85
SORGHUM	0.98	1.00	1.00	0.99
WHEAT	0.99	1.00	1.00	1.00
Average	0.84	0.90	0.86	0.87

The relative crop yields vary from a low of 53% for beans in 1999 to a high of 100% for both sorghum and wheat in 2000 and 2001. These reductions in yield are estimated as a function of only waterlogging and soil salinity. Using the relative crop yield estimates and the Otero county crop yields for each year, the potential average crop

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yield for each crop and year was identified. For example, if the average relative crop yield was estimated to be 80% for corn in 1999 and the actual reported yield for corn in 1999 was 100 bushels, the potential average crop yield for that year would have been 125 bushels (100/.8). Through this process, the potential yield for each crop and year was estimated (Table 3.7).

Table 3.7: Potential Crop Yields for each Year Given no Waterlogging or Soil Salinity Effects.

	1999	2000	2001	Average
ALFALFA (Ton)	5.35	5.80	5.56	5.57
BEANS (Cwt.)	42.42	34.55	40.34	39.10
CORN (Bu.)	208.25	183.89	210.49	200.88
GRASS (Ton)	2.07	2.43	3.12	2.54
MELONS (Cwt.)	223.88	273.46	279.89	259.08
ONION (Cwt.)	452.93	401.04	412.45	422.14
SORGHUM (Bu.)	80.52	80.18	78.78	79.83
WHEAT (Bu.)	77.67	71.54	70.19	73.13

Using the crop yield estimated under the current conditions for each field and year, the baseline profit levels were estimated. Table 3.8 shows a summary of the baseline profit levels aggregated across the six canal areas and in total, while figure 3.7 (page 63) shows the spatial variation in profit levels for each field and year.

Table 3.8: Total Annual Profits and Profit per Acre for each Canal Area under Current Conditions.

	Canal Area						
Total Profit	1	2	3	4	5	6	Total Area
1999	$2,035,644	$1,438,381	$3,019,485	$191,715	$2,090,218	$1,348,734	$10,124,177
2000	$2,692,228	$1,735,161	$3,297,513	$223,359	$2,475,923	$1,571,493	$11,995,677
2001	$2,315,541	$1,372,588	$3,358,922	$533,758	$1,965,511	$1,406,462	$10,952,782
Average	$2,347,804	$1,515,377	$3,225,307	$316,277	$2,177,217	$1,442,230	$11,024,212
Profit/Acre							
1999	$145.76	$206.47	$165.84	$53.44	$155.82	$166.22	$157.56
2000	$184.88	$259.13	$199.67	$68.36	$183.82	$198.94	$192.21
2001	$162.30	$203.31	$190.44	$135.77	$147.95	$175.52	$171.45
Average	$164.31	$222.97	$185.32	$85.86	$162.53	$180.23	$173.74

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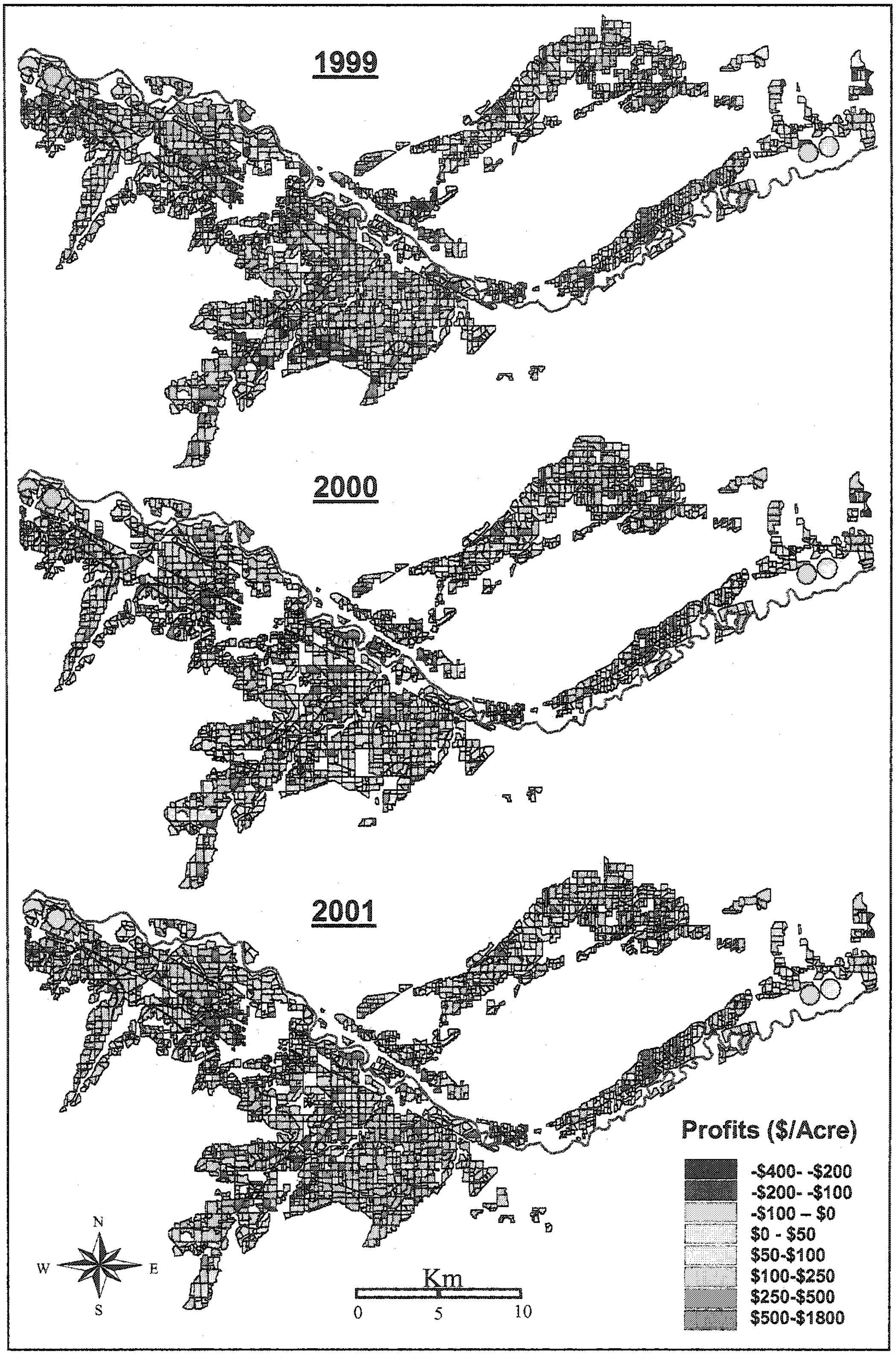

Figure 3.7: Average Baseline Profit Levels per Acre for each Field and Year under Current Conditions.

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As can be seen in table 3.8 and figure 3.7, the profitability levels vary significantly across canal areas and year. The lowest average profit level was estimated to occur in canal area four (Otero Canal) during 1999. This can also be seen figure 3.7, where many of fields located in canal area four were estimated to have negative returns. Consistent with these findingst, the highest average soil salinity level that was estimated to occur was within canal area four during 1999. However, the variation in profitability is not only due soil salinity and waterlogging levels, it is also dependant upon the crop distribution and other annual effects that have been embedded into the potential yields for each year. As a result of these changing conditions, the losses associated with soil salinity and waterlogging are also expected to vary across canal areas and years.

Cost of Salinity and Waterlogging

The total cost imposed on agricultural production was estimated by comparing the current baseline profitability levels with the level of profitability associated without yield reductions from soil salinity and waterlogging. The total value of forgone productivity as a result of soil salinity and waterlogging is estimated to range from approximately $3.1 to $5.4 million annually, averaging just over $4.3 million/year (Table 3.9).

Table 3.9: Forgone Profit Associated with Current Salinity and Waterlogging Levels for each Canal Area and in Total for each Year.

	Canal Area						
Total Profit	1	2	3	4	5	6	Total Area
1999	$934,401	$620,462	$1,842,708	$353,480	$931,513	$672,359	$5,354,923
2000	$606,333	$383,563	$945,283	$177,925	$564,844	$443,177	$3,121,125
2001	$994,689	$639,855	$1,433,195	$275,701	$478,973	$707,231	$4,529,644
Average	$845,141	$547,960	$1,407,062	$269,035	$658,443	$607,589	$4,335,231
Profit/Acre							
1999	$66.90	$89.06	$101.21	$98.54	$69.44	$82.86	$83.34
2000	$41.63	$57.29	$57.24	$54.45	$41.93	$56.10	$50.01
2001	$69.72	$94.78	$81.26	$70.14	$36.06	$88.27	$70.90
Average	$59.42	$80.38	$79.90	$74.38	$49.14	$75.74	$68.08

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In addition, figure 3.8 shows how the damage associated with soil salinity and waterlogging varied across fields from year to year.

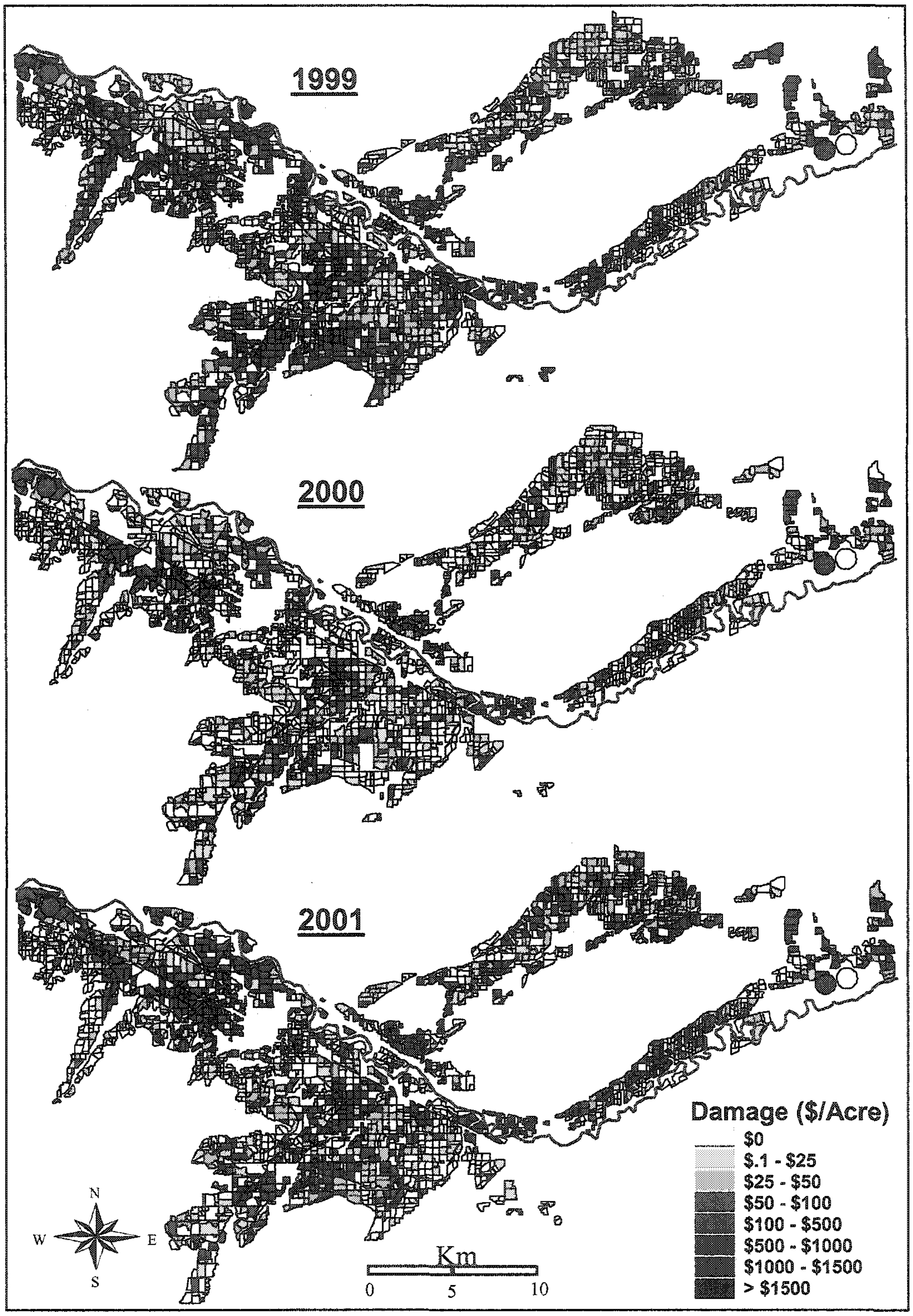

Figure 3.8: Average Level of Damage per Acre for each Field and Year Given Current Waterlogging and soil salinization Conditions.

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The average annual loss as a result of current soil salinity and waterlogging is estimated to be $68.08/acre, which reflects the difference between the current average profit level of $173.74/acre and the potential profit level of $241.82/acre. This difference represents the opportunity of increasing profits by approximately 39% if the effects of waterlogging and soil salinity could be removed. Given the significant losses that are currently occurring within the study area, additional research evaluating potential alternatives aimed at reducing these effects would be justified.

The model was also used to isolate the effects of waterlogging and soil salinization separately. The average annual cost of soil salinization was estimated to be $4,032,023 while the average annual cost of waterlogging was only $222,542. Since the combined effect of waterlogging and soil salinization was assumed to be multiplicative the two isolated effects do not sum to the total impact estimated above. Although the costs associated with soil salinization are higher than the costs of waterlogging, the two effects are not independent. Since soil salinity is directly affected by water table depth, some portion of the soil salinization costs is due indirectly to the depth of the water table. Therefore, the isolated waterlogging effect represents only the direct cost of waterlogging and does not account for the contribution that waterlogging has upon soil salinization. It would be anticipated that the indirect effect that water table depth has upon crop yields as a result of increased soil salinity would be significant.

In addition to the total losses under current conditions, the level of profitability associated with incremental changes in both water table depths and soil salinity levels has been identified. The surface of profitability as a function of these effects for 1999 can be seen in Figure 3.9.

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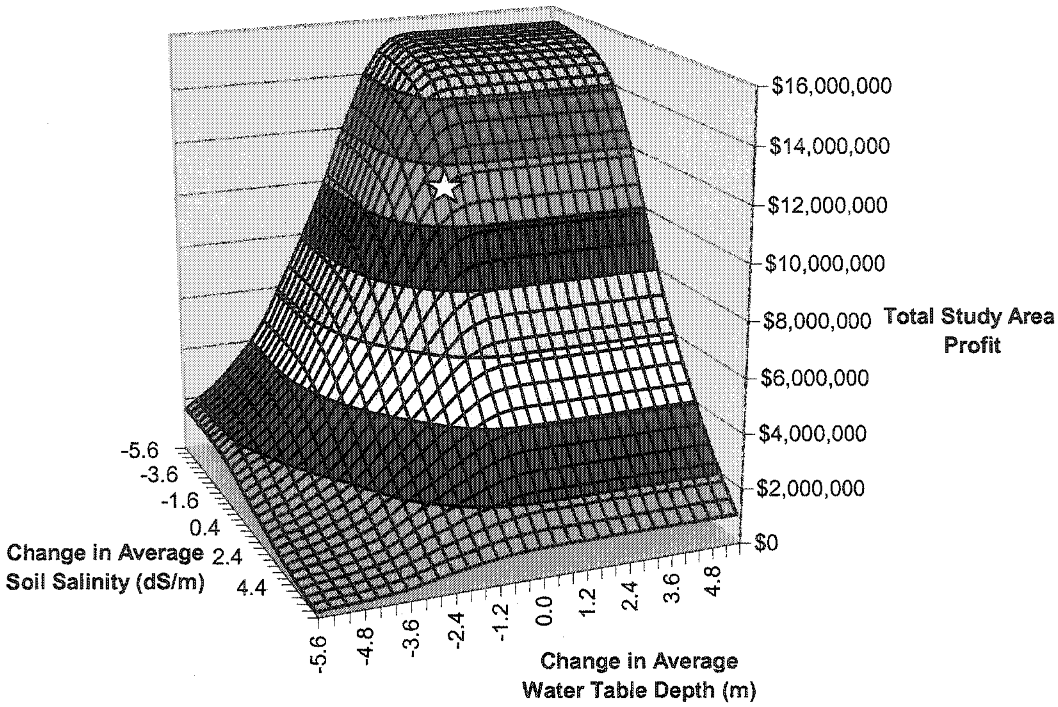

Figure 3.9: Average Annual Profits under Incremental Adjustments to Current Soil Salinity and Water Table Depths.

The location on the graph that corresponds with current conditions has been identified with a star. The current position indicates that relatively small direct benefits will occur from increasing the average water table depth. This is consistent with the earlier findings that the direct cost associated waterlogging was relatively small under current conditions. However, the graph clearly indicates that any slight decrease in the regional water table depth will result in significant losses to profitability. Although water table depths have been receding over time, it appears that the conditions have reached a point at which additional decreases could significantly threatened the viability of agriculture in the region.

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Sensitivity Analysis

To further understand the relationship between the agricultural costs of waterlogging and soil salinization, sensitivity analysis was conducted on all of the relevant parameters. The set of parameters that were adjusted and evaluated include potential crop yields, crop prices, soil salinity response thresholds, soil salinity response slope parameters, waterlogging response thresholds, and waterlogging response slope parameters. The adjustments reflect a 20% increase and a 20% decrease from the initial value of each parameter. After each parameter was adjusted, the model was used to reevaluate the costs of both waterlogging and soil salinity. The difference between the average annual costs associated with waterlogging and soil salinity estimated using the initial and adjusted parameters are presented in Table 3.10.

Table 3.10: Estimated Change in the Average Annual Cost of Waterlogging and Soil Salinization under a 20% Increase and Decrease in the Underlying Parameters.

Parameter Adjusted	20% Increase	20% Decrease
Potential Crop Yields	$867,046	-$867,046
Crop Prices	$1,132,237	-$1,132,237
Soil Salinity Response Thresholds	$716,438	-$652,346
Soil Salinity Response Slopes	$800,586	-$803,654
Waterlogging Response Thresholds	-$117,447	$189,835
Waterlogging Response Slopes	$44,274	-$44,462

This analysis indicates that the estimated costs associated with waterlogging and soil salinization are sensitive to the parameters that are used. The estimate of agricultural damages was most sensitive to a 20% change in crop prices. Increasing crop prices by 20% resulted in the estimated cost of waterlogging and soil salinization to increase by over 1.1 million dollars (26% increase in damage costs). Reducing crop prices by 20% resulted in a reduction of average annual costs by the same amount.

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When comparing the effects associated with changes in both the thresholds and slope parameters for waterlogging and soil salinization, the total costs were more responsive to changes in the soil salinity parameters. This occurred because the costs associated with soil salinization were found to be much larger than the direct costs associated with waterlogging. Given the limited response to changes in the waterlogging parameters, it appears that improving these estimates would only slightly increase the accuracy of the damage estimates. As such, focusing resources upon improving the parameter estimates describing the relationship between soil salinity and crop yields may be more beneficial.

Conclusions

The results of this study indicate that the production losses and associated forgone profits as a result of waterlogging and soil salinization are significantly impacting farmers located within the study area. Average forgone profit was estimated to be $4.3 million annually (approx. $68/acre per year). The combined effects of waterlogging and soil salinity have resulted in the average annual crop yields for individual crops to be reduced by as much as 42% (Beans, Salinity Sensitive) and the average annual crop yield loss associated with all crops to be 13%. Although the current loss of agricultural production is significant, the additional losses that will be incurred if conditions were to worsen indicates the need for additional research to identify what should be done.

If the average damage estimate from this study is applied to all of the irrigated acreage within Colorado's Arkansas River Basin (440,200 irrigated acres, Colorado Water Knowledge 2003), the direct damage to agricultural production in the Arkansas River Basin would be estimated at approximately $30 million a year. In addition to these

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direct losses to agricultural production, there would be additional costs imposed upon the agricultural communities that are affected.

Although water management practices for dealing with irrigation induced waterlogging and soil salinization have been well documented over time, it is critical to determine whether they are economically justified within particular regions. Future research will need to evaluate alternatives aimed at improving the current conditions in the basin. By estimating both the costs and effectiveness of alternatives aimed at reducing waterlogging and soil salinization along with the economic benefits, appropriate future actions can be identified.

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CHAPTER 4

EVALUATING ALTERNATIVES FOR DECREASING IRRIGATION INDUCED WATERLOGGING AND SALINIZATION

Introduction

Waterlogging and salinization have threatened the sustainability of irrigated agriculture for centuries. Historical records have revealed that many ancient civilizations that relied upon irrigated agriculture have failed. The Sumerian civilization of ancient Mesopotamia declined when agricultural productivity began to decrease as a result of waterlogging and salinization (Hillel 2000; Tanji 1990). The same process responsible for the demise of many ancient civilizations continues to plague current irrigated areas today. Currently, 20-25% of the worlds irrigated lands suffer from saline high water tables, including 27% of the United States irrigated lands (Wichelns 1999; Ghassemi et al. 1995; Tanji 1990; Postel 1989). It is estimated that worldwide crop productivity losses associated with salinity in irrigated areas is approximately $11 billion annually and increasing (Ghassemi et al. 1995).

The four primary reasons that irrigation causes waterlogging and salinization include seepage from poorly lined canals and reservoirs, excessive water application, inadequate provision of drainage, and inadequate application of water to leach away salts (Barrow 1991). As a result of excessive seepage and deep percolation from over irrigation, water enters the aquifer, typically saline, and decreases the water table depth.

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As the water table rises closer to the soil surface, salts can rise to the surface through capillary action and render the land unsuitable for agricultural production (Wichelns 1999). Although water management practices have been developed to reduce the effects of waterlogging and salinization, further research is needed to identify which of these practices have the ability to be cost effective within specific regions of the world.

The losses associated with salinization and waterlogging within the lower Arkansas Basin of Colorado are significant. This region has been continuously irrigated since the 1870's and began to develop high saline water tables by the early part of the twentieth century (Miles 1977). Average water table depths have risen by approximately one to four feet between 1969 and 1994 (Cain 1997). Currently, the Arkansas River is one of the most saline rivers in the United States (Tanji 1990; Miles 1977). In a recent survey of the region, 68% of producers stated that high salinity levels were a significant concern of theirs (Frasier et al. 1999).

The objective of this research is to estimate the cost effectiveness of alternatives aimed at decreasing waterlogging and soil salinity levels along a study section of the Lower Arkansas River Basin. In addition to the benefits associated with increased agricultural productivity, the ability of each alternative to reduce salt loads to the river will be addressed. Several types of alternatives will be evaluated including: reducing irrigation canal seepage (e.g. lining canals), reducing aquifer recharge rates (e.g. increasing irrigation efficiency), increasing subsurface drainage, increasing groundwater pumping, and the relocation of current acreage allocations. The general approach taken will be to estimate the inputs required and commensurate outcomes for each alternative through the use of hydrologic and economic models. Once the benefits and costs are

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identified for each alternative, they will be compared to the baseline conditions established in Chapter 3.

Review of Literature

Limited research is available analyzing the cost effectiveness of specific alternatives aimed at reducing waterlogging and soil salinity. One of the primary reasons for this relates to the difficulty associated with predicting the effectiveness of the alternatives. As a result of current hydrologic modeling efforts in the Arkansas Basin, the effects of specific alternatives can now be predicted and evaluated. Although limited research is available, a few articles describing the economics of salinity and irrigated agriculture are briefly reviewed.

Wichelns (1999) presents a comprehensive analytical overview of irrigated agriculture in the presence of waterlogging and salinization. Farm-level and project-level models of crop production are developed to identify policies that will encourage farmers to consider the effects of their irrigation practices on regional water tables and salinity. The farm-level model is formulated so that water table depth and quality are exogenous variables, such that individual producers have little or no incentive to consider the impacts of their activities on these variables. The project-level model includes multiple farms and an equation for the regional depth and quality of the water table, which is a function of total deep percolation from all farms. One of the primary results derived from the project-level model, indicates the conditions for optimal water application given the external costs associated with over application. It is shown how an increase in water table depth benefits overall productivity and that external costs are imposed when

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producers ignore their collective impacts upon water table depth. It is suggested that improvements in the definition of property rights and appropriate water pricing may improve water management and reduce the rate of increase of waterlogging and soil salinization. Although the analytical models presented in this study are valuable, the quantity of data required to apply these models is often prohibitive.

The majority of research on water management under saline conditions has focused upon optimal irrigation and drainage decisions under exogenous non-structural policies. Dinar and Knapp (1986) estimated optimal water applications under saline conditions using dynamic programming and response functions between crop yield and soil salinity estimated from field experiment data. Dinar et al. (1993) also used dynamic programming to evaluate a set of drainage abatement scenarios. It was found that policies directly controlling drainage levels were more cost-effective than those that targeted surface water uses.

Gates and Grismer (1989) developed a simulation model that identified economically optimal irrigation and drainage strategies when a saline shallow water table is present. The model was applied to cotton production using established conditions from the Western San Joaquin Valley of California. Expected regional net benefits were maximized given irrigation and drainage efficiencies equal to 78% and 91%, respectively. It was found that soil salinity levels increased and net benefits decreased steeply as irrigation efficiency increased above 81%. This results from the large expense of achieving such high efficiencies and the resulting decrease in leaching that occurs. This is consistent with the understanding that irrigators must leach salts from their soils through excess irrigation in order to preserve productivity (Young and Horner 1986).

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Gardner and Young (1988) assess strategies for controlling highly saline discharge from irrigated agriculture in the upper Colorado River Basin using a linear programming framework. They estimate costs of reducing salt discharges and evaluate nonstructural scenarios for motivating these reduced discharge levels. Hatchett et al. (1991) also used a regional model to evaluate nonstructural ways to control the level of highly saline drainage. By developing an integrated physical-economic model they were able to assess the effectiveness of several water pricing policies to reduce the amount of water application and the quantity of subsurface drainage flows. Results indicate that increased tier water prices would have the ability to reduce irrigation applications resulting in less deep percolation and subsurface drainage flows.

Although limited, there have been some studies that have evaluated the effects of structural alternatives for improving waterlogged and saline conditions. Sharma et al. (2000) evaluated the impact of a subsurface drainage system on wheat yields using field observations from a waterlogged region. Experimental field data was collected over an eight-year period starting from the time of initial installation of the subsurface drainage spaced at 25, 50, and 75 meters. Results indicate that soils could be reclaimed through the use of subsurface drainage using any of the spacing tested. Drains spaced at 25 meters were more effective in improving soil properties and crop yield during the first four years, but after the fourth year there was no significant difference. No attempt was made to compare the costs and value of benefits associated with each of the drain spacings.

Grieve et al. (1986) conducted a current assessment of waterlogging and soil salinity on irrigated agriculture in the Murray Valley of New South Wales, Australia.

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The study was able to compare salinity surveys that were conducted both before and two years after the operation of a vertical drainage (groundwater pumping) scheme. After two years of groundwater pumping, soil salinity surveys across the region showed that the percentage of saline soils had decreased from 72% to 46%. The total reduction in losses associated with these decreased soil salinity levels was estimated to be approximately $6.00/acre across the 77,000 acre region. The study did not estimate the benefits of reduced waterlogging associated with the vertical drainage scheme.

Jones and Marshall (1992) estimated the benefits associated with a proposed surface drainage scenario for an irrigation district within southern New South Wales, Australia. They estimated the present value over a thirty-year time period of providing district drainage in the study area to be worth $5.9 million (approx. $70/acre). The study used a simplified approach for estimating the benefits to agricultural productivity. When accessing the benefits associated with reduced waterlogging they applied constant yield reduction factors, which ignored the magnitude of the effect and crop specific responses. The effectiveness of the district drainage was also subjectively identified and assumed to reduce the effects of waterlogging by constant rate. The assumption concerning the effectiveness of the drainage scenario is oversimplified and is not expected to provide an accurate representation of the benefits. In addition, soil salinity conditions were assumed to increase at a constant rate of .05 dS/m per year and the addition of district drainage was assumed to decrease this rate by 25%. This assumption is also likely to oversimplify the soil salinization process and ignore any distributional changes.

While the study conducted by Jones and Marshall (1992) simplified the relationships between waterlogging and crop yields and the effectiveness of surface

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drainage on both waterlogging and soil salinization, the general approach is consistent with that used in this chapter. Both studies evaluate the benefits of an alternative by analyzing the returns to agriculture both with and without the specific scenario applied. The research presented in this chapter is unique because it evaluates a broad range of alternatives by combining sophisticated hydrologic modeling with detailed economic analysis. The hydrologic models are used to predict the effects of each alternative on water table depths, soil salinity levels, and salt load to the river. The economic models are then used to estimate the corresponding effects to profitability upon every field within the study area. Through this approach, the effects of each alternative on waterlogging, soil salinization, and salt load will be modeled more precisely than ever before.

Description of Study Area

The Arkansas River originates in the Rocky Mountains near Leadville, Colorado at an elevation of over 14,000 feet. The river flows south and east through Colorado for approximately 360 miles then enters the state of Kansas at an elevation of less than 3,400 feet (Miles 1977). The Arkansas River drains approximately 25,000 square miles (approx. 25% of the state) of Colorado and is the state's largest river basin.

This research focuses upon a 38.5-mile reach of the Lower Arkansas River consisting of approximately 65,000 acres of irrigated land. This section of the Arkansas Valley is located within Otero and Bent counties beginning at the town of Manzanola and extending down river past the city of La Junta. (Figure 4.1, page 82). Since 1998, extensive field data has been collected along this reach of the river as part of a multidisciplinary research project headed by Dr. Gates of the Department of Civil

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University (Gates et al. 2002). The major irrigated crops that are produced in this region consist of alfalfa, beans, corn, grass, melons, onions, sorghum, and wheat. The predominant irrigation technology that is used is an open ditch gravity flow furrow system. Six major canal companies service the study area: Holbrook (1), Rocky Ford (2), Catlin (3), Otero (4), Rocky Ford Highline (5), and Fort Lyon (6). The total irrigated acreage serviced by each canal will be the manageable unit that is considered for alternative adoption.

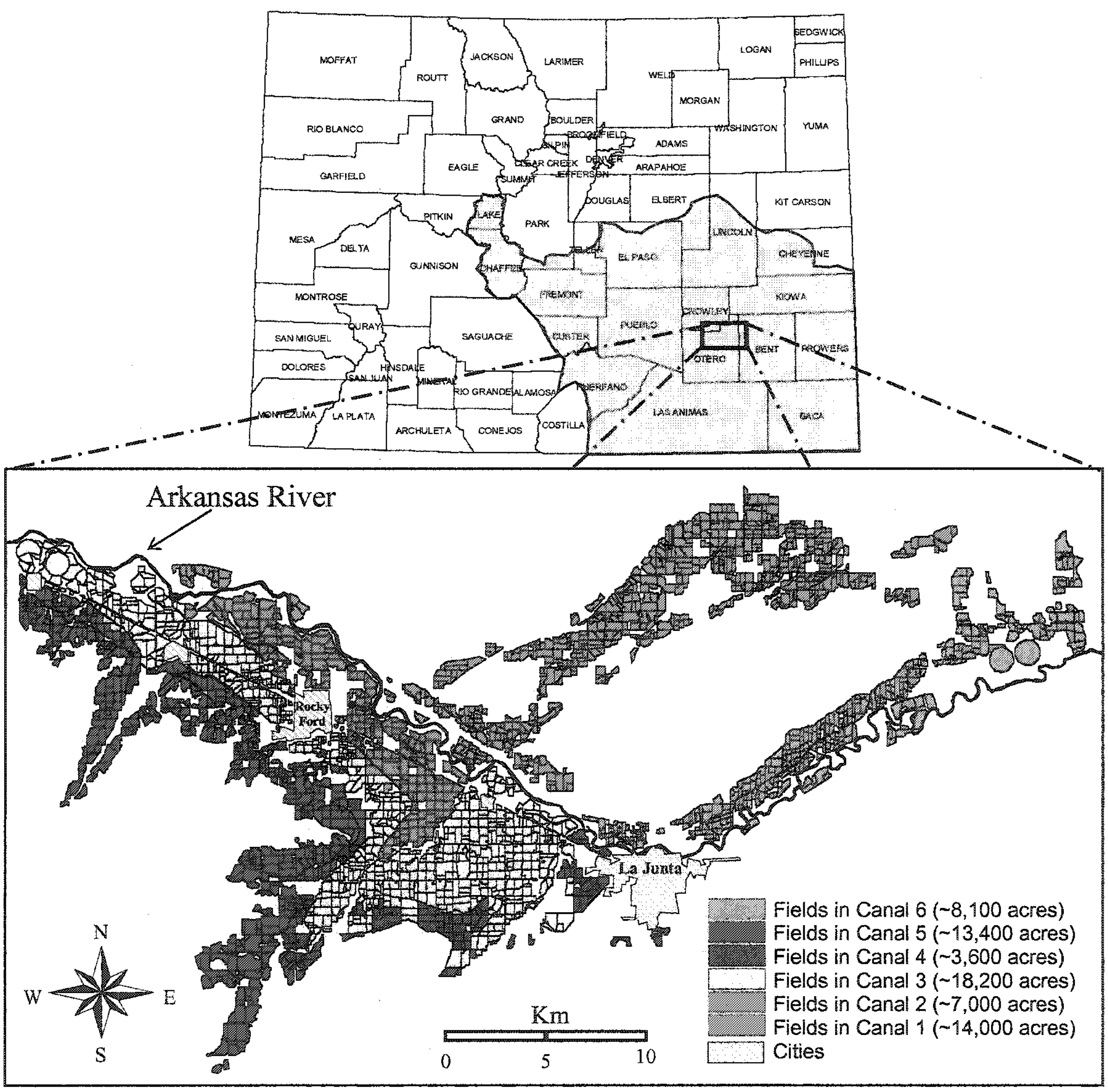

Figure 4.1: Map of Colorado Counties with Arkansas Basin Highlighted and Study Area Enlarged with Cities, River, and Irrigated Fields in each Canal Area Identified.

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Analytical Framework

The economic approach that is used in this study is to estimate the profitability of agriculture along the study section of the Arkansas Basin over a three-year period given the estimated conditions both before and after each alternative is imposed. Since the primary benefits that we are accounting for are returns from agricultural production, a model estimating the total profits within the study area will be used. The set of equations identified in (4.1) represent how total annual profits are estimated across all crops (k), irrigated fields (i), and canal areas (c) for each of the years.

$$\Pi = \sum_{c=1}^{C} \sum_{i=1}^{I} \sum_{k=1}^{K} \left[(P_k - HC_k) * Y_{cik} * A_{cik} - NHC_k \right]$$

(4.1) Where:

$$Y_{cik} = Y_k^P * RY_{cik}^S * RY_{cik}^{WTD}$$

$$RY_{cik}^S = 100 - b_k (EC_{ci} - a_k) \quad \text{for } EC_{ci} \geq a_k$$

$$RY_{cik}^{WTD} = 100 - d_k (c_k - WT_{ci}) \quad \text{for } WT_{ci} \leq c_k$$

Total profits (Π) are calculated by first identifying the difference between crop price (P_k) and per unit harvest costs (HC_k) which are multiplied by the estimated yield on each canal area field for each crop (Y_{cik}). This level of crop return is then multiplied by the quantity of acres of each crop on each canal area field (A_{cik}). Finally, the per acre non-harvest costs for each crop (NHC_k) are subtracted. As described in Chapter 3, the estimated yield of each crop on each canal area field represents the multiplicative effect of both salinity ($RY^S{}_{cik}$) and waterlogging ($RY^{WTD}{}_{cik}$) which is multiplied by the potential yield for each crop (Y_k^P). The model was written and solved using the General Algebraic Modeling System (GAMS) and can be seen in Appendix 3.1.

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The impact on agricultural returns will reflect the ability of each alternative to effect water table depths and soil salinity levels. The effect of each alternative on water table depths, soil salinity, and salt load to the river was estimated over a three-year time period by the Department of Civil Engineering at Colorado State University through the use of sophisticated hydrologic modeling. The hydrologic model was developed and calibrated through the use of extensive field data that was collected during 1999-2001. The hydrologic model applies a numerical finite-difference technique to simulate groundwater flow and salinity transport throughout the study area using a three dimensional grid containing 16,188 active cells. The active cells have a uniform X-Y dimension of 250 meters and vary in their depths as a result of aquifer thickness (for a complete description see Burkhalter 2003; Gates et al. 2002). To estimate the field level impact associated with both waterlogging and soil salinity, the hydrologic grid output was used to estimate the average condition for each irrigated field within the study area.

Once the water table depth and soil salinity levels are estimated for each field, the benefits or losses to agricultural productivity are found by comparing the outcomes of the economic model both with and without each alternative. A description of the economic model parameterization and estimates of the baseline conditions can be found in Chapter 3. The costs of implementing each alternative will be accounted for independently of the economic model above.

An additional effect that will be reported for each alternative is the impact that it has upon salt load to the river. A reduction in salt load would improve the quality of the water flowing downstream and generate additional positive benefits. Examples of these

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external downstream benefits could result from improved crop yields and reduced treatment costs for household water use.

Once the costs for each alternative are compared to the direct benefits to agricultural productivity within the study area and the impact to salt loads are addressed, the economically feasible solutions will be identified and the most promising alternatives will be revealed.

Summary of Alternatives Evaluated

Several types of alternatives are evaluated including: reducing seepage from irrigation canals (e.g. lining canal), reducing aquifer recharge rates (e.g. increasing irrigation efficiency), increasing subsurface drainage, increasing groundwater pumping, and relocating current acreage allocations. Once the characteristics of each alternative are identified, the methods and data required to estimate the costs are relatively straightforward. Changes in the prices and quantities of the relevant inputs are simply accounted.

Reducing Seepage from Irrigation Canals

This set of alternatives reflects the impacts associated with lining selected lengths of irrigation canals in order to reduce seepage. Gates (2002) estimated current seepage levels along the total reach of the Fort Lyon canal located within the study area to range from 15% to 27% of total diversions. These estimates are consistent with other findings that have reported the seepage losses within Catlin canal to be approximately 25% (Sayer et al. 1997). The large quantity of water lost to seepage in this region is a significant factor contributing to the occurrence of saline shallow water tables.

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A total of eight canal lining alternatives are evaluated. The set of alternatives represent lining all of the irrigation canals, each irrigation canal separately (six alternatives), and a 20% section of each canal with the highest seepage rate. Evaluating the lining of all canals will give an indication of the maximum effects available through this option, while examining each canal lined separately will allow for the effectiveness to be compared across the different canals. The last alternative which reflects lining a 20% section of each canal that has the highest seepage rate is more sophisticated and will allow for a better understanding of how the benefits of canal lining respond to the scale and location of adoption.

Several methods can be used to line irrigation canals in order to decrease seepage. These methods include buried geomembrane, exposed geomembrane, shotcrete, concrete, compacted clay, and the application of polyacrylamides. Swihart and Haynes (2002) present a comprehensive review of several canal-lining methods. One of the more cost-effective methods identified in this study was a concrete covered geomembrane liner. Additionally, Sayer et al. (1997) presented a comparison of canal lining techniques along the Catlin canal, which is located within the study area. Estimates of these local canal-lining costs ranged from $1.57/ft^2 for a soil-covered geomembrane to $3.26/ft^2 for a three-inch concrete liner. Both of the studies indicate that a covered geomembrane liner can reduce seepage by more than 90% and have a design life of 40-60 years. As such, the installation of a soil-covered geomembrane liner achieving a 90% reduction in seepage at a cost of $1.57/ft^2 will be applied in this chapter. Using an annual maintenance cost of $0.005/ft^2 (Swihart and Haynes 2002) and a design life of 50 years, the total annual cost is estimated to be $0.055/ft^2 (complete description of costs see Appendix 4.1).

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To apply the estimated cost per square foot, the total length of canal lined and the lining perimeter for each canal must also be specified (Table 4.1).

Table 4.1: Length, Width, Depth and Lining Perimeter of each Canal.

Canal #	Canal Name	Total Length (ft)[1]	Average Width (ft)[2]	Average Canal Depth (ft)[3]	Average Perimeter (ft)[4]
1	Holbrook	228,615	22.1	8.0	44.1
2	Rocky Ford	74,678	19.3	8.0	41.3
3	Catlin	165,105	24.4	6.0	42.4
4	Otero	179,015	13.3	8.0	35.3
5	RF Highline	208,205	24.8	8.0	46.8
6	Fort Lyon	124,134	75.0	14.0	109.0
	All Canals	979,752	29.8	8.7	53.2

[1] Directly measured, [2] Average value of approx. 7 measurements made on each canal, [3] Personal communication with employees from each canal, [4] Calculated as P= Width+2*Depth+6.

The total length and average width for each canal was estimated using direct measurements taken as part of the extensive field data collection initiated in 1998 (Gates et al. 2002). Average canal depths were estimated by employees from each of the respective canal companies. Once the width and depth was estimated for each canal, they were used to estimate the average canal-lining perimeter. The average canal lining perimeter reflects the distance needed to cover both the width and depth of each canal and includes an additional three feet on each side utilized to anchor the membrane liner on top of the canal. Using the costs and canal parameters identified above, the total annual cost associated with each of the eight alternatives can be seen in Table 4.2.

Table 4.2: Total Annual Cost for each Canal Lining Alternative.

Lining Alternatives	Total Annual Cost
Line All Canals	$2,735,760
Line Canal 1	$554,731
Line Canal 2	$169,480
Line Canal 3	$385,144
Line Canal 4	$347,180
Line Canal 5	$535,553
Line Canal 6	$743,672
Line 20% All Canals	$547,152

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Reducing Aquifer Recharge

This set of alternatives focuses upon decreasing the amount of aquifer recharge associated with excessive irrigation applications. The mechanism that will be used to decrease current recharge rates will reflect discrete structural changes in irrigation technologies. The current irrigation system that is most commonly used in the region consists of an open ditch furrow system. According to the methods used to parameterize the hydrologic model of the study area, the average baseline application efficiency is approximately 60% (Burkhalter 2003). Although the estimated baseline application efficiency appears to be somewhat high, it is within the range of typical efficiencies identified for traditional furrow systems as identified by Soltanpour, et al. (1999).

Three different levels of irrigation technology improvements will be evaluated. These technologies and the corresponding level of application efficiency are as follows: gated pipe (70% efficient), gated pipe with surge valve (80% efficient), and subsurface drip irrigation (90% efficient). The application efficiency for gated pipe reflects a 10% increase from current rates. By replacing the open ditch conveyance system with gated pipe, Buller et al. (1988) indicates the potential of increasing application efficiencies by as much as 10%-15%. This increase results from reducing the quantity of water lost to evaporation, infiltration, and transpiration from weeds that would currently be occurring along the open ditches. The application efficiencies specified for gated pipe with surge valves and subsurface drip irrigation were used as identified by Soltanpour et al. (1999).

Although center pivot sprinkler irrigation is often less expensive than subsurface drip irrigation (SDI), research by O'Brien et al. (1998) has shown that SDI is less expensive per acre when fields are 64 acres or less. The average irrigated field size

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within the study area is only 22.8 acres, with less than 4% of the fields being larger than 64 acres. Because of the small field sizes within the study area, SDI was assumed to be the most likely choice for a high efficiency irrigation alternative.

The installation costs associated with the adoption of gated pipe was estimated to cost approximately $8,429 ($370/acre) or $19.94/acre/year, the addition of surge valves increased the costs to approximately $10,700 ($469/acre) or $26.00/acre/year, and the cost of SDI was estimated to cost $21,251 ($664/acre) or approximately $74.80/acre/year (For detailed description of the cost see Appendix 4.2.

To convert the costs of increasing application efficiency into the costs of reducing aquifer recharge, it is necessary to identify the relationship between increased application efficiency and reduced aquifer recharge. Within the hydrologic model, aquifer recharge rates were assumed to account for 70% of applied water losses (portion of water applied not available for crop ET), following field estimates in the South Platte Valley by Walter (1995). Therefore, given an application efficiency of 60%, the level of water loss would be 40% (1-.6) and the associated level of aquifer recharge would be 28% (.7*.4=.28). To reflect a 10% decrease in aquifer recharge from 28% to 25.2%, the level of applied water loss must also decrease by 10%. Since the current water loss is 40%, a 10% reduction from 40% to 36% would only occur if application efficiency increased by 4%. Therefore, every 4% increase in application efficiency results in a 10% decrease in aquifer recharge rates. As such, gated pipe (70% efficient) corresponds to a 25% reduction in aquifer recharge, gated pipe with surge (80% efficient) corresponds to a 50% reduction in recharge, and subsurface drip (90% efficient) will correspond to a 75% reduction in recharge rates.

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Although the costs for only three levels of recharge reduction are calculated, the benefits associated with nine different levels were estimated. The nine levels of aquifer recharge that will be considered reflect incremental 10% reductions (10%-90%) from the established baseline levels.

Increasing Subsurface Drainage

This set of alternatives represents the installation of subsurface drains to a specified group of fields within the study area. Four subsurface drainage alternatives were evaluated as a result of analyzing drainage spaced at four different levels (50 m, 75 m, 100 m, 150 m) all having a consistent depth of 2.5 meters. Under each of the alternatives, approximately 16,400 acres of land that had an average baseline water table depth of less than two meters is modeled to represent the effects of drainage. These fields have been identified in Figure 4.2 and represent approximately 26% of the total area within the study region.

Figure 4.2: Shaded Fields were Selected for Modeled Drainage Alternatives.

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To identify the costs associated with each of the drainage alternatives, the cost per linear foot and total length of installation was estimated. The cost per linear foot of installation was identified through personnel communication with the owner of a local excavation company (Dewitt 2003). Although many methods of subsurface drainage are available, two typical systems that are commonly used in the region were identified. The more basic and less expensive method used is to install a six-inch corrugated plastic pipe without a gravel or sand envelope placed around it. This method was estimated to cost approximately $2.50 per linear foot and the equipment used at this cost was not capable of installation below 5 ½ feet deep. A more advanced system that utilizes the same six-inch pipe, but surrounds it with a sand or gravel envelope in order to help water drain was estimated to cost approximately $5.00 per linear foot. The equipment required for this installation is capable of reaching depths of up to 8 feet. Since the more sophisticated method is more consistent with the characteristics of the drains that were assumed for the hydrologic model, the installation costs associated with this method were applied. In addition to the installation costs, the annual maintenance costs and typical design life were identified in order to estimate the total annual cost of approximately $.2355 per linear foot (for detail of costs see Appendix 4.3).

The total length of drain installed under each alternative varied as a result of the different drain spacing considered. A total of 1,062 grid cells (250m by 250m) in the hydrologic model were modeled to reflect the effects of drainage. To estimate the total length of drainage for each alternative, the average number of drains that could be placed on each grid cell was identified. The average number of drain lines per cell equaled 5, 3.33, 2.5, and 1.66, for the drainage spaced at 50m, 75m, 100m, and 150m, respectively.

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The total length of drainage and total annual costs for each drainage alternative can be seen in table 4.3.

Table 4.3: Total Length of Drains Modeled and Total Annual Cost for each Level of Drainage.

Drainage Spacing	Total Length of Drainage (ft)	Total Annual Cost
50m	4,354,200	$1,026,501
75m	2,902,797	$684,333
100m	2,177,100	$513,250
150m	1,451,399	$342,167

Increasing Groundwater Pumping

This set of alternatives represents the evaluation of increasing groundwater pumping above current levels in order to increase the depth of the regional water table. Four pumping alternatives were specified, including increasing the quantity of water pumped from all existing wells by 25%, 50%, 100%, and 200%. Each of the alternatives was constructed as to only allow for increased pumping from existing wells, the location of which can be seen in Figure 4.3. During the three years modeled, a total of 215 wells were active, averaging 190 wells operated each year.

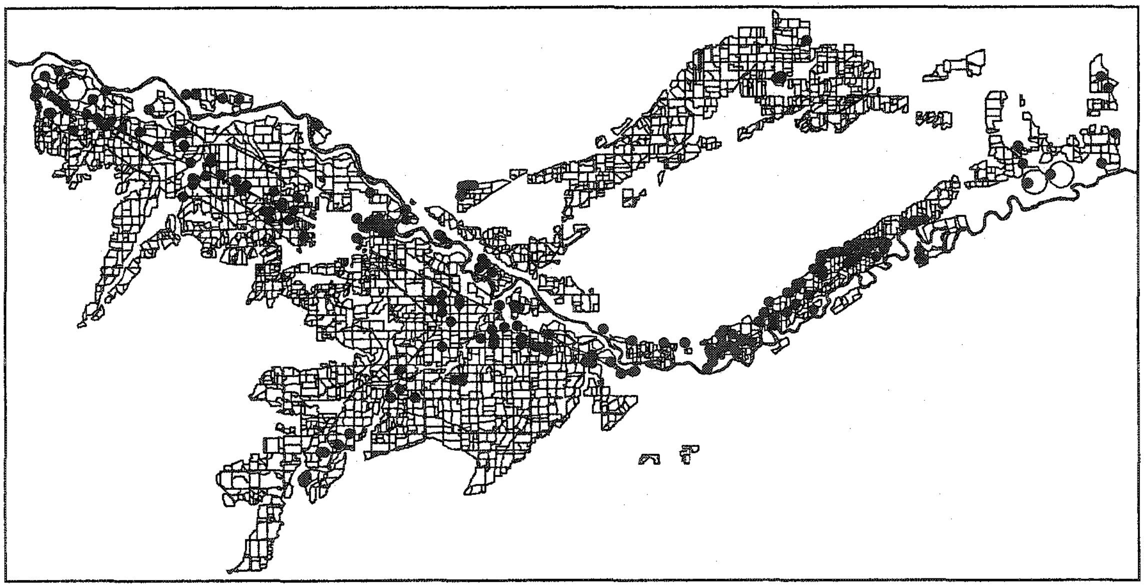

Figure 4.3: Location of Existing Wells used for Increasing Groundwater Pumping.

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For simplicity, the costs identified for each alternative will only reflect the additional energy requirements associated with each level of pumping. Although there may be additional depreciation of the pumping equipment and additional costs associated with routing water back to the river, they have not been included. In order to calculate the cost of pumping groundwater, a power coefficient for pumping must be identified. The power coefficient relates the amount of electrical energy required to a well in order to extract an additional unit of water. The equation describing the general form of the power coefficient, measured in kilowatt-hours of energy per acre-foot (*kWh/AF*), can be seen in equation 4.2.

$$\text{(4.2)} \qquad \textit{Power Coefficient}\ (PC) = \frac{(1.02 * TDH)}{EFF}$$

Where *TDH* is the total dynamic head, measured in feet, and *EFF* is a measure of the well pump efficiency. The value of 1.02 represents the number of kilowatt-hours required to lift one acre-foot of water one foot with 100% efficiency. Boyle Engineering Corporation (1990) identified the average power coefficient within the study area to be 89 *kWh/AF*, this value reflects the typical well pump efficiency and head in the region. Therefore, it takes approximately 89 kilowatt-hours of electricity to pump one additional acre-foot of groundwater to the surface within the study area. Given the current electricity rates specified for irrigation and pumping uses of \$0.04/*kWh* (Southeast Colorado Power Association 2003), it would cost approximately \$3.56/AF to pump groundwater.

The total quantity of groundwater pumped (in acre-feet) under baseline conditions, as identified by the state engineers office, and level of increased pumping modeled for each alternative can be seen in Table 4.4.

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Table 4.4: Total Groundwater Pumped under Baseline Conditions and the Additional Amount of Water Pumped under each Alternative.

	Total GW Pumped Baseline (AF)	Additional GW Pumped under each Alternative (AF)			
		25%	50%	100%	200%
1999	106,241	26,560	53,121	106,241	212,483
2000	172,259	43,065	86,129	172,259	344,518
2001	189,907	47,477	94,953	189,907	379,814
Average	156,136	39,034	78,068	156,136	312,271

Using the estimated cost of $3.56/AF for pumping groundwater, the total annual cost associated with each alternative was estimated (Table 4.5).

Table 4.5: Total Annual Costs Associated with each Groundwater Pumping Alternative.

	% Increase in Pumping			
	25%	50%	100%	200%
1999	$94,555	$189,110	$378,219	$756,438
2000	$153,310	$306,621	$613,241	$1,226,482
2001	$169,017	$338,034	$676,068	$1,352,137
Average	$138,961	$277,921	$555,843	$1,111,686

<u>Relocation of Crops</u>

This alternative is unique from the others because it does not make use of improved water management, but examines the redistribution of current cropping patterns (location of crop type in study area). Although it might be expected that crop types would be located to maximize the profitability of the region, the current location of crops as identified by the Farm Service Agency does not. This alternative will allow the economic model to reallocate crop production locations in order to maximize regional profits, while maintaining the total quantity of each crop type grown in each canal area. Although some factors may exist that would limit the ability of producers to grow certain crops on different fields within the study area (e.g. inability to move specialized

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equipment), in general it is believed that producers could adjust these planting decisions. The mathematical representation of the optimization model can be written as follows:

$$\text{Maximize } \Pi = \sum_{c=1}^{C} \sum_{i=1}^{I} \sum_{k=1}^{K} \left[(P_k - HC_k) * Y_{cik} * A_{cik} - NHC_k \right]$$

$$\text{Where:}$$

$$Y_{cik} = Y_k^P * RY_{cik}^S * RY_{cik}^{WTD} \tag{4.3}$$

$$RY_{cik}^S = 100 - b_k (EC_{ci} - a_k) \quad \text{for } EC_{ci} \geq a_k$$

$$RY_{cik}^{WTD} = 100 - d_k (c_k - WT_{ci}) \quad \text{for } WT_{ci} \leq c_k$$

$$\text{Subject to:}$$

$$\sum_{i=1}^{I} A_{cik} \leq B_{ck}$$

$$\sum_{k=1}^{K} A_{cik} \leq L_{ci}$$

This model represents only minor changes from the model presented in (4.1). In this case, total profits across the study area are optimized by selecting the quantity of acres of each crop on each canal area field (A_{cik}) instead of using the Farm Service Agency (FSA) information on what crop was actually grown on each field each year. The choice variable is subject to two sets of constraints. The first set of constraints restricts the sum of a crops acres across all fields within a canal command area to be less than or equal to the total quantity of each crop type grown in each canal area as specified by the local FSA (B_{ck}). Although the model can reallocate the location of planting decisions, this constraint forces the model to grow the same total quantity of acres of each crop in each canal area. The second set of constraints limits the total quantity of crop production on each canal area field to be less than or equal to the size of the field (L_{ci}).

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Combined Alternatives

In addition to evaluating all of the alternatives mentioned above individually, several combinations of alternatives will be considered. The specific combination of alternatives that will be selected and evaluated will be identified once the effects of each are known individually. By comparing the individual effects of alternatives to the combined effects, the interdependence between the different management approaches will be revealed. Specifically, it will be interesting to discover whether the sum of benefits associated with the individual alternatives will be greater than or less than the benefits associated with the combination of alternatives implemented simultaneously.

Results

For each alternative the direct benefits to agricultural production and the costs of implementing the alternative are compared. The direct benefit to agricultural production is estimated as the difference between the baseline level of agricultural returns to the new level of returns associated with each alternative. Although the benefits of each alternative are estimated for each field and year, they will be summarized into the three-year average impact for each canal area and in total. In addition, the effect that each alternative has upon salt load to the river will be presented and discussed. The results indicate which alternatives have the ability to improve current conditions and additionally, if any appear to be economically justified. Once the effects of each alternative have been evaluated, sensitivity analysis will be conducted for all of the relevant parameters (potential crop yields, crop prices, soil salinity response thresholds, soil salinity response slope parameters, waterlogging response thresholds, and

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waterlogging response slope parameters) to discover whether the general conclusions would be affected by these changes. For a detailed summary of economic output for each alternative see Appendix 4.4.

Reducing Seepage from Irrigation Canals

The average annual benefit to agricultural production associated with each of the canal lining alternatives can be seen in Table 4.6.

