MANAGEMENT STRATEGIES FOR

GRAVITY SPRINKLE IRRIGATION SYSTEMS

by

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TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS ii

LIST OF TABLES vii

LIST OF FIGURES x

ABSTRACT xii

INTRODUCTION 1

Background and Problem Statement 1

Objectives 2

REVIEW OF LITERATURE 4

Water Rights 5
Systems of Water Allocation 8
Equitability in Water Allocation 14
Hydraulic Network Analysis- General 15
Branching Networks 18
Cost-Benefit Analysis and Crop Production Functions 21
Waiting Time in Queuing Systems 23

METHODOLOGY 26

Operation of Delivery Systems for Irrigation 26
Management Strategies for Gravity Sprinkle Systems 27
Management Strategies Descriptions 30

On Demand (Unlimited Access to Water by All Users 30
Users Grouped in Rotation Blocks 30
Users Placed on Request 30
Supply Users Based on Crop Category 31
Min-Max Ranking System 31
Systems-Related Strategy 32
Low Labor Cost Scheme 32
One-Time Delivery 33
Continuous Supply with Monitoring 33

Theoretical Considerations of Strategies 33

Pure Demand Delivery, Unlimited Access to Water 33
Users Grouped in Rotation Blocks 35
Users Placed on Request 36
Supply Users Based on Crop Categories 37
Min-Max Ranking System 39
Supply Along System Types 40
Low Irrigation Labor Cost Scheme 41

TABLE OF CONTENTS (continued)

Page

A One-Time Delivery 43

Continuous Supply 45

The Computer Model 47

General Description 47
Main Program 48
Input Data 50
The Output 52
Submodel HYDRA 52

Computation of Crop Evapotranspiration 54
Computation of Reference Crop Evapotranspiration, Etr 54
Computations of Crop Coefficients, Kc 58
Soil Moisture Stress Coefficient, Ks 59
Irrigation Amounts and Delivery Time 63
Field Demand Capacity Determinations 64
Average Pressure in the Lateral 66
Field Irrigation Efficiency 69
Application Efficiency 69
Rotation Irrigation Requirement 74
Field Service Priority in the Queue 79
GSIS Hydraulic Network Analysis 82

Submodel SWBAL 91

Soil-Water Budgeting 91
Root Growth Function 94
Planting or Beginning Growth Date 96
Crop Yield Estimates 99
Crop Growth Stages 103

Submodel ATTR 104

Determination of Cost, Return and Benefits 104
Waiting Time 113
Equitability Inference 114

FIELD APPLICATION OF THE MODEL 116

Project Information 116

Irrigation Water Source 118
Historical Flow Records 118
Water Rights and Diversions 119
Stocks and Share Amounts 120

TABLE OF CONTENTS (continued)

Page

Farm and Field sizes 122
Soil Types 123
Crops 123

Water Distribution Pipe Network 128

RESULTS 130

Crop Water Use . .- 135
Cost, Return, and Benefit Analysis 140
Equitability in Allocations 145
Waiting Time 149
Resource Utilization Ratio 150

SUMMARY AND CONCLUSIONS 156

Summary 156

Conclusions 158

RECOMMENDATIONS 160

LITERATURE CITED 162

APPENDICES 170
Appendix 1: The Computer Model Program Coding 171
Appendix 2: Sample Input Files 219
Appendix 3: Description of Soils Classification 229
Appendix 4: A Printout of On-Demand Strategy Output 234
Appendix 5: Codings for Rotation Irrigation Strategies 245
Appendix 6: Summaries of Results for Other Strategies 248
Appendix 7: Streamflow Data for High Creek, near Richmond, Utah 330
Appendix 8: Estimation Procedure for Augmentation Cost 334

LIST OF TABLES

Table		Page
1.	Categorization of the Strategies for Water Allocations in GSIS's	29
2.	Crop Production Costs and Returns for Corn, Spring Grain, and Alfalfa in Utah for the Year 1985	38
3.	Shareholders and Stock Distribution in Shares for User Ranking in Four Stock Classes	40
4.	Hand-Move and Wheel-Move Lateral Sprinkle System Configurations in the Study Area	42
5.	Desirability Factors for Irrigation Labor Cost for Various Days and Shifts	43
6.	Possible Range of Days for a One-Time Delivery of Water to Different User Types in the Study Area	44
7.	A Summary of Functions of the Submodels	48
8.	Coefficients for Polynomial Equations Describing the Mean Crop Coefficients, Kcm	60
9.	Coefficients and Indices for Use with Friction Loss Gradients, J, and Lateral Flow Rate, Q, Equations	67
10.	Estimated Values for Coefficient K and Exponent a Used with Re versus ETr Equations	73
11.	The First Irrigation Date in a 15-Day Irrigation Rotation with 10 Days On and 5 Days Off	76
12.	Coefficients and Exponents Used in the Field Service Priority Equation	81
13.	Minor Loss Coefficients for Entrance Condition and Line Fittings	89
14.	Maximum and Minimum Root Depths, Days to Effective Cover, and Lengths of Growing Season for the Crops in the Study	95
15.	Corn and Wheat Calibrated Yield Equation Parameter Values for Kaysville, Utah; Kimberly, Idaho; and Logan, Utah	102
16.	Phenologic States and Corresponding Accumulated Growing Degree Days, GDD, for Corn and Wheat	104
17.	Alfalfa on Class I Land, Costs and Returns Per Acre	109

LIST OF TABLES (continued)

Table		Page
18.	Small Grain Costs and Returns Per Acre	110
19.	Corn, Silage, Costs and Returns Per Acre	Ill
20.	Irrigated Pasture Costs and Returns Per Acre	112
21.	Summarized Statistics on Streamflows in High Creek, near Richmond, Utah	118
22.	Percentage of Flow and Estimated Flow Rates Awarded to Richmond, Mt. Home, Coveville, and Webster Irrigation Companies Based on Kimball Decree Awards	120
23.	Statistics on Stock and Shares in Richmond Irrigation Company, Richmond, Utah	122
24.	Average Field Sizes, Infiltration Rates, and Water-Holding Capacities for the Soils of the Study Area, Richmond Irrigation Company, Richmond, Utah	125
25.	A Summary of Crop Distribution in Acres (Percentages) among Soil Types in the Study Area, Richmond Irrigation Company, Richmond, Utah	127
26.	Summary of Water Use by Field/User During a Normal Year with the On-Demand Strategy Invoked	136
27.	Summary of Water Use by Field/User During a Normal Year with Users in Rotation Blocks Strategy	137
28.	Summary of Water Use by Field/User During a Normal Year with Continuous Supply Strategy Invoked	138
29.	Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre from On-Demand Strategy, Normal Year	141
30.	Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre from Users in Rotation Blocks Strategy, Normal Year	142
31.	Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre from Continuous Supply Strategy in a Normal Year	143
32.	Field/User Stock Relative to Allocation Received and in Percentages Using On-Demand Strategy in a Normal Year	146

J

LIST OF TABLES (continued)

Table		Page
33.	Field/User Stock Relative to Allocation Received and in Percentages Using Users in Rotation Blocks Strategy in a Normal Year.	147
34.	Field/user Stock Relative to Allocation Received and in Percentages Using Continuous Supply Strategy in a Normal Year.	148
35.	A Summary of Attributes for Management Strategies Implemented in the Dry, Normal, and Wet Years (1979, 1986, and 1983, respectively).	152
36.	Allocation Codings for the Modified Rotation Irrigation Strategies.	246

LIST OF FIGURES

Figure		Page
1.	General Flowchart for the Gravity Sprinkle Irrigation System, GSIS, Model	49
2.	Representation of a Typical Gravity Sprinkle Irrigation System, GSIS	51
3.	The Submodel HYDRA	53
4.	Reference Crop Evapotranspiration, Etr, and Best-fit Polynomial for Etr as a Function of Time	57
5.	Plot of Mean Crop Coefficients Using the Polynomial Equations, and Root Growth Function Plots for Alfalfa, Silage Corn, and Small Grain	62
6.	Plot of Friction Loss Gradient as a Function of Flow Rate in Portable Aluminum Lateral Pipes	68
7.	Effective Portion of Water Applied by Sprinkling, Re, which Reached the Soil Surface under Different Environmental and Spray Conditions	72
8.	Schematics of a 15-Day Rotation Irrigation, 10 Days On and 5 Days Off, Users in Rotation Blocks	77
9.	Typical Fields that Constitute Rotation Blocks	78
10.	Field Service Priority, Pf_s, for Fields that Are Due for Irrigation, as a Function of Time	81
11.	A Simple GSIS Distribution Network	84
12.	The Flowchart of the Submodel SWBAL	92
13.	The Flowchart for Submodel ATTR	106
14.	Location Map for Richmond Irrigation Company, Richmond, Utah	117
15.	Plot of Allowed Diversion versus Flow Rate in High Creek, near Richmond, Utah, Based on Water Rights	121
16.	Study Area Soil Type Distribution	124
17.	Crop Distribution among Fields in the Study Area, Richmond Irrigation Company, Richmond, Utah	126
18.	Water Distribution Network Showing Pipe Layout and Pipe Elevations at the Delivery Points	129

LIST OF FIGURES (continued)

Figure		Page
19.	Available Flow and Demand Flow Hydrographs for Irrigation On Demand, Precipitation, Number of Pumps for Supply Augmentation, and Number of Users Irrigating Based on Dry Year (1979) Data, Richmond Irrigation Company, Richmond, Utah	131
20.	Available Flow and Demand Flow Hydrographs for Irrigation On Demand, Precipitation, Number of Pumps for Supply Augmentation, and Number of Users Irrigating Based on Normal Year (1986) Data, Richmond Irrigation Company, Richmond, Utah	132
21.	Available Flow and Demand Flow Hydrographs for Irrigation On Demand, Precipitation, Number of Pumps for Supply Augmentation, and Number of Users Irrigating Based on Wet Year (1983) Data, Richmond Irrigation Company, Richmond, Utah	133
22.	Benefit to Project for the Various Management Strategies Implemented in the Dry, Normal, and Wet Years	155

ABSTRACT

Management Strategies for

Gravity Sprinkle Irrigation Systems

by

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The study reported herein examined various management strategies which can be implemented for equitable allocation of water among users of a gravity sprinkle irrigation system. A computer model was developed and employed to effect allocations accordingly. Sequencing users to a schedule of when to draw water from the system was included to maintain mass balance. Historical streamflow records and other climatic data for three years, 1979, 1986, and 1983, representing normal, dry, and wet years, respectively, were used.

The equity aspects of water distribution were addressed, taking into account the shares of stock held in the irrigation company by each user. Allocations were proportionately determined for the individuals in relation to the numeric strength of the users' shares when demand was constrained by available streamflow. Diversions at turnouts in times of water shortage were strictly according to water rights. The developed water management strategies were applied to a real-life irrigation project, the Richmond Irrigation Company, Richmond, Utah.

The data used were collected from a study area covering more than six hundred acres and having twenty-three users. A set of criteria was used to compare the strategies. The criteria, described as strategy attributes, provided quantitative assessment of the strategies. The quantitative assessments were based on cost-benefit analysis, waiting time, and the resource-utilization ratio. The waiting time was estimated, but the assessment of its social repercussions beyond reducing available soil moisture and its resulting effect on crop yield were deemed outside the scope of the study.

Using pertinent crop, soil, water right, and historical data on streamflow and climate, the model determined the number of users irrigating, and the supply and demand flow hydrographs daily. At the end of the season, expected actual crop yields for the user/field were estimated, in addition to the other strategy attributes.

Allowing users unlimited access to water, a pure on-demand strategy, was most beneficial in terms of gross benefit to project; costs of augmentation were not included. There were no significant differences among the performances of all modified rotation strategies, and they were excelled by the non-rotation strategies except One-time delivery. One-time delivery recorded a waiting time or stress days of 101 days in the dry year, the highest among all strategies. The resource-utilization ratio ranged from 0.32 to 1.84, with higher ratios indicating a need for supply augmentation.

(340 pages)

INTRODUCTION

Background and Problem Statement

The water source for the gravity sprinkle irrigation system (GSIS) provides the resource as well as the potential energy for delivering water through the system. This is realized by virtue of the elevated location of the water source relative to the irrigated land. Most GSIS's are run-of-the-river systems; their main feature in many locations is the absence of storage reservoirs. Typically, supply to the systems is made by direct diversion from watercourses, such as rivers and creeks. Stream-flow hydrographs of typical rivers and creeks exhibit considerable seasonal fluctuation and often have steadily diminishing flow rates as the season advances. It therefore becomes necessary for users to map out various management plans to allow for effective utilization of the time-variant flows.

Mutual irrigation companies, some of which are incorporated associations, are formed and operated by users with explicit responsibilities for distributing water among themselves. A water right is granted to the company (users) by the state government, detailing allowable diversions that the company is authorized to make subject to streamflow amounts. Individual users buy stock for water in the company which entitles them to a share of the water diverted by the company. An assessment fee is charged seasonally for each share. The exact amount of water delivered to each user is a function of the number of shares owned by the user and the prevailing streamflow.

Early in the season, allocations of water among users are generally adequate and delivered amounts satisfy irrigation requirements of crops. This is largely possible due to abundant streamflow following the spring thaw of the winter snow pack and the relatively low crop-consumptive water use. Usually, no problems arise with the deliveries, or with satisfying what farmers perceive as adequate irrigation amounts, until about mid-season. From mid-season and beyond, equitable distribution of water among users at sufficient operating pressures becomes problematic and presents serious water-management problems to irrigation companies. The problems arise largely as a result of diminishing supply-stream flow rates. Anxieties in users arise, resulting in overloading of the system, caused by attempts to gain access to whatever little amount of water there is. With limited system flow and greater demand, the outcome often is little or no flow to some users. Inadequacy of pressure and sometimes negative pressures in some supply lines become common occurrences.

Strategies should be mapped out in advance by management to enable them to apply alternative operation schemes to ameliorate the late season water delivery problems. Strategies should actually cover the entire growing season and peak streamflow periods. The water delivery strategies should be those that facilitate allocation of water to all users which will be equitable.

Objectives

The purpose of this study was to identify and evaluate practical management strategies that could be used by gravity sprinkle system irrigation companies to aid water management. The study also compared

the attributes of the various strategies and quantified associated benefits of each.

The specific objectives are to:

1. Identify and select strategies for hydraulically balanced water allocations among users of a generalized gravity sprinkle irrigation system that satisfies equitability according to water rights.

2. Devise evaluation criteria for comparative analysis of alternative management strategies.

3. Develop an algorithm which will determine delivery times as a function of irrigation amounts, farm system characteristics, and delivery pressures throughout a gravity sprinkle irrigation system.

4. Apply this algorithm, as an enhanced management package, to the management of an existing gravity sprinkle system.

REVIEW OF LITERATURE

Water delivery management in gravity sprinkle irrigation systems is essentially concerned with diverting appropriated waters granted by water rights and allocating such waters to all stockholders. Irrigation companies that operate such systems need not only be familiar with the awards contained in the water rights but also should have an appreciation of the limitations of the system they operate. Such limitations may be associated with the physical dimension of the distribution network. While the major preoccupation of the water management team remains that of distributing water to users equitably, the team has to operate within the constraints of the allowed diversion it is permitted legally.

The reviews that follow in the subsequent sections of this chapter examine the relevant aspects which have bearing on management of water in GSIS's. The reviews start by examining water rights which are the legal and administrative instruments by which users jointly acquire right to water in any watercourse. It is also on the basis of this document that diversions are predicated. Methods of hydraulic network analysis are reviewed in both general terms and as they pertain to branching networks typified by GSIS's. Hydraulic network analysis provides the means for ascertaining deliveries made to users and whether or not such deliveries are equitable. Available literature dealing with equitability aspects and how allocations of water are implemented in irrigation projects are also reviewed.

Water Rights

In most arid lands of the world, including the western United States, agriculture depends almost entirely on irrigation. Irrigation has made possible the development of communities and settlements that have thrived and prospered on lands that, though fertile, hitherto lay idle. Irrigation water was the most important catalyst in the transformation that led to the development and maintenance of civilization in the arid West.

Harding (1940) presented a historical perspective to the development of irrigation in the western United States up to the settlement of the Mormon pioneers in the Salt Lake Valley in 1847. He stated that that was the first major colonization in the West which had agriculture, instead of mining, trapping, or religious activities among the Indians, for its principal purpose. Farmers looked to irrigation water as their lifeblood and did everything possible to guard it against intruders. To lose their irrigation water or right of access to its use would result in failures of most agricultural crops.

As in any "demand and supply" situation, irrigation water became controversial only when there was a deficit on the supply side. The question of right to the use of water arose and became a very important issue, so that steps had to be taken to determine the rights on a stream or river in order to settle disputes. This is historically what led to the development of the laws concerning irrigation and use of water. It also led to development of methods of adjudicating the streams and of obtaining information upon which a fair and just determination might be based (Bishop 1938).

Two major doctrines are in use with regards to water rights. These are the Doctrine of Riparian Rights and the Doctrine of Appropriation Rights. "Riparian" is from the Latin word "riparius," meaning pertaining to or belonging to the bank of a river. A riparian owner is one whose land abuts upon a river. The doctrine of riparian rights, according to its provisions, states that the owner of land bordering on a lake or stream is entitled to have the lake/stream flow on as it wants to do. In effect, such a body of water is to remain as nature placed it. This provision gives the riparian owner of land the right to have the flow in the river undiminished in quantity and unpolluted in quality. The provision recognizes two uses. The first, termed as ordinary or natural use, includes uses for domestic and livestock purposes. The second use, the provision termed extra-ordinary or artificial, includes uses for irrigation or mechanical purposes.

The states comprising the eastern portion of the U.S., which is a region with adequately distributed rainfall, have drainage rather than irrigation problems. Some of those states retained that portion of the English common law having to do with water rights. In the arid West, however, that was found inadequate as it pertained to irrigation (Huffman 1953). Bishop (1938) stated that the pioneers and early settlers of the state of Utah did not opt for its use, as it essentially prohibits consumptive use for any purpose. To have adhered to such doctrine would have meant no irrigation, as no diversions from the stream would be allowed. This doctrine proved inoperative in the state of Utah. The second doctrine, which is examined next, was more practical.

The second doctrine, the doctrine of appropriation rights, declares that, "he who is first in time is first in right" and that "beneficial use is the basis, measure, and the limit of the right." This doctrine grew out of the necessities of the pioneer public in the arid West. The practice of diversion and beneficial use of water was designated as "appropriation" and the person who diverted and used it was called an "appropriator." Bishop (1938) recalled that those who were first to appropriate the waters of a stream were also classed as first in the rights to continue to use it.

Appropriative water rights are not tied to the land in all instances. A water right may pass with the land but not necessarily so, as the doctrine allows for the transfer of use of water from one owner to another when the land does not change ownership. The doctrine permits the taking of water from one watershed for use in another watershed. However, as pointed out in Huffman (1953), some states have statutory restrictions upon such actions.

The State of California has, in effect, water rights on both the appropriation and the riparian doctrines. The two doctrines have been recognized by the courts since the early mining days in the Sierra Nevada foothills. Hutchins (1956) pointed to the operation of the two conflicting water rights in California as being responsible for the production of voluminous litigation.

Mutual irrigation or canal companies and private individuals acquire a right to use of water by first applying to the State Engineer. Determinations on prior rights and other routine processes are made, and finally an award is either granted or denied. In the event that an award

is granted to a company, the stockholders in the company are considered to be severally and jointly granted the rights which the company board of directors administer.

The process of acquisition of water rights by users varies from one state to another in the West. Harding (1940) presented an overview of the general administrative procedure in several states at that time. Huffman (1953) reported that many states required no more formality than the posting of a notice at the point of diversion and the filing of copies of the notice with the County Recorder or the County Clerk.

Systems of Water Allocation

The efficient operation of an irrigation water allocation system should guarantee delivery of water to the farm in the right amount and right pressure at the right time to be usable. Kaewkulaya (1980); Khanjani and Busch (1983); Bishop and Long (1983); and Kim, Busch and Yoo (1983) all reviewed methods of irrigation water delivery. There are three principal methods: demand, continuous supply, and rotation. These methods, developed for open-ditch irrigation systems, have been carried over to gravity sprinkle systems, which are closed-conduit systems. A number of variations and modifications of these basic methods also exist and are applied to open-ditch as well as closed-conduit systems. Fitzgerald and Arnold (1972) presented a method they referred to as a "rostered system" of delivery for a "run of the river" system used to serve large numbers of farmers in New Zealand.

Typified by fixed time intervals, the method is essentially a rigid rotation system. Replogle (1983) developed a nomenclature for the

various delivery system's operational policies and examined their impact on on-farm water use. Abdellaoui (1986) subdivided the modified delivery systems in Replogle (1983) in terms of rigid and flexible schedules.

The demand delivery method is characterized by the user placing an order for and receiving a supply of water in amount and time desired by the user. Delivery of water on-demand presupposes that individual system demands could be met by prevailing streamflows. Angeles and Hill (1985) presented irrigation water demand, crop yield, and water allocation models developed and applied to a run-of-the-river irrigation project in the Philippines. They stressed the need for local calibration of the model to match actual conditions before its application in overall planning, such as in water delivery scheduling. Bishop and Long (1983) indicated that the demand method can be operated to provide for equity among users, but additional hardware over and above those required for regular canal operations must be installed and recordkeeping substantially enhanced.

In the continuous supply delivery method a specific flow rate is delivered continuously to the farm. All flow rates within the system are fixed (either at the beginning of the season or at a few times during the season or both). Except in unusual circumstances, the delivery flow rates would not vary (Clemmens and Dedrick 1984). However, as Khanjani and Busch (1983) indicated, it is not convenient for farm managers to irrigate continuously, as most prefer flexibility in managing their irrigation application systems. The exceptions to this are center-pivot and trickle irrigation systems, in which constancy in supply is an advantage. Roosegrant (1985) reported that continuous supply delivery

systems cause system-wide water-use inefficiency due to high transport losses, storage of water in the paddy in excess of plant use requirements, and high drainage losses. The report quoted earlier works of Miranda and Levine (1979), Wickham (1973), Early (1976), Tabbal and Wickham (1976), and Moya (1976), which postulated that a continuous flow irrigation delivery system causes spatial misallocation of water, with the average amount of water delivered decreasing as the distance of farms from the water source increases. The authors contended also that the delivery system causes misallocation of water over time within the growing season.

By far the most common delivery method is rotation. In a study of the nature and operations of irrigation water companies in Utah Valley, Hudson (1962) reported that most companies use the rotation system of water delivery to users. With the rotation method, each user in a rotation block is given an exclusive use of the continuous flow of water for a specified period of time to accomplish his irrigation. The length of time the user has access to the water depends largely on the stream size allocated to the block and his area of land to be irrigated. In some irrigation systems in Idaho, users along each lateral may share the water on a rotation basis (Allen and Brockway 1979). Suryavanshi and Reddy (1986) discussed "the constant frequency-variable depth" method of water delivery, which is a modification of the rotation method. With that method, the authors indicated, the depth of irrigation in each rotation is varied according to the crop water need. The authors stated that implementing such modified rotation systems closely matches irrigation on demand.

Comparative studies of water delivery systems by a number of researchers in the Philippines, reported in Levine, Chin, and Miranda (1976), ranked rotation systems better than the others in terms of upholding equity and crop productivity. Using reductions in the number of disputes over water and the number of instances of water stealing and vandalism to irrigation structures as an indicator, Levine, Chin, and Miranda (1976) attributed the changes to equitable distribution of water that resulted from introducing rotation irrigation. The authors indicated that increases in paddy-rice areas and yields were for the same reason. Chow (1960) reported that rotation irrigation systems in Taiwan gave higher yields of rice and savings in water of at least 20-30 percent, and in the extreme case 50 percent, compared to a continuous supply method. Kaewkulaya (1980) cited two delivery system comparative studies. The first in the Philippines, reported in Wickham et al. (1974), showed that water use efficiency was slightly higher for areas under rotation irrigation. The second study, Miranda and Levine (1979), showed no significant differences in efficiency of water use among the three delivery methods investigated, including the rotation method, after transplanting during the wet season. However, during the dry season, differences in efficiencies among the systems were quite evident.

In all three methods of water allocation or variations thereof, effective performance of the delivery system influences the actual amounts of the allocated water that is received by users. Equitable distribution of irrigation water among users has been noted in Bishop and Long (1983) to be affected by the location of individual fields

relative to field turnouts. The farther away the field is to the turnout, the more disadvantaged a user served by that turnout is. This may be the case particularly with surface irrigation systems. The situation being similar to that described in Bishop and Long (1983) as "highority priority," in which a user near the main source of supply takes more than his fair share, often so much as to depress yields, while users at the "tail-end" of the system are left dry. In gravity sprinkle installations without pressure relief valves, closeness to supply source does not constitute an advantage, as delivery pressures may be lower.

Oad and Levine (1985) reported that within turnout areas, the equity of water distribution is variable, being influenced primarily by distance from the turnout and soil texture. Clemmens and Dedrick (1984) reported an investigation of water delivery performances in which they quantified the variability of delivery flow rates for an irrigation district. The district operated a flexible delivery system, in which farmers arranged the rate, frequency, and duration of the delivery. They found a coefficient of variation, CV, of instantaneous (1/2 hour) flow rate values averaged for each turnout ranging from 0.04 - 0.29. They found CV to be related to the location of the site within the delivery system. Lowdermilk, Early, and Freeman (1978) reported irrigation delivery efficiencies on field locations along watercourses.

Apart from inequities due to spatial differences in locations of farm turnouts, the point within the delivery system at which the rotation is introduced may enhance or worsen the case for fairness for all users. Roosegrant (1985) showed that even though rotation only along

the main canal generates over half the benefits of full rotation, the re-distributive impact in terms of benefits is reduced, with tail-enders (third section) income gains less than half of the gain with full rotation. The study further showed that extension of rotation irrigation from main through secondary canals provides around three-fourths of the aggregate benefits (relative to continuous supply irrigation) of full rotation, and over 90 percent of the income benefits to farms at the tail-end. Rotation delivery only at the tertiary canals to farm turnouts provides almost no system-wide benefits when compared to continuous flow. The absence of such benefits is attributed to the fact that tertiary canal level is not the most effective point for management intervention; the key management intervention points for water management reforms is at the main and secondary canal levels. If water is distributed inequitably at the main and secondary levels (i.e., through continuous flow to the tertiary level), rotation among farm turnouts provides neither aggregate income benefits nor benefits to farms at the tail-end (Roosegrant 1985).

Users at some point within the overall system are delivered some flow rate over a time period which may be substantially variant and bear little relation to their fair share. The product of flow rate and time reflects the volume amounts which represent the user's share in the common commodity.

Equitability in Water Allocation

The share, which entitles the stockholder to some proportion of the water diverted by an irrigation company, also imposes an obligation or assessment upon the user. The definition of a share of water is not universal. Freeman (1986) presented what may be typical of how mid-level organizations specify a share of water. The specifications range from shares defined in fixed percentage allotments (i.e., percent of total volume or percent of time period rotation) to use of priority system and user demand. The exact amount of water that can be equated to a share of water stock in an irrigation company is not fixed but subject to local circumstances. Kathpalia (1981); Singh, Goel, and Ali (1983) gave descriptions of the "Warabandi" used in Pakistan and Indian Punjab as a scheme used for the distribution of water among farmers within an outlet command. This scheme, the authors pointed out, ensures timely, adequate, and equitable distribution of water on a weekly or multiple-of-a-week basis. The system was described earlier by Reindinger (1974) as combination of shares by percentage time period rotation with share priority by location. The system embodies water being turned into the channel head to tail and which is being allocated to farmers according to a time period calculated to be proportional to farm area served. The entire channel flow is served to one farm at a time.

Three subdivisions of the "Warabandi" system presented in Singh, Goel, and Ali (1983) illustrate the value of a share of water as being decided on an area basis as in "Thok-wise Warabandi," a cultivator basis as in "Chak-wise Warabandi," or through mutual agreement relating to time as in "Village-wise Warabandi."

The authors identified the two major drawbacks in operating "Warabandi" as filling time and watercourse conveyance losses. Both factors are not usually taken into account in figuring out delivery times for users. The negative effect of the factors are felt more by tail-enders in the distribution system.

In the western United States, a significant portion of the water delivered to farms is through distribution systems operated by user organizations. Two such distinct organizations exist. These are mutual irrigation companies which are private and voluntary, and irrigation districts which are public and involuntary. The latter must follow definite procedures laid down by state and federal statutes (Allen and Brockway 1979). Water diversions by these companies are in accordance with water rights and weather which may determine streamflow. Individual irrigators/users in the company buy stock for water which entitles them to a specific share of water. The exact amount of water represented by a share of stock may vary with time during the growing season. Some companies, however, translate a share of water in volumetric terms into the amount of water delivered by a sprinkler of specific nozzle size, under unspecified pressure, over a twenty-four hour period.

Hydraulic Network Analysis- General

Analysis of flow in water distribution for closed or looped networks received considerable attention largely because the advent of digital computers made the laborious, iterative calculations more amenable to quick solutions. Solutions have been obtained for the problems by obtaining network flow distributions which satisfy conservation of mass

(flow continuity) at each junction and summation of head losses equal to zero around closed loops, or equal to the difference in hydraulic grade lines, HGL, around pseudo loops. While the former results in a linear algebraic equation, the relationships describing the head loss are non-linear algebraic equations.

Jeppson (1976) indicated that the most commonly used solution methods for hydraulic network analysis are Hardy Cross, Newton-Raphson, and Linear Theory. In a review, Wood and Charles (1972) stated that the first and probably the most widely used method of analysis is the Hardy Cross technique. With this method, as pointed out in Flammer, Jeppson, and Keedy (1982), each equation is solved separately instead of all the equations solved simultaneously. The Hardy Cross method had been found suitable for hand calculations, and a number of digital programs have been prepared for network analysis using the procedure (Wood and Charles 1972). The main drawbacks of the method are slowness and sometime lack of convergence. McCormick and Bellamy (1968) suggested measures to improve convergence to a solution of the method.

The Newton-Raphson method is another method that was applied successfully to hydraulic network analysis to formulate a set of simultaneous linear equations which can be solved for flow corrections for each loop in the network. Martin and Peters (1963) applied the Newton-Raphson method in a computer program to solve for unknown head in a network of pipes containing no valves and pumps. Convergence to a solution did not constitute a problem, they reported. Shamir and Howard (1968) described an extension of the method to include various hydraulic components in the network.

That work reported an earlier work (Shamir 1964) in which the Newton-Raphson method was used as one of a set of computer programs for economic analysis of water distribution networks. Lemieux (1965) and Smith (1966) reported subsequent use of the programs to solve for unknown heads and stated that convergence was always achieved. Giudice (1965) included a sensitivity analysis and considered the case of more than one fixed head. Epp and Fowler (1970), in a preliminary work in which the Newton-Raphson method was used, reported an efficient algorithm for solving flow in a hydraulic network based upon methods of numerical analysis and graph theory. Liu (1969) and Lemieux (1972) both presented methods of simultaneous solution of the head equations. Pitchai (1966), reported in Shamir and Howard (1968), used the Newton-Raphson method and treated networks with pumps as boundary conditions. They reported no proof of convergence with Pitchai's method nor the solution to the network that included pumps. Jeppson and Davis (1976) described a method for including pressure reducing valves, PRV's, in the analysis of pipe networks. The description also included methods for banding the coefficients, or Jacobian matrix, to increase computation efficiency.

Convergence is rapid using the Newton-Raphson method compared to the Hardy Cross because flow rates in all loops adjust simultaneously. This is important and an advantage in terms of computer storage, when analyzing networks involving a large number of pipes. The Newton-Raphson as well as the Hardy Cross methods require reasonable initial guesses for the flow distribution. If the "delta-Q" system of equations is to be solved, initialization must satisfy all junction continuity equations.

Linear theory method, which is the third analytical solution method as described in Wood and Charles (1972), was used by the authors to solve for flow distribution in a network. They pointed to the most significant advantages of the method as being rapid convergence and assurance of a solution in all cases. Marlow et al. (1966) and Isaacs and Mills (1980) presented a method based on the same theory to solve for junction heads simultaneously. Wood and Rayes (1981) examined the principal algorithms for solving a large number of actual pipe network problems and compared the results. Some of the convergence problems that were said to have been encountered with the simultaneous solution of the head equations were reported in Shamir and Howard (1968), Liu (1969), Collins and Kenington (1977), and Wood and Rayes (1981).

An analytical solution method proposed, although not given wide acceptance, was Duffin's (1947) work on application of non-linear networks to hydraulic networks applied by Warga (1954). McPherson (1962) gave a description of available direct electrical analogs used for hydraulic network analysis, including the most popular Fluid Network Analyzer developed by Mcllroy (1950). The main difficulty encountered with electrical analogs was with creating electrical circuits with a correct resistance to electrical flow relationship that could duplicate pipe flows.

Branching Networks

The gravity sprinkle irrigation system, supplied by one source and non-looped, typically provides an example of a branching hydraulic network. Such networks are tree-like, without any loops, and are

frequently used for rural water supply in addition to agricultural irrigation applications.

A typical gravity sprinkle system consists of a water source and a series of pipes: main, submain, manifold, and irrigating laterals. The irrigating laterals may be hand- or mechanical-move systems, examples of the latter are the center pivots, drag lines, and wheel moves. Success with operation of any of the systems depends on the availability of sufficient potential energy at the water source to provide adequate pressures at the sprinkler nozzles. The procedure for analyzing the system must include determination of pressures and discharges at the sprinklers as well as pressures in the lines. Such determinations are important in establishing equity in allocations.

The methods of analysis of the looped networks commonly used in urban water supply and non-looped, branching networks used in rural water supply and irrigation are not exactly identical. The complexities inborn in the former are largely due to the looping and the fact that the system has to cater to large population densities.

Tong et al. (1961) employed the method of equivalent length for the analysis of distribution networks which included iterative procedures similar to those in the Hardy Cross method; whereas Deb and Sarkar (1971) proposed an equivalent diameter method for the identification of an optimal solution. Swamee and Khanna (1974) observed that the equivalent diameter method failed to hold under mathematical scrutiny.

Deb (1974) developed a method for optimal analysis of branched networks which could be solved with the help of a desk calculator.

His procedure involves initially solving all the single branches in the network containing pipes in series only (not branching). This is followed by combining two single branches at a time and modifying the coefficients calculated previously for the same. Further, this linking of pairs of single branches (or modified combined pairs) is continued two at a time with recalculation of coefficients each time for all the linked single branches until the whole network is covered. In a real-life situation, an increase in the number of branches inevitably increases the number of computational steps and re-evaluations, which adds to the complexity of the process to obtain a final solution. Chiplunkar and Khanna (1983) presented an optimization algorithm for branching systems using the Lagrangian multiplier technique. The method was applied to complete gravity water supply systems as well as direct pumping systems.

Ormsbee and Wood (1986) applied the conservation of energy equations along energy paths to analyze distribution networks. Energy paths include that part of the hydraulic network which is in between fixed-grade nodes. A fixed-grade node is a point where a constant grade is maintained, such as a connection to a storage tank or reservoir or to a constant pressure region.

The reviews cited so far are largely concerned with irrigation physical systems per se. In subsequent paragraphs of this chapter, the state of knowledge in relation to tradeoffs in management decisions will be reviewed. This will be approached by first reviewing techniques used in comparative analysis, such as cost-benefit analysis and time analysis.

Cost-Benefit Analysis and Crop Production Functions

Selection of a best management strategy will be based on, among other things, the comparison of tangibles and intangibles. Tangibles are economic costs and benefits that may be valued in dollars; for example, the costs of producing a bale of alfalfa hay and the selling price of a bale of alfalfa hay or a ton of barley, respectively. Intangibles are social costs and benefits that do not have a market price but nonetheless comprise part of the level of satisfaction for services rendered.

Wallis (1978) presented three techniques for comparing tangible and intangible costs and benefits: (1) engineering judgement, (2) cost-benefit analysis, and (3) preference analysis. The major difference among the techniques is in the treatment of the intangibles. The author pointed out that the first technique avoids quantifying intangibles in the same units as tangibles, the second quantifies both tangibles and intangibles in monetary value, whilst the third quantifies both tangibles and intangibles in the (intangible) unit of preference. Most engineering projects require these kinds of comparisons.

Use of cost-benefit analysis, as in Evans, Walker, and Skogerboe (1983) and Tyagi (1986), both of which are illustrative of the analysis, provides for the identification of the most cost-effective management or control strategy. Cost-benefit analysis, acclaimed in Prest and Turvey (1965) as a practical way of assessing the desirability of projects, provides a tool for explicitly estimating tradeoffs in tangibles and intangibles.

To obtain estimates on which costs and benefits are based, crop production functions are needed. These functions relate crop yields to water use. Some of the earliest investigations, Cole (1938) and Leggett (1959), related wheat yields to available soil moisture in the spring plus any additional precipitation during the growing season. Later, numerous attempts at developing production functions for irrigated crops were embarked upon. Among the most comprehensive was the dry matter yield-transpiration relationship study by De Wit in 1958, as reported in Barrett and Skogerboe (1980). The study resulted in a wide range of data on field crops grown in containers from which evaporation was accounted for. Arkley (1963) reported an extension of De Wit's work which corrected for mean relative atmospheric humidity during times of most active growth. His graphs plotted for dry matter yields versus the corrected transpirations showed strong linear relationship with high correlation coefficients. He drew strong conclusions about deviations from linear relationships. Hanks, Gardner, and Florian (1969) obtained a linear relationship between dry matter yield and transpiration for grain sorghum at Akron, Colorado. In a similar study using line-source sprinklers in Logan, Utah, Hanks and Retta (1980) obtained a linear relationship between alfalfa yields and water use (r^2=.88). Hill (1983) investigated whether similar relationships exist between alfalfa yields and water use under commercial farm conditions in some counties in Utah. He found that alfalfa yields versus seasonal ET relationships were linear (r^=0.74). Doorenbos and Kassam (1979) provided relationships between relative yield decreases ($1 - Y_a/Y_m$) and relative evapotranspiration deficits ($l - ET_a/ET_m$) for many crops, including some

in this study. The relationships are linear at the various growth stages at which they were determined.

Some other works in the literature reported non-linear relationships between crop yields and water use. Musick and Dusek (1971) and Shipley and Regier (1975) reported diminishing curvilinear relationships between crop yield and applied water; the latter work was on maize, grain sorghum and wheat. Expanding the analysis in Musick and Duseck (1971) and including more data; Musick, New, and Duseck (1976) showed that relative grain yields of grain sorghum, wheat, and soybeans plotted against soil water depletion from 0-120 cm depth gave quadratic fits. Lack of a strong linear relationship between yield and seasonal evapotranspiration was found in the grain sorghum lysimeter study reported in Howell and Hiler (1975). The authors asserted that time of occurrence of deficit is more influential on crop yields than the magnitude of the deficits.

Waiting Time in Queuing Systems

Irrigation water allocations are characterized by time events such as beginning delivery time and total delivery time, both of which are analogous to arrival and service times, respectively, in classical Queuing system analysis. These characteristics make it possible to analyze irrigation water allocations in queuing models. One model that can be applied to such an analysis is the single channel queuing system with FIFO (First In First Out) discipline. Other models for a variety of applications are discussed in White, Schmidt, and Bennett (1975); Dinkel, Kochenberger, and Plane (1978); Anderson, Sweeney, and Williams

(1982); and Taha (1982). Conolly (1975) presents an extensive theoretical treatment of queuing systems, including unconventional single server systems. White, Schmidt, and Bennett (1975) provide computer models for the simulation of single and multiple channel queuing systems based on next event simulation.