Table 4.6: The Average Annual Benefit to Agricultural Production Associated with each Canal Lining Alternative for each Canal Area and in Total.

Canal Lining Alternative	Canal Area						
	1	2	3	4	5	6	Total
Line all canals	$139,431	$63,921	$56,915	$14,223	$75,547	-$3,800	$346,237
Line canal 1	$123,914	$43,817	$23,516	-$18,832	$4,674	-$4,344	$172,744
Line canal 2	-$50,042	$45,423	$20,857	-$18,729	$3,704	-$5,077	-$3,864
Line canal 3	-$49,649	$43,273	$41,719	-$10,564	$3,929	-$6,587	$22,121
Line canal 4	-$49,779	$46,712	$38,557	$1,825	$17,960	-$5,020	$50,255
Line canal 5	-$50,468	$47,490	$26,158	-$18,299	$52,830	-$2,271	$55,440
Line canal 6	-$49,030	$44,427	$24,091	-$18,777	$3,582	-$4,000	$293
20% of canals	-$14,733	$55,341	$44,614	$3,518	$3,529	-$6,712	$85,557

The impacts associated with the set of canal lining alternatives range from a low of $-3,864 to a high of $346,237. As expected, the most extensive canal lining alternative that examined lining all of the irrigation canals resulted in the largest gain to productivity. To better understand how the benefits of lining all canals vary spatially and temporally, figure 4.4 (Page 98) shows the estimated level of benefits for each field during each year. It can be seen that the impacts vary significantly, fields may benefit, bear additional costs, or be unaffected by the alternative. In 1999, a region located along the south central section of the study area appears to receive a high concentration of the benefits. This area is located around canals 3 and 4 (Catlin and Otero), and was found to be an area with relatively high baseline soil salinity levels for this year. However, it can

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be seen in later years (2000 and 2001) that the benefits within this area decrease and for many fields become negative.

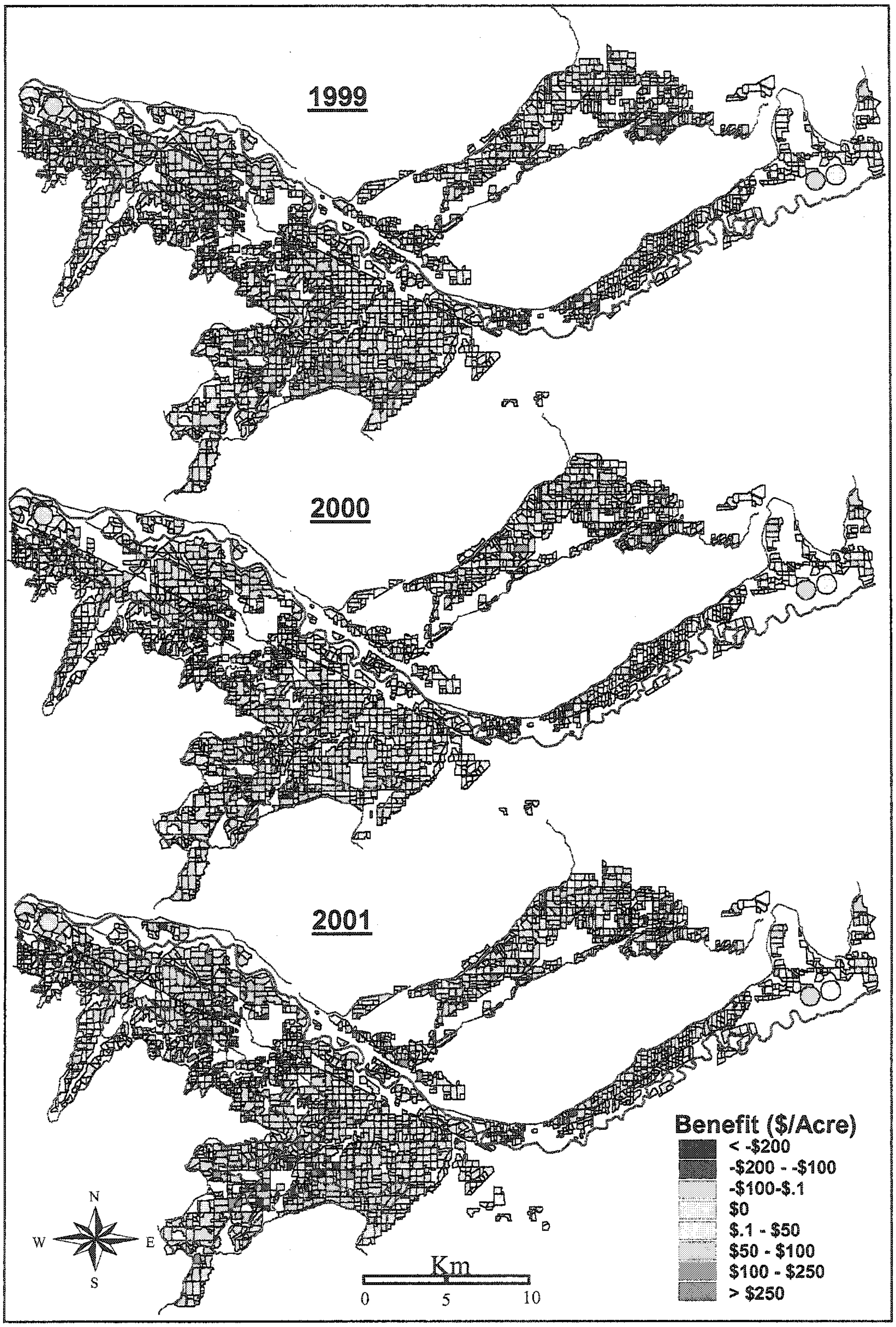

Figure 4.4: Benefits of Lining all Irrigations Canals for each Field and Year.

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To make the effects of each canal lining alternative more comparable, the benefits to agricultural productivity must be compared to the costs. Average annual benefit, annual costs, change in annual profits, ratio of benefits and costs, and reduction in costs that is needed for each alternative to breakeven (benefits = costs) is estimated (Table 4.7).

Table 4.7: Comparison of the Benefits to Agricultural Production and the Costs for each Canal Lining Alternative.

Canal Lining Alternative	Avg. Annual Benefit	Annual Costs	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven
Line all canals	$346,237	$2,735,760	-$2,389,522	0.127	87%
Line canal 1	$172,744	$554,731	-$381,987	0.311	69%
Line canal 2	-$3,864	$169,480	-$173,345	-0.023	102%
Line canal 3	$22,121	$385,144	-$363,023	0.057	94%
Line canal 4	$50,255	$347,180	-$296,925	0.145	86%
Line canal 5	$55,440	$535,553	-$480,112	0.104	90%
Line canal 6	$293	$743,672	-$743,379	0.000	100%
20% of all canals	$85,557	$547,152	-$461,595	0.156	84%

As can be seen in table 4.7, none of the canal-lining alternatives resulted in a benefit cost ratio greater than or equal to one. This means that the benefits to agricultural productivity were less than the costs associated with implementing each of the alternatives. The highest ratio of benefits to costs occurred from lining Canal 1 (Holbrook Canal), which had an average return of approximately $.31 for every dollar invested. Lining Canal 2 (Rocky Ford Canal) was estimated to reduce overall productivity and resulted in negative benefits to agriculture. This occurred because the hydrologic model predicted a slight decrease in overall water table depth for 1999 and slightly increased soil salinity levels for all three years for this alternative. Further hydrologic analysis will need to be examined to discover why these negative effects occurred.

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The returns associated with lining a 20% section of each canal having the highest seepage rate had an average annual benefit of $85,557. Since this alternative targeted the section of each canal with the highest seepage rates, it was expected to perform better per dollar invested than the alternative that simply lined the total length of all canals. This alternative did result in a larger return per dollar invested than the alternative lining all canals, however the difference was minor.

According to the above analysis, none of the canal lining alternatives is estimated to improve agricultural productivity in the study area enough to offset the high initial construction costs. However, this research indicates how much costs would need to be reduced in order to make each alternative breakeven.

Salt Load Effects

Although the benefits to agricultural productivity (within the study area) were less than the costs of implementing each of the canal lining alternatives, the additional effect upon salt load to the river should be addressed. Using the estimated effects upon salt load and the impact each alternative had upon regional profitability, the cost per unit reduction in salt load can be calculated (Table 4.8).

Table 4.8: Effect of Canal Lining Alternatives on Salt Load and Cost per Ton Reduction.

Lining Alternatives	Change in Weekly Salt Load (Ton)	% Change in Total Salt Load	Change in Avg. Annual Profits	Cost/Ton Salt Load Reduction
Line All Canals	-3,536	-19.43%	-$2,389,522	$13.00
Line Canal 1	-615	-3.38%	-$381,987	$11.95
Line Canal 2	426	2.34%	-$173,345	-
Line Canal 3	187	1.03%	-$363,023	-
Line Canal 4	184	1.01%	-$296,925	-
Line Canal 5	470	2.58%	-$480,112	-
Line Canal 6	987	5.42%	-$743,379	-
Line 20% All Canals	-996	-5.47%	-$461,595	$8.91

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The effect that each canal lining alternative has upon current salt loads to the river ranges from a decrease of approximately 19% to an increase of over 5%. For the canal lining alternatives that reduce salt load (lining all canals, lining only canal 1, and lining 20% of all canals), the average cost per ton of salt load reduction can be estimated. The costs of salt load reduction range from $13.00/ton to a low of $8.91/ton when a 20% section of each canal with the highest seepage rate is lined. If the downstream benefits associated with reduced salt load were estimated to exceed the costs of salt load reduction, these alternatives would become socially justified (Total benefits ≥ Total Costs).

<u>Reducing Aquifer Recharge</u>

The average annual benefit to agricultural production associated with each of the alternatives reducing the level of aquifer recharge can be seen in Table 4.9.

Table 4.9: The Average Annual Benefit to Agricultural Production Associated with each Alternative Reducing Aquifer Recharge Rates for each Canal Area and in Total.

Recharge Reduction	Canal Area 1	2	3	4	5	6	Total
10%	$92,167	$61,309	$97,791	$15,525	$47,191	$54,866	$368,850
20%	$162,815	$109,905	$180,736	$24,730	$75,883	$102,240	$656,309
30%	$215,835	$147,090	$250,285	$32,671	$98,834	$130,055	$874,770
40%	$254,597	$168,904	$298,362	$33,726	$111,898	$140,648	$1,008,135
50%	$285,266	$179,858	$334,354	$35,850	$112,832	$149,199	$1,097,358
60%	$303,160	$180,048	$338,272	$32,693	$98,912	$141,218	$1,094,304
70%	$304,208	$181,346	$317,522	$27,509	$66,218	$135,369	$1,032,172
80%	$291,926	$170,660	$265,038	$17,564	$34,118	$110,300	$889,607
90%	$260,139	$154,672	$200,937	$462	-$32,160	$79,611	$663,661

As anticipated, the results indicate that decreasing the level of field recharge rates will result in positive benefits for producers in the region. This occurs because reducing overall recharge rates successfully increased average water table depths and decreased

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average soil salinity levels. As aquifer recharge rates are decreased the annual benefits continue to increase until the rate has been reduced past 50%, additional reductions above this level causes the benefits to productivity to begin to decrease (Figure 4.5).

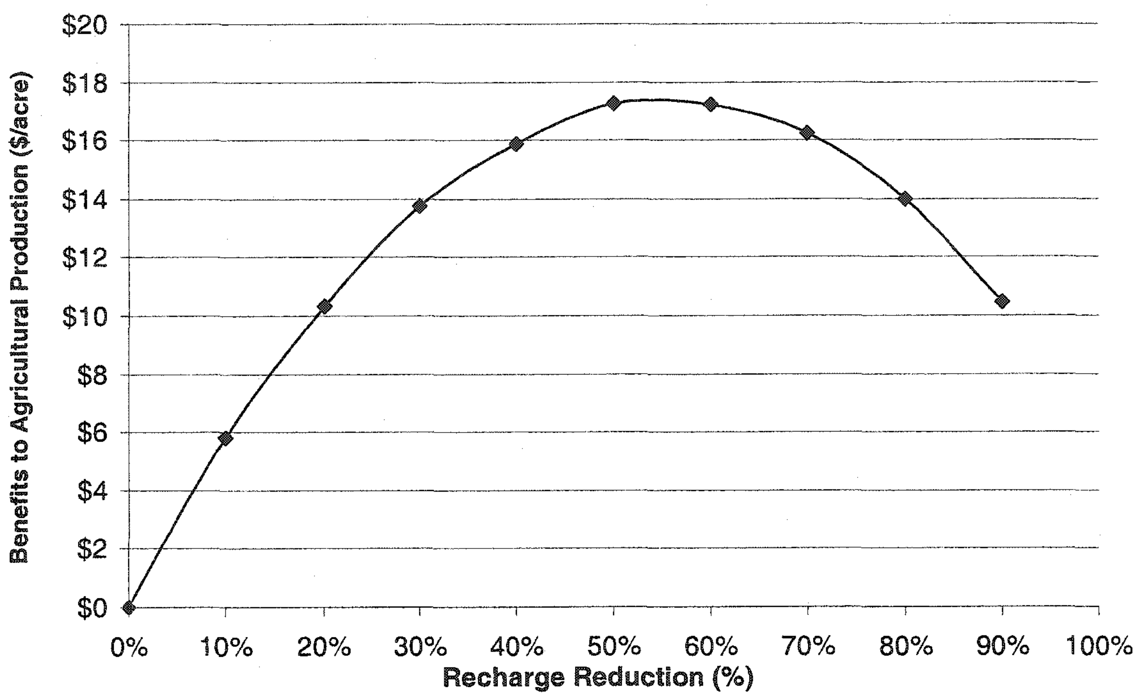

Figure 4.5: Average Annual Benefit to Agricultural Productivity per acre given each level of Aquifer Recharge Reduction.

Figure 4.5 shows how the benefits to agricultural productivity are maximized at $17.28/acre when the reduction in recharge is 50%. To gain a better understand of how the benefits of reducing aquifer recharge by 50% vary spatially and temporally, figure 4.6 (Page 103) shows the benefits on each field for each year. Although this figure shows that the benefits to productivity vary considerably, there does not appear to be any significant pattern to the benefits. This likely occurred because the reduction in aquifer recharge rates was applied to all fields across the study area. Therefore, no one canal area appears to benefit more than another.

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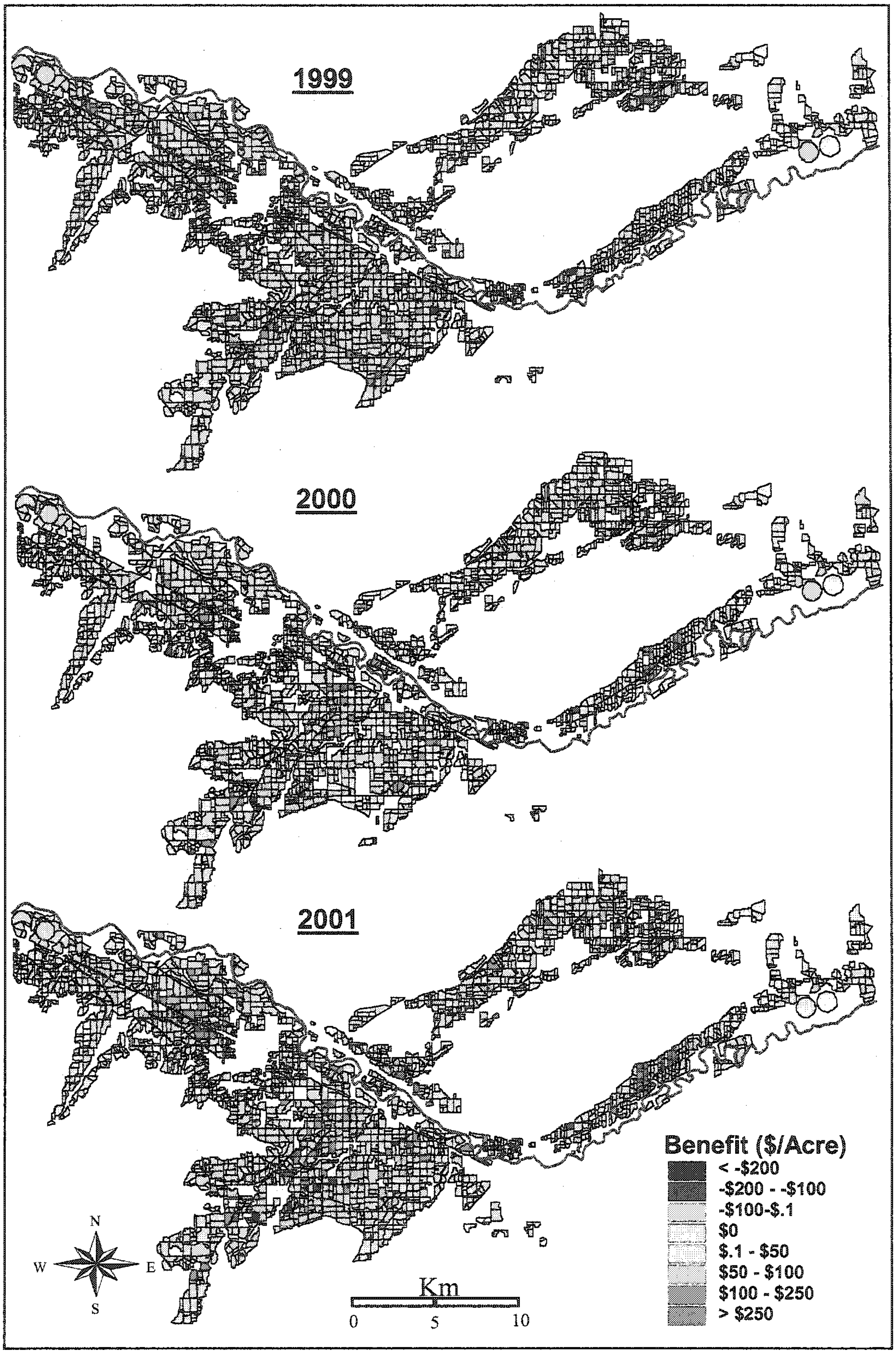

Figure 4.6: Benefits of Reducing Aquifer Recharge Rates by 50% for each Field and Year.

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Although each of the aquifer recharge reduction alternatives increased the value of productivity, the costs of obtaining these levels of reduction must be considered. As estimated earlier in the chapter, the annual cost of a gated pipe system was $19.94/acre, gated pipe with surge valve was approximately $26.00/acre, and the cost of a subsurface drip system was approximately $74.80/acre. Since the level of aquifer recharge reduction for gated pipe (25%) and subsurface drip (75%) do not directly correspond to any of the levels evaluated, benefits for these levels reflect the average of the levels evaluated above and below it. Table 4.10 summarizes both the costs and returns for the three levels of recharge reduction for which cost estimates were generated.

Table 4.10: Comparison of the Benefits to Agricultural Production and the Costs for each of the Aquifer Recharge Reduction Alternatives.

Recharge Reduction	Avg. Annual Benefit	Annual Costs	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven
25%	$765,539	$1,266,526	-$500,987	0.604	40%
50%	$1,097,358	$1,651,439	-$554,080	0.664	34%
75%	$960,889	$4,751,062	-$3,790,172	0.202	80%

Although gated pipe with surge valves (80% efficient) does correspond with the 50% level in recharge reduction, which maximizes the gains to agricultural productivity, the value of the benefits are unable to offset the costs. The ratio of the productivity benefits to the costs for a 50% reduction in aquifer recharge was the highest at approximately .66. This indicates that on average for every dollar invested in this alternative over 66% of the costs are expected to be recovered by the gains to agricultural productivity. Therefore, if the costs of reducing aquifer recharge by 50% were able to be reduced by approximately 34%, the productivity benefits of this alternative would equal the costs.

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Salt Load Effects

Although none of the irrigation technologies were found to increase overall productivity enough to offset the costs of adoption, the additional benefits associated with reduced salt load is considered. Using the estimated effects upon salt load and the impact each alternative had upon average annual profits, the cost per unit reduction in salt load is calculated (Table 4.11).

Table 4.11: Effect of Aquifer Recharge Reduction Alternatives on Salt Load and Cost per Ton Reduction.

Recharge Reduction	Change in Weekly Salt Load (Ton)	% Change in Total Salt Load	Change in Avg. Annual Profits	Cost/Ton Salt Load Reduction
10%	-522	-2.87%	-	-
20%	-1,048	-5.76%	-$500,987	$7.35
30%	-1,574	-8.65%		
40%	-2,091	-11.49%	-	-
50%	-2,619	-14.39%	-$554,080	$4.07
60%	-3,140	-17.25%	-	-
70%	-3,693	-20.29%	-$3,790,172	$18.26
80%	-4,289	-23.57%		
90%	-4,854	-26.67%	-	-

The set of alternatives reducing aquifer recharge rates are estimated to reduce current salt loads by as little as 3% to as much as 27%. Although each of the alternatives reduced salt load to the river, the average cost per ton of salt load reduction can only be estimated for the three alternatives that had the costs estimated. The costs of salt load reduction range from $18.26/ton to a low of only $4.07/ton when recharge reduction is reduced by 50% using gated pipe with surge valves. Compared to the other levels of recharge reduction, a 50% reduction maximizes the benefits to agricultural productivity, had the highest ratio of benefits to costs, and reduces salt load to the river at the lowest cost. As such, this appears to be the most attractive level of recharge reduction. In

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addition, if future research indicates that the benefits associated with reduced salt load exceeded $4.07/ton the total benefits would exceed the costs for this alternative.

Increasing Subsurface Drainage

The average annual benefit to agricultural production associated with each level of subsurface drainage can be seen in Table 4.12

Table 4.12: The Average Annual Benefit to Agricultural Production Associated with each Subsurface Drainage Alternative for each Canal Area and in Total.

	Canal Area						
Drain Spacing	1	2	3	4	5	6	Total
50 m	$171,644	$101,060	$79,353	$2,935	$664	-$27,686	$327,969
75 m	$129,160	$92,044	$58,480	-$7,341	$1,304	-$14,780	$258,867
100 m	$103,635	$80,539	$37,049	-$10,861	$888	-$14,501	$196,748
150 m	$69,017	$67,741	$2,604	-$11,110	-$1,974	-$5,372	$120,906

As anticipated, the closer the subsurface drainage is spaced the more beneficial. As such, the benefits to productivity are the highest when the drainage is spaced at 50 meters. To gain a better understand of how the benefits of drainage spaced at 50 meters vary spatially and temporally, figure 4.7 (page 107) shows the estimated benefits on each field for each year. The majority of effects correspond to the regions that were targeted for this alternative (see figure 4.2, page 90). However, many fields that are located near the targeted areas were also affected. Figure 4.7 also shows how the benefits appear to be much larger during 1999 as compared with either 2000 or 2001. This result occurred because the hydrologic model estimated improvements in soil salinization in the first year (1999), but predicted worse soil salinity conditions for both 2000 and 2001. When reviewing the related hydrologic analysis the negative soil salinity effects in 2000 and 2001 are referred to as a short term "modeling phenomenon" due to the reduction of water in the soil profile, which had previously had a dilution effect upon soil salinity. It

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is believed that the soil salinity levels would actually decrease overtime, but that the three-year model was unable to capture these long-term effects (Burkhalter 2003).

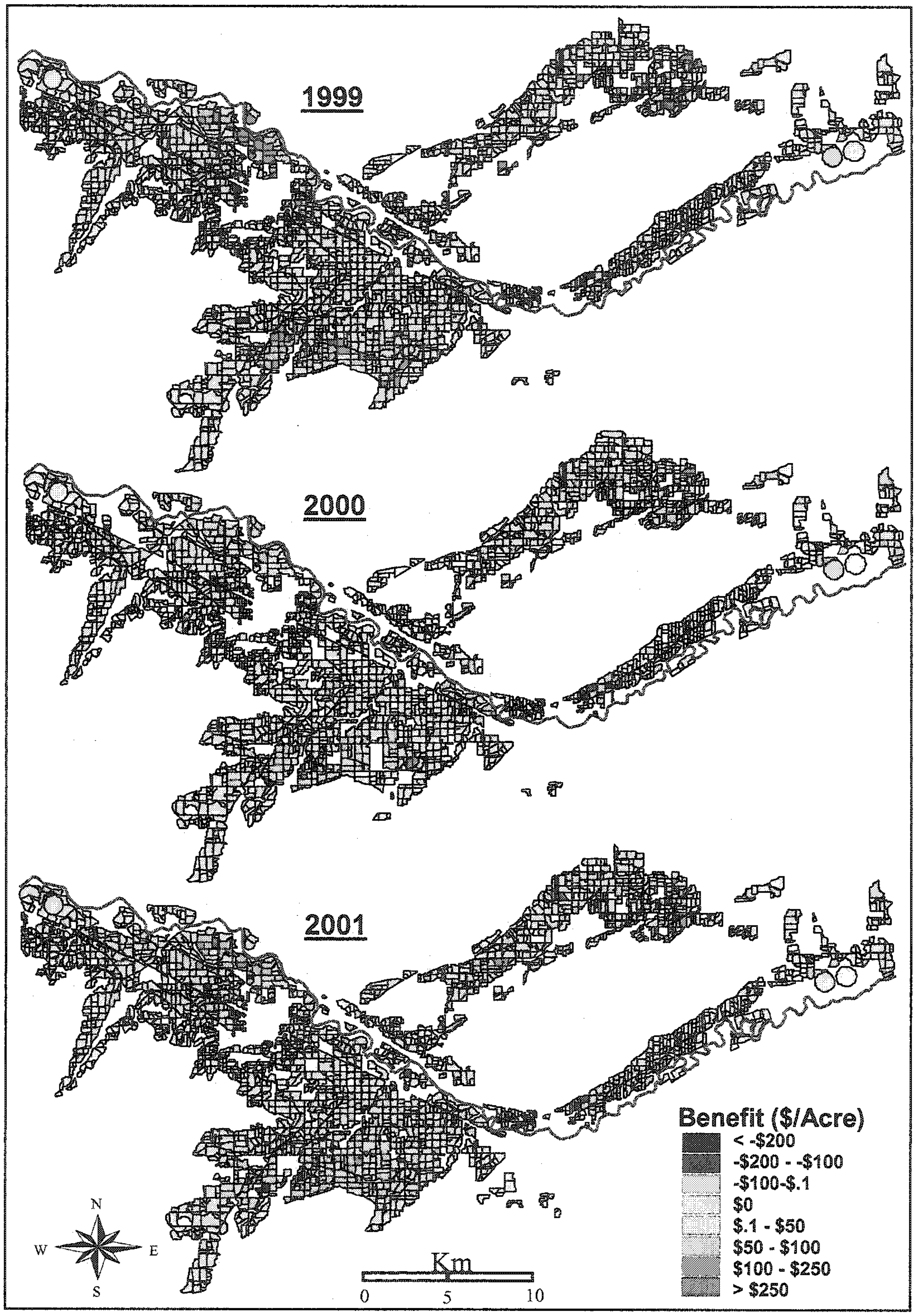

Figure 4.7: Benefits of Subsurface Drainage Using a 50 Meter Spacing for each Field and Year.

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Although each of the subsurface drainage alternatives increases the value of average annual production, these benefits are less than the annual costs associated with installing and maintaining the subsurface drainage (Table 4.13).

Table 4.13: Comparison of the Benefits to Agricultural Production and the Costs for each level of Subsurface Drainage Spacing.

Drain Spacing	Avg. Annual Benefit	Annual Costs	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven
50 meters	$327,969	$1,026,501	-$698,532	0.320	68%
75 meters	$258,867	$684,333	-$425,466	0.378	62%
100 meters	$196,748	$513,250	-$316,502	0.383	62%
150 meters	$120,906	$342,167	-$221,261	0.353	65%

These results indicate drainage spaced at 100 meters returns the highest average benefit per dollar invested, but that the annualized costs of subsurface drainage would still need to be decreased by approximately 62% in order to have the benefits equal the costs. Although none of the subsurface drainage alternatives were found to have the average benefit over a three year time period to be greater than the costs, it is believed that the long-term effectiveness will need to be determined to appropriately evaluate these alternatives. It is anticipated that this set of alternatives would become much more attractive if they were examined over a longer period of time.

Salt Load Effects

In addition to the direct effects that each drainage alternative has upon agricultural production within the study area, the additional impact upon salt load to the river is presented (Table 4.14). All of the subsurface drainage alternatives are estimated to increase total salt load to the river by as little as 3% to as much as 16%.

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Table 4.14: Effect of Subsurface Drainage on Salt Load.

Drain Spacing	Change in Weekly Salt Load (Ton)	% Change in Total Salt Load	Change in Avg. Annual Profits	Cost/Ton Salt Load Reduction
50 m	2,864	15.74%	-$698,532	-
75 m	1,367	7.51%	-$425,466	-
100 m	1,022	5.62%	-$316,502	-
150 m	521	2.86%	-$221,261	-

The increase in salt load results from the immediate drainage of highly saline groundwater that was located under the waterlogged lands that were targeted. However, additional research is needed to discover whether this increase in salt load would continue in the long run or be a short run phenomenon. Since all of the alternatives were found to increase salt load, there is no opportunity of evaluating the costs associated with reducing salt load. When considering the adoption of this set of alternatives, the external costs associated with increasing the salt load to the river must be considered.

Increasing Groundwater Pumping

The average annual benefit to agricultural production associated with each level of increased groundwater pumping can be seen in Table 4.15. Although increased pumping from existing wells does result in an increase in agricultural productivity, the level of increase was minor. The distribution of benefits associated with increasing current groundwater pumping rates by 200% can be seen in figure 4.8.

Table 4.15: The Average Annual Benefit to Agricultural Production Associated with each Groundwater Pumping Alternative for each Canal Area and in Total.

	Canal Area						
Pumping Increase	1	2	3	4	5	6	Total
25%	$3,203	$2,307	-$6,732	-$76	-$502	$2,918	$1,120
50%	$5,018	$6,968	-$3,372	$177	-$449	$8,149	$16,492
100%	$9,795	$11,787	$5,400	$668	$605	$12,105	$40,359
200%	$18,158	$26,952	$5,601	$614	$3,098	$22,782	$77,205

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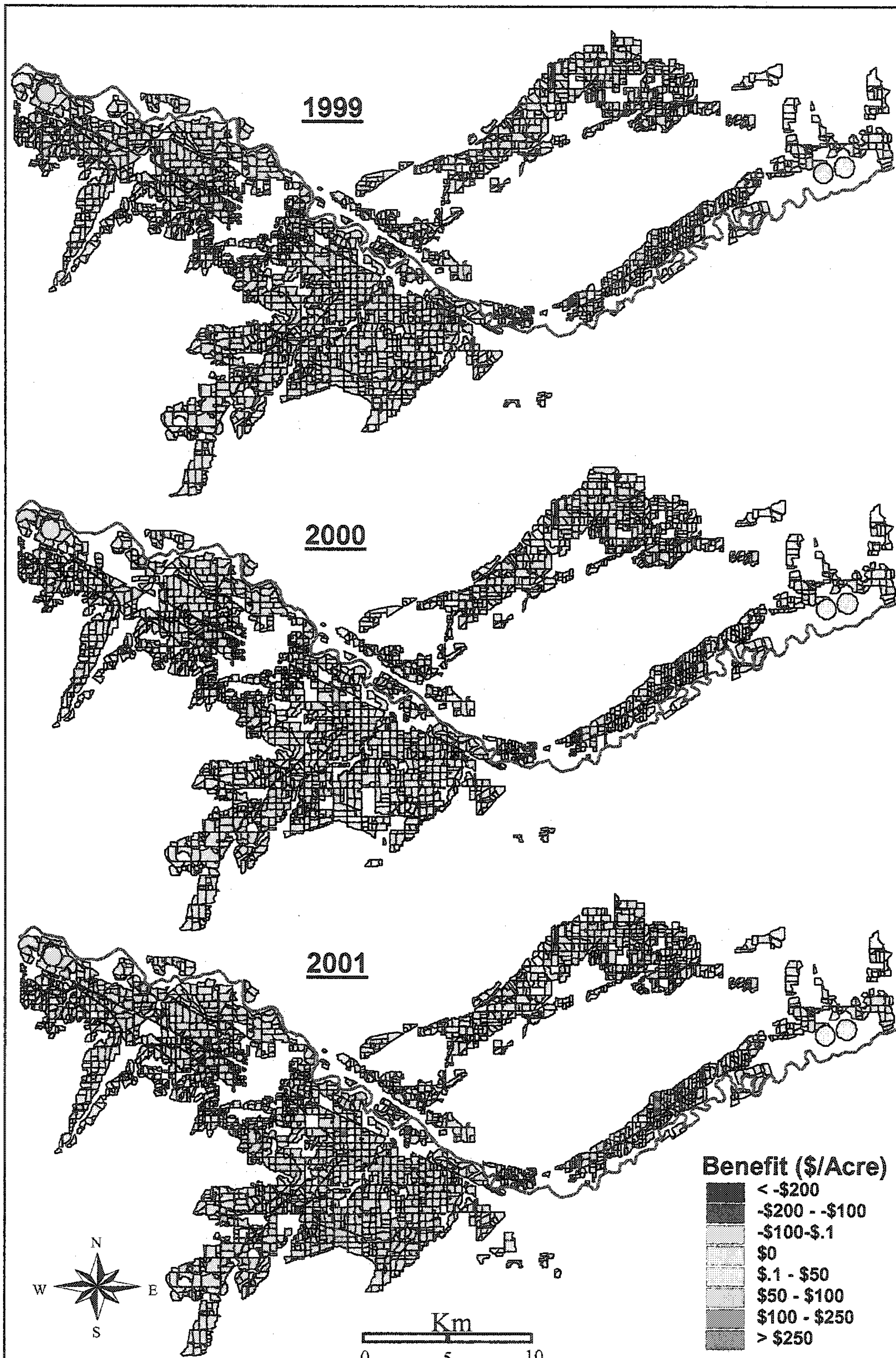

Figure 4.8: Benefits to Productivity Associated with Pumping Additional Groundwater for each Field and Year.

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Figure 4.8 indicates that the groundwater pumping alternative had little or no effect upon most of the fields within the study area for each year. Although the benefits of groundwater pumping were estimated to be relatively minimal across the study area, they must be compared to the costs for further evaluation. When the annual productivity benefits were compared to the estimated annual costs, the benefits were found to be much lower (Table 4.16).

Table 4.16: Comparison of the Benefits to Agricultural Production and the Costs for each level of Groundwater Pumping Increase.

Pumping Increase	Avg. Annual Benefit	Annual Costs	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven
25%	$1,120	$138,961	-$137,841	0.008	99%
50%	$16,492	$277,921	-$261,429	0.059	94%
100%	$40,359	$555,843	-$515,484	0.073	93%
200%	$77,205	$1,111,686	-$1,034,481	0.069	93%

On average, the largest expected return per dollar invested occurs under increasing groundwater pumping by 100%, which only results in a return of agricultural productivity valued at approximately $.07. This implies that the costs of pumping groundwater would need to be reduced by approximately 93% before the alternative would result in benefit that equaled the costs. The inability of these groundwater pumping alternatives to significantly increase agricultural returns indicates the limited potential of this method.

Salt Load Effects

Increased groundwater pumping was also estimated to increase total salt load to the river (Table 4.17).

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Table 4.17: Effect of Groundwater Pumping on Salt Load.

Pumping Increase	Change in Weekly Salt Load (Ton)	% Change in Total Salt Load	Change in Avg. Annual Profits	Cost/Ton Salt Load Reduction
25%	1,042	5.73%	-$137,841	-
50%	1,104	6.07%	-$261,429	-
100%	1,215	6.68%	-$515,484	-
200%	1,575	8.65%	-$1,034,481	-

As a result of minimal benefits to productivity and increased salt load to the river this set of alternatives does not appear to be promising.

Relocation of Crops

Relocating crop types in each canal area to maximize regional profits results in increased overall agricultural productivity as expected. The benefits of this alternative are presented for each of the three years in Table 4.18.

Table 4.18: Annual Benefit to Agricultural Production Associated with Relocating Crops in order to Maximize Regional Profits.

	Canal Command Area						
	1	2	3	4	5	6	Total
1999	$537,803	$316,700	$968,071	$161,660	$501,361	$428,297	$2,913,893
2000	$516,096	$235,344	$667,083	$130,385	$472,591	$324,736	$2,346,235
2001	$593,575	$304,575	$928,946	$205,168	$398,984	$460,357	$2,891,605
Average	$549,158	$285,540	$854,700	$165,738	$457,645	$404,464	$2,717,244

This alternative resulted in a three-year average benefit of approximately $2.7 million by increasing the average profitability by approximately $43/acre, from $174/acre to $217/acre. The distribution of the benefits for each of the years can also be seen in Figure 4.9 (page 113). Since this alternative allows for the crop choice on a given field to change, instead of examining the benefits of marginal changes to the quality to land, the distribution of benefits appears to be much more variable.

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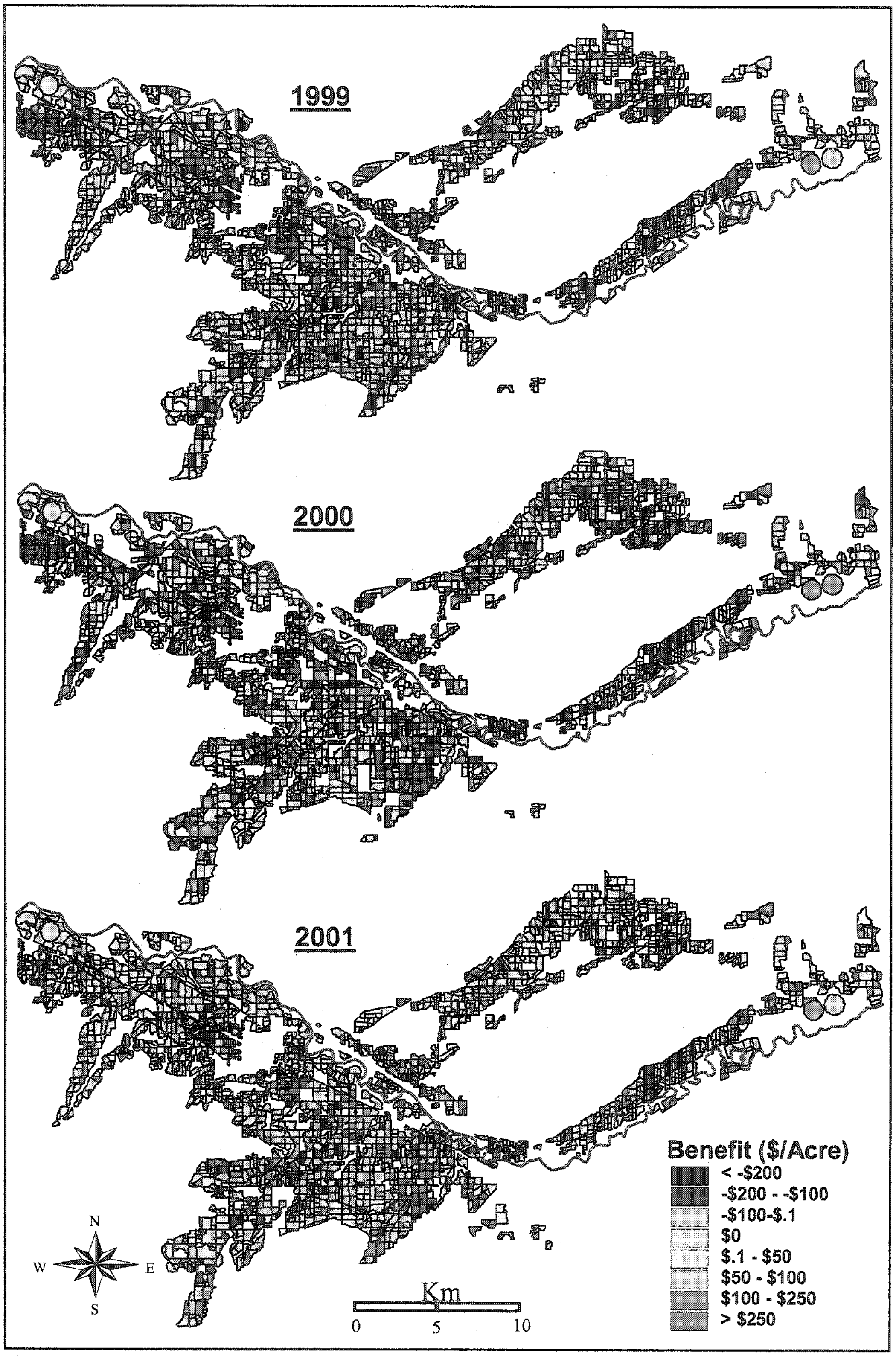

Figure 4.9: Benefits Associated with Relocating Crop Planting Decisions in order to Maximize Regional Profits for each Field and Year.

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When the optimal location of crops was compared to the established baseline locations it was found that on average only 27% of the total number of fields' crop choice was unchanged. The costs associated with relocating crops across the remaining 73% of the fields is unknown, however, these results indicate the large regional benefits that could be gained.

With such large potential gains it would be interesting to understand why current planting decisions are not consistent with maximizing regional profit. The answer is likely to reflect whether the model objective has correctly identified how decisions are made. If the objective of maximizing regional profit was in fact the only criteria behind crop location, it would be expected that given full information the crops would be placed optimally. If this objective is correct, then the average annual benefit of $2.7 million dollars could reflect the value of knowing the current distribution of waterlogging and soil salinization and how crop yields respond to these factors. Although additional information would be valuable to producers, lack of information is not the only reason why current crop locations do not maximize regional profits.

An additional reason explaining why individual producers have not made planting decisions consistent with maximizing regional profits is that maximizing regional profits is likely not their objective. Although total profits of the study area increase under this objective, some fields benefit while others suffer losses. Individual farmers will make decisions based upon their specific objectives, not the region's, and will reflect a set of farm specific parameters (crop knowledge, equipment, water supply, etc.). The objectives of individual farmers are taken into account under the baseline conditions as a result of using information about the actual crop type planted on each field. It is

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anticipated that with better information some crops would be relocated to increase productivity, however relocating all crops in order to maximize regional profits would not likely be possible due to the sophisticated centrally planned planting system that would be needed.

It is believed that the relocation of crops within a canal area will have no effect upon water table depths, soil salinity, and salt load.

Combined Alternatives

After reviewing the benefits of each alternative individually, several combinations of alternatives were evaluated. By examining the effects of applying more than one alternative at the same time, the interaction between alternatives can be discussed. Both the relocation of crops and increasing groundwater pumping alternatives were excluded from the combinations evaluated. The groundwater pumping alternatives were excluded because they were found to be relatively ineffective and increased salt load to the river. Relocation of crops was excluded because it did not attempt to reduce waterlogging and soil salinity, but examined the ability to respond to current levels. Instead, the alternative that benefited agricultural production the most from each of the remaining three categories was selected. As such, the four combination of alternatives evaluated include the following: (1) lining all canals and reducing aquifer recharge by 50%, (2) lining all canals and drainage spaced at 50 meters, (3) reducing aquifer recharge by 50% and drainage spaced at 50 meters, and finally (4) lining all canals, reducing aquifer recharge by 50%, and drainage spaced at 50 meters. The comparison of the benefits for each combination alternative and costs of implementation are presented in table 4.19.

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Table 4.19: Comparison of the Benefits to Agricultural Production and the Costs for each Combination Alternative.

Combining Alternatives	Avg. Annual Benefit	Annual Costs	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven
Line all canals & reduce recharge 50%	$1,373,466	$4,387,198	-$3,013,732	0.313	69%
Line all canals & drainage spaced 50m	$499,534	$3,762,261	-$3,262,726	0.133	87%
Reduce recharge 50% & drainage spaced 50m	$1,281,859	$2,677,940	-$1,396,080	0.479	52%
Reduce rech. 50%, line all canals & drainage (50m)	$1,438,424	$5,413,699	-$3,975,276	0.266	73%

The cost of each combination alternative simply reflects the sum of costs for each alternative individually. As can be seen in table 4.19, none of the combination alternatives result in benefits to productivity that are greater than the costs. In addition, if we compare the combined level of benefits to the sum of benefits associated with each of the alternatives evaluated individually, it can be seen that combining the alternatives results in less total benefit to agricultural production (Table 4.20).

Table 4.20: Comparison of the Total Benefits to Agricultural Productivity when Alternatives are Combined versus the Sum of Benefits when they are Separated.

Combined Alternatives	Average Annual Benefit Combined	Sum of Avg. Benefits when Separated	Difference Between Combined and Separated
Line all canals & reduce recharge 50%	$1,373,466	$1,443,595	-$70,129
Line all canals & drainage spaced 50m	$499,534	$674,206	-$174,673
Reduce recharge 50% & drainage spaced 50m	$1,281,859	$1,979,408	-$697,549
Reduce rech. 50%, line all canals & drainage (50m)	$1,438,424	$1,771,565	-$333,141

Although combining alternatives does not appear to intensify the effectiveness of the alternatives, the addition of another alternative does appear to contribute additional benefits to the initial alternative. In the case of lining all canals and reducing aquifer

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recharge by 50% the relationship is close to additive since the estimated benefits are within 5% of the sum of benefits when separated. This is not the case for combing a 50% reduction in aquifer recharge with subsurface drainage spaced at 50 meters. In this case, the benefits of the alternatives combined are 35% less than the sum of benefits when separated. These results are important and must be taken into account when several different methods for dealing with waterlogging and soil salinization are being considered for adoption.

Salt Load Effects

In addition to the direct effects that each combination alternative has upon agricultural production within the study area, the impact upon salt load to the river is presented (Table 4.21).

Table 4.21: Effect of Combination Alternatives on Salt Load and the Cost per Ton Reduction.

Combined Alternatives	Change in Weekly Salt Load (Ton)	% Change in Total Salt Load	Change in Avg. Annual Profits	Cost/Ton Salt Load Reduction
Line all canals & reduce recharge 50%	-5,933	-32.60%	-$3,013,732	$9.77
Line all canals & drainage spaced 50m	-1,623	-8.92%	-$3,262,726	$38.66
Reduce recharge 50% & drainage spaced 50m	-509	-2.80%	-$1,396,080	$52.75
Reduce rech. 50%, line all canals & drainage (50m)	-5,291	-29.07%	-$3,975,276	$14.45

Since all of the combination alternatives were estimated to reduce total salt load to the river, the estimated cost per ton of salt load reduction was estimated. As mentioned earlier, if future research was to indicate that the benefits of salt load reduction exceeded the costs of reducing salt load using each of the combination alternatives, then the total benefits of the alternatives would be greater than the total costs.

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Overview of all Alternatives

In order to compare and rank the effects of all the alternatives evaluated, several different criteria that have already been addressed could be used. Alternatives could be compared based upon their ability to increase benefits to agricultural productivity, the impact they have upon average annual profits, the ratio of the productivity benefits to the costs, the reduction in costs that would be needed to breakeven, or the cost at which salt load reductions are accomplished. Based upon the criteria, different alternatives will be considered more appealing. Table 4.22 summarizes the results of each alternative using the different criteria identified.

Although the benefits to productivity provide us with an understanding of the magnitude of effects that can be accomplished by each alternative, it does not provide any information about the means required to implement the alternative. As such, it is not expected to be a good indicator of overall alternative performance. However, the largest benefit to production occurs under the combination alternative where aquifer recharge rates are reduced by 50%, all of the canals are lined, and subsurface drainage is installed using a 50 meter spacing.

The estimated change in average annual profits (average annual benefits to productivity – annual cost) does account for both the benefits to productivity and the costs of implementing each of the alternatives. Since all of the alternatives were found to have the costs exceed the benefits to productivity, using this criterion would indicate that taking no action would be best. However, when comparing across the alternatives evaluated, increasing groundwater pumping by 25% results in the smallest overall loss to profitability. This occurs because the costs of implementing this alternative are much

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lower than the costs for all other alternatives. A limitation of this criterion is that it fails to acknowledge that the groundwater pumping alternatives resulted in very little benefits.

Table 4.22: Overview of all Alternatives.

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$346,237	-$2,389,522	0.127	87%	$13.00
Line Canal 1	$172,744	-$381,987	0.311	69%	$11.95
Line Canal 2	-$3,864	-$173,345	-0.023	102%	-
Line Canal 3	$22,121	-$363,023	0.057	94%	-
Line Canal 4	$50,255	-$296,925	0.145	86%	-
Line Canal 5	$55,440	-$480,112	0.104	90%	-
Line Canal 6	$293	-$743,379	0.000	100%	-
Line 20% All Canals	$85,557	-$461,595	0.156	84%	$8.91
Recharge Reduction					
10%	-	-	-	-	-
20%	$765,539	-$500,987	0.604	40%	$7.35
30%					
40%	-	-	-	-	-
50%	$1,097,359	-$554,080	0.664	34%	$4.07
60%	-	-	-	-	-
70%	$960,890	-$3,790,172	0.202	80%	$18.26
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$327,969	-$698,532	0.320	68%	-
75 m	$258,867	-$425,466	0.378	62%	-
100 m	$196,748	-$316,502	0.383	62%	-
150 m	$120,906	-$221,261	0.353	65%	-
Pumping Increase					
25%	$1,120	-$187,841	0.008	99%	-
50%	$16,492	-$261,429	0.059	94%	-
100%	$40,359	-$515,484	0.073	93%	-
200%	$77,205	-$1,034,481	0.069	93%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,373,466	-$3,013,732	0.313	69%	$9.77
Line all canals & drainage spaced 50m	$499,534	-$3,262,726	0.133	87%	$38.66
Reduce recharge 50% & drainage spaced 50m	$1,281,859	-$1,396,080	0.479	52%	$52.75
Reduce rech. 50%, line all canals & drainage (50m)	$1,438,424	-$3,975,276	0.266	73%	$14.45

*Shaded cells indicate highest ranking alternative within each criteria column.

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Using the ratio of productivity benefits to costs provides additional information about the magnitude of the benefits as compared to the costs. This criterion can also be represented by the reduction in costs that are needed to breakeven. Ranking the alternatives using these measures allows us to identify the method that would require the least percentage increase in benefits or decrease in costs to be justified (benefits ≥ costs). Under this criterion, reducing aquifer recharge rates by 50% would be preferred, since the benefits to productivity would equal the costs if the costs could be reduced by 34%.

The main limitation of all of the criteria that have been discussed so far is that they ignore the additional benefits associated with changes in salt load to the river. Although the benefit of reducing salt load is not estimated, estimating the cost at which salt load reduction is being accomplished is very useful. The average annual cost per ton salt load reduction ranges from a high of $52.75 to a low of only $4.07 when aquifer recharge rates are reduced by 50%. If future research determined that the benefits associated with salt load reduction were to exceed these costs, then these alternatives would all be economically justified. That is, the total benefits would be greater than the total costs.

Sensitivity Analysis

To understand how the evaluation of each alternative would be affected as a result of changes in the underlying parameters, sensitivity analysis was conducted. The set of parameters that were adjusted include: potential crop yields, crop prices, soil salinity response thresholds, soil salinity response slope parameters, waterlogging response thresholds, and waterlogging response slope parameters. The adjustments reflect a 20% increase and a 20% decrease from the initial value of each parameter. After each

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parameter adjustment was made, each of the alternatives was reevaluated. (See Appendix 4.5 for summarized results for each alternative under each parameter change).

In general, the effectiveness of alternatives are improved when a change is made to a parameter that causes crop yields to be more sensitive to either waterlogging or soil salinity. Additionally, when prices or potential yields are increased the benefits of the alternatives are increased. For example, under a 20% increase in crop prices the alternative that reduces aquifer recharge rates by 50%, reduces salt load at approximately $2.01/ton instead of $4.07/ton under the initial price levels.

Although the results vary when changes are made to these parameters, the ranking of alternatives under each criterion stays the same. In addition, under all of the parameter changes evaluated none of the alternatives are estimated to provide benefits to agricultural production in the study area that exceed the costs. Therefore, the general conclusions that are made in this study will hold for a wide range (+ or – 20%) of changes to the underlying parameters.

Conclusions

Each of the methods evaluated for reducing waterlogging and soil salinization were found to be capable of increasing the agricultural productivity of the study area. Although the high costs associated with each alternative were estimated to be greater than the direct benefits to productivity, this research identifies several water management alternatives that were able to reduce salt load to the river at relatively low cost.

In the case of using a soil-covered geomembrane liner to reduce canal seepage, three of the canal lining alternatives evaluated (lining all canals, lining canal one, and

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lining a 20% section of each canal with the highest seepage rate) were shown to reduce salt load to the river. These three alternatives accomplished salt load reductions at an average cost that ranged from approximately $8.91 to $13.00/ton. Due to the reduction in salt load, future research examining the benefits of salt load reduction may show that these alternatives are in fact economically justified (total benefits ≥ total costs). For reference, research by Gardner and Young (1985) estimated the benefits (damages avoided) of salt discharge reduction to be approximately $26/ton in the lower Colorado River Basin.

The most promising set of alternatives analyzed, was the reduction of aquifer recharge rates (i.e. deep percolation) resulting from improved irrigation application efficiencies. Although the costs of achieving reductions in aquifer recharge were greater than the benefits to productivity, this set of alternatives accomplished salt load reductions at the lowest costs. Specifically, it was shown that reducing aquifer recharge rates by 50% has the ability to increase agricultural productivity within the study area enough to offset more than 66% of the costs and ultimately reduced salt loads to the river at approximately $4.07/ton.

The set of alternatives that examined the potential of increasing groundwater pumping were shown to reduce total profitability of the region and increase total salt load to the river. As such, it is believed that this set of alternatives should be removed from potential adoption. Although the installation of subsurface drainage also reduced total profitability and was estimated to increase salt loads over the three years modeled, it is believed that the long-term effects need to be addressed further before this method is abandoned.

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The relocation of crop planting decisions resulted in the largest average benefit to the value of annual agricultural production. Although regional profits could be improved significantly, it is anticipated that costs associated with planning such an alternative would likely cause this method to be unfeasible.

This study provides useful information for comparing the effectiveness of each alternative on improving agricultural productivity within the study area over a three year time period. The importance of estimating the long-term effects and accounting for the additional impacts upon salt load are revealed. If the long-term hydrologic relationships were available, the effects of each alternative might become more apparent. In addition, longer-term modeling may also indicate whether baseline conditions were expected to improve or worsen. If it was anticipated that current conditions would continue to degrade without any action, the benefits of each alternative may increase significantly. Future research examining waterlogging and soil salinization will benefit from examining the long-term effects of alternatives and accounting for the value associated with reducing salt load to the river.

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APPENDIX 2.1

GAMS CODE FOR PLATTE RIVER BASIN OPTIMIZATION MODEL

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GAMS Code for Platte River Basin Optimization Model

```
SETS

CROP         Crop names /ALFALFA, CORN, BEETS, BEANS, WHEAT, IDLE/
PERIOD1      States of nature for the early water /S11, S12, S13/
PERIOD2      States of nature for late water  /S21, S22, S23/
IRRSTR1      Irrigation strategy for the first period /0, 1, 2, 3, 4, 5, X/
IRRSTR2      Irrigation strategy for the second period /0, 1, 2, 3, 4, 5, X/;

SCALARS

LANDAVAIL Available land in acres  /1000/
EFF          Irrigation Efficiency /XX/
*Replace XX with region specific application efficiency
CLOSS        Canal losses /XX/
*Replace XX with region specific canal loss estimates
;

PARAMETERS

$include C:\Platte_Parameters.prn
* This include file retrieves the following parameters:
* HARCOST(CROP) Harvest costs for each crop ($/unit harvested)
* PRICE(CROP) Prices for each crop ($/unit harvested)
;
$Include C:\flows.prn
* This include file retrieves the following parameters and tables:
* PROB1(PERIOD1) Probability of each state for early water supply
* EARLY(PERIOD1) Early water available in each state in total acre inches
* TABLE PROB2(PERIOD1,PERIOD2) Prob of each state of nature in period 2 given
* the state of nature in time period 1
TABLE LATE(PERIOD1,PERIOD2) Amount of water available in each state of nature
* during period 2 in acre inches
;

$Include C:\Include.prn
*gets the following data containing regional farm parameters for each of the five regions
* TABLE YIELD(CROP,IRRSTR2,IRRSTR1) Yields for each crop under each irrigation
* schedule
* TABLE NHARVCOST(CROP,IRRSTR2,IRRSTR1) Non-harvest costs for each
* irrigation schedule
* TABLE WATERREQE(CROP,IRRSTR1) water requirement for the early time period
* growth stages
* TABLE WATERREQL(CROP,IRRSTR2,IRRSTR1) Water requirement for the late
* time period growth stages
```


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POSITIVE VARIABLES

ACRES2(CROP,PERIOD1,PERIOD2,IRRSTR2,IRRSTR1) Acres of land in period 2
ACRES1(CROP,PERIOD1,IRRSTR1) Acres of land for each use in period 1

VARIABLES

PROFIT(CROP,PERIOD1,PERIOD2) Net profit
EXPFT(CROP,PERIOD1,PERIOD2) Expected net profit
TOTPFT1(PERIOD1,PERIOD2) Total expected profit in each state of nature
TOTPFT Total expected profit;

EQUATIONS

CALCPFT(CROP,PERIOD1,PERIOD2) Calculate profit
CALCEXPFT(CROP,PERIOD1,PERIOD2) Calculate expected profit
CALCTOPFT1(PERIOD1,PERIOD2) Calculate total expected profit for each state
CALCTOTPFT Calculate total expected profit
CALCROT1(PERIOD1) Alfalfa rotation constraint
CALCROT2(PERIOD1) Corn rotation constraint
CALCROT3(PERIOD1) Beets rotation constraint
CALCROT4(PERIOD1) Beans rotation constraint
CALCROT5(PERIOD1) Wheat rotation constraint
CALCLATE(PERIOD1,PERIOD2) Late Water constraint
CALCEARLY(PERIOD1) Early Water constraint
LAND(PERIOD1) Link first period crops (Including Idle) to land available
LINK1(CROP,PERIOD1,PERIOD2,IRRSTR1) Link acres in period 1 to period 2
;

```
CALCPFT(CROP,PERIOD1,PERIOD2).. PROFIT(CROP,PERIOD1,PERIOD2) =E=
        SUM( (IRRSTR2,IRRSTR1),((PRICE(CROP) - HARCOST(CROP))
        *YIELD(CROP,IRRSTR2,IRRSTR1)-HARVCOST(CROP,IRRSTR2,
        IRRSTR1))*ACRES2(CROP,PERIOD1,PERIOD2,IRRSTR2,IRRSTR1)) ;

CALCEXPFT(CROP,PERIOD1,PERIOD2).. EXPFT(CROP,PERIOD1,PERIOD2)
        =E= PROFIT(CROP,PERIOD1,PERIOD2) * PROB1(PERIOD1)
        *PROB2(PERIOD1,PERIOD2) ;

CALCTOPFT1(PERIOD1,PERIOD2).. TOTPFT1(PERIOD1,PERIOD2) =E= SUM(
        CROP, EXPFT(CROP,PERIOD1,PERIOD2));

CALCTOTPFT.. TOTPFT =E= SUM( (PERIOD1,PERIOD2), TOTPFT1(PERIOD1,
        PERIOD2) ) ;

CALCROT1(PERIOD1).. SUM(IRRSTR1, (ACRES1('ALFALFA',PERIOD1,
        IRRSTR1))) =L= 0.2*LANDAVAIL;
```


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```
CALCROT2(PERIOD1).. SUM(IRRSTR1, (ACRES1('CORN',PERIOD1,IRRSTR1)))
        =L= 0.55*LANDAVAIL;

CALCROT3(PERIOD1).. SUM(IRRSTR1, (ACRES1('BEETS',PERIOD1,IRRSTR1)))
        =L= 0.10*LANDAVAIL;

CALCROT4(PERIOD1).. SUM(IRRSTR1, (ACRES1('BEANS',PERIOD1,IRRSTR1)))
        =L= 0.05*LANDAVAIL;

CALCROT5(PERIOD1).. SUM(IRRSTR1, (ACRES1('WHEAT',PERIOD1,IRRSTR1)))
        =L= 0.10*LANDAVAIL;

CALCEARLY(PERIOD1).. SUM( (CROP,IRRSTR1), ACRES1(CROP,PERIOD1,
        IRRSTR1)*(WATERREQE(CROP,IRRSTR1))) =L= ((1-CLOSS)*EFF)*
        EARLY(PERIOD1);

CALCLATE(PERIOD1,PERIOD2).. SUM( (CROP,IRRSTR2,IRRSTR1), ACRES2
        (CROP,PERIOD1,PERIOD2,IRRSTR2,IRRSTR1)*(WATERREQL(CROP,
        IRRSTR2,IRRSTR1))) =L= ((1-CLOSS)*EFF)*LATE(PERIOD1,PERIOD2);

LAND(PERIOD1).. SUM( (CROP,IRRSTR1), ACRES1(CROP,PERIOD1,IRRSTR1))
        =E= LANDAVAIL ;

LINK1(CROP,PERIOD1,PERIOD2,IRRSTR1).. SUM( (IRRSTR2), ACRES2(CROP,
        PERIOD1,PERIOD2,IRRSTR2,IRRSTR1)) =E= ACRES1(CROP,PERIOD1,
        IRRSTR1) ;