In analyzing queuing systems, the three major events of interest to the analyst are arrivals, departures, and maximum clock time. Arrivals and departures are two events that the state of the system, i.e., number of customers or units in the system, are dependent upon. Maximum clock time is a term used to describe event time; it is pre-set by an observer or analyst of the system. An example of clock time is the arrival of an i-th customer or time of departure of a j-th customer from a service channel. Since the study of queuing systems has to do with time flow of events, the methods used to move the system simulated through time is equally important. Two time flow mechanisms are discussed in Naylor (1971). These time flow mechanisms are fixed time increment methods and variable time increment methods. In the former, a clock is updated by a fixed time increment, such as one day, one month, one year, etc. In the variable time increment method, on the other hand, the clock advances time to the next earliest event to occur. The next series of events that takes place does not necessarily have to occur at equal time gaps or integer multiples of any of the gaps, as with the fixed time increment methods. While there is no general rule for choosing an appropriate time flow mechanism, Naylor (1971) provided a guideline based on achievable efficiency with either of the methods.

In this study, waiting time, measured in days, is the time a customer or unit spends in the system minus the time service was actually rendered to the unit while in the system. The unit, in this case the field to be irrigated, is considered to enter the system on the day soil water content falls below management allowed deficit. If irrigation is provided on that day no waiting time is registered, otherwise a counter is set in motion to record the number of days elapsed until service is rendered.

METHODOLOGY

Operation of Delivery Systems for Irrigation

As indicated in the literature review, three broad categories of irrigation water delivery systems exist. These are (1) on-demand, (2) rotation, and (3) continuous delivery systems. Operation of pure on-demand and pure rotation systems are rare in real-life irrigation projects. Modified systems and mixtures of the pure systems are commonly in operation. A continuous delivery system in a certain respect is a modified rotation system. In all three categories, three factors are used in drawing the distinction among them. These factors are interval, flowrate, and duration of irrigation. The factors are essentially those of irrigation scheduling.

In operating a pure on-demand system, the three factors (i.e., frequency, amount, and duration) are not fixed. Rather, the water user is at liberty to demand irrigation whenever he desires, for an amount and duration of his determination. On the other hand, a pure rotation system is operated within the bounds of frequency, amount, and duration that are determined by the supply agency; such as water management officials as in government operated projects, or irrigation company or district water master.

On-demand deliveries are made in response to user's demand for service and so they are user-oriented, whereas rotation deliveries are scheduled for the operational convenience of management. To that extent, rotation deliveries are supply-agency oriented. The supplies under the latter scheme do not always match what the users perceive as their

requirements in terms of the amounts, duration, or frequency of delivery.

Modified versions of the pure delivery systems which are commonly in operation vary the factors of delivery systems such that delivery may, for instance, be made in fixed amounts but variable frequency, or whatever variation is convenient to the supplier.

The research studied here examines management strategies in the pure on-demand, continuous, and modified rotation delivery systems within the context of gravity sprinkle irrigation systems. The subsequent sections present the strategies, and some theoretical considerations.

Management Strategies for Gravity Sprinkle Systems

Water available to users, either directly from turnouts at water sources such as rivers and creeks or from groundwater, is legally a common commodity by virtue of a water right severally held by the stockholders. The commodity must therefore be shared among all the stockholders using an acceptable formula. The stockholders, who are the users, buy shares of stocks in the mutual irrigation company that holds the water right on behalf of all users.

The challenge for the management of the company is to translate stock values into a realistic and fair allocation of water to each user in such a manner that equity is maintained, in terms of the amount and time that water is delivered to individual users. Equity here is viewed in relation to individuals getting their share of water in the interest of common good. Time is an important element in the allocation process

because crop production occurs in sequential phenological phases that are responsive to environmental factors.

These factors are major determinants to growth and to the initiation and cessation of phases that are time-related. Management should attempt to deliver water to users in amounts and at times that render the commodity usable and effective. To do so, they must map out alternative operations schemes, or management strategies. The strategies are vehicles by means of which equitable delivery of water to each user is accomplished. Table 1 contains the categorization of the strategies. Discussions and theoretical considerations of the formulation of strategies are presented in a later section.

Table 1.-- Categorization of the Strategies for Water Allocations in GSIS's.

Strategy	composition
On-demand:	
1. Unlimited access to water by all users	fields treated singly
Modified demand:	
1. Supply on request	fields treated singly
2. One time delivery	
Rotation:	
1. Users in rotation blocks	contiguous fields as rotation blocks [3 blocks]
2. Among crop category	Crop types form a block [3 blocks]
3. Ranking of stocks	Range in shares of stock, each range constitutes a block [4 blocks]
4. System types	Hand move and wheel move laterals are a block each [2 blocks]
5. Low labor cost scheme	Off-farm and on-farm users constitute a block each [2 blocks]
Continuous flow:	
1. Continuous supply	fields are treated singly

Management Strategies Descriptions

On Demand (Unlimited Access to Water by All Users)

This is a strategy that seeks to allow all users access to water at all times. The implementation of this strategy is possible early in the season when an ample supply of water is available and crop water requirements are relatively low. Irrigation durations are similarly expected to be low. No intensive policing of the system is desirable.

The manner with which users may connect for service is expected to follow a random pattern. The main constraint anticipated is the capacity of the system hydraulics to satisfy demand from users needing water randomly within the same time frame.

Users Grouped in Rotation Blocks

User holdings are grouped in rotation blocks of determinate sizes (in acres), and each user in the block is allowed access to a fixed continuous flow amount and duration. The frequency is usually fixed, but may also be variable. Individual users within each block irrigating at the same time are grouped as rotation units. Users will have allocations figured out relative to their stocks. Rotations are expected to be rigid, as users are to take their flows only when due. One rotation unit made up of one or more blocks receives water at any one time.

Users Placed on Request

This strategy is a modified demand delivery system; it places a lot of responsibility on the user. It requires that he makes known his

request for water in advance of time of use to allow a sufficient lag time for scheduling and balancing of deliveries and total system flow rates by the project. Because this strategy allocates water subject to constraint in supply, the user's request may or may not be honored at the requested time. Some waiting may be imminent.

The strategy is particularly expedient during the later part of the season when water shortages are expected and irrigation amounts and/or frequencies are likely to be high. Users' requests are likely to be highest during times of critical crop growth stages. While it may be possible to anticipate incoming requests for water, it may not be possible that all requests made for deliveries at specific times will be met.

Supply Users Based on Crop Category

This strategy invokes the use of crop categories in allocation, taking into consideration the economic benefits derivable from the array of crops irrigated. Ranking of users' crops will be in effect and allocations will be along a specific crop category.

First to be allocated water will be users who grow crops with the highest economic value, and so on to users who grow economically least-derivable-benefit crops, such as pasture. The strategy is particularly well adapted to periods of diminishing streamflow.

Min-Max Ranking System

A ranking system whereby allocations are begun with users who hold the highest number of shares of stock taking all the flow. This group of

users is followed by the next lower level of users and finally by users who hold the least stocks.

When operating under deficit flow conditions, each user at any of the levels will have water for a time period commensurate with the size of his shares.

Systems-Related Strategy

This strategy relates to the two major gravity sprinkle irrigation systems, the hand-move and the wheel-move systems. Users will be classified into two groups under the type of system each operates.

Allocations using this strategy will therefore be along system types, in other words users operating wheel moves will be expected to be irrigating at about the same time. The exact time individuals within system groups are delivered water depends on the overall system hydraulic analysis.

Low Labor Cost Scheme

A management strategy is invoked whereby certain users are to receive their allocations during the low labor cost hours. The scheme is to differentiate on-farm from off-farm users. Under certain circumstances and locations, the cost of irrigation labor to the farmer is lower during weekday first-shift hours compared to other shifts. The first shift is between 8:00am and 4:00pm. The strategy is to make water available to the farmer during the least labor cost hours.

Urban and non-agricultural irrigation stockholders who use water for lawn sprinkling and backyard gardens will have access to water during

the second and third shifts on Saturdays and all three shifts Sundays. For the off-farm user, even if weekend irrigation labor costs are high, the demand on the labor is limited. By and large homeowners do the irrigation by themselves over the weekends, thus diminishing such costs that might be incurred.

One-Time Delivery

This strategy considers supplying the user his allocation of water in a one-time delivery. The one-time allocation will be estimated based on a quantity of water that would refill the entire root zone of his crop in a one-time delivery. Users, through mutual agreements, may trade water among themselves; management must be notified of such deals in advance of trades.

Continuous Supply with Monitoring

Continuous supply of water to users is to be maintained day or night as rations to users. Each user's ration is to be monitored by estimating and counting continuously the number of sprinklers he has operating. The rations are available to the user whether or not they are needed.

Theoretical Considerations of the Strategies

Pure Demand Delivery, Unlimited Access to Water

Pure on-demand delivery schedule connotes a non-imposition of restriction on access to water by a user in terms of how frequent that access is gained or to the amount of irrigation and duration for which

it takes place. Flexible schedules such as this are rare. Such schedules, if they can be implemented, are perceived to improve irrigation efficiency and overall crop yields and quality. This strategy is one that seeks to provide all users equal chances to water and for them to use it unimpeded until irrigation is completed.

Since demand is created by a desire of the user to irrigate, demand delivery systems have downstream regulation. Downstream regulation requires the use of either closed-pipe distribution systems or level-top canals. In closed-pipe systems, such as GSIS's, this downstream regulation is effected by the opening of a take-off valve hydrant.

Effecting delivery of water to users on demand invariably requires an increase in the size of the conveyance structure for the same volume of water that is delivered on continuous flow delivery systems. The operation of on-demand, though more efficient in terms of water use, has recordkeeping requirements which make it seemingly complex when compared to other delivery systems. To operate on-demand effectively, it is necessary to reasonably predict the pattern of water use in the project. Such projections should map out periods when irrigations occur, the irrigation amounts, and the durations of irrigations for the various combinations of crops and soils, and irrigation strategy.

Upon estimating irrigation amounts, individual field requirements of flow are estimated based on its area; project requirements are in turn obtained by summation of field requirements. Project requirements on a daily basis are compared to the supply stream, and if the supply stream is equal to or greater than project requirements then on-demand as a strategy for allocation is feasible. If the supply stream is less than

the project requirements then an alternative strategy to on-demand may have to be used.

The supply stream to a project is based on the divertable flow for which a project (users) or company has its water right determined. The water-righted supply stream or diversions are generally quoted in fractional or percentage amounts of a given stream flow in a body of water such as a creek, river, or groundwater source(s). The percentage or fraction may be fixed or variable over a season.

Users Grouped in Rotation Blocks

Rotation blocks, for the purpose of this study, operate at the lateral (tertiary) level. This is the level at which users operate their individual systems independently. They are linked to the supply laterals by their hydrant take-off valves.

In surface irrigation, two elements are important in designing and operating rotation blocks to optimize sequencing of water delivery to the blocks. These elements are the sizes and locations of the blocks relative to each other and to the supply source. In gravity sprinkle, however, relative locations are important considerations relative to pressure distribution and friction loss. The size of the rotation blocks, which may be delineated according to soil type, topographical, or submain boundaries, should neither be too large nor too small. If rotation blocks are too large, available system flow might become inadequate to satisfy the requirements of the rotation units. If too small, the blocks become too numerous and cumbersome to manage.

Operationally, irrigation water is continually delivered to rotation

blocks; within rotation blocks water is allocated to and rotated among users.

Users Placed on Request

This modified demand strategy is one that expects users to order their water one or more days ahead of use. It differs from the rigid demand system in that some time leeway is given between time of order and the time water is to be delivered. In pure or rigid demand systems, deliveries are expected to be instantaneous. The irrigation company, during the leeway period, would arrange a schedule so that it is able to meet requests made within an advance notice period.

The major problem of the water organizations, mutual irrigation companies, irrigation districts, etc. in this regard is anticipating demands and supplying enough water. The demands tend to be non-uniform and simultaneous. This indicates that water delivery cannot be scheduled long in advance because farmers do not, and perhaps cannot, assess their irrigation needs far in advance.

To predict on-request diversions, hydraulic factors such as traveling time, conveyance and application efficiencies, and irrigation interval are important. Management factors such as cultural practices, allowed soil moisture depletion, and moisture extraction pattern by plant roots are significant considerations. Institutional and social factors like preferred water-rights, holidays, and/or weekend effects are worthy of consideration. Soil events and farming practices like harvesting affect irrigation water management.

Most irrigation systems use upstream control, a system of releasing water from an upstream source in anticipation of demand downstream. Irrigators are required to order water in advance, as travelling time is required to convey water from points of diversion to turnouts. Allen and Brockway (1979) reported that 24 to 28 hours advance notice was required 3by irrigation personnel in southern Idaho; they reported two or more days as travelling time to deliver water from diversions to the distal end of canals in several systems. An irrigator requesting water must ensure that his advance notice is received earlier than the travelling time if he expects his request to be met. The enactment of a uniform advance notice duration, say 24 hours, given by all irrigators to management will auger well for avoidance of miscommunication. As indicated earlier, lack of ability of users to make definitive estimates of irrigation requirements in advance renders the project diversions, at best, rough estimates. Nonetheless the estimates are good indicators of possible incoming requests.

Supply Users Based on Crop Categories

Economic returns from crop enterprises will be used as a basis for setting the categories among the four crops in the study. The four crops are corn for silage, spring grain (barley), pasture, and alfalfa. Apart from pasture, the remaining three crops are grown on Class II irrigated cropland in Utah. The data included in Table 2 were obtained from Utah Agricultural Statistics (1986). The data clearly indicate higher economic returns are derivable from alfalfa as compared to the remaining two crops.

Table 2.--Crop Production Costs and Returns for Corn, Spring Grain, and Alfalfa in Utah for the Year 1985.

Crop	Total Receipt, $/ac	Costs, $/ac.			Net Return, $/ac.	
		Fixed*	Var	Total	Owner-Op	Op-Mgmt
Alfalfa	302.25	16.10	213.26	229.36	72.89	12.89
Barley	204.25	16.10	156.18	172.28	31.97	-28.03
Corn (silage)	374.00	16.10	330.74	346.84	27.16	-32.84

Owner-Op = Owner-operator
Op-Mgmt = Operator-Management
* same for all class II irrigated land
No data on pasture because its considered non-commercial.

The rationale for the use of this strategy is to attempt to save at least the crop that brings the highest returns for the farmer in times of water shortages.

Most users are owner-operators. A small percentage of the users rent the farmland on an annual rent basis. The number of such renters may vary from year to year. From Table 2 it can be seen that users who grow alfalfa have higher economic returns, followed by those who grow barley and silage corn, in that order. The difference in returns from corn and grains is relatively small, and for that reason they are assigned to the same category. As the growing season progresses and water shortages arise, allocations will be given to alfalfa first, followed by spring grain (barley), corn, and pastures. In effect, in the implementation of this strategy only alfalfa has first priority in allocation; the remaining three crops (grain, corn, and pasture) have second, third, and fourth priorities, respectively.

Min-Max Ranking System

Irrigation water stockholders acquire stock for water in share amounts that are highly variable. The variability generally tends to reflect the use to which the water may be put.

Observations show that large shares of stock are acquired by farmers who use the water for irrigation crop production. At the other end of the scale, small amounts of shares ranging from one to five shares are acquired by users who require such water for lawn sprinkling and/or backyard gardening. In between are stockholders with average-sized shares who use water for miscellaneous purposes, including small to medium size agricultural irrigation and lawn sprinkling for city parks, industrial, and commercial firms.

The data provided in Table 3 show the distribution of stockholders and share amounts held and percentage for each stock class. Three class lengths, 10, 20, and 40, were run in order to select a histogram with the least irregularities. The histogram with 40-class length was selected to reduce the number of groups to 4, which is convenient for ranking. Frequency distribution analysis resulted in the data in Table 3 and provided a means of stratifying the users on the numeric values of their stock.

In this study, four ranks are to be recognized and these ranks are to have parity with the classes shown in Table 3. The fourth rank, representing users who hold the large share amounts, has a share equivalent to about 18 percent of the total stock of the company. The first rank is small users; its shares represent about 41 percent of the total stock. In between are the second and third rankings.

Table 3.--Shareholders and Stock Distribution in Shares for User Ranking in Four Stock Classes.

Class	Class Interval* (shares held per stockholder)	Stockholders		Shares	
		Number	% of Total	Amount	% of Total
1	.5- 40.5	414	90.61	2472.49	40.75
2	40.5- 80.5	24	5.25	1376.53	22.69
3	80.5-120.5	12	2.62	1140.13	18.79
4	> 120.5	7	1.53	1078.50	17.77
				6067.65	

* Class interval is defined by the maximum and minimum values of the range.

The percentages of their holdings represent 23 and 19 percents of the total stock, respectively. In keeping with the subtitle terminology, the fourth and first ranks coincide with the maximum and minimum ranks.

Supply along System Types

Two sprinkle irrigation methods commonly used in GSIS's are included. The two methods are hand-move laterals and wheel-move laterals.

The systems' requirements in operating pressures and the resulting flow rates will vary with system type and the make and size of the nozzles. Pressure requirements at sprinkler nozzles as specified by most manufacturers range between 35 and 60 psi for best coefficients of uniformity with agricultural sprinklers.

For these methods, designated as systems in the strategy

classification, Table 4 shows some of the common configurations found in the field. Tremendous range and variation exists, particularly with nozzle sizes that are available. System capacity requirements are relatively variable because of variations in span numbers and lateral inlet pressure differences among locations.

Low Irrigation Labor Cost Scheme

The strategy's general objective is to make irrigation water available to farm users within a schedule that avoids weekend irrigation because of high irrigation labor cost over the weekend,in certain locations and circumstances, as compared to other times (shifts). To minimize such labor costs, it is desirable to irrigate all fields during weekdays, first shift; followed by first-shift Saturday; then second-shift weekdays, and first-shift Sunday. Shift times are 8.00am-4.00pm, 4.00pm-12.00pm, and 12.00pm-8.00am, for first, second and third shifts, respectively.

The strategy has more relevance to those locations where differentials exist in irrigation labor costs with shifts. Using the following relationship and assigning desirability factors for the three shifts, Trava, Heermann, and Labadie (1977) came up with an optimization scheme which significantly reduced irrigations from Saturday evenings through Sunday nights. Labor cost of any shift is estimated thus:

$$C(n)j = K(n)j \times WT(n)j \qquad (1)$$

where $K(n)j$ = labor cost for shift n on day j
$WT(n)j$ = labor availability weight for shift n on day j
$C(n)$-j - desirability factor for shift on day j.

Table 4.-- Hand-Move and Wheel-Move Lateral Sprinkle System Configurations in the Study Area.

Configuration	System type	
	Hand move	Wheel move
Lateral pipe dia., in	3-4	4-5
Spacings (ft x ft)	20 x 40 30 x 40 30 x 50	40 x 60
Nozzle sizes, in	11/64-7/32	5/32-1/4
Pressure required, psi	35-50	45-60
Lateral length, ft	400-720	1040-1280
Range of system Requirement, gpm	180-250	220-250

depending on number of spans (pipe lengths).

Using an artificial labor cost function to optimize the most desirable times (shifts) and applying weighting factors resulted in the desirability factors in Table 5. Since labor cost is directly proportional to desirability for all shifts on all days, the lower this factor is, the more desirable it is for the farmer who hires irrigation labor on said day(s) and shift(s).

The implication of this finding to the least labor cost strategy is that delivery schedules can be drawn to provide water to agricultural users Monday through Friday, shifts 1,2,3 and Saturday shifts 1 and 2. Non-agricultural users are to be serviced with water starting with the 3rd shift Saturday through the three shifts on Sunday. All farm users are expected to complete irrigations within the seventeen shifts, with each user taking water for a time period proportional to shares.

Table 5.-- Desirability Factors for Irrigation Labor Cost for Various Days and Shifts.

Day	Shifts		
	1	2	3
Sunday	15	35	40
Monday		10	25
Tuesday		10	25
Wednesday		10	25
Thursday		10	25
Friday		10	25
Saturday	5	20	30

Source: Trava, Heermann, and Labadie, 1977,

* low numbers indicate greater desirability for irrigation during the shift.

A One-Time Delivery

This strategy gives users the option of demanding to be supplied with water once during the season. The option may be particularly appealing to certain users who may wish to defer taking all of their earlier allocations but be credited later when streamflows are deficient. Alfalfa growers on medium to heavy soils, who hardly need irrigation before the first cutting, may opt for this. Similarly, grain farmers who could possibly rely on residual soil moisture and rainfall might find this strategy viable, since it guarantees them an ample quantity of water to fill up crop root zones, even though delivered in one delivery.

To effect the strategy two assumptions were made:

1. Users are familiar with streamflow hydrographs, and may wish to capitalize on applying ample amounts of water at one time rather than the meager amounts that other strategies would entitle them to when the flows diminish.

2. They are aware of the streamflow regime relative to times when phenologically moisture sensitive growth stages are reached during which soil moisture stress must be averted.

In light of the second assumption, management must identify the moisture sensitive periods for all users' crops for which demand for one-time irrigation deliveries may be made and develop contingencies in the event of such demands. The data in Table 6 present the ranges of dates during which a one-time delivery for water may be demanded by various user types. The range for pasture is continually grazed fields.

Table 6.--Possible Range of Days for a One-time Delivery of Water to Different User Types in the Study Area.

User Types	Range of Days (Julian Date)
Alfalfa growers	125-192[1]
Grain farmers	165-185[2]
Silage Corn growers	205-220[3]
Pasture growers	141-151^

1 - sometime after full cover of the first crop but before second cutting of alfalfa.
2 - period between heading and early grain filling. For an April 15th, planted spring grain it is between June 13th and July 4th.
3 - during period of vegetative growth; about 70-85 days after planting on May 15th.
4 - within the last 10 days in May.

To implement the strategy, specific dates are randomly generated for the users within the range of possible dates depending on user type. For each user, it will be assumed that he had no prior irrigations and relied on residual soil moisture and rainfall. On the date of demand for the one-time delivery, he is allowed to irrigate for a period long enough to refill crop root zones.

Continuous Supply

Users will be supplied with water daily on a continuous basis. Total volumes will depend on the shares of stock, but the delivery rate in gpm will depend on the number of sprinklers he would be allowed to run continuously to dispose of the volume allocated to him. The number of sprinklers the user is running daily for a specified time period must be monitored to ensure his conformity with the rules on the number of sprinklers he is allowed to operate.

Volume allocation on a continuous flow basis is determined as:

$$v_i = f_i V = 1.984 Q_s S_i / TS \qquad (2)$$

where v_i = volume allocated to user i, acre-ft.

f_i = ratio of users shares to the total shares of stock.

S_i = user's shares of stock

TS = total shares of stock of all users that are irrigating.

Q_s = allowed streamflow diversion for the day, cfs.

Depending on the streamflow and the resultant pressure at the delivery points, users will receive their water allocations daily within twenty-four hours, but the number of sprinklers may not vary and so a continuous monitoring of the number operating must be maintained.

The Computer Model

General Description

The computer model is comprised of four submodels. The first is the main program; the second, third, and fourth are designated as HYDRA, SWBAL, and ATTR submodels, respectively. The main program carries out the functions of reading in all input data, performing non-routine calculations such as supply hydrographs, and general control of flow of program.

The HYDRA submodel estimates reference crop evapotranspiration, Et_r, crop ET, irrigation requirement, field volumetric water demands, invokes a strategy for the allocation, and estimates field service priority. The hydraulic network analysis includes determinations of hydraulic grade-lines, operating pressures at delivery points using ground or pipe invert elevations, and sprinkler discharges.

The submodel SWBAL determines water uses and maintains a soil-water balance. It performs the tallying or aggregation of individual field demands. Itemization of potential and actual transpiration by crops and crop yield estimates are carried out in SWBAL.

ATTR uses information generated in the previous submodels to compute strategy attributes which provide a basis for comparison of the strategies. These attributes are included in Table 7, summarizing functions of the submodels. The general flow chart of the model is given as Figure 1. The paragraphs that follow discuss in detail the various submodels.

Table 7.--A Summary of Functions of the Submodels

Submodel	functions
Main program	read in input data control program flow non-routine calculations prints output
HYDRA	invokes a strategy Et_r calculations hydraulic network analysis estimating field demands
SWBAL	soil-water balance fields' demand aggregation crop yield estimates
ATTR	strategy attribute estimate - cost benefit analysis - waiting time - equitability

Main Program

The organization of the model for implementing the allocation primarily addresses the run-of the-river system. In the model, the main program serves the primary responsibility of controlling program flow. It also carries out a number of non-repetitive calculations. It uses appropriate subroutines to carry out the calculations.

An advantage of using the subroutines for performing repetitive calculations is that it keeps the main program smaller and easy to debug when errors arise.

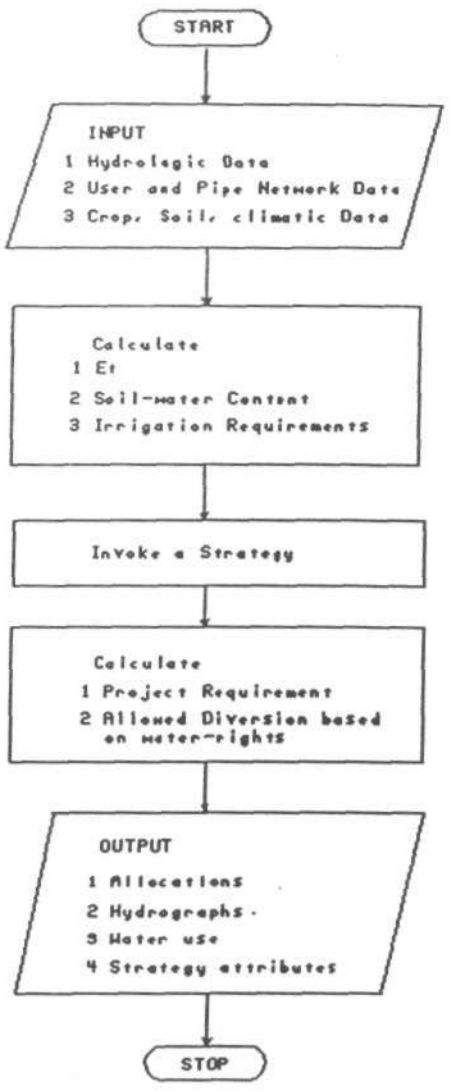


Figure 1.--General Flowchart for the Gravity Sprinkle Irrigation System, GSIS, Model.

Input Data

Input data specifications are grouped into two categories. The first category is for data pertaining to user information, while the second relates to information about the hydraulic network. These data sets are contained in files named UZAS.DAT and NETWK.DAT, respectively.

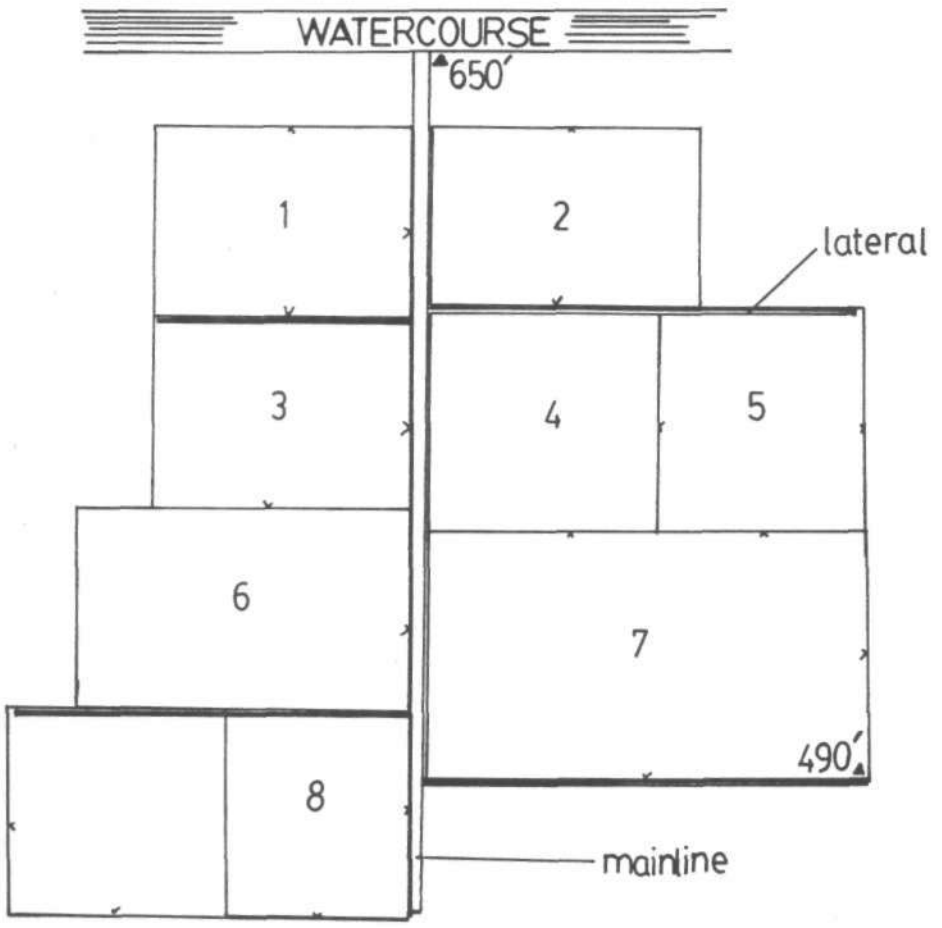
The user data consist of the following information with respect to each user as follows:

-- field/user code
-- user's field area in acres
-- shares of stocks
-- delivery pipe number serving the user
-- sprinkle system type
-- codes for rotation irrigation strategies
-- a code associated with sprinkler nozzle type
-- number of sprinklers operated by the user
-- crop type
-- planting/begin growth date of the crop

The hydraulic information relating to each pipe section in the network consists of:

-- pipe number
-- pipe diameter in inches
-- pipe length in feet
-- pipe material, e.g. Welded steel or PVC
-- Hazen-william's friction coefficient
-- elevation of the pipe at its downstream end
-- demand at end of pipe
-- node number
-- upstream pipe number
-- downstream pipe numbers, if none, zero is entered. Three downstream pipes are allowed at each node.

In the data files, UZAS.DAT and NETWK.DAT, user and hydraulic information are preceded by the number of users and number of pipe sections, respectively. Figure 2 depicts a typical gravity sprinkle irrigation system, GSIS, showing the physical layout.



Legend:

3 user
▲ elevation

Figure 2.--Representation of a Typical Gravity Sprinkle Irrigation System, GSIS.

For clarity, elevation contour lines are left out of the drawing, but it must be realized that the canal and associated diversion (turnout) structures are at higher elevations relative to the irrigated fields.

Field sizes, crop and soil types, and other site-specific input data are discussed later in the appropriate paragraphs dealing with model field application.

The Output

The output for any one allocation run contains information regarding the strategy used. In a tabular form, information on allocation is given in the following order for each user: user name, nozzle pressure, discharge per sprinkler, total delivery time, and scheduled time on/off. Additional output with respect to the run is contained in the file UNCODEM.DAT, from which plots are made of supply and demand hydrographs, number of users irrigating, numbers of pumps in use in situations where augmentation is applicable, and precipitation amounts.

Submodel HYDRA

The submodel HYDRA, illustrated by the flowchart given in Figure 3, provides a work area in which routine calculations of crop water requirements and the need for irrigation are performed. It uses data stored in files SOIL.DAT, CROP.DAT, and CUM.DAT at the various stages of the computations for crop ET, etc.

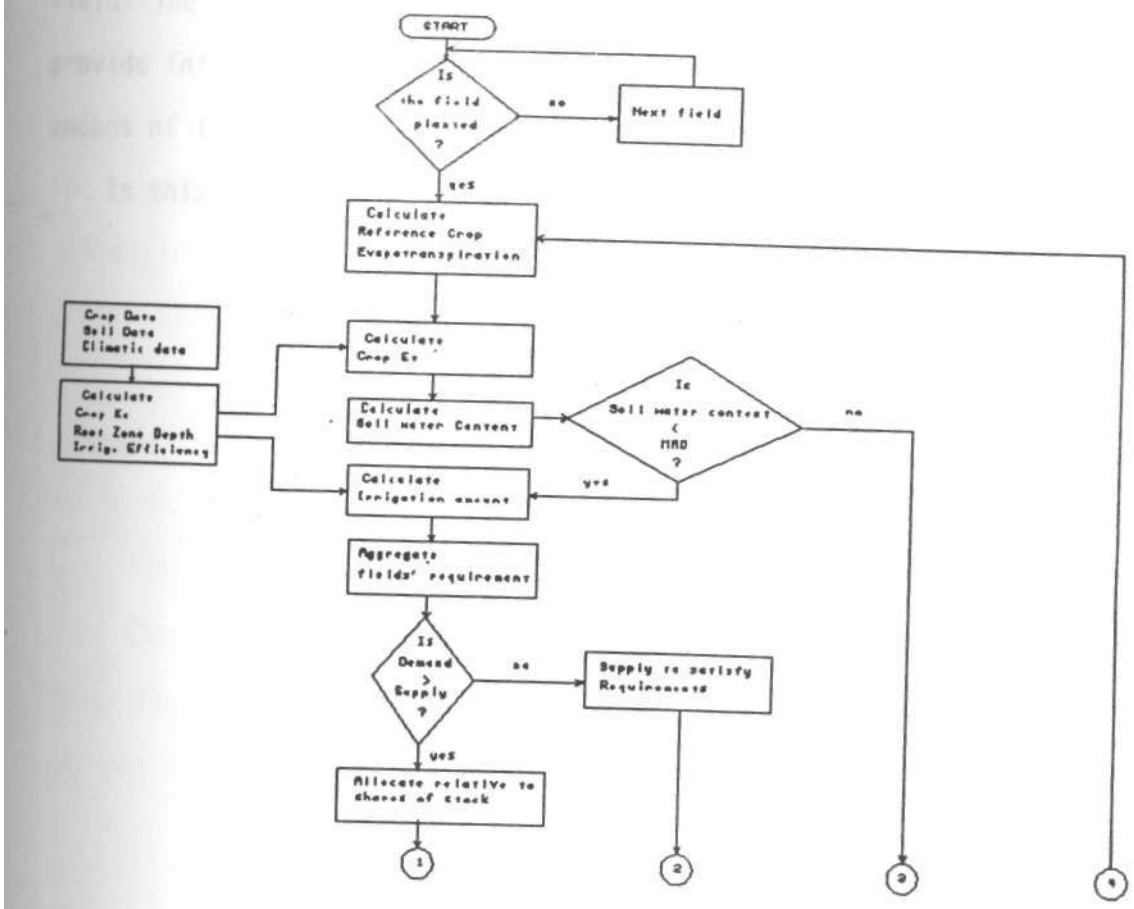


Figure 3.--The Submodel HYDRA.

Computation of Crop Evapotranspiration

Computation of crop evapotranspiration for the crops in the study (i.e., corn, spring grain, pasture, and alfalfa) is necessary in order to effect soil moisture budgeting of each crop/soil combination on each field. The computation will facilitate irrigation scheduling which will provide information as to when demand for irrigation would occur and the amount of irrigation water that is required.

In this study, actual crop evapotranspiration was computed from:

$$E_t = K_c . K_s . E_{tr} \qquad (3)$$

where E_t = estimated crop evapotranspiration

E_{tr} = the reference crop evapotranspiration computed from the Jensen-Haise equation.

Kc = crop coefficient computed by the use of a phenology clock. It is computed for each crop by a combination of julian day, planting, effective cover and harvest dates.

K_s = soil moisture stress coefficient. K_s=1 for an irrigation system in which maximum E_t is allowed.

Computation of Reference Crop Evapotranspiration, Et_r

A number of empirical formulae are available for estimating reference crop evapotranspiration using climatic data. The choice of any one formula is generally dictated by the availability of historical climatic data. The simplest, and perhaps one that is most widely used because of its simplicity, is the Blaney-Criddle formula. It requires an input of only temperature.

The second group of formulae is those that require both temperature and radiation (called temperature-radiation methods). Some of the formulae in this group may use sunshine records in lieu of solar radiation data.

The Penman Combination method and many of its modified versions combine both an energy term (radiation) and an aerodynamic term (wind and humidity) for estimating Et_r. This group of formulae is most suited to locations where facilities exist for collecting the necessary data. The data input for these methods is more than those required for the other equations.

For this study, the data were obtained from a weather station in Newton, Utah (the nearest weather station to Richmond, Utah) in a microprocessor (Datapod DP219). The instrument sampled air temperature and solar radiation and calculated reference crop evapotranspiration, Etr. The Datapod accumulated the calculated Et_r on a daily basis. A temperature-radiation (Jensen and Haise, 1963) equation for computing Etr was used to program the Datapod. The equation is in the form:

$$Et_r = C_t(T - T_x)R_s \times CF \qquad (4)$$

where Et_r = reference crop evapotranspiration, inches

C_t and T_x are site specific calibration coefficients.

T = average daily temperature (in degree F)

R_s = total daily solar radiation (in cal/cm^2)

CF = .000673

The site-specific coefficients were determined when the Jensen-Haise formula was calibrated against the modified Penman equation (Kimberly, Idaho parameters) at a few sites in northern Utah and southern Idaho. The values as given in Allen and Hill (1988) are T_x = -17.78 if temperature, T is measured in degree C (T_x = 0.0 if T is in degree F) with Ct being, respectively, 0.009 for valleys with extensive irrigated or wetland area and 0.011 where the surroundings were predominantly arid lands.

The daily Et_r values used herein were based on the accumulated values obtained from the Datapod. A 5th-power polynomial equation was derived that best fit the Datapod data. The general form of the polynomial equation is:

$$Et_r = B_0 + B_1X + B_2X^2 + B_3X^3 + B_4X^4 + B_5X^5 \quad (5)$$

where Et_r is as previously defined,

X = present day in julian day,
B_0 = 5.3699E-02
B_1 = -2.7443E-03
B_2 = 5.6347E-05
B_3 = -2.3162E-07
B_4 = 1.6664E-10, and
B_5 = 2.7704E-13.

The Datapod and polynomial estimated Et_r values are plotted in Figure 4. The polynomial equation was used in the model for daily estimates of Et_r for the site. Where such equations are used instead of raw data to estimate Et_r, it is imperative that the coefficients are those derived for the site.

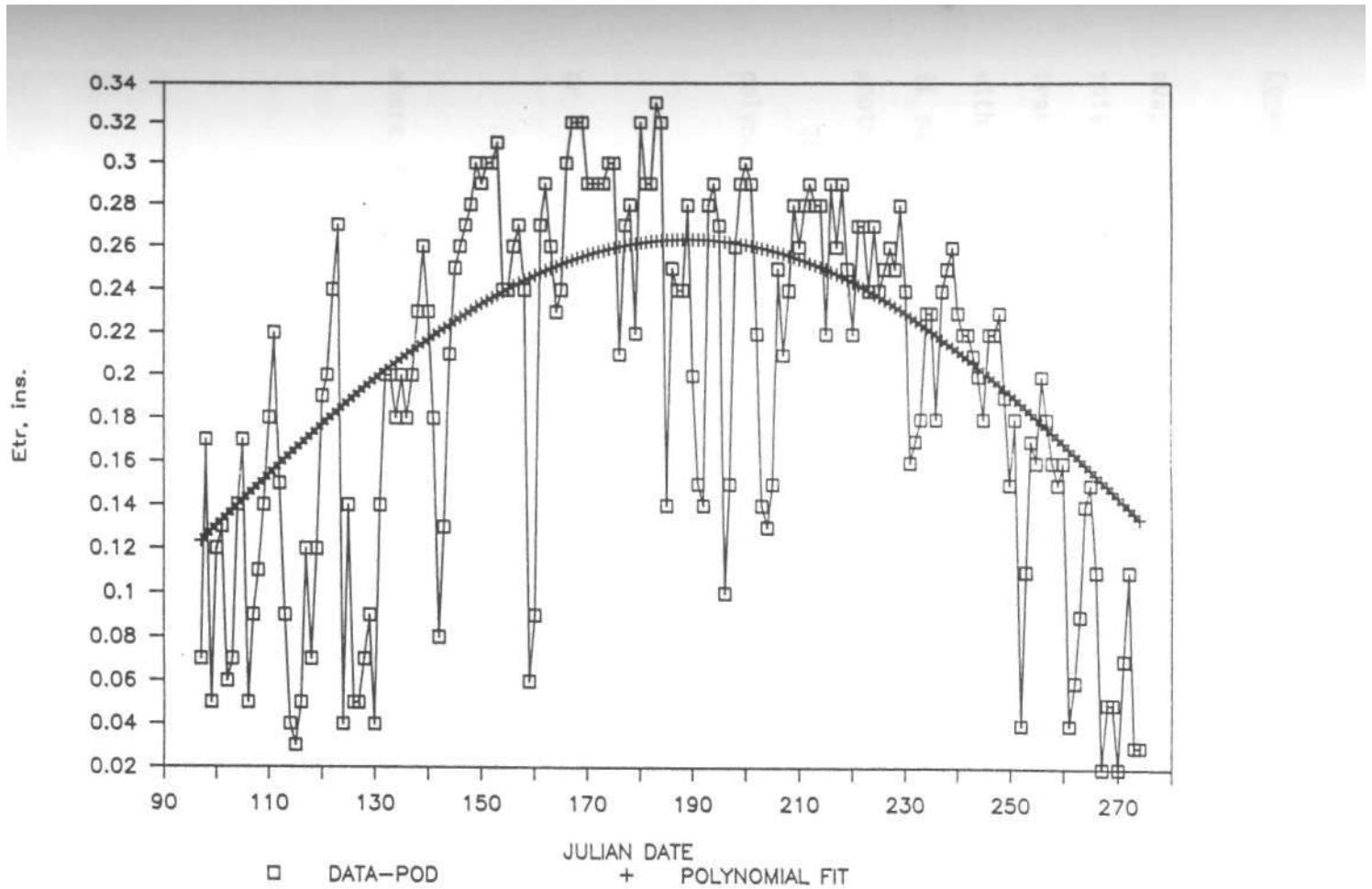


Figure 4.--Reference Crop Evapotranspiration, Et_r, and Best-fit Polynomial for Et_r as a Function of Time.

Computations of Crop Coefficients, K_c

The crop coefficient is defined as the ratio of actual crop evapotranspiration to reference crop evapotranspiration when soil moisture is non-limiting. This is a condition wherein the crop is transpiring freely without soil moisture stress. Crop coefficients vary with crop variety or species, time of planting, and growth stages. While it may be possible to transfer crop coefficients from one location to another, local or regionally calibrated coefficients are preferred.

The mean crop coefficient, K_{cm}, used in the model is given in two polynomial equations:

$$K_{cm} = a_0 + a_1 r + a_2 r^2 + a_3 r^3 \qquad (6a)$$

or

$$K_{cm} = b_0 + b_1 d + b_2 d^2 + b_3 d^3 \qquad (6b)$$

where K_{cm} = estimated daily mean crop coefficient, Et/Et_r, including evaporation from wet soil surfaces (Wright 1981 and Wright 1982).

r = percentage of time from planting to present time relative to days from planting to effective cover (estimated by subtracting planting date julian day from present day and dividing by the number of days from planting to effective cover), expressed as a percent. The r value is only used to estimate K_{cm} before effective cover.

d = number of days after effective cover, used in equation (6b) to estimate K_{cm} after effective cover.

$a_0,..,a_3,b_0,..,b_3$ are coefficients for the polynomial equations. Their values were determined by regression analysis. The values of the coefficients for the four crops in the study, and those of other crops, are given in Table 8 (Source: Allen and Hill 1988).

The mean crop coefficients using the polynomial equations are given in a composite plot for alfalfa, silage corn, and small grain as Figure 5. Plot for the root growth function (discussed later) is superimposed on the figure.

Soil Moisture Stress Coefficient, K_s

As plants use moisture and the soil water content begins to decrease from field capacity to permanent wilting point, extraction of water by the plant roots becomes progressively more difficult. K_s is a ratio used to express actual crop Et under limiting soil moisture condition to crop E_t when the soil moisture condition is at field capacity. It varies with evaporative demand rate, soil moisture content, the soil, and the crop. Various relationships are available in the literature relating K_s with soil moisture content.

In this study, the model proposed in Hill, Hanks, and Wright (1984) was used. The model assigns K_s a value of 1 from field capacity to a specified allowable soil moisture deficit variable with the crop. For higher deficits, K_s varies linearly to reach zero at permanent wilting point.

$$\text{i.e } K_s = 1.0 \qquad \text{if } AWC > Sm_{th} \tag{7a}$$

However, if the currently available soil water content is less than a threshold soil water content, then K_s is estimated as:

$$s = AWC/Sm_{th} \tag{7b}$$

where AWC = currently available soil water content.

Sm_{th} = threshold soil moisture value specified for the crop depending on its current growth stage.

Table 8.--Coefficients for Polynomial Equations Describing the Mean Crop Coefficients, K_{cm}[a].

Crop[c]	Before effective cover, r[b]				Limits on K_{cm}	
	a_0	a_1	a_2	a_3	Max	Min[d]
Spring grains	0.1580	-0.3084	2.966	-1.756	1.00	0.20
Beans	0.2078	-0.4680	2.562	-1.340	0.95	0.20
Peas	0.1983	-0.1972	1.667	-0.7323	0.93	0.20
Potatoes	0.1970	-0.6813	3.148	-1.884	0.78	0.20
Sugar beets	0.1965	.998E-2	-0.1929	1.000	1.00	0.20
Corn	0.2010	-0.7520	2.476	-0.9615	0.95	0.20
Alfalfa (before first cutting)	0.3113	1.248	-0.5599	0	1.00	0.30
Winter wheat	-0.1540	2.252	0.3415	-1.438	1.00	0.30
Pasture	0.80	0	0	0	0.80	0.80
Orchard, w/cover[e]						
apples-cherry	0.1855	1.503	-0.3093	-0.2894	1.10	0.30
peaches	0.1862	1.527	-0.7531	-0.04011	1.00	0.30
Garden[f]	0.2160	-0.0226	0.8178	-0.1877	0.85	0.25

Crop[c]	After effective cover, d[g]				Limits on K_{cm}[h]	
	b_0	b_1	b_2	b_3	Min	Days after
Spr. grains	1.004	0.02925	-0.1100E-2	0.7079E-5	0.1	70
Beans	0.9806	0.01745	-0.1295E-2	0.1232E-4	0.05	60
Peas	1.105	-0.02512	0.1799E-3	-0.3741E-6	0.1	70
Potatoes	0.7879	0.8353E-4	-0.3561E-4	-0.2817E-6	0.2	100
Sugar beets	1.187	-0.7856E-2	0.7628E-4	-0.4643E-6	0.0	100
Field corn	0.9740	-0.2157E-2	0.8648E-4	-0.1741E-5	0.25	90
Sweet corn	0.9514	0.4186E-2	-0.2097E-3	0.5963E-6	0.1	90
Alfalfa[i]	0.245	0.0378	0	0	--	--
Wint. wheat	1.052	0.0530	-0.1972E-2	0.1456E-4	0.1	70
Pasture	0.80	0	0	0		
Orchard, w/cover						
apples-cherry	1.090	-0.3638E-3	0.3000E-4	-0.6004E-6	0.8	90
peaches	1.001	-0.1422E-2	0.8196E-4	-0.1210E-5	0.8	90
Garden	0.8288	0.008379	-0.8141E-3	0.8243E-5	0.2	55

Table 8 footnotes on next page.

Table 8. footnotes.

[a]Adapted from: Allen and Hill (1988).
These equations were developed at USU Ag and Irrig Engrg. Dept. based on tabular values presented by Wright (1981), except for orchard and garden which were adapted to an alfalfa reference from FAO 24 (Doorenbos and Pruitt, 1977 rev.).
[b]Before effective cover: $k_{cm} = a_0 + a_1 r + a_2 r^2 + a_3 r^3$, r in percent/100.
[c]Some crop equations are not included in present microcomputer version.
[d]Wright (1981) suggests that the minimum k_{cm} value of 0.2 is appropriate for relatively dry surface soil conditions from planting until significant crop development. For moderately wet surface soil, as with pre-emergence irrigation or some precipitation, use 0.35 and for very wet conditions, 0.50.
[e]Begin growth April 1; estimated effective cover July 15.
[f]Garden represents a composite of several crops. Assumed planting date May 1, effective cover 90 days later.
[g]After effective cover: $k_{cm} = b_0 + b_1 d + b_2 d^2 + b_3 d^3$, d in days.
[h]Same maximum as before cover. Minimum value is imposed following the indicated days after effective cover.
[i]Time base is days since previous cutting, same maximum and minimum k_{cm} values as before effective cover.

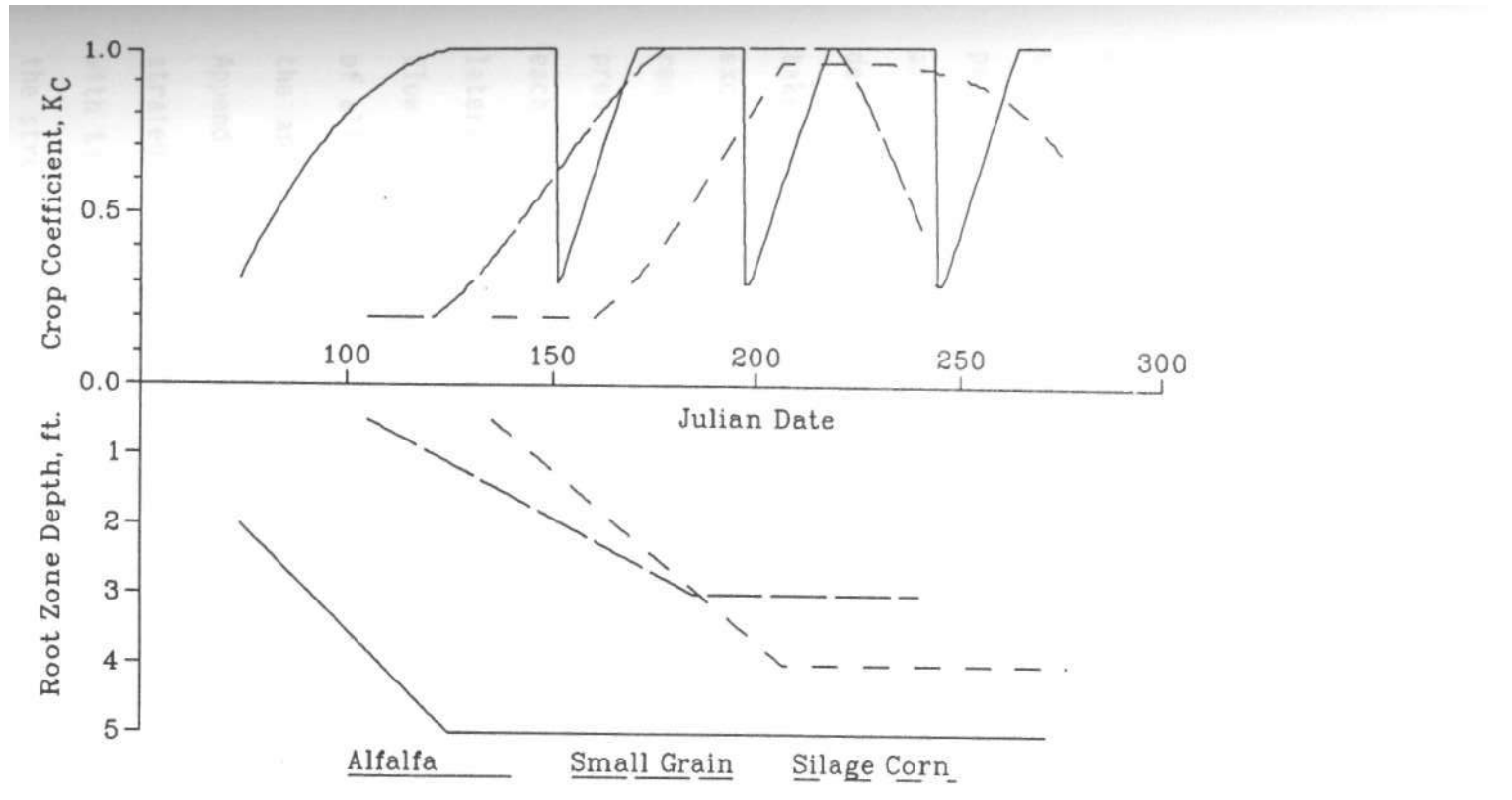


Figure 5.--Plot of Mean Crop Coefficients Using the Polynomial Equations, and Root Growth Function Plots for Alfalfa, Silage Corn, and Small Grain.

Irrigation Amounts and Delivery Time

Except when there is ample streamflow in excess of irrigation requirements, the two major factors that will determine irrigation amount and delivery time for each user in a constrained situation are stream flow during the periods of allocation, and the shares of stock that the user owns. These two factors are translated into volume amounts per day, in either acre-ft or cu-ft. Having estimated these volume amounts, flow rates, which are a function of pressures at each user's delivery point, are then used to estimate times (in hours) that it would take to deliver all of the user's volume. The delivery time, if it exceeds twenty-four hours, continues to the next day. The flow requirement for the next day takes into account any carry-over from the previous day(s). Flow rates are in gpm, or any other convenient unit for each of the sprinklers that the user has operating. Usually, average lateral pressure is estimated and used to estimate average sprinkler flow rate and application rate. As stated earlier, dividing total volume of allocated water by delivery flow rate or gross depth to be applied by the application rate gives an estimate of delivery time. Included in Appendix 4 is a sample output of allocated deliveries for the on-demand strategy. Note the variation of irrigation delivery times for each user with time. This is a result of the diminishing stream flow depicted by the streamflow hydrograph for any one year.

The depth of the applied water may not be equal to the required gross depth of irrigation. This is because the amounts in shares of stock that the farmer buys may not directly correlate to the crop or acreage of his field. While it is true that allocations made to the user

may not satisfy his crop needs or be frequent enough, the user has to settle for what his water right is.

Field Demand Capacity Determinations

Most of the studies reported in the literature regarding capacity determinations tended to be concerned with individual crops and sometimes single soil types, or were applied to a limited geographical area. Kaewkulaya (1980), Maidment and Hutchinson (1983), Angeles and Hill (1985), Abdellaoui (1986), and Keller (1987) are some recent works which treat more than a single crop and soil. Fonken, Steele, and Fischbach (1974) and Hagan and Wang (1977) treated canal capacities for sugar-beet and irrigated rice, respectively.

If water is to be delivered to users on an on-demand schedule, the irrigation demand for each field has to be related to soil moisture deficit, which is a function of the management-allowed depletion. Rotation schedule, on the other hand, imposes an irrigation demand tied to the rotation that either maintains the amount fixed or variable depending on the nature of the adapted schedule.

The computed net irrigation depth adjusted for losses by the application efficiency gives the gross irrigation depth which is then used to estimate field demand capacity as:

$$q = a \times d/t \qquad (8)$$

where q = field demand capacity, cfs.
a = field area, acre.
d = gross depth of irrigation, in.
t = time to apply the irrigation, hr.

The application efficiency, discussed later, used to estimate gross depth of application varies with level of management, environmental factors, and irrigation system type. The time of water application, t, can be related to infiltration rate of the soil in order to curtail surface runoff and/or ponding. The application rate is estimated thus:

$$i = 96.3 \times q_s/(S_m \times S_l) \qquad (9)$$

where i = application rate, in/hr

q_s = discharge per sprinkler, gpm

S_m = lateral spacing along mainline, ft

S_l = sprinkler spacing along laterals, ft

The application rate estimated from equation (9) will be constrained by soil infiltration rates, since no ponding is allowed as earlier indicated. Discharge from the sprinklers is a function of available operating pressure at the nozzle and the nozzle type. Operating pressure at the nozzle is based on the average pressure in the laterals. The relationship between sprinkler discharge and nozzle pressure is:

$$q_a = K_d P^{0.5} \qquad (10)$$

where q_a = sprinkler discharge in gpm.

K_d = sprinkler discharge coefficient

P = nozzle pressure in psi.

Average Pressure in the Lateral

Water is delivered to the user via the mainline to his lateral(s) with an inlet pressure, P_l. The relationship between lateral inlet pressure and average pressure in the lateral is (Keller 1986):

$$P_a = P_l - (3/4(P_f)_a + 1/2\tilde{o}P_e + P_r) \quad (11)$$

where P_a = average pressure in the lateral, psi.

P_l = lateral inlet pressure, psi.

$(P_f)_a$ = allowable pressure loss due to pipe friction, psi.

$\tilde{o}P_e$ = static pressure gain/loss due to elevation change between inlet and closed ends along the lateral; positive (+) uphill and negative (-) for downhill lateral, psi.

P_r = pressure loss due to riser height, psi. For hand move lateral in corn crop, a riser standing a maximum height of 8 ft results in P_r = 3.46 psi.

The allowable pressure loss due to pipe friction varies with the multiplicity of outlets in the lateral and is adjusted by a coefficient. It also varies with allowable head loss gradient. An equation for estimating $(P_f)_a$ (Keller 1986) is:

$$P_f = (J_a \times F \times (L/100))/K \quad (12a)$$

or

$$H_f = J_a \times F \times (L/100) \quad (12b)$$

where P_f = pressure loss due to pipe friction, psi

H_f = head loss due to pipe friction, ft

J_a = allowable head loss gradient, ft/100 ft.

L = length of the lateral, ft.

F = multiple outlet adjustment coefficient; for outlets ranging between 21 and 31 inclusive, F = 0.36

K = a conversion factor, (K = 2.31, English units).

A power relationship estimated the allowable head loss gradient in various pipe materials as a function of flow rate in the lateral as:

$$J_a = CQ^n \qquad (13)$$

where Q = flow rate in the lateral, gpm.

The values of the coefficients C and indices n, obtained from the plot of J_a versus Q included in Table 9, are shown in Figure 6 for various portable aluminum pipe laterals with couplings every 30 ft.

Table 9.--Coefficients and Indices for Use with Friction Loss Gradients, J, and Lateral Flow Rate, Q, Equations.

Pipe diameter	Coefficient, C	Index, n
2	0.00563	1.851
3	6.699E-04	1.856
4	1.680E-04	1.853
5	5.540E-05	1.852

original tabular data from Keller, J. (1986).

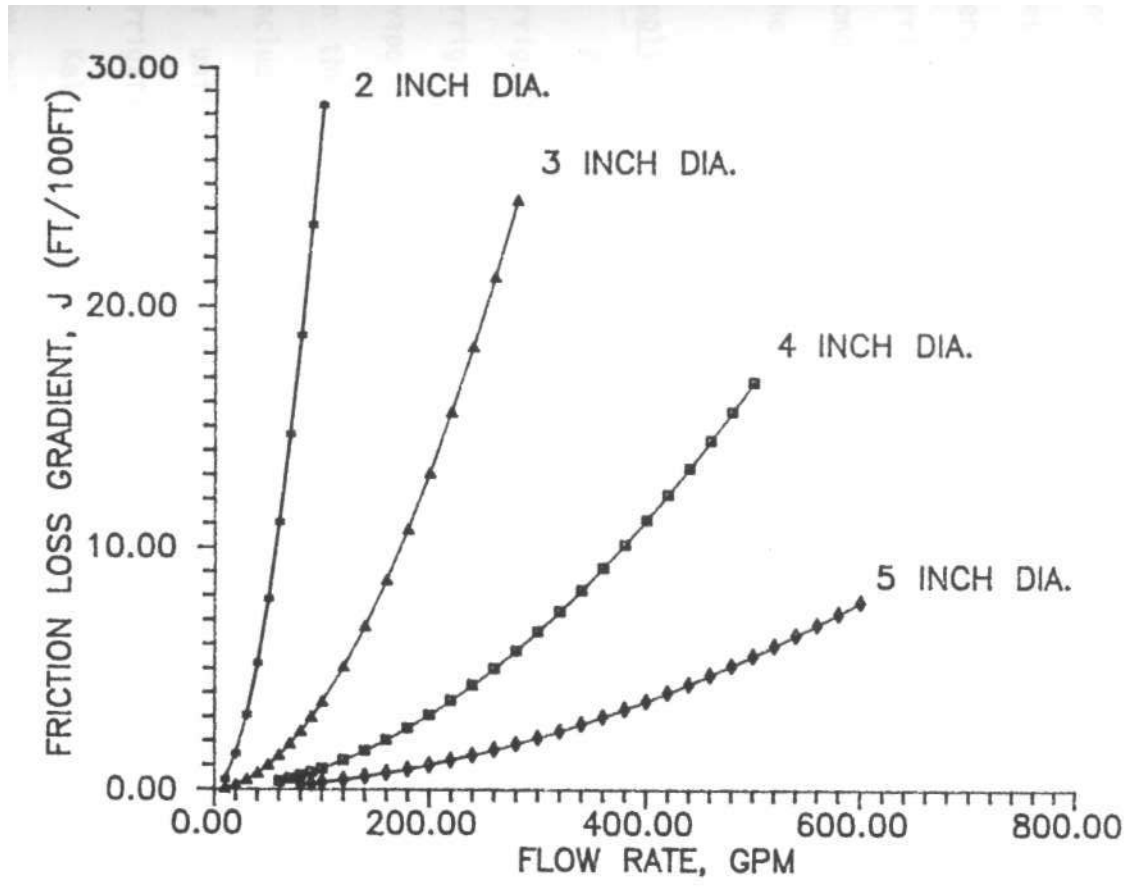


Figure 6.--Plot of Friction Loss Gradient as a Function of Flow Rate in Portable Aluminum Lateral Pipes.

Field Irrigation Efficiency

Field irrigation efficiency, as used herein, is defined as that portion of the water delivered to a sector (unit command area) outlet which is actually stored in the root zone for eventual use by the crops. The term encompasses both the on-farm irrigation application efficiency and the conveyance efficiency which accounts for conveyance losses between the turnout and the field. On-farm application efficiency is generally more difficult to determine and has more effect on field irrigation efficiency. This is because water is conveyed in closed conduits and conveyance losses, if any, are relatively low compared to the magnitudes of on-farm application efficiencies.

Application Efficiency

Application efficiency, E_a, is the ratio of average depth of applied irrigation water stored in the root zone to the average depth of irrigation applied. This ratio indicates losses of water that end up as evaporation and transpiration, since a large portion of the water stored in the root zone is used in evapotranspiration. The ratio does not include any indication of adequacy of irrigation. Combining some measure of uniformity, adequacy of irrigation, and of losses renders the irrigation efficiency concept more useful.

Keller (1986) suggested two concepts, application efficiency of the low quarter, E_q, and application efficiency based on the average of low half depth, E_h. The terms are useful for placing numerical values on application efficiencies for medium to high value crops and for lower value field and forage crops, respectively.

The efficiencies are estimated as:

$$E_q = DU \times R_e \times Q_e \quad (14)$$

and

$$E_h = CU \times R_e \times Q_e \quad (15)$$

where E_q = application efficiency of the low quarter

E_h = application efficiency based on low half average depth

R_e = effective portion of the applied water

Q_e = ratio of water effectively discharged through the sprinklers to total system discharge

DU = distribution uniformity for the water application

CU = coefficient of uniformity.

The ratio Q_e is a measure of how well the irrigation system is maintained. Where leaks and drainage losses occur, such as at sprinkler bearings and couplings, and can be kept at less than 1 percent, then $0.99 < Q_e < 1$. If the leaks can be eliminated entirely, then $Q_e = 1$. Some poorly maintained systems have $Q_e <= 0.90$. The model generates Q_e values for individual fields with values ranging between 0.90 and 1.

The effective portion of applied water, R_e, is arrived at from the itemization of wind drift (spray loss) and evaporation losses. The losses are relatively low when irrigating a fully vegetative canopy crop in low winds. Under the common conditions prevalent in the field, the losses range between 5 and 10 percent, in severe conditions even higher.

To estimate R_e, factors such as potential evapotranspiration and plant canopy are considered. A coarseness index, CI, was developed to estimate the nature of spray from sprinkler nozzle. The index is estimated from:

$$CI = K \times P^{1.3}/B \qquad (16)$$

where P = nozzle operating pressure, psi.

B = nozzle diameter, in

K = conversion factor, 1/64 for English units.

Using Figure 7 adopted from Keller (1986), if CI < 7 the spray is coarse and the lower portion of the figure is used. If CI > 17, the spray is fine and the upper portion of the figure is used instead. If 7 < CI < 17, then R_e is interpolated as:

$$R_e = (CI-7)/10 \times (R_e)_f + (17-CI)/10 \times (R_e)_c \qquad (17)$$

where $(R_e)_f$ = R_e value from fine spray curves.

$(R_e)_c$ = Re value from coarse spray curves.

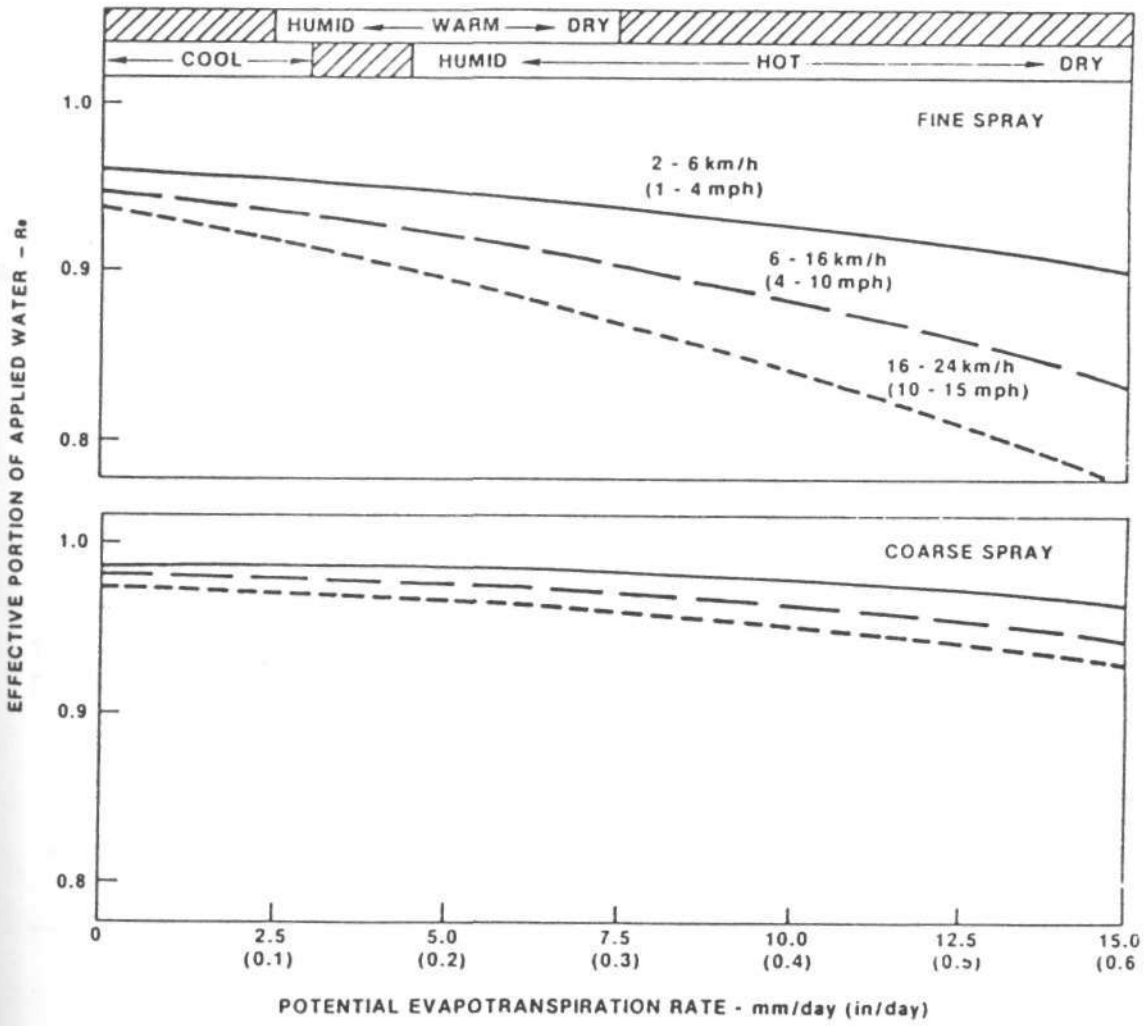


Figure 7.--Effective Portion of Water Applied by Sprinkling, Re, which Reached the Soil Surface under Different Environmental and Spray Conditions.

The spray curves are defined in a relationship with potential evapotranspiration for inclusion in the model as given in equations (18a) and (18b). Both equations are exponential decay functions of potential evapotranspiration. Table 10 contains values of coefficient K and exponent a for the equations for various wind conditions and spray types:

$$(R_e)_f = K \times EXP(a \times ET_r) \qquad (18a)$$

and

$$(R_e)_c = K \times EXP(a \times ET_r) \qquad (18b)$$

where ET_r = potential evapotranspiration, in/day

other terms are as previously defined.

Table 10.--Estimated Values for Coefficient K and Exponent a Used with R_e versus ET_r Equations.

Wind speed (mph)	Fine spray		Coarse spray	
	K	a	K	a
1 - 4	0.968	-0.117	0.954	-0.334
4 - 10	0.965	-0.236	0.988	-0.068
10 - 15	0.980	-0.084	0.989	-0.041

Rotation Irrigation Requirement

In each of the rotation-based strategies, rotation blocks, which may vary in number between two and four, are subdivided into rotation units. The number of rotation units in each block is not the same, as the number of fields constituting the blocks vary among blocks. It might be more convenient for management if all rotation units within the block are of the same size, but this is not the case in real life, since field sizes even within the same farm are often variable.

Irrigation water is continuously delivered to the rotation block turnout, and it is subdivided to rotation units. The delivery of the water to different rotation units is completed in one rotation interval. A rotation interval may be one week, ten days, two weeks, or more depending on the number of rotation units. Delivery of water for rotation irrigation can be implemented in one of two practical methods:

1. Fixed time-variable discharge method: Duration for the delivery of water is fixed and is usually one day or multiples thereof, but the discharge is varied depending on the size of the area to be served in the rotation unit. This method has wider application in surface irrigation where variable discharge at the user level can be accommodated. Variable discharges are not suitable for sprinkle irrigation as uniformities are adversely affected.

2. Variable time-fixed discharge method: The delivery of water to the rotation unit is of fixed discharge but the delivery time varies depending on the size of the area served. The rotation cycle is completed in the number of days it takes to serve water to all the rotation units in the block. Except where deliveries are constrained by

shares of stock of the user, the volume of water delivered should restore the soil moisture that was lost between rotation intervals. The variable discharge-fixed time method is used in the model.

In determining rotation irrigation requirements, all the assumptions previously made, when on-demand was considered, concerning estimates of rooting depths, crop coefficients, and available water are valid.

The first irrigation requirement is determined from April 11th for the first rotation and the process is repeated continuously thereafter for each rotation. A 15-day rotation cycle is used as illustrated in Figure 8 for the blocks shown in Figure 9, in which the rotation blocks constitute contiguous fields. Three blocks are demarcated with the strategy of users in rotation blocks. Table 11 gives the first irrigation dates of the cycles for all rotations. The dynamic water balance equation is:

$$SWS_{u,t} = SWS_{u,t-1} - ET_{u,t} + Ir_{u,t} + Pr_{u,t} - Dr_{u,t} \qquad (19)$$

subject to: $SWS_{u,t} = SWS_{fc}$ if $SWS_{u,t} > SWS_{fc}$

and $SWS_{u,t} = 0$ if $SWS_{u,t} < 0.0$

where $SWS_{u,t}$ = soil water storage within the root zone depth expressed as a depth of water on the day of u-th rotation period. After the irrigation, the soil water storage is set to SWS_{fc} if root zone is refilled.

SWS_{fc} = soil water storage within the root zone depth at field capacity water content, expressed as depth of water.

$ET_{u,t}$ = actual crop evapotranspiration for the day, expressed as depth of water. It is estimated from product of crop coefficient and

reference crop evapotranspiration for the day.

$Ir_{u,t}$ = irrigation depth applied on day t for u-th rotation.

$Pr_{u,t}$ = precipitation (rainfall) for the day, t in depth units.

$Dr_{u,t}$ = drainage that occurred from the root zone into deep percolation, expressed in depth units.

Table 11.-- The First Irrigation Date in a 15-day Irrigation Rotation with 10 Days On and 5 Days Off.

Rotation Number (1)	First irrigation date*	
	Julian Date (2)	Month, Date (3)
1	101	April 11
2	116	26
3	131	May 11
4	146	26
5	161	June 10
6	176	June 25
7	191	July 10
8	206	25
9	221	Aug. 9
10	236	24
11	251	Sept. 8
12	266	23

* for users in rotation unit 1.

It was assumed that all drainage losses are the results of effluent from the root zone due to excessive rainfall amounts. Irrigation raises soil water content to above management allowed deficit or possibly to field capacity moisture content; it makes no contribution to deep percolation.

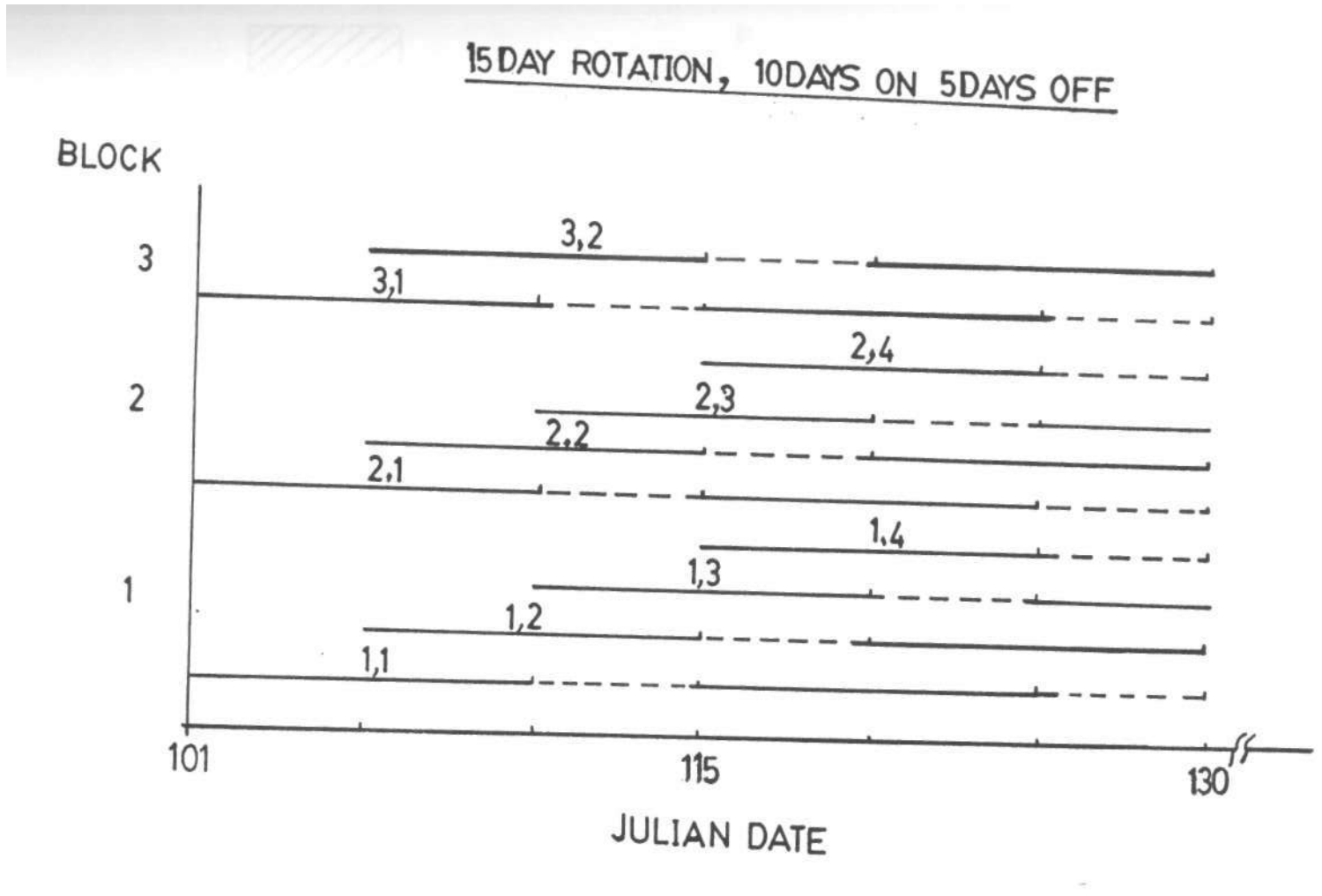


Figure 8.--Schematics of a 15-day Rotation Irrigation, 10 Days On and 5 Days Off, Users in Rotation Blocks.