MODEL DSSP3 /ALL/ ;
SOLVE DSSP3 USING LP MAXIMIZING TOTPFT ;
```


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APPENDIX 2.2

SUMMARY OF CROP BUDGET COSTS USED IN THE PLATTE RIVER BASIN

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Regional Cropping Costs in the Platte River Basin (Summarized)

REGION 1

	Non-Harvest Fixed	Irrigation Variable	Harvest	Harvest/Unit	Total
Alfalfa:	105.94	12.00	98.81	17.97	$216.75
Meadow Hay:	51.02	14.00	24.98	19.98	$90.00

REGION 2

	Non-Harvest Fixed	Irrigation Variable	Harvest	Harvest/Unit	Total
Corn:	155.61	18.75	17.16	0.12	$ 191.52
Alfalfa:	100.79	18.75	110.40	18.40	$ 229.94
Sugarbeets:	475.04	30.00	46.00	2.00	$ 551.04
Drybeans:	218.82	12.45	9.34	0.0047	$ 240.60
Wheat:	101.39	13.13	9.42	0.14	$ 123.93

REGION 3

	Non-Harvest Fixed	Irrigation Variable	Harvest	Harvest/Unit	Total
Corn:	169.68	11.10	34.85	0.23	$ 215.62
Alfalfa:	202.70	11.85	134.08	19.15	$ 348.63
Soybean:	110.31	6.68	10.73	0.23	$ 127.72

REGION 4

	Non-Harvest Fixed	Irrigation Variable	Harvest	Harvest/Unit	Total
Corn:	276.10	18.00	19.16	0.12	$313.25
Alfalfa:	105.94	12.00	98.81	17.97	$216.75
Sugarbeets:	462.21	18.00	77.79	3.24	$558.00
Drybeans:	254.93	18.00	21.47	0.0098	$294.40
Wheat	111.25	12.6	21.01	0.28	$144.86

REGION 5

	Non-Harvest Fixed	Irrigation Variable	Harvest	Harvest/Unit	Total
Corn:	276.10	18.00	19.16	0.12	$ 313.25
Alfalfa:	105.94	12.00	98.81	17.97	$ 216.75
Sugarbeets:	462.21	18.00	77.79	3.24	$ 558.00
Drybeans:	254.93	18.00	21.47	0.0098	$ 294.40
Wheat	111.25	12.60	21.01	0.28	$144.86

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APPENDIX 2.3

ESTIMATED MONTHLY AGRICULTURAL DIVERSIONS IN EACH REGION UNDER BASELINE CONDITIONS AND EACH ALTERNATIVE

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Region 1: Agricultural Diversion Estimates under Baseline Conditions
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	2,317	14,311	19,855	20,922	6,849	64,254
1976	0	0	0	0	0	0	0	8,204	17,056	19,807	16,937	6,242	68,246
1977	0	0	0	0	0	0	0	12,417	14,049	21,903	12,906	5,349	66,624
1978	0	0	0	0	0	0	0	2,553	10,977	14,640	15,582	8,856	52,608
1979	0	0	0	0	0	0	0	6,674	16,820	17,917	12,825	5,232	59,468
1980	0	0	0	0	0	0	0	9,293	19,886	21,582	14,969	7,029	72,759
1981	0	0	0	0	0	0	0	9,826	16,116	20,537	15,420	9,568	71,467
1982	0	0	0	0	0	0	0	8,278	15,979	16,752	18,710	6,547	66,266
1983	0	0	0	0	0	0	0	2,620	14,616	17,385	18,083	11,302	64,006
1984	0	0	0	0	0	0	0	2,233	20,719	19,025	20,731	9,469	72,177
1985	0	0	0	0	0	0	555	11,726	20,571	22,126	18,369	8,511	81,858
1986	0	0	0	0	0	0	0	7,886	19,603	22,213	20,104	7,345	77,151
1987	0	0	0	0	0	0	0	13,884	16,637	20,648	18,105	4,558	73,832
1988	0	0	0	0	0	0	0	10,798	24,411	25,057	19,174	7,311	86,751
1989	0	0	0	0	0	0	0	16,458	15,729	21,791	15,749	7,587	77,314
1990	0	0	0	0	0	0	65	10,631	20,323	20,110	14,350	10,852	76,331
1991	0	0	0	0	0	0	0	1,432	11,621	23,242	17,500	9,727	63,522
1992	0	0	0	0	0	0	0	22,126	13,716	15,780	16,084	9,170	76,876
1993	10	0	0	0	0	0	0	3,802	10,134	20,245	15,384	7,958	57,533
1994	14	0	0	0	0	0	0	19,478	17,439	19,511	13,926	8,243	78,611
1995	0	0	0	0	0	0	0	0	1,541	13,240	22,770	9,410	46,961
1996	0	0	0	0	0	0	311	10,790	14,461	22,173	18,450	8,297	74,482
1997	0	0	0	0	0	0	0	9,469	12,734	19,265	13,474	11,119	66,061
1998	0	0	0	0	0	0	0	15,907	10,822	17,823	13,416	10,752	68,720

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Region 2: Agricultural Diversion Estimates under Baseline Conditions
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18,669	0	0	0	0	0	14,440	188,225	187,249	371,368	369,248	269,443	1,418,642
1976	31,168	34	0	0	0	0	34,684	171,967	197,583	371,340	357,090	275,066	1,438,932
1977	30,994	0	0	0	0	0	18,410	204,538	178,639	345,168	283,217	213,695	1,274,661
1978	20,428	101	0	0	0	0	43,400	108,342	183,974	358,354	354,597	255,830	1,325,026
1979	0	0	0	0	0	0	21,002	147,042	176,928	344,872	349,349	249,322	1,288,515
1980	21,346	0	0	0	0	0	4,750	159,905	216,032	376,411	357,816	253,158	1,389,418
1981	24,215	0	0	0	0	0	8,145	68,868	218,803	349,631	326,848	236,874	1,233,384
1982	21,035	0	0	0	0	0	31,825	158,412	59,898	321,653	350,044	236,882	1,179,749
1983	7,300	0	0	0	0	0	16,087	64,116	176,349	369,770	380,341	267,422	1,281,385
1984	6,239	0	0	0	0	0	33,560	122,797	241,464	380,963	372,226	259,135	1,416,384
1985	23,622	0	0	0	0	0	29,751	219,614	247,897	392,788	384,245	253,115	1,551,032
1986	20,689	0	0	0	0	0	24,177	178,022	168,764	383,640	372,853	234,131	1,382,276
1987	9,559	0	0	0	0	0	30,332	113,550	163,349	378,041	312,992	197,399	1,205,222
1988	4,251	0	0	0	0	0	39,391	134,350	192,246	389,420	375,475	227,500	1,362,633
1989	15,871	0	0	0	0	0	29,616	152,477	172,153	364,128	335,576	141,484	1,211,305
1990	6,236	0	0	0	0	0	654	21,878	103,529	349,457	307,923	136,004	925,681
1991	4,220	0	0	0	0	0	17,109	51,780	122,684	347,192	349,433	206,472	1,098,890
1992	8,426	0	0	0	0	0	33,284	46,531	61,494	304,146	345,962	179,091	978,934
1993	7,310	12	0	0	0	0	21,797	173,473	88,191	345,327	330,203	190,385	1,156,698
1994	2,271	0	0	0	0	0	9,628	180,475	221,296	355,170	350,242	213,300	1,332,382
1995	11,421	214	0	0	0	0	11,207	47,481	115,394	324,524	373,708	249,362	1,133,311
1996	10,696	0	0	0	0	0	10,523	209,249	170,681	390,696	375,962	205,014	1,372,821
1997	8,831	0	0	0	0	0	2,451	193,968	99,460	381,626	335,365	240,109	1,261,810
1998	12,382	0	0	0	0	0	8,322	184,779	151,038	376,378	366,541	245,097	1,344,537

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Region 3: Agricultural Diversion Estimates under Baseline Conditions
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1,947	0	0	0	0	0	4,385	54,491	82,259	198,685	171,508	51,341	564,616
1976	5,896	0	0	0	0	171	7,607	53,371	97,862	203,925	183,586	52,896	605,314
1977	4,215	143	0	0	0	0	756	43,980	97,302	198,956	151,759	36,506	533,617
1978	1,661	0	0	0	0	0	3,914	52,991	96,900	208,388	172,980	54,331	591,165
1979	0	0	0	0	0	0	2,227	44,194	75,447	161,506	174,543	51,527	509,444
1980	2,169	0	0	0	0	0	3,945	51,300	94,781	229,000	177,912	40,450	599,557
1981	389	0	0	0	0	0	20,446	52,287	89,629	193,853	145,837	36,219	538,660
1982	1,382	0	0	0	0	0	5,320	40,498	62,550	189,984	173,117	43,914	516,765
1983	159	0	0	0	0	0	3,791	36,135	67,151	163,050	174,983	56,299	501,568
1984	406	0	0	0	0	0	206	27,026	68,425	200,003	179,864	53,135	529,065
1985	3,254	0	0	0	0	0	12,968	42,541	78,811	191,647	148,685	33,204	511,110
1986	1,479	0	0	0	0	30	9,098	47,053	96,559	197,016	151,108	28,385	530,728
1987	1,449	192	0	0	0	0	5,037	43,603	83,449	166,162	162,601	26,399	488,892
1988	930	192	0	0	0	0	7,388	45,716	116,738	182,411	156,910	28,708	538,993
1989	1,232	0	0	0	0	0	9,771	53,668	80,387	172,242	167,278	28,362	512,940
1990	299	0	0	0	0	0	7,265	44,792	84,309	206,859	163,633	44,062	551,219
1991	843	0	0	0	0	0	7,168	40,420	88,469	213,496	178,422	26,822	555,640
1992	581	0	0	0	0	60	7,207	44,679	65,348	143,853	158,243	65,105	485,076
1993	1,269	0	0	0	0	200	4,448	36,700	58,527	114,061	117,475	27,394	360,074
1994	196	3	0	0	0	590	9,391	41,856	81,528	162,581	168,987	33,851	498,983
1995	4,793	3	0	0	0	90	4,191	29,540	53,034	189,837	184,073	69,524	535,085
1996	493	0	0	0	0	91	5,331	36,320	61,026	158,211	128,922	31,350	421,744
1997	0	0	0	0	0	0	1,242	41,747	82,107	218,957	151,439	41,854	537,346
1998	0	0	0	0	0	0	7,188	43,461	81,630	183,467	151,914	32,118	499,778

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Region 4: Agricultural Diversion Estimates under Baseline Conditions
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	59,841	68,597	50,775	42,619	37,194	46,374	43,317	69,536	92,343	100,514	91,135	68,809	771,054
1976	59,818	59,739	54,737	43,788	54,670	38,193	47,589	65,189	71,161	56,649	76,512	60,060	688,105
1977	62,294	53,881	58,621	46,600	48,425	39,411	41,602	60,398	63,006	44,582	63,113	53,089	635,022
1978	47,941	43,136	53,155	42,751	43,564	45,192	44,696	72,727	105,402	96,982	65,482	52,752	713,780
1979	55,016	66,134	59,249	44,349	35,790	62,713	52,227	79,090	69,539	97,688	91,180	70,236	783,211
1980	88,036	55,811	25,045	18,350	22,809	37,121	27,093	104,311	94,594	144,492	126,436	83,066	827,164
1981	81,873	63,795	54,241	37,101	49,349	53,445	51,916	66,995	74,557	105,795	107,909	73,510	820,486
1982	69,376	60,829	50,721	47,762	47,483	51,840	44,011	65,203	92,362	141,596	126,160	106,948	904,291
1983	104,224	75,939	28,467	15,639	12,241	34,928	18,956	92,908	91,392	149,491	140,869	84,389	849,443
1984	62,791	43,976	20,955	17,659	27,232	61,363	42,557	100,025	105,739	149,858	134,134	97,097	863,386
1985	69,411	60,770	48,251	22,293	19,046	80,892	77,552	80,727	101,171	137,587	128,889	88,175	914,764
1986	69,481	63,689	26,526	30,597	49,859	75,523	27,278	103,931	93,748	139,369	131,911	76,696	888,608
1987	81,792	68,230	49,137	39,101	45,727	26,233	49,654	82,279	95,827	147,765	128,124	97,771	911,640
1988	82,144	80,181	47,845	9,795	12,552	59,952	76,454	99,849	106,506	142,650	136,643	95,310	949,881
1989	74,056	70,575	42,877	32,436	37,963	66,956	52,811	77,334	99,341	134,959	117,394	105,764	912,466
1990	73,811	75,263	50,571	45,638	31,570	53,901	66,498	81,756	122,778	134,999	128,485	94,896	960,166
1991	92,566	75,735	45,295	35,569	46,248	48,193	54,865	80,578	136,069	148,164	141,207	93,035	997,524
1992	84,614	88,946	75,511	35,373	30,751	49,755	90,400	76,494	107,825	125,820	135,706	95,506	996,701
1993	83,345	79,754	35,275	29,010	42,846	44,461	58,014	86,053	136,716	152,487	137,181	87,296	972,438
1994	64,910	80,835	61,569	48,317	31,974	53,135	71,158	80,670	105,861	110,421	88,732	58,959	856,541
1995	68,018	70,277	65,371	61,097	49,035	49,211	44,027	103,383	85,420	154,128	147,474	94,258	991,699
1996	82,030	68,116	58,423	37,607	30,731	42,522	71,428	99,015	128,852	155,021	128,573	81,448	983,766
1997	71,190	91,235	48,693	27,833	41,625	38,706	79,493	99,140	114,748	158,560	140,521	94,816	1,006,560
1998	73,300	55,568	45,165	13,131	32,415	41,827	81,892	98,860	88,322	141,973	144,883	105,519	922,855

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Region 5: Agricultural Diversion Estimates under Baseline Conditions
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	57,405	7,299	2,310	1,060	1,800	3,207	15,352	126,310	173,420	224,832	225,105	114,114	952,214
1976	37,364	12,436	13,378	4,473	4,253	4,406	22,197	101,903	196,105	242,497	210,821	112,937	962,770
1977	42,658	13,648	6,306	2,812	5,693	7,648	34,763	115,160	205,276	197,831	178,654	90,782	901,231
1978	51,167	16,335	7,440	8,770	6,570	3,631	25,187	104,826	173,490	225,815	207,628	93,286	924,145
1979	49,138	6,298	17,188	10,384	9,945	7,362	23,902	106,822	168,363	233,341	187,016	88,133	907,892
1980	42,909	2,162	3,303	4,660	1,853	5,007	11,506	103,357	176,374	234,397	196,717	97,787	880,032
1981	52,394	18,362	6,670	5,700	4,047	5,357	25,674	99,459	185,145	230,957	198,567	96,821	929,153
1982	72,564	15,798	9,299	5,732	4,895	6,179	35,159	98,300	170,733	220,589	190,625	94,225	924,098
1983	37,053	8,040	2,566	3,408	4,858	7,381	17,756	103,751	165,153	209,302	193,894	101,778	854,940
1984	41,151	6,195	5,589	184	134	4,312	6,627	103,138	177,021	255,763	189,672	93,753	883,539
1985	35,542	6,538	14,887	6,528	5,524	6,199	55,041	117,433	211,338	239,505	206,975	89,941	995,451
1986	23,734	3,266	99	4,148	2,756	13,845	40,613	125,285	173,738	234,157	191,938	84,473	898,052
1987	36,141	10,440	4,612	4,813	3,045	4,794	50,261	120,392	180,413	218,839	177,218	85,363	896,331
1988	30,818	8,674	5,459	5,529	5,037	8,392	31,474	128,412	181,165	212,978	198,058	85,857	901,853
1989	50,799	9,742	5,944	4,654	4,606	8,456	50,351	120,181	175,610	232,489	183,971	82,777	929,580
1990	41,327	11,532	7,319	5,975	8,811	21,829	36,620	109,283	173,466	219,039	172,398	91,027	898,626
1991	40,645	11,129	8,072	6,372	5,966	10,323	31,754	113,764	179,274	228,994	184,514	91,987	912,794
1992	33,412	12,499	9,680	7,255	6,652	13,343	30,611	121,562	169,092	210,342	165,252	77,555	857,255
1993	33,546	19,053	8,266	7,083	5,939	7,839	21,149	124,558	175,729	231,781	184,782	86,873	906,598
1994	36,741	10,065	6,305	5,258	4,741	10,968	34,758	119,237	192,949	200,020	179,279	84,168	884,489
1995	34,283	15,442	7,175	6,259	5,795	11,141	35,056	110,085	167,318	194,793	186,201	98,968	872,516
1996	24,691	21,876	9,253	5,518	7,298	11,946	94,498	128,178	173,079	217,422	174,639	83,974	952,372
1997	28,536	6,955	11,307	16,971	9,343	13,030	38,973	114,256	168,261	234,426	150,917	79,127	872,102
1998	27,881	1,108	3,061	3,985	5,116	10,962	59,983	113,903	182,291	241,500	167,039	93,273	910,102

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Region 1: Agricultural Diversion Estimates for Alternative "Region 1 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	2,317	14,311	19,855	20,922	6,849	64,254
1976	0	0	0	0	0	0	0	8,204	17,056	19,807	16,937	6,242	68,246
1977	0	0	0	0	0	0	0	12,417	14,049	21,903	12,906	5,349	66,624
1978	0	0	0	0	0	0	0	2,553	10,977	14,640	15,582	8,856	52,608
1979	0	0	0	0	0	0	0	6,674	16,820	17,917	12,825	5,232	59,468
1980	0	0	0	0	0	0	0	9,293	19,886	21,582	14,969	7,029	72,759
1981	0	0	0	0	0	0	0	10,185	16,116	20,537	15,420	9,568	71,826
1982	0	0	0	0	0	0	0	8,880	15,979	16,752	18,710	6,547	66,868
1983	0	0	0	0	0	0	0	2,620	14,616	17,385	18,083	11,302	64,006
1984	0	0	0	0	0	0	0	2,233	20,719	19,025	20,731	9,469	72,177
1985	0	0	0	0	0	0	555	11,726	20,571	22,126	18,369	8,511	81,858
1986	0	0	0	0	0	0	0	7,886	19,603	22,213	20,104	7,345	77,151
1987	0	0	0	0	0	0	0	13,884	16,637	20,648	18,105	4,558	73,832
1988	0	0	0	0	0	0	0	10,798	24,411	25,057	19,174	7,311	86,751
1989	0	0	0	0	0	0	0	17,245	16,863	22,418	15,749	7,587	79,862
1990	0	0	0	0	0	0	65	10,631	20,323	20,110	14,350	10,852	76,331
1991	0	0	0	0	0	0	0	2,219	11,621	23,242	17,500	9,727	64,309
1992	0	0	0	0	0	0	0	22,126	13,716	15,780	16,084	9,170	76,876
1993	10	0	0	0	0	0	0	3,802	10,134	20,245	15,384	7,958	57,533
1994	14	0	0	0	0	0	0	19,478	17,439	19,511	13,926	8,243	78,611
1995	0	0	0	0	0	0	0	0	1,541	13,240	22,770	9,410	46,961
1996	0	0	0	0	0	0	311	10,790	14,461	22,173	18,450	8,297	74,482
1997	0	0	0	0	0	0	0	9,469	12,734	19,265	13,474	11,119	66,061
1998	0	0	0	0	0	0	0	15,907	10,822	17,823	13,416	10,752	68,720

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Region 2: Agricultural Diversion Estimates for Alternative "Region 1 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18,669	0	0	0	0	0	14,440	188,225	187,249	371,368	369,248	269,443	1,418,642
1976	31,168	34	0	0	0	0	34,684	171,967	197,583	371,340	357,090	275,066	1,438,932
1977	30,994	0	0	0	0	0	18,410	204,538	178,639	345,168	283,217	213,695	1,274,661
1978	20,428	101	0	0	0	0	43,400	108,342	183,974	358,354	354,597	255,830	1,325,026
1979	0	0	0	0	0	0	21,002	147,042	176,928	344,872	349,349	249,322	1,288,515
1980	21,346	0	0	0	0	0	4,750	159,905	216,032	376,411	357,816	253,158	1,389,418
1981	24,215	0	0	0	0	0	8,145	68,868	218,803	349,631	326,848	236,874	1,233,384
1982	21,035	0	0	0	0	0	31,825	158,412	59,898	321,653	350,044	236,882	1,179,749
1983	7,300	0	0	0	0	0	16,087	64,116	176,349	369,770	380,341	267,422	1,281,385
1984	6,239	0	0	0	0	0	33,560	122,797	241,464	380,963	372,226	259,135	1,416,384
1985	23,622	0	0	0	0	0	29,751	219,614	247,897	392,788	384,245	253,115	1,551,032
1986	20,689	0	0	0	0	0	24,177	178,022	168,764	383,640	372,853	234,131	1,382,276
1987	9,559	0	0	0	0	0	30,332	113,550	163,349	378,041	312,992	197,399	1,205,222
1988	4,251	0	0	0	0	0	39,391	134,350	192,246	389,420	375,475	227,500	1,362,633
1989	15,871	0	0	0	0	0	29,616	152,477	172,153	364,128	335,576	141,484	1,211,305
1990	6,236	0	0	0	0	0	654	21,878	103,529	349,457	307,923	136,004	925,681
1991	4,220	0	0	0	0	0	17,109	51,780	122,684	347,192	349,433	206,472	1,098,890
1992	8,426	0	0	0	0	0	33,284	46,531	61,494	304,146	345,962	179,091	978,934
1993	7,310	12	0	0	0	0	21,797	173,473	88,191	345,327	330,203	190,385	1,156,698
1994	2,271	0	0	0	0	0	9,628	180,475	221,296	355,170	350,242	213,300	1,332,382
1995	11,421	214	0	0	0	0	11,207	47,481	115,394	324,524	373,708	249,362	1,133,311
1996	10,696	0	0	0	0	0	10,523	209,249	170,681	390,696	375,962	205,014	1,372,821
1997	8,831	0	0	0	0	0	2,451	193,968	99,460	381,626	335,365	240,109	1,261,810
1998	12,382	0	0	0	0	0	8,322	184,779	151,038	376,378	366,541	245,097	1,344,537

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Region 3: Agricultural Diversion Estimates for Alternative "Region 1 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1,947	0	0	0	0	0	4,385	54,491	82,259	198,654	171,508	51,341	564,585
1976	5,896	0	0	0	0	171	7,607	53,371	97,862	203,925	183,586	52,896	605,314
1977	4,215	143	0	0	0	0	756	43,980	97,302	198,956	151,759	36,506	533,617
1978	1,661	0	0	0	0	0	3,914	52,991	96,900	208,388	172,980	54,331	591,165
1979	0	0	0	0	0	0	2,227	44,194	75,447	161,494	174,543	51,527	509,432
1980	2,169	0	0	0	0	0	3,945	51,300	94,781	229,000	177,912	40,450	599,557
1981	389	0	0	0	0	0	20,446	52,287	89,629	193,853	145,837	36,219	538,660
1982	1,382	0	0	0	0	0	5,320	40,498	62,550	189,984	173,117	43,914	516,765
1983	159	0	0	0	0	0	3,791	36,135	67,151	161,767	174,983	56,299	500,285
1984	406	0	0	0	0	0	206	27,026	68,425	199,548	179,864	53,135	528,610
1985	3,254	0	0	0	0	0	12,968	42,541	78,811	191,147	148,228	33,204	510,153
1986	1,479	0	0	0	0	30	9,098	47,053	96,559	196,633	151,108	28,385	530,345
1987	1,449	192	0	0	0	0	5,037	43,603	83,449	166,162	161,184	26,399	487,475
1988	930	192	0	0	0	0	7,388	45,716	116,738	180,464	156,731	28,708	536,867
1989	1,232	0	0	0	0	0	9,771	53,668	80,387	172,242	167,278	28,362	512,940
1990	299	0	0	0	0	0	7,265	44,792	84,309	203,594	163,633	44,062	547,954
1991	843	0	0	0	0	0	7,168	40,420	88,469	211,523	178,214	26,822	553,459
1992	581	0	0	0	0	60	7,207	44,679	65,348	143,853	158,243	65,105	485,076
1993	1,269	0	0	0	0	200	4,448	36,700	58,527	114,061	117,475	27,394	360,074
1994	196	3	0	0	0	590	9,391	41,856	81,528	162,581	168,987	33,851	498,983
1995	4,793	3	0	0	0	90	4,191	29,540	53,034	189,837	184,073	69,524	535,085
1996	493	0	0	0	0	91	5,331	36,320	61,026	157,710	128,780	31,350	421,101
1997	0	0	0	0	0	0	1,242	41,747	82,107	218,957	151,439	41,854	537,346
1998	0	0	0	0	0	0	7,188	43,461	81,630	183,467	151,914	32,118	499,778

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Region 4: Agricultural Diversion Estimates for Alternative "Region 1 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	59,841	68,597	50,775	42,619	37,194	46,374	43,317	69,535	92,343	100,514	91,043	68,809	770,961
1976	59,857	59,774	54,737	43,788	54,670	38,193	47,589	65,207	71,161	56,649	76,521	60,081	688,227
1977	62,314	53,881	58,621	46,600	48,425	39,411	41,602	60,398	63,006	44,584	63,113	53,079	635,034
1978	47,920	43,107	53,128	42,751	43,564	45,192	44,657	72,708	105,402	96,982	65,420	52,735	713,566
1979	55,002	66,122	59,249	44,349	35,790	62,713	52,227	79,090	69,539	97,688	91,180	70,236	783,185
1980	88,036	55,811	25,045	18,350	22,809	37,121	27,093	104,311	94,594	144,492	126,436	83,066	827,164
1981	81,873	63,795	54,241	37,101	49,349	53,445	51,916	66,995	74,557	105,715	107,840	73,510	820,337
1982	69,376	60,829	50,721	47,762	47,483	51,840	44,011	65,222	92,404	141,596	126,160	106,948	904,352
1983	104,224	75,939	28,467	15,639	12,241	34,928	18,956	92,908	91,392	149,491	140,869	84,389	849,443
1984	62,791	43,976	20,955	17,659	27,232	61,363	42,557	100,025	105,739	149,858	134,134	97,097	863,386
1985	69,411	60,770	48,251	22,293	19,046	80,892	77,552	80,727	101,171	137,587	128,889	88,175	914,764
1986	69,481	63,689	26,526	30,597	49,859	75,523	27,278	103,931	93,748	139,369	131,911	76,696	888,608
1987	81,792	68,230	49,137	39,101	45,727	26,233	49,654	82,279	95,827	147,835	128,143	97,771	911,729
1988	82,144	80,181	47,845	9,795	12,552	59,952	76,454	99,849	106,506	142,650	136,643	95,310	949,881
1989	74,056	70,581	42,877	32,436	37,963	66,956	52,811	77,334	99,306	134,911	117,311	105,701	912,243
1990	73,811	75,263	50,571	45,638	31,570	53,901	66,498	81,756	122,778	135,070	128,489	94,896	960,241
1991	92,565	75,733	45,295	35,569	46,248	48,193	54,865	80,578	136,069	148,164	141,207	93,035	997,521
1992	84,614	88,946	75,511	35,373	30,751	49,755	90,400	76,494	107,825	125,890	135,780	95,506	996,845
1993	83,345	79,754	35,275	29,010	42,846	44,461	58,014	86,053	136,716	152,487	137,181	87,296	972,438
1994	64,910	80,835	61,569	48,317	31,974	53,135	71,158	80,670	105,861	110,397	88,745	58,970	856,541
1995	68,081	70,300	65,371	61,097	49,035	49,211	44,027	103,383	85,420	154,128	147,474	94,258	991,785
1996	82,030	68,116	58,423	37,607	30,731	42,522	71,428	99,015	128,852	155,021	128,573	81,448	983,766
1997	71,190	91,215	48,693	27,833	41,625	38,706	79,493	99,140	114,748	158,560	140,521	94,816	1,006,540
1998	73,300	55,568	45,165	13,131	32,415	41,827	81,892	98,860	88,322	141,973	144,883	105,519	922,855

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Region 5: Agricultural Diversion Estimates for Alternative "Region 1 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	57,405	7,299	2,310	1,060	1,800	3,207	15,352	126,310	173,420	224,832	225,237	114,114	952,346
1976	37,364	12,436	13,378	4,473	4,253	4,406	22,197	101,923	196,105	242,516	210,821	112,937	962,809
1977	42,658	13,648	6,306	2,812	5,693	7,648	34,763	115,159	205,274	197,849	178,808	90,788	901,406
1978	51,167	16,335	7,440	8,770	6,570	3,631	25,187	104,826	173,490	225,815	207,576	93,278	924,085
1979	49,138	6,298	17,188	10,384	9,945	7,362	23,903	106,822	168,363	233,341	187,016	88,133	907,893
1980	42,909	2,162	3,303	4,660	1,853	5,007	11,506	103,357	176,374	234,397	196,717	97,787	880,032
1981	52,394	18,362	6,670	5,700	4,047	5,357	25,674	99,514	185,480	230,912	198,600	96,817	929,527
1982	72,564	15,798	9,299	5,732	4,895	6,179	35,159	98,301	170,733	220,589	190,625	94,225	924,099
1983	37,053	8,040	2,566	3,408	4,858	7,381	17,756	103,751	165,153	209,302	193,894	101,778	854,940
1984	41,152	6,195	5,589	184	134	4,312	6,627	103,138	177,021	255,763	189,672	93,753	883,540
1985	35,542	6,538	14,887	6,528	5,524	6,199	55,041	117,433	211,338	239,505	206,975	89,941	995,451
1986	23,734	3,266	99	4,148	2,756	13,845	40,613	125,323	173,738	234,157	191,943	84,473	898,095
1987	36,141	10,440	4,612	4,813	3,045	4,794	50,261	120,392	180,416	219,048	177,404	85,428	896,794
1988	30,825	8,680	5,459	5,529	5,037	8,392	31,474	128,416	181,165	213,010	198,062	85,884	901,933
1989	50,800	9,742	5,944	4,654	4,606	8,456	50,351	120,182	175,270	232,368	183,928	82,733	929,034
1990	41,326	11,531	7,319	5,965	8,800	21,820	36,612	109,227	173,466	219,031	172,392	91,027	898,516
1991	40,643	11,129	8,071	6,372	5,966	10,323	31,753	113,764	179,274	229,027	184,514	91,987	912,823
1992	33,412	12,499	9,680	7,255	6,652	13,343	30,611	121,562	168,988	210,316	165,252	77,539	857,109
1993	33,546	19,050	8,266	7,083	5,939	7,839	21,149	124,574	175,729	231,781	184,750	86,873	906,579
1994	36,741	10,065	6,305	5,258	4,742	10,968	34,759	119,237	192,949	200,235	179,405	84,259	884,923
1995	34,288	15,447	7,175	6,259	5,802	11,141	35,062	110,106	167,318	194,793	186,201	98,968	872,560
1996	24,691	21,876	9,253	5,518	7,298	11,946	94,498	128,178	173,079	217,422	174,578	83,974	952,311
1997	28,536	6,955	11,307	16,971	9,343	13,030	38,973	114,256	168,261	234,426	150,917	79,127	872,102
1998	27,881	1,108	3,061	3,985	5,116	10,962	59,983	113,903	182,291	241,500	167,039	93,273	910,102

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Region 1: Agricultural Diversion Estimates for Alternative "Region 2 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	2,317	14,311	19,855	20,922	6,849	64,254
1976	0	0	0	0	0	0	0	8,204	17,056	19,807	16,937	6,242	68,246
1977	0	0	0	0	0	0	0	12,417	14,049	21,903	12,906	5,349	66,624
1978	0	0	0	0	0	0	0	2,553	10,977	14,640	15,582	8,856	52,608
1979	0	0	0	0	0	0	0	6,674	16,820	17,917	12,825	5,232	59,468
1980	0	0	0	0	0	0	0	9,293	19,886	21,582	14,969	7,029	72,759
1981	0	0	0	0	0	0	0	10,074	16,116	20,537	15,420	9,568	71,715
1982	0	0	0	0	0	0	0	8,879	15,979	16,752	18,710	6,547	66,867
1983	0	0	0	0	0	0	0	2,620	14,616	17,385	18,083	11,302	64,006
1984	0	0	0	0	0	0	0	2,233	20,719	19,025	20,731	9,469	72,177
1985	0	0	0	0	0	0	555	11,726	20,571	22,126	18,369	8,511	81,858
1986	0	0	0	0	0	0	0	7,886	19,603	22,213	20,104	7,345	77,151
1987	0	0	0	0	0	0	0	13,884	16,637	20,648	18,105	4,558	73,832
1988	0	0	0	0	0	0	0	10,798	24,411	25,057	19,174	7,311	86,751
1989	0	0	0	0	0	0	0	16,908	16,451	22,780	15,749	7,587	79,475
1990	0	0	0	0	0	0	65	10,631	20,323	20,110	14,350	10,852	76,331
1991	0	0	0	0	0	0	0	1,432	11,621	23,242	17,500	9,727	63,522
1992	0	0	0	0	0	0	0	22,126	13,716	15,780	16,084	9,170	76,876
1993	10	0	0	0	0	0	0	3,802	10,134	20,245	15,384	7,958	57,533
1994	14	0	0	0	0	0	0	19,478	17,439	19,511	13,926	8,243	78,611
1995	0	0	0	0	0	0	0	0	1,541	13,240	22,770	9,410	46,961
1996	0	0	0	0	0	0	311	10,790	14,461	22,173	18,450	8,297	74,482
1997	0	0	0	0	0	0	0	9,469	12,734	19,265	13,474	11,119	66,061
1998	0	0	0	0	0	0	0	15,907	10,822	17,823	13,416	10,752	68,720

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Region 2: Agricultural Diversion Estimates for Alternative "Region 2 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18,669	0	0	0	0	0	14,440	187,053	185,860	367,681	365,631	267,431	1,406,765
1976	31,168	34	0	0	0	0	34,684	170,601	196,537	367,891	353,793	272,710	1,427,418
1977	30,994	0	0	0	0	0	18,410	202,929	177,636	342,147	280,556	211,559	1,264,231
1978	20,428	101	0	0	0	0	43,400	107,676	182,548	355,082	351,341	253,647	1,314,223
1979	0	0	0	0	0	0	21,002	145,697	175,912	341,580	345,989	247,305	1,277,485
1980	21,346	0	0	0	0	0	4,750	159,045	214,202	372,708	354,690	251,205	1,377,946
1981	24,215	0	0	0	0	0	8,145	68,241	217,156	346,513	323,986	235,308	1,223,564
1982	21,035	0	0	0	0	0	31,825	157,432	59,572	318,922	346,732	235,020	1,170,538
1983	7,300	0	0	0	0	0	16,087	63,788	175,438	366,122	376,853	265,683	1,271,271
1984	6,239	0	0	0	0	0	33,560	122,318	240,073	377,544	368,943	257,476	1,406,153
1985	23,622	0	0	0	0	0	29,751	218,308	246,036	389,162	380,941	251,729	1,539,549
1986	20,689	0	0	0	0	0	24,177	177,169	167,951	379,871	369,385	232,842	1,372,084
1987	9,559	0	0	0	0	0	30,332	112,872	162,262	374,700	309,872	195,827	1,195,424
1988	4,251	0	0	0	0	0	39,391	133,683	191,070	385,744	372,011	225,638	1,351,788
1989	15,871	0	0	0	0	0	29,616	151,639	170,932	360,745	332,564	140,347	1,201,714
1990	6,236	0	0	0	0	0	654	21,810	103,131	346,700	305,365	134,813	918,709
1991	4,220	0	0	0	0	0	17,109	51,737	122,233	344,261	346,542	204,840	1,090,942
1992	8,426	0	0	0	0	0	33,284	45,983	60,912	301,802	342,979	177,211	970,597
1993	7,310	12	0	0	0	0	21,797	172,700	87,880	342,394	327,189	188,717	1,147,999
1994	2,271	0	0	0	0	0	9,628	179,741	219,810	351,854	346,974	211,678	1,321,956
1995	11,421	214	0	0	0	0	11,207	47,389	115,134	322,095	370,060	247,238	1,124,758
1996	10,696	0	0	0	0	0	10,523	208,169	169,796	386,842	372,361	203,450	1,361,837
1997	8,831	0	0	0	0	0	2,451	193,015	98,875	378,079	332,586	238,541	1,252,378
1998	12,382	0	0	0	0	0	8,322	183,926	150,463	372,789	363,130	243,285	1,334,297

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Region 3: Agricultural Diversion Estimates for Alternative "Region 2 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1,947	0	0	0	0	0	4,385	54,491	82,259	198,319	171,508	51,341	564,250
1976	5,896	0	0	0	0	171	7,607	53,371	97,862	203,925	182,169	52,896	603,897
1977	4,215	143	0	0	0	0	756	43,980	97,302	198,956	151,759	36,506	533,617
1978	1,661	0	0	0	0	0	3,914	52,991	96,900	208,388	172,980	54,331	591,165
1979	0	0	0	0	0	0	2,227	44,194	75,447	161,506	174,543	51,527	509,444
1980	2,169	0	0	0	0	0	3,945	51,300	94,781	225,735	177,912	40,450	596,292
1981	389	0	0	0	0	0	20,446	52,287	89,629	193,853	145,837	36,219	538,660
1982	1,382	0	0	0	0	0	5,320	40,498	62,550	189,984	173,117	43,914	516,765
1983	159	0	0	0	0	0	3,791	36,135	67,151	159,785	173,566	56,299	496,886
1984	406	0	0	0	0	0	206	27,026	68,425	196,738	179,176	53,135	525,112
1985	3,254	0	0	0	0	0	12,968	42,541	78,811	188,382	148,547	33,204	507,707
1986	1,479	0	0	0	0	30	9,098	47,053	96,559	193,751	151,108	28,385	527,463
1987	1,449	192	0	0	0	0	5,037	43,603	83,449	165,468	161,184	26,399	486,781
1988	930	192	0	0	0	0	7,388	45,716	116,738	179,146	156,910	28,708	535,728
1989	1,232	0	0	0	0	0	9,771	53,668	80,387	172,242	167,278	28,362	512,940
1990	299	0	0	0	0	0	7,265	44,792	84,309	203,594	163,633	44,062	547,954
1991	843	0	0	0	0	0	7,168	40,420	88,469	210,231	177,444	26,822	551,397
1992	581	0	0	0	0	60	7,207	44,679	65,348	143,853	158,243	65,105	485,076
1993	1,269	0	0	0	0	200	4,448	36,700	58,527	114,061	117,475	27,394	360,074
1994	196	3	0	0	0	590	9,391	41,856	81,528	162,581	168,987	33,851	498,983
1995	4,793	3	0	0	0	90	4,191	29,540	53,034	189,837	184,073	69,524	535,085
1996	493	0	0	0	0	91	5,331	36,320	61,026	157,710	127,505	31,350	419,826
1997	0	0	0	0	0	0	1,242	41,747	82,107	215,692	151,012	41,854	533,654
1998	0	0	0	0	0	0	7,188	43,461	81,630	183,467	151,914	32,118	499,778

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Region 4: Agricultural Diversion Estimates for Alternative "Region 2 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	59,841	68,597	50,775	42,619	37,194	46,374	43,317	69,496	92,343	100,514	91,043	68,809	770,922
1976	59,853	59,771	54,737	43,788	54,670	38,193	47,589	65,206	71,161	56,649	76,521	60,067	688,205
1977	62,304	53,881	58,621	46,600	48,425	39,411	41,602	60,399	63,006	44,583	63,113	53,082	635,027
1978	47,914	43,101	53,122	42,751	43,564	45,192	44,656	72,850	105,402	96,982	65,482	52,792	713,808
1979	55,051	66,166	59,249	44,349	35,790	62,713	52,227	79,090	69,539	97,688	91,180	70,236	783,278
1980	88,036	55,811	25,045	18,350	22,809	37,121	27,093	104,311	94,594	144,492	126,436	83,066	827,164
1981	81,873	63,795	54,241	37,101	49,349	53,445	51,916	66,995	74,557	105,693	107,827	73,510	820,302
1982	69,376	60,829	50,721	47,762	47,483	51,840	44,011	65,220	92,374	141,596	126,160	106,948	904,320
1983	104,224	75,939	28,467	15,639	12,241	34,928	18,956	92,908	91,392	149,491	140,869	84,389	849,443
1984	62,791	43,976	20,955	17,659	27,232	61,363	42,557	100,025	105,739	149,858	134,134	97,097	863,386
1985	69,411	60,770	48,251	22,293	19,046	80,892	77,552	80,727	101,171	137,587	128,889	88,175	914,764
1986	69,481	63,689	26,526	30,597	49,859	75,523	27,278	103,931	93,748	139,369	131,911	76,696	888,608
1987	81,792	68,230	49,137	39,101	45,727	26,233	49,654	82,279	95,827	147,827	128,141	97,771	911,719
1988	82,144	80,181	47,845	9,795	12,552	59,952	76,454	99,849	106,506	142,650	136,643	95,310	949,881
1989	74,056	70,581	42,877	32,436	37,963	66,956	52,811	77,334	99,306	134,911	117,344	105,712	912,287
1990	73,811	75,263	50,571	45,638	31,570	53,901	66,498	81,756	122,778	135,066	128,489	94,896	960,237
1991	92,565	75,733	45,295	35,569	46,248	48,193	54,865	80,578	136,069	148,164	141,207	93,035	997,521
1992	84,614	88,946	75,511	35,373	30,751	49,755	90,400	76,494	107,825	125,854	135,827	95,506	996,856
1993	83,345	79,754	35,275	29,010	42,846	44,461	58,014	86,053	136,716	152,487	137,181	87,296	972,438
1994	64,910	80,835	61,569	48,317	31,974	53,135	71,158	80,670	105,861	110,397	88,745	58,983	856,554
1995	68,102	70,318	65,371	61,097	49,035	49,211	44,027	103,383	85,420	154,128	147,474	94,258	991,824
1996	82,030	68,116	58,423	37,607	30,731	42,522	71,428	99,015	128,852	155,021	128,573	81,448	983,766
1997	71,190	91,213	48,693	27,833	41,625	38,706	79,493	99,140	114,748	158,560	140,521	94,816	1,006,538
1998	73,300	55,568	45,165	13,131	32,415	41,827	81,892	98,860	88,322	141,973	144,883	105,519	922,855

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Region 5: Agricultural Diversion Estimates for Alternative "Region 2 WY Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	57,405	7,299	2,310	1,060	1,800	3,207	15,352	126,303	173,420	224,832	225,238	114,114	952,340
1976	37,364	12,436	13,378	4,473	4,253	4,406	22,197	101,923	196,105	242,516	210,821	112,937	962,809
1977	42,658	13,648	6,306	2,812	5,693	7,648	34,763	115,160	205,229	197,841	178,754	90,772	901,284
1978	51,167	16,335	7,440	8,770	6,570	3,631	25,187	104,826	173,490	225,815	207,637	93,286	924,154
1979	49,138	6,298	17,188	10,384	9,945	7,362	23,903	106,822	168,363	233,341	187,016	88,133	907,893
1980	42,909	2,162	3,303	4,660	1,853	5,007	11,506	103,357	176,374	234,397	196,717	97,787	880,032
1981	52,394	18,362	6,670	5,700	4,047	5,357	25,674	99,514	185,139	230,819	198,545	96,806	929,027
1982	72,564	15,798	9,299	5,732	4,895	6,179	35,159	98,286	170,733	220,589	190,625	94,225	924,084
1983	37,053	8,040	2,566	3,408	4,858	7,381	17,756	103,751	165,153	209,302	193,894	101,778	854,940
1984	41,151	6,195	5,589	184	134	4,312	6,627	103,138	177,021	255,763	189,672	93,753	883,539
1985	35,542	6,538	14,887	6,528	5,524	6,199	55,041	117,433	211,338	239,505	206,975	89,941	995,451
1986	23,734	3,266	99	4,148	2,756	13,845	40,613	125,323	173,738	234,157	191,943	84,473	898,095
1987	36,141	10,440	4,612	4,813	3,045	4,794	50,261	120,392	180,761	219,131	177,476	85,444	897,310
1988	30,825	8,680	5,459	5,529	5,037	8,392	31,475	128,430	181,165	213,014	198,063	85,884	901,953
1989	50,800	9,742	5,944	4,654	4,606	8,456	50,351	120,182	175,611	232,489	183,971	82,777	929,583
1990	41,327	11,532	7,319	5,975	8,811	21,829	36,620	109,246	173,466	219,032	172,393	91,027	898,577
1991	40,643	11,129	8,072	6,372	5,966	10,323	31,753	113,764	179,274	229,027	184,514	91,987	912,824
1992	33,412	12,499	9,680	7,255	6,652	13,343	30,611	121,563	169,069	210,331	165,293	77,575	857,283
1993	33,554	19,053	8,266	7,083	5,939	7,839	21,149	124,576	175,729	231,781	184,750	86,873	906,592
1994	36,741	10,065	6,305	5,258	4,742	10,968	34,759	119,237	192,949	200,281	179,435	84,279	885,019
1995	34,288	15,447	7,175	6,259	5,804	11,141	35,063	110,111	167,318	194,793	186,201	98,968	872,568
1996	24,691	21,876	9,253	5,518	7,298	11,946	94,498	128,178	173,079	217,422	174,578	83,974	952,311
1997	28,536	6,955	11,307	16,971	9,343	13,030	38,973	114,256	168,261	234,426	150,917	79,127	872,102
1998	27,881	1,108	3,061	3,985	5,116	10,962	59,983	113,903	182,291	241,500	167,039	93,273	910,102

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Region 1: Agricultural Diversion Estimates for Alternative "Region 2 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	2,317	14,311	19,855	20,922	6,849	64,254
1976	0	0	0	0	0	0	0	8,204	17,056	19,807	16,937	6,242	68,246
1977	0	0	0	0	0	0	0	12,417	14,049	21,903	12,906	5,349	66,624
1978	0	0	0	0	0	0	0	2,553	10,977	14,640	15,582	8,856	52,608
1979	0	0	0	0	0	0	0	6,674	16,820	17,917	12,825	5,232	59,468
1980	0	0	0	0	0	0	0	9,293	19,886	21,582	14,969	7,029	72,759
1981	0	0	0	0	0	0	0	9,826	16,116	20,537	15,420	9,568	71,467
1982	0	0	0	0	0	0	0	8,278	15,979	16,752	18,710	6,547	66,266
1983	0	0	0	0	0	0	0	2,620	14,616	17,385	18,083	11,302	64,006
1984	0	0	0	0	0	0	0	2,233	20,719	19,025	20,731	9,469	72,177
1985	0	0	0	0	0	0	555	11,726	20,571	22,126	18,369	8,511	81,858
1986	0	0	0	0	0	0	0	7,886	19,603	22,213	20,104	7,345	77,151
1987	0	0	0	0	0	0	0	13,884	16,637	20,648	18,105	4,558	73,832
1988	0	0	0	0	0	0	0	10,798	24,411	25,057	19,174	7,311	86,751
1989	0	0	0	0	0	0	0	16,458	15,729	22,780	15,749	7,587	78,303
1990	0	0	0	0	0	0	65	10,631	20,323	20,110	14,350	10,852	76,331
1991	0	0	0	0	0	0	0	1,432	11,621	23,242	17,500	9,727	63,522
1992	0	0	0	0	0	0	0	22,126	13,716	15,780	16,084	9,170	76,876
1993	10	0	0	0	0	0	0	3,802	10,134	20,245	15,384	7,958	57,533
1994	14	0	0	0	0	0	0	19,478	17,439	19,511	13,926	8,243	78,611
1995	0	0	0	0	0	0	0	0	1,541	13,240	22,770	9,410	46,961
1996	0	0	0	0	0	0	311	10,790	14,461	22,173	18,450	8,297	74,482
1997	0	0	0	0	0	0	0	9,469	12,734	19,265	13,474	11,119	66,061
1998	0	0	0	0	0	0	0	15,907	10,822	17,823	13,416	10,752	68,720

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Region 2: Agricultural Diversion Estimates for Alternative "Region 2 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18,669	0	0	0	0	0	14,440	187,243	185,750	368,505	366,401	267,414	1,408,422
1976	31,168	34	0	0	0	0	34,684	171,106	195,880	368,291	354,414	273,085	1,428,662
1977	30,994	0	0	0	0	0	18,410	203,227	177,499	342,351	280,513	211,686	1,264,680
1978	20,428	101	0	0	0	0	43,400	107,781	182,678	355,858	351,762	253,599	1,315,607
1979	0	0	0	0	0	0	21,002	145,921	175,127	342,290	346,772	247,416	1,278,528
1980	21,346	0	0	0	0	0	4,750	158,605	214,115	373,347	354,882	251,092	1,378,137
1981	24,215	0	0	0	0	0	8,145	67,870	217,230	346,974	324,277	234,954	1,223,665
1982	21,035	0	0	0	0	0	31,825	156,619	58,901	319,411	347,525	234,917	1,170,233
1983	7,300	0	0	0	0	0	16,087	63,132	174,911	366,937	377,416	265,290	1,271,073
1984	6,239	0	0	0	0	0	33,560	121,920	239,490	378,067	369,236	257,305	1,405,817
1985	23,622	0	0	0	0	0	29,751	217,724	245,811	389,744	381,359	251,095	1,539,106
1986	20,689	0	0	0	0	0	24,177	176,647	167,358	380,767	370,135	232,141	1,371,914
1987	9,559	0	0	0	0	0	30,332	112,564	162,270	375,382	311,044	195,665	1,196,816
1988	4,251	0	0	0	0	0	39,391	133,582	190,910	386,468	372,607	225,388	1,352,597
1989	15,871	0	0	0	0	0	29,616	150,825	170,151	361,305	332,769	139,680	1,200,217
1990	6,236	0	0	0	0	0	654	21,070	102,179	346,845	305,300	133,765	916,049
1991	4,220	0	0	0	0	0	17,109	50,518	121,723	344,596	346,524	204,311	1,089,001
1992	8,426	0	0	0	0	0	33,284	44,706	60,163	301,827	343,008	176,878	968,292
1993	7,310	12	0	0	0	0	21,797	172,082	87,153	342,875	327,925	188,801	1,147,955
1994	2,271	0	0	0	0	0	9,628	179,153	219,259	352,467	347,381	211,219	1,321,378
1995	11,421	214	0	0	0	0	11,207	47,398	114,381	322,415	370,807	247,457	1,125,300
1996	10,696	0	0	0	0	0	10,523	207,779	169,217	387,771	373,264	203,802	1,363,052
1997	8,831	0	0	0	0	0	2,451	192,652	98,431	378,900	333,243	238,414	1,252,922
1998	12,382	0	0	0	0	0	8,322	183,221	149,662	373,569	363,752	243,299	1,334,207

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Region 3: Agricultural Diversion Estimates for Alternative "Region 2 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1,947	0	0	0	0	0	4,385	54,491	82,259	198,685	171,508	51,341	564,616
1976	5,896	0	0	0	0	171	7,607	53,371	97,862	203,925	183,586	52,896	605,314
1977	4,215	143	0	0	0	0	756	43,980	97,302	198,956	151,759	36,506	533,617
1978	1,661	0	0	0	0	0	3,914	52,991	96,900	208,388	172,980	54,331	591,165
1979	0	0	0	0	0	0	2,227	44,194	75,447	161,498	174,543	51,527	509,436
1980	2,169	0	0	0	0	0	3,945	51,300	94,781	229,000	177,912	40,450	599,557
1981	389	0	0	0	0	0	20,446	52,287	89,629	193,853	145,837	36,219	538,660
1982	1,382	0	0	0	0	0	5,320	40,498	62,550	189,984	173,117	43,914	516,765
1983	159	0	0	0	0	0	3,791	36,135	67,151	162,766	174,983	56,299	501,284
1984	406	0	0	0	0	0	206	27,026	68,425	197,454	179,864	53,135	526,516
1985	3,254	0	0	0	0	0	12,968	42,541	78,811	189,116	148,685	33,204	508,579
1986	1,479	0	0	0	0	30	9,098	47,053	96,559	194,291	151,108	28,385	528,003
1987	1,449	192	0	0	0	0	5,037	43,603	83,449	165,205	161,184	26,399	486,518
1988	930	192	0	0	0	0	7,388	45,716	116,738	180,119	156,910	28,708	536,701
1989	1,232	0	0	0	0	0	9,771	53,668	80,387	172,242	167,278	28,362	512,940
1990	299	0	0	0	0	0	7,265	44,792	84,309	204,061	164,979	44,062	549,767
1991	843	0	0	0	0	0	7,168	40,420	88,469	212,793	178,422	26,822	554,937
1992	581	0	0	0	0	60	7,207	44,679	65,348	143,853	158,243	65,105	485,076
1993	1,269	0	0	0	0	200	4,448	36,700	58,527	114,061	117,475	27,394	360,074
1994	196	3	0	0	0	590	9,391	41,856	81,528	162,581	168,987	33,851	498,983
1995	4,793	3	0	0	0	90	4,191	29,540	53,034	189,833	184,073	69,524	535,081
1996	493	0	0	0	0	91	5,331	36,320	61,026	159,927	128,922	31,350	423,460
1997	0	0	0	0	0	0	1,242	41,747	82,107	218,434	151,439	41,854	536,823
1998	0	0	0	0	0	0	7,188	43,461	81,630	183,467	151,914	32,118	499,778

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Region 4: Agricultural Diversion Estimates for Alternative "Region 2 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	59,841	68,597	50,775	42,619	37,194	46,374	43,317	69,496	92,343	100,514	91,043	68,809	770,922
1976	59,854	59,771	54,737	43,788	54,670	38,193	47,589	65,206	71,161	56,649	76,521	60,067	688,206
1977	62,304	53,881	58,621	46,600	48,425	39,411	41,602	60,417	63,006	44,538	63,071	52,891	634,767
1978	47,772	42,991	53,024	42,751	43,564	45,151	44,586	72,795	105,402	96,982	65,462	52,769	713,249
1979	55,029	66,154	59,249	44,349	35,790	62,713	52,227	79,090	69,539	97,688	91,180	70,236	783,244
1980	88,036	55,811	25,045	18,350	22,809	37,121	27,093	104,311	94,594	144,492	126,436	83,066	827,164
1981	81,873	63,795	54,241	37,101	49,349	53,445	51,916	66,995	74,557	105,730	107,847	73,510	820,359
1982	69,376	60,829	50,721	47,762	47,483	51,840	44,011	65,225	92,416	141,596	126,160	106,948	904,367
1983	104,224	75,939	28,467	15,639	12,241	34,928	18,956	92,908	91,392	149,491	140,869	84,389	849,443
1984	62,791	43,976	20,955	17,659	27,232	61,363	42,557	100,025	105,739	149,858	134,134	97,097	863,386
1985	69,411	60,770	48,251	22,293	19,046	80,892	77,552	80,727	101,171	137,587	128,889	88,175	914,764
1986	69,481	63,689	26,526	30,597	49,859	75,521	27,278	103,931	93,748	139,369	131,911	76,696	888,606
1987	81,792	68,230	49,137	39,101	45,727	26,233	49,654	82,279	95,827	147,835	128,143	97,771	911,729
1988	82,144	80,181	47,845	9,795	12,552	59,952	76,454	99,849	106,506	142,650	136,643	95,305	949,876
1989	74,056	70,577	42,877	32,436	37,963	66,956	52,811	77,334	99,306	134,916	117,307	105,702	912,241
1990	73,811	75,263	50,571	45,638	31,570	53,901	66,498	81,756	122,778	135,046	128,489	94,896	960,217
1991	92,566	75,735	45,295	35,569	46,248	48,193	54,865	80,578	136,069	148,164	141,207	93,035	997,524
1992	84,614	88,946	75,511	35,373	30,751	49,755	90,400	76,494	107,825	125,870	135,799	95,506	996,844
1993	83,345	79,754	35,275	29,010	42,846	44,461	58,014	86,053	136,716	152,487	137,181	87,296	972,438
1994	64,910	80,835	61,569	48,317	31,974	53,135	71,158	80,670	105,861	110,397	88,745	58,954	856,525
1995	68,023	70,261	65,371	61,097	49,035	49,211	44,027	103,383	85,420	154,128	147,474	94,258	991,688
1996	82,030	68,116	58,423	37,607	30,731	42,522	71,428	99,015	128,852	155,021	128,573	81,448	983,766
1997	71,190	91,215	48,693	27,833	41,625	38,706	79,493	99,140	114,748	158,560	140,521	94,816	1,006,540
1998	73,300	55,568	45,165	13,131	32,415	41,827	81,892	98,860	88,322	141,973	144,883	105,519	922,855

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Region 5: Agricultural Diversion Estimates for Alternative "Region 2 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	57,405	7,299	2,310	1,060	1,800	3,207	15,352	126,304	173,420	224,832	225,237	114,114	952,340
1976	37,364	12,436	13,378	4,473	4,253	4,406	22,197	101,923	196,105	242,516	210,821	112,937	962,809
1977	42,658	13,648	6,306	2,812	5,693	7,648	34,763	115,052	205,234	197,546	178,474	90,759	900,593
1978	51,156	16,326	7,440	8,770	6,570	3,631	25,187	104,826	173,490	225,815	207,576	93,278	924,065
1979	49,138	6,298	17,188	10,384	9,945	7,362	23,903	106,822	168,363	233,341	187,016	88,133	907,893
1980	42,909	2,162	3,303	4,660	1,853	5,007	11,506	103,357	176,374	234,397	196,717	97,787	880,032
1981	52,394	18,362	6,670	5,700	4,047	5,357	25,674	99,517	185,480	230,969	198,617	96,817	929,604
1982	72,564	15,798	9,299	5,732	4,895	6,179	35,159	98,328	170,733	220,589	190,625	94,225	924,126
1983	37,053	8,040	2,566	3,408	4,858	7,381	17,756	103,751	165,153	209,302	193,894	101,778	854,940
1984	41,152	6,195	5,589	184	134	4,312	6,627	103,138	177,021	255,763	189,672	93,753	883,540
1985	35,542	6,538	14,887	6,528	5,524	6,199	55,041	117,433	211,338	239,505	206,906	89,941	995,382
1986	23,734	3,266	99	4,148	2,756	13,845	40,613	125,320	173,738	234,157	191,943	84,473	898,092
1987	36,141	10,440	4,612	4,813	3,045	4,794	50,261	120,392	180,420	219,049	177,408	85,444	896,819
1988	30,825	8,680	5,459	5,529	5,037	8,392	31,474	128,416	181,165	212,991	198,061	85,879	901,908
1989	50,800	9,742	5,944	4,654	4,606	8,456	50,351	120,182	175,269	232,289	183,908	82,723	928,924
1990	41,327	11,529	7,319	5,963	8,799	21,819	36,611	109,224	173,466	219,031	172,392	91,027	898,507
1991	40,643	11,129	8,071	6,372	5,966	10,323	31,753	113,764	179,274	229,027	184,513	91,987	912,822
1992	33,412	12,499	9,680	7,255	6,652	13,343	30,611	121,565	169,270	210,372	165,254	77,580	857,493
1993	33,546	19,060	8,266	7,083	5,939	7,839	21,149	124,579	175,729	231,781	184,750	86,873	906,594
1994	36,741	10,065	6,305	5,258	4,742	10,968	34,759	119,237	192,949	200,103	179,299	84,198	884,624
1995	34,283	15,443	7,175	6,259	5,795	11,141	35,056	110,086	167,318	194,793	186,201	98,968	872,518
1996	24,691	21,876	9,253	5,518	7,298	11,946	94,498	128,178	173,079	217,422	174,578	83,974	952,311
1997	28,536	6,955	11,307	16,971	9,343	13,030	38,973	114,256	168,261	234,426	150,917	79,127	872,102
1998	27,881	1,108	3,061	3,985	5,116	10,962	59,983	113,903	182,291	241,500	167,039	93,273	910,102

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Region 1: Agricultural Diversion Estimates for Alternative "Region 3 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	2,317	14,311	19,855	20,922	6,849	64,254
1976	0	0	0	0	0	0	0	8,204	17,056	19,807	16,937	6,242	68,246
1977	0	0	0	0	0	0	0	12,417	14,049	21,903	12,906	5,349	66,624
1978	0	0	0	0	0	0	0	2,553	10,977	14,640	15,582	8,856	52,608
1979	0	0	0	0	0	0	0	6,674	16,820	17,917	12,825	5,232	59,468
1980	0	0	0	0	0	0	0	9,293	19,886	21,582	14,969	7,029	72,759
1981	0	0	0	0	0	0	0	9,826	16,116	20,537	15,420	9,568	71,467
1982	0	0	0	0	0	0	0	8,278	15,979	16,752	18,710	6,547	66,266
1983	0	0	0	0	0	0	0	2,620	14,616	17,385	18,083	11,302	64,006
1984	0	0	0	0	0	0	0	2,233	20,719	19,025	20,731	9,469	72,177
1985	0	0	0	0	0	0	555	11,726	20,571	22,126	18,369	8,511	81,858
1986	0	0	0	0	0	0	0	7,886	19,603	22,213	20,104	7,345	77,151
1987	0	0	0	0	0	0	0	13,884	16,637	20,648	18,105	4,558	73,832
1988	0	0	0	0	0	0	0	10,798	24,411	25,057	19,174	7,311	86,751
1989	0	0	0	0	0	0	0	16,458	15,729	21,791	15,749	7,587	77,314
1990	0	0	0	0	0	0	65	10,631	20,323	20,110	14,350	10,852	76,331
1991	0	0	0	0	0	0	0	1,432	11,621	23,242	17,500	9,727	63,522
1992	0	0	0	0	0	0	0	22,126	13,716	15,780	16,084	9,170	76,876
1993	10	0	0	0	0	0	0	3,802	10,134	20,245	15,384	7,958	57,533
1994	14	0	0	0	0	0	0	19,478	17,439	19,511	13,926	8,243	78,611
1995	0	0	0	0	0	0	0	0	1,541	13,240	22,770	9,410	46,961
1996	0	0	0	0	0	0	311	10,790	14,461	22,173	18,450	8,297	74,482
1997	0	0	0	0	0	0	0	9,469	12,734	19,265	13,474	11,119	66,061
1998	0	0	0	0	0	0	0	15,907	10,822	17,823	13,416	10,752	68,720

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Region 2: Agricultural Diversion Estimates for Alternative "Region 3 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18,669	0	0	0	0	0	14,440	188,225	187,249	371,368	369,248	269,443	1,418,642
1976	31,168	34	0	0	0	0	34,684	171,967	197,583	371,340	357,090	275,066	1,438,932
1977	30,994	0	0	0	0	0	18,410	204,538	178,639	345,168	283,217	213,695	1,274,661
1978	20,428	101	0	0	0	0	43,400	108,342	183,974	358,354	354,597	255,830	1,325,026
1979	0	0	0	0	0	0	21,002	147,042	176,928	344,872	349,349	249,322	1,288,515
1980	21,346	0	0	0	0	0	4,750	159,905	216,032	376,411	357,816	253,158	1,389,418
1981	24,215	0	0	0	0	0	8,145	68,868	218,803	349,631	326,848	236,874	1,233,384
1982	21,035	0	0	0	0	0	31,825	158,412	59,898	321,653	350,044	236,882	1,179,749
1983	7,300	0	0	0	0	0	16,087	64,116	176,349	369,770	380,341	267,422	1,281,385
1984	6,239	0	0	0	0	0	33,560	122,797	241,464	380,963	372,226	259,135	1,416,384
1985	23,622	0	0	0	0	0	29,751	219,614	247,897	392,788	384,245	253,115	1,551,032
1986	20,689	0	0	0	0	0	24,177	178,022	168,764	383,640	372,853	234,131	1,382,276
1987	9,559	0	0	0	0	0	30,332	113,550	163,349	378,041	312,992	197,399	1,205,222
1988	4,251	0	0	0	0	0	39,391	134,350	192,246	389,420	375,475	227,500	1,362,633
1989	15,871	0	0	0	0	0	29,616	152,477	172,153	364,128	335,576	141,484	1,211,305
1990	6,236	0	0	0	0	0	654	21,878	103,529	349,457	307,923	136,004	925,681
1991	4,220	0	0	0	0	0	17,109	51,780	122,684	347,192	349,433	206,472	1,098,890
1992	8,426	0	0	0	0	0	33,284	46,531	61,494	304,146	345,962	179,091	978,934
1993	7,310	12	0	0	0	0	21,797	173,473	88,191	345,327	330,203	190,385	1,156,698
1994	2,271	0	0	0	0	0	9,628	180,475	221,296	355,170	350,242	213,300	1,332,382
1995	11,421	214	0	0	0	0	11,207	47,481	115,394	324,524	373,708	249,362	1,133,311
1996	10,696	0	0	0	0	0	10,523	209,249	170,681	390,696	375,962	205,014	1,372,821
1997	8,831	0	0	0	0	0	2,451	193,968	99,460	381,626	335,365	240,109	1,261,810
1998	12,382	0	0	0	0	0	8,322	184,779	151,038	376,378	366,541	245,097	1,344,537

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Region 3: Agricultural Diversion Estimates for Alternative "Region 3 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1,947	0	0	0	0	0	4,385	53,910	80,908	194,959	168,160	50,347	554,616
1976	5,896	0	0	0	0	171	7,607	52,790	96,511	200,199	180,238	51,902	595,314
1977	4,215	143	0	0	0	0	756	43,399	95,951	195,230	148,411	35,512	523,617
1978	1,661	0	0	0	0	0	3,914	52,410	95,549	204,662	169,632	53,337	581,165
1979	0	0	0	0	0	0	2,227	43,613	74,096	157,780	171,195	50,533	499,444
1980	2,169	0	0	0	0	0	3,945	50,719	93,430	222,009	174,564	39,456	586,292
1981	389	0	0	0	0	0	20,446	51,706	88,278	190,127	142,489	35,225	528,660
1982	1,382	0	0	0	0	0	5,320	39,917	61,199	186,258	169,769	42,920	506,765
1983	159	0	0	0	0	0	3,791	35,554	65,800	156,059	171,635	55,305	488,303
1984	406	0	0	0	0	0	206	26,445	67,074	193,012	176,516	52,141	515,800
1985	3,254	0	0	0	0	0	12,968	41,960	77,460	184,656	145,337	32,210	497,845
1986	1,479	0	0	0	0	30	9,098	46,472	95,208	190,025	147,760	27,391	517,463
1987	1,449	192	0	0	0	0	5,037	43,022	82,098	160,938	157,836	25,405	475,977
1988	930	192	0	0	0	0	7,388	45,135	115,387	175,420	153,562	27,714	525,728
1989	1,232	0	0	0	0	0	9,771	53,087	79,036	168,516	163,930	27,368	502,940
1990	299	0	0	0	0	0	7,265	44,211	82,958	199,868	160,285	43,068	537,954
1991	843	0	0	0	0	0	7,168	39,839	87,118	206,505	175,074	25,828	542,375
1992	581	0	0	0	0	60	7,207	44,098	63,997	140,127	154,895	64,111	475,076
1993	1,269	0	0	0	0	200	4,448	36,119	57,176	110,335	114,127	26,400	350,074
1994	196	3	0	0	0	590	9,391	41,275	80,177	158,855	165,639	32,857	488,983
1995	4,793	3	0	0	0	90	4,191	28,959	51,683	186,111	182,142	68,530	526,502
1996	493	0	0	0	0	91	5,331	35,739	59,675	153,984	124,157	30,356	409,826
1997	0	0	0	0	0	0	1,242	41,166	80,756	211,966	146,674	40,860	522,664
1998	0	0	0	0	0	0	7,188	42,880	80,279	177,459	148,566	31,124	487,496

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Region 4: Agricultural Diversion Estimates for Alternative "Region 3 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	59,841	68,597	50,775	42,619	37,194	46,374	43,317	69,496	92,343	100,514	91,135	68,809	771,014
1976	59,814	59,736	54,737	43,788	54,670	38,193	47,589	65,205	71,161	56,649	76,514	60,094	688,150
1977	62,312	53,881	58,621	46,600	48,425	39,411	41,602	60,400	63,006	44,538	63,067	53,006	634,869
1978	47,935	43,135	53,165	42,751	43,564	45,192	44,725	72,928	105,402	96,982	65,599	52,801	714,179
1979	55,063	66,174	59,249	44,349	35,790	62,713	52,227	79,090	69,539	97,688	91,180	70,236	783,298
1980	88,036	55,811	25,045	18,350	22,809	37,121	27,093	104,311	94,594	144,492	126,436	83,066	827,164
1981	81,873	63,795	54,241	37,101	49,349	53,445	51,916	66,995	74,557	105,829	107,906	73,510	820,517
1982	69,376	60,829	50,721	47,762	47,483	51,840	44,011	65,185	92,395	141,596	126,160	106,948	904,306
1983	104,224	75,939	28,467	15,639	12,241	34,928	18,956	92,908	91,392	149,491	140,869	84,389	849,443
1984	62,791	43,976	20,955	17,659	27,232	61,363	42,557	100,025	105,739	149,858	134,134	97,097	863,386
1985	69,411	60,770	48,251	22,293	19,046	80,892	77,552	80,727	101,171	137,587	128,889	88,175	914,764
1986	69,481	63,689	26,526	30,597	49,859	75,523	27,278	103,931	93,748	139,369	131,911	76,696	888,608
1987	81,792	68,230	49,137	39,101	45,727	26,233	49,654	82,279	95,827	147,829	128,139	97,771	911,719
1988	82,144	80,181	47,845	9,795	12,552	59,952	76,454	99,849	106,506	142,650	136,643	95,305	949,876
1989	74,056	70,576	42,877	32,436	37,963	66,956	52,811	77,334	99,306	134,911	117,344	105,711	912,281
1990	73,811	75,263	50,571	45,638	31,570	53,901	66,498	81,756	122,778	135,052	128,489	94,896	960,223
1991	92,565	75,733	45,295	35,569	46,248	48,193	54,865	80,578	136,069	148,164	141,207	93,035	997,521
1992	84,614	88,946	75,511	35,373	30,751	49,755	90,400	76,494	107,825	125,870	135,791	95,506	996,836
1993	83,345	79,754	35,275	29,010	42,846	44,461	58,014	86,053	136,716	152,487	137,181	87,296	972,438
1994	64,910	80,835	61,569	48,317	31,974	53,135	71,158	80,670	105,861	110,383	88,732	58,930	856,474
1995	68,006	70,280	65,371	61,097	49,035	49,211	44,027	103,383	85,420	154,128	147,474	94,258	991,690
1996	82,030	68,116	58,423	37,607	30,731	42,522	71,428	99,015	128,852	155,021	128,573	81,448	983,766
1997	71,190	91,215	48,693	27,833	41,625	38,706	79,493	99,140	114,748	158,560	140,521	94,816	1,006,540
1998	73,300	55,568	45,165	13,131	32,415	41,827	81,892	98,860	88,322	141,973	144,883	105,519	922,855

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Region 5: Agricultural Diversion Estimates for Alternative "Region 3 NE Transfer B"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	57,405	7,299	2,310	1,060	1,800	3,207	15,352	126,304	173,420	224,832	225,105	114,114	952,208
1976	37,364	12,436	13,378	4,473	4,253	4,406	22,197	101,905	196,105	242,497	210,821	112,937	962,772
1977	42,658	13,648	6,306	2,812	5,693	7,648	34,763	115,160	205,229	197,578	178,610	90,827	900,932
1978	51,161	16,329	7,440	8,770	6,570	3,631	25,187	104,826	173,490	225,815	207,637	93,286	924,142
1979	49,138	6,298	17,188	10,384	9,945	7,362	23,903	106,822	168,363	233,341	187,016	88,133	907,893
1980	42,909	2,162	3,303	4,660	1,853	5,007	11,506	103,357	176,374	234,397	196,717	97,787	880,032
1981	52,394	18,362	6,670	5,700	4,047	5,357	25,674	99,514	185,480	231,033	198,619	96,828	929,678
1982	72,564	15,798	9,299	5,732	4,895	6,179	35,159	98,346	170,733	220,589	190,625	94,225	924,144
1983	37,053	8,040	2,566	3,408	4,858	7,381	17,756	103,751	165,153	209,302	193,894	101,778	854,940
1984	41,152	6,195	5,589	184	134	4,312	6,627	103,138	177,021	255,763	189,672	93,753	883,540
1985	35,542	6,538	14,887	6,528	5,524	6,199	55,041	117,433	211,338	239,505	206,969	89,941	995,445
1986	23,734	3,266	99	4,148	2,756	13,845	40,613	125,323	173,738	234,157	191,943	84,473	898,095
1987	36,141	10,440	4,612	4,813	3,045	4,794	50,261	120,392	180,760	219,126	177,473	85,426	897,283
1988	30,825	8,680	5,459	5,529	5,037	8,392	31,475	128,391	181,165	212,983	198,052	85,874	901,862
1989	50,800	9,742	5,944	4,654	4,606	8,456	50,351	120,182	175,610	232,489	183,971	82,777	929,582
1990	41,327	11,532	7,319	5,975	8,811	21,829	36,620	109,246	173,466	219,032	172,393	91,027	898,577
1991	40,643	11,129	8,072	6,372	5,966	10,323	31,753	113,764	179,274	228,994	184,513	91,987	912,790
1992	33,412	12,499	9,680	7,255	6,652	13,343	30,611	121,563	169,257	210,365	165,295	77,604	857,536
1993	33,554	19,060	8,266	7,083	5,939	7,839	21,149	124,562	175,729	231,781	184,745	86,873	906,580
1994	36,741	10,065	6,305	5,258	4,741	10,968	34,758	119,237	192,949	200,026	179,307	84,179	884,534
1995	34,283	15,443	7,175	6,259	5,795	11,141	35,056	110,086	167,318	194,793	186,201	98,968	872,518
1996	24,691	21,876	9,253	5,518	7,298	11,946	94,498	128,178	173,079	217,422	174,578	83,974	952,311
1997	28,536	6,955	11,307	16,971	9,343	13,030	38,973	114,256	168,261	234,426	150,917	79,127	872,102
1998	27,881	1,108	3,061	3,985	5,116	10,962	59,983	113,903	182,291	241,500	167,039	93,273	910,102

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Region 1: Agricultural Diversion Estimates for Alternative "Region 4 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	2,317	14,311	19,855	20,922	6,849	64,254
1976	0	0	0	0	0	0	0	8,204	17,056	19,807	16,937	6,242	68,246
1977	0	0	0	0	0	0	0	12,417	14,049	21,903	12,906	5,349	66,624
1978	0	0	0	0	0	0	0	2,553	10,977	14,640	15,582	8,856	52,608
1979	0	0	0	0	0	0	0	6,674	16,820	17,917	12,825	5,232	59,468
1980	0	0	0	0	0	0	0	9,293	19,886	21,582	14,969	7,029	72,759
1981	0	0	0	0	0	0	0	9,826	16,116	20,537	15,420	9,568	71,467
1982	0	0	0	0	0	0	0	8,278	15,979	16,752	18,710	6,547	66,266
1983	0	0	0	0	0	0	0	2,620	14,616	17,385	18,083	11,302	64,006
1984	0	0	0	0	0	0	0	2,233	20,719	19,025	20,731	9,469	72,177
1985	0	0	0	0	0	0	555	11,726	20,571	22,126	18,369	8,511	81,858
1986	0	0	0	0	0	0	0	7,886	19,603	22,213	20,104	7,345	77,151
1987	0	0	0	0	0	0	0	13,884	16,637	20,648	18,105	4,558	73,832
1988	0	0	0	0	0	0	0	10,798	24,411	25,057	19,174	7,311	86,751
1989	0	0	0	0	0	0	0	16,458	15,729	21,791	15,749	7,587	77,314
1990	0	0	0	0	0	0	65	10,631	20,323	20,110	14,350	10,852	76,331
1991	0	0	0	0	0	0	0	1,432	11,621	23,242	17,500	9,727	63,522
1992	0	0	0	0	0	0	0	22,126	13,716	15,780	16,084	9,170	76,876
1993	10	0	0	0	0	0	0	3,802	10,134	20,245	15,384	7,958	57,533
1994	14	0	0	0	0	0	0	19,478	17,439	19,511	13,926	8,243	78,611
1995	0	0	0	0	0	0	0	0	1,541	13,240	22,770	9,410	46,961
1996	0	0	0	0	0	0	311	10,790	14,461	22,173	18,450	8,297	74,482
1997	0	0	0	0	0	0	0	9,469	12,734	19,265	13,474	11,119	66,061
1998	0	0	0	0	0	0	0	15,907	10,822	17,823	13,416	10,752	68,720

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Region 2: Agricultural Diversion Estimates for Alternative "Region 4 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18,669	0	0	0	0	0	14,440	188,225	187,249	371,368	369,248	269,443	1,418,642
1976	31,168	34	0	0	0	0	34,684	171,967	197,583	371,340	357,090	275,066	1,438,932
1977	30,994	0	0	0	0	0	18,410	204,538	178,639	345,168	283,217	213,695	1,274,661
1978	20,428	101	0	0	0	0	43,400	108,342	183,974	358,354	354,597	255,830	1,325,026
1979	0	0	0	0	0	0	21,002	147,042	176,928	344,872	349,349	249,322	1,288,515
1980	21,346	0	0	0	0	0	4,750	159,905	216,032	376,411	357,816	253,158	1,389,418
1981	24,215	0	0	0	0	0	8,145	68,868	218,803	349,631	326,848	236,874	1,233,384
1982	21,035	0	0	0	0	0	31,825	158,412	59,898	321,653	350,044	236,882	1,179,749
1983	7,300	0	0	0	0	0	16,087	64,116	176,349	369,770	380,341	267,422	1,281,385
1984	6,239	0	0	0	0	0	33,560	122,797	241,464	380,963	372,226	259,135	1,416,384
1985	23,622	0	0	0	0	0	29,751	219,614	247,897	392,788	384,245	253,115	1,551,032
1986	20,689	0	0	0	0	0	24,177	178,022	168,764	383,640	372,853	234,131	1,382,276
1987	9,559	0	0	0	0	0	30,332	113,550	163,349	378,041	312,992	197,399	1,205,222
1988	4,251	0	0	0	0	0	39,391	134,350	192,246	389,420	375,475	227,500	1,362,633
1989	15,871	0	0	0	0	0	29,616	152,477	172,153	364,128	335,576	141,484	1,211,305
1990	6,236	0	0	0	0	0	654	21,878	103,529	349,457	307,923	136,004	925,681
1991	4,220	0	0	0	0	0	17,109	51,780	122,684	347,192	349,433	206,472	1,098,890
1992	8,426	0	0	0	0	0	33,284	46,531	61,494	304,146	345,962	179,091	978,934
1993	7,310	12	0	0	0	0	21,797	173,473	88,191	345,327	330,203	190,385	1,156,698
1994	2,271	0	0	0	0	0	9,628	180,475	221,296	355,170	350,242	213,300	1,332,382
1995	11,421	214	0	0	0	0	11,207	47,481	115,394	324,524	373,708	249,362	1,133,311
1996	10,696	0	0	0	0	0	10,523	209,249	170,681	390,696	375,962	205,014	1,372,821
1997	8,831	0	0	0	0	0	2,451	193,968	99,460	381,626	335,365	240,109	1,261,810
1998	12,382	0	0	0	0	0	8,322	184,779	151,038	376,378	366,541	245,097	1,344,537

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Region 3: Agricultural Diversion Estimates for Alternative "Region 4 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1,947	0	0	0	0	0	4,385	54,491	82,259	198,685	171,508	51,341	564,616
1976	5,896	0	0	0	0	171	7,607	53,371	97,862	203,925	182,169	52,896	603,897
1977	4,215	143	0	0	0	0	756	43,980	97,302	198,956	151,759	36,506	533,617
1978	1,661	0	0	0	0	0	3,914	52,991	96,900	208,388	172,980	54,331	591,165
1979	0	0	0	0	0	0	2,227	44,194	75,447	161,506	174,543	51,527	509,444
1980	2,169	0	0	0	0	0	3,945	51,300	94,781	225,735	176,495	40,450	594,875
1981	389	0	0	0	0	0	20,446	52,287	89,629	193,853	145,837	36,219	538,660
1982	1,382	0	0	0	0	0	5,320	40,498	62,550	189,984	173,117	43,914	516,765
1983	159	0	0	0	0	0	3,791	36,135	67,151	159,785	173,566	56,299	496,886
1984	406	0	0	0	0	0	206	27,026	68,425	196,738	179,317	53,135	525,253
1985	3,254	0	0	0	0	0	12,968	42,541	78,811	188,382	147,284	33,204	506,444
1986	1,479	0	0	0	0	30	9,098	47,053	96,559	193,928	151,108	28,385	527,640
1987	1,449	192	0	0	0	0	5,037	43,603	83,449	163,625	161,184	26,399	484,938
1988	930	192	0	0	0	0	7,388	45,716	116,738	179,146	155,633	28,708	534,451
1989	1,232	0	0	0	0	0	9,771	53,668	80,387	172,242	167,278	28,362	512,940
1990	299	0	0	0	0	0	7,265	44,792	84,309	203,594	163,633	44,062	547,954
1991	843	0	0	0	0	0	7,168	40,420	88,469	210,231	177,005	26,822	550,958
1992	581	0	0	0	0	60	7,207	44,679	65,348	143,853	158,243	65,105	485,076
1993	1,269	0	0	0	0	200	4,448	36,700	58,527	114,061	117,475	27,394	360,074
1994	196	3	0	0	0	590	9,391	41,856	81,528	162,581	168,987	33,851	498,983
1995	4,793	3	0	0	0	90	4,191	29,540	53,034	189,837	185,490	69,524	536,502
1996	493	0	0	0	0	91	5,331	36,320	61,026	157,710	127,505	31,350	419,826
1997	0	0	0	0	0	0	1,242	41,747	82,107	215,692	150,022	41,854	532,664
1998	0	0	0	0	0	0	7,188	43,461	81,630	180,202	150,686	32,118	495,285

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Region 4: Agricultural Diversion Estimates for Alternative "Region 4 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	59,841	68,597	50,775	42,619	37,194	46,374	43,317	69,509	90,674	97,955	88,637	67,115	762,607
1976	59,310	59,227	54,737	43,788	54,670	38,193	47,589	63,847	69,492	56,134	75,944	58,755	681,686
1977	61,764	53,881	58,621	46,600	48,425	39,411	41,602	59,440	61,337	44,170	61,640	52,741	629,632
1978	47,616	42,779	52,829	42,751	43,564	44,953	44,407	71,839	103,733	94,423	65,003	52,266	706,163
1979	54,557	65,740	59,249	44,349	35,790	62,713	52,227	77,509	67,870	95,129	88,682	68,542	772,357
1980	88,036	55,811	25,045	18,350	22,809	37,121	27,093	102,730	92,925	141,933	123,938	81,372	817,163
1981	81,286	63,795	54,241	37,101	49,349	53,445	51,916	65,414	72,888	105,374	107,550	71,816	814,175
1982	69,376	60,829	50,721	47,762	47,483	51,840	44,011	64,353	91,443	139,037	123,662	105,254	895,771
1983	104,224	75,939	28,467	15,639	12,241	34,928	18,956	91,327	89,723	146,932	138,371	82,695	839,442
1984	62,791	43,976	20,955	17,659	27,232	61,363	42,557	98,444	104,070	147,299	131,636	95,403	853,385
1985	69,411	60,770	48,251	22,293	19,046	80,892	77,552	79,146	99,502	135,032	126,391	86,481	904,767
1986	69,481	63,689	26,526	30,597	49,859	75,114	27,278	102,350	92,079	136,810	129,413	75,002	878,198
1987	81,792	68,230	49,137	39,101	45,727	26,233	49,654	80,698	94,158	145,261	127,654	96,077	903,722
1988	82,144	80,181	47,845	9,795	12,552	59,952	76,454	98,268	104,837	140,091	134,145	94,014	940,278
1989	74,056	70,037	42,877	32,436	37,963	66,956	52,811	75,753	98,154	134,508	117,022	104,659	907,232
1990	73,811	75,263	50,571	45,638	31,570	53,901	66,498	80,175	121,109	134,654	125,991	93,202	952,383
1991	91,999	75,209	45,295	35,569	46,248	48,193	54,865	78,997	134,400	145,785	138,709	91,341	986,610
1992	84,614	88,946	75,511	35,373	30,751	49,755	90,400	74,913	106,156	125,374	134,751	93,812	990,356
1993	83,345	79,754	35,275	29,010	42,846	44,461	58,014	84,472	135,047	149,928	134,683	85,602	962,437
1994	64,910	80,835	61,569	48,317	31,974	53,135	71,158	79,089	104,192	110,056	88,468	58,644	852,347
1995	67,734	70,093	65,371	61,097	49,035	49,211	44,027	101,802	83,751	151,569	144,976	92,564	981,230
1996	82,030	68,116	58,423	37,607	30,731	42,522	71,428	97,434	127,183	152,462	126,209	79,754	973,899
1997	71,190	90,719	48,693	27,833	41,625	38,706	79,493	97,559	113,079	156,001	138,023	93,122	996,043
1998	73,300	55,568	45,165	13,131	32,415	41,827	81,892	97,279	86,653	139,414	142,385	103,825	912,854

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Region 5: Agricultural Diversion Estimates for Alternative "Region 4 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	57,405	7,299	2,310	1,060	1,800	3,207	15,352	126,313	173,420	224,832	225,107	114,114	952,219
1976	37,364	12,436	13,378	4,473	4,253	4,406	22,197	101,905	196,105	242,497	210,821	112,937	962,772
1977	42,658	13,648	6,306	2,812	5,693	7,648	34,763	115,160	205,163	197,709	179,881	90,747	902,188
1978	51,175	16,341	7,440	8,770	6,570	3,631	25,187	104,826	173,490	225,815	207,571	93,277	924,093
1979	49,138	6,298	17,188	10,384	9,945	7,362	23,902	106,822	168,363	233,341	187,016	88,133	907,892
1980	42,909	2,162	3,303	4,660	1,853	5,007	11,506	103,357	176,374	234,397	196,717	97,787	880,032
1981	52,394	18,362	6,670	5,700	4,047	5,357	25,674	100,840	185,499	230,956	198,618	96,810	930,927
1982	72,410	15,798	9,299	5,732	4,895	6,179	35,159	98,336	170,733	220,589	190,625	94,225	923,980
1983	37,053	8,040	2,566	3,408	4,858	7,381	17,756	103,751	165,153	209,302	193,894	101,778	854,940
1984	41,151	6,195	5,589	184	134	4,312	6,627	103,138	177,021	255,763	189,672	93,753	883,539
1985	35,542	6,538	14,887	6,528	5,524	6,199	55,041	117,433	211,338	240,493	206,975	89,941	996,439
1986	23,734	3,266	99	4,148	2,756	13,845	40,613	125,323	173,738	234,157	191,943	84,473	898,095
1987	36,141	10,440	4,612	4,813	3,045	4,794	50,261	120,392	180,760	219,084	177,458	85,444	897,244
1988	30,825	8,680	5,459	5,529	5,037	8,392	31,475	128,391	181,165	213,006	198,055	85,855	901,869
1989	50,800	9,742	5,944	4,654	4,606	8,456	50,351	120,173	175,606	232,453	184,017	82,766	929,568
1990	41,330	11,534	7,325	5,971	8,809	21,827	36,618	109,240	173,466	219,083	172,393	91,027	898,623
1991	40,643	11,129	8,072	6,372	5,966	10,323	31,753	113,764	179,274	229,027	184,513	91,987	912,823
1992	33,412	12,499	9,680	7,255	6,652	13,343	30,611	121,581	169,100	210,329	165,254	77,559	857,275
1993	33,546	19,055	8,266	7,083	5,939	7,839	21,149	124,558	175,729	231,781	185,681	86,873	907,499
1994	36,741	10,065	6,305	5,258	4,741	10,968	34,758	119,237	192,949	200,153	179,343	84,196	884,714
1995	34,283	15,443	7,090	6,259	5,795	11,141	35,056	110,086	167,318	194,793	186,201	98,968	872,433
1996	24,691	21,876	9,253	5,518	7,298	11,946	94,498	128,178	173,079	217,422	175,407	83,974	953,140
1997	28,536	6,955	11,307	16,971	9,343	13,030	38,973	114,256	168,261	234,426	150,917	79,127	872,102
1998	27,881	1,108	3,061	3,985	5,116	10,962	59,983	113,903	182,291	241,500	167,039	93,273	910,102

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Region 1: Agricultural Diversion Estimates for Alternative "Region 5 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	2,317	14,311	19,855	20,922	6,849	64,254
1976	0	0	0	0	0	0	0	8,204	17,056	19,807	16,937	6,242	68,246
1977	0	0	0	0	0	0	0	12,417	14,049	21,903	12,906	5,349	66,624
1978	0	0	0	0	0	0	0	2,553	10,977	14,640	15,582	8,856	52,608
1979	0	0	0	0	0	0	0	6,674	16,820	17,917	12,825	5,232	59,468
1980	0	0	0	0	0	0	0	9,293	19,886	21,582	14,969	7,029	72,759
1981	0	0	0	0	0	0	0	9,826	16,116	20,537	15,420	9,568	71,467
1982	0	0	0	0	0	0	0	8,278	15,979	16,752	18,710	6,547	66,266
1983	0	0	0	0	0	0	0	2,620	14,616	17,385	18,083	11,302	64,006
1984	0	0	0	0	0	0	0	2,233	20,719	19,025	20,731	9,469	72,177
1985	0	0	0	0	0	0	555	11,726	20,571	22,126	18,369	8,511	81,858
1986	0	0	0	0	0	0	0	7,886	19,603	22,213	20,104	7,345	77,151
1987	0	0	0	0	0	0	0	13,884	16,637	20,648	18,105	4,558	73,832
1988	0	0	0	0	0	0	0	10,798	24,411	25,057	19,174	7,311	86,751
1989	0	0	0	0	0	0	0	16,458	15,729	21,791	15,749	7,587	77,314
1990	0	0	0	0	0	0	65	10,631	20,323	20,110	14,350	10,852	76,331
1991	0	0	0	0	0	0	0	1,432	11,621	23,242	17,500	9,727	63,522
1992	0	0	0	0	0	0	0	22,126	13,716	15,780	16,084	9,170	76,876
1993	10	0	0	0	0	0	0	3,802	10,134	20,245	15,384	7,958	57,533
1994	14	0	0	0	0	0	0	19,478	17,439	19,511	13,926	8,243	78,611
1995	0	0	0	0	0	0	0	0	1,541	13,240	22,770	9,410	46,961
1996	0	0	0	0	0	0	311	10,790	14,461	22,173	18,450	8,297	74,482
1997	0	0	0	0	0	0	0	9,469	12,734	19,265	13,474	11,119	66,061
1998	0	0	0	0	0	0	0	15,907	10,822	17,823	13,416	10,752	68,720

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Region 2: Agricultural Diversion Estimates for Alternative "Region 5 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18,669	0	0	0	0	0	14,440	188,225	187,249	371,368	369,248	269,443	1,418,642
1976	31,168	34	0	0	0	0	34,684	171,967	197,583	371,340	357,090	275,066	1,438,932
1977	30,994	0	0	0	0	0	18,410	204,538	178,639	345,168	283,217	213,695	1,274,661
1978	20,428	101	0	0	0	0	43,400	108,342	183,974	358,354	354,597	255,830	1,325,026
1979	0	0	0	0	0	0	21,002	147,042	176,928	344,872	349,349	249,322	1,288,515
1980	21,346	0	0	0	0	0	4,750	159,905	216,032	376,411	357,816	253,158	1,389,418
1981	24,215	0	0	0	0	0	8,145	68,868	218,803	349,631	326,848	236,874	1,233,384
1982	21,035	0	0	0	0	0	31,825	158,412	59,898	321,653	350,044	236,882	1,179,749
1983	7,300	0	0	0	0	0	16,087	64,116	176,349	369,770	380,341	267,422	1,281,385
1984	6,239	0	0	0	0	0	33,560	122,797	241,464	380,963	372,226	259,135	1,416,384
1985	23,622	0	0	0	0	0	29,751	219,614	247,897	392,788	384,245	253,115	1,551,032
1986	20,689	0	0	0	0	0	24,177	178,022	168,764	383,640	372,853	234,131	1,382,276
1987	9,559	0	0	0	0	0	30,332	113,550	163,349	378,041	312,992	197,399	1,205,222
1988	4,251	0	0	0	0	0	39,391	134,350	192,246	389,420	375,475	227,500	1,362,633
1989	15,871	0	0	0	0	0	29,616	152,477	172,153	364,128	335,576	141,484	1,211,305
1990	6,236	0	0	0	0	0	654	21,878	103,529	349,457	307,923	136,004	925,681
1991	4,220	0	0	0	0	0	17,109	51,780	122,684	347,192	349,433	206,472	1,098,890
1992	8,426	0	0	0	0	0	33,284	46,531	61,494	304,146	345,962	179,091	978,934
1993	7,310	12	0	0	0	0	21,797	173,473	88,191	345,327	330,203	190,385	1,156,698
1994	2,271	0	0	0	0	0	9,628	180,475	221,296	355,170	350,242	213,300	1,332,382
1995	11,421	214	0	0	0	0	11,207	47,481	115,394	324,524	373,708	249,362	1,133,311
1996	10,696	0	0	0	0	0	10,523	209,249	170,681	390,696	375,962	205,014	1,372,821
1997	8,831	0	0	0	0	0	2,451	193,968	99,460	381,626	335,365	240,109	1,261,810
1998	12,382	0	0	0	0	0	8,322	184,779	151,038	376,378	366,541	245,097	1,344,537

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Region 3: Agricultural Diversion Estimates for Alternative "Region 5 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1,947	0	0	0	0	0	4,385	54,491	82,259	198,685	171,508	51,341	564,616
1976	5,896	0	0	0	0	171	7,607	53,371	97,862	203,925	182,169	52,896	603,897
1977	4,215	143	0	0	0	0	756	43,980	97,302	198,956	151,759	36,506	533,617
1978	1,661	0	0	0	0	0	3,914	52,991	96,900	208,388	172,980	54,331	591,165
1979	0	0	0	0	0	0	2,227	44,194	75,447	161,506	174,543	51,527	509,444
1980	2,169	0	0	0	0	0	3,945	51,300	94,781	225,735	176,791	40,450	595,171
1981	389	0	0	0	0	0	20,446	52,287	89,629	193,853	145,837	36,219	538,660
1982	1,382	0	0	0	0	0	5,320	40,498	62,550	189,984	173,117	43,914	516,765
1983	159	0	0	0	0	0	3,791	36,135	67,151	159,785	173,566	56,299	496,886
1984	406	0	0	0	0	0	206	27,026	68,425	196,738	179,864	53,135	525,800
1985	3,254	0	0	0	0	0	12,968	42,541	78,811	188,382	148,153	33,204	507,313
1986	1,479	0	0	0	0	30	9,098	47,053	96,559	194,430	151,108	28,385	528,142
1987	1,449	192	0	0	0	0	5,037	43,603	83,449	162,897	161,184	26,399	484,210
1988	930	192	0	0	0	0	7,388	45,716	116,738	179,146	155,599	28,708	534,417
1989	1,232	0	0	0	0	0	9,771	53,668	80,387	172,242	167,278	28,362	512,940
1990	299	0	0	0	0	0	7,265	44,792	84,309	203,594	163,633	44,062	547,954
1991	843	0	0	0	0	0	7,168	40,420	88,469	210,231	177,704	26,822	551,657
1992	581	0	0	0	0	60	7,207	44,679	65,348	143,853	158,243	65,105	485,076
1993	1,269	0	0	0	0	200	4,448	36,700	58,527	114,061	117,475	27,394	360,074
1994	196	3	0	0	0	590	9,391	41,856	81,528	162,581	168,987	33,851	498,983
1995	4,793	3	0	0	0	90	4,191	29,540	53,034	189,837	185,490	69,524	536,502