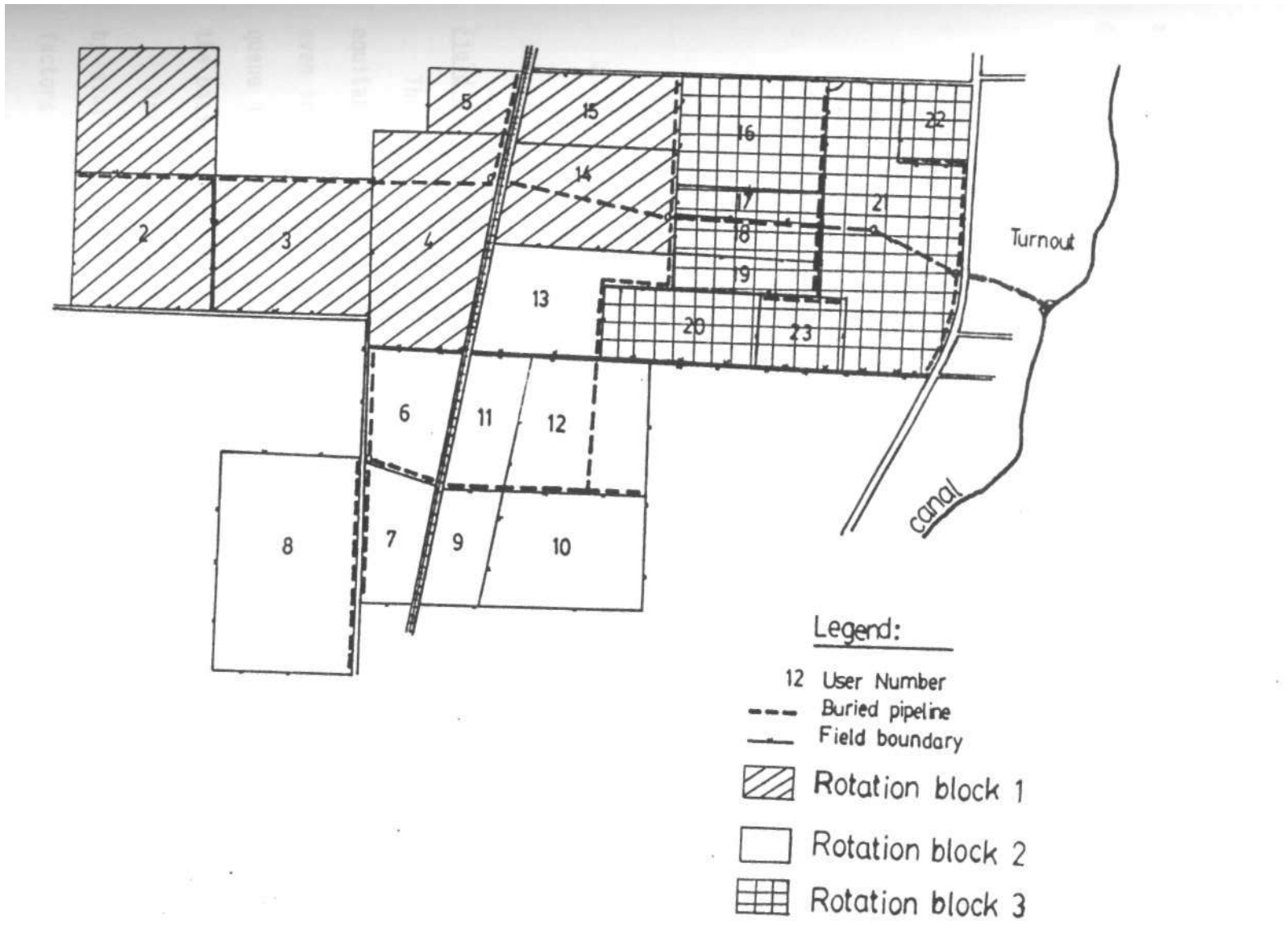


Figure 9.--Typical Fields that Constitute Rotation Blocks.

Runoff is assumed equal to zero, as all rainfall and irrigation is assumed to have infiltrated into the soil. The irrigation requirement is estimated as:

$$Q_R = \sum_{b=1}^{NB} \sum_{u=1}^{NU} [(SWS_{fc} - SWS_{u,t})/\epsilon] \times A_u/RI \times K \qquad (20)$$

where Q_R = irrigation requirement for a particular rotation, in cfs.

A_u = user field area, in acres

RI = rotation interval, in days

NU = number of users in the rotation block

NB = number of blocks in the rotation unit

ϵ = estimated user irrigation efficiency

K = conversion factor (K=0.042).

Field Service Priority in the Queue

The study emphasis is on implementing strategies that facilitate equitable allocation of water to all users. The available water supply, even in times of shortage, must be equitably shared by all users in the queue in the interest of common good. The queue discipline will be on the basis of "First Come First Served", FCFS.

Arrival in the queue when operating on-demand schedule is triggered by available soil water content and management allowed deficit. Both factors are discussed later. Field priority in a queue is important particularly when shortages in the supply stream are imminent. Some governing rules with regards to allocations will need to be enforced. Prioritization becomes irrelevant if the available supply is abundant.

For all modified rotation strategies, arrival will be regulated by strategy objectives. Arrivals that are generated in the model show some of the arrivals occurring in the morning hours, mainly by full-time farmers. The rest of the arrivals are generated to occur in the evening hours. The model user selects the ratio of morning to afternoon arrivals.

Field service priority, P_{fs}, for all fields that have arrived (i.e., due for irrigation) are estimated by an exponential relationship given by equation (21). Figure 10 shows a semi-logarithmic plot of the field service priority, P_{fs}, as a function of time in days.

$$P_{fs} = K \times EXP(aT) \tag{21}$$

where P_{fs} = field service priority in the queue for a field/user.

K = a coefficient, depending on crop.

a = an exponent depending on crop and stage of growth for alfalfa.

T = time in days since soil water content fell below allowed deficit.

values of a and K are given in Table 12.

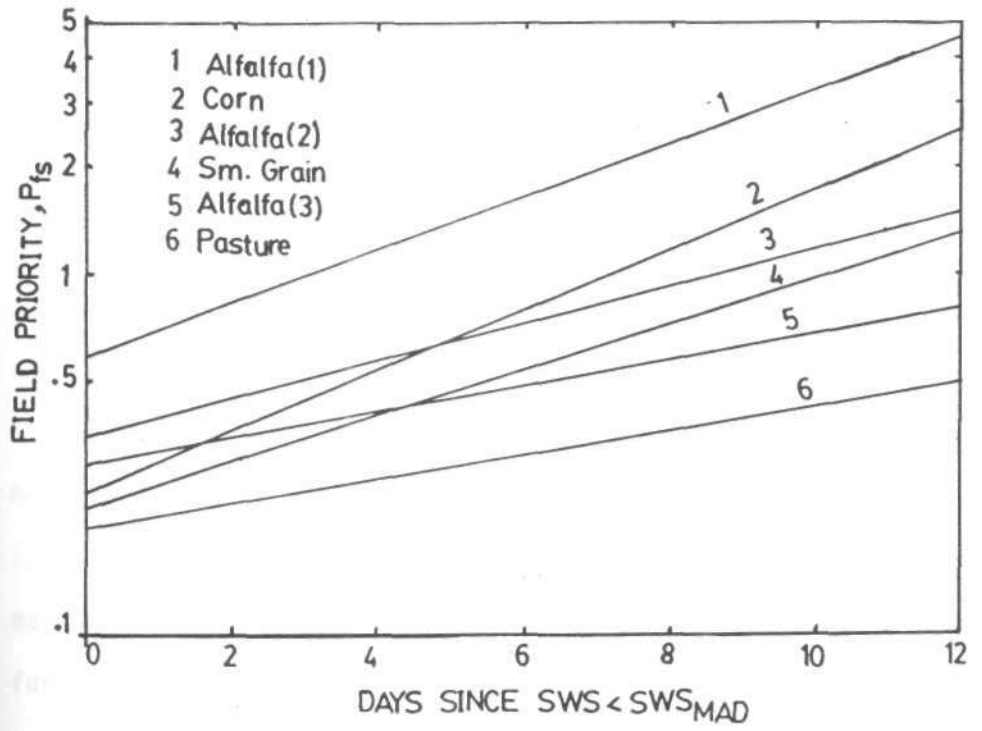


Figure 10.--Field Service Priority, P_{fs}, for Fields that Are Due for Irrigation, as a Function of Time.

Table 12.--Coefficients and Exponents Used in the Field Service Priority Equation.

Crop	K	a
Alfalfa(1)	1.8221	0.3338
Alfalfa(2)	1.4333	0.0950
Alfalfa(3)	1.3499	0.0417
Corn, silage	1.2840	0.1875
S. Grain	1.2523	0.0896
Pasture	1.2214	0.0250

Figures in bracket correspond to growth stage before cutting of alfalfa.

GSIS Hydraulic Network Analysis

The gravity sprinkle irrigation system, GSIS, is essentially a hydraulic branching network. Jeppson (1976) described this kind of network as one made up of a number of pipes connected to the main to form the topology of a tree. It is quite distinct from the more complicated, looping networks in which a path or loop could be traced through the pipelines that returns to the same starting point.

Two versions of branching networks exist. The first and perhaps the most common is the one found in agricultural irrigation, such as gravity sprinkle and rural water supply systems. In this version, flow from the main pipe diverges into a number of submains. From the submains flow further diverges into laterals. This type of branching network is considered in this study. The second version is the reverse of the first, water moves first into laterals at the divergent end of the network into submains and then finally converge into the main pipe. The second version has been applied extensively in sewer and drainage systems. The rest of the discussion and analysis that follow will relate specifically to the first version. To aid in understanding the analysis of the hydraulic networks the component parts of a typical network will be described along with definitions of some of the terminologies.

A GSIS distribution network will normally consist of a number of pipe sections of varying lengths, diameters, and perhaps pressure ratings, possibly made of different materials. These pipe sections contain fittings such as bends, elbows, and valves. The sections may end at a terminal node, such as delivery point, or at a junction node.
A junction node exists where two or more pipe sections connect, and it

is the point where flow enters or leaves a pipe section to other sections. Demand may occur at a junction node. A fixed-grade node is a point where a constant hydraulic grade-line, HGL, is assumed to be maintained, such as at the supply canal or at a reservoir.

For illustrative purposes, the diagram in Figure 11 represents a simple GSIS distribution network with demands occurring at both the terminal and junction nodes. No loops exist; energy paths, however, may exist if two fixed-grade nodes, such as two supply canals or one canal and a reservoir, are in the network, if both are hydraulically connected. Most GSIS's have only one fixed-grade node, the supply canal with the associated intake structures at which constant grade is maintained. In a few installations, a source pump at a reservoir may be added to the system for augmentation to satisfy external demands should a serious deficit occur at the primary source (i.e., supply canal).

In this case an energy path would exist if both sources are contributing water to the distribution network. In analyzing a branching network, such as a GSIS, flow rates in any pipe can be calculated as the summation of the flow rates in the pipe downstream of it. Such downstream flows arise from external demands. For a given set of external demands, analysis proceeds with initially determining unknown heads at various pipe section ends that are responsible for flow in that section, since flow only occurs hydraulically in response to an energy gradient. Having determined the unknown heads, flow amounts in various sections are estimated. For a balanced network, pressures or hydraulic grade!ine inter-nodally should not be negative.

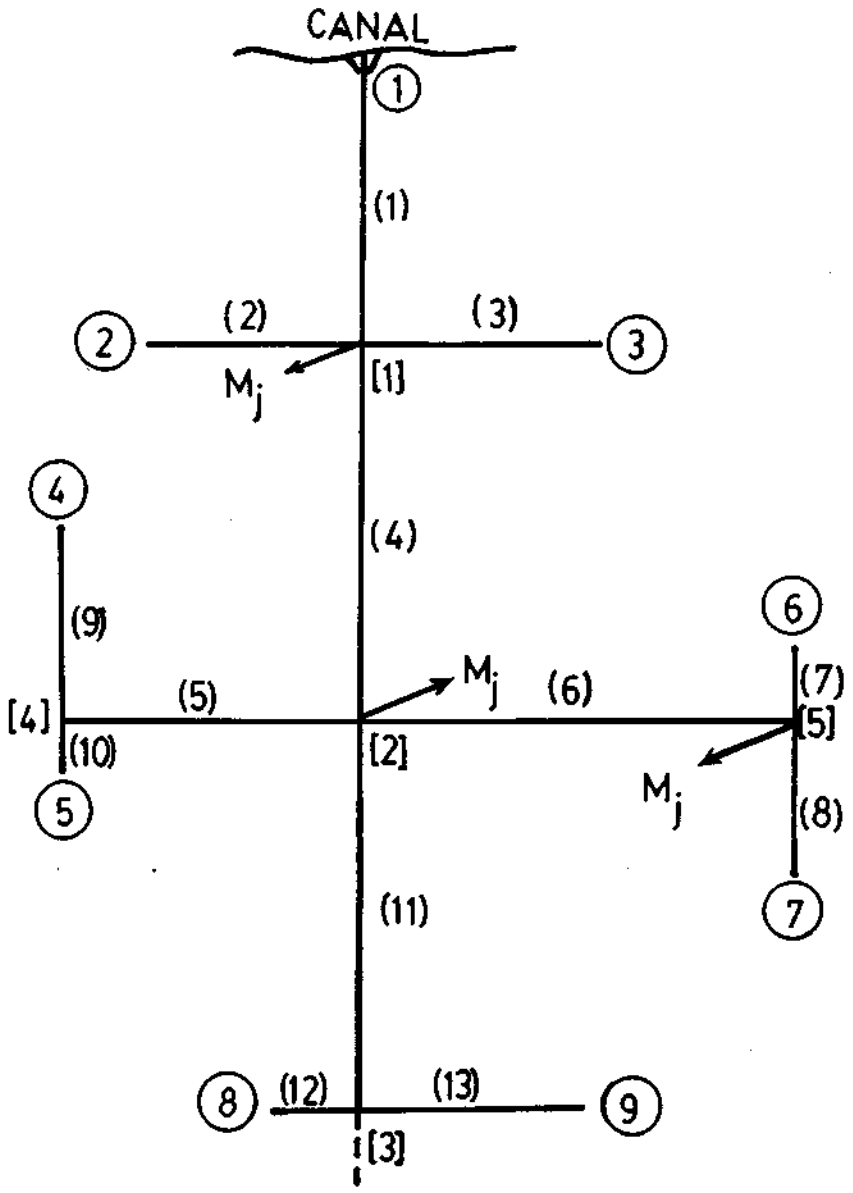


Figure 11.--A Simple GSIS Distribution Network.

Using the illustrative diagram above for a simple typical GSIS, the following relationship holds for determining the number of pipe sections in the network:

$$p = j + t + (f-1) \tag{22}$$

where p = number of pipe sections in the network

j = number of junction nodes

t = number of terminal nodes

f = number of fixed-grade nodes

$f-1$ = number of paths between fixed-grade nodes.

As in any distribution network, the two basic equations governing flow of fluid in the GSIS are the conservation of mass and conservation of energy equations. At each junction node, j, the conservation of mass equation, $F_m(Q)$, requires that the sum of all flows into and out of the junction node minus any external demand, M_j, must equal to zero. This equation can be expressed thus:

$$F_m(Q) = \sum_{n=1}^{Nj} Q_n - M_j = 0 \tag{23}$$

where N_j = number of pipe sections connected at the junction node, j.

Similarly, in order to satisfy the conservation of energy equation, $F_e(Q)$, then the sum of line losses, H_l, and minor losses, H_m, over any section of the network, minus any energy added to the liquid by a pump,

E_p, minus the difference in elevation grade at the ends of the sections, δE_k, must equal to zero. This relationship can be expressed for any pipe section as:

$$F_e(Q) = \sum_{n=1}^{N_k} [(H_l)_n + (H_m)_n - E_p] - \Delta E_k = 0 \qquad (24)$$

where N_k = number of pipes in the pipe section (or path), k.

The line loss, H_l, as shown in equation (24) above, represents a head difference that is responsible for creating flow, Q, in that pipe section. The general form of the relationship between head loss and flow rate is given by a non-linear equation as:

$$H_l = K_p Q^n \qquad (25)$$

where K_p = a pipeline constant that is a function of pipe length, diameter, and roughness.

n = an exponent.

values of K_p and n both depend on physical parameters of the pipe and the friction loss equation used.

Primarily, the analysis of the network considers heads at the nodes as unknowns; therefore, j+t-1 independent continuity equations must be written, one for each node. To solve for head at the node, j, the equations must be written in the form similar to that presented in Jeppson (1976), thus:

$$\left[\frac{(H_i-H_j)^{1/nij}}{K_{ij}}\right]_{out} - \left[\frac{(H_i-H_j)^{1/nij}}{K_{ij}}\right]_{in} = C \qquad (26)$$

where K_{ij} is the same as the pipe constant, K_p for the pipe section ij.

In the computations, a sign convention is adopted to overcome the problem that will arise by attempting to raise a negative value to a power and by writing a negative within the inner bracket that contains flow in the opposite direction. In line with this convention, inflows to a node will be considered positive while outflows are negative. The ij subscripts represent flow from or into node j with respect to an outer node, i. The external demand, M_j, is imposed on the system at node, j.

The pipe constant, K_p, can be calculated using any of the head loss relationships, such as those of Darcy-Weisbach, Manning, or Hazen-Williams. Because of its wide practical applications, the Hazen-Williams formula was used in this study. Using the formula, the pipe constant, K_p, as in equation (25), or K_{ij}, as in equation (26), will be:

$$K_{ij} = \frac{4.73 L_{ij}}{CHW_{ij}^{1.852} \; D_{ij}^{4.87}} \qquad (27)$$

where D_{ij}, L_{ij} = diameters and lengths of pipes in the pipe section i,j.

CHW_{ij} = Hazen-William's coefficient for pipe(s) in the section i,j.

Minor losses, though numerically small, are nonetheless important. In large networks, they are sometimes neglected in the analysis because they constitute only a small percentage of the total head loss, compared to line losses that would result from several hundreds of feet of a pipe section. As included in equation (24), minor losses, H_m, in the pipe section can be expressed as:

$$H_m = K_m Q^2 \qquad (28)$$

where K_m = minor loss constant, it is a function of minor loss coefficient for fittings in the pipe section, and is also a function of the pipe diameter. Typical values of K_m are given in Table 13.

In pure GSIS, pumps are not used, and all the energy required for distributing water throughout the network is derived from potential energy. Infrequently, however, a user may find the need to install a booster in his part of the network to enhance the delivery pressure of the water as delivered to him. This aspect is not covered in this study. A source pump may, however, be installed in the network by an irrigation company to occasionally add water to the network from an auxiliary source, such as a reservoir or a well.

Table 13.--Minor Loss Coefficients for Entrance Condition and Line Fittings.

Entrance condition/fittings	K_m
Entrance Condition at the intake	
Square cornered	1.00
Rounded cornered	0.50
Inward projecting, or re-entrant	0.05
Gate Valves	
fully open	0.19
3/4 open	1.00
1/2 open	5.60
Globe Valve, fully open	10.00
Angle Valve, fully open	5.00
Ball Check Valve, fully open	70.00
Foot Valve, fully open	15.00
Tee, through side outlet	1.80
Elbow, standard	0.90
Elbow, 45 degrees	0.40

If a pump is installed, a relationship between the pump energy, E_p, as in equation (24) and discharge, Q, must be formulated. Generally, such a pump characteristic curve is easily described by a polynomial of at least the second order. This relationship is:

$$E_p = fn(Q) = C_1 + C_2Q + C_3Q^2 \qquad (29)$$

where C_1, C_2, C_3 are coefficients for the polynomial; three pairs of H and Q values from the pump characteristic curve are all that is necessary to establish the values of these coefficients.

The change in elevation is estimated in equation (24) by E_k. Substituting the components discussed above as functions of heads in the conservation of energy equation (24) results in a system of equations for each pipe section in which heads, H_j, at the end of the pipe sections are solved for as the unknowns. Elevations, external demands, and canal inlet heads are of known values. Upon solution of the unknown heads, the flow rate in each pipe section in the network is estimated thus:

$$Q_{ij} = (H_{ij}/K_{ij})^{n_{ij}} \qquad (30)$$

where all terms are as previously defined.

Submodel SWBAL

Soil-Water Budgeting

The soil-water budget is a simple water balance equation which maintains a daily bookkeeping of water in a number of hydrological phases within the climatic/soil/crop environment. These hydrological phases may indicate that water is either moving from the atmosphere into the soil, as in the case of rainfall, or from the soil/plant environment into the atmosphere, as in the case of evapotranspiration. The flowchart for the submodel SWBAL is given in Figure 12. The budgeting is based on the premise that the balance of soil-water in a root zone is a function of water inputs from precipitation and irrigation and outputs such as evapotranspiration and drainage losses. The soil-water budget equation is:

$$SWS_n = SWS_{n-1} + Pr_n + IR_n - ET_n - DR_n \qquad (31)$$

where SWS_n = soil water content at the end of the present day.

SWS_{n-1} = ending soil water content the day before.

Pr_n = precipitation amount for the present day.

IR_n = irrigation depth for the present day.

ET_n = actual crop evapotranspiration for the day.

DR_n = drainage losses that might have occurred that day if field capacity storage is exceed.

n = present day subscript which refers to a julian day.

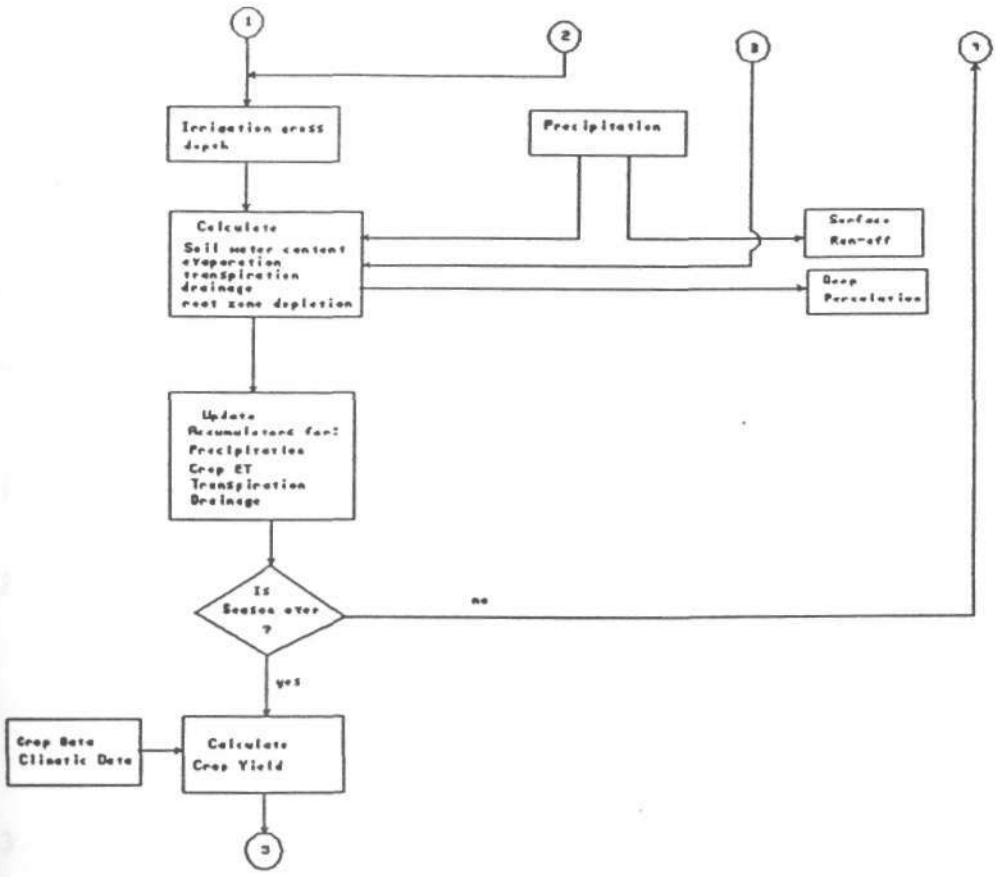


Figure 12.--The Flowchart of the Submodel SWBAL.

For each day, contribution from precipitation such as rainfall is added to the residual soil moisture. An estimate of the crop evapotranspiration is computed and its amount is deducted to arrive at the soil-water content for that day. If the soil-water content is greater than the field capacity, then the excess water is considered as a loss. Field capacity is the upper limit constraint on soil-water content. As the crop continues to use the stored water from irrigation, a lower limit set by management is reached and an addition of water to the soil is called for. This lower limit depends on management policy as to what the allowed depletion should be. A 50 percent allowed depletion is common in practice. Simplifying assumptions made herein are:

1. The soils are assumed to be homogeneous, and the root zone profile may or may not be layered.

2. Root depth is constant for pasture. But for the remaining three crops, alfalfa, small grain, silage corn, a root growth function was used to estimate the expanding root zone depths using assumed values of maximum and minimum root depths. Maximum root is assumed unrestricted by soil depth.

3. Drainage accounts for deep percolation losses out of the root zone. The deep percolation losses are assumed to occur whenever the soil water content exceeds the field capacity of the soil.

4. In case of a multi-layered root zone, it is assumed that infiltrating water fully refills each soil to field capacity before moving down to the next layer below.

5. It is assumed that no upward movement of water into the root zone from a water table occurs and lateral movement of water is negligible.

6. Sprinkler nozzles were correctly sized to disallow surface runoff and ponding. Surface runoff and ponding might, however, result from intense rainfall.

The submodel uses soil data contained in the file SOIL.DAT. For each soil type entries are made with respect to its available water, infiltration rate, and the coefficients needed for the two evaporation equations discussed below.

Root Growth Function

Except for pasture, for which a constant root zone depth is assumed, the remaining three crops have dynamic root zones. A root growth function is included in the model which estimates root zone depth as a function of time or crop coefficient. Two versions of the function are given below; the model used the first version of the function given as equation (32a). Both versions assume that root growth progresses linearly from the minimum root depth at the time of planting, or begin growth, to a maximum root depth value at full cover. The root growth function can be expressed as:

$$RZD = Rd_{min}+((JD-JDPL)/(JDCV-JDPL))(Rd_{max}-Rd_{min}) \quad (32a)$$

or

$$RZD = Rd_{min}+((Kc-Kc_{min})/(Kc_{max}-Kc_{min}))(Rd_{max}-Rd_{min}) \quad (32b)$$

if $RZD > Rd_{max}$ then $RZD = Rd_{max}$

where RZD = root zone depth

JD = present day julian day

JDPL = planting date julian day

JDCV = julian day for the effective cover

Kc = crop coefficient at the present day

Kc_{max} = maximum crop coefficient

Kc_{min} = minimum crop coefficient

Rd_{max} = maximum root depth for the crop

Rd_{min} = minimum root depth for the crop.

Typical values of maximum and minimum root depths are given in Table 14. These parameters are crop specific and are stored in the CROP.DAT file in Appendix 2.

Table 14.--Maximum and Minimum Root Depths, Days to Effective Cover, and Lengths of Growing Season for the Crops in the Study.

Crop	Maximum (Minimum) Root depths (ft)	Days to eff. cover (days)	Length of Growing Season (days)
Corn, silage	4.0(0.5)	72	142
Spring Grain	3.0(0.5)	80	135
Alfalfa	5.0(2.0)	76(46)*	168
Pasture	2.5(2.5)	N/A	200[1]

* first value is interval in days between beginning growth and first cutting of alfalfa; second value in brackets is the interval in days between subsequent cuttings. Three cuttings expected in the season.

1 third week of March through first or second week of October.

N/A = not applicable.

Soil moisture at the start of the season, referred to as beginning soil water in the budget, is computed for each combination of crop and soil. Using a relationship such as equation (31), off-season budgeting

could be maintained which could provide initialization for the soil-water budget for the cropping season. Such initialization could also be provided by estimates using a neutron probe or other techniques that estimate soil water storage. Where such an initialization estimate is unavailable, the model provides an option of estimating initializations by randomly generating such estimates of available water for each soil type in the soil profile.

Planting or Beginning Growth Date

Where planting or beginning growth date for each field is known and contained in the file UZAS.DAT, such dates were used. In the event that these dates are not specified, the model generates the dates within the given range for the crop. For corn and small grain, optimal planting dates were given as May 15th and April 15th, respectively. Planting date range for both crops was two weeks, one week before and after the optimal. For alfalfa and pasture, beginning growth dates were estimated based on the first day (starting March 15th) with a three-day moving average temperature equal to or exceeding 40 degrees F. After a first date was identified, a planting date range of two weeks was effected. With the optimal planting date and range for the four crops, planting dates for individual fields were generated using a random number generator assuming that the random variates, planting dates, were normally distributed with a mean as the optimal planting date.

In the submodel HYDRA discussed earlier, crop evapotranspiration, ET, is calculated for each field daily. This estimate is included in the water budget as shown in equation (30). As part of maintaining the

balance on water use, the submodel SWBAL splits evapotranspiration into its major components, evaporation and transpiration.

Evaporation essentially occurs from the top soil layer. The actual evaporation of water from soil surface since last wetting of the surface by irrigation or rainfall could be estimated as a function of time. Actual evaporation is estimated from potential evaporation by either of the two equations given in Hill, Hanks, and Wright (1984):

$$E = E_p/(N^{(t-1)}) \tag{33a}$$

or

$$E = E_p(1.0 - (t/t_d)^{0.5}) \tag{33b}$$

where E = actual soil evaporation

E_p = potential soil evaporation

N = a coefficient which determines the decay time of the evaporation after a wetting. A value of N=2 could be used as proposed in Hill, Hanks, and Wright (1984).

t = time in days since the last soil surface wetting.

t_d = time in days required for the soil surface to dry after a significant wetting. Suggested values for t_d are t_d=5 for loam soil at Kimberly; t_d=7 for more clayey soil; and t_d=3 or less for sandy soils.

Potential evaporation of water, E_p, from the top soil is calculated by:

$$E_p = K_e Et_r \tag{34}$$

where Et_r = reference crop evapotranspiration

K_e = evaporation coefficient.

The evaporation coefficient, K_e, is a function of K_{ct} and is estimated by:

$$K_e = 1-K_{ct} \qquad (35)$$

where K_{ct} = crop transpiration coefficient.

If K_e is less than 0.08, it is set equal to 0.08. From equation (35) the sum of K_e and K_{ct} is assumed to be 1.0 subject to K_{ct}=0.0 before crop emergence.

In the submodel, equation (33b) was used.

The actual transpiration by crops uses water drawn from the root zone. Values of crop transpiration may be estimated by:

$$T = (T_p/0.5).SWS/AW \quad \text{if } SWS/AW < 0.5 \qquad (36a)$$

or

$$T = T_p \quad \text{if } SWS/AW \Rightarrow 0.5 \qquad (36b)$$

and potential transpiration was computed by:

$$T_p = K_{ct}Et_r \qquad (37)$$

where K_{ct} and Et_r are as previously defined

SWS = existing or remaining soil water storage in any layer.

AW = total available water-holding capacity (field capacity - wilting point) for the soil.

The crop transpiration coefficient, K_{ct}, is estimated in the model by two third-power polynomial equations for the periods between emergence and effective cover and after effective cover. Coefficients for the equations for corn and wheat are given in Hill, Hanks, and Wright (1984). For alfalfa, K_{ct} is estimated as:

$$K_{ct} = 0.020 + 2.218r - 1.986r_4^2 + 0.740r_3^3 \quad (38)$$

subject to $0.25 <= r <= 0.98$

where r is determined by:

$$r = \hat{E}EJHO/\hat{E}ET^{EC} \quad (39)$$

and $\hat{E}EJHO$ = summation of Et_r based on Jensen-Haise equation, with no elevation correction, from beginning growth or previous cutting to the present.

$\hat{E}ET^{EC}$ = 6 inches (15.2 cm).

the value of r is reset to zero after each cutting of the alfalfa crop.

Crop Yield Estimates

A number of crop yield estimation models have been proposed. Many of these models estimate crop yields as a function of applied irrigation water, relative evapotranspiration deficits, relative transpiration, etc. Potential crop yield can be estimated from the ratio of actual to potential transpiration, T/T_p, for each growth stage.

To estimate grain production where conditions during one stage of

growth are more critical than others, the method of Jensen used in Hill, Hanks, and Wright (1984) is adopted for use in the model. The season is divided into growth stages and relative production is estimated as:

$$Y/Y_p = (T_1/T_{p1})^{a1} x (T_2/T_{p2})^{a2} x \ldots\ldots\ldots x (T_n/T_{pn})^{an} \qquad (40)$$

where Y = actual or estimated harvestable grain yield at specific moisture content; usually 15.5% for corn, and 10% for small grain.

Y_p = potential crop yield.

T_i = cumulative transpiration in growth period i.

T_{pi} = cumulative potential transpiration which occurred when soil water is not limiting during growth period i.

ai = an exponent to allow for weighting growth period i.

i = 1,2,....,n represent the n growth stages.

Grain yield is approximately 42 percent of dry matter, and the latter is about 30 percent of silage yield for corn. Therefore, to estimate corn silage yield from grain yield obtained in equation (40), the following relationship is used:

$$Y_{sl} = \frac{Y}{S_{gsf}} \qquad (41a)$$

and

$$S_{gsf} = 1/(1.155 \times 0.42 \times 0.30) = 6.87 \qquad (41b)$$

where Y_{sl} = silage corn yield, ton/acre.

Y = grain yield at 15.5% moisture content.

S_{gsf} = corn grain yield to silage yield conversion factor.

Use of equation (40) alone was found unsatisfactory for predicting yields with late planting dates for which transpiration ratio were high but yield was low. Hill, Johnson, and Ryan (1979) hypothesized that this was due to dry matter accumulation and proposed the use of a seasonal yield factor to adjust for the total dry matter yield. Seasonal yield factor was estimated as:

$$SLF = 1.0, \quad \text{if } T_p \Rightarrow T_{pth} \tag{42a}$$

or

$$SLF = (T_p/T_{pth})^a, \quad \text{if } T_p < T_{pth} \tag{42b}$$

where SLF = seasonal yield factor

T_p = accumulated potential transpiration for a full season or selected growth stage thereof

T_{pth} = corresponding threshold transpiration for adequate total dry matter prediction for the whole season or selected growth stage

a = a constant weighting factor.

Included in Table 15 are parameter values for corn and wheat for the calibrated yield equation. These parameter values, which are crop specific, are stored in the file CROP.DAT.

Table 15.--Corn and Wheat Calibrated Yield Equation Parameter Values for Kaysville, Utah; Kimberly, Idaho; and Logan, Utah.

Crop/ Year/site	Equation (40)[1] L2	L3	L4	L5	L6	Equation a	SLF T_{pth}	Y_p T/ha
Corn (NKPX 20) 1980								
Kaysville	.1	.25	.78	.70		3.5	10.3	9.2
Kimberly	1.43	.6	.3	.1		2.8	8.1	9.9
Logan	.5	.22	.65	.65		1.7	10.0	11.3
All Sites	.17	.1	.35	.5		.92	11.6	10.0
Wheat (Fieldwin) 1980								
Kaysville	.5	3.9	.1	2.4	1.14	8.4	10.7	7.1
Kimberly	.1	.84	.1	5.0	.76	2.0	10.3	7.8
Logan	.1	.1	.1	.6	1.29	7.55	13.9	9.6
All Sites	.1	.26	.1	.11	1.64	4.9	9.5	9.5

Adapted from: Hill, Hanks, and Wright (1984).

1 L1 = 0.0 for all crops as T_p=0.0 from planting to emergence.

2 Accumulated T_p for growth stages 4 and 5, and 5 and 6, respectively, for corn and wheat.

For alfalfa and pasture, yield was estimated from:

$$\frac{Y}{Y_p} = \frac{T}{T_p} \qquad (43)$$

where Y = total dry matter yield

Y_p = potential yield when transpiration is equal to potential transpiration

T = transpiration

T_p = potential transpiration which occurred when soil water is not limiting.

Crop Growth Stages

Crop growth progresses through a number of growth stages beginning with planting (or begin growth, in the case of alfalfa and pasture) through to physiologic maturity. In the model, growth progress was estimated using a phenology clock. The phenology clock used is based on growing degree days, GDD, for corn and wheat. Gilmore and Rogers (1958) suggested the method of calculating GDD as:

$$GDD = (TH/2 + TL/2) - 50 \qquad (44)$$

where GDD = growing degree days, deg. F

TH = maximum daily air temperature (T_{max}), if T_{max} > 86 deg F, then TH=86 deg. F

TL = minimum daily air temperature (T_{min}), if T_{min} < 50 deg. F, then TL=50 deg. F

From planting date the daily GDD's are accumulated and the values are compared with the crop's required accumulated GDD's for a particular growth stage end points to be reached. This comparison is continued throughout the growing season and forms the basis for moving the crop from one growth stage to the next. The data in Table 16 include values of accumulated GDD's required to reach specific phenologic states for corn and wheat crops.

Table 16.--Phenologic States and Corresponding Accumulated Growing Degree Days, GDD, for Corn and Wheat.

Corn (NKPX 20)		Wheat (Fieldwin)	
Phenologic State	Accumulated GDD*	Phenologic State	Accumulated GDD*
Planting	0	Planting	0
Emergence	86	Emergence	64
4 leaf	258	Begin Tillering	162
Silk Emergence	1218	Begin Stem Extension	391
Dough	1622	Heading	746
Physiologic Maturity	2186	Begin Ripening	946
		Physiologic Maturity	1790

Source: Table 5, Hill, Hanks, and Wright (1984).

* Accumulated values, using 50-86 method are from planting to the indicated stage, from observed values in Kaysville, Kimberly, and Logan.

Submodel ATTR

Determination of Cost, Return and Benefits

The essence of engaging in any economic activity, crop production included, is to derive some benefits. In other words, a producer, in this case the farmer, must receive revenues in excess of his costs in order to operate a profitable enterprise.

The submodel ATTR, depicted in Figure 13, evaluates attributes of the various strategies, including costs, returns, and benefits. The benefit that might accrue are:

$$\text{Benefit} = \text{Returns} - \text{Costs} \tag{45}$$

Returns are revenues or accounts receivable that come to the farmer as a result of selling his produce. Usually, the prices offered for the produce reflect current market prices for the commodity. Production costs are expenses the farmer has to incur as he engages in production. Returns, for the purpose of this study will be initially estimated on a per acre basis as follows:

$$\text{Returns} = \text{Price/unit weight} \times \text{Yield/acre} + \text{BYP} \tag{46}$$

where unit weight may be a ton or a Kg.
In the case of pasture the unit weight may be replaced by AUM (Animal Unit Month) 1 AUM=360 Kg DM [Scarnecchia and Kothmann, (1982)].

Yield is crop production per unit area. Crop yields estimates were discussed in preceding paragraphs.

BYP = revenues from by-product sales.

Production costs for all four crops are conveniently subdivided into four sub-unit costs: yield dependent, constant or fixed, area dependent, and capital costs.

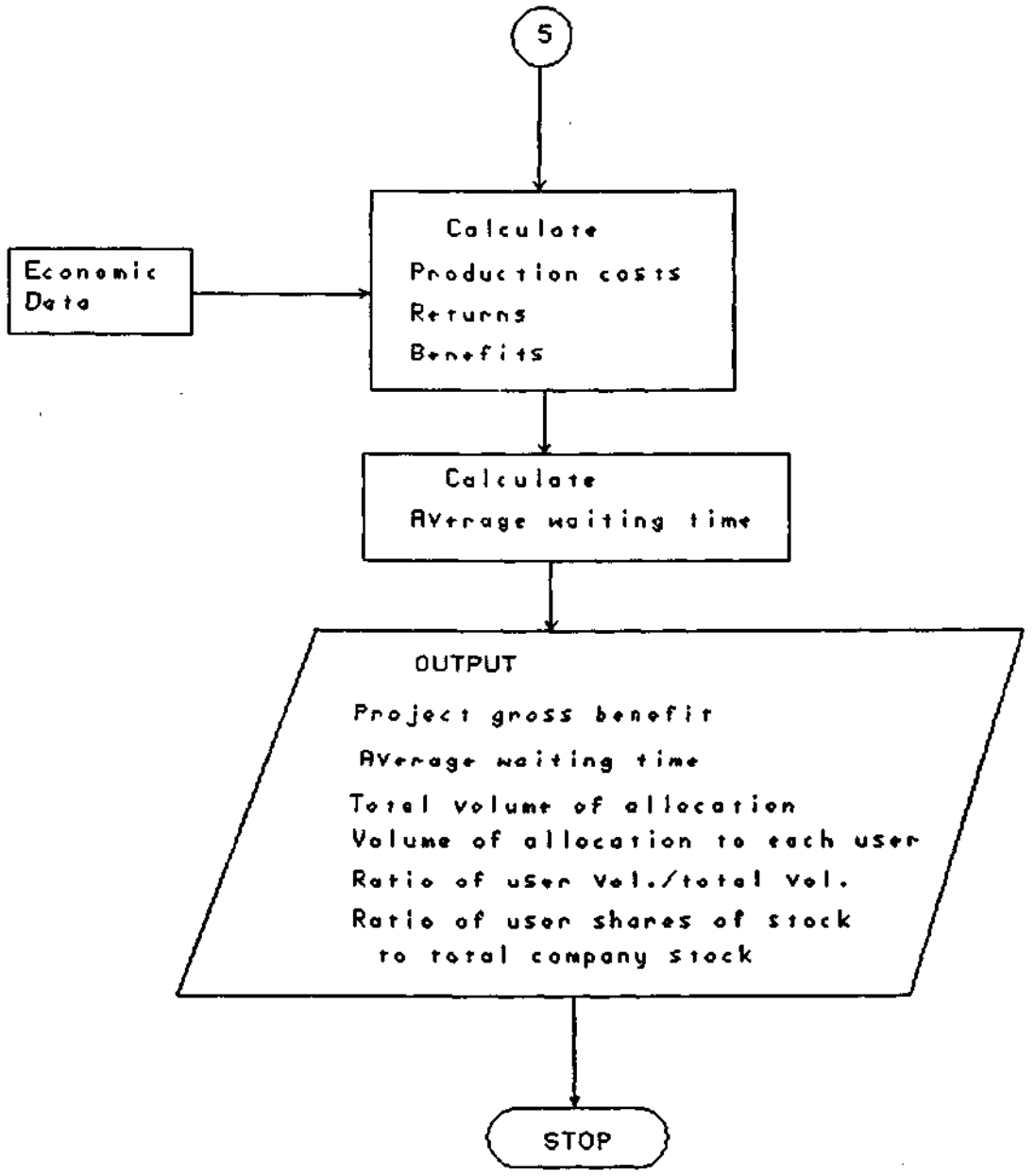


Figure 13 The Flowch..t for Subrod.l ATTR

The summation of these sub-unit costs provide the total cost per acre as:

$$TC = (C_y + C_c + C_a + C_k)A \qquad (47)$$

where TC = total cost.

C_y = yield dependent costs, such as costs of fertilizers and fertilizing, swathing and baling in the case of alfalfa, or clipping in pasture production.

Y = yield in ton per acre for the crop.

C_c = constant costs, such as the cost associated with land tax.

C_a = area dependent costs, such as water assessment and irrigating costs.

C_k = capital costs. Its value is dependent on the investment cost of the capital item, interest rate, and the pay-back period. For both the hand-move and wheel-move lateral systems an interest rate of 12 percent per year and pay-back period of 15 years are assumed for the estimation of capital recovery factor, CRF. The annualized capital cost is divided by the area served by the system to obtain per acre annual capital cost.

A = area in acre.

The annual costs of capital items such as the irrigation systems are calculated based on initial investment costs, or present worth, and capital recovery factor, CRF, as:

$$\text{Annual cost} = \text{investment cost} \times CRF \qquad (48)$$

and

$$CRF = i(1+i)^n/((1+i)^n-1) \quad (49)$$

where i = annual interest rate in decimal

n = payback period, years.

The costs per acre in each of the four sub-units itemized for the four crops and included in Tables 17 through Table 20 are stored in the file ECON.DAT. Where appropriate, total sub-unit costs are given as subtotal in the tables. The itemized costs are identified as costs associated with either labor, machinery, or supply/service with rates indicated.

For each management strategy, estimates of gross benefits are determined. In each case, the gross benefits are determined for the entire project and a breakdown of the gross benefit reflecting each field's contribution is also included.

Table 17.--Alfalfa on Class I Land, Costs and Returns Per Acre.

Item	Rate	$/acre Labor	Machinery	Supply/ Services	Total
Returns:					
Alfalfa	$60/ton @ 5ton/acre				300.00
By-product, 0.25 AUM	$9.00/AUM				2.25
Costs:					
1. Yield dependent:					
Fertilizers, 20lb. av P	$0.22/lb			4.40	4.40
Herbicides/insecticides				7.33	7.33
Spraying	(1 time)	0.26	1.08		1.34
Fertilizing	(1 time)	0.26	1.71		1.97
Swathing	(3 times)	2.19	26.38		28.57
Baling	(3 times)	3.39	25.26		28.65
Hauling (SP wagon)	(3 times)	2.52	25.29		27.81
	subtotal				100.07
2. Constant costs:					
Land Tax	$90 assessed @ 70 mills			6.30	6.30
	subtotal				6.30
3. Area dependent:					
Water, assessment	$6.00/stock			6.00	6.00
Irrigating	2 moves/day @ 0.5 hr/move	3.00			3.00
	subtotal				
4. Capital costs:					
Irrigation system,					
Hand-move			10.45		10.45
Wheel-move			26.91		26.91

Capital cost based on CRF=0.1468 (i=12%, n=15 years)

Returns and Yield dependent costs extracted from 1988 Utah Agricultural Statistics. Water assessment and irrigating costs obtained from Richmond Irrigation Company, 1987.

Table 18.--Small Grain Costs and Returns Per Acre.

Item	Rate	$/acre Labor	Machinery	Supply/ Services	Total
Returns:					
Barley	$2.00/bu @ 80bu./ac				160.00
By-product					4.55
Costs:					
1. Yield dependent:					
90 lb. Seeds,	@ $0.10/lb.			9.00	9.00
Planting	(1 time)	1.64	10.37		12.01
Fertilizers,					
80lb. av N	$0.22/lb.			17.60	17.60
30lb. av P	$0.22/lb.			6.60	6.60
Fertilizing	(1 time)	custom			3.00
0.5 lb. Herbicides	$2.80/lb			1.40	1.40
Herb. Applic.	(1 time)	0.26	1.08		1.34
Combining	(1 time)	custom			25.00
Hauling	(1 time)	custom $0.15/cwt			5.76
Storage for six months	@ $0.03/cwt/month			6.91	6.91
subtotal					88.62
2. Constant costs:					
Land preparation,					
Plowing	(1 time)	2.15	19.73		21.88
Disking	(1 time)	0.95	9.90		10.85
Harrowing	(1 time)	0.48	3.43		3.91
Land Tax	$90 assessed @ 70 mills			6.30	6.30
subtotal					42.94
3. Area dependent:					
Water, assessment	$6.00/stock				6.00
Irrigating	2 moves/day @ 0.5 hr/move	3.00			3.00
4. Capital costs:					
Irrigation system,					
Hand-move			10.45		10.45
Wheel-move			26.91		26.91

Capital cost based on CRF=0.1468 (i=12%, n=15 years)

Returns and Yield dependent costs extracted from 1988 Utah Agricultural Statistics. Water assessment and irrigating costs obtained from Richmond Irrigation Company, 1987.

Table 19.--Corn, Silage, Costs and Returns Per Acre.

Item	Rate	$/acre Labor	Machinery	Supply/ Services	Total
Returns:					
Corn, silage	$22.00/ton @ 21ton/acre				462.00
Costs:					
1. Yield dependent:					
20 lb. Seeds,	@ $0.24/lb			4.80	4.80
Planting	(1 time)	1.64	10.37		12.01
Fertilizers,					
155lb av N	$0.22/lb			34.10	34.10
50 lb av P	$0.22/lb			11.00	11.00
Fertilizing	(1 time)	0.26	1.71		1.97
0.5 lb Herbicides @ $2.80/lb				1.40	1.40
Herbicide Applic.		0.26	1.08		1.34
Harvesting* $2.60/ton @ 21ton/ac.					54.60
subtotal					121.22
2. Constant costs:					
Seedbed preparation,					
Plowing	(1 time)	2.15	19.73		21.88
Disking	(1 time)	0.95	9.90		10.85
Harrowing	(1 time)	0.48	3.43		3.91
Cultivation, inter-row	(1 time)	0.67	2.48		3.15
Land Tax	$90 assessed @ 70 mills			6.30	6.30
subtotal					46.09
3. Area dependent:					
Water, assessment	$6.00/stock				6.00
Irrigating	2 moves/day 3.00 @ 0.5 hr/move				3.00
4. Capital costs:					
Irrigation system,					
Hand-move			10.45		10.45
Wheel-move			26.91		26.91

Capital cost based on CRF=0.1468 (i=12%, n=15 years)
* Harvesting include chopping, hauling and packing.
Returns and Yield dependent costs extracted from 1988 Utah Agricultural Statistics. Water assessment and irrigating costs obtained from Richmond Irrigation Company, 1987.

Table 20.--Irrigated Pasture Costs and Returns Per Acre.

Item	Rate	$/acre Labor	Machinery	Supply/ Services	Total
Returns:					
Pasture	$5.70/AUM @ 2.7ton/acre				38.30
Costs:					
1. Yield dependent:					
Fertilizers,					
33.5lb av N	$0.22/lb			7.37	7.37
13.5lb av P	$0.22/lb			2.97	2.97
Fertilizing	(1 time)	0.26	1.71		1.97
Clipping		1.00	2.15		3.15
subtotal					15.46
2. Constant costs:					
Land preparation,					
Harrowing	(1 time)	0.48	3.43		3.91
Land Tax	$90 assessed @ 70 mills			6.30	6.30
subtotal					10.21
3. Area dependent:					
Water, assessment	$6.00/stock				6.00
Irrigating	2 moves/day @ 0.5 hr/move	3.00			3.00
subtotal					
4. Capital costs:					
Irrigation system,					
Hand-move			10.45		10.45
Wheel-move			26.91		26.91

Capital cost based on CRF=0.1468 (i=12%, n=15 years)

1 AUM is approx. 360 kg DM (900 lb DM).

Yield dependent costs extracted from 1988 Utah Agricultural Statistics. Water assessment and irrigating costs obtained from Richmond Irrigation Company, 1987.

Waiting Time

Cost-benefit analysis, the focus of the preceding paragraphs, was employed for comparing the various management strategies in this study. In this section, time disposition in relation to implementing the various strategies will be discussed, to obtain measures for waiting time and utilization ratio for the irrigation resource, water.

Waiting time is the time a unit spends in the system before service is provided. If on the day irrigation is desired the user is able to irrigate, no waiting time is recorded. In other words, no time was spent in the queue and waiting time was equal to zero. In certain real-life situations, many instances are observed where queuing for services is inevitable. In all such situations, arrival rates for service is higher than the service rate. The rate at which service is provided to incoming customers is less than the rate of arrivals. In irrigation, hydraulic constraints in the delivery systems or limited streamflow where physical constraints of the system do not exist might result in some delay in the delivery of water to certain users. In situations where water is not available on-demand, users have to wait to receive water in turns through some rotation schedule. Within any time interval, each of the allocation strategies will show for the hydraulic conditions the number of users that are allocated water simultaneously. These users are considered as units that have arrived. Units that may have arrived for service at the same time, may not exit from service at the same time. The time of departure from service for a unit depends on service time. The service time for each user depends upon the volume of water allocated, which in itself depends on the soil and crop parameters for

the field irrigated, flow rate delivered to the user, and the application rate which is a function of nozzle pressure. In effect, each unit arriving will have its arrival and service times.

Average time in the queue and resource utilization ratio are the two measures of effectiveness to be computed. Average time in the queue is computed by dividing the total time in the queue by the total number of units that entered the system. Consideration for reneging does not arise, as all fields that are due for irrigation were assumed to have waited for the service. Utilization ratio is used as a measure of the fraction of allowed diversion that was effectively allocated and applied to the fields on a seasonal basis.

Equitability Inference

This aspect is treated in the model by comparing total volume allocations to user relative to total diverted volume at the turnout with the ratio of the user's share of stock to total company stock. The volumes are based on seasonal amounts. It was assumed that equity was achieved if the user received water in a ratio equal to, or greater than, the ratio of his stock. The criteria for assessing equitability is:

$$V_u/V \;=>\; S_u/TS \qquad (50)$$

where V_u = total volume allocated to user, u, during the irrigation season.

S_u = shares of stock owned by user, u.

V = total volume of allocations to all users for the entire season.

TS = total declared shares of stock of the company sold to user.

u = u-th user.

FIELD APPLICATION OF THE MODEL

Information and data for this study were obtained from a study site in the Richmond Irrigation Company project at Richmond, Cache County, Utah. The data collection was begun in the summer of 1986.

Project Information

The Richmond Irrigation Company, located in north Cache County as shown on the map given as Figure 14, was formed about the year 1860 by a group of users for the sole purpose of distributing water among members for irrigation and municipal uses. The water is obtained mainly from High Creek, near Richmond, Utah, some five miles northeast of the city of Richmond. Over 80 percent of the diversions made by the company at the present time are allocated to agricultural users. The original method of irrigation was flooding. The users, who are the stockholders in the company, individually own and operate farms within the perimeter of what is referred to hereafter as the project.

The gravity sprinkle irrigation project, constructed in phases was begun in the early 1970s (Soil Conservation Service 1974). Design assistance for the four sectors of the project was provided by the Soil Conservation Service. Each sector is served by an intake structure conveying water into a mainline for the fields in the sector. The irrigation company has a total of ten thousand acres for which water rights have been granted. The data collected were gathered largely in the fourth sector, which has an area of about 620 acres.

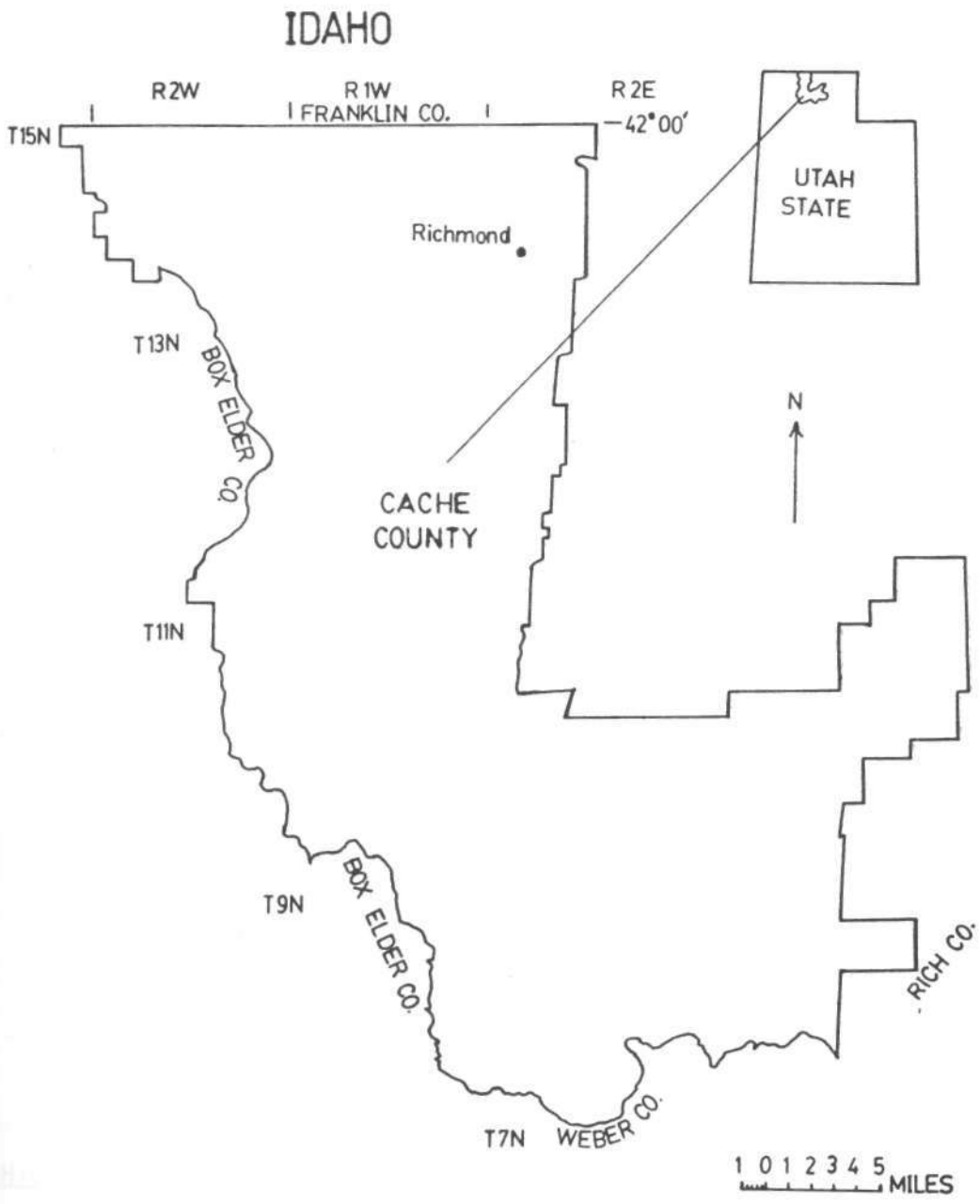


Figure 14.--Location Map for Richmond Irrigation Company, Richmond, Utah.

Irrigation Water Source

The irrigation water for Richmond Irrigation Company is obtained from High Creek, near Richmond. The creek flows continuously throughout summer months. Stream gage records collected and published by USGS on the watercourse reveal diminishing flows in the creek about mid-summer to the end of summer when demands for water irrigation are high. Table 21 includes some relevant statistics on the High Creek.

Table 21.--Summarized Statistics on Streamflows in High Creek, near Richmond, Utah.

Pertinent information	Recorded Data
Period of Record	1944-1985(1)
Drainage Area, mi^2	16.2
Av. Discharge, cfs(ac-ft/yr.)(2)	29.2(25,650)
Extreme Maximum Discharge, cfs	485
Extreme Minimum Discharge, cfs	2.6(3)

Source: U.S. Geological Survey Water-Data Report, Water Resources Data, Utah Water Year 1979, 1983 and 1986.
(1) records are not continuous, gaps exist.
(2) 15 years (1946-52, 1972, 1979-86)
(3) as a result of ice jam upstream (Jan. 15th, 1950)

Historical Flow Records

Historical streamflow records of daily flow in the creek were collected. From the daily records of the last ten years, (1977-1986), records for three years representing a 'wet', a 'dry' and a 'normal' year were selected. From the records, included in Appendix 7, the dry, wet, and normal years occurred in 1979, 1983, and 1986, respectively. These data are used in the model by accessing CLIM.DRY, CLIM.NOM or

CUM.WET depending on the season type; the dry year sample is included in Appendix 2.

Water Rights and Diversions

Richmond Irrigation Company has decreed water rights on High Creek to divert water for the irrigation of 10,000 acres within its project. The acquisition came through Kimball Decree Award #38. The priority date for the first right to the company was issued on May 1, 1860. Three other irrigation companies that also have rights on High Creek are Coveville, Webster, and Mt. Home.

The interpretation of these awards which are in three parts, included as Table 22, gives Richmond Irrigation Company the right to divert 78.4 percent of the flows in High Creek for all flows between 5 and 50 cfs. If the flow in the creek is greater than 50 cfs and up to 92.2 cfs, the company has an additional award to divert 20.2 percent of the flow that is in excess of 50 cfs. At this 92.2 cfs flow, which is regarded as maximum ditch flow, the company by virtue of the two awards has rights to divert a total of 47.2 cfs. A third award, that comes into effect if flows in the creek are greater than 92.2 cfs, allows the company an additional increase of 20.2 percent subject to an upper ceiling of 70 cfs. The upper ceiling was granted following a recent determination by the State Engineer's office.

A summary of these awards and the equivalent flow rates representing percentages, that were converted from the fractional amounts contained in the original decree given in Table 22, is plotted as Figure 15.

Table 22.--Percentage of Flow and Estimated Flow Rates Awarded to Richmond, Mt. Home, Coveville, and Webster Irrigation Companies Based on Kimball Decree Awards.*

Flow in High Creek, cfs.	Flow Rate for the Company, cfs.			
	Richmond	Mt. Home	Coveville	Webster
5-50	3.92-39.2	.36-3.65	.55-5.45	3.4-1.7
% of flow	78.4	7.3	10.9	3.4
50-100	40.21-49.3	5.55-20.0	6.52-15.0	2.71-10
% of flow	20.2	38.3	21.3	20.2
100-150	50.31-59.4	20.0	15.0	10.0
% of flow	20.2			

Source: Utah Division of Water Resources.
* Richmond, Award #38; Mt. Home, Award #35; Coveville, Award #37; Webster Award #36.

The percentages were used with daily streamflows in wet, dry, and normal years to estimate project-allowed diversions at the turnout.

Stocks and Share Amounts

The data in Table 23 present some statistics on stockholders and distribution of shares in Richmond Irrigation Company. The irrigation water stock of Richmond Irrigation Company, which is typical of most companies, exhibits some variability in the amount of shares acquired by the users. The company has a total of 457 stockholders, severally owning a total of 6067.65 shares of stock. Analysis showed the mean and median shares as 13.28 and 3, respectively; the standard deviation was estimated as 26.74. This large standard deviation value accounts for the high variability of share values about the mean. The range was 228, the lowest stock value being 1 share. Stock in share amounts of 45.5 and less represent 53 percent of all stock.

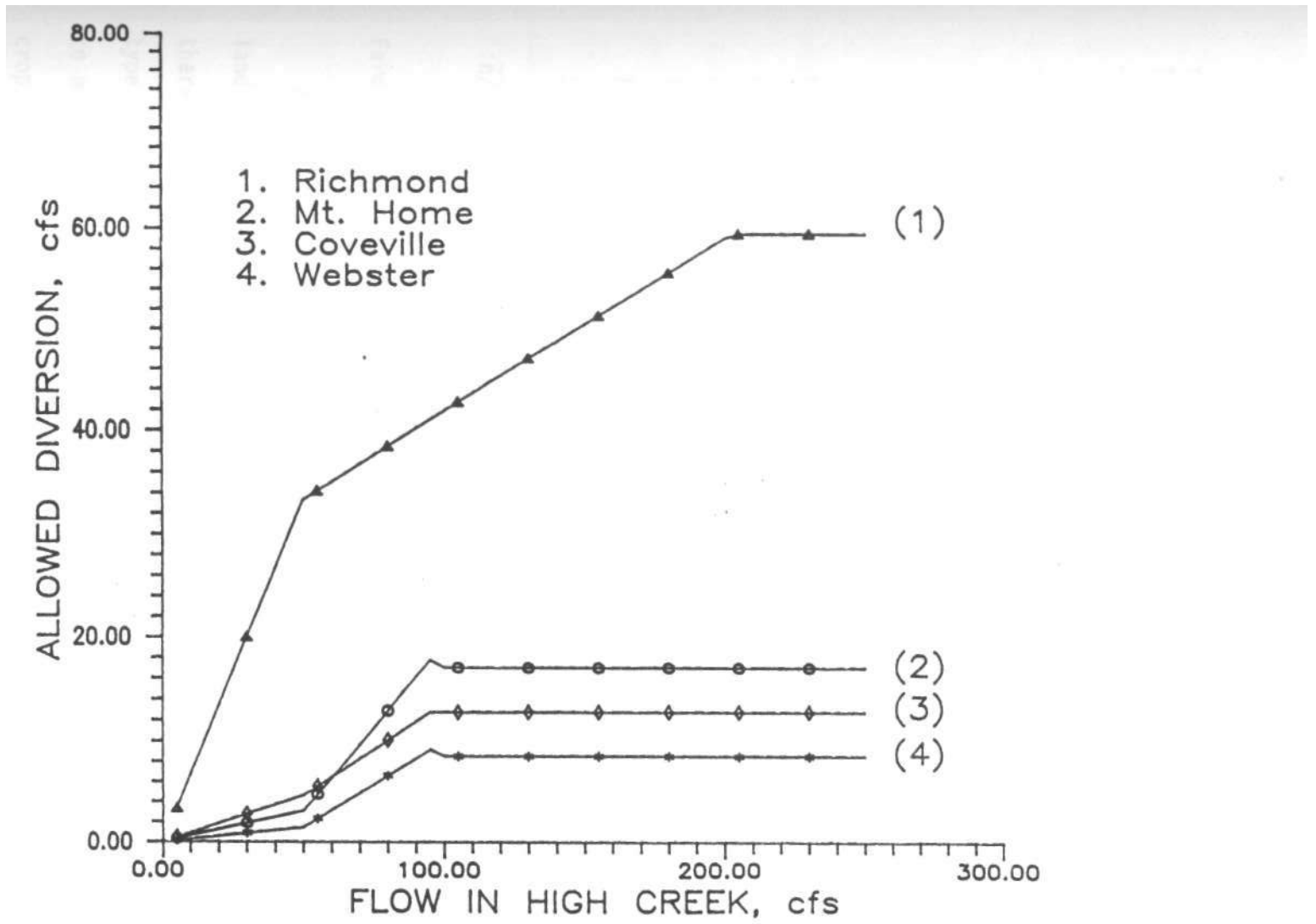


Figure 15.--Plot of Allowed Diversion versus Flow Rate in High Creek, near Richmond, Utah, Based on Water Rights.

Table 23.--Statistics on Stock and Shares in Richmond Irrigation Company, Richmond, Utah.

Pertinent data on	Value
Number of stockholders	457
Total shares of stocks	6,067.65
Average shares owned	13.28
Minimum shares acquired	1.0
Maximum shares acquired	229.0
Range	228
Percentage of stock (as agricultural)	n/a
Flood irrigation stock (%)	0.0
Sprinkle irrigation stock (%)	100.0

n/a = not available

Farm and Field Sizes

A field, for the purpose of this study, is defined as a piece of land with unique crop, soil and physical characteristics. A field will therefore be expected to consist of one crop on essentially one soil type. This distinction, which may not be universal, is an important one to make. Fields will have physical boundaries based on either soils or crop differentiation or perhaps some physical barriers. Such a physical barrier may be the location of some fields on a bench while the rest of the fields on the farm are low-lying. One or more fields constitute a

Records of farm sizes can be directly obtained by making individual contact with the farming community. On a regional basis, information on farm/field sizes has to be obtained from a land registry, where one exists, or from aerial photography. In this study, field sizes were obtained through interviews with farmers. The recorded field sizes in the study area range from 5 to 80 acres with a mean of about 27.3 acres.

Soil Types

Soil types are defined here by their textural classification. Texture is the main determinant for the amount of water held in pore spaces within a soil mass. The precise nomenclature of the soils in the fields given in the soil survey data, super-imposed on the study area map, is given in Figure 16. The most common soil type among the fields is Trenton silty clay loam on 0-3% slopes. The data in Table 24 show a breakdown on average field sizes among soil types. The data also include average infiltration rates and available soil-water-holding capacities. Appendix 3 contains brief descriptions of the soils.

Crops

Crops in the project area all fall within the category of irrigated or dryland commercial crops. Data on crop distribution on a project basis and among fields within the project, are generally scarce. Often, distribution of crops among fields varies with climatic and soil conditions, economics, and farmer preferences. It can be expected that crop distribution among fields will vary from one project to another.

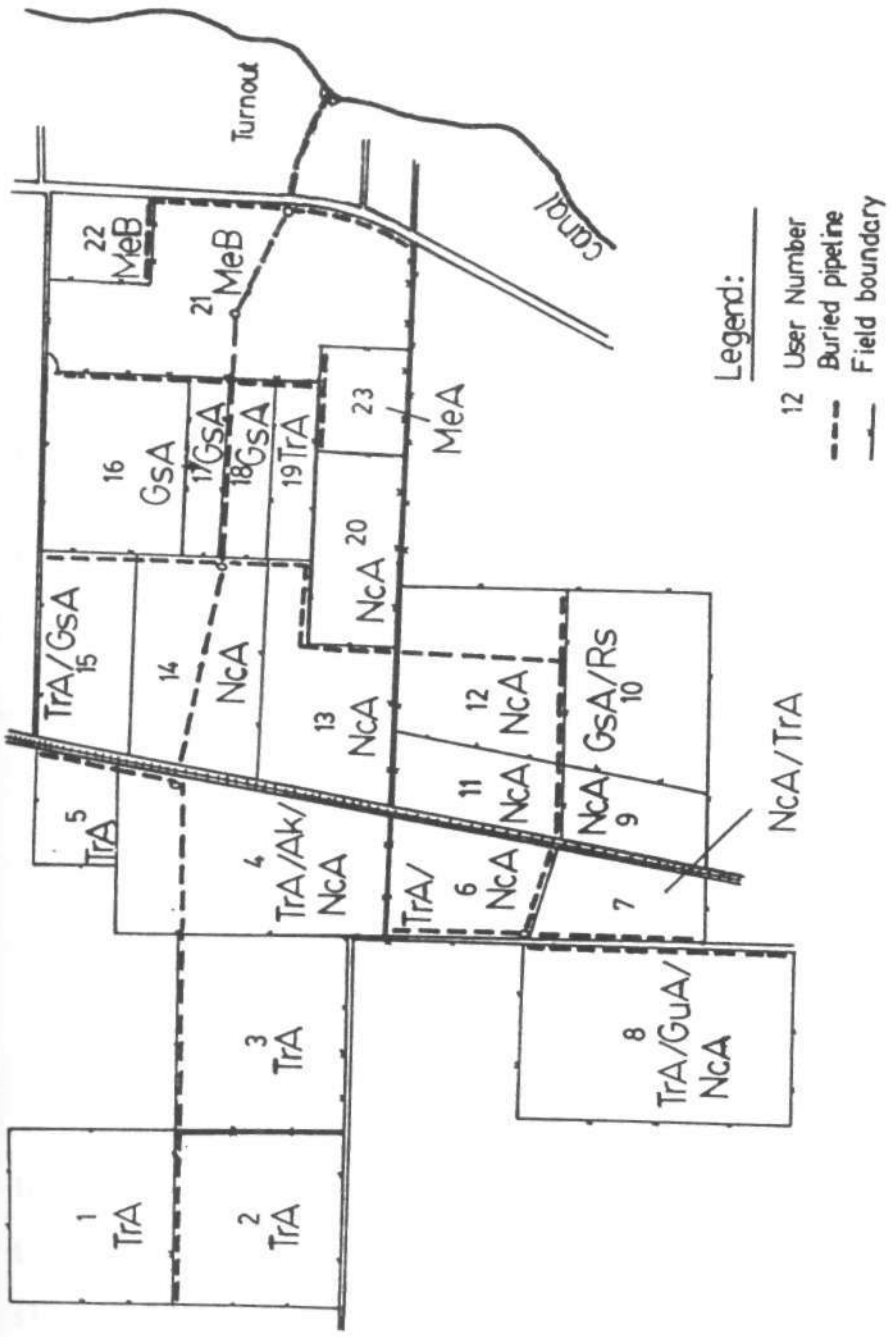


Figure 16.--Study Area Soil Type Distribution.

Table 24.--Average Field Sizes, Infiltration Rates, and Water-Holding Capacities for the Soils of the Study Area, Richmond Irrigation Company, Richmond, Utah.

	Soil types(1)					
	Trenton	Airport	Greenson	Nibley	Mendon	Roshe
Average field size, acres	32.5	12.5	10.0	28.3	20.6	10.5
Av. infiltration rate, in/hr	.06-.20	<0.20	.63-2.00	.06-0.20	.2-.63	.63-2
Available Water Holding Capacity, in/ft(2)	1.86	1.62	2.04	2.04	2.34	2.04

(1) Trenton silty clay loam, 0-2% slope (TrA)

Airport silty clay loam, 0-3% slope (Ak)

Greenson loam, 0-3% slope (GsA)
Greenson loam, over deep clay, 3-6% slope (GuA)

Nibley silty clay loam, 0-3% slope (NcA)

Mendon silt loam, 0-3% slope (MeA)
Mendon silt loam, 3-6% slope (MeB)

Roshe springs silt loam, 0-3% slope (Rs)

(2) mid-interval values.

Crop assignments to fields during the 1986 growing season are shown in Figure 17. Table 25 is a summary of crop distribution among soil types. Alfalfa, as seen in the table, is largely planted on the Trenton silty clay loam and Nibley silty clay loam soils.

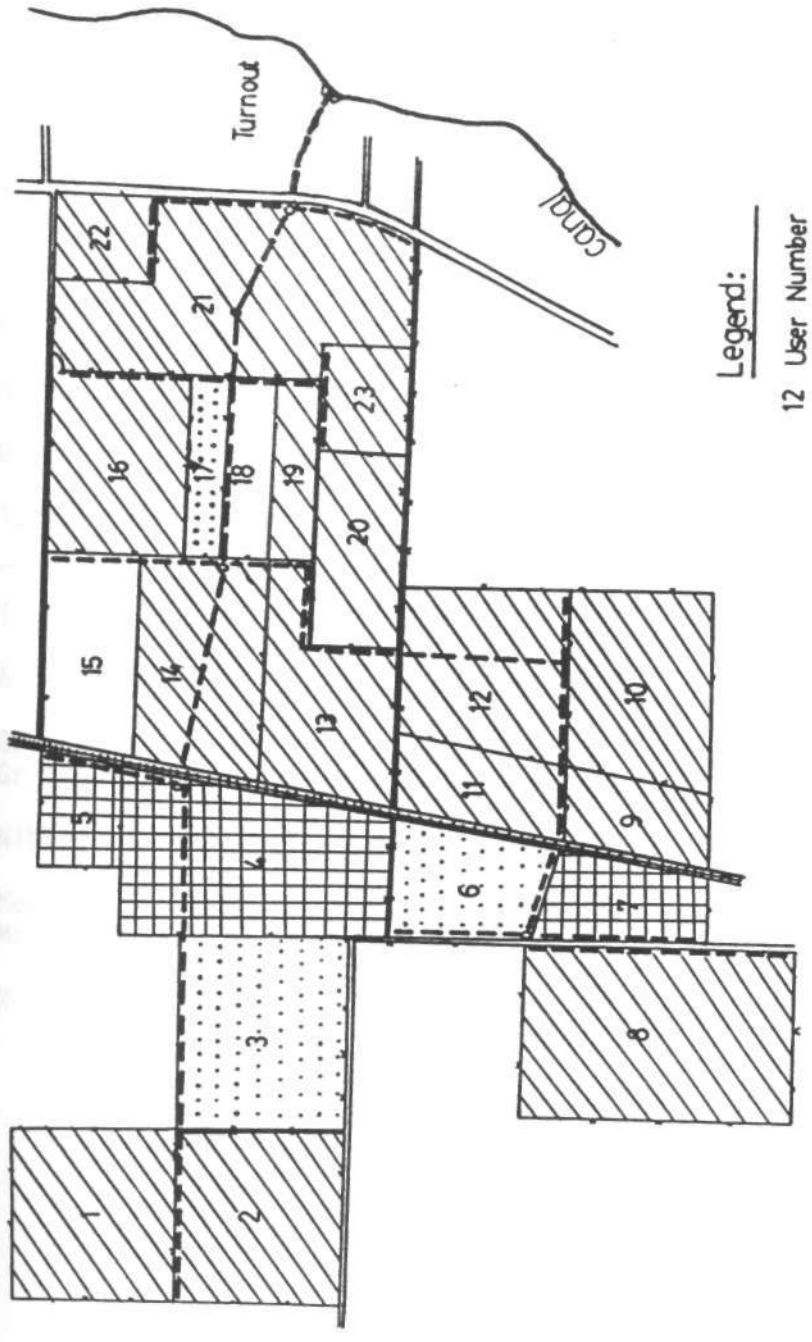


Figure 17.--Crop Distribution among Fields in the Study Area, Richmond Irrigation Company, Richmond, Utah.

Table 25.--A Summary of Crop Distribution in Acres (Percentages) among Soil Types in the Study Area, Richmond Irrigation Company, Richmond, Utah.

Soil type	Alfalfa Acres(%)	Corn Acres(%)	Sm. Grain Acres(%)	Pasture Acres(%)	Total Acres
Trenton	136(54)	15(6)	54(21)	48(19)	253.0
Airport	0(0)	0(0)	0(0)	12.5(100)	12.5
Greenson	79(73)	20(27)	0(0)	0(0)	99.0
Nibley	166(85)	0(0)	6(4)	19.5(11)	191.5
Mendon	62(100)	0(0)	0(0)	0(0)	62.0
Roshe	9(100)	0(0)	0(0)	0(0)	9.0
Total area	452	35	60	80	627.0

Trenton silty clay loam, 0-2% slope (TrA)

Airport silty clay loam, 0-3% slope (Ak)

Greenson loam, 0-3% slope (GsA)
Greenson loam, over deep clay, 0-1% slope (GuA)

Nibley silty clay loam, 0-3% slope (NcA)

Mendon silt loam, 0-3% slope (MeA)
Mendon silt loam, 3-6% slope (MeB)

Roshe springs silt loam, 0-3% slope (Rs)

Water Distribution Pipe Network

Pipeline hydraulic network layout data are vital for establishing whether or not deliveries are hydraulically balanced with the adopted strategy. The detailed pipe information is included in file NETWK.DAT in Appendix 2. The information gathered include:

___ project layout, indicating locations of turnouts and delivery points of users.

___ pipe sizes: diameters, lengths pipe layout and numbers given in Figure 18.

___ pipe types, in terms of materials used in pipe make such as welded steel, aluminum, pvc, asbestos, etc. as each material has different Hazen-William's pipe coefficient.