1996	493	0	0	0	0	91	5,331	36,320	61,026	157,710	127,505	31,350	419,826
1997	0	0	0	0	0	0	1,242	41,747	82,107	215,692	150,022	41,854	532,664
1998	0	0	0	0	0	0	7,188	43,461	81,630	180,202	151,725	32,118	496,324

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Region 4: Agricultural Diversion Estimates for Alternative "Region 5 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	59,841	68,597	50,775	42,619	37,194	46,374	43,317	70,616	92,343	100,514	91,135	68,809	772,134
1976	59,272	59,228	54,737	43,788	54,670	38,193	47,589	65,360	71,161	58,926	78,534	60,581	692,039
1977	61,970	53,881	58,621	46,600	48,425	39,411	41,602	60,841	63,006	44,547	62,719	52,738	634,361
1978	47,503	42,795	52,879	42,751	43,564	45,079	44,534	73,278	105,402	96,982	67,498	53,668	715,933
1979	54,529	65,733	59,249	44,349	35,790	62,713	52,227	79,090	69,539	97,688	91,180	70,236	782,323
1980	88,036	55,811	25,045	18,350	22,809	37,121	27,093	104,311	94,594	144,492	126,436	83,066	827,164
1981	81,283	63,795	54,241	37,101	49,349	53,445	51,916	66,995	74,557	105,431	109,935	73,510	821,558
1982	69,338	60,829	50,721	47,762	47,483	51,840	44,011	65,704	93,263	141,596	126,160	106,948	905,655
1983	104,224	75,939	28,467	15,639	12,241	34,928	18,956	92,908	91,392	149,491	140,869	84,389	849,443
1984	62,791	43,976	20,955	17,659	27,232	61,363	42,557	100,025	105,739	149,858	134,134	97,097	863,386
1985	69,411	60,770	48,251	22,293	19,046	80,892	77,552	80,727	101,171	137,697	128,889	88,175	914,874
1986	69,481	63,689	26,526	30,597	49,859	75,144	27,278	103,931	93,748	139,369	131,911	76,696	888,229
1987	81,792	68,230	49,137	39,101	45,727	26,233	49,654	82,279	95,827	150,024	130,250	97,771	916,025
1988	82,144	80,181	47,845	9,795	12,552	59,952	76,454	99,849	106,506	142,650	136,643	95,546	950,117
1989	74,056	70,051	42,877	32,436	37,963	66,956	52,811	77,334	99,985	135,676	119,527	106,250	915,922
1990	73,811	75,263	50,571	45,638	31,570	53,901	66,498	81,756	122,778	137,329	128,489	94,896	962,500
1991	91,995	75,222	45,295	35,569	46,248	48,193	54,865	80,578	136,069	148,482	141,207	93,035	996,758
1992	84,614	88,946	75,511	35,373	30,751	49,755	90,400	76,494	107,825	128,080	137,249	95,506	1,000,504
1993	83,345	79,754	35,275	29,010	42,846	44,461	58,014	86,053	136,716	152,487	137,181	87,296	972,438
1994	64,910	80,835	61,569	48,317	31,974	53,135	71,158	80,670	105,861	110,364	88,684	59,790	857,267
1995	67,504	69,938	65,371	61,097	49,035	49,211	44,027	103,383	85,420	154,128	147,474	94,258	990,846
1996	82,030	68,116	58,423	37,607	30,731	42,522	71,428	99,015	128,852	155,021	128,707	81,448	983,900
1997	71,190	90,716	48,693	27,833	41,625	38,706	79,493	99,140	114,748	158,560	140,521	94,816	1,006,041
1998	73,300	55,568	45,165	13,131	32,415	41,827	81,892	98,860	88,322	141,973	144,883	105,519	922,855

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Region 5: Agricultural Diversion Estimates for Alternative "Region 5 CO Transfer D"
(Measured in Acre-Feet)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	57,405	7,299	2,310	1,060	1,800	3,207	15,352	125,130	171,471	222,037	222,514	112,623	942,208
1976	37,364	12,436	13,378	4,473	4,253	4,406	22,197	100,732	194,156	239,702	208,230	111,446	952,773
1977	42,658	13,648	6,306	2,812	5,693	7,648	34,763	113,987	203,214	197,234	178,574	90,610	897,147
1978	51,167	16,335	7,440	8,770	6,570	3,631	25,187	103,653	171,541	223,020	204,985	91,787	914,086
1979	49,138	6,298	17,188	10,384	9,945	7,362	23,903	105,649	166,414	230,546	184,425	86,642	897,894
1980	42,909	2,162	3,303	4,660	1,853	5,007	11,506	102,184	174,425	231,602	194,126	96,296	870,033
1981	52,394	18,362	6,670	5,700	4,047	5,357	25,674	99,201	183,535	230,719	196,021	95,319	922,999
1982	72,373	15,798	9,299	5,732	4,895	6,179	35,159	97,163	168,784	217,794	188,034	92,734	913,944
1983	37,053	8,040	2,566	3,408	4,858	7,381	17,756	102,578	163,204	206,507	191,303	100,287	844,941
1984	41,152	6,195	5,589	184	134	4,312	6,627	101,965	175,072	252,968	187,081	92,262	873,541
1985	35,542	6,538	14,887	6,528	5,524	6,199	55,041	116,260	209,389	237,698	204,384	88,450	986,440
1986	23,734	3,266	99	4,148	2,756	13,845	40,613	124,150	171,789	231,362	189,352	82,982	888,096
1987	36,141	10,440	4,612	4,813	3,045	4,794	50,261	119,219	178,476	216,141	174,767	83,935	886,644
1988	30,825	8,680	5,459	5,529	5,037	8,392	31,474	127,239	179,216	210,215	195,471	84,371	891,908
1989	50,801	9,742	5,944	4,655	4,606	8,456	50,351	119,008	173,661	231,317	181,448	81,308	921,297
1990	41,336	11,543	7,327	5,974	8,809	21,829	36,620	108,072	171,517	216,369	169,804	89,536	888,736
1991	40,643	11,129	8,072	6,372	5,966	10,323	31,753	112,591	177,325	226,232	181,923	90,496	902,825
1992	33,412	12,499	9,680	7,255	6,652	13,343	30,611	120,408	167,269	207,565	162,663	76,085	847,442
1993	33,546	19,059	8,266	7,083	5,939	7,839	21,149	123,388	173,780	228,986	183,059	85,382	897,476
1994	36,741	10,065	6,305	5,258	4,741	10,968	34,758	118,064	191,000	199,640	178,788	82,708	879,036
1995	34,283	15,443	7,153	6,259	5,795	11,141	35,056	108,913	165,369	191,998	183,610	97,477	862,497
1996	24,691	21,876	9,253	5,518	7,298	11,946	94,498	127,005	171,130	214,627	172,777	82,483	943,102
1997	28,536	6,955	11,307	16,971	9,343	13,030	38,973	113,083	166,312	231,631	148,326	77,636	862,103
1998	27,881	1,108	3,061	3,985	5,116	10,962	59,983	112,730	180,342	238,705	164,448	91,782	900,103

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APPENDIX 2.4

SUMMARY OF ECONOMIC OUTPUT FOR EACH REGION UNDER BASELINE CONDITIONS AND EACH ALTERNATIVE

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"Baseline", Region 1

Objective Value = $25,313.53

Water Available in Acre-Feet

	Low	Medium	High
Early	14124	29307	42875
Late	14322	29605	55885

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2914	0.0416	0.0000	$10,838	$14,527	$14,527
Medium Early	0.0416	0.1249	0.1665	$10,960	$25,150	$32,934
High Early	0.0000	0.1665	0.1665	$7,282	$25,517	$49,381

Average Cropping Activity

		Water Diverted(in/acre)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	100	87.2	87.2	87.2	3.0	3.0	3.0
Medium Early	100	87.2	87.2	87.2	3.0	3.0	3.0
High Early	100	62.6	87.2	87.2	2.0	3.0	3.0
HAY(T)							
Low Early	900	21.9	26.4	26.4	0.4	0.4	0.4
Medium Early	900	38.8	55.8	65.3	0.4	0.9	1.1
High Early	900	56.6	70.8	100.0	0.4	1.1	1.7
IDLE							
Low Early	0	--	--	--	--	--	--
Medium Early	0	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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"Baseline", Region 2

Objective Value = $169,021.86

Water Available in Acre-Feet

	Low	Medium	High
Early	5978	9457	11384
Late	32043	35433	37627

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1665	0.1249	0.0416	$161,071	$161,071	$161,071
Medium Early	0.0833	0.1665	0.0833	$164,949	$174,157	$174,157
High Early	0.0833	0.0416	0.2081	$163,471	$173,418	$179,363

Average Cropping Activity

		Water Diverted(in/acre)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	35	80.5	80.5	80.5	5.0	5.0	5.0
Medium Early	158	59.1	80.5	80.5	3.6	5.0	5.0
High Early	200	54.4	69.6	80.5	3.3	4.3	5.0
CORN(bu)							
Low Early	450	50.8	50.8	50.8	144.8	144.8	144.8
Medium Early	450	50.8	50.8	50.8	144.8	144.8	144.8
High Early	450	50.0	50.8	50.8	143.0	144.8	144.8
BEETS(T)							
Low Early	100	36.9	36.9	36.9	22.3	22.3	22.3
Medium Early	100	36.9	36.9	36.9	22.3	22.3	22.3
High Early	100	36.9	36.9	36.9	22.3	22.3	22.3
BEANS(lbs)							
Low Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Medium Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
High Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Wheat(bu)							
Low Early	50	15.0	15.0	15.0	58.5	58.5	58.5
Medium Early	50	15.2	15.2	15.2	58.6	58.6	58.6
High Early	50	30.0	30.0	30.0	65.0	65.0	65.0
IDLE							
Low Early	165	--	--	--	--	--	--
Medium Early	42	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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"Baseline", Region 3

Objective Value = $166,159.45

Water Available in Acre-Feet

	Low	Medium	High
Early	3800	4845	5585
Late	19736	22228	24700

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1249	0.1249	0.0833	$156,411	$156,818	$156,818
Medium Early	0.1249	0.0833	0.1249	$152,289	$175,357	$183,378
High Early	0.0833	0.1249	0.1249	$152,289	$175,357	$183,378

Average Cropping Activity

		Water Diverted(in/acre)			Crop Yield		
CORN(bu)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	715	29.8	29.9	29.9	165.4	165.7	165.7
Medium Early	850	25.9	28.8	29.9	148.8	161.3	165.7
High Early	850	25.9	28.8	29.9	148.8	161.3	165.7
SOYBEAN(bu)							
Low Early	100	22.3	22.3	22.3	54.7	54.7	54.7
Medium Early	100	22.3	22.3	22.3	54.7	54.7	54.7
High Early	100	22.3	22.3	22.3	54.7	54.7	54.7
IDLE							
Low Early	185	--	--	--	--	--	--
Medium Early	50	--	--	--	--	--	--
High Early	50	--	--	--	--	--	--

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"Baseline", Region 4

Objective Value = $142,219.48

Water Available in Acre-Feet

	Low	Medium	High
Early	5730	6931	8153
Late	18498	26125	27719

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2498	0.0416	0.0416	$125,613	$125,613	$125,613
Medium Early	0.0833	0.1665	0.0833	$91,486	$154,822	$154,822
High Early	0.0000	0.1249	0.2081	$79,235	$155,835	$166,475

Average Cropping Activity

		Water Diverted(in/acre)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	179	57.1	57.1	57.1	5.4	5.4	5.4
Medium Early	164	38.6	57.1	57.1	3.5	5.4	5.4
High Early	200	45.5	49.1	57.1	3.7	4.6	5.4
CORN(bu)							
Low Early	242	32.4	32.4	32.4	163.0	163.0	163.0
Medium Early	540	25.5	32.4	32.4	134.7	163.0	163.0
High Early	550	21.4	32.4	32.4	117.8	163.0	163.0
BEETS(T)							
Low Early	100	37.8	37.8	37.8	24.3	24.3	24.3
Medium Early	100	37.8	37.8	37.8	24.3	24.3	24.3
High Early	100	37.8	37.8	37.8	24.3	24.3	24.3
BEANS(lbs)							
Low Early	50	37.2	37.2	37.2	2276.7	2276.7	2276.7
Medium Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
High Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
Wheat(bu)							
Low Early	100	5.3	5.3	5.3	61.2	61.2	61.2
Medium Early	100	5.3	5.3	5.3	61.2	61.2	61.2
High Early	100	9.9	9.9	9.9	68.0	68.0	68.0
IDLE							
Low Early	329	--	--	--	--	--	--
Medium Early	46	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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"Baseline", Region 5

Objective Value = $176,894.42

Water Available in Acre-Feet

	Low	Medium	High
Early	9183	9908	11031
Late	29634	31673	34305

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.0416	0.0833	0.2081	$172,069	$177,776	$177,776
Medium Early	0.1249	0.1249	0.0833	$170,161	$181,460	$181,460
High Early	0.1665	0.1249	0.0416	$176,930	$176,930	$176,930

Average Cropping Activity

		Water Diverted(in/acre)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	300	53.6	57.1	57.1	4.7	5.0	5.0
Medium Early	300	50.3	57.1	57.1	4.4	5.0	5.0
High Early	300	57.1	57.1	57.1	5.0	5.0	5.0
CORN(bu)							
Low Early	244	42.9	42.9	42.9	155.7	155.7	155.7
Medium Early	273	42.9	42.9	42.9	155.7	155.7	155.7
High Early	214	42.9	42.9	42.9	155.7	155.7	155.7
BEETS(T)							
Low Early	150	44.9	44.9	44.9	24.7	24.7	24.7
Medium Early	150	44.9	44.9	44.9	24.7	24.7	24.7
High Early	150	44.9	44.9	44.9	24.7	24.7	24.7
BEANS(lbs)							
Low Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Medium Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
High Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Wheat(bu)							
Low Early	100	14.0	14.0	14.0	68.1	68.1	68.1
Medium Early	100	18.7	18.7	18.7	71.9	71.9	71.9
High Early	100	23.3	23.3	23.3	75.7	75.7	75.7
IDLE							
Low Early	106	--	--	--	--	--	--
Medium Early	77	--	--	--	--	--	--
High Early	136	--	--	--	--	--	--

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Alternative "Region 1 WY Transfer D", Region 1

Objective Value = $25,013.26

Water Available in Acre-Feet

	Low	Medium	High
Early	13713	28896	42464
Late	14133	29416	55696

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2914	0.0416	0.0000	$10,655	$14,029	$14,029
Medium Early	0.0416	0.1249	0.1665	$10,779	$24,967	$32,436
High Early	0.0000	0.1665	0.1665	$7,106	$25,337	$48,884

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	100	87.2	87.2	87.2	3.0	3.0	3.0
Medium Early	100	87.2	87.2	87.2	3.0	3.0	3.0
High Early	100	62.6	87.2	87.2	2.0	3.0	3.0
HAY(T)							
Low Early	900	21.2	25.4	25.4	0.3	0.4	0.4
Medium Early	900	38.1	55.1	64.3	0.4	0.9	1.1
High Early	900	55.9	70.2	99.0	0.4	1.0	1.7
IDLE							
Low Early	0	--	--	--	--	--	--
Medium Early	0	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 1 WY Transfer D", Region 2

Objective Value = $169,021.86

Water Available in Acre-Feet

	Low	Medium	High
Early	5978	9457	11384
Late	32043	35433	37627

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1665	0.1249	0.0416	$161,071	$161,071	$161,071
Medium Early	0.0833	0.1665	0.0833	$164,949	$174,157	$174,157
High Early	0.0833	0.0416	0.2081	$163,471	$173,418	$179,363

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	35	80.5	80.5	80.5	5.0	5.0	5.0
Medium Early	158	59.1	80.5	80.5	3.6	5.0	5.0
High Early	200	54.4	69.6	80.5	3.3	4.3	5.0
CORN(bu)							
Low Early	450	50.8	50.8	50.8	144.8	144.8	144.8
Medium Early	450	50.8	50.8	50.8	144.8	144.8	144.8
High Early	450	50.0	50.8	50.8	143.0	144.8	144.8
BEETS(T)							
Low Early	100	36.9	36.9	36.9	22.3	22.3	22.3
Medium Early	100	36.9	36.9	36.9	22.3	22.3	22.3
High Early	100	36.9	36.9	36.9	22.3	22.3	22.3
BEANS(lbs)							
Low Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Medium Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
High Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Wheat(bu)							
Low Early	50	15.0	15.0	15.0	58.5	58.5	58.5
Medium Early	50	15.2	15.2	15.2	58.6	58.6	58.6
High Early	50	30.0	30.0	30.0	65.0	65.0	65.0
IDLE							
Low Early	165	--	--	--	--	--	--
Medium Early	42	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 1 WY Transfer D", Region 3

Objective Value = $166,022.66

Water Available in Acre-Feet

	Low	Medium	High
Early	3800	4845	5585
Late	19706	22205	24663

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1249	0.1249	0.0833	$156,134	$156,818	$156,818
Medium Early	0.1249	0.0833	0.1249	$152,011	$175,144	$183,378
High Early	0.0833	0.1249	0.1249	$152,011	$175,144	$183,378

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
CORN(bu)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	715	29.8	29.9	29.9	165.2	165.7	165.7
Medium Early	850	25.9	28.8	29.9	148.6	161.2	165.7
High Early	850	25.9	28.8	29.9	148.6	161.2	165.7
SOYBEAN(bu)							
Low Early	100	22.3	22.3	22.3	54.7	54.7	54.7
Medium Early	100	22.3	22.3	22.3	54.7	54.7	54.7
High Early	100	22.3	22.3	22.3	54.7	54.7	54.7
IDLE							
Low Early	185	--	--	--	--	--	--
Medium Early	50	--	--	--	--	--	--
High Early	50	--	--	--	--	--	--

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Alternative "Region 1 WY Transfer D", Region 4

Objective Value = $142,216.15

Water Available in Acre-Feet

	Low	Medium	High
Early	5730	6931	8153
Late	18496	26125	27719

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2498	0.0416	0.0416	$125,607	$125,607	$125,607
Medium Early	0.0833	0.1665	0.0833	$91,467	$154,822	$154,822
High Early	0.0000	0.1249	0.2081	$79,216	$155,835	$166,475

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	179	57.1	57.1	57.1	5.4	5.4	5.4
Medium Early	164	38.6	57.1	57.1	3.5	5.4	5.4
High Early	200	45.5	49.1	57.1	3.7	4.6	5.4
CORN(bu)							
Low Early	242	32.4	32.4	32.4	163.0	163.0	163.0
Medium Early	540	25.5	32.4	32.4	134.7	163.0	163.0
High Early	550	21.4	32.4	32.4	117.8	163.0	163.0
BEETS(T)							
Low Early	100	37.8	37.8	37.8	24.3	24.3	24.3
Medium Early	100	37.8	37.8	37.8	24.3	24.3	24.3
High Early	100	37.8	37.8	37.8	24.3	24.3	24.3
BEANS(lbs)							
Low Early	50	37.2	37.2	37.2	2276.7	2276.7	2276.7
Medium Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
High Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
Wheat(bu)							
Low Early	100	5.3	5.3	5.3	61.2	61.2	61.2
Medium Early	100	5.3	5.3	5.3	61.2	61.2	61.2
High Early	100	9.9	9.9	9.9	68.0	68.0	68.0
IDLE							
Low Early	329	--	--	--	--	--	--
Medium Early	46	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 1 WY Transfer D", Region 5

Objective Value = $176,909.09

Water Available in Acre-Feet

	Low	Medium	High
Early	9184	9907	11030
Late	29641	31672	34306

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.0416	0.0833	0.2081	$172,097	$177,786	$177,786
Medium Early	0.1249	0.1249	0.0833	$170,201	$181,455	$181,455
High Early	0.1665	0.1249	0.0416	$176,948	$176,948	$176,948

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	300	53.6	57.1	57.1	4.7	5.0	5.0
Medium Early	300	50.3	57.1	57.1	4.4	5.0	5.0
High Early	300	57.1	57.1	57.1	5.0	5.0	5.0
CORN(bu)							
Low Early	244	42.9	42.9	42.9	155.7	155.7	155.7
Medium Early	273	42.9	42.9	42.9	155.7	155.7	155.7
High Early	214	42.9	42.9	42.9	155.7	155.7	155.7
BEETS(T)							
Low Early	150	44.9	44.9	44.9	24.7	24.7	24.7
Medium Early	150	44.9	44.9	44.9	24.7	24.7	24.7
High Early	150	44.9	44.9	44.9	24.7	24.7	24.7
BEANS(lbs)							
Low Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Medium Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
High Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Wheat(bu)							
Low Early	100	14.0	14.0	14.0	68.1	68.1	68.1
Medium Early	100	18.7	18.7	18.7	71.9	71.9	71.9
High Early	100	23.3	23.3	23.3	75.7	75.7	75.7
IDLE							
Low Early	106	--	--	--	--	--	--
Medium Early	77	--	--	--	--	--	--
High Early	136	--	--	--	--	--	--

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Alternative "Region 2 WY Transfer D", Region 1

Objective Value = $25,313.53

Water Available in Acre-Feet

	Low	Medium	High
Early	14124	29307	42875
Late	14322	29605	55885

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2914	0.0416	0.0000	$10,838	$14,527	$14,527
Medium Early	0.0416	0.1249	0.1665	$10,960	$25,150	$32,934
High Early	0.0000	0.1665	0.1665	$7,282	$25,517	$49,381

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	100	87.2	87.2	87.2	3.0	3.0	3.0
Medium Early	100	87.2	87.2	87.2	3.0	3.0	3.0
High Early	100	62.6	87.2	87.2	2.0	3.0	3.0
HAY(T)							
Low Early	900	21.9	26.4	26.4	0.4	0.4	0.4
Medium Early	900	38.8	55.8	65.3	0.4	0.9	1.1
High Early	900	56.6	70.8	100.0	0.4	1.1	1.7
IDLE							
Low Early	0	--	--	--	--	--	--
Medium Early	0	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 2 WY Transfer D", Region 2

Objective Value = $168,595.07

Water Available in Acre-Feet

	Low	Medium	High
Early	5949	9405	11316
Late	31765	35125	37305

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1665	0.1249	0.0416	$160,962	$160,962	$160,962
Medium Early	0.0833	0.1665	0.0833	$164,517	$173,644	$173,644
High Early	0.0833	0.0416	0.2081	$162,696	$172,799	$178,709

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	34	80.5	80.5	80.5	5.0	5.0	5.0
Medium Early	152	58.4	80.5	80.5	3.6	5.0	5.0
High Early	194	54.4	69.3	80.5	3.3	4.3	5.0
CORN(bu)							
Low Early	450	50.8	50.8	50.8	144.8	144.8	144.8
Medium Early	450	50.8	50.8	50.8	144.8	144.8	144.8
High Early	450	49.7	50.8	50.8	142.5	144.8	144.8
BEETS(T)							
Low Early	100	36.9	36.9	36.9	22.3	22.3	22.3
Medium Early	100	36.9	36.9	36.9	22.3	22.3	22.3
High Early	100	36.9	36.9	36.9	22.3	22.3	22.3
BEANS(lbs)							
Low Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Medium Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
High Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Wheat(bu)							
Low Early	50	15.0	15.0	15.0	58.5	58.5	58.5
Medium Early	50	17.5	17.5	17.5	59.6	59.6	59.6
High Early	50	30.0	30.0	30.0	65.0	65.0	65.0
IDLE							
Low Early	166	--	--	--	--	--	--
Medium Early	48	--	--	--	--	--	--
High Early	6	--	--	--	--	--	--

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Alternative "Region 2 WY Transfer D", Region 3

Objective Value = $165,793.02

Water Available in Acre-Feet

	Low	Medium	High
Early	3800	4845	5585
Late	19684	22121	24583

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1249	0.1249	0.0833	$155,930	$156,818	$156,818
Medium Early	0.1249	0.0833	0.1249	$151,808	$174,366	$183,378
High Early	0.0833	0.1249	0.1249	$151,808	$174,366	$183,378

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
CORN(bu)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	715	29.7	29.9	29.9	165.1	165.7	165.7
Medium Early	850	25.8	28.7	29.9	148.5	160.8	165.7
High Early	850	25.8	28.7	29.9	148.5	160.8	165.7
SOYBEAN(bu)							
Low Early	100	22.3	22.3	22.3	54.7	54.7	54.7
Medium Early	100	22.3	22.3	22.3	54.7	54.7	54.7
High Early	100	22.3	22.3	22.3	54.7	54.7	54.7
IDLE							
Low Early	185	--	--	--	--	--	--
Medium Early	50	--	--	--	--	--	--
High Early	50	--	--	--	--	--	--

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Alternative "Region 2 WY Transfer D", Region 4

Objective Value = $142,218.66

Water Available in Acre-Feet

	Low	Medium	High
Early	5730	6931	8153
Late	18497	26126	27720

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2498	0.0416	0.0416	$125,610	$125,610	$125,610
Medium Early	0.0833	0.1665	0.0833	$91,469	$154,825	$154,825
High Early	0.0000	0.1249	0.2081	$79,226	$155,842	$166,475

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	179	57.1	57.1	57.1	5.4	5.4	5.4
Medium Early	164	38.6	57.1	57.1	3.5	5.4	5.4
High Early	200	45.5	49.1	57.1	3.7	4.6	5.4
CORN(bu)							
Low Early	242	32.4	32.4	32.4	163.0	163.0	163.0
Medium Early	540	25.5	32.4	32.4	134.7	163.0	163.0
High Early	550	21.4	32.4	32.4	117.8	163.0	163.0
BEETS(T)							
Low Early	100	37.8	37.8	37.8	24.3	24.3	24.3
Medium Early	100	37.8	37.8	37.8	24.3	24.3	24.3
High Early	100	37.8	37.8	37.8	24.3	24.3	24.3
BEANS(lbs)							
Low Early	50	37.2	37.2	37.2	2276.7	2276.7	2276.7
Medium Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
High Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
Wheat(bu)							
Low Early	100	5.3	5.3	5.3	61.2	61.2	61.2
Medium Early	100	5.3	5.3	5.3	61.2	61.2	61.2
High Early	100	9.9	9.9	9.9	68.0	68.0	68.0
IDLE							
Low Early	329	--	--	--	--	--	--
Medium Early	46	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 2 WY Transfer D", Region 5

Objective Value = $176,910.81

Water Available in Acre-Feet

	Low	Medium	High
Early	9183	9908	11032
Late	29643	31674	34305

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.0416	0.0833	0.2081	$172,119	$177,776	$177,776
Medium Early	0.1249	0.1249	0.0833	$170,207	$181,462	$181,462
High Early	0.1665	0.1249	0.0416	$176,954	$176,954	$176,954

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	300	53.7	57.1	57.1	4.7	5.0	5.0
Medium Early	300	50.3	57.1	57.1	4.4	5.0	5.0
High Early	300	57.1	57.1	57.1	5.0	5.0	5.0
CORN(bu)							
Low Early	244	42.9	42.9	42.9	155.7	155.7	155.7
Medium Early	273	42.9	42.9	42.9	155.7	155.7	155.7
High Early	214	42.9	42.9	42.9	155.7	155.7	155.7
BEETS(T)							
Low Early	150	44.9	44.9	44.9	24.7	24.7	24.7
Medium Early	150	44.9	44.9	44.9	24.7	24.7	24.7
High Early	150	44.9	44.9	44.9	24.7	24.7	24.7
BEANS(lbs)							
Low Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Medium Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
High Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Wheat(bu)							
Low Early	100	14.0	14.0	14.0	68.1	68.1	68.1
Medium Early	100	18.7	18.7	18.7	71.9	71.9	71.9
High Early	100	23.3	23.3	23.3	75.7	75.7	75.7
IDLE							
Low Early	106	--	--	--	--	--	--
Medium Early	77	--	--	--	--	--	--
High Early	136	--	--	--	--	--	--

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Alternative "Region 2 NE Transfer B", Region 1

Objective Value = $25,313.53

Water Available in Acre-Feet

	Low	Medium	High
Early	14124	29307	42875
Late	14322	29605	55885

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2914	0.0416	0.0000	$10,838	$14,527	$14,527
Medium Early	0.0416	0.1249	0.1665	$10,960	$25,150	$32,934
High Early	0.0000	0.1665	0.1665	$7,282	$25,517	$49,381

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	100	87.2	87.2	87.2	3.0	3.0	3.0
Medium Early	100	87.2	87.2	87.2	3.0	3.0	3.0
High Early	100	62.6	87.2	87.2	2.0	3.0	3.0
HAY(T)							
Low Early	900	21.9	26.4	26.4	0.4	0.4	0.4
Medium Early	900	38.8	55.8	65.3	0.4	0.9	1.1
High Early	900	56.6	70.8	100.0	0.4	1.1	1.7
IDLE							
Low Early	0	--	--	--	--	--	--
Medium Early	0	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 2 NE Transfer B", Region 2

Objective Value = $168,578.15

Water Available in Acre-Feet

	Low	Medium	High
Early	5913	9385	11301
Late	31777	35172	37342

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1665	0.1249	0.0416	$160,826	$160,826	$160,826
Medium Early	0.0833	0.1665	0.0833	$164,472	$173,695	$173,695
High Early	0.0833	0.0416	0.2081	$162,690	$172,902	$178,784

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	33	80.5	80.5	80.5	5.0	5.0	5.0
Medium Early	153	58.3	80.5	80.5	3.5	5.0	5.0
High Early	195	54.4	69.4	80.5	3.3	4.3	5.0
CORN(bu)							
Low Early	450	50.8	50.8	50.8	144.8	144.8	144.8
Medium Early	450	50.8	50.8	50.8	144.8	144.8	144.8
High Early	450	49.7	50.8	50.8	142.4	144.8	144.8
BEETS(T)							
Low Early	100	36.9	36.9	36.9	22.3	22.3	22.3
Medium Early	100	36.9	36.9	36.9	22.3	22.3	22.3
High Early	100	36.9	36.9	36.9	22.3	22.3	22.3
BEANS(lbs)							
Low Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Medium Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
High Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Wheat(bu)							
Low Early	50	15.0	15.0	15.0	58.5	58.5	58.5
Medium Early	50	16.6	16.6	16.6	59.2	59.2	59.2
High Early	50	30.0	30.0	30.0	65.0	65.0	65.0
IDLE							
Low Early	167	--	--	--	--	--	--
Medium Early	47	--	--	--	--	--	--
High Early	5	--	--	--	--	--	--

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Alternative "Region 2 NE Transfer B", Region 3

Objective Value = $166,011.88

Water Available in Acre-Feet

	Low	Medium	High
Early	3800	4845	5585
Late	19715	22185	24667

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1249	0.1249	0.0833	$156,217	$156,818	$156,818
Medium Early	0.1249	0.0833	0.1249	$152,094	$174,959	$183,378
High Early	0.0833	0.1249	0.1249	$152,094	$174,959	$183,378

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
CORN(bu)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	715	29.8	29.9	29.9	165.3	165.7	165.7
Medium Early	850	25.9	28.8	29.9	148.7	161.1	165.7
High Early	850	25.9	28.8	29.9	148.7	161.1	165.7
SOYBEAN(bu)							
Low Early	100	22.3	22.3	22.3	54.7	54.7	54.7
Medium Early	100	22.3	22.3	22.3	54.7	54.7	54.7
High Early	100	22.3	22.3	22.3	54.7	54.7	54.7
IDLE							
Low Early	185	--	--	--	--	--	--
Medium Early	50	--	--	--	--	--	--
High Early	50	--	--	--	--	--	--

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Alternative "Region 2 NE Transfer B", Region 4

Objective Value = $142,212.82

Water Available in Acre-Feet

	Low	Medium	High
Early	5730	6931	8153
Late	18494	26125	27720

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2498	0.0416	0.0416	$125,602	$125,602	$125,602
Medium Early	0.0833	0.1665	0.0833	$91,448	$154,822	$154,822
High Early	0.0000	0.1249	0.2081	$79,197	$155,835	$166,475

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	179	57.1	57.1	57.1	5.4	5.4	5.4
Medium Early	164	38.6	57.1	57.1	3.5	5.4	5.4
High Early	200	45.5	49.1	57.1	3.7	4.6	5.4
CORN(bu)							
Low Early	242	32.4	32.4	32.4	163.0	163.0	163.0
Medium Early	540	25.5	32.4	32.4	134.6	163.0	163.0
High Early	550	21.4	32.4	32.4	117.8	163.0	163.0
BEETS(T)							
Low Early	100	37.8	37.8	37.8	24.3	24.3	24.3
Medium Early	100	37.8	37.8	37.8	24.3	24.3	24.3
High Early	100	37.8	37.8	37.8	24.3	24.3	24.3
BEANS(lbs)							
Low Early	50	37.2	37.2	37.2	2276.7	2276.7	2276.7
Medium Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
High Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
Wheat(bu)							
Low Early	100	5.3	5.3	5.3	61.2	61.2	61.2
Medium Early	100	5.3	5.3	5.3	61.2	61.2	61.2
High Early	100	9.9	9.9	9.9	68.0	68.0	68.0
IDLE							
Low Early	329	--	--	--	--	--	--
Medium Early	46	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 2 NE Transfer B", Region 5

Objective Value = $176,897.01

Water Available in Acre-Feet

	Low	Medium	High
Early	9184	9908	11029
Late	29634	31671	34306

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.0416	0.0833	0.2081	$172,058	$177,786	$177,786
Medium Early	0.1249	0.1249	0.0833	$170,168	$181,455	$181,455
High Early	0.1665	0.1249	0.0416	$176,930	$176,930	$176,930

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	300	53.6	57.1	57.1	4.7	5.0	5.0
Medium Early	300	50.3	57.1	57.1	4.4	5.0	5.0
High Early	300	57.1	57.1	57.1	5.0	5.0	5.0
CORN(bu)							
Low Early	244	42.9	42.9	42.9	155.7	155.7	155.7
Medium Early	273	42.9	42.9	42.9	155.7	155.7	155.7
High Early	214	42.9	42.9	42.9	155.7	155.7	155.7
BEETS(T)							
Low Early	150	44.9	44.9	44.9	24.7	24.7	24.7
Medium Early	150	44.9	44.9	44.9	24.7	24.7	24.7
High Early	150	44.9	44.9	44.9	24.7	24.7	24.7
BEANS(lbs)							
Low Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Medium Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
High Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Wheat(bu)							
Low Early	100	14.0	14.0	14.0	68.1	68.1	68.1
Medium Early	100	18.7	18.7	18.7	71.9	71.9	71.9
High Early	100	23.3	23.3	23.3	75.7	75.7	75.7
IDLE							
Low Early	106	--	--	--	--	--	--
Medium Early	77	--	--	--	--	--	--
High Early	136	--	--	--	--	--	--

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Alternative "Region 3 NE Transfer B", Region 1

Objective Value = $25,313.53

Water Available in Acre-Feet

	Low	Medium	High
Early	14124	29307	42875
Late	14322	29605	55885

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2914	0.0416	0.0000	$10,838	$14,527	$14,527
Medium Early	0.0416	0.1249	0.1665	$10,960	$25,150	$32,934
High Early	0.0000	0.1665	0.1665	$7,282	$25,517	$49,381

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	100	87.2	87.2	87.2	3.0	3.0	3.0
Medium Early	100	87.2	87.2	87.2	3.0	3.0	3.0
High Early	100	62.6	87.2	87.2	2.0	3.0	3.0
HAY(T)							
Low Early	900	21.9	26.4	26.4	0.4	0.4	0.4
Medium Early	900	38.8	55.8	65.3	0.4	0.9	1.1
High Early	900	56.6	70.8	100.0	0.4	1.1	1.7
IDLE							
Low Early	0	--	--	--	--	--	--
Medium Early	0	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 3 NE Transfer B", Region 2

Objective Value = $169,021.86

Water Available in Acre-Feet

	Low	Medium	High
Early	5978	9457	11384
Late	32043	35433	37627

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1665	0.1249	0.0416	$161,071	$161,071	$161,071
Medium Early	0.0833	0.1665	0.0833	$164,949	$174,157	$174,157
High Early	0.0833	0.0416	0.2081	$163,471	$173,418	$179,363

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	35	80.5	80.5	80.5	5.0	5.0	5.0
Medium Early	158	59.1	80.5	80.5	3.6	5.0	5.0
High Early	200	54.4	69.6	80.5	3.3	4.3	5.0
CORN(bu)							
Low Early	450	50.8	50.8	50.8	144.8	144.8	144.8
Medium Early	450	50.8	50.8	50.8	144.8	144.8	144.8
High Early	450	50.0	50.8	50.8	143.0	144.8	144.8
BEETS(T)							
Low Early	100	36.9	36.9	36.9	22.3	22.3	22.3
Medium Early	100	36.9	36.9	36.9	22.3	22.3	22.3
High Early	100	36.9	36.9	36.9	22.3	22.3	22.3
BEANS(lbs)							
Low Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Medium Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
High Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Wheat(bu)							
Low Early	50	15.0	15.0	15.0	58.5	58.5	58.5
Medium Early	50	15.2	15.2	15.2	58.6	58.6	58.6
High Early	50	30.0	30.0	30.0	65.0	65.0	65.0
IDLE							
Low Early	165	--	--	--	--	--	--
Medium Early	42	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 3 NE Transfer B", Region 3

Objective Value = $162,940.51

Water Available in Acre-Feet

	Low	Medium	High
Early	3730	4775	5515
Late	19203	21666	24158

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1249	0.1249	0.0833	$151,883	$154,205	$154,205
Medium Early	0.1249	0.0833	0.1249	$147,355	$170,155	$183,378
High Early	0.0833	0.1249	0.1249	$147,355	$170,155	$183,378

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
CORN(bu)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	702	29.5	29.9	29.9	164.1	165.7	165.7
Medium Early	850	25.3	28.2	29.9	146.1	158.5	165.7
High Early	850	25.3	28.2	29.9	146.1	158.5	165.7
SOYBEAN(bu)							
Low Early	100	22.3	22.3	22.3	54.7	54.7	54.7
Medium Early	100	22.3	22.3	22.3	54.7	54.7	54.7
High Early	100	22.3	22.3	22.3	54.7	54.7	54.7
IDLE							
Low Early	198	--	--	--	--	--	--
Medium Early	50	--	--	--	--	--	--
High Early	50	--	--	--	--	--	--

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Alternative "Region 3 NE Transfer B", Region 4

Objective Value = $142,223.72

Water Available in Acre-Feet

	Low	Medium	High
Early	5731	6931	8153
Late	18499	26125	27719

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2498	0.0416	0.0416	$125,623	$125,623	$125,623
Medium Early	0.0833	0.1665	0.0833	$91,496	$154,822	$154,822
High Early	0.0000	0.1249	0.2081	$79,245	$155,835	$166,475

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	179	57.1	57.1	57.1	5.4	5.4	5.4
Medium Early	164	38.6	57.1	57.1	3.5	5.4	5.4
High Early	200	45.5	49.1	57.1	3.7	4.6	5.4
CORN(bu)							
Low Early	242	32.4	32.4	32.4	163.0	163.0	163.0
Medium Early	540	25.5	32.4	32.4	134.7	163.0	163.0
High Early	550	21.4	32.4	32.4	117.8	163.0	163.0
BEETS(T)							
Low Early	100	37.8	37.8	37.8	24.3	24.3	24.3
Medium Early	100	37.8	37.8	37.8	24.3	24.3	24.3
High Early	100	37.8	37.8	37.8	24.3	24.3	24.3
BEANS(lbs)							
Low Early	50	37.2	37.2	37.2	2276.7	2276.7	2276.7
Medium Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
High Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
Wheat(bu)							
Low Early	100	5.3	5.3	5.3	61.2	61.2	61.2
Medium Early	100	5.3	5.3	5.3	61.2	61.2	61.2
High Early	100	9.9	9.9	9.9	68.0	68.0	68.0
IDLE							
Low Early	329	--	--	--	--	--	--
Medium Early	46	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 3 NE Transfer B", Region 5

Objective Value = $176,902.53

Water Available in Acre-Feet

	Low	Medium	High
Early	9184	9908	11032
Late	29637	31673	34306

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.0416	0.0833	0.2081	$172,075	$177,786	$177,786
Medium Early	0.1249	0.1249	0.0833	$170,177	$181,460	$181,460
High Early	0.1665	0.1249	0.0416	$176,938	$176,938	$176,938

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	300	53.6	57.1	57.1	4.7	5.0	5.0
Medium Early	300	50.3	57.1	57.1	4.4	5.0	5.0
High Early	300	57.1	57.1	57.1	5.0	5.0	5.0
CORN(bu)							
Low Early	244	42.9	42.9	42.9	155.7	155.7	155.7
Medium Early	273	42.9	42.9	42.9	155.7	155.7	155.7
High Early	214	42.9	42.9	42.9	155.7	155.7	155.7
BEETS(T)							
Low Early	150	44.9	44.9	44.9	24.7	24.7	24.7
Medium Early	150	44.9	44.9	44.9	24.7	24.7	24.7
High Early	150	44.9	44.9	44.9	24.7	24.7	24.7
BEANS(lbs)							
Low Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Medium Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
High Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Wheat(bu)							
Low Early	100	14.0	14.0	14.0	68.1	68.1	68.1
Medium Early	100	18.7	18.7	18.7	71.9	71.9	71.9
High Early	100	23.3	23.3	23.3	75.7	75.7	75.7
IDLE							
Low Early	106	--	--	--	--	--	--
Medium Early	77	--	--	--	--	--	--
High Early	136	--	--	--	--	--	--

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Alternative "Region 4 CO Transfer D", Region 1

Objective Value = $25,313.53

Water Available in Acre-Feet

	Low	Medium	High
Early	14124	29307	42875
Late	14322	29605	55885

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2914	0.0416	0.0000	$10,838	$14,527	$14,527
Medium Early	0.0416	0.1249	0.1665	$10,960	$25,150	$32,934
High Early	0.0000	0.1665	0.1665	$7,282	$25,517	$49,381

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	100	87.2	87.2	87.2	3.0	3.0	3.0
Medium Early	100	87.2	87.2	87.2	3.0	3.0	3.0
High Early	100	62.6	87.2	87.2	2.0	3.0	3.0
HAY(T)							
Low Early	900	21.9	26.4	26.4	0.4	0.4	0.4
Medium Early	900	38.8	55.8	65.3	0.4	0.9	1.1
High Early	900	56.6	70.8	100.0	0.4	1.1	1.7
IDLE							
Low Early	0	--	--	--	--	--	--
Medium Early	0	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 4 CO Transfer D", Region 2

Objective Value = $169,021.86

Water Available in Acre-Feet

	Low	Medium	High
Early	5978	9457	11384
Late	32043	35433	37627

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1665	0.1249	0.0416	$161,071	$161,071	$161,071
Medium Early	0.0833	0.1665	0.0833	$164,949	$174,157	$174,157
High Early	0.0833	0.0416	0.2081	$163,471	$173,418	$179,363

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	35	80.5	80.5	80.5	5.0	5.0	5.0
Medium Early	158	59.1	80.5	80.5	3.6	5.0	5.0
High Early	200	54.4	69.6	80.5	3.3	4.3	5.0
CORN(bu)							
Low Early	450	50.8	50.8	50.8	144.8	144.8	144.8
Medium Early	450	50.8	50.8	50.8	144.8	144.8	144.8
High Early	450	50.0	50.8	50.8	143.0	144.8	144.8
BEETS(T)							
Low Early	100	36.9	36.9	36.9	22.3	22.3	22.3
Medium Early	100	36.9	36.9	36.9	22.3	22.3	22.3
High Early	100	36.9	36.9	36.9	22.3	22.3	22.3
BEANS(lbs)							
Low Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Medium Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
High Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Wheat(bu)							
Low Early	50	15.0	15.0	15.0	58.5	58.5	58.5
Medium Early	50	15.2	15.2	15.2	58.6	58.6	58.6
High Early	50	30.0	30.0	30.0	65.0	65.0	65.0
IDLE							
Low Early	165	--	--	--	--	--	--
Medium Early	42	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 4 CO Transfer D", Region 3

Objective Value = $165,596.51

Water Available in Acre-Feet

	Low	Medium	High
Early	3800	4845	5585
Late	19629	22107	24583

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1249	0.1249	0.0833	$155,421	$156,818	$156,818
Medium Early	0.1249	0.0833	0.1249	$151,298	$174,237	$183,378
High Early	0.0833	0.1249	0.1249	$151,298	$174,237	$183,378

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
CORN(bu)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	715	29.6	29.9	29.9	164.8	165.7	165.7
Medium Early	850	25.8	28.7	29.9	148.2	160.7	165.7
High Early	850	25.8	28.7	29.9	148.2	160.7	165.7
SOYBEAN(bu)							
Low Early	100	22.3	22.3	22.3	54.7	54.7	54.7
Medium Early	100	22.3	22.3	22.3	54.7	54.7	54.7
High Early	100	22.3	22.3	22.3	54.7	54.7	54.7
IDLE							
Low Early	185	--	--	--	--	--	--
Medium Early	50	--	--	--	--	--	--
High Early	50	--	--	--	--	--	--

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Alternative "Region 4 CO Transfer D", Region 4

Objective Value = $140,825.47

Water Available in Acre-Feet

	Low	Medium	High
Early	5651	6838	8058
Late	18243	25804	27330

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2498	0.0416	0.0416	$124,336	$124,336	$124,336
Medium Early	0.0833	0.1665	0.0833	$90,421	$153,265	$153,265
High Early	0.0000	0.1249	0.2081	$78,866	$154,641	$164,831

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	176	57.1	57.1	57.1	5.4	5.4	5.4
Medium Early	162	38.6	57.1	57.1	3.5	5.4	5.4
High Early	200	45.4	49.4	57.1	3.7	4.6	5.4
CORN(bu)							
Low Early	236	32.4	32.4	32.4	163.0	163.0	163.0
Medium Early	532	25.5	32.4	32.4	134.4	163.0	163.0
High Early	536	21.4	32.4	32.4	117.8	163.0	163.0
BEETS(T)							
Low Early	100	37.8	37.8	37.8	24.3	24.3	24.3
Medium Early	100	37.8	37.8	37.8	24.3	24.3	24.3
High Early	100	37.8	37.8	37.8	24.3	24.3	24.3
BEANS(lbs)							
Low Early	50	37.2	37.2	37.2	2276.7	2276.7	2276.7
Medium Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
High Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
Wheat(bu)							
Low Early	100	5.3	5.3	5.3	61.2	61.2	61.2
Medium Early	100	5.3	5.3	5.3	61.2	61.2	61.2
High Early	100	9.7	9.7	9.7	67.7	67.7	67.7
IDLE							
Low Early	337	--	--	--	--	--	--
Medium Early	56	--	--	--	--	--	--
High Early	14	--	--	--	--	--	--

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Alternative "Region 4 CO Transfer D", Region 5

Objective Value = $176,945.17

Water Available in Acre-Feet

	Low	Medium	High
Early	9189	9908	11032
Late	29653	31680	34311

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.0416	0.0833	0.2081	$172,106	$177,840	$177,840
Medium Early	0.1249	0.1249	0.0833	$170,243	$181,475	$181,475
High Early	0.1665	0.1249	0.0416	$176,981	$176,981	$176,981

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	300	53.6	57.1	57.1	4.7	5.0	5.0
Medium Early	300	50.3	57.1	57.1	4.4	5.0	5.0
High Early	300	57.1	57.1	57.1	5.0	5.0	5.0
CORN(bu)							
Low Early	245	42.9	42.9	42.9	155.7	155.7	155.7
Medium Early	274	42.9	42.9	42.9	155.7	155.7	155.7
High Early	214	42.9	42.9	42.9	155.7	155.7	155.7
BEETS(T)							
Low Early	150	44.9	44.9	44.9	24.7	24.7	24.7
Medium Early	150	44.9	44.9	44.9	24.7	24.7	24.7
High Early	150	44.9	44.9	44.9	24.7	24.7	24.7
BEANS(lbs)							
Low Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Medium Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
High Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Wheat(bu)							
Low Early	100	14.0	14.0	14.0	68.1	68.1	68.1
Medium Early	100	18.7	18.7	18.7	71.9	71.9	71.9
High Early	100	23.3	23.3	23.3	75.7	75.7	75.7
IDLE							
Low Early	105	--	--	--	--	--	--
Medium Early	76	--	--	--	--	--	--
High Early	136	--	--	--	--	--	--

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Alternative "Region 5 CO Transfer D", Region 1

Objective Value = $25,313.53

Water Available in Acre-Feet

	Low	Medium	High
Early	14124	29307	42875
Late	14322	29605	55885

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2914	0.0416	0.0000	$10,838	$14,527	$14,527
Medium Early	0.0416	0.1249	0.1665	$10,960	$25,150	$32,934
High Early	0.0000	0.1665	0.1665	$7,282	$25,517	$49,381

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	100	87.2	87.2	87.2	3.0	3.0	3.0
Medium Early	100	87.2	87.2	87.2	3.0	3.0	3.0
High Early	100	62.6	87.2	87.2	2.0	3.0	3.0
HAY(T)							
Low Early	900	21.9	26.4	26.4	0.4	0.4	0.4
Medium Early	900	38.8	55.8	65.3	0.4	0.9	1.1
High Early	900	56.6	70.8	100.0	0.4	1.1	1.7
IDLE							
Low Early	0	--	--	--	--	--	--
Medium Early	0	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 5 CO Transfer D", Region 2

Objective Value = $169,021.86

Water Available in Acre-Feet

	Low	Medium	High
Early	5978	9457	11384
Late	32043	35433	37627

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1665	0.1249	0.0416	$161,071	$161,071	$161,071
Medium Early	0.0833	0.1665	0.0833	$164,949	$174,157	$174,157
High Early	0.0833	0.0416	0.2081	$163,471	$173,418	$179,363

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	35	80.5	80.5	80.5	5.0	5.0	5.0
Medium Early	158	59.1	80.5	80.5	3.6	5.0	5.0
High Early	200	54.4	69.6	80.5	3.3	4.3	5.0
CORN(bu)							
Low Early	450	50.8	50.8	50.8	144.8	144.8	144.8
Medium Early	450	50.8	50.8	50.8	144.8	144.8	144.8
High Early	450	50.0	50.8	50.8	143.0	144.8	144.8
BEETS(T)							
Low Early	100	36.9	36.9	36.9	22.3	22.3	22.3
Medium Early	100	36.9	36.9	36.9	22.3	22.3	22.3
High Early	100	36.9	36.9	36.9	22.3	22.3	22.3
BEANS(lbs)							
Low Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Medium Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
High Early	200	24.3	24.3	24.3	2272.3	2272.3	2272.3
Wheat(bu)							
Low Early	50	15.0	15.0	15.0	58.5	58.5	58.5
Medium Early	50	15.2	15.2	15.2	58.6	58.6	58.6
High Early	50	30.0	30.0	30.0	65.0	65.0	65.0
IDLE							
Low Early	165	--	--	--	--	--	--
Medium Early	42	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 5 CO Transfer D", Region 3

Objective Value = $165,620.01

Water Available in Acre-Feet

	Low	Medium	High
Early	3800	4845	5585
Late	19631	22116	24594

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.1249	0.1249	0.0833	$155,439	$156,818	$156,818
Medium Early	0.1249	0.0833	0.1249	$151,317	$174,320	$183,378
High Early	0.0833	0.1249	0.1249	$151,317	$174,320	$183,378

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
CORN(bu)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	715	29.7	29.9	29.9	164.8	165.7	165.7
Medium Early	850	25.8	28.7	29.9	148.2	160.7	165.7
High Early	850	25.8	28.7	29.9	148.2	160.7	165.7
SOYBEAN(bu)							
Low Early	100	22.3	22.3	22.3	54.7	54.7	54.7
Medium Early	100	22.3	22.3	22.3	54.7	54.7	54.7
High Early	100	22.3	22.3	22.3	54.7	54.7	54.7
IDLE							
Low Early	185	--	--	--	--	--	--
Medium Early	50	--	--	--	--	--	--
High Early	50	--	--	--	--	--	--

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Alternative "Region 5 CO Transfer D", Region 4

Objective Value = $142,406.37

Water Available in Acre-Feet

	Low	Medium	High
Early	5743	6933	8153
Late	18550	26197	27748

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.2498	0.0416	0.0416	$125,849	$125,849	$125,849
Medium Early	0.0833	0.1665	0.0833	$91,454	$155,026	$155,026
High Early	0.0000	0.1249	0.2081	$79,730	$156,316	$166,475

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	179	57.1	57.1	57.1	5.4	5.4	5.4
Medium Early	164	38.6	57.1	57.1	3.5	5.4	5.4
High Early	200	45.8	49.5	57.1	3.8	4.6	5.4
CORN(bu)							
Low Early	244	32.4	32.4	32.4	163.0	163.0	163.0
Medium Early	544	25.5	32.4	32.4	134.6	163.0	163.0
High Early	550	21.4	32.4	32.4	117.8	163.0	163.0
BEETS(T)							
Low Early	100	37.8	37.8	37.8	24.3	24.3	24.3
Medium Early	100	37.8	37.8	37.8	24.3	24.3	24.3
High Early	100	37.8	37.8	37.8	24.3	24.3	24.3
BEANS(lbs)							
Low Early	50	37.2	37.2	37.2	2276.7	2276.7	2276.7
Medium Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
High Early	50	19.7	37.2	37.2	1493.5	2276.7	2276.7
Wheat(bu)							
Low Early	100	5.3	5.3	5.3	61.2	61.2	61.2
Medium Early	100	5.3	5.3	5.3	61.2	61.2	61.2
High Early	100	9.9	9.9	9.9	68.0	68.0	68.0
IDLE							
Low Early	327	--	--	--	--	--	--
Medium Early	43	--	--	--	--	--	--
High Early	0	--	--	--	--	--	--

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Alternative "Region 5 CO Transfer D", Region 5

Objective Value = $175,997.53

Water Available in Acre-Feet

	Low	Medium	High
Early	9092	9812	10935
Late	29317	31290	33926

Joint Probabilities and Expected Net Returns for each Water Condition

	Probabilities			Expected Returns		
	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	0.0416	0.0833	0.2081	$171,353	$176,795	$176,795
Medium Early	0.1249	0.1249	0.0833	$169,496	$180,429	$180,429
High Early	0.1665	0.1249	0.0416	$176,077	$176,077	$176,077

Average Cropping Activity

		Water Diverted(in)			Crop Yield		
ALFALFA(T)	Acres	Low Late	Med Late	High Late	Low Late	Med Late	High Late
Low Early	300	53.8	57.1	57.1	4.7	5.0	5.0
Medium Early	300	50.5	57.1	57.1	4.4	5.0	5.0
High Early	300	57.1	57.1	57.1	5.0	5.0	5.0
CORN(bu)							
Low Early	233	42.9	42.9	42.9	155.7	155.7	155.7
Medium Early	262	42.9	42.9	42.9	155.7	155.7	155.7
High Early	205	42.9	42.9	42.9	155.7	155.7	155.7
BEETS(T)							
Low Early	150	44.9	44.9	44.9	24.7	24.7	24.7
Medium Early	150	44.9	44.9	44.9	24.7	24.7	24.7
High Early	150	44.9	44.9	44.9	24.7	24.7	24.7
BEANS(lbs)							
Low Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Medium Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
High Early	100	41.4	41.4	41.4	2303.3	2303.3	2303.3
Wheat(bu)							
Low Early	100	14.0	14.0	14.0	68.1	68.1	68.1
Medium Early	100	18.7	18.7	18.7	71.9	71.9	71.9
High Early	100	23.3	23.3	23.3	75.7	75.7	75.7
IDLE							
Low Early	117	--	--	--	--	--	--
Medium Early	88	--	--	--	--	--	--
High Early	145	--	--	--	--	--	--

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APPENDIX 2.5

ESTIMATED BASELINE RIVER FLOWS, TARGET FLOWS, SHORTAGES, AND ESTIMATED FLOWS FOR EACH ALTERNATIVE THROUGH GRAND ISLAND, NE (CRITICAL HABITAT REACH)

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Estimated baseline monthly river flows through Grand Island, NE (Acre-Feet)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	53,430	48,892	58,810	74,419	73,130	102,807	91,360	65,407	98,096	85,824	26,463	69,495	848,133
1976	44,104	58,425	94,720	78,963	109,190	106,052	95,781	74,992	22,881	7,297	5,521	25,841	723,767
1977	45,385	44,558	58,994	54,264	70,389	91,247	133,512	121,263	56,899	5,370	17,629	58,431	757,941
1978	56,180	55,819	60,526	49,019	57,071	220,529	107,990	58,818	54,035	2,352	6,259	26,175	754,773
1979	33,259	46,127	59,712	51,488	45,985	165,119	93,500	86,346	94,283	92,982	20,678	34,496	823,975
1980	26,311	43,539	124,133	104,627	164,431	225,789	264,073	446,049	444,887	81,774	26,944	33,206	1,985,763
1981	33,645	39,617	66,207	70,441	63,970	80,998	46,933	68,006	26,127	12,509	68,281	43,507	620,241
1982	51,519	64,348	84,796	71,472	105,191	119,236	60,661	90,591	74,876	24,814	31,669	45,917	825,090
1983	60,284	85,433	119,161	140,058	168,360	191,686	181,464	371,075	769,766	698,895	432,678	413,121	3,631,981
1984	166,776	92,320	212,377	304,472	405,006	426,721	581,562	691,664	537,504	231,217	93,718	205,251	3,948,588
1985	208,863	299,219	272,976	167,066	201,341	271,740	138,117	164,852	127,328	40,587	55,071	100,040	2,047,200
1986	130,562	88,641	126,681	166,686	186,286	171,296	195,156	227,098	182,515	145,473	131,213	189,791	1,941,398
1987	224,407	158,355	151,309	148,579	141,245	217,328	225,629	191,228	212,242	79,434	44,326	76,299	1,870,381
1988	103,667	118,082	106,986	116,673	194,265	155,058	116,155	119,753	104,645	58,396	54,277	57,539	1,305,496
1989	61,503	53,066	75,029	95,418	91,802	123,533	43,941	56,713	67,387	74,537	28,522	107,049	878,500
1990	63,191	61,140	44,328	121,773	93,036	125,078	111,592	99,785	66,207	21,251	26,400	35,250	869,031
1991	29,793	46,922	42,566	46,398	84,804	74,430	41,467	72,269	77,012	22,536	27,497	33,785	599,479
1992	20,525	51,975	59,423	81,558	85,298	141,088	75,178	72,384	51,088	53,898	11,915	45,674	750,004
1993	58,999	53,435	75,253	78,344	74,078	276,396	87,812	97,658	96,639	200,707	101,113	106,368	1,306,802
1994	121,613	116,602	118,221	93,431	96,734	170,268	76,993	106,705	70,411	71,488	31,156	62,308	1,135,930
1995	54,854	55,348	75,152	95,717	72,652	81,935	82,901	145,929	521,523	370,317	56,748	111,888	1,724,964
1996	136,820	121,438	94,146	80,904	98,332	139,020	115,524	193,052	171,976	81,526	114,844	135,622	1,483,204
1997	167,682	143,199	110,263	107,757	122,894	148,911	128,468	206,002	204,940	114,042	123,614	162,701	1,740,473
1998	193,079	198,567	197,512	220,372	198,109	175,233	258,369	282,422	185,919	91,265	121,638	98,496	2,220,981
Average	89,435	89,378	103,720	109,162	125,150	166,729	139,756	171,253	179,966	111,187	69,091	94,927	1,449,754

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Estimated monthly target flows through Grand Island, NE as identified by USFWS.(Acre-Feet)

YEAR	Type	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1976	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1977	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1978	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1979	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1980	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1981	dry	79,900	56,500	36,900	36,900	95,800	114,000	101,200	67,000	47,600	49,200	49,200	41,700	775,900
1982	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1983	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1984	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1985	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1986	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1987	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1988	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1989	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1990	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1991	dry	79,900	56,500	36,900	36,900	95,800	114,000	101,200	67,000	47,600	49,200	49,200	41,700	775,900
1992	dry	79,900	56,500	36,900	36,900	95,800	114,000	101,200	67,000	47,600	49,200	49,200	41,700	775,900
1993	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1994	avg	110,700	83,300	61,500	61,500	143,000	167,500	142,800	150,000	158,700	73,800	73,800	65,500	1,292,100
1995	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1996	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1997	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
1998	wet	147,600	101,200	61,500	61,500	143,000	167,500	142,800	170,800	158,700	73,800	73,800	65,500	1,367,700
Average		125,300	88,900	58,425	58,425	137,100	160,813	137,600	150,025	144,813	70,725	70,725	62,525	1,265,375

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Estimated monthly shortages as a result of baseline river flows through Grand Island, NE (Acre-Feet).

YEAR	Type	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	avg	57,270	34,408	2,690	0	69,870	64,693	51,440	84,593	60,604	0	47,337	0	472,905
1976	avg	66,596	24,875	0	0	33,810	61,448	47,019	75,008	135,819	66,503	68,279	39,659	619,016
1977	avg	65,315	38,742	2,506	7,236	72,611	76,253	9,288	28,737	101,801	68,430	56,171	7,069	534,159
1978	avg	54,520	27,481	974	12,481	85,929	0	34,810	91,182	104,665	71,448	67,541	39,325	590,356
1979	avg	77,441	37,173	1,788	10,012	97,015	2,381	49,300	63,654	64,417	0	53,122	31,004	487,307
1980	wet	121,289	57,661	0	0	0	0	0	0	0	0	46,856	32,294	258,100
1981	dry	46,255	16,883	0	0	31,830	33,002	54,267	0	21,473	36,691	0	0	240,401
1982	avg	59,181	18,952	0	0	37,809	48,264	82,139	59,409	83,824	48,986	42,131	19,583	500,278
1983	wet	87,316	15,767	0	0	0	0	0	0	0	0	0	0	103,083
1984	wet	0	8,880	0	0	0	0	0	0	0	0	0	0	8,880
1985	wet	0	0	0	0	0	0	4,683	5,948	31,372	33,213	18,729	0	93,945
1986	wet	17,038	12,559	0	0	0	0	0	0	0	0	0	0	29,597
1987	wet	0	0	0	0	1,755	0	0	0	0	0	29,474	0	31,229
1988	wet	43,933	0	0	0	0	12,442	26,645	51,047	54,055	15,404	19,523	7,961	231,010
1989	avg	49,197	30,234	0	0	51,198	43,967	98,859	93,287	91,313	0	45,278	0	503,333
1990	avg	47,509	22,160	17,172	0	49,922	42,422	31,208	50,215	92,493	52,549	47,400	30,250	483,300
1991	dry	50,107	9,578	0	0	10,996	39,570	59,733	0	0	26,664	21,703	7,915	226,266
1992	dry	59,375	4,525	0	0	10,502	0	26,022	0	0	0	37,285	0	137,709
1993	wet	88,601	47,765	0	0	68,922	0	54,988	73,142	62,061	0	0	0	395,479
1994	avg	0	0	0	0	46,266	0	65,807	43,295	88,289	2,312	42,644	3,192	291,805
1995	wet	92,746	45,852	0	0	70,348	85,565	59,899	24,871	0	0	17,052	0	396,333
1996	wet	10,780	0	0	0	44,668	28,480	27,276	0	0	0	0	0	111,204
1997	wet	0	0	0	0	20,106	18,589	14,332	0	0	0	0	0	53,027
1998	wet	0	0	0	0	0	0	0	0	0	0	0	0	0
Average		45,603	18,896	1,047	1,239	33,482	23,212	33,238	31,016	41,341	17,592	27,522	9,094	283,280

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Estimated monthly river flows through Grand Island, NE as a result of Region 1 WY Transfer D. (Acre-Feet)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	53,793	49,110	58,827	74,419	73,573	103,217	91,686	65,944	98,480	85,824	26,763	69,652	851,288
1976	44,427	58,546	94,720	78,963	109,354	106,350	96,009	75,356	23,539	7,619	6,006	26,033	726,922
1977	45,752	44,776	59,008	54,305	70,797	91,675	133,564	121,424	57,471	5,754	17,944	58,471	760,941
1978	56,457	55,959	60,531	49,082	57,508	220,529	108,167	59,281	54,567	2,715	6,602	26,375	757,773
1979	33,736	46,356	59,723	51,550	46,582	165,134	93,804	86,738	94,680	92,982	21,005	34,687	826,977
1980	27,721	44,209	124,134	104,627	164,431	225,789	264,073	446,049	444,887	81,997	27,489	33,581	1,988,987
1981	34,222	39,828	66,207	70,441	64,367	81,410	47,610	68,006	26,395	12,967	68,281	43,507	623,241
1982	51,874	64,462	84,797	71,472	105,418	119,525	61,154	90,947	75,379	25,108	31,922	46,034	828,092
1983	62,825	85,892	119,210	140,108	168,411	191,694	181,486	371,116	769,766	698,895	432,802	413,137	3,635,342
1984	166,776	95,320	212,377	304,472	405,006	426,721	581,562	691,664	537,504	231,217	93,889	205,300	3,951,808
1985	208,863	299,219	272,976	167,066	201,341	271,740	138,267	165,042	128,722	41,648	55,669	100,040	2,050,593
1986	132,289	89,914	126,681	166,686	186,286	171,296	195,156	227,098	182,515	145,473	131,351	189,837	1,944,582
1987	224,407	158,355	151,309	148,579	141,414	217,328	225,629	191,228	213,081	80,254	47,157	76,299	1,875,040
1988	104,238	118,082	106,986	116,673	194,265	155,220	116,501	120,416	105,347	58,596	54,531	57,642	1,308,497
1989	61,796	53,246	75,029	95,418	92,107	123,795	44,530	57,269	67,931	74,537	28,792	107,049	881,499
1990	63,486	61,278	44,435	121,773	93,036	125,341	111,786	100,097	66,781	21,577	26,694	35,438	871,722
1991	30,457	47,049	42,566	46,398	84,950	74,955	42,259	72,269	77,012	22,890	27,785	33,890	602,480
1992	21,818	52,074	59,423	81,558	85,527	141,088	75,745	72,384	51,088	53,898	12,727	45,674	753,004
1993	59,671	53,797	75,273	78,407	74,601	276,435	88,229	98,213	97,110	200,707	101,113	106,369	1,309,925
1994	121,613	116,602	118,221	93,431	97,210	170,268	77,670	107,150	71,319	71,512	31,594	62,341	1,138,931
1995	55,556	55,695	75,152	95,717	73,184	82,583	83,354	146,117	521,551	370,326	56,877	111,890	1,728,002
1996	137,111	121,438	94,146	80,904	99,537	139,788	116,260	193,052	171,976	81,526	114,844	135,622	1,486,204
1997	167,682	143,199	110,263	107,757	124,031	149,963	129,279	206,002	204,940	114,163	123,725	162,749	1,743,753
1998	193,079	198,567	197,512	220,372	198,109	175,233	258,369	282,422	187,030	92,396	121,797	98,546	2,223,432
Average	89,985	89,707	103,729	109,174	125,460	166,962	140,090	171,470	180,378	111,441	69,473	95,007	1,452,876

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Estimated monthly river flows through Grand Island, NE as a result of Region 2 WY Transfer D. (Acre-Feet)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	54,135	49,315	58,843	74,419	73,990	103,603	91,993	66,448	98,842	85,824	28,962	70,464	856,838
1976	44,711	58,652	94,720	78,963	109,498	106,612	96,210	75,676	24,119	7,903	6,143	26,364	729,571
1977	46,010	44,929	59,018	54,333	71,084	91,977	133,601	121,538	57,873	6,025	18,167	58,499	763,054
1978	56,669	56,065	60,535	49,131	57,841	220,529	108,302	59,636	54,973	2,993	6,865	26,528	760,067
1979	34,118	46,539	59,732	51,599	47,061	165,145	94,047	87,052	94,998	92,984	21,267	34,840	829,382
1980	28,952	44,795	124,134	104,627	164,432	225,789	264,073	446,049	444,887	81,774	27,964	33,909	1,991,385
1981	34,571	39,955	66,207	70,441	64,607	81,658	48,019	68,006	26,557	13,243	68,281	43,507	625,052
1982	52,053	64,519	84,796	71,472	105,532	119,671	61,402	91,127	75,632	25,256	32,049	46,094	829,603
1983	64,481	86,191	119,185	140,083	168,384	191,686	181,464	371,085	769,766	698,895	432,678	413,121	3,637,019
1984	166,776	97,334	212,377	304,472	405,006	426,721	581,562	691,664	537,504	231,217	93,718	205,709	3,954,060
1985	208,863	299,219	272,976	167,066	201,341	271,740	138,397	165,208	129,207	42,576	56,193	100,040	2,052,826
1986	133,436	90,760	126,681	166,686	186,286	171,296	195,156	227,098	182,515	145,473	131,814	189,967	1,947,168
1987	224,407	158,355	151,309	148,579	141,515	217,328	225,629	191,228	212,242	79,434	48,857	76,299	1,875,182
1988	104,678	118,082	106,986	116,673	194,265	155,344	116,768	120,927	105,889	58,750	54,965	57,722	1,311,049
1989	61,962	53,348	75,029	95,418	92,280	123,944	44,864	57,584	68,240	74,537	28,945	107,049	883,200
1990	63,527	61,297	44,449	121,773	93,036	125,378	111,813	100,140	66,861	21,623	26,735	35,464	872,096
1991	30,655	47,087	42,566	46,398	84,993	75,111	42,495	72,269	77,012	22,995	27,871	33,921	603,373
1992	22,286	52,109	59,423	81,558	85,610	141,088	75,950	72,384	51,088	53,898	13,021	45,674	754,089
1993	59,954	53,950	75,266	78,396	74,821	276,396	88,405	98,446	97,308	200,707	101,113	106,368	1,311,130
1994	121,613	116,602	118,221	93,431	97,544	170,268	78,145	107,463	71,956	71,528	31,902	62,364	1,141,037
1995	55,835	55,833	75,152	95,717	73,396	82,840	83,534	146,192	521,558	370,329	56,928	111,892	1,729,206
1996	137,342	121,438	94,146	80,904	100,494	140,398	116,844	193,052	171,976	81,526	114,844	135,622	1,488,586
1997	167,682	143,199	110,263	107,757	124,646	150,531	129,717	206,002	204,940	114,042	123,614	163,132	1,745,525
1998	193,079	198,567	197,512	220,372	198,109	175,233	258,369	282,422	185,919	91,909	123,768	99,235	2,224,494
Average	90,325	89,923	103,730	109,178	125,657	167,095	140,282	171,612	180,494	111,477	69,861	95,158	1,454,791

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Estimated monthly river flows through Grand Island, NE as a result of Region 2 NE Transfer B. (Acre-Feet)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	53,913	49,182	58,833	74,419	73,719	103,352	91,794	66,120	98,607	87,236	28,960	71,037	857,172
1976	44,535	58,586	94,720	78,963	109,409	106,450	96,085	75,477	23,760	7,727	5,988	27,264	728,964
1977	45,861	44,840	59,012	54,317	70,918	91,803	133,580	121,472	57,641	5,869	18,038	58,483	761,834
1978	56,519	55,990	60,532	49,097	57,606	220,529	108,207	59,385	54,686	2,797	6,679	26,420	758,447
1979	33,878	46,424	59,726	51,568	46,760	165,138	93,894	86,855	94,798	92,982	21,103	34,744	827,870
1980	28,378	44,522	124,133	104,627	164,431	225,789	264,073	446,049	444,887	83,206	29,300	33,756	1,993,151
1981	34,374	39,883	66,207	70,441	64,472	81,518	47,789	68,006	26,466	13,088	68,281	43,507	624,032
1982	51,958	64,489	84,806	71,472	105,471	119,594	61,270	91,032	75,498	25,177	31,982	46,062	828,811
1983	63,691	86,048	119,213	140,110	168,413	191,702	181,489	371,116	769,766	698,895	435,061	414,664	3,640,168
1984	166,776	96,441	212,377	304,472	405,006	426,721	581,562	691,664	537,504	231,217	95,963	206,330	3,956,033
1985	208,863	299,219	272,976	167,066	201,341	271,740	138,349	165,146	128,881	42,231	57,161	100,040	2,053,013
1986	132,888	90,356	126,681	166,686	186,286	171,296	195,156	227,098	182,515	145,473	133,189	191,062	1,948,686
1987	224,407	158,355	151,309	148,579	141,429	217,328	225,629	191,228	212,242	79,434	47,420	76,299	1,873,659
1988	104,411	118,082	106,986	116,673	194,265	155,269	116,607	120,618	105,561	58,657	56,497	57,674	1,311,300
1989	61,926	53,326	75,029	95,418	92,242	123,911	44,790	57,515	68,172	74,537	28,911	107,049	882,826
1990	63,560	61,312	44,461	121,773	93,036	125,408	111,835	100,175	66,926	21,659	26,768	35,485	872,398
1991	30,647	47,085	42,569	46,398	84,991	75,105	42,485	72,269	77,012	22,991	29,900	33,920	605,372
1992	22,315	52,111	59,423	81,558	85,615	141,088	75,962	72,384	51,088	53,898	13,039	45,674	754,155
1993	59,763	53,847	75,273	78,406	74,672	276,432	88,286	98,289	97,174	200,707	101,113	106,369	1,310,331
1994	121,613	116,602	118,221	93,431	97,414	170,268	77,961	107,342	71,709	71,522	31,783	62,355	1,140,221
1995	55,585	55,709	75,152	95,717	73,206	82,609	83,373	146,125	521,527	370,317	56,882	111,888	1,728,090
1996	137,189	121,438	94,146	80,904	99,862	139,996	116,458	193,052	171,976	81,560	117,107	135,664	1,489,352
1997	167,748	143,199	110,324	107,833	124,208	150,126	129,405	206,002	204,940	114,042	125,161	163,837	1,746,825
1998	193,079	198,567	197,512	220,372	198,109	175,233	258,369	282,422	185,919	93,622	123,713	99,634	2,226,551
Average	90,162	89,817	103,734	109,179	125,537	167,017	140,184	171,535	180,386	111,619	70,417	95,384	1,454,969

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Estimated monthly river flows through Grand Island, NE as a result of Region 3 NE Transfer B. (Acre-Feet)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	53,951	49,205	58,834	74,419	73,765	103,395	91,828	66,176	99,356	86,632	29,381	70,011	856,953
1976	44,567	58,598	94,720	78,963	109,425	106,479	96,108	75,513	23,824	7,759	6,005	26,364	728,325
1977	45,911	44,870	59,014	54,322	70,974	91,861	133,587	121,494	57,767	5,921	18,081	58,488	762,290
1978	56,577	56,019	60,533	49,110	57,697	220,529	108,244	59,482	55,047	2,872	6,751	26,698	759,559
1979	33,942	46,455	59,728	51,576	46,841	165,140	93,935	86,908	95,162	96,236	21,147	35,022	832,092
1980	28,332	44,500	124,133	104,627	164,431	225,789	264,073	446,049	444,887	81,774	28,565	33,744	1,990,904
1981	34,472	39,919	66,207	70,441	64,539	81,588	47,904	68,006	26,511	15,757	68,281	44,030	627,655
1982	52,028	64,511	84,796	71,472	105,516	119,651	61,367	91,102	75,744	25,235	32,031	46,440	829,893
1983	63,926	86,091	119,161	140,058	168,360	191,686	181,464	371,116	769,766	698,895	432,702	413,432	3,636,657
1984	166,776	96,620	212,377	304,472	405,006	426,721	581,562	691,664	537,504	231,217	95,378	205,568	3,954,865
1985	208,863	299,219	272,976	167,066	201,341	271,740	138,331	165,124	128,764	42,107	57,085	100,369	2,052,985
1986	133,037	90,466	126,681	166,686	186,286	171,296	195,156	227,098	182,515	145,473	133,101	190,107	1,947,902
1987	224,407	158,355	151,309	148,579	141,487	217,328	225,629	191,228	212,953	79,434	48,384	76,654	1,875,747
1988	104,485	118,082	106,986	116,673	194,265	155,290	116,651	120,703	105,651	58,683	56,214	57,871	1,311,554
1989	61,923	53,324	75,029	95,418	92,239	123,909	44,786	57,510	68,167	74,537	31,396	107,572	885,810
1990	63,614	61,337	44,481	121,773	93,522	125,455	111,870	100,232	67,047	21,719	26,822	35,582	873,454
1991	30,745	47,104	42,566	46,398	85,013	75,182	42,602	72,269	77,012	23,043	29,131	34,117	605,182
1992	22,379	52,116	59,423	81,558	85,626	141,088	75,991	72,384	51,374	53,898	13,402	46,197	755,436
1993	59,962	53,954	75,253	78,344	74,827	276,396	88,410	98,453	97,457	200,707	101,113	106,881	1,311,757
1994	121,613	116,602	118,221	93,431	97,416	170,268	77,963	107,343	71,712	74,001	31,784	62,355	1,142,709
1995	55,860	55,845	75,152	95,717	73,415	82,863	83,551	146,199	522,411	373,561	58,222	112,508	1,735,304
1996	137,237	121,438	94,146	80,904	100,059	140,121	116,579	193,179	172,872	81,526	114,844	135,952	1,488,857
1997	167,682	143,199	110,263	107,757	124,524	150,418	129,630	206,002	204,940	114,042	123,614	162,701	1,744,772
1998	193,079	198,567	197,512	220,372	198,109	175,233	258,369	282,422	186,282	91,265	124,132	98,762	2,224,104
Average	90,224	89,850	103,729	109,172	125,612	167,059	140,233	171,569	180,614	111,929	70,315	95,309	1,455,615

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Estimated monthly river flows through Grand Island, NE as a result of Region 4 CO Transfer D. (Acre-Feet)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	53,939	49,198	58,834	74,419	73,751	103,382	91,817	66,158	98,634	86,112	28,536	70,675	855,455
1976	44,556	58,594	94,720	78,963	109,419	106,469	96,100	75,501	23,803	7,748	5,984	26,110	727,967
1977	45,899	44,863	59,014	54,321	70,960	91,847	133,585	121,489	57,699	5,908	18,071	58,487	762,143
1978	56,568	56,015	60,534	49,108	57,682	220,529	108,238	59,467	55,423	2,860	6,740	26,455	759,619
1979	33,926	46,447	59,727	51,574	46,821	165,140	93,925	86,895	95,615	95,144	21,136	35,575	831,925
1980	28,285	44,477	124,133	104,627	164,431	225,789	264,073	446,049	444,887	81,774	27,706	33,732	1,989,963
1981	34,453	39,912	66,207	70,441	64,526	81,575	47,881	68,006	26,502	13,150	68,281	43,507	624,441
1982	52,016	64,507	84,796	71,472	105,508	119,641	61,351	91,090	75,580	25,225	32,023	46,081	829,290
1983	63,842	86,075	119,161	140,058	168,360	191,686	181,464	372,171	769,766	698,895	432,678	413,121	3,637,277
1984	166,776	96,520	212,377	304,472	405,006	426,721	581,562	691,664	537,504	231,217	93,718	206,111	3,953,648
1985	208,863	299,219	272,976	167,066	201,341	271,740	138,326	165,866	128,731	42,072	55,908	100,040	2,052,148
1986	132,980	90,423	126,681	166,686	186,286	171,296	195,156	227,098	182,515	145,473	132,882	190,702	1,948,178
1987	224,407	158,355	151,309	148,579	141,481	217,328	225,629	192,238	213,306	79,434	48,290	77,180	1,877,536
1988	104,466	118,082	106,986	116,673	194,265	155,284	116,639	120,830	105,628	58,676	54,632	57,684	1,309,845
1989	61,914	53,318	75,029	95,418	92,229	123,900	44,766	57,677	68,149	74,537	28,900	107,049	882,886
1990	63,604	61,333	44,477	121,773	93,512	125,447	111,863	100,221	67,567	21,708	26,812	35,513	873,830
1991	30,723	47,100	42,566	46,398	85,008	75,165	42,576	73,395	77,012	23,031	27,900	33,932	604,806
1992	22,336	52,113	59,423	81,558	85,618	141,088	75,972	73,362	51,088	53,898	13,052	45,674	755,182
1993	59,940	53,942	75,253	78,344	74,810	276,396	88,396	98,435	97,298	200,707	101,113	106,368	1,311,002
1994	121,613	116,602	118,221	93,431	97,400	170,268	77,940	107,874	71,682	71,521	31,770	62,354	1,140,676
1995	55,837	55,834	75,152	95,717	73,397	82,842	83,536	146,193	522,912	372,441	57,295	113,079	1,734,235
1996	137,227	121,438	94,146	80,904	100,019	140,096	116,554	194,245	173,219	81,536	114,844	136,592	1,490,820
1997	167,682	143,199	110,263	107,757	124,486	150,383	129,603	206,878	204,940	114,042	123,614	162,701	1,745,548
1998	193,079	198,567	197,512	220,372	198,109	175,233	258,369	283,075	186,630	91,265	121,638	99,199	2,223,048
Average	90,205	89,839	103,729	109,172	125,601	167,052	140,222	171,912	180,670	111,599	69,730	95,330	1,455,061

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Estimated monthly river flows through Grand Island, NE as a result of Region 5 CO Transfer D. (Acre-Feet)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1975	53,914	49,183	58,833	74,419	73,721	103,354	91,795	66,123	98,609	86,538	28,488	70,371	855,348
1976	44,534	58,586	94,720	78,963	109,408	106,449	96,085	75,477	23,759	7,727	5,962	26,097	727,767
1977	45,874	44,848	59,013	54,318	70,933	91,818	133,582	121,478	57,661	5,882	18,050	58,484	761,941
1978	56,549	56,005	60,533	49,104	57,653	220,529	108,226	59,436	55,737	2,836	6,717	26,441	759,766
1979	33,895	46,432	59,727	51,570	46,781	165,139	93,905	86,868	95,840	95,277	21,114	35,304	831,852
1980	28,191	44,433	124,133	104,627	164,431	225,789	264,073	446,049	444,887	81,774	27,670	33,706	1,989,763
1981	34,415	39,898	66,207	70,441	64,500	81,547	47,836	68,006	26,484	13,119	68,281	43,507	624,241
1982	51,992	64,500	84,796	71,472	105,493	119,622	61,318	91,066	75,546	25,206	32,006	46,074	829,091
1983	63,672	86,045	119,161	140,058	168,360	191,686	181,464	371,775	769,766	698,895	432,678	413,135	3,636,695
1984	166,776	96,320	212,377	304,472	405,006	426,721	581,562	691,664	537,504	231,217	94,496	205,877	3,953,992
1985	208,863	299,219	272,976	167,066	201,341	271,740	138,316	165,479	128,664	42,001	55,868	100,040	2,051,573
1986	132,865	90,338	126,681	166,686	186,286	171,296	195,156	227,098	182,515	145,473	132,915	190,462	1,947,771
1987	224,407	158,355	151,309	148,579	141,470	217,328	225,629	191,850	213,563	79,434	48,101	76,750	1,876,775
1988	104,428	118,082	106,986	116,673	194,265	155,273	116,616	120,637	105,581	58,663	54,615	57,677	1,309,496
1989	61,894	53,306	75,029	95,418	92,209	123,882	44,727	57,454	68,113	74,537	28,882	107,049	882,500
1990	63,584	61,323	44,470	121,773	93,491	125,429	111,850	100,201	67,835	21,686	26,792	35,500	873,934
1991	30,679	47,091	42,566	46,398	84,998	75,130	42,523	72,991	77,012	23,007	27,881	33,925	604,201
1992	22,250	52,106	59,423	81,558	85,603	141,088	75,934	73,019	51,088	53,898	12,998	45,674	754,639
1993	59,895	53,918	75,253	78,344	74,775	276,396	88,368	98,398	97,267	200,707	101,113	106,368	1,310,802
1994	121,613	116,602	118,221	93,431	97,368	170,268	77,895	107,426	71,832	71,520	31,741	62,352	1,140,269
1995	55,790	55,811	75,152	95,717	73,362	82,799	83,506	146,180	523,142	372,563	57,267	112,797	1,734,086
1996	137,208	121,438	94,146	80,904	99,939	140,044	116,505	193,838	173,456	81,536	114,844	136,287	1,490,145
1997	167,682	143,199	110,263	107,757	124,411	150,313	129,549	206,466	204,940	114,042	123,614	162,701	1,744,937
1998	193,079	198,567	197,512	220,372	198,109	175,233	258,369	282,668	186,867	91,265	121,638	99,000	2,222,679
Average	90,169	89,817	103,729	109,172	125,580	167,036	140,200	171,735	180,736	111,617	69,739	95,232	1,454,761

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APPENDIX 3.1

GAMS CODE FOR EVALUATING WATERLOGGING AND SOIL SALINITY IN THE ARKANSAS RIVER BASIN

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GAMS CODE FOR EVALUATING WATERLOGGING AND SOIL SALINITY IN THE ARKANSAS RIVER BASIN

SETS

```
FIELD      Field Numbers /1*3482/
AT         Field Attributes /SIZE,CROP,AREA,SALT,WTD/
COMAREA    Total Area List /1*6/
CROP       Crops  /1*8/

*Canal Areas: 1-Holbrook  2-Rocky Ford, 3-Catlin, 4-Otero, 5-RF Highline, 6-Fort Lyon
*Crop types: 1-Alfalfa,2-Beans,3-Corn,4-Grass,5-Melons,6-Onion,7-Sorghum,8-Wheat
;
```

SCALARS

```
SALTADJUST       Used to adjust the soil salinity input  /0/
WTDADJUST        Used to adjust the WTD input            /0/
*Values entered here will be subtracted from soil salinity values or added to water table
*depths if needed
;
```

PARAMETERS

```
$include C:\Arkansas_Parameters.prn
* This include file retrieves the following parameters:
* PRICE(CROP) Ten year average crop prices.
* MYIELD(CROP) Potential yield for each crop given no salinity or waterlogging.
* HARCOST(CROP) Harvest costs for each crop (dollars per harvested unit).
* NHARCOST(CROP) Non-Harvest costs for each crop (dollars per acre).
* STHRESHOLD(CROP) Threshold value for each crops response to soil salinity(dS/m).
* SSLOPE(CROP) Slope value for each crops response to soil salinity.
* WTMIN(CROP) Threshold value for each crops response to waterlogging (m).
* WTIMPACT(CROP) Slope value for each crops response to waterlogging.
;

$include C:\Arkansas_Field_Data.prn
*This include file retrieves the table DATA(FIELD,AT), which contains the following
data for each irrigated field: field size, crop type, canal area, avg. soil salinity, and avg.
water table depth.
```


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```
PARAMETERS

ACNOW(FIELD,CROP)           Used to fix crop selection of each field to observed.
AREAID(FIELD,COMAREA)       Used to identify which canal services each field.
COMSIZE(COMAREA)            Calculates total acres within each canal area.
TOTSIZE                     Calculates the total acreage in the study area.
SHARE(FIELD,COMAREA)        Calculates share each fields has of total canal area
AVSALT(COMAREA)             Calculates weighted avg salinity level for canal area
AVWTD(COMAREA)              Calculates weighted average of WTD for canal area
SYIELD(CROP,FIELD)          Yield per acre as a function of salinity
WLYIELD(CROP,FIELD)         Yield per acre as a function of water table
YIELD(FIELD,CROP)           Total yield as a function of both salinity and WTD
TOTSALT                     Total weighted average level of soil salinity
TOTWTD                      Total weighted average level of water table depth
;

ACNOW(FIELD,CROP) = DATA(FIELD,"SIZE")$(DATA(FIELD,"CROP")EQ
      ORD(CROP));

AREAID(FIELD,COMAREA) = 1$(DATA(FIELD,"AREA")EQ ORD(COMAREA))+
      0$(DATA(FIELD,"AREA") NE ORD(COMAREA));

COMSIZE(COMAREA) = SUM(FIELD $  AREAID(FIELD,COMAREA),
      DATA(FIELD, "SIZE"));

TOTSIZE = SUM(COMAREA, COMSIZE(COMAREA));

SHARE(FIELD,COMAREA)$(COMSIZE(COMAREA) GT 0) =DATA(FIELD,"SIZE")
      *AREAID(FIELD,COMAREA)/COMSIZE(COMAREA);

AVSALT(COMAREA)  = SUM(FIELD, (SHARE(FIELD,COMAREA)*
      (DATA(FIELD, "SALT") -SALTADJUST)));

AVWTD(COMAREA) = SUM(FIELD, (SHARE(FIELD, COMAREA)*(DATA(FIELD,
      "WTD")+WTDADJUST)));

SYIELD(CROP,FIELD)$(DATA(FIELD,"SIZE") GT 0) = MAX(MYIELD(CROP)
      (SSLOPE(CROP)*(MAX((DATA(FIELD,"SALT")-SALTADJUST)
      STHRESHOLD(CROP),0))/100*MYIELD(CROP)),0);

WLYIELD(CROP,FIELD)$(DATA(FIELD,"SIZE") GT 0) = MAX(MYIELD(CROP)
      (WTIMPACT(CROP)*(MAX(WTMIN(CROP)(DATA(FIELD,"WTD")+
      WTDADJUST),0))/100*MYIELD(CROP)),0);
```


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```
YIELD(FIELD,CROP)$(DATA(FIELD,"SIZE") GT 0) =SYIELD(CROP,FIELD)/
        MYIELD(CROP)*WLYIELD(CROP,FIELD)/MYIELD(CROP)*
        MYIELD(CROP);

TOTSALT = SUM( COMAREA, (AVSALT(COMAREA)*COMSIZE(COMAREA)))
        /TOTSIZE;

TOTWTD = SUM( COMAREA, (AVWTD(COMAREA)*COMSIZE(COMAREA)))
        /TOTSIZE;
```

POSITIVE VARIABLES

```
ACRES(CROP,FIELD)        Quantity of acres in each crop for each field
;
```

VARIABLES

```
PROFIT(FIELD)            Total profit on each field
TOTALPROF                Total profit over the entire study area for all fields
AREAPROFT(COMAREA)       Total profit aggregated across canal area
;
```

EQUATIONS

```
QPROFIT(FIELD)           Calculates profit for each crop on each field
QTOTALPROF               Calculates total profit for the entire study area
QAREAPRFT(COMAREA)       Calculates total profit for each canal area
FIELDACRE(FIELD)         Restricts total planted field acreage to field size
CROPROT(CROP,COMAREA)    Restricting crop choice in canal area to identified mix
;

QPROFIT(FIELD)..  PROFIT(FIELD) =E=SUM(CROP,(YIELD(FIELD,CROP) *
        ACRES(CROP,FIELD)*(PRICE(CROP)-HARCOST(CROP))
        (ACRES(CROP,FIELD)*NHARCOST(CROP))));

QTOTALPROF..  TOTALPROF =E= SUM(FIELD, PROFIT(FIELD));

QAREAPRFT(COMAREA)..  AREAPROFT(COMAREA) =E= SUM(FIELD $
        AREAID(FIELD,COMAREA), PROFIT(FIELD));

FIELDACRE(FIELD)..  SUM(CROP, ACRES(CROP,FIELD)) =E=
        DATA(FIELD,"SIZE");
```


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```
CROPROT(CROP,COMAREA).. SUM(FIELD $ AREAID(FIELD,COMAREA),
        ACRES(CROP,FIELD)) =L= SUM(FIELD $AREAID(FIELD,COMAREA),
        ACNOW(FIELD,CROP));

ACRES.FX(CROP,FIELD) = ACNOW(FIELD,CROP);

*The above statement forces the GAMS model to solve using the acre decisions that have
*already been made and are provided to the model in the table DATA(FIELD,AT).
*without this statement the model will optimally select crop choice locations to maximize
*profits.

MODEL ARK /ALL/;
SOLVE ARK USING NLP MAXIMIZING TOTALPROF;
```

PARAMETERS

```
PLANTEDY(CROP,COMAREA) Weighted yield for each crop for each canal area
TOTYIELD(CROP)         Weighted crop yield for the entire study area
RS(CROP,COMAREA)       Relative Yield as a function of soil salinity
RWTD(CROP,COMAREA)     Relative Yield as a function of water table depth
RYIELD(CROP,COMAREA)   Relative Yield for each crop for the study area
RYIELD2(CROP)          Relative Yield for each crop
;
PLANTEDY(CROP,COMAREA) = SUM(FIELD $ AREAID(FIELD,COMAREA),
        ACRES.l(CROP,FIELD)*YIELD(FIELD,CROP))/SUM(FIELD $
        AREAID(FIELD,COMAREA), ACRES.l(CROP,FIELD));

TOTYIELD(CROP) = SUM(FIELD,ACRES.l(CROP,FIELD)*YIELD(FIELD,CROP))/
        SUM(FIELD, ACRES.L(CROP,FIELD));

RYIELD(CROP,COMAREA) = PLANTEDY(CROP,COMAREA)/MYIELD(CROP);

RYIELD2(CROP) = TOTYIELD(CROP)/MYIELD(CROP);
```


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APPENDIX 3.2

SUMMARY OF AVERAGE CROP YIELDS FOR OTERO COUNTY AND TEN-YEAR AVERAGE CROP PRICES

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Average Crop Yields for Otero County (1999-2001)[1].

	1999	2000	2001	Average
ALFALFA (Ton)	4.60	5.30	4.80	4.90
BEANS (Cwt.)	22.50	21.70	22.90	22.37
CORN (Bu.)	165.50	162.50	172.00	166.67
GRASS (Ton)	2.00	2.40	3.05	2.48
MELONS (Cwt.)	180.00	240.00	230.00	216.67
ONION (Cwt.)	375.00	355.00	345.00	358.33
SORGHUM (Bu.)	79.25	80.00	78.50	79.25
WHEAT (Bu.)	77.00	71.50	70.00	72.83

Ten-Year Average Crop Prices for the State of Colorado (1992-2001)[1].

	10 Year Average State Price
ALFALFA (Ton)	$86.70
BEANS (Cwt.)	$18.88
CORN (Bu.)	$2.40
GRASS (Ton)	$84.85
MELONS (Cwt.)	$12.62
ONION (Cwt.)	$13.94
SORGHUM (Bu.)	$2.10
WHEAT (Bu.)	$3.21

[1] Colorado Agricultural Statistics, Prepared by the Colorado Agricultural Statistics Service. Lakewood, Colorado. Available online at: www.nass.usda.gov/co

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APPENDIX 3.3

SUMMARY OF LOWER ARKANSAS RIVER BASIN CROP BUDGETS

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IRRIGATED ALFALFA HAY

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST PER ACRE
GROSS RECEIPTS FROM PRODUCTION:				
ALFALFA	TON	86.70*	4.90*	424.83
TOTAL RECEIPTS				424.83
DIRECT COSTS:				
OPERATING--PREHARVEST				
PHOSPHATE	LBS.	0.44	40.00	17.60
INSECTICIDE	LBS.	14.37	0.25	3.59
APPLICATION	ACRE	5.00	1.00	5.00
SEED	ACRE	8.00	1.00	8.00
IRRIGATION WATER	ACRE	1.00	22.00	22.00
IRRIGATION LABOR	HR.	10.00	4.00	40.00
MACH FUEL & LUBE	ACRE			19.42
MACH REPAIRS	ACRE			7.97
INTEREST ON OP. CAP.	DOLS	0.09	72.66	6.54
TOTAL PREHARVEST:	DOLS			130.11
OPERATING--HARVEST:				
CUSTOM SWATH	ACRE	9.00	4.00	36.00
CUSTOM BALE (SM. SQ.)	TON	10.00	4.75	47.50
CUSTOM HAUL/STACK	TON	6.25	4.75	29.69
INTEREST ON OP. CAP.	DOLS	0.09	51.90	4.67
TOTAL HARVEST:				117.86
TOTAL OPERATING COSTS:				247.97
PROPERTY AND OWNERSHIP COSTS:				
MACHINERY REPLACEMENT	DOLS			17.05
MACHINERY TAXES & INSURANCE	DOLS			3.46
GENERAL FARM OVERHEAD	DOLS			15.00
REAL ESTATE TAXES	DOLS			6.00
TOTAL PROPERTY AND OWNERSHIP COSTS:	DOLS			41.50
TOTAL DIRECT COSTS:				289.48
NET RECEIPTS--FACTOR PAYMENTS:				135.35

*Uses three-year (99-01) average Otero county yield and ten-year average price.

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IRRIGATED BEANS

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST PER ACRE
GROSS RECEIPTS FROM PRODUCTION:				
BEANS	CWT.	18.88*	22.37*	422.35
TOTAL RECEIPTS				422.35
DIRECT COSTS:				
OPERATING--PREHARVEST				
18-46-0	LBS.	0.14	200.00	28.00
HERBICIDE (LASSO)	QT.	6.35	2.00	12.70
HERBICIDE (EPTAM)	PT.	4.20	2.00	8.40
SEED	LBS.	0.35	70.00	24.50
IRRIGATION WATER	ACIN.	1.20	24.00	28.80
IRRIGATION LABOR	HR.	7.00	3.00	21.00
MACH FUEL & LUBE	ACRE			9.13
MACH REPAIRS	ACRE			7.86
INTEREST ON OP. CAP.	DOLS	0.10	84.88	8.49
TOTAL PREHARVEST:	DOLS			148.88
OPERATING--HARVEST:				
CUSTOM COMBINING	ACRE	28.00	1.00	28.00
MACH FUEL & LUBE	ACRE			2.46
MACH REPAIRS	ACRE			1.40
INTEREST ON OP. CAP.	DOLS	0.10	10.62	1.06
TOTAL HARVEST:				32.92
TOTAL OPERATING COSTS:				181.80
PROPERTY AND OWNERSHIP COSTS:				
MACHINERY REPLACEMENT	DOLS			16.51
MACHINERY TAXES & INSURANCE	DOLS			3.12
GENERAL FARM OVERHEAD	DOLS			13.00
REAL ESTATE TAXES	DOLS			8.63
TOTAL PROPERTY AND OWNERSHIP COSTS:	DOLS			41.26
TOTAL DIRECT COSTS:				223.06
NET RECEIPTS--FACTOR PAYMENTS:				199.29

*Uses three-year (99-01) average Otero county yield and ten-year average price.

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IRRIGATED CORN GRAIN

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST PER ACRE
GROSS RECEIPTS FROM PRODUCTION:				
CORN	BU.	2.4*	166.67*	400.00
TOTAL RECEIPTS				400.00
DIRECT COSTS:				
OPERATING--PREHARVEST				
NITROGEN	LBS.	0.21	150.00	31.50
PHOSPHATE	LBS.	0.44	50.00	22.00
INSECTICIDE	ACRE	29.16	1.00	29.16
SEED	ACRE	25.00	1.00	25.00
HERBICIDE	ACRE	8.88	1.00	8.88
CUSTOM APPLICATION	ACRE	5.00	2.00	10.00
IRRIGATION WATER	ACRE	1.00	22.00	22.00
IRRIGATION LABOR	HR.	10.00	5.00	50.00
MACH FUEL & LUBE	ACRE			21.67
MACH REPAIRS	ACRE			14.20
INTEREST ON OP. CAP.	DOLS	0.09	150.42	13.54
TOTAL PREHARVEST:	DOLS			247.94
OPERATING--HARVEST:				
CUSTOM HARVEST	ACRE	34.20	1.00	34.20
INTEREST ON OP. CAP.	DOLS	0.09	5.70	0.51
TOTAL HARVEST:				34.71
TOTAL OPERATING COSTS:				282.65
PROPERTY AND OWNERSHIP COSTS:				
MACHINERY REPLACEMENT	DOLS			29.12
MACHINERY TAXES & INSURANCE	DOLS			5.63
GENERAL FARM OVERHEAD	DOLS			15.00
REAL ESTATE TAXES	DOLS			18.00
TOTAL PROPERTY AND OWNERSHIP COSTS:	DOLS			67.75
TOTAL DIRECT COSTS:				350.40
NET RECEIPTS--FACTOR PAYMENTS:				49.60

*Uses three-year (99-01) average Otero county yield and ten-year average price.

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IRRIGATED GRASS HAY

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST PER ACRE
GROSS RECEIPTS FROM PRODUCTION:				
GRASS HAY	TON	84.85*	2.48*	210.43
TOTAL RECEIPTS				210.43
DIRECT COSTS:				
OPERATING--PREHARVEST				
NITROGEN (ACTUAL)	LBS.	0.30	100.00	30.00
PHOSPHATE (ACTUAL) ALLOCATE	LBS.	0.26	20.00	5.20
FERTILIZER APPLICATION	ACRE	5.00	1.00	5.00
AERATOR RENTAL	ACRE	2.50	1.00	2.50
IRRIGATION WATER	ACRE	1.00	22.00	22.00
IRRIGATION LABOR	HR.	10.00	4.00	40.00
MACH FUEL & LUBE	ACRE			0.38
MACH REPAIRS	ACRE			0.16
INTEREST ON OP. CAP.	DOLS	0.10	32.51	3.25
TOTAL PREHARVEST:	DOLS			108.49
OPERATING--HARVEST:				
BALER TWINE-WIRE	TON	1.60	3.00	4.80
SEASONAL LABOR	HR.	7.00	2.00	14.00
MACH FUEL & LUBE	ACRE			4.29
MACH REPAIRS	ACRE			3.14
INTEREST ON OP. CAP.	DOLS	0.10	13.11	1.31
TOTAL HARVEST:				27.54
TOTAL OPERATING COSTS:				136.03
PROPERTY AND OWNERSHIP COSTS:				
MACHINERY REPLACEMENT	DOLS			7.57
MACHINERY TAXES & INSURANCE	DOLS			1.34
GENERAL FARM OVERHEAD	DOLS			10.00
REAL ESTATE TAXES	DOLS			4.06
TOTAL PROPERTY AND OWNERSHIP COSTS:	DOLS			22.98
TOTAL DIRECT COSTS:				159.01
NET RECEIPTS--FACTOR PAYMENTS:				51.42

*Uses three-year (99-01) average Otero county yield and ten-year average price.

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IRRIGATED MELONS

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST PER ACRE
GROSS RECEIPTS FROM PRODUCTION:				
CANTALOUPE	Cwt.	12.62*	216.67*	2734.38
TOTAL RECEIPTS				2734.38
DIRECT COSTS:				
OPERATING--PREHARVEST				
PHOSPHORUS (8-20-5-5-.5)	LBS.	0.10	250.00	25.00
FERTILIZER CUST APP	ACRE	4.50	1.00	4.50
SEED	LBS.	208.00	0.75	156.00
IRRIGATE	ACRE	2.00	7.00	14.00
HERBICIDE	ACRE	9.00	4.00	36.00
HERBICIDE CUST APP	ACRE	7.80	4.00	31.20
HOE (HAND LABOR)	ACRE	30.00	5.00	150.00
WATER	ACRE	24.00	1.00	24.00
MACH FUEL & LUBE	ACRE			14.33
MACH REPAIRS	ACRE			10.39
INTEREST ON OP. CAP.	DOLS	0.10	301.85	30.19
TOTAL PREHARVEST:	DOLS			495.61
OPERATING--HARVEST:				
HARVEST	ACRE	35.00	9.00	315.00
INTEREST ON OP. CAP.	DOLS	0.10	131.25	13.13
TOTAL HARVEST:				328.13
TOTAL OPERATING COSTS:				823.74
PROPERTY AND OWNERSHIP COSTS:				
MACHINERY REPLACEMENT	DOLS			20.69
MACHINERY TAXES & INSURANCE	DOLS			3.95
GENERAL FARM OVERHEAD	DOLS			100.00
REAL ESTATE TAXES	DOLS			15.00
TOTAL PROPERTY AND OWNERSHIP COSTS:	DOLS			139.64
TOTAL DIRECT COSTS:				963.38
NET RECEIPTS--FACTOR PAYMENTS:				1771.00

*Uses three-year (99-01) average Otero county yield and ten-year average price.

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IRRIGATED ONIONS (SEED)

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST PER ACRE
GROSS RECEIPTS FROM PRODUCTION:				
ONIONS	CWT	13.94*	358.33*	4995.12
TOTAL RECEIPTS				4995.12
DIRECT COSTS:				
OPERATING--PREHARVEST				
PHOSPHORUS (8-20-5-5-.5)	LBS.	0.10	500.00	50.00
FERTILIZER CUST APP	ACRE	4.50	2.00	9.00
IRRIGATE	ACRE	2.00	10.00	20.00
HERBICIDE	ACRE	14.08	3.00	42.24
HERBICIDE CUST APP	ACRE	7.50	2.00	15.00
NITROGEN APPLICATION	ACRE	4.50	1.00	4.50
INSECTICIDE	ACRE	13.42	4.00	53.68
INSECTICIDE CUST APP	ACRE	7.80	3.00	23.40
HOE (HAND LABOR)	ACRE	30.00	3.00	90.00
FUNGICIDE	ACRE	12.00	7.00	84.00
FUNGICIDE AERIAL APP	ACRE	5.00	8.00	40.00
WATER	ACRE	24.00	1.00	24.00
SEED	LBS.	100.00	1.00	100.00
MACH FUEL & LUBE	ACRE			11.63
MACH REPAIRS	ACRE			7.20
INTEREST ON OP. CAP.	DOLS	0.10	351.23	35.12
TOTAL PREHARVEST:	DOLS			609.77
OPERATING--HARVEST:				
HARVEST & SORT & GRADE	ACRE	3000.00	1.00	3000.00
INTEREST ON OP. CAP.	DOLS	0.10	1000.00	100.00
TOTAL HARVEST:				3100.00
TOTAL OPERATING COSTS:				3709.77
PROPERTY AND OWNERSHIP COSTS:				
MACHINERY REPLACEMENT	DOLS			18.07
MACHINERY TAXES & INSURANCE	DOLS			3.42
GENERAL FARM OVERHEAD	DOLS			100.00
REAL ESTATE TAXES	DOLS			15.00
TOTAL PROPERTY AND OWNERSHIP COSTS:	DOLS			136.49
TOTAL DIRECT COSTS:				3846.26
NET RECEIPTS--FACTOR PAYMENTS:				1148.86

*Uses three-year (99-01) average Otero county yield and ten-year average price.

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IRRIGATED SORGHUM

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST PER ACRE
GROSS RECEIPTS FROM PRODUCTION:				
SORGHUM	BU.	2.1*	79.25*	166.43
TOTAL RECEIPTS				166.43
DIRECT COSTS:				
OPERATING--PREHARVEST				
NITROGEN	LBS.	0.21	30.00	6.30
SEED	ACRE	3.50	1.00	3.50
HERBICIDE	ACRE	11.70	1.00	11.70
CUSTOM APPLICATION	ACRE	7.50	1.00	7.50
IRRIGATION WATER	ACRE	1.00	22.00	22.00
IRRIGATION LABOR	HR.	10.00	4.00	40.00
MACH FUEL & LUBE	ACRE			2.70
MACH REPAIRS	ACRE			5.11
INTEREST ON OP. CAP.	DOLS	0.09	22.94	2.06
TOTAL PREHARVEST:	DOLS			100.87
OPERATING--HARVEST:				
CUSTOM HARVEST/HAUL	ACRE	19.44	1.00	19.44
INTEREST ON OP. CAP.	DOLS	0.09	4.86	0.44
TOTAL HARVEST:				19.88
TOTAL OPERATING COSTS:				120.75
PROPERTY AND OWNERSHIP COSTS:				
MACHINERY REPLACEMENT	DOLS			5.47
MACHINERY TAXES & INSURANCE	DOLS			1.01
GENERAL FARM OVERHEAD	DOLS			7.00
REAL ESTATE TAXES	DOLS			1.75
TOTAL PROPERTY AND OWNERSHIP COSTS:	DOLS			15.23
TOTAL DIRECT COSTS:				135.98
NET RECEIPTS--FACTOR PAYMENTS:				30.45

*Uses three-year (99-01) average Otero county yield and ten-year average price.

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IRRIGATED WINTER WHEAT

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST PER ACRE
GROSS RECEIPTS FROM PRODUCTION:				
WHEAT	BU	3.21*	72.83*	233.78
TOTAL RECEIPTS				233.78
DIRECT COSTS:				
OPERATING--PREHARVEST				
FERTILIZER	ACRE	12.80	1.00	12.80
SEED	ACRE	5.33	1.00	5.33
IRRIGATION WATER	ACRE	1.00	22.00	22.00
IRRIGATION LABOR	HR.	10.00	4.00	40.00
MACH FUEL & LUBE	ACRE			3.26
MACH REPAIRS	ACRE			2.93
INTEREST ON OP. CAP.	DOLS	0.09	79.60	7.16
TOTAL PREHARVEST:	DOLS			93.48
OPERATING--HARVEST:				
TRUCK DRIVER	HRS.	8.00	0.35	2.80
MACH FUEL & LUBE	ACRE			7.97
MACH REPAIRS	ACRE			9.34
INTEREST ON OP. CAP.	DOLS	0.09	10.05	0.90
TOTAL HARVEST:				21.01
TOTAL OPERATING COSTS:				114.49
PROPERTY AND OWNERSHIP COSTS:				
MACHINERY REPLACEMENT	DOLS			52.55
MACHINERY TAXES & INSURANCE	DOLS			9.02
GENERAL FARM OVERHEAD	DOLS			10.00
REAL ESTATE TAXES	DOLS			6.00
TOTAL PROPERTY AND OWNERSHIP COSTS:	DOLS			77.56
TOTAL DIRECT COSTS:				192.05
NET RECEIPTS--FACTOR PAYMENTS:				41.73

*Uses three-year (99-01) average Otero county yield and ten-year average price.

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APPENDIX 4.1

ITEMIZED DESCRIPTION OF THE COSTS ASSOCIATED WITH LINING IRRIGATION CANALS WITH A SOIL COVERED GEOMEMBRANE LINER

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Costs of Installing a Soil & Gravel Covered Geomembrane Liner (56,000 square feet)[1]

Item	Quanitity	Unit	Unit Price	Amount
Mobilization	1	each	2,900	2,900.00
Excavate Canal (12 inches depth)	2,100	cubic yard	5	10,500.00
Preparing Subgrades for PVC Lining	56,000	square feet	0.05	2,800.00
Furnish and Install Liner (20 mil PVC)	58,800	square feet	0.25	14,700.00
Backfill Liner (6 inches depth)	1,050	cubic yard	4	4,200.00
Install Gravel Cover (6 Inches depth)	1,050	cubic yard	25	26,250.00
			Subtotal	61,350.00
			Contingencies	17,000.00
			Unlisted Items (15%)	9,650.00
			Total Field Cost	88,000.00
			Cost/square foot	$1.57
			Annualized cost/square foot (50 yr. life @ 2%)	$0.050
			Annual maintenance ($/sf)[2]	$0.005
			Total annual cost/square foot	$0.055

[1]Detailed costs from Sayer et al. (1997). [2]Annual maintenance costs from Swihart and Haynes (2002).

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APPENDIX 4.2

ITEMIZED DESCRIPTION OF THE COSTS OF INSTALLING GATED PIPE WITH AND WITHOUT SURGE VALVES AND SUBSURFACE DRIP IRRIGATION SYSTEMS

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Capital Investment for a 1/5 mile Gated Pipe System With and Without Surge Valves[1]

Item	Unit Price	Unit	Quantity	Design Life (yrs)	Total Cost w/o Surge Valve	Total Cost with Surge Valve
Mainline						
12" PVC pipe 80#	3.66	ft.	792	30	$2,898.72	$2,898.72
Installation[2]	1.00	ft.	792	30	$792.00	$792.00
Gated Pipe						
10" PVC pipe	2.66	ft.	1,056	20	$2,808.96	$2,808.96
End plugs	15.70	each	2	20	$31.40	$31.40
Risers, Valves, Hydrants, etc.						
Riser	107.00	each	2	20	$214.00	$214.00
Alfalfa Valve	160.00	each	2	20	$320.00	$320.00
Hydrant, 12"x10"	382.00	each	2	20	$764.00	$764.00
Surge Valve	723.00	each	2	20	-	$1,446.00
Controller	815.00	each	1	20	-	$815.00
Inlet Structure[2]	600.00	each	1	20	$600.00	$600.00
Total Capital Cost					$8,429.08	$10,690.08
Average Total Cost/Irr. Acre (22.8 Acres, 940 ft. run)					$369.70	$468.86
Total Annualized Cost/Acre (Using Design Life and 2% discount)					$19.94	$26.00

[1] Costs were quoted from a supplier (The Pipeyard Inc.) in Rocky Ford, CO June 2003.

[2] Cost of mainline installation and inlet structure from Smathers, King, Patterson (1993).

Capital Requirements for a Subsurface Drip Irrigation System (32 Acre Field)[1]

Item	Unit Price	Unit	Quantity	Total Cost
203 mm mainline pipe	4.27	meter	178	761.00
152 mm lateral pipe	2.46	meter	178	439.00
102 mm flushlines	1.97	meter	719	1416.00
Dripline	0.0984	meter	84,898	8354.00
Dripline Connectors	2.46	meter	288	708.00
203 mm x 152 mm reducer coupling	25	each	1	25.00
203 mm pressure control valve	440	each	1	440.00
152 mm end caps	45	each	1	45.00
102 mm elbows	30	each	4	120.00
102 mm x 51 mm reducing bushing	18	each	4	72.00
51 mm plugs	6	each	4	24.00
Air vents	25	each	6	150.00
PVC glue	250	each	1	250.00
Trenching	2.23	meter	1,076	2400.00
Filter	2200	each	1	2200.00
Pressure Gages	20	each	7	140.00
Producer Labor (installation)	8	hour	155	1240.00
Tractor Use	7	hour	31	217.00
Miscellaneous	2500	each	1	2500.00
Total Capital Cost				$21,501.00
Total Capital Cost/Acre				$671.91
Total Annualized Cost/Acre (10 years at 2%)				$74.80

[1] System Requirements and costs were obtained from O'Brien et al. (1998) for Western Kansas.

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APPENDIX 4.3

ITEMIZED DESCRIPTION OF THE COSTS OF INSTALLING SUBSURFACE DRAINAGE

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Costs of installing subsurface drainage eight feet deep. ($/linear foot installation)[1]

Item	$/Linear Foot
Materials	
Drain, 6" Corrugated Pipe	$1.00
Envelope, Sand	$1.00
Labor and Machinery	$4.00
Total Installation Cost ($/linear ft.)	$5.00
Annualized cost (30 yr. design life[2] at 2%)	$0.2230
Annual Maintenance[2] (.25% of installation cost)	$0.0125
Total Annual Cost ($/linear ft.)	$0.2355

[1] Costs quoted from local excavator (Dewitt Excavating) in Lamar, CO August 2003.

[2] Design life and annual maintenance costs are from Skaggs and Chescheir (1999).