___ ground elevations at points of deliveries

___ irrigation systems to which deliveries are made, i.e. hand-move or wheel-move lateral systems.

___ number of sprinklers and nozzle sizes.

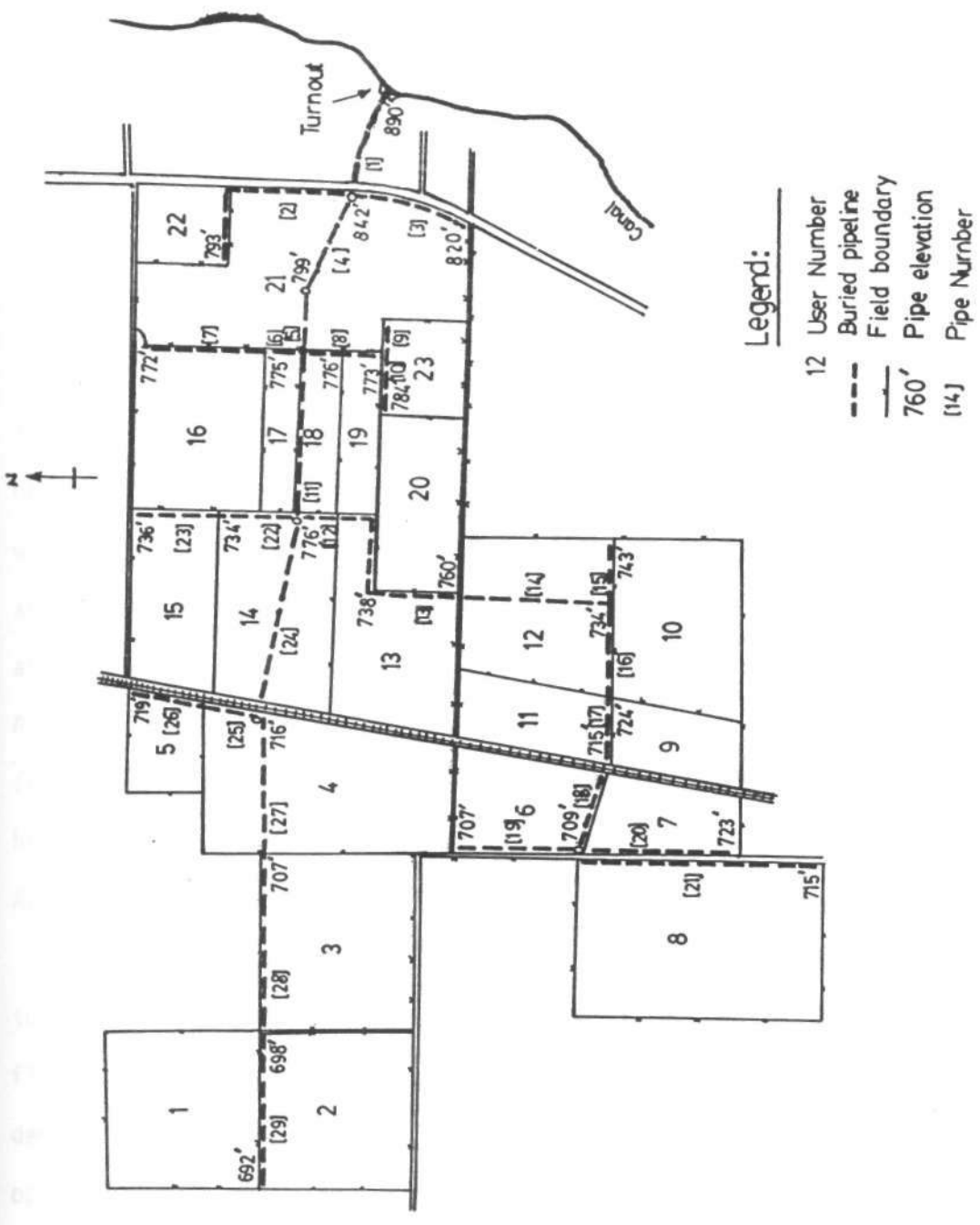


Figure 18.--Water Distribution Network Showing Pipe Layout and Pipe Elevations at the Delivery Points.

RESULTS

The computer model was run for each of the nine strategies and for the three years representing dry (1979), normal (1986), and wet (1983) years. The representative years were selected from water year records of High Creek, near Richmond, Utah for the nine years October 1978 through September 1987. In the three representative years the available streamflow hydrographs for diversions to the study area allowed by water rights varied from 0.5 cfs to a maximum of 6.3 cfs. Figures 19-21 include the hydrographs of available (supply) and demand flows when an on-demand strategy was invoked for allocations for the dry, normal, and wet years, respectively. Also included on the plots are precipitation amounts and dates of occurrence, the number of pumps operating to augment supply flow to meet demand, and the number of users irrigating. A partial print-out of daily allocations to users for the normal year for the on-demand schedule is in Appendix 4. The demand flows in the hydrographs are an aggregation of the individual field demands shown in Appendix 4.

The supply hydrographs exhibit three regions, more distinguishable in the normal and wet years, described here as rising flow, constant flow and receding flow regions. For the test years, with allocations on-demand, the results in Figures 19-21 show that it was infeasible to operate the strategy for allocations without augmentation throughout the growing season. This is evidently so because demand flow rates on the system outstripped the supply flow rates in some instances. This is particularly noticeable in the flow-receding region where there were days with demand-to-supply ratios of over 8:1.

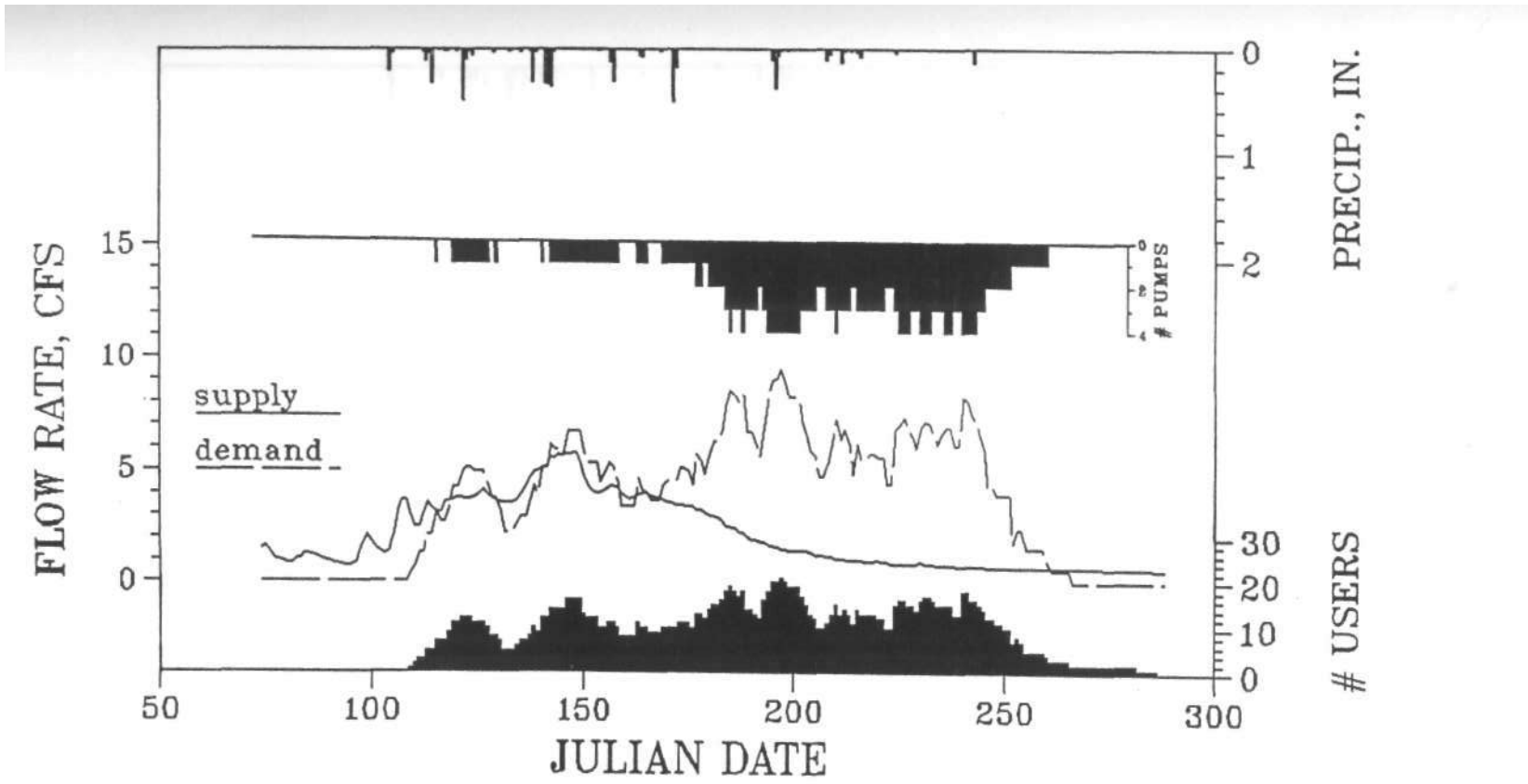


Figure 19.--Available Flow and Demand Flow Hydrographs for Irrigation On Demand, Precipitation, Number of Pumps for Supply Augmentation, and Number of Users Irrigating Based on Dry Year (1979) Data, Richmond Irrigation Company, Richmond, Utah.

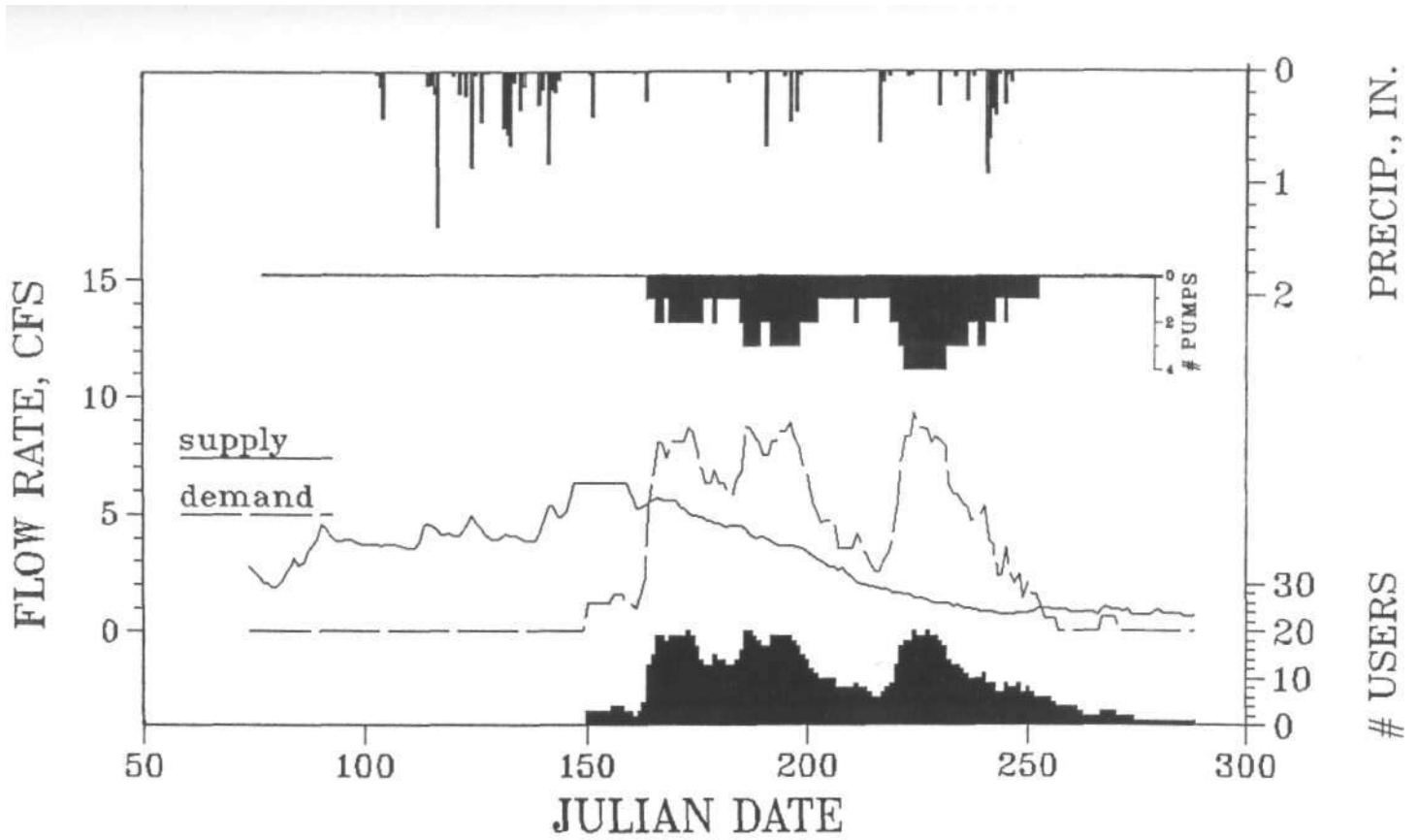


Figure 20.--Available Flow and Demand Flow Hydrographs for Irrigation On Demand, Precipitation, Number of Pumps for Supply Augmentation, and Number of Users Irrigating Based on Normal Year (1986) Data, Richmond Irrigation Company, Richmond, Utah.

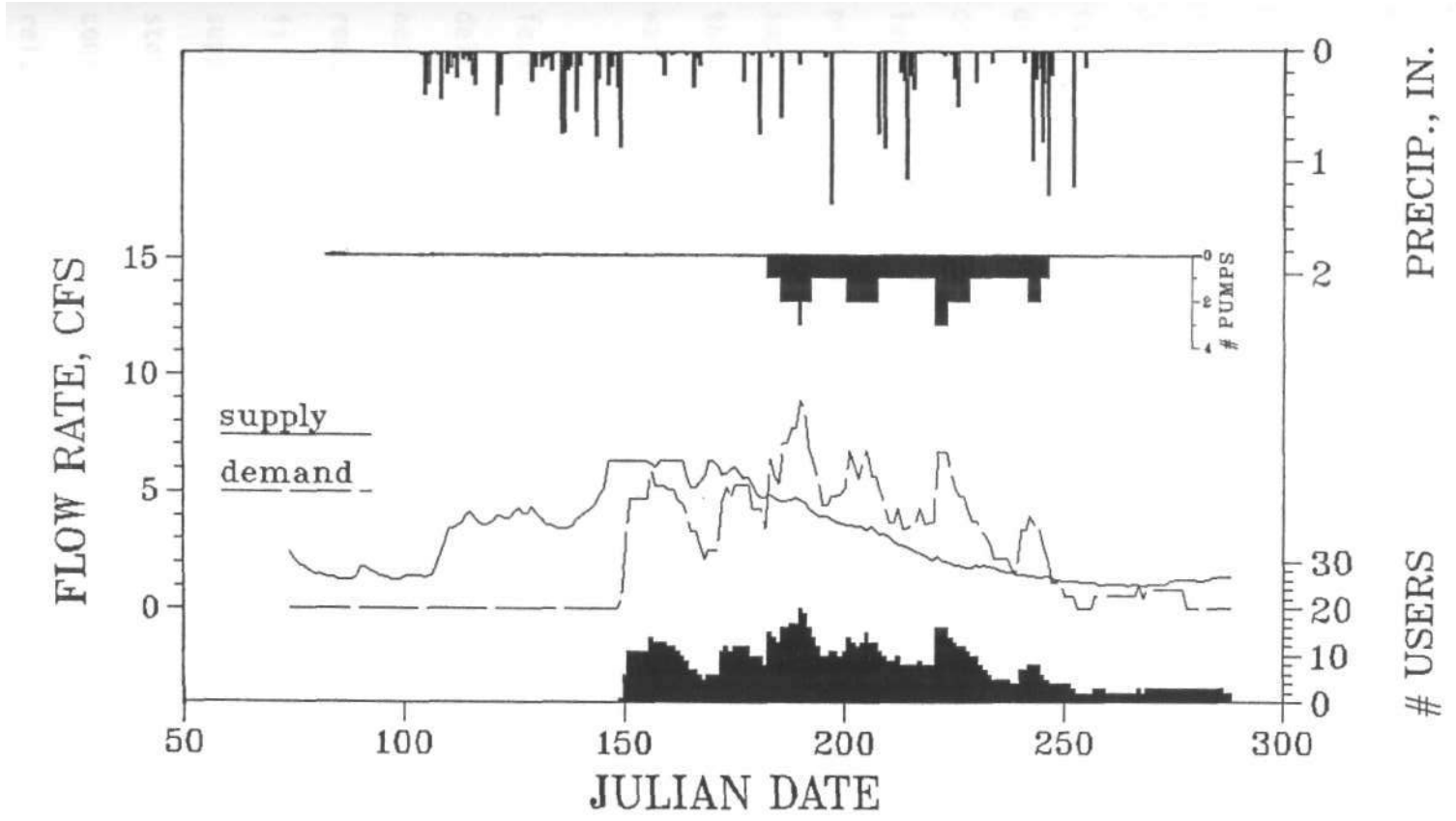


Figure 21.--Available Flow and Demand Flow Hydrographs for Irrigation On Demand, Precipitation, Number of Pumps for Supply Augmentation, and Number of Users Irrigating Based on Wet Year (1983) Data, Richmond Irrigation Company, Richmond, Utah.

Peak flows in High Creek occur between Julian dates 146 and 157 (May 26th - June 6th). The maximum allowed diversion occurs at this interval and falls gradually with time, which ironically is the beginning of increasing demands for irrigation. In the normal and wet years, it was possible for management to operate on demand from the earliest irrigation date, Julian date 101 (April 11th) to Julian date 135 and Julian date 175, respectively. Within these intervals, demand flow rates could be easily satisfied by supply. However, the hydrographs for the dry year (Fig. 19) clearly indicate the existence of significant deficits in supply for operation of on-demand. These deficits were largely due to low streamflow and minimal contribution of scanty precipitation in meeting the crop ET. Operating on-demand was virtually impossible as the demand flow rates remained consistently higher than the supply. Except for about ten days intermittently, at least one pump was operated continuously.

Beyond, those intervals in normal and wet years when on-demand is feasible, some constraints in delivery operations are inevitable. Water delivery by rotation or another non-flexible delivery scheme may be necessary when allocations on-demand are no longer viable for the remainder of the season. If conjunctive water uses are applicable, this is the time at which the company could start supplementing the surface supply source with auxiliary sources such as groundwater, reservoir storage, or traded water from a neighboring irrigation company and continue to operate on-demand. Supplementing with traded water is a relatively weak proposition as water shortage tend to be across the

Irrigation companies within a vicinity that are likely to trade water with each other may be similarly affected by the shortage. In the test dry year pumping from groundwater was considered more feasible, and the number of pumps operated to meet demand as a function of time are shown in Figures 19, 20, and 21. In a majority of run-of-the-river GSIS's with no augmentation, the only option to maintaining equitability in the allocations is to resort to less flexible allocation schedules, such as rotation or continuous supply. The study examined cases where flow to meet demand were augmented as well as constrained situations whereby the company made do with the flow at its disposal. The resulting crop water use, project benefits, waiting time, etc. are discussed in subsequent paragraphs.

Crop Water Use

Assuming on-demand continues for the rest of the season, the data in Table 26 summarizes, for the normal year, water use information on a seasonal basis for each field. Tables 27 and 28, respectively, present similar information resulting from implementing rotation and continuous supply strategies. The data include cropped area, the number of irrigations applied, total net depth of applied irrigation, rainfall amounts, deep percolation drainage, root zone depletion, and crop ET. The remainder of the results of crop water use for the other strategies are included in Appendix 6.

From the dry year results in Appendix 6, it can be seen that irrigation contributed substantially to satisfying crop ET.

Table 26--Summary of Water Use by Field/User During a Normal Year with the On-Demand Strategy Invoked.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	3	16.1	0.0	11.1	2.4	29.7
CARI593	ALFALFA	40	3	16.3	0.2	11.1	2.4	29.6
CARI688	S/GRAIN	40	6	18.3	3.3	7.4	0.6	23.0
CARI836	PASTURE	50	7	19.5	2.2	11.4	0.1	28.8
CARI525	PASTURE	10	6	16.4	1.8	11.1	2.6	28.3
CARI750	S/GRAIN	20	6	18.6	3.6	7.9	0.1	23.0
CARI142	PASTURE	20	7	19.2	2.3	11.4	0.6	28.9
CARI950	ALFALFA	80	2	17.2	0.0	11.1	-1.1	27.2
CARI011	ALFALFA	15	3	16.1	0.1	11.1	2.5	29.6
CARI066	ALFALFA	30	3	15.9	0.4	11.1	3.0	29.6
CARI122	ALFALFA	15	3	16.0	0.6	11.4	2.7	29.6
CARI474	ALFALFA	30	3	16.7	0.7	11.4	2.1	29.6
CARI299	ALFALFA	30	3	16.1	0.3	11.4	2.4	29.6
CARI869	ALFALFA	35	3	16.1	0.1	11.1	2.5	29.6
CARI958	CORN/SL	25	3	12.5	0.2	6.8	1.3	20.4
CARI481	ALFALFA	30	4	20.1	0.7	11.1	-0.9	29.6
CARI986	S/GRAIN	10	6	18.4	3.0	6.9	0.6	22.9
CARI399	CORN/SL	10	4	15.6	2.0	6.8	0.2	20.7
CARI640	ALFALFA	10	3	16.0	0.0	11.1	2.7	29.8
CARI059	ALFALFA	25	3	16.2	0.9	11.5	2.8	29.5
CARI618	ALFALFA	50	2	13.4	0.0	11.7	4.7	29.8
CARI181	ALFALFA	7	3	15.9	0.1	11.1	2.7	29.7
CARI714	ALFALFA	5	3	15.8	0.5	11.4	2.8	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Table 27--Summary of Water Use by Field/User During a Normal Year with Users in Rotation Blocks Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	17.7	5.8	11.1	6.7	29.7
CARI593	ALFALFA	40	10	22.6	9.3	11.1	5.2	29.6
CARI688	S/GRAIN	40	10	15.7	9.6	7.4	6.2	19.7
CARI836	PASTURE	50	10	14.0	6.4	11.4	5.0	24.0
CARI525	PASTURE	10	10	22.3	11.0	11.1	5.2	27.6
CARI750	S/GRAIN	20	10	12.5	8.2	7.9	6.1	18.3
CARI142	PASTURE	20	10	23.6	11.7	11.4	4.7	27.9
CARI950	ALFALFA	80	10	2.6	0.0	11.1	8.2	22.0
CARI011	ALFALFA	15	10	22.5	8.7	11.1	4.7	29.6
CARI066	ALFALFA	30	10	22.4	8.9	11.1	5.1	29.6
CARI122	ALFALFA	15	11	23.4	9.3	11.4	4.0	29.6
CARI474	ALFALFA	30	11	23.4	9.4	11.4	4.1	29.6
CARI299	ALFALFA	30	10	22.7	9.0	11.4	4.5	29.6
CARI869	ALFALFA	35	10	11.6	3.1	11.1	8.2	27.8
CARI958	CORN/SL	25	10	17.8	5.4	6.8	0.5	19.8
CARI481	ALFALFA	30	10	17.5	5.9	11.1	7.0	29.6
CARI986	S/GRAIN	10	10	32.5	21.2	6.9	4.7	22.9
CARI399	CORN/SL	10	9	21.2	7.9	6.8	0.2	20.3
CARI640	ALFALFA	10	9	15.3	3.7	11.1	7.0	29.8
CARI059	ALFALFA	25	10	11.4	3.5	11.5	7.6	27.0
CARI618	ALFALFA	50	9	15.6	4.2	11.7	6.7	29.8
CARI181	ALFALFA	7	9	19.3	6.5	11.1	5.7	29.7
CARI714	ALFALFA	5	10	24.4	10.3	11.4	4.0	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Table 28.--Summary of Water Use by Field/User During a Normal Year with Continuous Supply Strategy Invoked.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	16	18.0	5.4	11.1	6.0	29.7
CARI593	ALFALFA	40	16	23.1	8.8	11.1	4.2	29.6
CARI688	S/GRAIN	40	13	16.5	9.8	7.4	6.3	20.4
CARI836	PASTURE	50	16	14.3	6.0	11.4	5.0	24.7
CARI525	PASTURE	10	16	22.6	10.5	11.1	5.1	28.3
CARI750	S/GRAIN	20	13	12.8	8.0	7.9	6.2	19.0
CARI142	PASTURE	20	16	23.6	11.3	11.4	4.9	28.7
CARI950	ALFALFA	80	16	2.7	0.0	11.1	8.2	22.0
CARI011	ALFALFA	15	16	22.9	8.6	11.1	4.2	29.6
CARI066	ALFALFA	30	16	23.0	9.0	11.1	4.5	29.6
CARI122	ALFALFA	15	16	23.6	9.2	11.4	3.6	29.6
CARI474	ALFALFA	30	16	24.0	9.4	11.4	3.5	29.6
CARI299	ALFALFA	30	16	22.9	8.7	11.4	4.0	29.6
CARI869	ALFALFA	35	16	11.9	3.0	11.1	8.2	28.2
CARI958	CORN/SL	25	14	21.0	7.2	6.8	0.3	20.8
CARI481	ALFALFA	30	16	16.2	5.1	11.1	7.4	29.6
CARI986	S/GRAIN	10	13	30.6	19.2	6.9	4.7	22.9
CARI399	CORN/SL	10	14	20.1	6.9	6.8	0.2	20.2
CARI640	ALFALFA	10	16	14.3	3.2	11.1	7.6	29.8
CARI059	ALFALFA	25	16	11.0	3.5	11.5	7.6	26.6
CARI618	ALFALFA	50	16	14.6	3.6	11.7	7.1	29.8
CARI181	ALFALFA	7	16	18.0	5.5	11.1	6.0	29.7
CARI714	ALFALFA	5	16	22.9	8.8	11.4	4.0	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

For alfalfa fields, seasonal net depth of applied irrigation amounted to 25 to 29 inches applied in 5 to 6 irrigations. Rainfall contributed 5.4 inches to most fields. The differences in amounts of rainfall received during the growing season by fields were due to differences in planting dates. Drainage from alfalfa and pasture fields was less than 0.4 inches on the medium soils, while corn and small grain fields had 0.6 inches. The differences might be attributed to the inability of the well-moistened shallow root depth corn and grain fields to absorb more water from the earlier rains of the season, since beginning soil water content in most fields was about field capacity. The antecedent water content for all fields was high.

The average seasonal actual crop ET's were 30, 20, 23, and 28 inches, for alfalfa, corn, small grain, and pasture, respectively. In fields with root zone depletion calculated as a negative amount, this indicates that there was more water left in the root zone at the season end than at planting or begin growth.

In the wet year, rainfall supplied over 18 inches on the average to alfalfa fields; the farmers needed an average of about three irrigations for the season on the on-demand schedule. Seasonal totals of deep percolation drainage from corn and small grain fields were substantial in the wet year. However, with the one-time delivery strategy, effluent from the root zones of alfalfa and pasture was lower than those of corn and small grain fields.

In normal years, which are more prevalent, unless constrained, alfalfa receiving an average of 11 inches of rainfall requires 17 to 20 inches in 3 to 4 irrigations for medium soils and 17 inches in 2 to 3

irrigations for heavy soils. Corn and small grain planted later obtains 7 and 8 inches, respectively, from rainfall, with irrigation making up the difference of about 16 inches, depending on the soil type. With on-demand, drainage out of the root zone in normal years is modest for alfalfa and pasture but high for corn and small grain fields. In the test normal year a number of fields had substantial drainage occur when rain fell a few days after irrigation. On-demand seems to provide a better water use option compared to other strategies, if the water for augmentation is available. However, if users are constrained to available natural resources, the next best option is rotation. No significant differences in seasonal net irrigations were observed among the modified rotation strategies.

Cost, Return, and Benefit Analysis

Data on accumulated actual and potential crop transpiration for each crop field at the various physiologic growth stages for corn and small grains, and seasonal totals for alfalfa and pasture for the normal year as a result of implementing allocations on demand, rotation, and continuous supply, respectively, are shown in Tables 29, 30, and 31. For each strategy actual crop yield, which is directly proportional to the ratio of actual to potential transpiration, is estimated and included in the tables for all fields. For corn and small grain, any reduction in transpiration causing stress in the crop and resulting in zero accumulation of actual transpiration at any of its growth stages might amount to a reduction of the dry matter yield.

Table 29.--Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre from On-Demand Strategy, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	CUMULATIVE TRANSPIRATION ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/ac.
CARI430	ALFALFA	28.9	28.9	7.6	18200	5720	12480	312
CARI593	ALFALFA	28.9	28.9	7.6	18200	5640	12560	314
CARI688	S/GRAIN	0.2	0.2	3.8	11240	6160	5080	127
		0.9	0.9					
		3.3	3.3					
		2.5	2.5					
		9.2	9.2					
CARI836	PASTURE	27.4	27.4	2.7	2100	3400	-1300	-26
CARI525	PASTURE	26.9	26.9	2.7	420	710	-290	-29
CARI750	S/GRAIN	0.4	0.4	3.8	5620	3020	2600	130
		1.1	1.1					
		3.8	3.8					
		2.5	2.5					
		8.7	8.7					
CARI142	PASTURE	27.5	27.5	2.7	840	1780	-940	-47
CARI950	ALFALFA	29.0	24.7	6.5	31120	9360	21760	272
CARI011	ALFALFA	28.9	28.9	7.6	6825	2535	4290	286
CARI066	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI122	ALFALFA	28.9	28.9	7.6	6825	2535	4290	286
CARI474	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI299	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI869	ALFALFA	28.9	28.9	7.6	15925	4760	11165	319
CARI958	CORN/SL	0.0	0.0	24.7	13600	4800	8800	352
		3.2	3.2					
		4.6	4.6					
		5.6	5.6					
CARI481	ALFALFA	28.9	28.9	7.6	13650	4710	8940	298
CARI986	S/GRAIN	0.2	0.2	3.8	2810	1950	860	86
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	9.6					
CARI399	CORN/SL	0.0	0.0	24.7	5440	2220	3220	322
		3.4	3.4					
		4.8	4.8					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1660	2890	289
CARI059	ALFALFA	28.9	28.9	7.6	11375	3450	7925	317
CARI618	ALFALFA	28.7	28.4	7.5	22550	6650	15900	318
CARI181	ALFALFA	28.9	28.9	7.6	3185	1099	2086	298
CARI714	ALFALFA	28.9	28.9	7.6	2275	810	1465	293

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Table 30.--Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre from Users in Rotation Block Strategy, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	CUMULATIVE TRANSPIRATION ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.3	7.4	17880	6560	11320	283
CARI593	ALFALFA	28.9	28.9	7.6	18200	6480	11720	293
CARI688	S/GRAIN	0.2	0.2	2.4	7280	6640	640	16
		0.9	0.9					
		3.3	3.3					
		2.5	2.5					
		9.2	6.5					
CARI836	PASTURE	27.4	19.3	1.9	1450	3850	-2400	-48
CARI525	PASTURE	26.9	24.8	2.5	380	830	-450	-45
CARI750	S/GRAIN	0.4	0.4	1.2	1800	3260	-1460	-73
		1.1	1.1					
		3.8	3.8					
		2.5	2.5					
		8.7	3.5					
CARI142	PASTURE	27.5	25.0	2.4	760	1960	-1200	-60
CARI950	ALFALFA	29.0	16.6	4.3	20960	11280	9680	121
CARI011	ALFALFA	28.9	28.8	7.6	6825	2850	3975	265
CARI066	ALFALFA	28.9	28.8	7.5	13620	5010	8610	287
CARI122	ALFALFA	28.9	28.8	7.5	6810	2895	3915	261
CARI474	ALFALFA	28.9	28.9	7.6	13650	5100	8550	285
CARI299	ALFALFA	28.9	28.8	7.5	13650	5010	8640	288
CARI869	ALFALFA	28.9	24.5	6.4	13510	5495	8015	229
CARI958	CORN/SL	0.0	0.0	18.2	9975	5325	4650	186
		3.2	3.2					
		4.6	4.6					
		5.6	3.5					
CARI481	ALFALFA	28.9	28.3	7.4	13380	5250	8130	271
CARI986	S/GRAIN	0.2	0.2	3.8	2810	2070	740	74
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	9.6					
CARI399	CORN/SL	0.0	0.0	16.7	3670	2370	1300	130
		3.4	3.4					
		4.8	4.8					
		5.5	3.0					
CARI640	ALFALFA	29.0	28.3	7.4	4450	1840	2610	261
CARI059	ALFALFA	28.9	23.4	6.1	9200	3975	5225	209
CARI618	ALFALFA	28.7	28.4	7.5	22500	7700	14800	296
CARI181	ALFALFA	28.9	28.8	7.5	3185	1225	1960	280
CARI714	ALFALFA	28.9	28.9	7.6	2275	915	1360	272

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Table 3I.--Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre from Continuous Supply Strategy in a Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	CUMULATIVE TRANSPIRATION ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/ac.
CARI430	ALFALFA	28.9	28.8	7.5	18160	7280	10880	272
CARI593	ALFALFA	28.9	28.9	7.6	18200	7200	11000	275
CARI688	S/GRAIN	0.2	0.2	2.9	8720	7000	1720	43
		0.9	0.9					
		3.3	3.3					
		2.5	2.5					
		9.2	7.5					
CARI836	PASTURE	27.4	20.7	2.0	1550	4750	-3200	-64
CARI525	PASTURE	26.9	26.2	2.6	400	1010	-610	-61
CARI750	S/GRAIN	0.4	0.4	1.6	2420	3440	-1020	-51
		1.1	1.1					
		3.8	3.8					
		2.5	2.5					
		8.7	4.4					
CARI142	PASTURE	27.5	26.1	2.5	780	2320	-1540	-77
CARI950	ALFALFA	29.0	16.7	4.4	21040	12720	8320	104
CARI011	ALFALFA	28.9	28.9	7.6	6825	3120	3705	247
CARI066	ALFALFA	28.9	28.9	7.6	13650	5550	8100	270
CARI122	ALFALFA	28.9	28.9	7.6	6825	3120	3705	247
CARI474	ALFALFA	28.9	28.9	7.6	13650	5550	8100	270
CARI299	ALFALFA	28.9	28.9	7.6	13650	5550	8100	270
CARI869	ALFALFA	28.9	24.9	6.5	13720	6125	7595	217
CARI958	CORN/SL	0.0	0.0	19.6	10775	5625	5150	206
		3.2	3.2					
		4.6	4.6					
		5.6	3.9					
CARI481	ALFALFA	28.9	28.0	7.3	13230	5790	7440	248
CARI986	S/GRAIN	0.2	0.2	3.8	2810	2160	650	65
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	9.6					
CARI399	CORN/SL	0.0	0.0	16.8	3700	2520	1180	118
		3.4	3.4					
		4.8	4.8					
		5.5	3.0					
CARI640	ALFALFA	29.0	27.7	7.2	4350	2050	2300	230
CARI059	ALFALFA	28.9	22.8	6.0	8975	4425	4550	182
CARI618	ALFALFA	28.7	28.0	7.4	22200	8750	13450	269
CARI181	ALFALFA	28.9	28.8	7.5	3178	1372	1806	258
CARI714	ALFALFA	28.9	28.9	7.6	2275	1005	1270	254

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

In the event of total yield loss, any financial return credited to such a crop must be from the sale of its by-product, such as straw. Most corn fields come to heading at a time when streamflow is in the receding region, and with most constrained allocation strategies water that is so allocated to users seldom satisfies crop demand. Consequently, the crop may be water-stressed and the yield become depressed. From the data it can be observed that because of the low streamflow and the low allocations received before maturity of corn, the stresses that occur at the flowering and yield formation growth stages are invariably the causes of the depressed crop yields. Operation-induced water stress was observed in two alfalfa fields, CARI950 and CARI618, where only two on-demand irrigations were given. The stress was because of limited equipment (i.e., laterals) to complete one irrigation on time before the next irrigation was due. In those fields, crop yields were below potential in the three years, including the wet year, not because of supply deficits but because of operational constraints.

The last four entries in the tables are estimates of farm field revenues from crop yields and perhaps by-products, cost of production, benefits, and benefits per acre. Benefit is a profit if positive and loss if negative. Farmers that grow pasture hardly break even even when harvested yields are at potential. This is because the returns or revenue from the sale of the crop are less than the production costs. This case is demonstrated by pasture planted on fields CARI836, CARI525, and CARI142. The benefits made from the sale of alfalfa, silage corn, and small grains were for most fields positive, though those for small grain were relatively modest.

The fields under pasture incurred heavy financial losses. This statement is substantiated by the benefits received by the individual users for the different enterprises in the normal year. With the crops not water stressed, average benefits to users were as follows: alfalfa, $302 per acre ($40/ton); silage corn, $337 per acre ($14/ton); small grain, $114 per acre ($30/ton); and pasture, -$34 per acre (-$13/ton). With the constrained allocation strategies these benefits were lower, and indeed some alfalfa fields in the dry year returned negative benefits (i.e., losses) to users because the crops were severely stressed of water.

Equitability in Allocations

Tables 32, 33, and 34 show total allocations received in the season by fields based on on-demand, rotation, and continuous supply allocation strategies in the normal year. The relative ratios (user allocation divided by total allocations to all users) compared to the ratios of users' shares of stock to company total stock are included in the tables. Some inferences can be drawn as to equitability in the allocations among users. Comparing the two ratios per se, it is observed that some users received more or less water than their shares of stock would otherwise entitle them to. No restrictions were imposed by allocations on-demand. Users, including those with few shares, received as much water as their fields needed. A case in point is CARI950 (80 acres of alfalfa and 12 shares of stock) with 2.1% of company stock, which received over 13% of the total allocations of the normal year.

Table 32.--Field/User Stock Relative to Allocation Received and in Percentages Using On-Demand Strategy in a Normal Year

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	69.0	6.0
CARI593	51.0	9.1	70.0	6.0
CARI688	40.0	7.1	81.9	7.1
CARI836	39.0	7.0	103.2	8.9
CARI525	12.5	2.2	18.2	1.6
CARI750	15.0	2.7	42.4	3.7
CARI142	26.0	4.6	41.6	3.6
CARI950	12.0	2.1	157.4	13.6
CARI011	19.0	3.4	26.6	2.3
CARI066	38.0	6.8	52.3	4.5
CARI122	19.0	3.4	25.6	2.2
CARI474	38.0	6.8	56.6	4.9
CARI299	38.0	6.8	55.8	4.8
CARI869	23.0	4.1	60.1	5.2
CARI958	20.0	3.6	33.6	2.9
CARI481	27.0	4.8	67.1	5.8
CARI986	19.0	3.4	20.4	1.8
CARI399	8.0	1.4	17.5	1.5
CARI640	8.0	1.4	18.3	1.6
CARI059	14.0	2.5	45.2	3.9
CARI618	41.0	7.3	76.1	6.6
CARI181	7.0	1.2	12.2	1.0
CARI714	6.3	1.1	8.8	0.8

MONTH	AUG. VOLUME (acre-ft)	AUG. HR (hour)	ENERGY (kwh)	COSTS $	DISCOUNTS $	NET BILL $
APRIL	0.00	0	0	713.75	0.00	713.75
MAY	0.00	0	0	713.75	0.00	713.75
JUNE	77.56	432	19336	14502.15	554.52	13947.64
JULY	179.16	744	44663	31799.81	1208.81	30591.01
AUGUST	269.23	744	67117	46976.20	1788.87	45187.34
SEPTEMBER	24.78	216	6177	5317.71	214.56	5103.15

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 550.7
TOTAL AUGMENTATION COST = $ 96,257.00

TOTAL BENEFIT TO PROJECT = $ 51,111.00
AVERAGE WAITING TIME (DAYS) = 7

TOTAL WATER ALLOCATED (ACRE-FT) = 1159.9
RESOURCE UTILIZATION RATIO = 1.02

Table 33.--Field/User Stock Relative to Allocation Received and in Percentages Using Users in Rotation Blocks Strategy in a Normal Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	77.3	7.5
CARI593	51.0	9.1	99.0	9.5
CARI688	40.0	7.1	68.9	6.6
CARI836	39.0	7.0	75.3	7.3
CARI525	12.5	2.2	24.2	2.3
CARI750	15.0	2.7	26.5	2.6
CARI142	26.0	4.6	51.5	5.0
CARI950	12.0	2.1	19.3	1.9
CARI011	19.0	3.4	37.0	3.6
CARI066	38.0	6.8	72.6	7.0
CARI122	19.0	3.4	38.6	3.7
CARI474	38.0	6.8	74.5	7.2
CARI299	38.0	6.8	69.2	6.7
CARI869	23.0	4.1	37.1	3.6
CARI958	20.0	3.6	43.8	4.2
CARI481	27.0	4.8	48.0	4.6
CARI986	19.0	3.4	33.9	3.3
CARI399	8.0	1.4	27.3	2.6
CARI640	8.0	1.4	15.5	1.5
CARI059	14.0	2.5	20.7	2.0
CARI618	41.0	7.3	48.5	4.7
CARI181	7.0	1.2	14.7	1.4
CARI714	6.3	1.1	13.3	1.3

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 110,330.00

AVERAGE WAITING TIME (DAYS) = 38

TOTAL WATER ALLOCATED (ACRE-FT) = 1036.7

RESOURCE UTILIZATION RATIO = 0.91

Table 34.--Field/User Stock Relative to Allocation Received and in Percentages Using Continuous Supply Strategy in a Normal Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	78.8	7.4
CARI593	51.0	9.1	101.0	9.5
CARI688	40.0	7.1	72.7	6.8
CARI836	39.0	7.0	77.6	7.3
CARI525	12.5	2.2	24.5	2.3
CARI750	15.0	2.7	28.2	2.6
CARI142	26.0	4.6	52.1	4.9
CARI950	12.0	2.1	21.3	2.0
CARI011	19.0	3.4	37.5	3.5
CARI066	38.0	6.8	75.0	7.0
CARI122	19.0	3.4	38.8	3.6
CARI474	38.0	6.8	78.5	7.4
CARI299	38.0	6.8	75.2	7.0
CARI869	23.0	4.1	43.0	4.0
CARI958	20.0	3.6	54.1	5.1
CARI481	27.0	4.8	44.0	4.1
CARI986	19.0	3.4	31.8	3.0
CARI399	8.0	1.4	21.1	2.0
CARI640	8.0	1.4	14.7	1.4
CARI059	14.0	2.5	21.6	2.0
CARI618	41.0	7.3	49.5	4.6
CARI181	7.0	1.2	13.7	1.3
CARI714	6.3	1.1	12.5	1.2

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 102,651.00

AVERAGE WAITING TIME (DAYS) = 35

TOTAL WATER ALLOCATED (ACRE-FT) = 1067.4

RESOURCE UTILIZATION RATIO = 0.94

Those users that got far less than their shares generally owned more shares than they needed to. While no absolute agreement between the two ratios exist with on-demand allocations, the constrained allocations attempted to ration water based on shares of stock. It can be observed in Tables 33 and 34 that a close agreement between the two percentage values exists. Similar data given in Appendix 6 for the on-request tend to show that the allocations favored the more profitable crop, alfalfa.