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APPENDIX 4.4

SUMMARY OF ECONOMIC OUTPUT FOR BASELINE CONDITIONS AND EACH ALTERNATIVE

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Summarized Economic Output as a Result of Baseline Conditions.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,035,644	1,438,381	3,019,485	191,715	2,090,218	1,348,734	10,124,177
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	145.76	206.47	165.84	53.44	155.82	166.22	157.56
Soil salinity(dS/m)	3.39	3.23	3.42	4.62	3.37	3.54	3.47
Water table (m)	2.8	2.65	2.89	3.75	5.46	4.38	3.62
Relative Crop Yields							
Alfalfa	0.883	0.815	0.843	0.709	0.884	0.869	0.859
Beans	0.494	0.691	0.615	0.000	0.473	0.458	0.530
Corn	0.799	0.822	0.804	0.664	0.814	0.741	0.795
Grass	0.972	0.969	0.970	0.928	0.985	0.959	0.967
Melons	0.779	0.838	0.780	0.701	0.839	0.830	0.804
Onion	0.816	0.900	0.777	0.926	0.837	0.903	0.828
Sorghum	0.999	0.988	0.991	0.975	1.000	0.956	0.984
Wheat	0.997	0.984	0.996	0.912	0.991	1.000	0.991

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,692,228	1,735,161	3,297,513	223,359	2,475,923	1,571,493	11,995,677
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	184.88	259.13	199.67	68.36	183.82	198.94	192.21
Soil salinity(dS/m)	2.55	2.7	2.73	3.74	2.57	3.15	2.76
Water table (m)	3.25	3.06	4.04	5.99	8.76	6.41	5.17
Relative Crop Yields							
Alfalfa	0.925	0.883	0.910	0.832	0.941	0.897	0.913
Beans	0.696	0.726	0.688	0.342	0.573	0.418	0.628
Corn	0.878	0.900	0.893	0.794	0.914	0.815	0.884
Grass	0.992	0.995	0.978	0.977	0.994	0.977	0.987
Melons	0.855	0.905	0.875	0.644	0.878	0.889	0.878
Onion	0.912	0.869	0.877	0.942	0.884	0.873	0.885
Sorghum	0.996	0.990	1.000	1.000	1.000	1.000	0.998
Wheat	0.999	1.000	1.000	1.000	0.999	1.000	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,315,541	1,372,588	3,358,922	533,758	1,965,511	1,406,462	10,952,782
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	162.3	203.31	190.44	135.77	147.95	175.52	171.45
Soil salinity(dS/m)	3.68	3.79	3.3	3.88	2.66	3.83	3.41
Water table (m)	3.51	3.29	4.43	6.59	9.24	6.55	5.5
Relative Crop Yields							
Alfalfa	0.850	0.784	0.869	0.835	0.935	0.838	0.864
Beans	0.388	0.606	0.553	0.204	0.686	0.423	0.568
Corn	0.774	0.797	0.847	0.735	0.887	0.723	0.817
Grass	0.977	0.973	0.985	0.965	0.989	0.963	0.977
Melons	0.795	0.850	0.827	0.791	0.844	0.819	0.822
Onion	0.819	0.780	0.824	0.829	0.887	0.868	0.836
Sorghum	0.997	0.983	0.999	1.000	1.000	0.997	0.996
Wheat	0.996	1.000	0.999	0.983	0.997	1.000	0.997

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Summarized Economic Output as a Result of Lining all Canals.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,194,275	1,497,336	3,204,111	268,753	2,102,935	1,374,131	10,641,541
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	157.11	214.93	175.98	74.92	156.76	169.35	165.61
Soil salinity(dS/m)	3.19	3.12	3.32	4.45	3.34	3.55	3.37
Water table (m)	3.26	2.74	3.15	4.49	5.94	4.58	3.97
Relative Crop Yields							
Alfalfa	0.912	0.843	0.860	0.757	0.888	0.881	0.878
Beans	0.513	0.727	0.627	0.186	0.487	0.373	0.541
Corn	0.816	0.838	0.821	0.713	0.819	0.749	0.809
Grass	0.971	0.978	0.972	0.969	0.987	0.963	0.974
Melons	0.827	0.848	0.802	0.805	0.839	0.840	0.825
Onion	0.832	0.905	0.817	0.927	0.830	0.900	0.842
Sorghum	1.000	0.994	1.000	0.982	1.000	0.981	0.993
Wheat	0.998	0.990	0.997	0.971	0.996	1.000	0.995

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,826,857	1,781,748	3,284,331	210,610	2,527,983	1,544,941	12,176,472
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	194.12	266.09	198.87	64.45	187.68	195.57	195.1
Soil salinity(dS/m)	2.4	2.65	2.78	4.19	2.4	3.25	2.73
Water table (m)	4.39	3.51	5.03	7.37	9.89	6.57	6.08
Relative Crop Yields							
Alfalfa	0.949	0.923	0.907	0.782	0.953	0.886	0.923
Beans	0.688	0.748	0.701	0.466	0.573	0.456	0.650
Corn	0.908	0.920	0.897	0.796	0.928	0.806	0.895
Grass	0.992	0.997	0.971	0.966	0.996	0.978	0.986
Melons	0.879	0.904	0.870	0.533	0.879	0.890	0.880
Onion	0.914	0.870	0.862	0.942	0.898	0.780	0.882
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	0.999	1.000	1.000	0.985	0.999	1.000	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,440,572	1,458,810	3,358,222	512,139	2,127,375	1,396,216	11,293,334
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	171.06	216.08	190.4	130.28	160.14	174.25	176.78
Soil salinity(dS/m)	3.37	3.5	3.28	4.05	2.22	3.88	3.22
Water table (m)	4.79	3.96	5.74	7.97	10.56	6.79	6.61
Relative Crop Yields							
Alfalfa	0.880	0.836	0.872	0.823	0.957	0.828	0.880
Beans	0.423	0.598	0.552	0.243	0.793	0.469	0.588
Corn	0.804	0.842	0.847	0.771	0.924	0.719	0.837
Grass	0.982	0.980	0.980	0.953	0.995	0.962	0.978
Melons	0.808	0.856	0.833	0.723	0.894	0.822	0.828
Onion	0.794	0.783	0.802	0.839	0.928	0.866	0.834
Sorghum	0.999	1.000	1.000	0.991	1.000	0.999	0.999
Wheat	0.996	1.000	0.998	0.983	0.999	1.000	0.997

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Summarized Economic Output as a Result of Lining Catlin Canal.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	1,967,729	1,472,158	3,110,437	215,480	2,085,418	1,328,481	10,179,702
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	140.89	211.31	170.84	60.07	155.46	163.72	158.42
Soil salinity(dS/m)	3.46	3.18	3.37	4.58	3.37	3.56	3.46
Water table (m)	2.73	2.55	2.99	3.93	5.46	4.33	3.62
Relative Crop Yields							
Alfalfa	0.875	0.833	0.851	0.739	0.885	0.866	0.861
Beans	0.479	0.724	0.603	0.048	0.474	0.410	0.523
Corn	0.774	0.831	0.814	0.669	0.812	0.737	0.795
Grass	0.965	0.972	0.971	0.933	0.986	0.955	0.966
Melons	0.766	0.841	0.790	0.746	0.838	0.826	0.806
Onion	0.823	0.907	0.797	0.929	0.838	0.897	0.836
Sorghum	0.999	0.992	0.997	0.919	1.000	0.935	0.976
Wheat	0.993	0.988	0.996	0.914	0.991	1.000	0.992

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,682,561	1,775,695	3,319,649	202,952	2,480,742	1,570,089	12,031,687
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	184.21	265.19	201.01	62.11	184.17	198.76	192.78
Soil salinity(dS/m)	2.54	2.65	2.72	4.1	2.54	3.15	2.76
Water table (m)	3.25	2.96	4.43	6.72	8.83	6.43	5.32
Relative Crop Yields							
Alfalfa	0.915	0.912	0.915	0.786	0.944	0.896	0.913
Beans	0.681	0.755	0.712	0.427	0.574	0.379	0.652
Corn	0.873	0.918	0.902	0.784	0.915	0.813	0.888
Grass	0.991	0.995	0.971	0.965	0.995	0.979	0.985
Melons	0.871	0.905	0.870	0.491	0.877	0.894	0.879
Onion	0.902	0.876	0.867	0.945	0.885	0.821	0.880
Sorghum	0.974	1.000	1.000	1.000	1.000	1.000	0.994
Wheat	0.996	1.000	1.000	0.986	0.999	1.000	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,244,174	1,428,097	3,370,992	498,708	1,977,280	1,408,357	10,927,609
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	157.29	211.53	191.13	126.86	148.84	175.76	171.05
Soil salinity(dS/m)	3.74	3.68	3.28	4.1	2.62	3.83	3.41
Water table (m)	3.49	3.15	5.01	7.35	9.33	6.63	5.72
Relative Crop Yields							
Alfalfa	0.840	0.816	0.871	0.810	0.937	0.837	0.863
Beans	0.379	0.565	0.552	0.075	0.657	0.387	0.550
Corn	0.761	0.828	0.859	0.762	0.893	0.721	0.825
Grass	0.972	0.976	0.974	0.954	0.992	0.964	0.974
Melons	0.781	0.850	0.823	0.728	0.845	0.823	0.815
Onion	0.789	0.821	0.819	0.829	0.893	0.863	0.837
Sorghum	0.985	0.990	1.000	1.000	1.000	0.996	0.994
Wheat	0.993	1.000	0.998	0.984	0.998	0.999	0.997

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Summarized Economic Output as a Result of Lining Fort Lyon Canal.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	1,967,945	1,464,396	3,038,645	205,180	2,085,891	1,374,855	10,136,913
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	140.91	210.2	166.89	57.2	155.49	169.44	157.76
Soil salinity(dS/m)	3.46	3.19	3.41	4.63	3.36	3.55	3.47
Water table (m)	2.73	2.53	2.88	3.86	5.42	4.58	3.61
Relative Crop Yields							
Alfalfa	0.875	0.829	0.848	0.735	0.885	0.881	0.862
Beans	0.479	0.721	0.606	0.044	0.471	0.374	0.519
Corn	0.774	0.829	0.807	0.668	0.812	0.749	0.794
Grass	0.965	0.974	0.969	0.933	0.987	0.963	0.967
Melons	0.766	0.839	0.778	0.709	0.838	0.840	0.803
Onion	0.823	0.906	0.788	0.929	0.837	0.903	0.833
Sorghum	0.999	0.991	0.995	0.924	0.999	0.981	0.989
Wheat	0.993	0.988	0.996	0.912	0.991	1.000	0.991

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,683,474	1,780,847	3,340,665	195,458	2,480,812	1,543,642	12,024,898
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	184.28	265.96	202.28	59.82	184.18	195.41	192.68
Soil salinity(dS/m)	2.54	2.65	2.72	4.14	2.54	3.25	2.77
Water table (m)	3.26	2.83	4.07	6.39	8.71	6.57	5.19
Relative Crop Yields							
Alfalfa	0.916	0.903	0.915	0.784	0.944	0.885	0.910
Beans	0.682	0.770	0.718	0.364	0.574	0.438	0.652
Corn	0.874	0.917	0.900	0.781	0.916	0.806	0.887
Grass	0.991	0.995	0.969	0.967	0.995	0.977	0.985
Melons	0.872	0.911	0.879	0.477	0.877	0.889	0.882
Onion	0.902	0.879	0.873	0.945	0.883	0.783	0.879
Sorghum	0.974	1.000	1.000	1.000	1.000	1.000	0.994
Wheat	0.996	1.000	1.000	0.981	0.999	1.000	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,244,905	1,434,168	3,368,882	491,862	1,975,694	1,396,192	10,911,704
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	157.35	212.43	191.01	125.12	148.72	174.24	170.8
Soil salinity(dS/m)	3.74	3.67	3.3	4.22	2.62	3.89	3.43
Water table (m)	3.54	2.96	4.52	7.02	9.2	6.84	5.55
Relative Crop Yields							
Alfalfa	0.841	0.808	0.869	0.801	0.936	0.827	0.860
Beans	0.380	0.574	0.582	0.073	0.659	0.452	0.571
Corn	0.761	0.826	0.855	0.749	0.894	0.718	0.823
Grass	0.972	0.978	0.973	0.955	0.992	0.961	0.974
Melons	0.781	0.859	0.821	0.730	0.842	0.823	0.816
Onion	0.790	0.828	0.815	0.829	0.890	0.869	0.836
Sorghum	0.985	0.986	0.999	1.000	1.000	0.998	0.994
Wheat	0.993	1.000	0.998	0.983	0.998	1.000	0.997

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Summarized Economic Output as a Result of Lining RF Highline Canal.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	1,967,257	1,464,663	3,070,067	207,614	2,104,247	1,328,647	10,142,495
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	140.86	210.24	168.62	57.87	156.86	163.74	157.85
Soil salinity(dS/m)	3.46	3.19	3.39	4.62	3.34	3.56	3.47
Water table (m)	2.73	2.53	2.9	3.9	5.79	4.33	3.66
Relative Crop Yields							
Alfalfa	0.875	0.829	0.850	0.738	0.887	0.866	0.861
Beans	0.479	0.721	0.624	0.044	0.491	0.410	0.536
Corn	0.773	0.830	0.809	0.671	0.820	0.737	0.795
Grass	0.965	0.974	0.969	0.933	0.986	0.955	0.966
Melons	0.766	0.839	0.782	0.709	0.839	0.826	0.802
Onion	0.823	0.906	0.791	0.929	0.833	0.897	0.833
Sorghum	0.999	0.991	0.996	0.945	1.000	0.935	0.978
Wheat	0.993	0.988	0.996	0.912	0.996	1.000	0.992

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,682,105	1,781,253	3,324,231	193,400	2,515,958	1,576,692	12,073,639
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	184.18	266.02	201.29	59.19	186.79	199.59	193.46
Soil salinity(dS/m)	2.54	2.64	2.75	4.13	2.41	3.13	2.74
Water table (m)	3.22	2.87	4.17	6.53	9.43	6.41	5.35
Relative Crop Yields							
Alfalfa	0.916	0.907	0.911	0.782	0.952	0.896	0.913
Beans	0.680	0.772	0.706	0.347	0.571	0.489	0.644
Corn	0.873	0.917	0.900	0.781	0.927	0.815	0.890
Grass	0.991	0.994	0.969	0.967	0.997	0.979	0.985
Melons	0.871	0.910	0.877	0.478	0.875	0.894	0.881
Onion	0.902	0.879	0.872	0.945	0.894	0.854	0.886
Sorghum	0.974	1.000	1.000	1.000	1.000	1.000	0.994
Wheat	0.996	1.000	1.000	0.981	0.999	1.000	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,242,647	1,442,684	3,360,096	492,922	2,069,937	1,414,537	11,022,823
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	157.19	213.69	190.51	125.39	155.81	176.53	172.54
Soil salinity(dS/m)	3.75	3.66	3.31	4.21	2.34	3.82	3.36
Water table (m)	3.44	3.03	4.64	7.21	9.98	6.55	5.71
Relative Crop Yields							
Alfalfa	0.841	0.813	0.868	0.801	0.952	0.837	0.864
Beans	0.379	0.581	0.578	0.072	0.788	0.494	0.593
Corn	0.760	0.829	0.854	0.754	0.913	0.724	0.828
Grass	0.972	0.977	0.973	0.955	0.994	0.965	0.975
Melons	0.780	0.861	0.823	0.729	0.857	0.824	0.818
Onion	0.790	0.823	0.809	0.829	0.898	0.863	0.834
Sorghum	0.985	0.988	1.000	1.000	1.000	0.996	0.994
Wheat	0.993	1.000	0.998	0.981	0.999	0.999	0.997

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Summarized Economic Output as a Result of Lining Holbrook Canal.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,190,412	1,463,918	3,038,117	205,110	2,085,997	1,329,130	10,312,683
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	156.84	210.13	166.87	57.18	155.5	163.8	160.49
Soil salinity(dS/m)	3.2	3.19	3.41	4.63	3.36	3.56	3.42
Water table (m)	3.2	2.53	2.88	3.86	5.42	4.33	3.68
Relative Crop Yields							
Alfalfa	0.911	0.829	0.848	0.735	0.885	0.866	0.871
Beans	0.513	0.721	0.606	0.044	0.471	0.414	0.527
Corn	0.815	0.829	0.807	0.668	0.812	0.737	0.798
Grass	0.970	0.974	0.969	0.933	0.987	0.955	0.967
Melons	0.828	0.838	0.778	0.709	0.838	0.826	0.811
Onion	0.830	0.906	0.788	0.927	0.837	0.897	0.834
Sorghum	1.000	0.991	0.995	0.924	0.999	0.935	0.977
Wheat	0.998	0.988	0.996	0.912	0.991	1.000	0.992

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,807,025	1,780,075	3,340,830	195,459	2,480,262	1,574,603	12,178,255
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	192.76	265.84	202.29	59.82	184.14	199.33	195.13
Soil salinity(dS/m)	2.45	2.65	2.72	4.14	2.54	3.14	2.74
Water table (m)	4.12	2.83	4.07	6.39	8.72	6.43	5.37
Relative Crop Yields							
Alfalfa	0.946	0.903	0.915	0.784	0.944	0.896	0.921
Beans	0.687	0.769	0.718	0.364	0.574	0.431	0.652
Corn	0.903	0.917	0.900	0.781	0.916	0.813	0.892
Grass	0.990	0.995	0.969	0.967	0.995	0.979	0.985
Melons	0.875	0.911	0.879	0.477	0.877	0.894	0.883
Onion	0.921	0.879	0.873	0.943	0.883	0.852	0.886
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	0.999	1.000	1.000	0.981	0.999	1.000	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,417,717	1,433,586	3,367,522	491,766	1,979,414	1,409,923	11,099,928
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	169.46	212.35	190.93	125.09	149	175.96	173.75
Soil salinity(dS/m)	3.5	3.67	3.3	4.23	2.62	3.82	3.37
Water table (m)	4.46	2.96	4.52	7.08	9.18	6.63	5.73
Relative Crop Yields							
Alfalfa	0.874	0.808	0.869	0.802	0.936	0.838	0.871
Beans	0.421	0.568	0.580	0.073	0.672	0.438	0.572
Corn	0.794	0.826	0.855	0.749	0.894	0.721	0.828
Grass	0.978	0.978	0.973	0.953	0.992	0.965	0.975
Melons	0.811	0.859	0.822	0.730	0.843	0.823	0.822
Onion	0.805	0.828	0.815	0.829	0.890	0.863	0.837
Sorghum	0.999	0.986	0.999	1.000	1.000	0.996	0.997
Wheat	0.995	1.000	0.998	0.983	0.998	0.999	0.997

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Summarized Economic Output as a Result of Lining Otero Canal

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	1,967,780	1,468,351	3,127,647	257,666	2,085,649	1,328,681	10,235,774
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	140.9	210.77	171.78	71.83	155.48	163.75	159.3
Soil salinity(dS/m)	3.46	3.18	3.36	4.48	3.36	3.56	3.45
Water table (m)	2.73	2.54	3	4.36	5.53	4.33	3.66
Relative Crop Yields							
Alfalfa	0.875	0.831	0.855	0.755	0.886	0.866	0.862
Beans	0.479	0.724	0.612	0.089	0.473	0.414	0.530
Corn	0.774	0.831	0.814	0.710	0.811	0.737	0.797
Grass	0.965	0.974	0.969	0.967	0.987	0.955	0.971
Melons	0.766	0.839	0.789	0.784	0.839	0.826	0.807
Onion	0.823	0.907	0.809	0.930	0.836	0.897	0.839
Sorghum	0.999	0.992	1.000	0.960	1.000	0.935	0.979
Wheat	0.993	0.988	0.996	0.967	0.992	1.000	0.993

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,682,770	1,778,300	3,320,035	201,110	2,491,131	1,573,929	12,047,275
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	184.23	265.58	201.03	61.55	184.94	199.24	193.03
Soil salinity(dS/m)	2.54	2.65	2.74	4.23	2.53	3.14	2.77
Water table (m)	3.26	2.89	4.36	6.9	9	6.39	5.34
Relative Crop Yields							
Alfalfa	0.916	0.910	0.910	0.786	0.944	0.896	0.911
Beans	0.680	0.747	0.709	0.387	0.574	0.395	0.647
Corn	0.873	0.917	0.899	0.784	0.916	0.814	0.887
Grass	0.991	0.994	0.971	0.964	0.995	0.979	0.985
Melons	0.871	0.908	0.877	0.519	0.880	0.894	0.882
Onion	0.902	0.879	0.869	0.944	0.888	0.854	0.883
Sorghum	0.974	1.000	1.000	1.000	1.000	1.000	0.994
Wheat	0.996	1.000	1.000	0.988	0.999	1.000	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,243,526	1,439,615	3,343,908	495,532	2,008,751	1,409,019	10,940,351
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	157.25	213.24	189.59	126.05	151.21	175.84	171.25
Soil salinity(dS/m)	3.74	3.67	3.31	4.2	2.57	3.83	3.41
Water table (m)	3.51	3.07	4.84	7.46	9.54	6.63	5.72
Relative Crop Yields							
Alfalfa	0.841	0.815	0.870	0.813	0.939	0.837	0.863
Beans	0.379	0.566	0.556	0.143	0.678	0.403	0.560
Corn	0.760	0.828	0.851	0.755	0.897	0.721	0.823
Grass	0.972	0.977	0.977	0.950	0.992	0.965	0.974
Melons	0.781	0.860	0.824	0.716	0.866	0.823	0.818
Onion	0.789	0.820	0.802	0.841	0.908	0.863	0.833
Sorghum	0.985	0.989	1.000	1.000	1.000	0.996	0.994
Wheat	0.993	1.000	0.998	0.980	0.998	0.999	0.997

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Summarized Economic Output as a Result of Lining Rocky Ford Canal.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	1,967,235	1,483,862	3,020,218	205,051	2,086,715	1,328,900	10,091,980
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	140.86	212.99	165.88	57.16	155.56	163.77	157.06
Soil salinity(dS/m)	3.46	3.17	3.42	4.63	3.36	3.56	3.47
Water table (m)	2.72	2.68	2.89	3.86	5.42	4.33	3.6
Relative Crop Yields							
Alfalfa	0.875	0.835	0.848	0.735	0.885	0.866	0.860
Beans	0.479	0.727	0.595	0.044	0.475	0.414	0.521
Corn	0.773	0.835	0.804	0.668	0.812	0.737	0.792
Grass	0.965	0.976	0.969	0.933	0.987	0.955	0.966
Melons	0.766	0.845	0.777	0.709	0.838	0.826	0.801
Onion	0.823	0.904	0.784	0.927	0.837	0.897	0.831
Sorghum	0.999	0.993	0.995	0.924	0.999	0.935	0.977
Wheat	0.993	0.989	0.996	0.912	0.991	1.000	0.991

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,683,115	1,773,647	3,341,733	195,353	2,481,542	1,573,897	12,049,288
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	184.25	264.88	202.35	59.78	184.23	199.24	193.07
Soil salinity(dS/m)	2.54	2.65	2.72	4.14	2.53	3.14	2.76
Water table (m)	3.27	3.12	4.12	6.4	8.7	6.39	5.21
Relative Crop Yields							
Alfalfa	0.916	0.914	0.914	0.783	0.944	0.896	0.913
Beans	0.680	0.747	0.721	0.363	0.574	0.394	0.651
Corn	0.873	0.914	0.901	0.782	0.916	0.813	0.887
Grass	0.991	0.995	0.969	0.966	0.995	0.979	0.985
Melons	0.871	0.908	0.878	0.477	0.877	0.894	0.882
Onion	0.902	0.868	0.874	0.943	0.883	0.853	0.881
Sorghum	0.974	1.000	1.000	1.000	1.000	1.000	0.994
Wheat	0.996	1.000	1.000	0.981	0.999	1.000	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,242,938	1,424,890	3,376,540	492,241	1,974,508	1,408,659	10,919,775
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	157.21	211.06	191.44	125.21	148.63	175.8	170.93
Soil salinity(dS/m)	3.74	3.65	3.3	4.22	2.62	3.83	3.42
Water table (m)	3.52	3.33	4.57	7.03	9.18	6.65	5.58
Relative Crop Yields							
Alfalfa	0.840	0.818	0.867	0.801	0.936	0.837	0.861
Beans	0.378	0.623	0.585	0.072	0.658	0.401	0.579
Corn	0.761	0.827	0.857	0.750	0.893	0.721	0.824
Grass	0.972	0.978	0.972	0.955	0.992	0.964	0.974
Melons	0.780	0.847	0.823	0.730	0.842	0.823	0.814
Onion	0.792	0.785	0.818	0.829	0.890	0.863	0.831
Sorghum	0.985	0.992	0.999	1.000	1.000	0.996	0.994
Wheat	0.993	1.000	0.998	0.983	0.998	0.999	0.997

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Summarized Economic Output as a Result of Lining a 20% Section of each Canal with the Highest Seepage Rate.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,000,726	1,477,091	3,107,318	256,222	2,085,497	1,341,803	10,268,657
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	143.26	212.02	170.67	71.42	155.46	165.36	159.81
Soil salinity(dS/m)	3.37	3.17	3.36	4.49	3.37	3.55	3.43
Water table (m)	2.9	2.55	2.98	4.31	5.45	4.4	3.68
Relative Crop Yields							
Alfalfa	0.883	0.834	0.855	0.751	0.885	0.875	0.866
Beans	0.479	0.727	0.610	0.157	0.474	0.413	0.532
Corn	0.785	0.833	0.813	0.705	0.812	0.741	0.799
Grass	0.969	0.975	0.970	0.968	0.986	0.960	0.973
Melons	0.766	0.842	0.784	0.784	0.838	0.826	0.805
Onion	0.827	0.908	0.805	0.929	0.837	0.897	0.839
Sorghum	0.999	0.993	0.995	0.934	0.999	0.935	0.977
Wheat	0.993	0.989	0.996	0.968	0.991	1.000	0.993

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,706,789	1,787,869	3,338,917	207,520	2,477,048	1,565,454	12,083,596
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	185.88	267.01	202.18	63.51	183.9	198.17	193.62
Soil salinity(dS/m)	2.47	2.65	2.73	4.23	2.55	3.19	2.76
Water table (m)	3.72	2.89	4.26	6.75	8.74	6.4	5.36
Relative Crop Yields							
Alfalfa	0.925	0.911	0.913	0.789	0.943	0.888	0.914
Beans	0.689	0.776	0.721	0.449	0.573	0.391	0.662
Corn	0.877	0.919	0.901	0.778	0.915	0.812	0.888
Grass	0.990	0.996	0.972	0.962	0.995	0.978	0.985
Melons	0.868	0.911	0.879	0.552	0.877	0.894	0.882
Onion	0.909	0.879	0.867	0.944	0.882	0.861	0.882
Sorghum	0.975	1.000	1.000	1.000	1.000	1.000	0.994
Wheat	0.997	1.000	1.000	0.984	0.999	1.000	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,291,699	1,447,191	3,363,527	495,645	1,979,695	1,399,297	10,977,054
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	160.63	214.36	190.7	126.08	149.02	174.63	171.83
Soil salinity(dS/m)	3.6	3.63	3.28	4.25	2.63	3.88	3.39
Water table (m)	4.02	3.04	4.71	7.28	9.23	6.64	5.72
Relative Crop Yields							
Alfalfa	0.849	0.817	0.873	0.815	0.937	0.829	0.865
Beans	0.389	0.580	0.564	0.187	0.658	0.401	0.565
Corn	0.770	0.832	0.854	0.749	0.893	0.720	0.825
Grass	0.979	0.978	0.976	0.946	0.992	0.965	0.975
Melons	0.785	0.859	0.823	0.716	0.844	0.823	0.817
Onion	0.806	0.830	0.805	0.842	0.901	0.863	0.836
Sorghum	0.985	0.989	1.000	1.000	1.000	0.996	0.994
Wheat	0.995	1.000	0.998	0.982	0.998	0.999	0.997

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 10%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,090,808	1,470,308	3,095,650	212,469	2,101,641	1,361,248	10,332,125
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	149.71	211.05	170.03	59.23	156.67	167.76	160.8
Soil salinity(dS/m)	3.3	3.16	3.37	4.55	3.34	3.51	3.41
Water table (m)	2.87	2.71	2.97	3.82	5.57	4.43	3.69
Relative Crop Yields							
Alfalfa	0.893	0.824	0.850	0.717	0.888	0.873	0.866
Beans	0.506	0.711	0.623	0.000	0.463	0.458	0.534
Corn	0.809	0.831	0.812	0.675	0.818	0.743	0.802
Grass	0.973	0.970	0.969	0.936	0.985	0.959	0.968
Melons	0.793	0.845	0.791	0.747	0.843	0.835	0.814
Onion	0.819	0.906	0.782	0.932	0.832	0.904	0.830
Sorghum	1.000	0.990	0.995	0.992	1.000	0.961	0.987
Wheat	0.998	0.986	0.996	0.923	0.992	1.000	0.992

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,765,976	1,792,259	3,370,351	233,581	2,531,513	1,620,111	12,313,790
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	189.94	267.66	204.08	71.48	187.94	205.09	197.31
Soil salinity(dS/m)	2.41	2.52	2.62	3.6	2.44	2.98	2.62
Water table (m)	3.3	3.15	4.17	6.12	8.83	6.44	5.26
Relative Crop Yields							
Alfalfa	0.937	0.900	0.919	0.839	0.951	0.910	0.924
Beans	0.728	0.760	0.721	0.411	0.588	0.503	0.662
Corn	0.894	0.919	0.903	0.808	0.923	0.824	0.895
Grass	0.993	0.996	0.979	0.983	0.995	0.980	0.989
Melons	0.866	0.918	0.881	0.645	0.890	0.908	0.889
Onion	0.929	0.888	0.882	0.870	0.895	0.868	0.895
Sorghum	1.000	0.993	1.000	1.000	1.000	1.000	0.999
Wheat	0.999	1.000	1.000	1.000	0.999	1.000	1.000

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,463,129	1,467,491	3,503,292	549,359	2,040,070	1,509,928	11,533,269
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	172.64	217.37	198.63	139.74	153.57	188.44	180.53
Soil salinity(dS/m)	3.4	3.49	3.1	3.7	2.45	3.54	3.17
Water table (m)	3.52	3.38	4.57	6.69	9.37	6.61	5.59
Relative Crop Yields							
Alfalfa	0.872	0.812	0.884	0.842	0.948	0.860	0.882
Beans	0.460	0.661	0.586	0.224	0.720	0.543	0.605
Corn	0.809	0.830	0.867	0.757	0.905	0.755	0.842
Grass	0.982	0.978	0.987	0.974	0.991	0.969	0.982
Melons	0.825	0.874	0.845	0.800	0.864	0.851	0.845
Onion	0.841	0.810	0.833	0.812	0.902	0.890	0.851
Sorghum	0.998	0.987	1.000	1.000	1.000	1.000	0.998
Wheat	0.997	1.000	0.999	0.989	0.998	1.000	0.998

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 20%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,131,126	1,493,120	3,170,854	226,172	2,113,266	1,373,288	10,507,826
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	152.59	214.32	174.16	63.05	157.53	169.24	163.53
Soil salinity(dS/m)	3.24	3.1	3.31	4.51	3.32	3.49	3.36
Water table (m)	2.93	2.77	3.05	3.9	5.67	4.48	3.77
Relative Crop Yields							
Alfalfa	0.901	0.832	0.858	0.721	0.891	0.877	0.872
Beans	0.515	0.729	0.654	0.000	0.454	0.454	0.548
Corn	0.815	0.837	0.820	0.682	0.820	0.747	0.807
Grass	0.973	0.972	0.968	0.944	0.985	0.959	0.969
Melons	0.802	0.851	0.799	0.783	0.847	0.837	0.821
Onion	0.822	0.910	0.789	0.904	0.832	0.909	0.833
Sorghum	1.000	0.992	0.998	0.999	1.000	0.967	0.990
Wheat	0.998	0.987	0.996	0.933	0.993	1.000	0.993

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,822,829	1,835,273	3,425,838	237,280	2,567,159	1,664,627	12,553,006
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	193.84	274.09	207.44	72.62	190.59	210.73	201.14
Soil salinity(dS/m)	2.3	2.37	2.54	3.58	2.34	2.83	2.51
Water table (m)	3.39	3.24	4.32	6.16	8.94	6.52	5.36
Relative Crop Yields							
Alfalfa	0.946	0.913	0.925	0.837	0.958	0.920	0.932
Beans	0.751	0.795	0.747	0.455	0.601	0.527	0.688
Corn	0.906	0.933	0.911	0.816	0.930	0.836	0.905
Grass	0.994	0.996	0.977	0.983	0.995	0.982	0.989
Melons	0.875	0.928	0.885	0.633	0.893	0.923	0.897
Onion	0.941	0.901	0.889	0.858	0.903	0.882	0.904
Sorghum	1.000	0.996	1.000	1.000	1.000	1.000	1.000
Wheat	0.999	1.000	1.000	0.999	0.999	1.000	1.000

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,577,902	1,547,453	3,621,435	559,569	2,078,876	1,595,493	11,980,729
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	180.69	229.21	205.33	142.34	156.49	199.12	187.54
Soil salinity(dS/m)	3.17	3.22	2.93	3.59	2.31	3.29	2.97
Water table (m)	3.63	3.47	4.72	6.86	9.48	6.75	5.72
Relative Crop Yields							
Alfalfa	0.889	0.833	0.897	0.850	0.956	0.879	0.896
Beans	0.515	0.719	0.618	0.281	0.718	0.606	0.637
Corn	0.836	0.860	0.884	0.778	0.916	0.783	0.863
Grass	0.985	0.986	0.985	0.976	0.992	0.975	0.984
Melons	0.847	0.893	0.859	0.795	0.878	0.878	0.864
Onion	0.868	0.830	0.836	0.812	0.906	0.908	0.861
Sorghum	0.999	0.988	1.000	1.000	1.000	1.000	0.998
Wheat	0.998	1.000	0.999	0.988	0.998	1.000	0.998

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 30%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,162,250	1,513,501	3,226,380	236,828	2,124,217	1,375,703	10,638,880
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	154.82	217.25	177.21	66.02	158.35	169.54	165.57
Soil salinity(dS/m)	3.18	3.05	3.26	4.48	3.3	3.49	3.33
Water table (m)	3	2.84	3.14	3.98	5.78	4.53	3.85
Relative Crop Yields							
Alfalfa	0.907	0.839	0.866	0.726	0.893	0.878	0.877
Beans	0.522	0.742	0.671	0.000	0.459	0.388	0.548
Corn	0.820	0.843	0.824	0.689	0.821	0.750	0.811
Grass	0.974	0.974	0.967	0.955	0.984	0.959	0.971
Melons	0.809	0.855	0.807	0.800	0.849	0.840	0.827
Onion	0.825	0.913	0.790	0.899	0.835	0.911	0.835
Sorghum	1.000	0.994	1.000	1.000	1.000	0.974	0.992
Wheat	0.998	0.988	0.997	0.942	0.993	1.000	0.994

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,855,117	1,864,569	3,475,559	241,533	2,586,868	1,691,282	12,714,927
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	196.06	278.46	210.45	73.92	192.05	214.1	203.73
Soil salinity(dS/m)	2.23	2.28	2.45	3.55	2.28	2.76	2.44
Water table (m)	3.46	3.33	4.47	6.3	9.06	6.56	5.46
Relative Crop Yields							
Alfalfa	0.951	0.922	0.930	0.832	0.963	0.924	0.938
Beans	0.773	0.822	0.774	0.472	0.615	0.567	0.711
Corn	0.914	0.942	0.918	0.831	0.934	0.839	0.912
Grass	0.995	0.994	0.978	0.983	0.994	0.982	0.989
Melons	0.879	0.934	0.889	0.649	0.896	0.937	0.902
Onion	0.949	0.911	0.891	0.856	0.904	0.890	0.908
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	1.000	1.000	1.000	1.000	0.999	1.000	1.000

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,673,550	1,609,331	3,724,835	568,484	2,117,069	1,649,868	12,343,137
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	187.39	238.38	211.19	144.61	159.36	205.9	193.21
Soil salinity(dS/m)	2.99	3.03	2.77	3.46	2.2	3.14	2.81
Water table (m)	3.68	3.57	4.88	7.03	9.59	6.8	5.83
Relative Crop Yields							
Alfalfa	0.902	0.850	0.906	0.851	0.964	0.891	0.907
Beans	0.561	0.749	0.653	0.269	0.733	0.652	0.666
Corn	0.861	0.881	0.899	0.802	0.923	0.795	0.878
Grass	0.987	0.987	0.986	0.981	0.992	0.978	0.986
Melons	0.869	0.909	0.870	0.799	0.890	0.899	0.879
Onion	0.881	0.852	0.840	0.793	0.914	0.923	0.870
Sorghum	0.999	0.990	1.000	1.000	1.000	1.000	0.999
Wheat	0.998	1.000	1.000	0.990	0.998	1.000	0.998

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 40%.

	Canal Area						
1999	1	2	3	4	5	6	Study Area
Profit ($)	2,188,601	1,522,822	3,264,943	245,152	2,125,034	1,369,521	10,716,073
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	156.71	218.59	179.32	68.34	158.41	168.78	166.77
Soil salinity(dS/m)	3.14	3.02	3.23	4.45	3.3	3.51	3.31
Water table (m)	3.06	2.9	3.22	4.06	5.9	4.59	3.93
Relative Crop Yields							
Alfalfa	0.912	0.844	0.871	0.731	0.894	0.878	0.881
Beans	0.526	0.749	0.680	0.000	0.461	0.342	0.547
Corn	0.823	0.847	0.828	0.693	0.821	0.750	0.814
Grass	0.973	0.975	0.968	0.964	0.983	0.957	0.971
Melons	0.816	0.856	0.812	0.814	0.850	0.837	0.830
Onion	0.826	0.914	0.793	0.883	0.833	0.913	0.836
Sorghum	1.000	0.994	1.000	1.000	1.000	0.979	0.994
Wheat	0.998	0.989	0.997	0.950	0.994	1.000	0.994

	Canal Area						
2000	1	2	3	4	5	6	Study Area
Profit ($)	2,881,928	1,883,490	3,508,768	235,544	2,603,807	1,697,792	12,811,330
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	197.9	281.29	212.46	72.08	193.31	214.92	205.28
Soil salinity(dS/m)	2.17	2.21	2.41	3.62	2.26	2.73	2.4
Water table (m)	3.5	3.43	4.62	6.43	9.25	6.64	5.58
Relative Crop Yields							
Alfalfa	0.955	0.929	0.931	0.817	0.965	0.924	0.940
Beans	0.795	0.844	0.790	0.475	0.619	0.608	0.724
Corn	0.923	0.948	0.925	0.834	0.935	0.841	0.917
Grass	0.995	0.993	0.977	0.981	0.994	0.983	0.989
Melons	0.882	0.936	0.891	0.610	0.900	0.940	0.905
Onion	0.951	0.919	0.893	0.843	0.911	0.888	0.912
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	1.000	1.000	1.000	1.000	0.999	1.000	1.000

	Canal Area						
2001	1	2	3	4	5	6	Study Area
Profit ($)	2,736,673	1,646,528	3,797,295	569,316	2,138,507	1,681,319	12,569,638
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	191.81	243.89	215.3	144.82	160.98	209.83	196.76
Soil salinity(dS/m)	2.85	2.89	2.67	3.43	2.13	3.06	2.72
Water table (m)	3.73	3.69	5.05	7.11	9.71	6.86	5.93
Relative Crop Yields							
Alfalfa	0.912	0.863	0.913	0.846	0.968	0.897	0.914
Beans	0.601	0.772	0.667	0.231	0.744	0.722	0.679
Corn	0.876	0.897	0.907	0.818	0.928	0.803	0.888
Grass	0.988	0.988	0.985	0.981	0.992	0.976	0.986
Melons	0.881	0.915	0.882	0.799	0.900	0.911	0.889
Onion	0.893	0.860	0.847	0.794	0.916	0.935	0.877
Sorghum	0.999	0.991	1.000	1.000	1.000	1.000	0.999
Wheat	0.998	1.000	1.000	0.992	0.998	1.000	0.999

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 50%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,215,726	1,537,396	3,293,893	252,666	2,126,277	1,370,948	10,796,906
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	158.65	220.68	180.91	70.43	158.5	168.95	168.03
Soil salinity(dS/m)	3.11	3	3.21	4.42	3.3	3.52	3.29
Water table (m)	3.13	2.97	3.31	4.14	6	4.63	4.01
Relative Crop Yields							
Alfalfa	0.917	0.847	0.874	0.734	0.893	0.879	0.883
Beans	0.528	0.759	0.682	0.000	0.459	0.343	0.549
Corn	0.826	0.852	0.831	0.700	0.822	0.751	0.817
Grass	0.973	0.976	0.968	0.970	0.982	0.956	0.972
Melons	0.825	0.859	0.816	0.823	0.850	0.838	0.833
Onion	0.827	0.916	0.795	0.890	0.834	0.913	0.837
Sorghum	1.000	0.994	1.000	1.000	1.000	0.984	0.995
Wheat	0.999	0.991	0.997	0.956	0.993	1.000	0.995

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,899,215	1,885,666	3,536,050	232,164	2,597,467	1,702,553	12,853,115
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	199.09	281.61	214.11	71.05	192.84	215.53	205.95
Soil salinity(dS/m)	2.11	2.22	2.38	3.66	2.28	2.73	2.39
Water table (m)	3.61	3.52	4.77	6.56	9.41	6.66	5.7
Relative Crop Yields							
Alfalfa	0.958	0.928	0.934	0.811	0.964	0.923	0.940
Beans	0.811	0.865	0.801	0.470	0.613	0.605	0.731
Corn	0.929	0.950	0.928	0.839	0.934	0.840	0.919
Grass	0.995	0.992	0.978	0.979	0.993	0.982	0.988
Melons	0.884	0.935	0.896	0.585	0.899	0.945	0.907
Onion	0.953	0.925	0.894	0.854	0.912	0.891	0.914
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	1.000	1.000	1.000	0.996	0.999	1.000	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,784,269	1,662,641	3,849,037	571,551	2,146,406	1,700,785	12,714,689
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	195.15	246.27	218.23	145.39	161.57	212.26	199.03
Soil salinity(dS/m)	2.75	2.83	2.6	3.39	2.1	2.98	2.65
Water table (m)	3.83	3.79	5.21	7.32	9.86	6.82	6.05
Relative Crop Yields							
Alfalfa	0.919	0.867	0.918	0.845	0.969	0.900	0.918
Beans	0.631	0.775	0.683	0.172	0.740	0.732	0.687
Corn	0.888	0.906	0.912	0.832	0.931	0.806	0.894
Grass	0.989	0.987	0.986	0.980	0.990	0.976	0.986
Melons	0.890	0.918	0.889	0.802	0.901	0.921	0.896
Onion	0.897	0.868	0.852	0.800	0.922	0.941	0.883
Sorghum	1.000	0.992	1.000	1.000	1.000	1.000	0.999
Wheat	0.998	1.000	1.000	0.992	0.998	1.000	0.999

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 60%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,234,102	1,544,642	3,305,791	254,463	2,118,873	1,363,417	10,821,288
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	159.97	221.72	181.57	70.93	157.95	168.03	168.41
Soil salinity(dS/m)	3.09	2.99	3.21	4.44	3.31	3.55	3.29
Water table (m)	3.21	3.03	3.4	4.23	6.12	4.68	4.09
Relative Crop Yields							
Alfalfa	0.920	0.850	0.876	0.737	0.893	0.877	0.885
Beans	0.526	0.764	0.680	0.000	0.450	0.333	0.545
Corn	0.828	0.855	0.833	0.702	0.820	0.748	0.817
Grass	0.973	0.976	0.968	0.970	0.981	0.956	0.972
Melons	0.831	0.859	0.816	0.827	0.850	0.836	0.834
Onion	0.827	0.918	0.800	0.853	0.832	0.913	0.838
Sorghum	1.000	0.994	1.000	1.000	1.000	0.986	0.995
Wheat	0.999	0.992	0.997	0.963	0.993	1.000	0.995

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,909,000	1,878,759	3,527,401	223,415	2,581,175	1,686,225	12,805,974
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	199.76	280.58	213.59	68.37	191.63	213.46	205.19
Soil salinity(dS/m)	2.09	2.24	2.39	3.75	2.32	2.8	2.41
Water table (m)	3.71	3.62	4.93	6.7	9.56	6.78	5.83
Relative Crop Yields							
Alfalfa	0.961	0.929	0.932	0.803	0.960	0.918	0.939
Beans	0.820	0.817	0.808	0.449	0.588	0.536	0.722
Corn	0.932	0.950	0.927	0.825	0.930	0.834	0.917
Grass	0.995	0.989	0.975	0.976	0.992	0.980	0.987
Melons	0.884	0.932	0.894	0.589	0.898	0.947	0.906
Onion	0.948	0.928	0.892	0.812	0.912	0.814	0.910
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	1.000	1.000	1.000	0.996	0.999	1.000	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,809,790	1,662,875	3,857,544	569,033	2,128,342	1,700,701	12,728,285
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	196.94	246.31	218.71	144.75	160.21	212.25	199.24
Soil salinity(dS/m)	2.72	2.82	2.59	3.41	2.16	3.03	2.66
Water table (m)	3.9	3.9	5.39	7.36	9.97	6.94	6.17
Relative Crop Yields							
Alfalfa	0.924	0.871	0.918	0.842	0.969	0.898	0.919
Beans	0.648	0.765	0.680	0.136	0.723	0.635	0.678
Corn	0.891	0.908	0.914	0.841	0.927	0.801	0.894
Grass	0.989	0.984	0.982	0.978	0.989	0.970	0.984
Melons	0.896	0.916	0.891	0.803	0.892	0.928	0.899
Onion	0.898	0.869	0.855	0.773	0.914	0.944	0.882
Sorghum	1.000	0.994	1.000	1.000	1.000	1.000	0.999
Wheat	0.998	1.000	1.000	0.992	0.998	1.000	0.999

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 70%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,238,426	1,554,109	3,305,709	255,823	2,107,198	1,356,416	10,817,681
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	160.28	223.08	181.56	71.31	157.08	167.16	168.35
Soil salinity(dS/m)	3.09	2.97	3.22	4.45	3.34	3.59	3.3
Water table (m)	3.3	3.1	3.49	4.32	6.23	4.74	4.18
Relative Crop Yields							
Alfalfa	0.923	0.855	0.877	0.739	0.891	0.876	0.886
Beans	0.523	0.767	0.679	0.000	0.442	0.327	0.542
Corn	0.827	0.858	0.833	0.704	0.817	0.744	0.817
Grass	0.972	0.974	0.967	0.970	0.981	0.954	0.971
Melons	0.832	0.861	0.814	0.829	0.850	0.835	0.834
Onion	0.826	0.920	0.801	0.834	0.830	0.912	0.837
Sorghum	1.000	0.994	1.000	1.000	1.000	0.988	0.996
Wheat	0.999	0.993	0.997	0.967	0.993	1.000	0.996

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,916,975	1,875,033	3,494,840	217,580	2,541,689	1,675,102	12,721,218
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	200.31	280.02	211.62	66.59	188.7	212.05	203.83
Soil salinity(dS/m)	2.09	2.28	2.44	3.86	2.45	2.89	2.48
Water table (m)	3.75	3.72	5.1	6.91	9.62	6.86	5.93
Relative Crop Yields							
Alfalfa	0.963	0.929	0.929	0.795	0.954	0.914	0.937
Beans	0.825	0.811	0.793	0.447	0.563	0.402	0.705
Corn	0.933	0.948	0.924	0.822	0.918	0.824	0.912
Grass	0.995	0.988	0.973	0.970	0.988	0.977	0.984
Melons	0.885	0.930	0.889	0.582	0.896	0.944	0.904
Onion	0.950	0.930	0.890	0.786	0.909	0.894	0.912
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	1.000	1.000	1.000	0.995	0.999	1.000	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,800,634	1,661,026	3,827,936	557,957	2,081,421	1,701,279	12,630,252
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	196.3	246.03	217.04	141.93	156.68	212.32	197.7
Soil salinity(dS/m)	2.71	2.84	2.63	3.43	2.26	3.1	2.7
Water table (m)	3.95	4	5.57	7.51	10.06	7	6.27
Relative Crop Yields							
Alfalfa	0.926	0.869	0.916	0.838	0.965	0.893	0.918
Beans	0.657	0.739	0.674	0.105	0.689	0.806	0.665
Corn	0.893	0.912	0.910	0.838	0.912	0.801	0.890
Grass	0.988	0.980	0.979	0.977	0.989	0.971	0.983
Melons	0.887	0.916	0.887	0.786	0.891	0.929	0.894
Onion	0.895	0.871	0.854	0.748	0.897	0.949	0.878
Sorghum	0.999	0.995	1.000	1.000	1.000	1.000	0.999
Wheat	0.998	1.000	0.999	0.994	0.998	1.000	0.999

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 80%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,237,347	1,554,733	3,283,034	256,155	2,092,859	1,345,956	10,770,084
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	160.2	223.17	180.32	71.41	156.01	165.87	167.61
Soil salinity(dS/m)	3.1	2.98	3.25	4.48	3.37	3.64	3.33
Water table (m)	3.35	3.17	3.58	4.4	6.35	4.8	4.27
Relative Crop Yields							
Alfalfa	0.923	0.856	0.875	0.739	0.888	0.873	0.885
Beans	0.519	0.769	0.659	0.000	0.434	0.316	0.530
Corn	0.827	0.859	0.831	0.705	0.815	0.741	0.816
Grass	0.971	0.973	0.967	0.970	0.979	0.954	0.970
Melons	0.832	0.859	0.812	0.831	0.849	0.832	0.833
Onion	0.823	0.920	0.799	0.822	0.827	0.911	0.835
Sorghum	1.000	0.994	1.000	1.000	1.000	0.989	0.996
Wheat	0.999	0.994	0.998	0.973	0.993	0.999	0.996

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,901,768	1,859,244	3,443,908	204,282	2,480,846	1,644,097	12,534,144
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	199.27	277.66	208.53	62.52	184.18	208.13	200.84
Soil salinity(dS/m)	2.15	2.36	2.53	4.04	2.6	3.06	2.58
Water table (m)	3.8	3.82	5.26	7.04	9.84	6.9	6.06
Relative Crop Yields							
Alfalfa	0.963	0.923	0.922	0.783	0.945	0.905	0.932
Beans	0.825	0.780	0.786	0.444	0.538	0.552	0.695
Corn	0.931	0.945	0.917	0.793	0.904	0.808	0.903
Grass	0.991	0.986	0.970	0.963	0.984	0.973	0.980
Melons	0.880	0.926	0.882	0.569	0.890	0.944	0.899
Onion	0.942	0.931	0.887	0.761	0.897	0.800	0.901
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	1.000	1.000	1.000	0.990	0.999	1.000	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,780,076	1,644,133	3,744,091	541,088	2,060,301	1,667,537	12,437,227
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	194.86	243.53	212.28	137.64	155.09	208.11	194.68
Soil salinity(dS/m)	2.75	2.95	2.75	3.53	2.34	3.3	2.8
Water table (m)	4.03	4.11	5.77	7.73	10.25	7.11	6.42
Relative Crop Yields							
Alfalfa	0.925	0.862	0.908	0.836	0.958	0.879	0.912
Beans	0.656	0.730	0.645	0.000	0.659	0.572	0.633
Corn	0.888	0.906	0.901	0.825	0.913	0.787	0.884
Grass	0.987	0.974	0.976	0.974	0.986	0.966	0.980
Melons	0.880	0.913	0.878	0.771	0.885	0.930	0.889
Onion	0.888	0.871	0.842	0.716	0.892	0.944	0.870
Sorghum	0.999	0.996	1.000	1.000	1.000	0.999	0.999
Wheat	0.998	1.000	0.999	0.993	0.998	0.998	0.998

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 90%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,226,827	1,557,398	3,254,617	254,169	2,073,393	1,331,556	10,697,960
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	159.45	223.55	178.76	70.85	154.56	164.1	166.49
Soil salinity(dS/m)	3.14	2.97	3.29	4.54	3.41	3.69	3.37
Water table (m)	3.45	3.23	3.68	4.49	6.47	4.84	4.36
Relative Crop Yields							
Alfalfa	0.922	0.859	0.873	0.735	0.884	0.870	0.883
Beans	0.513	0.769	0.654	0.000	0.420	0.304	0.523
Corn	0.825	0.860	0.829	0.705	0.811	0.736	0.813
Grass	0.971	0.971	0.964	0.969	0.978	0.952	0.969
Melons	0.830	0.859	0.808	0.831	0.847	0.829	0.830
Onion	0.820	0.918	0.795	0.797	0.824	0.905	0.831
Sorghum	1.000	0.994	1.000	1.000	1.000	0.986	0.995
Wheat	0.999	0.995	0.998	0.977	0.994	0.999	0.996

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,870,967	1,842,311	3,372,990	187,466	2,375,846	1,611,405	12,260,985
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	197.15	275.14	204.24	57.37	176.39	203.99	196.46
Soil salinity(dS/m)	2.25	2.44	2.66	4.38	2.86	3.27	2.75
Water table (m)	3.91	3.92	5.44	7.21	9.98	6.95	6.18
Relative Crop Yields							
Alfalfa	0.960	0.918	0.915	0.757	0.917	0.893	0.921
Beans	0.820	0.767	0.771	0.431	0.520	0.457	0.679
Corn	0.925	0.939	0.906	0.775	0.885	0.794	0.891
Grass	0.989	0.983	0.962	0.953	0.978	0.970	0.975
Melons	0.873	0.922	0.873	0.559	0.875	0.941	0.891
Onion	0.935	0.929	0.881	0.727	0.886	0.785	0.894
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	0.998	0.997	1.000	0.981	0.996	1.000	0.997

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,726,036	1,610,436	3,651,125	508,582	1,985,934	1,622,560	12,104,672
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	191.07	238.54	207.01	129.37	149.49	202.49	189.48
Soil salinity(dS/m)	2.9	3.1	2.91	3.85	2.49	3.55	2.98
Water table (m)	4.16	4.24	5.97	7.92	10.37	7.16	6.57
Relative Crop Yields							
Alfalfa	0.918	0.850	0.899	0.818	0.943	0.866	0.901
Beans	0.646	0.712	0.610	0.000	0.656	0.463	0.607
Corn	0.878	0.896	0.889	0.800	0.900	0.768	0.870
Grass	0.983	0.965	0.972	0.965	0.982	0.949	0.973
Melons	0.867	0.905	0.871	0.739	0.846	0.926	0.877
Onion	0.878	0.861	0.833	0.675	0.876	0.936	0.859
Sorghum	0.998	0.998	1.000	1.000	1.000	0.996	0.998
Wheat	0.998	1.000	0.999	0.983	0.998	0.999	0.998

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Summarized Economic Output as a Result of Drainage Spaced at 50 meters.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,266,788	1,616,777	3,312,042	266,924	2,087,475	1,340,694	10,890,700
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	162.31	232.07	181.91	74.41	155.61	165.23	169.49
Soil salinity(dS/m)	3.06	2.9	3.26	4.46	3.37	3.64	3.32
Water table (m)	3.24	3.26	3.24	4.13	5.49	4.49	3.92
Relative Crop Yields							
Alfalfa	0.927	0.906	0.871	0.747	0.885	0.874	0.890
Beans	0.498	0.719	0.670	0.063	0.472	0.309	0.539
Corn	0.836	0.879	0.836	0.710	0.814	0.743	0.822
Grass	0.975	0.974	0.972	0.968	0.985	0.954	0.973
Melons	0.829	0.867	0.810	0.837	0.840	0.828	0.831
Onion	0.854	0.904	0.817	0.928	0.832	0.904	0.846
Sorghum	1.000	0.994	0.993	1.000	1.000	0.988	0.996
Wheat	0.999	1.000	0.999	0.954	0.991	0.999	0.996

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,824,631	1,760,608	3,300,603	192,795	2,476,805	1,522,521	12,077,964
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	193.97	262.93	199.86	59	183.88	192.74	193.53
Soil salinity(dS/m)	2.42	2.7	2.8	4.36	2.58	3.39	2.81
Water table (m)	3.74	3.59	4.36	6.18	8.78	6.45	5.45
Relative Crop Yields							
Alfalfa	0.953	0.912	0.901	0.764	0.941	0.882	0.918
Beans	0.726	0.745	0.716	0.419	0.575	0.466	0.655
Corn	0.910	0.918	0.896	0.764	0.913	0.791	0.888
Grass	0.989	0.989	0.975	0.964	0.994	0.966	0.983
Melons	0.871	0.898	0.876	0.513	0.881	0.881	0.878
Onion	0.919	0.869	0.869	0.943	0.882	0.873	0.883
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	0.999	1.000	1.000	0.986	0.999	0.999	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,466,926	1,471,924	3,301,333	497,916	1,969,364	1,380,417	11,087,880
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	172.91	218.02	187.18	126.66	148.24	172.27	173.56
Soil salinity(dS/m)	3.39	3.46	3.32	4.28	2.66	3.98	3.36
Water table (m)	3.85	3.78	4.69	6.81	9.26	6.68	5.74
Relative Crop Yields							
Alfalfa	0.882	0.841	0.865	0.810	0.936	0.822	0.874
Beans	0.467	0.600	0.542	0.154	0.674	0.476	0.558
Corn	0.821	0.845	0.850	0.731	0.887	0.714	0.830
Grass	0.980	0.976	0.984	0.946	0.989	0.956	0.975
Melons	0.808	0.864	0.820	0.753	0.851	0.819	0.823
Onion	0.808	0.777	0.787	0.795	0.889	0.870	0.820
Sorghum	0.998	1.000	1.000	0.982	1.000	0.986	0.996
Wheat	0.997	1.000	0.999	0.980	0.997	0.997	0.997

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Summarized Economic Output as a Result of Drainage Spaced at 75 meters.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,238,041	1,609,538	3,275,482	255,560	2,088,593	1,347,823	10,815,036
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	160.25	231.03	179.9	71.24	155.7	166.1	168.31
Soil salinity(dS/m)	3.11	2.92	3.29	4.5	3.37	3.61	3.34
Water table (m)	3.15	3.21	3.17	4.05	5.49	4.45	3.87
Relative Crop Yields							
Alfalfa	0.921	0.902	0.869	0.742	0.885	0.873	0.887
Beans	0.497	0.718	0.672	0.018	0.474	0.416	0.552
Corn	0.831	0.879	0.832	0.695	0.815	0.744	0.818
Grass	0.974	0.975	0.970	0.966	0.985	0.955	0.973
Melons	0.828	0.863	0.808	0.831	0.840	0.826	0.829
Onion	0.838	0.909	0.806	0.924	0.832	0.903	0.840
Sorghum	1.000	0.994	0.992	1.000	1.000	0.983	0.994
Wheat	0.999	1.000	0.999	0.950	0.991	0.999	0.996

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,776,676	1,750,335	3,282,603	186,830	2,479,944	1,540,817	12,017,205
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	190.68	261.4	198.77	57.18	184.11	195.05	192.55
Soil salinity(dS/m)	2.51	2.74	2.82	4.38	2.58	3.3	2.83
Water table (m)	3.66	3.54	4.31	6.15	8.78	6.43	5.41
Relative Crop Yields							
Alfalfa	0.946	0.906	0.901	0.764	0.942	0.890	0.917
Beans	0.712	0.749	0.703	0.378	0.574	0.439	0.643
Corn	0.901	0.914	0.893	0.758	0.914	0.801	0.887
Grass	0.987	0.990	0.974	0.963	0.994	0.969	0.983
Melons	0.858	0.896	0.875	0.509	0.881	0.884	0.875
Onion	0.917	0.869	0.866	0.940	0.883	0.839	0.881
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	0.999	1.000	1.000	0.979	0.999	0.999	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,416,175	1,462,388	3,293,275	484,420	1,967,028	1,393,710	11,016,995
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	169.35	216.61	186.72	123.22	148.07	173.93	172.45
Soil salinity(dS/m)	3.51	3.52	3.35	4.33	2.66	3.92	3.39
Water table (m)	3.78	3.74	4.65	6.76	9.27	6.67	5.7
Relative Crop Yields							
Alfalfa	0.873	0.833	0.864	0.806	0.935	0.830	0.871
Beans	0.444	0.610	0.546	0.103	0.676	0.447	0.559
Corn	0.808	0.841	0.846	0.721	0.887	0.720	0.827
Grass	0.976	0.976	0.982	0.946	0.990	0.957	0.974
Melons	0.800	0.863	0.822	0.734	0.849	0.819	0.821
Onion	0.812	0.777	0.782	0.800	0.888	0.869	0.818
Sorghum	0.997	1.000	1.000	0.993	1.000	0.991	0.997
Wheat	0.997	1.000	0.999	0.978	0.997	0.998	0.997

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Summarized Economic Output as a Result of Drainage Spaced at 100 meters.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,216,519	1,604,062	3,243,635	247,887	2,087,997	1,342,207	10,742,308
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	158.71	230.25	178.15	69.1	155.65	165.41	167.18
Soil salinity(dS/m)	3.15	2.94	3.31	4.54	3.37	3.6	3.35
Water table (m)	3.09	3.16	3.13	3.99	5.48	4.42	3.83
Relative Crop Yields							
Alfalfa	0.916	0.901	0.867	0.738	0.885	0.872	0.884
Beans	0.497	0.717	0.662	0.000	0.473	0.417	0.547
Corn	0.826	0.878	0.828	0.686	0.814	0.742	0.816
Grass	0.974	0.974	0.970	0.960	0.985	0.957	0.972
Melons	0.827	0.861	0.806	0.827	0.839	0.825	0.828
Onion	0.828	0.908	0.799	0.924	0.833	0.903	0.837
Sorghum	1.000	0.994	0.992	1.000	1.000	0.976	0.992
Wheat	0.999	1.000	0.999	0.946	0.991	1.000	0.996

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,747,487	1,739,277	3,267,074	186,412	2,478,643	1,547,507	11,966,401
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	188.67	259.75	197.83	57.05	184.02	195.9	191.74
Soil salinity(dS/m)	2.59	2.8	2.85	4.35	2.58	3.27	2.86
Water table (m)	3.65	3.5	4.27	6.12	8.77	6.42	5.38
Relative Crop Yields							
Alfalfa	0.940	0.901	0.899	0.769	0.941	0.891	0.914
Beans	0.701	0.740	0.698	0.359	0.574	0.436	0.637
Corn	0.892	0.910	0.891	0.757	0.914	0.801	0.884
Grass	0.988	0.989	0.972	0.964	0.994	0.973	0.983
Melons	0.855	0.893	0.874	0.501	0.880	0.884	0.874
Onion	0.917	0.869	0.862	0.941	0.883	0.887	0.882
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	0.999	1.000	1.000	0.980	0.999	1.000	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,390,312	1,444,406	3,276,358	481,949	1,967,676	1,393,471	10,954,171
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	167.54	213.95	185.76	122.6	148.12	173.9	171.47
Soil salinity(dS/m)	3.59	3.6	3.37	4.32	2.67	3.91	3.42
Water table (m)	3.78	3.7	4.62	6.65	9.25	6.66	5.68
Relative Crop Yields							
Alfalfa	0.866	0.825	0.863	0.805	0.934	0.830	0.867
Beans	0.426	0.605	0.540	0.081	0.689	0.444	0.556
Corn	0.798	0.835	0.844	0.716	0.887	0.718	0.823
Grass	0.975	0.974	0.981	0.947	0.990	0.958	0.973
Melons	0.803	0.858	0.821	0.732	0.849	0.819	0.820
Onion	0.808	0.776	0.779	0.810	0.887	0.869	0.816
Sorghum	0.997	1.000	0.999	0.991	1.000	0.993	0.997
Wheat	0.997	1.000	0.998	0.980	0.997	0.999	0.997

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Summarized Economic Output as a Result of Drainage Spaced at 150 meters.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,189,839	1,599,531	3,185,275	236,669	2,086,556	1,348,480	10,646,349
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	156.8	229.6	174.95	65.97	155.54	166.19	165.69
Soil salinity(dS/m)	3.21	2.97	3.34	4.57	3.37	3.57	3.38
Water table (m)	2.99	3.07	3.06	3.91	5.48	4.4	3.77
Relative Crop Yields							
Alfalfa	0.909	0.898	0.861	0.733	0.885	0.870	0.880
Beans	0.496	0.719	0.666	0.000	0.471	0.448	0.553
Corn	0.821	0.876	0.821	0.678	0.814	0.742	0.812
Grass	0.973	0.972	0.968	0.947	0.985	0.960	0.970
Melons	0.827	0.862	0.800	0.812	0.839	0.828	0.826
Onion	0.822	0.906	0.790	0.924	0.832	0.903	0.832
Sorghum	1.000	0.994	0.992	1.000	1.000	0.967	0.990
Wheat	0.999	1.000	0.998	0.946	0.991	1.000	0.996

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,712,922	1,724,749	3,239,931	187,707	2,476,342	1,560,526	11,902,177
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	186.3	257.58	196.18	57.44	183.85	197.55	190.71
Soil salinity(dS/m)	2.65	2.87	2.87	4.23	2.58	3.21	2.87
Water table (m)	3.49	3.42	4.21	6.13	8.76	6.41	5.32
Relative Crop Yields							
Alfalfa	0.935	0.894	0.896	0.772	0.941	0.894	0.912
Beans	0.687	0.731	0.686	0.350	0.574	0.428	0.629
Corn	0.883	0.908	0.888	0.759	0.914	0.808	0.882
Grass	0.990	0.987	0.970	0.971	0.994	0.976	0.984
Melons	0.850	0.890	0.870	0.488	0.879	0.887	0.871
Onion	0.913	0.869	0.861	0.939	0.883	0.873	0.880
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	0.999	1.000	1.000	0.984	0.999	1.000	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,347,703	1,425,073	3,258,526	491,125	1,962,834	1,401,567	10,886,828
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	164.55	211.08	184.75	124.93	147.75	174.91	170.41
Soil salinity(dS/m)	3.68	3.7	3.41	4.21	2.67	3.86	3.45
Water table (m)	3.68	3.63	4.57	6.68	9.25	6.65	5.64
Relative Crop Yields							
Alfalfa	0.858	0.813	0.861	0.804	0.935	0.835	0.864
Beans	0.401	0.599	0.535	0.078	0.673	0.433	0.549
Corn	0.785	0.826	0.841	0.712	0.886	0.721	0.819
Grass	0.975	0.970	0.978	0.956	0.989	0.961	0.974
Melons	0.797	0.857	0.817	0.753	0.846	0.819	0.818
Onion	0.807	0.776	0.786	0.820	0.887	0.868	0.819
Sorghum	0.997	1.000	1.000	0.998	1.000	0.996	0.998
Wheat	0.996	1.000	0.999	0.983	0.997	0.999	0.997

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Summarized Economic Output as a Result of Increasing Ground Water Pumping by 25%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,036,819	1,440,949	3,020,374	191,858	2,091,619	1,348,098	10,129,717
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	145.84	206.83	165.89	53.48	155.92	166.14	157.65
Soil salinity(dS/m)	3.39	3.24	3.42	4.62	3.37	3.54	3.47
Water table (m)	2.81	2.66	2.91	3.75	5.46	4.39	3.63
Relative Crop Yields							
Alfalfa	0.883	0.816	0.844	0.709	0.884	0.869	0.859
Beans	0.495	0.693	0.611	0.000	0.473	0.459	0.529
Corn	0.799	0.822	0.804	0.664	0.815	0.742	0.795
Grass	0.972	0.969	0.970	0.928	0.985	0.959	0.967
Melons	0.780	0.839	0.780	0.701	0.839	0.830	0.804
Onion	0.815	0.900	0.777	0.926	0.837	0.899	0.828
Sorghum	0.999	0.988	0.993	0.976	1.000	0.957	0.985
Wheat	0.997	0.984	0.996	0.912	0.991	1.000	0.991

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,695,396	1,737,568	3,289,484	222,751	2,476,542	1,574,594	11,996,335
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	185.09	259.49	199.18	68.17	183.86	199.33	192.22
Soil salinity(dS/m)	2.55	2.69	2.74	3.76	2.57	3.14	2.76
Water table (m)	3.29	3.08	4.07	5.93	8.7	6.42	5.18
Relative Crop Yields							
Alfalfa	0.926	0.885	0.910	0.830	0.941	0.897	0.914
Beans	0.694	0.735	0.686	0.342	0.573	0.420	0.628
Corn	0.878	0.900	0.892	0.794	0.914	0.815	0.883
Grass	0.992	0.996	0.977	0.977	0.994	0.977	0.987
Melons	0.855	0.906	0.874	0.644	0.878	0.890	0.878
Onion	0.915	0.870	0.873	0.942	0.884	0.886	0.885
Sorghum	0.997	0.991	1.000	1.000	1.000	1.000	0.998
Wheat	0.999	1.000	1.000	1.000	0.999	1.000	1.000

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,320,808	1,374,533	3,345,866	533,997	1,961,986	1,412,752	10,949,943
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	162.67	203.6	189.7	135.84	147.69	176.31	171.4
Soil salinity(dS/m)	3.67	3.79	3.3	3.92	2.67	3.81	3.41
Water table (m)	3.55	3.3	4.46	6.59	9.25	6.6	5.53
Relative Crop Yields							
Alfalfa	0.852	0.785	0.871	0.835	0.934	0.838	0.865
Beans	0.386	0.592	0.535	0.205	0.672	0.439	0.553
Corn	0.774	0.797	0.846	0.735	0.887	0.726	0.817
Grass	0.977	0.973	0.984	0.964	0.989	0.963	0.977
Melons	0.796	0.853	0.826	0.792	0.845	0.821	0.823
Onion	0.819	0.780	0.823	0.830	0.887	0.865	0.836
Sorghum	0.997	0.985	0.999	1.000	1.000	0.996	0.997
Wheat	0.996	1.000	0.999	0.983	0.997	1.000	0.997

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Summarized Economic Output as a Result of Increasing Ground Water Pumping by 50%.