Waiting Time

Waiting time, as it was defined earlier, is a parameter used to obtain an average for the total number of days during which soil moisture level in the field has been depleted below the management-allowed deficit, MAD, and at which point the field is considered due for irrigation. For all fields in this study, MAD was set at 50 percent of available water. The waiting time, or stress-days as it is referred to in some literature, varied among users and depended on the strategy used. For the on-demand strategy waiting time in the dry, normal, or wet years was 11, 7, and 5 days, respectively, and is attributed to field(s) that suffered operational-induced stresses. Waiting times in the normal year are given in Tables 32, 33, and 34. For other strategies, included in Appendix 6, waiting time varied from 28 days to 101 days. Waiting time was shortest for continuous supply, because users continued to receive some amounts of water daily. These irrigation amounts might not be adequate for some fields at certain growth stage(s), nonetheless it was an addition to the soil water content. One-time delivery strategy had a waiting time of 101 days in the dry year. With one-time delivery,

once irrigation is applied any further accretion to the root zone is from rainfall. If the depth of rainfall is insignificant, the field may remain waiting for as long as the moisture content remains below MAD. With the modified rotation strategies, even though the user has access to water every 15 days, the irrigation depth applied may not be large enough to raise water content to or above MAD, and so the field remains on a waiting status. With rotation, the average waiting time in the dry year was 85 days. There were ^o significant differences observed among waiting times for the strategies in specific years, as shown in Table 35. Generally, waiting time for all strategies is longest in dry years and shortest in the wet year. Waiting time has some relationship with crop yields in that the longer the waiting time with a given strategy the more the individual fields are stressed and the less the crop yield and potential benefits to the users.

Resource Utilization Ratio

The resource utilization ratio is used to obtain a measure of how closely the total allocations to users were to the available water resource at the disposal of the company. Allocation on-demand simulated a situation that did not limit any user to how much or when to irrigate. The utilization ratio, then, reflected how much was needed and used relative to what was available. In the dry year, the water utilization ratio amounted to 1.84; users required about 84 percent more water in volumetric terms on a seasonal basis than they had water rights for in order to operate on demand.

The specific times when the additional supply is needed become more

apparent by examining the demand-and-supply hydrographs in Figures 19, 20, and 21. In normal and wet years the ratios show that there was enough volume of water to meet seasonal demands; however, this is to be realized only if the assumption of trading with surplus water at the beginning of the season or availability of storage reservoir holds. Either option makes it possible for the company to augment its deficient supply later in the season. If the assumption does not hold, then the company will have to pump from groundwater. The cost of such augmentation for the normal year is included in footnotes to Table 32 and 35.

With the other strategies allocations were constrained by available water, which meant that users had to make do with irrigations that were less than crop demand and/or fewer irrigations. To match allocations closely with what was available the ratios had to be less than 1.0, as earlier in the season water was available but not really needed. The utilization ratios ranged between 0.32 and 0.94 for the various strategies. In the wet year, there was on the average above 10 percent surplus water, mainly earlier in the season. With the one-time delivery strategy, where only one heavy irrigation was given to refill root zones, in the normal year just about 35 percent of the streamflow was utilized. Augmentation was needed if streamflow was low since the commitment for the one-time delivery had to be fulfilled.

The data in Table 35, averages of five runs, summarizes the results of the response of the irrigation system to all of the allocation strategies in what are described as "attributes of the management strategies."

Table 35.--A Summary of Attributes for Management Strategies Implemented in the Dry, Normal, and Wet Years (1979, 1986, and 1983, respectively).

Strategy	Season type	Benefit $	Wait time days	Water supplied		R.U.R
				Stream	Augm.	
On demand:						
1a Unlimited access to water[a]	dry	143,464	11	663	845	1.84
	norm.	153,961	7	591	551	1.00
	wet	154,331	5	715	237	0.79
1b Unlimited access to water[b]	dry	-5,214	11	662	845	1.84
	norm.	51,111	7	609	551	1.02
	wet	105,509	5	730	237	0.80
Modified demand:						
3 User on Request	dry	64,268	74	744	0	0.91
	norm.	89,183	58	591	0	0.52
	wet	136,231	34	759	0	0.63
8 One time delivery[c]	dry	5,294	101	382	199	0.71
	norm.	84,175	67	392	7	0.35
	wet	117,441	65	389	1	0.32
Rotation:						
2 Users in Rotation Blocks	dry	34,203	79	689	0	0.84
	norm.	110,330	38	1037	0	0.91
	wet	127,400	29	1069	0	0.89
4 Among Crop categories	dry	19,651	91	685	0	0.83
	norm.	105,760	43	1015	0	0.89
	wet	125,414	37	1045	0	0.87
5 Stock Ranks	dry	28,757	81	705	0	0.86
	norm.	109,227	40	1046	0	0.92
	wet	128,314	35	1083	0	0.90
6 System types	dry	28,280	83	676	0	0.82
	norm.	106,015	42	1037	0	0.91
	wet	125,889	38	1074	0	0.89
7 Labor cost scheme	dry	21,426	90	694	0	0.85
	norm.	103,073	43	1031	0	0.90
	wet	123,639	38	1077	0	0.90

Table 35.--A Summary of Attributes for Management Strategies Implemented in the Dry, Normal, and Wet Years (1979, 1986, and 1983, respectively), (continued).

Strategy	Season type	Benefit $	Wait time days	Water supplied		R.U.R
				Stream	Augm.	
Continuous Supply:						
9 Continuous supply	dry	23,841	80	735	0	0.89
	norm.	102,651	35	1067	0	0.94
	wet	117,763	28	1112	0	0.93

Water supplied, measured in acre-ft.

RUR = Resource Utilization Ratio, defined as the ratio of water supplied (stream plus augmentation) and allocated to users to streamflow resource available to project for which water-right is granted.

[a]Assumes unlimited access to water, with no cost supply augmentation during times when flow demand exceeds available supply hydrographs (see Figs. 19, 20, and 21)

[b]Augmentation costs included were $144,735, $96,257, and $44,679 for dry, normal, and wet years respectively.

[c]Augmentation costs included were $38,405, $5,665, and $4,479 for dry, normal, and wet years respectively.

For the first entry, benefit to the project assumed a zero cost augmentation, a situation in which the company incurred no cost for the augmentation. The second entry, which considered augmentation cost in order to arrive at the total benefit, is more realistic. The procedure used in estimating the augmentation cost is given in Appendix 8. Total benefit to project is plotted, as a function of strategy number for the various season types, in Figure 22. On-demand strategy, the first entry, returns the highest total benefit to the users if augmentation has no cost. But if augmentation is to be paid for, on-demand, despite its flexibility, is a lower revenue-earning option for the project than the other strategies. On-request, because of its bias toward more profitable crops, enhanced higher productivity and returned higher benefits to the project relative to the amount of water supplied. The high productivity is, however, at the expense of equitability in the allocations. Continuous supply performed no better than any of the modified rotation strategies in terms of monetary benefits; it had a slightly lower average waiting time in the dry year. One-time delivery performed almost as well as on-request in the normal year but returned less benefits than any other strategies, except on-demand with augmentation cost taken into account. The one heavy dosage of irrigation given to refill the root zone was not beneficial to grain crops in particular as some fields failed, more so in the dry year.

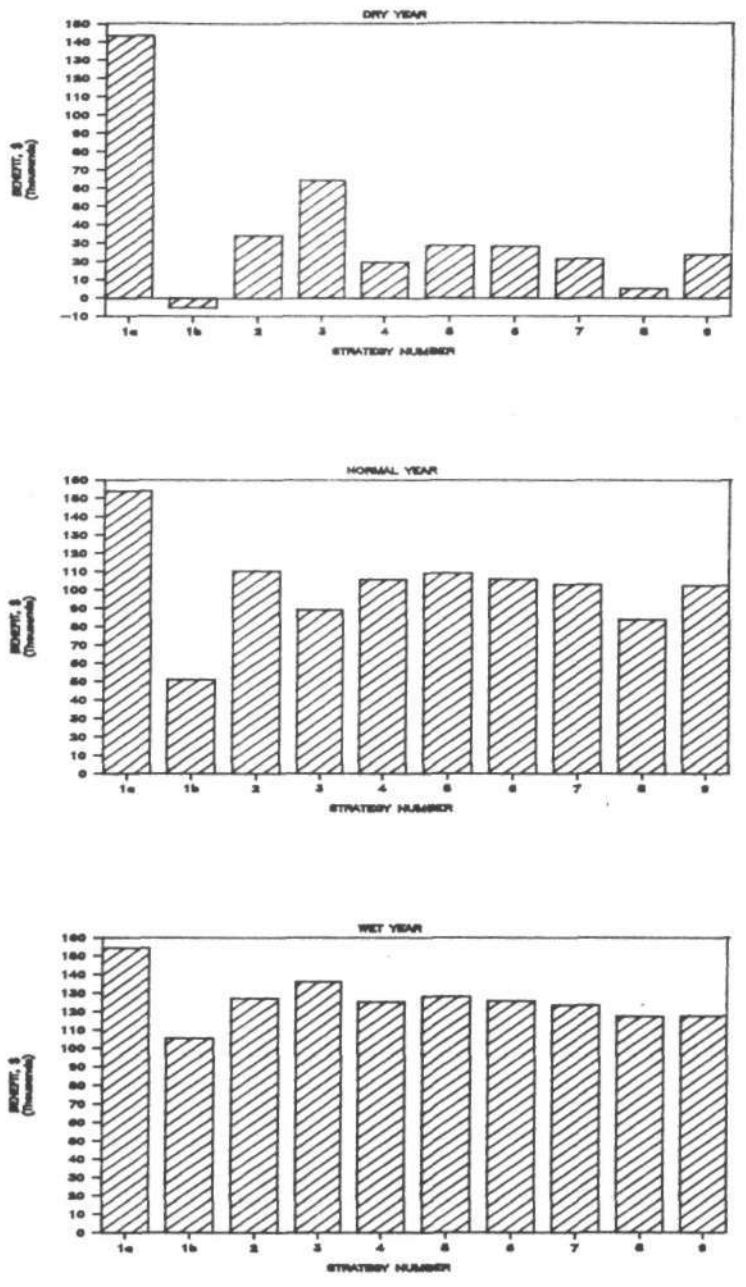


Figure 22.--Benefit to Project for the Various Management Strategies Implemented in the Dry, Normal, and Wet Years.

SUMMARY AND CONCLUSIONS

Summary

The reliability of estimates for project-level irrigation requirements is a function of the accuracy of field-level demands. Field-level demands, in practice, have not always matched the crop requirement, sometimes due to the kind of irrigation scheduling procedure. In run-of-the-river GSIS's, where the time-variant streamf1ows are not always adequate in meeting all of irrigation requirements, management strategies must be developed to ensure equitable allocations of the available water at any given time.

To satisfy equitability in water allocations, which is a legal pre-requisite, the issue is one of ensuring that stockholders get some share of the water that is commensurate with their stockholding. Any constraint should also be borne by all users and restrictions applied by management should be universal.

The study reported herein identified a number of practical management strategies that are applied to water allocations. The strategies were: (1) On-demand, a situation where no restrictions are imposed on the users in terms of the amount and number of irrigations applied; (2) Users in rotation blocks, where the criteria for block assignment is essentially the location of a user's field; (3) On-request; (4) Rotation among crop categories; (5) rotation based on stock ranking; (6) Rotation based on system types; (7) Rotation based on a labor cost scheme; (8) One-time delivery; and (9) Continuous supply.

An allocation model was developed and used to simulate demands for water by each field throughout the growing season using the various strategies. These demands, determined as a function of crop, soil, field characteristics, and management strategy, were aggregated at the irrigation system turnouts on a daily basis. Input data for the model included users' field data and shares of stock owned in the irrigation company, water-rights held by the company on behalf of all users, historical streamflow data for the creek for which the users had rights, and climatic data for the project location.

The model was applied to an actual field situation using field data from a real-life project. Users' field data for the model included fields with different crops for which planting dates may or may not have been specified and soil type(s) in multiple or single layered profile. The responses of the system to the various allocation strategies studied were measured as attributes of the strategies in terms of harvested crop yields, economic benefit, waiting time, and equitability in the allocations. The attributes provided a numeric scale by which the efficacy of the strategies could be evaluated by management.

Considerations of conjunctive use of groundwater beyond the cost for augmentation, included in Appendix 8, were not addressed and evaluated; neither was cropped-area reduction. Groundwater and surface water were used for implementing strategies 1) and 8), on-demand and one-time delivery, respectively. The use of the former was necessary when surface water was deficient in meeting demand. For both strategies the volume of augmentation, electric power and energy requirements, and costs for augmentation were estimated for the dry, normal, and wet years. Monetary

benefit to the project took into consideration the cost for augmentation where applicable.

The performance of the allocation model was found quite satisfactory. It provided comprehensive outputs needed for management decisions. Calibration of the model in order to completely validate some of the assumptions made was, however, not possible due to time limitation on the study.

Conclusions

The major contribution of this study lies with the identification of the various management strategies and the development of a gravity sprinkle irrigation system water allocation model, the GSIS Model. The model, if calibrated, can provide a valuable management-decision tool for improvement of management operations of gravity sprinkle irrigation systems. Its use could improve management over the current practice of allocations which may give no consideration to the crop environment and the hydraulic system.

Specific conclusions related to the application of the model to field situation are:

1. The model in any particular seasonal situation can show precisely from demand and supply hydrographs up to what point in the growing season allocations on-demand are feasible. Periods and magnitudes of deficits and surpluses in supply stream can be identified. The choice of a management strategy that promotes either high productivity or equitability could be rationally made based on strategy attributes.

2. On-demand, as the most flexible allocation strategy, was not possible throughout the entire growing season for the three years studied.

3. The project does not derive substantial benefits by implementing on-demand strategy, due to the extra expense of flow augmentation. If the company desires higher productivity than equitability, then it is better off operating on request, thereby giving more water to the more profitable enterprise, such as alfalfa.

4. Continuous supply and modified rotation strategies both facilitate allocations more equitably, but at the expense of high productivity. Both strategies adequately address the legal implications of stockholding. There were no significant differences in benefits to project relative to how the rotations were organized.

5. Of the rigid allocation schedules, waiting time was lowest with continuous supply, particularly in the wet year. In contrast, benefits to project were lower with continuous supply than with rotation.

6. Augmentation in a dry year is not advisable as it results in financial loss to the project, largely because of high pumping energy costs.

RECOMMENDATIONS

The following are recommendations for future research on gravity sprinkle irrigation systems. They are not necessarily limited to further work on the GSIS model.

1. The present work is mainly concerned with a single supply source (i.e., surface water). There is the need to expand on the present work and examine selective groundwater augmentation for profitable crops, if users are willing to foot the bill.

2. There is the need to improve on the methodology currently used to determine appropriate numbers of shares of stock for water to buy in a company. Such determinations need to take into account the various crops and soils factors, and field and system characteristics.

3. Field data should be collected for the calibration of the model and validation of assumptions made. The data must include farm revenues (receipts from sale of produce) and expenditures for the various enterprises.

4. An investigation is needed of combinations and permutations of optimal rotation block sizes and number of blocks within a unit command area or project sector for random generation of users for allocation.

5. Develop a methodology by which users could be stratified, based on some criteria, to receive allocations simultaneously with some users on demand and others in rotation.

6. Investigate users' (farmers) reactions to computer-estimated crop demands, using models such as GSIS, CRPSM, etc., in relation to crop demands as perceived by farmers. Determine demonstrable potential economic and social benefits, in terms of water use efficiency and

reduction in litigations over water disputes, that could be derived from the use of computerized irrigation scheduling.

7. Investigate how to incorporate some social considerations under which farmers trade water among themselves into the allocation model.

8. Develop a graphics interface to compliment the output from the allocation model.

9. In lieu of a computerized allocation facility, projects without pressure-reducing valves should develop an extension education campaign with the cooperation of county agents to encourage users at low-lying locations to use sprinklers with pressure control nozzles. Field demonstrations should be conducted to practically show users how the device works and the overall benefits of using it.

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APPENDICES

Appendix 1: The Computer Model Program Coding.

The following are Variable Names and Description of inputs to the Main Program and submodels. The program listing for the model is provided subsequently.

Variable Name	Description
I or U	variable for maintaining count of users
JD	Julian Date
N, n	Normal Year
D, d	Dry Year
W, w	Wet Year
TH(JD)	Maximum Daily air temperature, °F.
TL(JD)	Minimum Daily air temperature, °F.
PN(JD)	Daily Precipitation, inches.
HQ(JD)	Daily streamflow, cfs.
WS(JD)	Daily 24-hour wind run, miles/day
SWS(I, JD)	Soil water storage for a user/field on a specific day.
TW(I)	Time in days since last wetting of the soil surface for a specific field.
YLD(I)	Crop Yield in tons/acre.
PFS(I)	Field Service Priority with respect to constrained allocation for a user.
TUVOL(I)	An accumulator for total seasonal user allocations, in acre-ft.
APRT(I)	Application rate from user's sprinkler at the prevailing nozzle pressure.
JDDEP(I)	Julian date at which a user departs service, i.e. the date delivery of irrigation water is ceased.

HRDEP(I)	estimated hour of the day (between 0.00 and 24.00 hr) when service is terminated.
TARR(I)	generated time of arrival of user for service.
SVT(I)	total service time during which irrigation water is continuously delivered to the user, in hours.
ARRDT(I)	user arrival date for service.
IRR	net depth of irrigation.
IRRG(I)	gross depth of irrigation to be applied, taking into account user irrigation efficiency, in inches.
VOL(I)	user allocation for an irrigation event, in acre-ft.
TYME(I)	waiting time accumulator for a user in a queue.
JDPLM(I)	Julian date at which crop reaches physiologic maturity.
JDM(I)	number of days from planting to maturity for a specific user crop.
EVT(I)	summation of evaporation from the cropped soil surface for the season in inches.
TP	potential crop transpiration, as estimated daily from Et_r, in inches.
TTP(I)	summation of potential crop transpiration for the season, in inches.
TP(I)	summation of potential crop transpiration for the growth stages, in inches.
TST(I)	summation of actual crop transpiration for the season, in inches.
TT(I)	summation of actual crop transpiration for the growth stages, in inches.
DRNG(I)	season's total of drainage from a field, in inches.
DN(I)	drainage for the specific date out of a user field following an irrigation or rainfall event, in inches.

UQ(I)	flow rate to a user, in cfs.
TUQ(JD)	total flow rate to all users on a specific date, in cfs.
AVW(I)	available water depending on user soil type and depth, in inches.
NIRR(I)	number of irrigations in the season for a user.
JDPL(I)	Julian date at which the field was planted or begin growth occured for a specific user/field.
TAV	three-day moving average for a daily mean temperature equal to or above 40°F.
LOWVAL, UPVAL	upper and lower values of a range within which random variates are to be generated.
GENV	generated random variate.
DSPLY$	screen display option.
NUI(JD)	number of users irrigating on a specific date.
DQ(JD)	Demand flow rate for a given date, cfs.
CN	crop code, a number.
KPR	crop specific coefficient for the estimation of field service priority.
ALPHA	an exponent for use with the field service priority equation.
EJHO(I)	variable that sum up EJHO (reference crop evapotranspiration using Jensen-Haise formula, with no elevation correction) from begin growth or previous cutting to the present date, in inches.
YEC(I)	number of days to reach effectiv cover.
DEPTH(I)	thickness of all the soil layers in the soil profile of a user field, in inches.
RZD	root zone depth, in ft.
TLAYER	thickness of each layer, in inches.
EFF(I)	estimated user irrigation efficiency, in %.

IRT(I)	seasonal total of gross irrigation depths for the user.
RNFL(I)	seasonal total of precipitation received on a specific field, in inches.
DPLT(I)	seasonal total of crop root zone depletion, in inches.
ETT(I)	user's seasonal crop ET, in inches.
TWT(I)	total waiting time by a user with a specific strategy invoked.
AVWT	average waiting time for all users.
TSALL	total allocations to all users over the entire season, in acre-ft.
TDVOL	total volume of water diverted at the intake, in acre-ft.
TS1	total shares of stock of all users allocated water.
N	an exponent for the Hazen-William's equation.
RN	reciprocal of N.
K(I)	pipeline constant for the pipeline section serving a user.
R(I)	reciprocal of K(I) raised to power 1/N.
QQ(I)	sum of flows to pipes downstream of a pipe section serving the user.
HH(0)	water surface elevation at intake, in ft.
HH(I)	head of water at the delivery points serving the user, in ft.
OH(I)	lateral inlet head, in ft.
LDIA	lateral pipe diameter, in inches.
DS(I)	discharge per sprinkler, in gpm/S.
PAV(I)	average pressure at the sprinkler nozzle of the user, in psi.
NRU	number of rotation units.

MBL	number of rotation blocks for the specific strategy considered.
TBL(RU)	total number of shares of stock of users in a block for a specific rotation unit.
WELLCOST	cost of irrigation well for supply augmentation.
WELLNO	number of wells.
PUMPCOST	cost of well pump.
SHLTCOST	pump and equipment shelter cost.
ATTDCOST	cost of attending to pump installation at $/100 hr.
LUBREPCOST	lubrication and repair cost, $/100 hr
DPUMPING	depth of pumping.
PEFF	pump efficiency, in decimal.
COSTPKW(1)	cost per KW, first 100 KW.
COSTPKW(2)	cost per KW, all additional KW.
IRATE	interest rate, in %.
YEARS(M)	lives of wells, pumps, and shelter in years.
COSTPEN(1)	cost per KWh, first 100 KWh per KW.
COSTPEN(2)	cost per KWh, next 25,000 KWh.
COSTPEN(3)	cost per KWh, all additional KWh.
TERMPERC	term percentage.
SERVCHG	service charge, in $ per service connection.
VOLTDCOST(1)	voltage discount per KWh, first 100 KW of power.
VOLTDCOST(2)	voltage discount, all additional KW.
CRF2(M)	capital recovery factors for wells, pumps, and shelter.
FXCOST	fixed cost.
MNTH	month (4 through 9, April to Sept.)