	Canal Area						
1999	1	2	3	4	5	6	Study Area
Profit ($)	2,036,842	1,446,315	3,027,242	192,156	2,090,422	1,349,385	10,142,363
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	145.84	207.6	166.27	53.57	155.83	166.3	157.84
Soil salinity(dS/m)	3.39	3.23	3.41	4.62	3.37	3.54	3.46
Water table (m)	2.82	2.67	2.92	3.75	5.47	4.4	3.64
Relative Crop Yields							
Alfalfa	0.884	0.818	0.844	0.710	0.884	0.869	0.860
Beans	0.495	0.694	0.614	0.000	0.470	0.461	0.530
Corn	0.800	0.823	0.805	0.664	0.814	0.742	0.795
Grass	0.972	0.968	0.969	0.928	0.985	0.959	0.966
Melons	0.779	0.841	0.782	0.701	0.840	0.831	0.805
Onion	0.815	0.900	0.776	0.926	0.837	0.899	0.827
Sorghum	0.999	0.988	0.995	0.977	1.000	0.959	0.985
Wheat	0.997	0.984	0.996	0.912	0.991	1.000	0.992

	Canal Area						
2000	1	2	3	4	5	6	Study Area
Profit ($)	2,695,752	1,741,252	3,292,231	222,909	2,474,116	1,573,716	11,999,976
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	185.12	260.04	199.35	68.22	183.68	199.22	192.28
Soil salinity(dS/m)	2.55	2.68	2.74	3.76	2.57	3.14	2.76
Water table (m)	3.3	3.11	4.1	5.94	8.7	6.46	5.2
Relative Crop Yields							
Alfalfa	0.926	0.886	0.910	0.830	0.941	0.897	0.914
Beans	0.692	0.741	0.684	0.344	0.573	0.421	0.628
Corn	0.879	0.902	0.891	0.794	0.913	0.816	0.884
Grass	0.992	0.995	0.977	0.977	0.994	0.977	0.987
Melons	0.856	0.906	0.876	0.644	0.877	0.889	0.878
Onion	0.910	0.870	0.873	0.942	0.885	0.886	0.884
Sorghum	0.998	0.992	1.000	1.000	1.000	1.000	0.998
Wheat	0.999	1.000	1.000	1.000	0.999	1.000	1.000

	Canal Area						
2001	1	2	3	4	5	6	Study Area
Profit ($)	2,325,874	1,379,467	3,346,332	534,297	1,965,769	1,428,033	10,979,772
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	163.02	204.33	189.73	135.91	147.97	178.22	171.87
Soil salinity(dS/m)	3.66	3.78	3.3	3.92	2.66	3.8	3.4
Water table (m)	3.53	3.33	4.49	6.59	9.25	6.71	5.55
Relative Crop Yields							
Alfalfa	0.853	0.787	0.871	0.835	0.935	0.839	0.866
Beans	0.385	0.599	0.540	0.202	0.688	0.451	0.560
Corn	0.775	0.799	0.847	0.736	0.886	0.727	0.818
Grass	0.977	0.973	0.985	0.964	0.989	0.963	0.977
Melons	0.797	0.853	0.825	0.794	0.845	0.832	0.824
Onion	0.818	0.780	0.819	0.830	0.887	0.867	0.834
Sorghum	0.997	0.987	0.999	1.000	1.000	0.996	0.997
Wheat	0.996	1.000	0.999	0.983	0.997	1.000	0.997

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Summarized Economic Output as a Result of Increasing Ground Water Pumping by 100%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,039,805	1,452,979	3,036,592	192,711	2,090,195	1,349,439	10,161,720
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	146.05	208.56	166.78	53.72	155.81	166.3	158.14
Soil salinity(dS/m)	3.38	3.22	3.41	4.62	3.37	3.54	3.46
Water table (m)	2.83	2.7	2.96	3.76	5.48	4.44	3.66
Relative Crop Yields							
Alfalfa	0.885	0.820	0.846	0.711	0.885	0.869	0.861
Beans	0.496	0.698	0.611	0.000	0.482	0.455	0.531
Corn	0.800	0.824	0.806	0.664	0.815	0.742	0.796
Grass	0.972	0.969	0.970	0.928	0.985	0.959	0.967
Melons	0.779	0.843	0.784	0.701	0.840	0.831	0.806
Onion	0.817	0.901	0.776	0.926	0.833	0.899	0.826
Sorghum	0.999	0.989	0.999	0.979	1.000	0.962	0.987
Wheat	0.997	0.985	0.996	0.912	0.991	1.000	0.992

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,697,285	1,745,435	3,298,184	222,909	2,479,373	1,575,442	12,018,628
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	185.22	260.67	199.71	68.22	184.07	199.44	192.58
Soil salinity(dS/m)	2.55	2.67	2.73	3.76	2.57	3.13	2.75
Water table (m)	3.28	3.15	4.15	5.94	8.76	6.52	5.23
Relative Crop Yields							
Alfalfa	0.927	0.888	0.912	0.830	0.941	0.897	0.915
Beans	0.687	0.739	0.683	0.347	0.574	0.446	0.628
Corn	0.879	0.904	0.892	0.794	0.915	0.815	0.884
Grass	0.992	0.996	0.977	0.977	0.994	0.978	0.987
Melons	0.856	0.906	0.877	0.640	0.878	0.891	0.879
Onion	0.907	0.871	0.872	0.942	0.886	0.871	0.884
Sorghum	0.999	0.993	1.000	1.000	1.000	1.000	0.999
Wheat	0.999	1.000	1.000	1.000	0.999	1.000	1.000

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,335,707	1,383,076	3,357,342	535,215	1,963,901	1,438,122	11,013,363
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	163.71	204.86	190.35	136.15	147.83	179.48	172.39
Soil salinity(dS/m)	3.65	3.76	3.29	3.92	2.67	3.76	3.39
Water table (m)	3.51	3.39	4.56	6.61	9.26	6.71	5.57
Relative Crop Yields							
Alfalfa	0.855	0.790	0.872	0.836	0.935	0.842	0.867
Beans	0.381	0.600	0.540	0.196	0.669	0.492	0.557
Corn	0.775	0.799	0.849	0.737	0.887	0.730	0.819
Grass	0.977	0.976	0.985	0.963	0.989	0.964	0.977
Melons	0.800	0.854	0.828	0.796	0.846	0.833	0.827
Onion	0.818	0.782	0.818	0.830	0.888	0.870	0.834
Sorghum	0.997	0.990	1.000	1.000	1.000	0.996	0.997
Wheat	0.996	1.000	0.999	0.983	0.997	1.000	0.997

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Summarized Economic Output as a Result of Increasing Ground Water Pumping by 200%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,049,546	1,461,198	3,047,900	193,067	2,094,548	1,350,948	10,197,206
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	146.75	209.74	167.4	53.82	156.14	166.49	158.7
Soil salinity(dS/m)	3.36	3.21	3.4	4.62	3.37	3.55	3.45
Water table (m)	2.85	2.74	3.02	3.78	5.49	4.5	3.7
Relative Crop Yields							
Alfalfa	0.887	0.824	0.848	0.712	0.884	0.869	0.862
Beans	0.497	0.702	0.610	0.000	0.483	0.454	0.531
Corn	0.801	0.826	0.806	0.664	0.815	0.742	0.797
Grass	0.973	0.969	0.969	0.928	0.985	0.959	0.967
Melons	0.779	0.845	0.786	0.701	0.841	0.830	0.807
Onion	0.822	0.902	0.777	0.926	0.837	0.903	0.829
Sorghum	0.999	0.990	1.000	0.983	1.000	0.969	0.989
Wheat	0.997	0.986	0.996	0.912	0.991	1.000	0.992

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,704,438	1,758,502	3,302,978	222,270	2,479,360	1,576,724	12,044,271
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	185.72	262.62	200	68.02	184.07	199.6	192.99
Soil salinity(dS/m)	2.55	2.66	2.72	3.77	2.56	3.13	2.75
Water table (m)	3.33	3.23	4.26	5.97	8.72	6.7	5.29
Relative Crop Yields							
Alfalfa	0.928	0.892	0.913	0.828	0.941	0.897	0.915
Beans	0.678	0.752	0.696	0.351	0.573	0.438	0.636
Corn	0.881	0.907	0.894	0.792	0.915	0.817	0.886
Grass	0.992	0.994	0.976	0.977	0.994	0.978	0.987
Melons	0.856	0.907	0.874	0.638	0.879	0.890	0.878
Onion	0.912	0.887	0.872	0.943	0.886	0.888	0.887
Sorghum	1.000	0.997	1.000	1.000	1.000	1.000	1.000
Wheat	0.999	1.000	1.000	1.000	0.999	1.000	1.000

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,343,903	1,407,286	3,341,846	535,336	1,967,037	1,467,363	11,062,771
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	164.28	208.45	189.47	136.18	148.07	183.13	173.17
Soil salinity(dS/m)	3.63	3.73	3.28	3.92	2.66	3.71	3.37
Water table (m)	3.57	3.48	4.69	6.53	9.27	6.91	5.66
Relative Crop Yields							
Alfalfa	0.858	0.794	0.874	0.835	0.934	0.844	0.869
Beans	0.374	0.614	0.536	0.191	0.688	0.410	0.559
Corn	0.774	0.807	0.851	0.735	0.886	0.734	0.821
Grass	0.977	0.976	0.985	0.965	0.990	0.963	0.978
Melons	0.800	0.863	0.820	0.797	0.846	0.847	0.828
Onion	0.821	0.786	0.813	0.831	0.892	0.909	0.838
Sorghum	0.997	0.996	1.000	1.000	1.000	0.997	0.998
Wheat	0.996	1.000	0.999	0.982	0.997	1.000	0.997

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Summarized Economic Output as a Result of Optimally Selecting Crop Locations.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,573,447	1,755,081	3,987,556	353,375	2,591,580	1,777,031	13,038,070
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	184.26	251.92	219.01	98.51	193.19	219	202.91
Soil salinity(dS/m)	3.39	3.23	3.42	4.62	3.37	3.54	3.47
Water table (m)	2.8	2.65	2.89	3.75	5.46	4.38	3.62
Relative Crop Yields							
Alfalfa	0.914	0.871	0.875	0.854	0.888	0.896	0.891
Beans	0.838	0.849	0.807	0.728	0.895	0.866	0.837
Corn	0.922	0.893	0.889	0.803	0.896	0.943	0.897
Grass	0.969	0.982	0.928	0.889	0.978	0.947	0.951
Melons	0.959	0.963	0.949	0.915	0.987	0.960	0.959
Onion	0.938	0.946	0.928	0.890	0.962	0.946	0.943
Sorghum	0.971	0.963	0.975	0.999	0.994	0.978	0.979
Wheat	0.994	0.961	0.976	0.787	1.000	0.982	0.977

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	3,208,324	1,970,505	3,964,596	353,744	2,948,514	1,896,229	14,341,911
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	220.32	294.28	240.06	108.26	218.9	240.04	229.8
Soil salinity(dS/m)	2.55	2.7	2.73	3.74	2.57	3.15	2.76
Water table (m)	3.25	3.06	4.04	5.99	8.76	6.41	5.17
Relative Crop Yields							
Alfalfa	0.966	0.925	0.932	0.923	0.959	0.925	0.946
Beans	1.000	0.888	0.923	0.949	0.984	0.955	0.936
Corn	0.996	0.942	0.957	0.927	0.980	0.967	0.967
Grass	0.999	1.000	1.000	0.980	1.000	0.976	0.995
Melons	1.000	0.987	0.997	1.000	1.000	1.000	0.997
Onion	0.996	0.960	0.971	0.987	1.000	0.997	0.985
Sorghum	0.995	0.996	0.960	0.977	0.989	0.983	0.985
Wheat	0.995	1.000	1.000	0.993	1.000	0.987	0.998

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,909,116	1,677,162	4,287,868	738,926	2,364,495	1,866,819	13,844,386
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	203.9	248.42	243.11	187.96	177.99	232.98	216.71
Soil salinity(dS/m)	3.68	3.79	3.3	3.88	2.66	3.83	3.41
Water table (m)	3.51	3.29	4.43	6.59	9.24	6.55	5.5
Relative Crop Yields							
Alfalfa	0.885	0.842	0.893	0.908	0.958	0.862	0.896
Beans	0.948	0.810	0.895	1.000	1.000	0.989	0.908
Corn	0.929	0.846	0.924	0.975	0.994	0.922	0.933
Grass	0.957	0.967	0.978	0.938	1.000	0.925	0.965
Melons	0.999	0.975	0.998	1.000	1.000	1.000	0.995
Onion	0.983	0.929	0.978	1.000	1.000	0.998	0.980
Sorghum	0.974	0.996	0.982	0.995	0.987	0.984	0.984
Wheat	0.998	1.000	0.997	0.955	1.000	0.978	0.994

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Summarized Economic Output as a Result of Lining all Canals and Reducing Aquifer Recharge Rates by 50%.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,293,237	1,598,298	3,379,927	285,761	2,132,866	1,387,209	11,077,298
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	164.2	229.42	185.64	79.66	159	170.96	172.39
Soil salinity(dS/m)	2.98	2.87	3.15	4.29	3.28	3.54	3.22
Water table (m)	3.73	3.11	3.65	4.97	6.54	4.81	4.43
Relative Crop Yields							
Alfalfa	0.936	0.881	0.887	0.769	0.895	0.886	0.898
Beans	0.540	0.772	0.688	0.086	0.459	0.336	0.557
Corn	0.839	0.871	0.843	0.735	0.823	0.756	0.828
Grass	0.972	0.977	0.971	0.970	0.984	0.957	0.973
Melons	0.836	0.867	0.819	0.837	0.849	0.842	0.839
Onion	0.834	0.920	0.809	0.872	0.836	0.913	0.844
Sorghum	1.000	0.994	1.000	1.000	1.000	0.991	0.997
Wheat	0.999	0.995	0.999	0.998	0.994	1.000	0.998

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,988,042	1,905,938	3,554,866	251,789	2,627,919	1,680,355	13,008,910
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	205.19	284.64	215.25	77.06	195.1	212.72	208.44
Soil salinity(dS/m)	1.84	2.16	2.31	3.46	2.14	2.83	2.27
Water table (m)	4.98	4.13	6.05	8.34	10.74	6.85	6.83
Relative Crop Yields							
Alfalfa	0.977	0.949	0.940	0.830	0.967	0.911	0.950
Beans	0.841	0.814	0.812	0.559	0.596	0.601	0.738
Corn	0.950	0.959	0.929	0.873	0.942	0.837	0.926
Grass	0.991	0.991	0.979	0.976	0.993	0.978	0.987
Melons	0.901	0.935	0.895	0.589	0.903	0.948	0.911
Onion	0.932	0.926	0.896	0.835	0.924	0.789	0.911
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	1.000	1.000	1.000	0.995	0.999	1.000	1.000

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,893,072	1,738,129	3,922,435	609,693	2,250,587	1,692,911	13,106,827
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	202.78	257.45	222.39	155.09	169.41	211.27	205.16
Soil salinity(dS/m)	2.32	2.51	2.42	2.86	1.71	3.04	2.37
Water table (m)	5.48	4.7	6.96	8.87	11.31	7.04	7.42
Relative Crop Yields							
Alfalfa	0.952	0.911	0.934	0.882	0.980	0.889	0.938
Beans	0.703	0.749	0.677	0.458	0.790	0.725	0.700
Corn	0.918	0.937	0.918	0.888	0.951	0.805	0.911
Grass	0.989	0.989	0.993	0.984	0.995	0.973	0.988
Melons	0.887	0.933	0.897	0.783	0.955	0.924	0.904
Onion	0.889	0.874	0.861	0.790	0.959	0.950	0.895
Sorghum	0.997	1.000	1.000	1.000	1.000	1.000	0.999
Wheat	0.998	1.000	1.000	1.000	0.999	1.000	0.999

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Summarized Economic Output as a Result of Lining all Canals and Drainage Spaced at 50 meters.

	Canal Area						
1999	1	2	3	4	5	6	Study Area
Profit ($)	2,299,874	1,618,036	3,351,470	290,694	2,105,686	1,356,793	11,022,553
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	164.68	232.25	184.08	81.03	156.97	167.21	171.54
Soil salinity(dS/m)	2.98	2.89	3.24	4.36	3.34	3.65	3.28
Water table (m)	3.63	3.32	3.46	4.75	5.98	4.67	4.23
Relative Crop Yields							
Alfalfa	0.936	0.907	0.877	0.764	0.888	0.880	0.896
Beans	0.517	0.721	0.668	0.305	0.478	0.328	0.556
Corn	0.842	0.879	0.840	0.730	0.820	0.747	0.826
Grass	0.973	0.976	0.971	0.968	0.987	0.953	0.973
Melons	0.833	0.867	0.816	0.840	0.840	0.833	0.835
Onion	0.854	0.905	0.820	0.930	0.833	0.900	0.847
Sorghum	1.000	0.994	1.000	1.000	1.000	0.991	0.997
Wheat	0.999	1.000	0.999	0.990	0.996	0.999	0.998

	Canal Area						
2000	1	2	3	4	5	6	Study Area
Profit ($)	2,868,473	1,772,843	3,301,675	205,924	2,528,055	1,511,722	12,188,692
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	196.98	264.76	199.92	63.02	187.69	191.37	195.3
Soil salinity(dS/m)	2.27	2.63	2.78	4.25	2.41	3.44	2.73
Water table (m)	4.77	3.89	5.25	7.47	9.93	6.64	6.29
Relative Crop Yields							
Alfalfa	0.961	0.917	0.906	0.767	0.954	0.873	0.924
Beans	0.756	0.756	0.725	0.477	0.573	0.431	0.667
Corn	0.921	0.920	0.895	0.791	0.927	0.794	0.895
Grass	0.987	0.992	0.971	0.965	0.996	0.967	0.983
Melons	0.881	0.901	0.870	0.534	0.879	0.885	0.879
Onion	0.907	0.871	0.877	0.944	0.897	0.785	0.885
Sorghum	1.000	1.000	1.000	1.000	1.000	0.998	1.000
Wheat	0.999	1.000	1.000	0.982	0.999	0.998	0.999

	Canal Area						
2001	1	2	3	4	5	6	Study Area
Profit ($)	2,479,276	1,518,716	3,327,121	518,127	2,130,386	1,386,365	11,359,992
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	173.77	224.95	188.64	131.8	160.36	173.02	177.82
Soil salinity(dS/m)	3.23	3.27	3.27	3.99	2.23	3.98	3.18
Water table (m)	5.1	4.26	5.9	7.95	10.53	6.77	6.75
Relative Crop Yields							
Alfalfa	0.891	0.859	0.874	0.827	0.957	0.818	0.884
Beans	0.536	0.622	0.524	0.290	0.796	0.460	0.578
Corn	0.832	0.859	0.845	0.786	0.922	0.719	0.843
Grass	0.981	0.977	0.981	0.953	0.995	0.957	0.977
Melons	0.798	0.877	0.830	0.725	0.902	0.823	0.829
Onion	0.790	0.787	0.794	0.808	0.931	0.871	0.831
Sorghum	0.999	1.000	1.000	0.965	1.000	0.994	0.997
Wheat	0.997	1.000	0.999	0.978	0.999	0.998	0.997

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 50% and Drainage Spaced at 50 m.

1999	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,317,803	1,655,483	3,405,601	280,041	2,128,912	1,362,551	11,150,391
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	165.96	237.63	187.05	78.06	158.7	167.92	173.53
Soil salinity(dS/m)	2.95	2.74	3.15	4.33	3.3	3.59	3.21
Water table (m)	3.45	3.51	3.59	4.45	6.03	4.72	4.25
Relative Crop Yields							
Alfalfa	0.938	0.916	0.888	0.760	0.894	0.881	0.901
Beans	0.530	0.762	0.680	0.015	0.462	0.291	0.542
Corn	0.844	0.894	0.846	0.730	0.823	0.752	0.832
Grass	0.975	0.976	0.972	0.970	0.982	0.951	0.972
Melons	0.836	0.872	0.821	0.844	0.850	0.833	0.839
Onion	0.864	0.919	0.820	0.893	0.835	0.914	0.852
Sorghum	1.000	0.994	1.000	1.000	1.000	0.988	0.996
Wheat	0.999	1.000	0.999	0.980	0.993	0.999	0.997

2000	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,988,290	1,892,783	3,562,775	219,518	2,597,175	1,660,901	12,921,441
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	205.21	282.67	215.73	67.18	192.82	210.25	207.04
Soil salinity(dS/m)	1.9	2.15	2.33	3.86	2.27	2.93	2.36
Water table (m)	3.96	3.94	4.98	6.77	9.45	6.76	5.91
Relative Crop Yields							
Alfalfa	0.976	0.942	0.936	0.792	0.965	0.904	0.945
Beans	0.857	0.815	0.809	0.504	0.613	0.613	0.735
Corn	0.947	0.955	0.932	0.818	0.934	0.827	0.922
Grass	0.992	0.990	0.978	0.968	0.993	0.971	0.985
Melons	0.900	0.932	0.899	0.537	0.897	0.938	0.909
Onion	0.952	0.925	0.899	0.857	0.911	0.894	0.916
Sorghum	1.000	1.000	1.000	1.000	1.000	0.998	0.999
Wheat	1.000	1.000	1.000	0.987	0.999	0.998	0.999

2001	Canal Area 1	2	3	4	5	6	Study Area
Profit ($)	2,862,324	1,726,645	3,865,674	566,633	2,142,602	1,682,502	12,846,380
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	200.62	255.75	219.17	144.14	161.28	209.97	201.09
Soil salinity(dS/m)	2.49	2.55	2.54	3.4	2.1	3.12	2.56
Water table (m)	4.12	4.19	5.36	7.31	9.86	6.93	6.21
Relative Crop Yields							
Alfalfa	0.943	0.912	0.924	0.847	0.970	0.880	0.928
Beans	0.706	0.745	0.675	0.026	0.730	0.737	0.671
Corn	0.917	0.933	0.917	0.847	0.930	0.806	0.904
Grass	0.988	0.987	0.985	0.970	0.990	0.972	0.983
Melons	0.880	0.927	0.890	0.803	0.898	0.925	0.896
Onion	0.908	0.871	0.847	0.778	0.923	0.942	0.882
Sorghum	1.000	1.000	1.000	1.000	1.000	0.996	0.999
Wheat	0.999	1.000	1.000	0.992	0.998	0.998	0.999

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Summarized Economic Output as a Result of Reducing Aquifer Recharge Rates by 50%, Lining all Canals, and Drainage Spaced at 50 m.

	Canal Area						
1999	1	2	3	4	5	6	Study Area
Profit ($)	2,337,942	1,656,694	3,408,116	292,392	2,134,688	1,375,032	11,204,864
Acres planted	13,966	6,967	18,207	3,587	13,415	8,114	64,256
Profit/acre ($/Ac)	167.4	237.8	187.19	81.51	159.13	169.46	174.38
Soil salinity(dS/m)	2.88	2.73	3.12	4.25	3.28	3.59	3.18
Water table (m)	3.97	3.59	3.88	5.19	6.58	4.92	4.64
Relative Crop Yields							
Alfalfa	0.945	0.917	0.892	0.776	0.895	0.886	0.906
Beans	0.543	0.765	0.681	0.091	0.464	0.296	0.549
Corn	0.849	0.894	0.849	0.741	0.824	0.753	0.835
Grass	0.974	0.977	0.973	0.970	0.984	0.951	0.973
Melons	0.836	0.872	0.818	0.846	0.849	0.838	0.839
Onion	0.857	0.920	0.810	0.873	0.837	0.914	0.848
Sorghum	1.000	0.994	1.000	1.000	1.000	0.988	0.996
Wheat	0.999	1.000	0.999	0.998	0.994	0.999	0.998

	Canal Area						
2000	1	2	3	4	5	6	Study Area
Profit ($)	3,009,422	1,903,513	3,571,902	250,452	2,632,746	1,663,781	13,031,817
Acres planted	14,562	6,696	16,515	3,268	13,470	7,900	62,410
Profit/acre ($/Ac)	206.66	284.28	216.28	76.65	195.46	210.62	208.81
Soil salinity(dS/m)	1.74	2.07	2.28	3.51	2.12	2.92	2.24
Water table (m)	5.19	4.39	6.16	8.32	10.73	6.96	6.94
Relative Crop Yields							
Alfalfa	0.982	0.945	0.943	0.825	0.968	0.905	0.950
Beans	0.882	0.830	0.807	0.577	0.606	0.631	0.741
Corn	0.951	0.956	0.930	0.871	0.942	0.832	0.926
Grass	0.991	0.992	0.982	0.974	0.994	0.974	0.987
Melons	0.907	0.936	0.898	0.584	0.902	0.944	0.913
Onion	0.931	0.927	0.904	0.836	0.925	0.789	0.914
Sorghum	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Wheat	1.000	1.000	1.000	0.990	0.999	0.999	0.999

	Canal Area						
2001	1	2	3	4	5	6	Study Area
Profit ($)	2,908,756	1,764,608	3,930,871	608,848	2,250,999	1,687,143	13,151,225
Acres planted	14,267	6,751	17,637	3,931	13,285	8,013	63,885
Profit/acre ($/Ac)	203.88	261.38	222.87	154.88	169.44	210.55	205.86
Soil salinity(dS/m)	2.24	2.33	2.4	2.84	1.72	3.07	2.33
Water table (m)	5.66	4.9	7	8.92	11.3	7.14	7.51
Relative Crop Yields							
Alfalfa	0.956	0.924	0.936	0.886	0.980	0.883	0.940
Beans	0.761	0.734	0.663	0.462	0.798	0.748	0.692
Corn	0.925	0.945	0.922	0.890	0.951	0.805	0.914
Grass	0.990	0.990	0.995	0.982	0.995	0.972	0.989
Melons	0.886	0.943	0.899	0.778	0.954	0.925	0.906
Onion	0.888	0.876	0.861	0.767	0.959	0.947	0.895
Sorghum	0.998	1.000	1.000	1.000	1.000	0.999	0.999
Wheat	0.998	1.000	1.000	1.000	0.999	1.000	1.000

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APPENDIX 4.5

SUMMARY OF ECONOMIC RESULTS FOR EACH ALTERNATIVE UNDER EACH PARAMETER CHANGE (SENSITIVITY ANALYSIS SUMMARY)

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Summaried results for each alternative under a 20% increase in potential crop yields.

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$415,485	-$2,320,275	0.152	85%	$12.62
Line Canal 1	$207,292	-$347,438	0.374	63%	$10.87
Line Canal 2	-$4,637	-$174,117	-0.027	103%	-
Line Canal 3	$26,545	-$358,599	0.069	93%	-
Line Canal 4	$60,306	-$286,874	0.174	83%	-
Line Canal 5	$66,529	-$469,024	0.124	88%	-
Line Canal 6	$351	-$743,320	0.000	100%	-
Line 20% All Canals	$102,669	-$444,483	0.188	81%	$8.58
Recharge Reduction					
10%	-	-	-	-	-
20%	$918,647	-$347,879	0.725	27%	$5.10
30%					
40%	-	-	-	-	-
50%	$1,316,830	-$334,609	0.797	20%	$2.46
60%	-	-	-	-	-
70%	$1,153,068	-$3,597,995	0.243	76%	$17.34
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$393,563	-$632,938	0.383	62%	-
75 m	$310,640	-$373,693	0.454	55%	-
100 m	$236,098	-$277,152	0.460	54%	-
150 m	$145,087	-$197,080	0.424	58%	-
Pumping Increase					
25%	$1,343	-$137,618	0.010	99%	-
50%	$19,790	-$258,131	0.071	93%	-
100%	$48,430	-$507,413	0.087	91%	-
200%	$92,645	-$1,019,041	0.083	92%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,538,231	-$2,848,967	0.351	65%	$9.23
Line all canals & drainage spaced 50m	$599,441	-$3,162,820	0.159	84%	$37.48
Reduce recharge 50% & drainage spaced 50m	$1,538,231	-$1,139,709	0.574	43%	$43.06
Reduce rech. 50%, line all canals & drainage (50m)	$1,726,108	-$3,687,591	0.319	68%	$13.40

**Shaded cells indicate highest ranking alternative within each criteria column.*

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Summaried results for each alternative under a 20% decrease in potential crop yields.

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$276,990	-$2,458,770	0.101	90%	$13.37
Line Canal 1	$138,195	-$416,536	0.249	75%	$13.03
Line Canal 2	-$3,091	-$172,572	-0.018	102%	-
Line Canal 3	$17,697	-$367,447	0.046	95%	-
Line Canal 4	$40,204	-$306,976	0.116	88%	-
Line Canal 5	$44,352	-$491,201	0.083	92%	-
Line Canal 6	$234	-$743,437	0.000	100%	-
Line 20% All Canals	$68,446	-$478,706	0.125	87%	$9.24
Recharge Reduction					
10%	-	-	-	-	-
20%	$612,431	-$654,095	0.484	52%	$9.59
30%					
40%	-	-	-	-	-
50%	$877,887	-$773,552	0.532	47%	$5.68
60%	-	-	-	-	-
70%	$768,712	-$3,982,350	0.162	84%	$19.19
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$262,376	-$764,125	0.256	74%	-
75 m	$207,093	-$477,240	0.303	70%	-
100 m	$157,399	-$355,851	0.307	69%	-
150 m	$96,725	-$245,442	0.283	72%	-
Pumping Increase					
25%	$896	-$138,065	0.006	99%	-
50%	$13,193	-$264,728	0.047	95%	-
100%	$32,287	-$523,556	0.058	94%	-
200%	$61,764	-$1,049,922	0.056	94%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,025,487	-$3,361,711	0.234	77%	$10.90
Line all canals & drainage spaced 50m	$399,627	-$3,362,633	0.106	89%	$39.84
Reduce recharge 50% & drainage spaced 50m	$1,025,487	-$1,652,452	0.383	62%	$62.43
Reduce rech. 50%, line all canals & drainage (50m)	$1,150,739	-$4,262,960	0.213	79%	$15.49

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summaried results for each alternative under a 20% increase in crop prices.

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$432,499	-$2,303,260	0.158	84%	$12.53
Line Canal 1	$217,037	-$337,694	0.391	61%	$10.56
Line Canal 2	-$6,299	-$175,779	-0.037	104%	-
Line Canal 3	$28,069	-$357,076	0.073	93%	-
Line Canal 4	$63,817	-$283,363	0.184	82%	-
Line Canal 5	$68,914	-$466,639	0.129	87%	-
Line Canal 6	-$349	-$744,021	0.000	100%	-
Line 20% All Canals	$108,235	-$438,917	0.198	80%	$8.47
Recharge Reduction					
10%	-	-	-	-	-
20%	$960,331	-$306,195	0.758	24%	$4.49
30%					
40%	-	-	-	-	-
50%	$1,377,232	-$274,207	0.834	17%	$2.01
60%	-	-	-	-	-
70%	$1,205,244	-$3,545,818	0.254	75%	$17.09
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$408,596	-$617,905	0.398	60%	-
75 m	$320,398	-$363,935	0.468	53%	-
100 m	$242,005	-$271,245	0.472	53%	-
150 m	$146,760	-$195,407	0.429	57%	-
Pumping Increase					
25%	$1,405	-$137,556	0.010	99%	-
50%	$19,825	-$258,096	0.071	93%	-
100%	$48,993	-$506,850	0.088	91%	-
200%	$97,214	-$1,014,472	0.087	91%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,724,802	-$2,662,396	0.393	61%	$8.63
Line all canals & drainage spaced 50m	$624,596	-$3,137,665	0.166	83%	$37.18
Reduce recharge 50% & drainage spaced 50m	$1,611,705	-$1,066,234	0.602	40%	$40.28
Reduce rech. 50%, line all canals & drainage (50m)	$1,807,235	-$3,606,464	0.334	67%	$13.11

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summaried results for each alternative under a 20% decrease in crop prices.

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$259,975	-$2,475,784	0.095	90%	$13.47
Line Canal 1	$128,450	-$426,280	0.232	77%	$13.33
Line Canal 2	-$1,430	-$170,910	-0.008	101%	-
Line Canal 3	$16,173	-$368,971	0.042	96%	-
Line Canal 4	$36,692	-$310,488	0.106	89%	-
Line Canal 5	$41,967	-$493,585	0.078	92%	-
Line Canal 6	$935	-$742,737	0.001	100%	-
Line 20% All Canals	$62,879	-$484,272	0.115	89%	$9.35
Recharge Reduction					
10%	-	-	-	-	-
20%	$570,747	-$695,779	0.451	55%	$10.21
30%					
40%	-	-	-	-	-
50%	$817,486	-$833,953	0.495	50%	$6.12
60%	-	-	-	-	-
70%	$716,535	-$4,034,527	0.151	85%	$19.44
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$247,343	-$779,158	0.241	76%	-
75 m	$197,335	-$486,998	0.288	71%	-
100 m	$151,491	-$361,759	0.295	70%	-
150 m	$95,053	-$247,114	0.278	72%	-
Pumping Increase					
25%	$834	-$138,127	0.006	99%	-
50%	$13,159	-$264,762	0.047	95%	-
100%	$31,724	-$524,119	0.057	94%	-
200%	$57,195	-$1,054,491	0.051	95%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,022,131	-$3,365,067	0.233	77%	$10.91
Line all canals & drainage spaced 50m	$374,472	-$3,387,788	0.100	90%	$40.14
Reduce recharge 50% & drainage spaced 50m	$952,013	-$1,725,926	0.356	64%	$65.21
Reduce rech. 50%, line all canals & drainage (50m)	$1,069,612	-$4,344,087	0.198	80%	$15.79

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summarized results for each alternative under a 20% increase in the waterlogging threshold parameters for each crop (makes crops more sensitive to waterlogging).

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$455,559	-$2,280,201	0.167	83%	$12.40
Line Canal 1	$234,809	-$319,921	0.423	58%	$10.01
Line Canal 2	$1,659	-$167,822	0.010	99%	-
Line Canal 3	$39,096	-$346,048	0.102	90%	-
Line Canal 4	$68,330	-$278,851	0.197	80%	-
Line Canal 5	$63,573	-$471,980	0.119	88%	-
Line Canal 6	$8,124	-$735,548	0.011	99%	-
Line 20% All Canals	$116,277	-$430,875	0.213	79%	$8.32
Recharge Reduction					
10%	-	-	-	-	-
20%	$814,434	-$452,092	0.643	36%	$6.63
30%					
40%	-	-	-	-	-
50%	$1,184,142	-$467,297	0.717	28%	$3.43
60%	-	-	-	-	-
70%	$1,080,175	-$3,670,887	0.227	77%	$17.69
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$484,804	-$541,697	0.472	53%	-
75 m	$406,788	-$277,545	0.594	41%	-
100 m	$337,336	-$175,914	0.657	34%	-
150 m	$247,702	-$142,446	0.712	29%	-
Pumping Increase					
25%	$4,103	-$134,858	0.030	97%	-
50%	$21,694	-$256,227	0.078	92%	-
100%	$49,312	-$506,531	0.089	91%	-
200%	$93,900	-$1,017,786	0.084	92%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,452,126	-$2,935,072	0.331	67%	$9.51
Line all canals & drainage spaced 50m	$671,327	-$3,090,934	0.178	82%	$36.62
Reduce recharge 50% & drainage spaced 50m	$1,452,126	-$1,225,814	0.542	46%	$46.31
Reduce rech. 50%, line all canals & drainage (50m)	$1,619,064	-$3,794,635	0.299	70%	$13.79

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summarized results for each alternative under a 20% decrease in the waterlogging threshold parameters for each crop (makes crops less sensitive to waterlogging).

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$271,109	-$2,464,651	0.099	90%	$13.41
Line Canal 1	$129,840	-$424,891	0.234	77%	$13.29
Line Canal 2	-$9,174	-$178,654	-0.054	105%	-
Line Canal 3	$14,426	-$370,718	0.037	96%	-
Line Canal 4	$37,765	-$309,415	0.109	89%	-
Line Canal 5	$51,297	-$484,256	0.096	90%	-
Line Canal 6	-$6,254	-$749,926	-0.008	101%	-
Line 20% All Canals	$67,702	-$479,450	0.124	88%	$9.25
Recharge Reduction					
10%	-	-	-	-	-
20%	$732,900	-$533,626	0.579	42%	$7.83
30%					
40%	-	-	-	-	-
50%	$1,036,534	-$614,905	0.628	37%	$4.51
60%	-	-	-	-	-
70%	$882,745	-$3,868,317	0.186	81%	$18.64
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$228,964	-$797,537	0.223	78%	-
75 m	$165,705	-$518,628	0.242	76%	-
100 m	$107,179	-$406,071	0.209	79%	-
150 m	$40,400	-$301,767	0.118	88%	-
Pumping Increase					
25%	-$655	-$139,616	-0.005	100%	-
50%	$13,019	-$264,902	0.047	95%	-
100%	$32,458	-$523,385	0.058	94%	-
200%	$61,699	-$1,049,987	0.056	94%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,174,468	-$3,212,730	0.268	73%	$10.41
Line all canals & drainage spaced 50m	$391,851	-$3,370,409	0.104	90%	$39.94
Reduce recharge 50% & drainage spaced 50m	$1,174,468	-$1,503,472	0.439	56%	$56.80
Reduce rech. 50%, line all canals & drainage (50m)	$1,325,175	-$4,088,524	0.245	76%	$14.86

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summarized results for each alternative under a 20% increase in the waterlogging slope response parameter for each crop (makes crops more sensitive to waterlogging).

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$375,433	-$2,360,326	0.137	86%	$12.84
Line Canal 1	$188,404	-$366,326	0.340	66%	$11.46
Line Canal 2	-$5,965	-$175,446	-0.035	104%	-
Line Canal 3	$21,311	-$363,833	0.055	94%	-
Line Canal 4	$51,329	-$295,851	0.148	85%	-
Line Canal 5	$53,753	-$481,800	0.100	90%	-
Line Canal 6	$80	-$743,591	0.000	100%	-
Line 20% All Canals	$88,426	-$458,726	0.162	84%	$8.85
Recharge Reduction					
10%	-	-	-	-	-
20%	$780,124	-$486,402	0.616	38%	$7.13
30%					
40%	-	-	-	-	-
50%	$1,122,671	-$528,768	0.680	32%	$3.88
60%	-	-	-	-	-
70%	$992,550	-$3,758,512	0.209	79%	$18.11
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$365,984	-$660,517	0.357	64%	-
75 m	$294,622	-$389,711	0.431	57%	-
100 m	$230,722	-$282,528	0.450	55%	-
150 m	$151,243	-$190,924	0.442	56%	-
Pumping Increase					
25%	$1,911	-$137,050	0.014	99%	-
50%	$17,950	-$259,971	0.065	94%	-
100%	$43,278	-$512,565	0.078	92%	-
200%	$82,545	-$1,029,141	0.074	93%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,323,153	-$3,064,045	0.302	70%	$9.93
Line all canals & drainage spaced 50m	$540,744	-$3,221,516	0.144	86%	$38.17
Reduce recharge 50% & drainage spaced 50m	$1,323,153	-$1,354,786	0.494	51%	$51.19
Reduce rech. 50%, line all canals & drainage (50m)	$1,481,040	-$3,932,659	0.274	73%	$14.29

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summarized results for each alternative under a 20% decrease in the waterlogging slope response parameter for each crop (makes crops less sensitive to waterlogging).

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$316,854	-$2,418,905	0.116	88%	$13.16
Line Canal 1	$157,083	-$397,647	0.283	72%	$12.44
Line Canal 2	-$1,762	-$171,242	-0.010	101%	-
Line Canal 3	$22,896	-$362,248	0.059	94%	-
Line Canal 4	$48,994	-$298,186	0.141	86%	-
Line Canal 5	$57,129	-$478,424	0.107	89%	-
Line Canal 6	$506	-$743,165	0.001	100%	-
Line 20% All Canals	$82,502	-$464,650	0.151	85%	$8.97
Recharge Reduction					
10%	-	-	-	-	-
20%	$750,766	-$515,760	0.593	41%	$7.56
30%					
40%	-	-	-	-	-
50%	$1,071,859	-$579,580	0.649	35%	$4.25
60%	-	-	-	-	-
70%	$929,042	-$3,822,020	0.196	80%	$18.42
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$289,767	-$736,734	0.282	72%	-
75 m	$222,925	-$461,408	0.326	67%	-
100 m	$162,587	-$350,663	0.317	68%	-
150 m	$90,382	-$251,785	0.264	74%	-
Pumping Increase					
25%	$328	-$138,633	0.002	100%	-
50%	$15,033	-$262,888	0.054	95%	-
100%	$37,439	-$518,404	0.067	93%	-
200%	$71,865	-$1,039,821	0.065	94%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,240,378	-$3,146,820	0.283	72%	$10.20
Line all canals & drainage spaced 50m	$458,137	-$3,304,124	0.122	88%	$39.15
Reduce recharge 50% & drainage spaced 50m	$1,240,378	-$1,437,562	0.463	54%	$54.31
Reduce rech. 50%, line all canals & drainage (50m)	$1,395,620	-$4,018,079	0.258	74%	$14.60

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summarized results for each alternative under a 20% increase in the soil salinity threshold parameter for each crop (makes crops less sensitive to soil salinity).

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$328,576	-$2,407,184	0.120	88%	$13.09
Line Canal 1	$166,289	-$388,442	0.300	70%	$12.15
Line Canal 2	-$6,833	-$176,314	-0.040	104%	-
Line Canal 3	$17,947	-$367,197	0.047	95%	-
Line Canal 4	$48,179	-$299,001	0.139	86%	-
Line Canal 5	$44,154	-$491,399	0.082	92%	-
Line Canal 6	-$413	-$744,085	-0.001	100%	-
Line 20% All Canals	$83,920	-$463,232	0.153	85%	$8.94
Recharge Reduction					
10%	-	-	-	-	-
20%	$705,507	-$561,019	0.557	44%	$8.23
30%					
40%	-	-	-	-	-
50%	$1,004,625	-$646,814	0.608	39%	$4.75
60%	-	-	-	-	-
70%	$881,603	-$3,869,459	0.186	81%	$18.64
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$324,405	-$702,096	0.316	68%	-
75 m	$260,482	-$423,851	0.381	62%	-
100 m	$203,234	-$310,016	0.396	60%	-
150 m	$129,845	-$212,322	0.379	62%	-
Pumping Increase					
25%	$1,512	-$137,449	0.011	99%	-
50%	$15,498	-$262,423	0.056	94%	-
100%	$38,501	-$517,342	0.069	93%	-
200%	$73,486	-$1,038,200	0.066	93%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,168,047	-$3,219,151	0.266	73%	$10.43
Line all canals & drainage spaced 50m	$472,252	-$3,290,009	0.126	87%	$38.98
Reduce recharge 50% & drainage spaced 50m	$1,168,047	-$1,509,893	0.436	56%	$57.05
Reduce rech. 50%, line all canals & drainage (50m)	$1,299,884	-$4,113,815	0.240	76%	$14.95

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Summarized results for each alternative under a 20% decrease in the soil salinity threshold parameter for each crop (makes crops more sensitive to soil salinity).

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$358,523	-$2,377,236	0.131	87%	$12.93
Line Canal 1	$174,439	-$380,291	0.314	69%	$11.90
Line Canal 2	-$3,139	-$172,620	-0.019	102%	-
Line Canal 3	$22,668	-$362,476	0.059	94%	-
Line Canal 4	$49,423	-$297,757	0.142	86%	-
Line Canal 5	$61,689	-$473,864	0.115	88%	-
Line Canal 6	-$2,119	-$745,791	-0.003	100%	-
Line 20% All Canals	$83,841	-$463,311	0.153	85%	$8.94
Recharge Reduction					
10%	-	-	-	-	-
20%	$808,732	-$457,794	0.639	36%	$6.71
30%					
40%	-	-	-	-	-
50%	$1,166,830	-$484,609	0.707	29%	$3.56
60%	-	-	-	-	-
70%	$1,017,917	-$3,733,145	0.214	79%	$17.99
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$324,033	-$702,468	0.316	68%	-
75 m	$252,649	-$431,684	0.369	63%	-
100 m	$186,944	-$326,306	0.364	64%	-
150 m	$111,351	-$230,816	0.325	67%	-
Pumping Increase					
25%	$255	-$138,706	0.002	100%	-
50%	$16,169	-$261,752	0.058	94%	-
100%	$40,613	-$515,230	0.073	93%	-
200%	$77,812	-$1,033,874	0.070	93%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,364,752	-$3,022,446	0.311	69%	$9.80
Line all canals & drainage spaced 50m	$513,298	-$3,248,962	0.136	86%	$38.50
Reduce recharge 50% & drainage spaced 50m	$1,364,752	-$1,313,188	0.510	49%	$49.61
Reduce rech. 50%, line all canals & drainage (50m)	$1,548,684	-$3,865,015	0.286	71%	$14.05

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summarized results for each alternative under a 20% increase in the soil salinity slope response parameter for each crop (makes crops more sensitive to soil salinity).

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$375,545	-$2,360,214	0.137	86%	$12.84
Line Canal 1	$192,096	-$362,634	0.346	65%	$11.34
Line Canal 2	$859	-$168,622	0.005	99%	-
Line Canal 3	$29,371	-$355,773	0.076	92%	-
Line Canal 4	$58,121	-$289,059	0.167	83%	-
Line Canal 5	$70,438	-$465,115	0.132	87%	-
Line Canal 6	$2,684	-$740,987	0.004	100%	-
Line 20% All Canals	$97,069	-$450,083	0.177	82%	$8.69
Recharge Reduction					
10%	-	-	-	-	-
20%	$898,787	-$367,739	0.710	29%	$5.39
30%					
40%	-	-	-	-	-
50%	$1,285,320	-$366,119	0.778	22%	$2.69
60%	-	-	-	-	-
70%	$1,115,714	-$3,635,348	0.235	77%	$17.52
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$344,567	-$681,934	0.336	66%	-
75 m	$265,459	-$418,874	0.388	61%	-
100 m	$194,163	-$319,087	0.378	62%	-
150 m	$108,300	-$233,867	0.317	68%	-
Pumping Increase					
25%	$365	-$138,596	0.003	100%	-
50%	$17,880	-$260,041	0.064	94%	-
100%	$44,770	-$511,073	0.081	92%	-
200%	$85,972	-$1,025,714	0.077	92%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,486,621	-$2,900,577	0.339	66%	$9.40
Line all canals & drainage spaced 50m	$544,118	-$3,218,142	0.145	86%	$38.13
Reduce recharge 50% & drainage spaced 50m	$1,486,621	-$1,191,319	0.555	44%	$45.01
Reduce rech. 50%, line all canals & drainage (50m)	$1,668,029	-$3,745,670	0.308	69%	$13.61

*Shaded cells indicate highest ranking alternative within each criteria column.

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Summarized results for each alternative under a 20% decrease in the soil salinity slope response parameter for each crop (makes crops less sensitive to soil salinity).

Alternative	Benefits to Productivity	Change in Avg. Annual Profits	Ratio of Benefits to Costs	Reduction in Costs Needed to Breakeven	Cost/Ton Salt Load Reduction
Line All Canals	$316,732	-$2,419,028	0.116	88%	$13.16
Line Canal 1	$154,538	-$400,192	0.279	72%	$12.52
Line Canal 2	-$7,459	-$176,940	-0.044	104%	-
Line Canal 3	$16,314	-$368,830	0.042	96%	-
Line Canal 4	$43,746	-$303,434	0.126	87%	-
Line Canal 5	$41,918	-$493,635	0.078	92%	-
Line Canal 6	-$1,073	-$744,745	-0.001	100%	-
Line 20% All Canals	$74,616	-$472,536	0.136	86%	$9.12
Recharge Reduction					
10%	-	-	-	-	-
20%	$632,042	-$634,484	0.499	50%	$9.31
30%					
40%	-	-	-	-	-
50%	$911,722	-$739,717	0.552	45%	$5.43
60%	-	-	-	-	-
70%	$808,576	-$3,942,487	0.170	83%	$19.00
80%					
90%	-	-	-	-	-
Drain Spacing					
50 m	$313,053	-$713,448	0.305	70%	-
75 m	$254,123	-$430,210	0.371	63%	-
100 m	$201,735	-$311,515	0.393	61%	-
150 m	$135,362	-$206,805	0.396	60%	-
Pumping Increase					
25%	$1,812	-$137,149	0.013	99%	-
50%	$15,058	-$262,863	0.054	95%	-
100%	$35,731	-$520,112	0.064	94%	-
200%	$68,310	-$1,043,376	0.061	94%	-
Combined Alternatives					
Line all canals & reduce recharge 50%	$1,081,474	-$3,305,724	0.247	75%	$10.71
Line all canals & drainage spaced 50m	$455,970	-$3,306,290	0.121	88%	$39.18
Reduce recharge 50% & drainage spaced 50m	$1,081,474	-$1,596,466	0.404	60%	$60.32
Reduce rech. 50%, line all canals & drainage (50m)	$1,209,823	-$4,203,876	0.223	78%	$15.28

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