AUGVOL(MNTH)	total month's augmentation, in ac-ft.
KW(MNTH)	power used by the pump for the month.
KWHTOT(MNTH)	total energy used by the pump(s) for the month.
VOLTDIS	voltage discount.
TERMDIS	term discount.
DISCOUNT(MNTH)	discount earned in the month.
NETBILL(MNTH)	net bill for the month, taking into account any discount.
SSBILL	season's bill for the total cost of augmentation.

```
' ********************************************************
' This program is written to effect distribution of water
' among users of Gravity sprinkle irrigation systems using
' crop, soil, hydraulic and other input data from sequential
' files.
' ********************************************************
'
'          ------------------------------------------------
'                          MAIN PROGRAM
'          ------------------------------------------------

    DIM TH(305), TL(305), PN(305), HQ(305), WS(305), DQ(305)
    DIM NUI(305),PUMPN(305), ETR(305), YEARS(3), CRF2(3)
    DIM US(2), JDB(4), ANTWC(6), AUGVOL(10), AUGHOUR(10)
    DIM COSTPKW(2), COSTPEN(3), VOLTDCOST(2), MONTH$(10)
    DIM KWHTOT(10), DEMCOST(10), ENECOST(10), KW(10), QAV(3)
    DIM DM(12)

    DATA 4,6,9,6,22,18

    CLS
    LOCATE 8, 15: PRINT "              TODAY IS "; DATE$
    PRINT : PRINT : PRINT
    PRINT : PRINT "            SEASONS ARE RATED AS:": PRINT
    PRINT "                Normal   - N        ": PRINT
    PRINT "                  Wet    - W        ": PRINT
    PRINT "                  Dry    - D        ": PRINT
    PRINT : PRINT
    INPUT "ENTER  N W or D      "; SEASON$


    IF SEASON$ = "N" OR SEASON$ = "n" THEN
       OPEN "I", #2, "C:CLIM.NOM"
    ELSEIF SEASON$ = "W" OR SEASON$ = "w" THEN
       OPEN "I", #2, "C:CLIM.WET"
    ELSEIF SEASON$ = "D" OR SEASON$ = "d" THEN
       OPEN "I", #2, "C:CLIM.DRY"
    END IF
    FOR K = 74 TO 304
    INPUT #2, TH(K), TL(K), PN(K), HQ(K), WS(K)    'clim data
    IF HQ(K) <= 50 THEN
    HQ(K) = .784 * HQ(K)
    ELSEIF HQ(K) > 50 THEN
    HQ(K) = .784 * 50 + .202 * (HQ(K) - 50)
    END IF
    IF HQ(K) > 70 THEN HQ(K) = 70
    WS(K) = WS(K) / 24          ' wind run in miles/hr.
    NEXT K
    INPUT #2, PLT
    FOR M = 1 TO PLT
    INPUT #2, ANTWC(M)          ' antecedent soil water
    ANTWC(M) = .7 * ANTWC(M)    ' assuming 70% of precip
```

```
                    ' was stored in the soil
NEXT M
CLOSE #2

OPEN "I", #1, "C:UZAS.DAT"       ' users' input file
INPUT #1, NS

DIM N$(NS), AR(NS), S(NS), SP(NS), BN(NS), PG(NS)
DIM DS(NS), SEM(NS), STK(NS), SY$(NS), LL(NS), Y(NS)
DIM SPN(NS), ASP(NS), DN(NS), CT$(NS), PLD$(NS), EFF(NS)
DIM PAV(NS), PRF$(NS), ET(NS), JDPL(NS), YEC(NS)
DIM EJHO(NS), SWS(NS, 305), TW(NS), YLD(NS), PFS(NS)
DIM PFS2(NS), TUVOL(NS), ZA(NS, 10), ZP(NS, 10), IRT(NS)
DIM RNFL(NS), DPLT(NS), ETT(NS), APRT(NS), JDDEP(NS)
DIM HRDEP(NS), TARR(NS), SVT(NS, 20), BARR(NS), IRRG(NS)
DIM VOL(NS), TYME(NS), JDPLM(NS), GSS(NS), EVT(NS)
DIM TTP(NS), TP(NS), TST(NS), TT(NS), GDDT(NS), ARRDT(NS)
DIM DRNG(NS), UQ(NS), DT(NS), AVW(NS), BLK(NS) TC(NS)
DIM RTUN(NS), BENF(NS), NIRR(NS), TBL(NS) BSW(NS)
DIM NNSVT(NS, 20), TOT(NS, 20), TIME2(NS), ZPT(NS)
DIM TYM(NS, 15), IRG(NS, 15), IRN(NS, 15), DRN(NS, 15)
DIM TWR(NS, 15), COUNTER(NS), IRTOT(NS, 15)
DIM DRNTOT(NS, 15), RNTOT(NS, 15), SWC(NS, 15)
DIM EVTR(NS, 15), TTPR(NS, 15), TTR(NS, 15), TSTR(NS, 15)
DIM TPR(NS, 15), TRTR(NS, 15, 10), TPTR(NS, 15, 10)
DIM ZAR(NS, 15, 10), ZPR(NS, 15, 10), SWCR(NS, 15, 2)
DIM MAXRZS(NS), KCT(NS)
'dimensioned for NS number of users (irrigators).

TS1 = 0
FOR J = 1 TO NS
INPUT #1, N$(J), AR(J), S(J), SP(J), BN(J), PG(J),
STK(J), SEM(J), LL(J), SY$(J), Y(J), SPN(J), ASP(J),
CT$(J), PLD$(J), PRF$(J)
TS1 = TS1 + S(J)
NEXT J
CLOSE #1

OPEN "I", #2, "C:NETWK.DAT"            'pipe network data
INPUT #2, NP
DIM D(NP), L(NP), M$(NP), CHW(NP), ND(NP), PU(NP)
DIM PD(NP, 3), K(NP), R(NP), HH(NP), QV(NP), QQ(NP)
DIM EL(NP), OH(NP), QV2(NP), QV3(NP), KM(NP)
FOR I = 1 TO NP
INPUT #2, I, D(I), L(I), M$(I), CHW(I), EL(I), QV(I),
ND(I), PU(I)
D(I) = D(I) / 12
QV2(I) = QV(I): QV3(I) = QV(I)     'QV2 & QV3 are
                                    temporary stores
FOR L = 1 TO 3
INPUT #2, PD(I, L)
```

```
NEXT L
NEXT I
CLOSE #2

OPEN "I", #4, "C:ECON.DAT"
INPUT #4, S7, CT
REDIM SYST$(S7), INVCOST(S7), INTR(S7), YEAR(S7)
FOR J = 1 TO S7
INPUT #4, SYST$(J), INVCOST(J), INTR(J), YEAR(J)
INTR(J) = INTR(J) / 100                    'interest rate in decimal
NEXT J
REDIM CTY$(CT), RETN(CT), BYPR(CT), YDCOST(CT), CC(CT),
ARDCOST(CT), IRRCOST(CT)
FOR NY = 1 TO CT
INPUT #4, CTY$(NY), RETN(NY), BYPR(NY), YDCOST(NY),
CC(NY), ARDCOST(NY), IRRCOST(NY)
NEXT NY
CLOSE #4

OPEN "I", #5, "C:CROP.DAT"
INPUT #5, CT
REDIM CTY$(CT), RDMAX(CT), RDMIN(CT), KCMAX(CT)
REDIM KCMIN(CT), EC(CT), JDM(CT), A0(CT), A1(CT), A2(CT)
REDIM A3(CT), B0(CT), B1(CT), B2(CT), B3(CT), AT0(CT)
REDIM AT1(CT), AT2(CT), AT3(CT), BT0(CT), BT1(CT)
REDIM BT2(CT), BT3(CT), LAMBDA(CT, 6), ALP(CT), TPTH(CT)
REDIM YP(CT), GDD(CT, 7), A5(6), TRT(NS, 7), TPT(NS, 7)

FOR J = 1 TO CT
INPUT #5, CTY$(J), RDMAX(J), RDMIN(J), KCMAX(J),
KCMIN(J), EC(J), JDM(J), A0(J), A1(J), A2(J), A3(J),
B0(J), B1(J), B2(J), B3(J), AT0(J), AT1(J), AT2(J),
AT3(J), BT0(J), BT1(J), BT2(J), BT3(J)
FOR K = 1 TO 6
INPUT #5, LAMBDA(J, K)
NEXT K
INPUT #5, ALP(J), TPTH(J), YP(J)
FOR L = 1 TO 7
INPUT #5, GDD(J, L)
NEXT L
NEXT J
FOR K = 0 TO 5
INPUT #5, A5(K)                ' coefficients for ETr vs JD equation
NEXT K
CLOSE #5

OPEN "I", #6, "C:SOIL.DAT"      ' soil data
INPUT #6, ST
DIM STY$(ST), INFL(ST), WHC(ST)
FOR I = 1 TO ST
INPUT #6, STY$(I), INFL(I), WHC(I)
NEXT I
```

```
CLOSE #6

OPEN "I", #7, "C:SPRK.DAT"          ' sprinkler & wind conditions.
 INPUT #7, NSP                      '# of sprinkler types in file
 REDIM Y2(NSP), SNS$(NSP), NZD(NSP), SDC(NSP)
 FOR L = 1 TO NSP
 INPUT #7, Y2(L), SNS$(L), NZD(L), SDC(L)  'nozzles ID, size, dia,
                                           ' and coeff.
 NEXT L
 INPUT #7, LT                        ' number of lateral sizes.
 REDIM LD(LT), LC(LT), LNN(LT)
 FOR M = 1 TO LT
 INPUT #7, LD(M), LC(M), LNN(M)       ' dia., coeff., & index
 NEXT M
 INPUT #7, WC                        ' number of wind conditions
 REDIM WINDC$(WC), KF(WC), AF(WC), KCS(WC), ACS(WC)
 FOR N = 1 TO WC
 INPUT #7, WINDC$(N), KF(N), AF(N), KCS(N), ACS(N)
 NEXT N
 FOR J = 1 TO 12
 INPUT #7, DM(J)                      ' days in each month.
 NEXT J
 CLOSE #7

 OPEN "I", #8, "C:BEGSW.DAT"
 FOR I = 1 TO NS
 INPUT #8, BSW(I)                   ' begin soil water in profile
 NEXT I
 CLOSE #8

PRINT : PRINT
INPUT "ENTER WATER SURFACE ELEV. IN CANAL "; HHO
PRINT : PRINT
INPUT "ENTER PROPORTIONATE DIVERSION, OR  1 FOR ALL"; FR
PRINT
FOR K = 74 TO 303: HQ(K) = FR * HQ(K): NEXT K
PRINT "DO YOU WISH CONSIDER MINOR LOSSES ?"
INPUT "Y/N"; YA$
IF YA$ = "Y" OR YA$ = "y" THEN GOSUB MLOSS
PRINT
PRINT "DO YOU WANT SCREEN DISPLAY?"
INPUT "Y/N"; DSPLY$

 OPEN "O", #3, "C:HYD.DAT"

 IF SEASON$ = "N" OR SEASON$ = "n" THEN
  PRINT #3, SPC(25); "*** NORMAL YEAR ***"
 ELSEIF SEASON$ = "W" OR SEASON$ = "w" THEN
  PRINT #3, SPC(25); "*** WET YEAR ***"
 ELSEIF SEASON$ = "D" OR SEASON$ = "d" THEN
  PRINT #3, SPC(25); "*** DRY YEAR ***"
 END IF
```

```
   PRINT #3,
   OPEN "O", #10, "C:UNCODEM.DAT"
1  CLS :  BEEP    'display the strategies on screen
   LOCATE 5, 25: PRINT " MANGEMENT STRATEGIES": PRINT
   LOCATE 7, 15: PRINT " 1  On-Demand delivery"
   LOCATE 8, 15: PRINT " 2  users in rotation blocks"
   LOCATE 9, 15: PRINT " 3  user placed on request"
   LOCATE 10, 15: PRINT " 4  supply based on category among crops"
   LOCATE 11, 15: PRINT " 5  supply based on ranking of stocks"
   LOCATE 12, 15: PRINT " 6  supply along system types"
   LOCATE 13, 15: PRINT " 7  supply according to low labor cost scheme"
   LOCATE 14, 15: PRINT " 8  a one-time delivery"
   LOCATE 15, 15: PRINT " 9  continuous supply"
   LOCATE 16, 15: PRINT "10  HELP"

'  ------------------------------------------------
'            STRATEGY SELECTION
'  ------------------------------------------------

   LOCATE 22, 1
   PRINT "SELECT A STRATEGY BY ITS NUMBER OR 10 FOR HELP"
   INPUT CHOICE
   ON CHOICE GOTO 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000

2  FOR U = 1 TO NS
5  B$ = LEFT$(PLD$(U), 3)
   GS = VAL(RIGHT$(PLD$(U), 2))
   IF B$ = "MAR" THEN
   JDPL(U) = 59 + GS
   ELSEIF B$ = "APR" THEN
   JDPL(U) = 90 + GS
   ELSEIF B$ = "MAY" THEN
   JDPL(U) = 120 + GS
   ELSEIF B$ = "JUN" THEN
   JDPL(U) = 151 + GS
   END IF
   IF GS <= 0 THEN JDPL(U) = 0

   ' ------------------------------------------------
   '  FOR FIELDS WITH UNSPECIFIED PLANTING DATES IN FILE
   ' ------------------------------------------------
     IF JDPL(U) = 0 THEN
     UPVAL = 22: LOWVAL = 8
     IF CT$(U) = "ALFALFA" OR CT$(U) = "PASTURE" THEN JD = 74
19   TAV = ((TH(JD) + TL(JD)) / 2 + (TH(JD - 1) + TL(JD - 1))
     / 2 + (TH(JD - 2) + TL(JD - 2)) / 2) / 3
     IF TAV >= 48 THEN 7        'Tav. (3 day moving average)
     JD = JD + 1
     GOTO 19
7    BEGROW = JD                ' BEGROW = begin growth
     MDAT = BEGROW - 59
     IF MDAT > 31 THEN
```

```
MDAT = MDAT - 31
PLD$(U) = "APR" + STR$(INT(MDAT))
ELSE
PLD$(U) = "MAR" + STR$(INT(MDAT))
END IF
ELSEIF CT$(U) = "CORN/SL" THEN
GOSUB NOMDIST
MDAT = GENV
PLD$(U) = "MAY" + STR$(INT(MDAT))
ELSEIF CT$(U) = "S/GRAIN" THEN
GOSUB NOMDIST
MDAT = GENV
PLD$(U) = "APR" + STR$(INT(MDAT))
END IF
GOTO 5
END IF
IF CT$(U) = "ALFALFA" THEN
CN = 1
ELSEIF CT$(U) = "CORN/SL" THEN
CN = 2
ELSEIF CT$(U) = "S/GRAIN" THEN
CN = 3
ELSEIF CT$(U) = "PASTURE" THEN
CN = 4
END IF
JDPLM(U) = JDPL(U) + JDM(CN)
NEXT U
-------------------------------------------------
        ZEROING DAILY ARRAY CUMMULATORS
-------------------------------------------------
             'initializing
FOR I = 1 TO NS
YEC(I) = 0: EJHO(I) = 0: GDDT(I) = 0
IRT(I) = 0: RNFL(I) = 0: DRNG(I) = 0
DPLT(I) = 0: ETT(I) = 0: TUVOL(I) = 0
TYME(I) = 0: NIRR(I) = 0: TIME2(I) = 0
YLD(I) = 0: GDDT(I) = 0
IF CT$(I) = "CORN/SL" OR CT$(I) = "S/GRAIN" THEN
TTP(I) = 0: TP(I) = 0: TT(I) = 0: TST(I) = 0: EVT(I) = 0
FOR GS = 1 TO 7
ZA(I, GS) = 0: ZP(I, GS) = 0
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
TRT(I, GS) = 0: TPT(I, GS) = 0
ELSEIF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT =
 7 OR STRAT = 9 THEN
FOR XY = 1 TO D2
TRTR(I, XY, GS) = 0
TPTR(I, XY, GS) = 0
ZAR(I, XY, GS) = 0
ZPR(I, XY, GS) = 0
NEXT XY
```

```
END IF
NEXT GS
ELSEIF CT$(I) = "ALFALFA" OR CT$(I) = "PASTURE" THEN
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
TTP(I) = 0: TT(I) = 0: TST(I) = 0
TP(I) = 0: EVT(I) = 0
ELSEIF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT =
 7 OR STRAT = 9 THEN
FOR XY = 1 TO D2
TTPR(I, XY) = 0: TTR(I, XY) = 0: TSTR(I, XY) = 0
TPR(I, XY) = 0: EVTR(I, XY) = 0
NEXT XY
END IF
END IF
NEXT I

TDVOL = 0
IF AUG$ = "Y" OR AUG$ = "y" THEN
FOR MN = 4 TO 10
KW(MN) = 0
KWH(MN) = 0
AUGVOL(MN) = 0
AUGHOUR(MN) = 0
NEXT MN
END IF
BEGIRR = 101                    'earliest irrig. date April 11th.

FOR JD = 74 TO 288
DVOL = 1.984 * HQ(JD)
IF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT = 7 OR
 STRAT = 9 THEN
TOTSH = 0
IF STRAT = 9 THEN
D2 = 10                         'days to complete an irrigation cycle
FOR I = 1 TO NS
IF JDPL(I) <= JD AND JDPLM(I) >= JD THEN COUNTER(I) = COUNTER(I)+ 1
IF COUNTER(I) > D2 THEN COUNTER(I) = 1
TOTSH = TOTSH + S(I)
END IF
NEXT I
ELSE
FOR BL = 1 TO MBL
IF COUNTER(BL) <= D2 THEN
TBL(BL) = 0
FOR I = 1 TO NS
IF BLK(I) = BL AND JDPL(I) <= JD AND JDPLM(I) >= JD THEN TBL(BL) =
 TBL(BL) + S(I)
END IF
NEXT I
TOTSH = TOTSH + TBL(BL)
END IF
NEXT BL
```

```
END IF
END IF
TUQ = 0
FOR I = 1 TO NS
IF JDDEP(I) >= JD THEN
TUQ = TUQ + UQ(I)
END IF
NEXT I
TVOL = 0
NUI(JD) = 0
DQ(JD) = 0
FOR U = 1 TO NS
IF CT$(U) = "ALFALFA" THEN
CN = 1
ELSEIF CT$(U) = "CORN/SL" THEN
CN = 2
ELSEIF CT$(U) = "S/GRAIN" THEN
CN = 3
ELSEIF CT$(U) = "PASTURE" THEN
CN = 4
END IF
IF JD >= JDPL(U) AND JD <= JDPLM(U) THEN
JDCV = JDPL(U) + EC(CN)
ETR(JD) = A5(0) + A5(1) * JD + A5(2) * JD ^ 2 + A5(3) * JD ^ 3 +
 A5(4) * JD ^ 4 + A5(5) * JD ^ 5
EJHO(U) = EJHO(U) + ETR(JD)
ETEC = 6!
'  ------------------------------------------------
'      ROOT GROWTH FUNCTION AND CROP COEFFICIENT
'  ------------------------------------------------

   R2 = EJHO(U) / ETEC
   IF CN = 1 THEN
   KCT(U) = .02 + 2.218 * R2 - 1.986 * R2 ^ 2 + .74 * R2 ^ 3
   IF KCT(U) < .25 THEN KCT(U) = .25
   IF KCT(U) > .98 THEN KCT(U) = .98
   END IF
   IF JD <= JDCV THEN
   R1 = (JD - JDPL(U)) / (JDCV - JDPL(U))
   RZD = RDMIN(CN) + R1 * (RDMAX(CN) - RDMIN(CN))
   R = (JD - JDPL(U)) / EC(CN)
   KC = A0(CN) + A1(CN) * R + A2(CN) * R ^ 2 + A3(CN) * R ^ 3
   IF CN = 2 OR CN = 3 THEN
   KCT(U) = AT0(CN) + AT1(CN) * R + AT2(CN) * R ^ 2 + AT3(CN) * R ^ 3
   END IF
   ELSE
   YEC(U) = YEC(U) + 1
   IF CN = 1 THEN
   IF JD <= 150 THEN
   RZD = RDMAX(CN)
   KC = KCMAX(CN)
```

```
      IF JD = 150 THEN
      YEC(U) = 0
      EJHO(U) = 0
      END IF
      GOTO 20
      END IF
      IF JD > 150 THEN
      IF YEC(U) > 46 THEN
      YEC(U) = 0
      EJHO(U) = 0
      END IF
      KC = BO(CN) + B1(CN) * YEC(U) + B2(CN) * YEC(U) ^ 2 + B3(CN) *
       YEC(U) ^ 3
      END IF
      IF KC < .3 THEN KC = KCMIN(CN)
      ELSE
      KC = BO(CN) + B1(CN) * YEC(U) + B2(CN) * YEC(U) ^ 2 + B3(CN) *
       YEC(U) ^ 3
      IF CN = 2 OR CN = 3 THEN
      KCT(U) = BTO(CN) + BT1(CN) * YEC(U) + BT2(CN) * YEC(U) ^ 2 +
       BT3(CN) * YEC(U) ^ 3
      END IF
      END IF
      RZD = RDMAX(CN)
20    END IF
      IF KC < .2 THEN KC = .2
      IF KCT(U) < 0! THEN KCT(U) = 0!
      IF CN = 2 AND KCT(U) > .88 THEN KCT(U) = .88
      IF CN = 3 AND KCT(U) > .95 THEN KCT(U) = .95
      IF CN = 4 THEN KCT(U) = .76
      IF KC > KCMAX(CN) THEN KC = KCMAX(CN)
      IF CN = 4 THEN
      KC = KCMAX(CN)
      RZD = RDMAX(CN)
      END IF
      ET(U) = KC * ETR(JD)

'  ------------------------------------------------
'    AVAILABLE WATER IN LAYERED SOIL PROFILE
'  ------------------------------------------------
'
'                       SOIL CODE:
'
'              LOAM   -  loam
'              CLLO   -  clay loam
'              STLO   -  silt loam
'              STCL   -  silty clay loam
'              LMCL   -  loamy clay
'              LMSN   -  loamy sands
'              CLAY   -  clay
'
```

```
LY = VAL(LEFT$(PRF$(U), 1))
REDIM DEPTH(LY), WHCS(LY)
TAW = 0
TLAYER = 0
MAXRZS(U) = 0
FOR K = 1 TO LY
DESCR$ = MID$(PRF$(U), (7 * (K - 1) + 5), 4)   'layer description
DEPTH(K) = VAL(MID$(PRF$(U), (7 * (K - 1) + 3), 2))
DEPTH(K) = DEPTH(K) / 12
TLAYER = TLAYER + DEPTH(K)
FOR I = 1 TO ST
IF STY$(I) = DESCR$ THEN
WHCS(K) = WHC(I)
END IF
NEXT I
MAXRZS(U) = MAXRZS(U) + WHCS(K) * DEPTH(K)
IF RZD > TLAYER THEN
AW = WHCS(K) * DEPTH(K)
ELSE
AW = WHCS(K) * (DEPTH(K) - (TLAYER - RZD))
IF RZD < (TLAYER - DEPTH(K)) THEN AW = 0
END IF
TAW = TAW + AW
NEXT K
RZS = TAW                        ' RZS=root zone storage
AVW(U) = .5 * RZS                ' MAD=50%
IF JD = JDPL(U) THEN
IF BSW(U) = 0 THEN
IF JDPL(U) >= 60 AND JDPL(U) < 91 THEN
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
SWS(U, JD - 1) = ANTWC(1)
ELSE
FOR M = 1 TO D2
SWC(U, M) = ANTWC(1)
NEXT M
END IF
ELSEIF JDPL(U) >= 91 AND JDPL(U) < 121 THEN
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
SWS(U, JD - 1) = ANTWC(2)
ELSE
FOR M = 1 TO D2
SWC(U, M) = ANTWC(2)
NEXT M
END IF
ELSEIF JDPL(U) >= 121 AND JDPL(U) < 151 THEN
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
SWS(U, JD - 1) = ANTWC(3)
ELSE
FOR M = 1 TO D2
SWC(U, M) = ANTWC(3)
NEXT M
END IF
```

```
END IF
ELSE
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
SWS(U, JD - 1) = BSW(U)
ELSE
FOR M = 1 TO D2
SWC(U, M) = BSW(U)
NEXT M
END IF
END IF
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
IF SWS(U, JD - 1) > MAXRZS(U) THEN SWS(U, JD - 1) = MAXRZS(U)
ELSE
FOR M = 1 TO D2
IF SWC(U, M) > MAXRZS(U) THEN SWC(U, M) = MAXRZS(U)
IF JD = JDPL(U) THEN SWCR(U, M, 1) = SWC(U, M)
NEXT M
END IF
END IF

'  ------------------------------------------
'          WATER BUDGETING
'  ------------------------------------------

IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
DN(U) = 0: IRR = 0
ELSE
FOR XY = 1 TO D2
DRN(U, XY) = 0: IRN(U, XY) = 0
NEXT XY
END IF
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
IF SWS(U, JD - 1) > MAXRZS(U) THEN
DN(U) = SWS(U, JD - 1) - MAXRZS(U)
END IF
ELSE
FOR XY = 1 TO D2
IF SWC(U, XY) > MAXRZS(U) THEN
DRN(U, XY) = SWC(U, XY) - MAXRZS(U)
END IF
NEXT XY
END IF
IF JD < BEGIRR THEN 22
IF STRAT = 1 AND SWS(U, JD - 1) < AVW(U) THEN
IRR = RZS - SWS(U, JD - 1)
ELSEIF STRAT = 3 AND SWS(U, JD - 1) < AVW(U) THEN
IF TUQ < HQ(JD) THEN
IRR = RZS - SWS(U, JD - 1)
ELSE
IRR = 0
END IF
ELSEIF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT =
```

```
 7 THEN
IF COUNTER(BLK(U)) <= D2 AND JDPL(U) <= JD AND JDPLM(U) >= JD THEN
VOL(U) = (S(U) / TOTSH) * DVOL
IRG(U, COUNTER(BLK(U))) = 12 * VOL(U) / (AR(U) / D2)
GOSUB APPEFF
IRN(U, COUNTER(BLK(U))) = IRG(U, COUNTER(BLK(U))) * EFF(U)
IF IRN(U, COUNTER(BLK(U))) > MAXRZS(U) THEN IRN(U, COUNTER(BLK(U)))
 = MAXRZS(U)
ELSE
IRN(U, COUNTER(BLK(U))) = 0
IRG(U, COUNTER(BLK(U))) = 0
VOL(U) = 0
END IF
ELSEIF STRAT = 8 THEN
IF DT(U) <= JD AND SWS(U, JD - 1) < AVW(U) THEN
IRR = RZS - SWS(U, JD - 1)
DT(U) = 9999                                  ' a flag for no return
END IF
ELSEIF STRAT = 9 THEN
IF COUNTER(U) <= D2 AND JDPL(U) <= JD AND JDPLM(U) >= JD THEN
VOL(U) = (S(U) / TOTSH) * DVOL
IRG(U, COUNTER(U)) = 12 * VOL(U) / (AR(U) / D2)
GOSUB APPEFF
IRN(U, COUNTER(U)) = IRG(U, COUNTER(U)) * EFF(U)
IF IRN(U, COUNTER(U)) > MAXRZS(U) THEN IRN(U, COUNTER(U))
 = MAXRZS(U) - SWC(U, COUNTER(U))
ELSE
IRN(U, COUNTER(U)) = 0
IRG(U, COUNTER(U)) = 0
VOL(U) = 0
END IF
END IF
IF JDDEP(U) >= JD AND IRR <> 0 THEN IRR = 0
IF IRR < 0 THEN IRR = 0
22  IF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT = 7 OR
 STRAT = 9 THEN
FOR XY = 1 TO D2
IF STRAT <> 9 THEN
IF XY <> COUNTER(BLK(U)) THEN IRN(U, XY) = 0
ELSEIF STRAT = 9 THEN
IF XY <> COUNTER(U) THEN IRN(U, XY) = 0
END IF
SWC(U, XY) = SWC(U, XY) + PN(JD) - ET(U) + IRN(U, XY) - DRN(U, XY)
IF SWC(U, XY) < AVW(U) THEN TYM(U, XY) = TYM(U, XY) + 1
IF SWC(U, XY) < 0 THEN SWC(U, XY) = 0
IF JD = JDPLM(U) THEN SWCR(U, XY, 2) = SWC(U, XY)
IF SWCR(U, XY, 2) > MAXRZS(U) THEN SWCR(U, XY, 2) = MAXRZS(U)
IRTOT(U, XY) = IRTOT(U, XY) + IRN(U, XY)
DRNTOT(U, XY) = DRNTOT(U, XY) + DRN(U, XY)
RNTOT(U, XY) = RNTOT(U, XY) + PN(JD)
NEXT XY
ELSE
```

```
IF SWS(U, JD - 1) < AVW(U) THEN
TYME(U) = TYME(U) + 1
TIME2(U) = TIME2(U) + 1
END IF
SWS(U, JD) = SWS(U, JD - 1) + PN(JD) - ET(U) + IRR - DN(U)
IRT(U) = IRT(U) + IRR              'sum of net depth irrig. applied
DRNG(U) = DRNG(U) + DN(U)          'sum of drainage
RNFL(U) = RNFL(U) + PN(JD)         'sum of rainfall
IF SWS(U, JD) < 0 THEN SWS(U, JD) = 0
END IF
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
IF IRR > 0 THEN NIRR(U) = NIRR(U) + 1
ELSEIF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT =
 7 THEN
IF COUNTER(BLK(U)) = D2 THEN NIRR(U) = NIRR(U) + 1
ELSEIF STRAT = 9 THEN
IF COUNTER(U) = D2 THEN NIRR(U) = NIRR(U) + 1
END IF
IF JDDEP(U) = 0 THEN
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
IF IRR <> 0 THEN
GOSUB APPEFF
IRRG(U) = IRR / EFF(U)              'gross depth.
VOL(U) = AR(U) * IRRG(U) / 12       'volume (acre-feet)
END IF
END IF
END IF
TVOL = TVOL + VOL(U)               'for all users.
END IF
NEXT U

FOR U = 1 TO NS
IF VOL(U) <> 0 OR JDDEP(U) >= JD THEN
NUI(JD) = NUI(JD) + 1
END IF
NEXT U
IF NUI(JD) >= 1 THEN
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN GOSUB ARRGNT
S = 0
QVIN = 0
FOR I = 1 TO NS
IF JD >= JDPL(I) AND JD <= JDPLM(I) THEN
IF VOL(I) <> 0 OR JDDEP(I) > JD THEN
S = S + 1
IF JDDEP(I) = 0 THEN
TARR(I) = BARR(S)                  'user's arrival time
END IF
QVIN = QVIN + QV(SP(I))            'summation for initial guesss
ELSE
QV(SP(I)) = 0
NNSVT(I, NIRR(I) + 1) = NNSVT(I, NIRR(I) + 1) + 1
END IF
```

```
END IF
NEXT I
GOSUB HYDRA
END IF

DQ(JD) = 0
IF NUI(JD) >= 1 THEN
IF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT = 7 OR
 STRAT = 9 THEN
FOR I = 1 TO NS: HRDEP(I) = 0: NEXT I
FOR T = 1 TO 24
QT = 0
FOR I = 1 TO NS
IF JDPL(I) <= JD AND JD <= JDPLM(I) THEN
IF HRDEP(I) >= T THEN
QT = QT + UQ(I)
ELSEIF VOL(I) > 0 AND HRDEP(I) = 0 THEN
IF STRAT = 9 THEN
SVT(I, NIRR(I)) = IRG(I, COUNTER(I)) / APRT(I)
ELSE
SVT(I, NIRR(I)) = IRG(I, COUNTER(BLK(I))) / APRT(I)
END IF
IF SVT(I, NIRR(I)) > 0 THEN UQ(I) = 12 * VOL(I) / SVT(I, NIRR(I))
END IF
END IF
NEXT I
FOR I = 1 TO NS
IF JDPL(I) <= JD AND JD <= JDPLM(I) THEN
IF QT < HQ(JD) AND UQ(I) > 0 AND HRDEP(I) = 0 THEN
IF UQ(I) > HQ(JD) THEN
SVT(I, NIRR(I)) = SVT(I, NIRR(I)) * UQ(I) / HQ(JD)
UQ(I) = HQ(JD)
END IF
QT = QT + UQ(I)
IF QT > HQ(JD) THEN
QT = QT - UQ(I)
ELSE
TARR(I) = T
HRDEP(I) = TARR(I) + SVT(I, NIRR(I))
ARRDT(I) = JD
JDDEP(I) = JD
IF HRDEP(I) > 24 THEN
HRDEP(I) = HRDEP(I) - 24
JDDEP(I) = JDDEP(I) + 1
END IF
END IF
END IF
END IF
NEXT I
IF QT > DQ(JD) THEN DQ(JD) = QT
NEXT T
ELSEIF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
```

```
FOR I = 1 TO NS
IF JDPL(I) <= JD AND JD <= JDPLM(I) THEN
IF VOL(I) <> 0 AND JDDEP(I) = 0 THEN
SETTIME = IRRG(I) / APRT(I)
SVT(I, NIRR(I)) = (AR(I) * 43560 / (ASP(I) * SPN(I))) * SETTIME
                  'service time
ARRV = (TARR(I) + SVT(I, NIRR(I))) / 24
TARV = FIX(ARRV)
HRDEP(I) = INT((ARRV - TARV) * 24)
JDDEP(I) = TARV + JD
TARR(I) = INT(TARR(I))
ARRDT(I) = JD
END IF
END IF
IF JDPL(I) <= JD AND JD <= JDPLM(I) THEN
IF VOL(I) <> 0 OR JDDEP(I) >= JD THEN
IF SVT(I, NIRR(I)) <> 0 THEN UQ(I) = VOL(I) * 12 / SVT(I, NIRR(I))
DQ(JD) = DQ(JD) + UQ(I)
END IF
END IF
NEXT I
END IF
END IF

 IF STRAT = 3 AND DQ(JD) > HQ(JD) THEN GOSUB PRIO
 FOR U = 1 TO NS
 IF JDPL(U) <= JD AND JD <= JDPLM(U) THEN
 IF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT = 7
  OR STRAT = 9 THEN
FOR XY = 1 TO D2
TWR(U, XY) = TWR(U, XY) + 1
IF IRN(U, XY) > 0 OR PN(JD) > .5 THEN TWR(U, XY) = 0
GOSUB TREV
NEXT XY
ELSE
IRR = IRRG(U) * EFF(U)
TW(U) = TW(U) + 1
IF IRR > 0 OR PN(JD) > .5 THEN TW(U) = 0
GOSUB TREV
END IF
IF ARRDT(U) = JD AND VOL(U) <> 0 THEN TUVOL(U) = TUVOL(U) + VOL(U)
END IF
NEXT U

IF JD >= BEGIRR THEN GOSUB AUT
FOR J = 1 TO NP
QV(J) = QV2(J)
NEXT J
FOR I2 = 1 TO NS
IF JDDEP(I2) = JD THEN
JDDEP(I2) = 0
VOL(I2) = 0
```

```
END IF
NEXT I2
IF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT = 7
 THEN
IF JD >= BEGIRR THEN
FOR BL = 1 TO MBL
COUNTER(BL) = COUNTER(BL) + 1
IF COUNTER(BL) > RI THEN COUNTER(BL) = 1  'count for next rotation
NEXT BL
END IF
END IF
IF JD >= BEGIRR THEN TDVOL = TDVOL + DVOL

IF STRAT = 1 OR STRAT = 8 THEN
QAUG = DQ(JD) - HQ(JD)
IF QAUG > 0 THEN AUGV = 1.983 * QAUG        'in acre-ft.
END IF
IF JD >= 101 AND JD <= 120 THEN
MNTH = 4: MONTH$(MNTH) = "APRIL"
ELSEIF JD >= 121 AND JD <= 151 THEN
MNTH = 5: MONTH$(MNTH) = "MAY"
ELSEIF JD >= 152 AND JD <= 181 THEN
MNTH = 6: MONTH$(MNTH) = "JUNE"
ELSEIF JD >= 182 AND JD <= 212 THEN
MNTH = 7: MONTH$(MNTH) = "JULY"
ELSEIF JD >= 213 AND JD <= 243 THEN
MNTH = 8: MONTH$(MNTH) = "AUGUST"
ELSEIF JD >= 244 AND JD <= 273 THEN
MNTH = 9: MONTH$(MNTH) = "SEPTEMBER"
END IF
AUGVOL(MNTH) = AUGVOL(MNTH) + AUGV
IF AUG$ = "Y" OR AUG$ = "y" THEN
IF QAUG > 0 THEN
PUMPN(JD) = CINT((QAUG / 2!) + .5)
KWATT = 453 * QAUG * DPUMPING / (3960 * PEFF * .745)
KWH = 24 * KWATT
AUGHR = 24
ELSE
AUGV = 0
PUMPN(JD) = 0
AUGHR = 0
KWATT = 0
KWH = 0
END IF
KW(MNTH) = KW(MNTH) + KWATT
KWHTOT(MNTH) = KWHTOT(MNTH) + KWH
AUGHOUR(MNTH) = AUGHOUR(MNTH) + AUGHR
END IF
NEXT JD
TWT = 0: UWT = 0: TSALL = 0
FOR I = 1 TO NS
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
```

```
  IF TYME(I) > 0 THEN
  UWT = UWT + 1
  TWT = TWT + TYME(I)
  END IF
  ELSE
  FOR XY = 1 TO D2
  IF TYM(I, XY) > 0 THEN
  UWT = UWT + 1
  TWT = TWT + TYM(I, XY)
  END IF
  NEXT XY
  END IF
  TSALL = TSALL + TUVOL(I)
  NEXT I
  RUR = TSALL / TDVOL
  IF UWT <> 0 THEN
  AVWT = INT(TWT / UWT)                    ' av. waiting time
  ELSE
  AVWT = 0
  END IF
  GOSUB YIELD
  KP$ = "_____________________________________________________________________"
  PRINT #3,
  PRINT #3, KP$
  PRINT #3, "                                          SEASONAL TOTAL
"
  PRINT   #3,   "FIELD/
                          "
  _____________________________"
      PRINT #3, "USER                    # OF  NET                  RT-Z
CROP"
      PRINT #3, "CODE     CROP      AREA  IRRG  IRRG  DRAIN  RAIN  DEPL
ET  "
      PRINT #3, "                   (ac)        (in)  (in)   (in)  (in)
(in)"
      PRINT #3, KP$
      IF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT = 7
OR STRAT = 9 THEN
      FOR I = 1 TO NS
      DPLT(I) = 0: IRT(I) = 0: DRNG(I) = 0: RNFL(I) = 0
      NEXT I
      END IF
      FOR I = 1 TO NS
      IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
      DPLT(I) = SWS(I, JDPL(I) - 1) - SWS(I, JDPLM(I))    'depletion
      ELSEIF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT =
       7 OR STRAT = 9 THEN
      FOR XY = 1 TO D2
      DPLTN = SWCR(I, XY, 1) - SWCR(I, XY, 2)
      DPLT(I) = DPLT(I) + DPLTN
      IRT(I) = IRT(I) + IRTOT(I, XY)
      DRNG(I) = DRNG(I) + DRNTOT(I, XY)
      RNFL(I) = RNFL(I) + RNTOT(I, XY)
```

```
      EVT(I) = EVT(I) + EVTR(I, XY)
      NEXT XY
      DPLT(I) = DPLT(I) / D2: IRT(I) = IRT(I) / D2
      DRNG(I) = DRNG(I) / D2: RNFL(I) = RNFL(I) / D2
      EVT(I) = EVT(I) / D2                    'mean for all strips combined
      END IF
      ETT(I) = IRT(I) + RNFL(I) + DPLT(I) - DRNG(I)
      PRINT #3, N$(I); TAB(9); CT$(I); TAB(18); USING "###     ##    ##.#
##.#     ##.#    ##.#    ##.#"; AR(I); NIRR(I); IRT(I); DRNG(I); RNFL(I);
DPLT(I); ETT(I)
      NEXT I
      PRINT #3, KP$
      PRINT #3, "RT-Z DEPL = Root Zone Depletion"
      PRINT #3, "NET IRRG = Applied water that infiltrated
      the soil surface"
      PRINT #3,
      GOSUB BENCOMP
      PRINT #3,
      PRINT #3,
      PRINT #3, "FIELD/              USER STOCK AS                    USER
ALLOCATION"
      PRINT #3, "USER      USER    AS A RATIO OF   USER         AS A RATIO
OF   "
      PRINT #3, "CODE         STOCK    COMPANY STOCK     ALLOCATION    ALL
ALLOCATIONS"
      PRINT #3, "                     (%)           (ac-ft)          (%)
   "
      P       R       I       N       T                 #       3       ,
"                                                                        "
 ------------------------------------------------------------------------
      FOR I = 1 TO NS
      PRINT #3, N$(I); TAB(10); USING "###.#      ##.#          #####.#
      ##.#"; S(I); (S(I) / TSI) * 100; TUVOL(I); (TUVOL(I) / TSALL) *
100
      NEXT I
      P       R       I       N       T                 #       3       ,
"                                                                        "
 ------------------------------------------------------------------------
      PRINT #3,

      IF AUG$ = "Y" OR AUG$ = "y" THEN
       'DEMAND:
       FOR MNTH = 4 TO 9
     DEMCOST(MNTH) = 0
       IF KW(MNTH) <= 100 THEN
     DEMCOST(MNTH) = KW(MNTH) * COSTPKW(1)
       END IF
       IF KW(MNTH) > 100 THEN
     DEMCOST(MNTH) = 100 * COSTPKW(1) + (KW(MNTH) - 100) *
         COSTPKW(2)
       END IF

       'ENERGY:
     ENECOST(MNTH) = 0
```

```
  IF KWHTOT(MNTH) <= 100 THEN
     ENECOST(MNTH) = COSTPEN(1) * KWHTOT(MNTH) * KW(MNTH)
  ELSEIF KWHTOT(MNTH)>100 AND KWHTOT(MNTH) <= 25100 THEN
ENECOST(MNTH) = COSTPEN(1) * 100 * KW(MNTH) +
    (COSTPEN(2) * (KWHTOT(MNTH) - 100))
  ELSEIF KWHTOT(MNTH) > 25100 THEN
ENECOST(MNTH) = ((KWHTOT(MNTH) - 25100) * COSTPEN(3))
  + (25000 * COSTPEN(2)) + (100 * COSTPEN(1) * KW(MNTH))
  END IF

' DISCOUNTS:
     TERMDIS = (TERMPERC / 100) * (DEMCOST(MNTH) +
    ENECOST(MNTH))
     IF KW(MNTH) <= 100 THEN
     VOLTDIS = VOLTDCOST(1) * KW(MNTH)
     ELSEIF KW(MNTH) > 100 THEN
     VOLTDIS = VOLTDCOST(1) * 100 + VOLTDCOST(2) *
  (KW(MNTH) - 100)
     END IF
     DISCOUNT(MNTH) = TERMDIS + VOLTDIS

     ' OFF-SEASON FIXED COST:
     ' (Repayment on equipment for the 6 months period,
    Oct. thru' March)
     OFFSCOST = 6 * FXCOST

     ' MISCELLANEOUS COSTS:
' (attendance and lube & repair costs per 100 hr of operation)
     MISCOST(MNTH) = (ATTDCOST + LUBREPCOST) * (AUGHOUR(MNTH) /
100)

        ' SERVICE CHARGE:
        '  (All customers for service connection)
        '  included in AUGMENT.DAT file as SERVCHG

      MNBILL(MNTH) = FXCOST + SERVCHG + MISCOST(MNTH) + DEMCOST(MNTH) +
       ENECOST(MNTH)
      NETBILL(MNTH) = MNBILL(MNTH) - DISCOUNT(MNTH)
      SSBILL = SSBILL + NETBILL(MNTH)                    ' season's bill
      NEXT MNTH
      PROJBEN = PROJBEN - SSBILL - OFFSCOST
      END IF
     IF AUG$ = "y" OR AUG$ = "Y" THEN
     PRINT #3,
     PRINT #3,
     PRINT #3, "MONTH    AUG. VOLUME AUG. HR ENERGY COSTS DISCOUNTS NET
BILL"
     PRINT #3, "          (acre-ft)  (hour)  (kwh)    $       $          $
  "
     P       R       I       N       T                #      3       ,
"                                                                    "
 ____________________________________________________________________
     FOR MNTH = 4 TO 9
```

```
      PRINT #3, USING "\          \#####.##      ###   ######   #####.##
####.##   #####.##";  MONTH$(MNTH);  AUGVOL(MNTH);  AUGHOUR(MNTH);
KWHTOT(MNTH); MNBILL(MNTH); DISCOUNT(MNTH); NETBILL(MNTH)
      NEXT MNTH
      P       R       I       N       T                 #       3       ,
"                                                                      "
 ----------------------------------------------------------------------
      PRINT #3,
      END IF
      TOTAUG = 0
      IF STRAT = 1 OR STRAT = 8 THEN
      FOR MNTH = 4 TO 9
      TOTAUG = TOTAUG + AUGVOL(MNTH)
      NEXT MNTH
      END IF
      PRINT #3, "TOTAL VOLUME OF AUGMENTATION (AC-FT) = "; USING
"#####.#"; TOTAUG
      PRINT #3,
      PRINT #3, "TOTAL AUGMENTATION COST = $"; USING "#######,.00";
SSBILL
      PRINT #3,
      PRINT #3, "TOTAL BENEFIT TO PROJECT = $"; USING "#######,.00";
PROJBEN
      PRINT #3,
      PRINT #3, "AVERAGE WAITING TIME (DAYS) = "; AVWT
      PRINT #3,
      PRINT #3, "TOTAL WATER ALLOCATED (ACRE-FT) = "; USING "#######.#";
TSALL
      PRINT #3,
      PRINT #3, "RESOURCE UTILIZATION RATIO = "; USING "#.##"; RUR
      PRINT #3,
      FOR JD = 74 TO 288
      IF AUG$ = "Y" OR AUG$ = "y" THEN
      PRINT #10, JD, NUI(JD); USING "   ###.##   ###.##   ###.##   ##";
PN(JD); HQ(JD); DQ(JD); PUMPN(JD)
      ELSE
      PRINT #10, JD, NUI(JD); USING "  ###.##"; PN(JD); HQ(JD); DQ(JD)
      END IF
      NEXT JD
      OPEN "O", #9, "GR.DAT"
      FOR I = 1 TO NS
      PRINT #9, NIRR(I)
      FOR K = 1 TO NIRR(I)
      PRINT #9, NNSVT(I, K), SVT(I, K)
      NEXT K
      NEXT I
      CLOSE #9
      IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN GOSUB GRAPH
      GOTO 1500
100   CLS           'strategy 1- On-demand delivery
      STRAT = 1
      SCREEN 1
      LOCATE 8, 15: PRINT " STRATEGY #1"
```

```
     PRINT : PRINT : PRINT
     PRINT "ALLOW USERS UNLIMITED ACCESS TO WATER"
     PRINT "                on-demand                    "
     LOCATE 22, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
     LOCATE 24, 1: INPUT "IS AUGMENTATION TO BE COSTED, Y/N"; AUG$
     IF AUG$ = "Y" OR AUG$ = "y" THEN GOSUB AUG
     IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
     SCREEN 0: WIDTH 80
     GOSUB NOTIS
     GOTO 2
200 CLS       'strategy #2- Users in rotation block
     SCREEN 1
     LOCATE 8, 15: PRINT " STRATEGY #2"
     PRINT : PRINT : PRINT
     PRINT "       USERS IN ROTATION BLOCKS"
     LOCATE 23, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
     IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
     SCREEN 0: WIDTH 80
     PRINT : PRINT
     STRAT = 2
     GOSUB UPDATE
     PRINT #3, "USERS IN ROTATION BLOCKS": PRINT #3,
     GOSUB NOTIS
     PRINT #3,
     GOTO 2
300 CLS               'strategy #3- users placed on request
     STRAT = 3
     SCREEN 1
     LOCATE 8, 15: PRINT " STRATEGY #3"
     PRINT : PRINT : PRINT
     PRINT "           USERS PLACED ON REQUEST"
     LOCATE 23, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
     IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
     SCREEN 0: WIDTH 80
     GOSUB NOTIS
     GOTO 2
400 CLS : 'strategy #4-  based on categories among crops
     SCREEN 1
     LOCATE 8, 13: PRINT "STRATEGY #4"
     PRINT : PRINT : PRINT
     PRINT "SUPPLY BASED ON GROUP AMONG CROPS"
     LOCATE 15, 15: PRINT "  CROP           GROUP"
     LOCATE 16, 15: PRINT " Alfalfa           1  "
     LOCATE 17, 15: PRINT " Small Grain       2  "
     LOCATE 18, 15: PRINT " Silage Corn       2  "
     LOCATE 19, 15: PRINT " Pasture           3  "
     LOCATE 24, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
     IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
     SCREEN 0: WIDTH 80
     PRINT #3, : PRINT #3, TAB(20); "ALLOCATION AMONG CROP CATEGORIES"
     PRINT #3,
     STRAT = 4
```

```
     GOSUB UPDATE
     PRINT #3,
     GOSUB NOTIS
     GOTO 2
500 CLS        'strategy #5-based on ranking of users stocks
     SCREEN 1
     LOCATE 6, 15: PRINT " STRATEGY #5"
     PRINT : PRINT : PRINT
     PRINT "SUPPLY BASED ON RANKING OF USERS' STOCKS": PRINT
     LOCATE 12, 13: PRINT "STOCKS WERE RANKED AS:"
     LOCATE 13, 15: PRINT "Shares of Stock Range    Class Rank"
     LOCATE 14, 15: PRINT "    .5 -  12.5                1"
     LOCATE 15, 15: PRINT "  12.5 -  36.0                2"
     LOCATE 16, 15: PRINT "  36.0 and higher             3"
     LOCATE 24, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
     IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
     SCREEN 0: WIDTH 80
     PRINT #3,
     PRINT #3, TAB(25); "ALLOCATIONS BASED ON STOCKS RANKING"
     PRINT #3,
     STRAT = 5
     GOSUB UPDATE
     PRINT #3,
     GOSUB NOTIS
     GOTO 2
600 CLS : 'strategy #6- supply along system types
     SCREEN 1
     LOCATE 8, 15: PRINT " STRATEGY #6"
     PRINT : PRINT : PRINT
     PRINT "    SUPPLY ACCORDING TO SYSTEM TYPES"
     LOCATE 15, 11: PRINT "SPRINKLE SYSTEM TYPES ARE:"
     LOCATE 16, 11: PRINT "  1 Hand-move laterals"
     LOCATE 17, 11: PRINT "  2 Wheel-move   ,,    "
     LOCATE 24, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
     IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
     SCREEN 0: WIDTH 80
     PRINT #3,
     PRINT #3, "ALLOCATIONS BASED ON SYSTEM TYPES": PRINT #3,
     PRINT #3,
     STRAT = 6
     GOSUB UPDATE
     PRINT #3,
     GOSUB NOTIS
     GOTO 2
700 CLS : ' strategy #7- low irrigation labor cost scheme
     SCREEN 1
     LOCATE 8, 15: PRINT " STRATEGY #7"
     PRINT : PRINT : PRINT
     PRINT "SUPPLY DURING LOW IRRIGATION LABOR COST PERIOD"
     LOCATE 23, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
     IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
     SCREEN 0: WIDTH 80
```

```
      PRINT #3,
      STRAT = 7
      GOSUB UPDATE
      PRINT #3, TAB(15); "SUPPLY DURING LOW IRRIGATION LABOR COST PERIOD"
      PRINT #3, : PRINT #3,
      GOSUB NOTIS
      GOTO 2
800 CLS : 'strategy #8- user supplied once
      STRAT = 8
      SCREEN 1
      LOCATE 8, 15: PRINT " STRATEGY #8"
      PRINT : PRINT : PRINT
      LOCATE 12, 13: PRINT "A ONE-TIME DELIVERY"
      LOCATE 22, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
      LOCATE 24, 1: INPUT "IS AUGMENTATION TO BE COSTED? Y/N"; AUG$
      IF AUG$ = "Y" OR AUG$ = "y" THEN GOSUB AUG
      IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
      SCREEN 0: WIDTH 80
      PRINT #3, : PRINT #3, "ONE-TIME DELIVERY": PRINT #3,
      STRAT = 8
      '
      '
      '          ********************************************
      '          *                    POSSIBLE REQ.DAY      *
      '          *      CROP          EARLIEST    LATEST    *
      '          *      ----          --------    ------    *
      '          *     ALFALFA          125         192     *
      '          *     S/GRAIN          165         185     *
      '          *     CORN, SILLAGE    205         220     *
      '          *     PASTURE          141         151     *
      '          *                                          *
      '          ********************************************
      '
      FOR J9 = 1 TO NS
      IF CT$(J9) = "ALFALFA" THEN
      LOWVAL = 125
      UPVAL = 192
      ELSEIF CT$(J9) = "S/GRAIN" THEN
      LOWVAL = 165
      UPVAL = 185
      ELSEIF CT$(J9) = "CORN/SL" THEN
      LOWVAL = 205
      UPVAL = 220
      ELSEIF CT$(J9) = "PASTURE" THEN
      LOWVAL = 141
      UPVAL = 151
      END IF
      GOSUB NOMDIST
      DT(J9) = INT(GENV)
      NEXT J9
      GOSUB NOTIS
      GOTO 2
```

```
900 CLS : 'strategy #9- continuous supply with metering
     SCREEN 1
     LOCATE 8, 15: PRINT " STRATEGY #9"
     PRINT : PRINT : PRINT
     PRINT "            CONTINUOUS SUPPLY"
     LOCATE 23, 1: INPUT "DO YOU WISH TO CONTINUE, Y/N"; A$
     IF A$ = "N" OR A$ = "n" THEN SCREEN 0: WIDTH 80: GOTO 1
     SCREEN 0: WIDTH 80
     PRINT #3, TAB(26); "CONTINUOUS SUPPLY"
     PRINT #3,
     GOSUB NOTIS
     STRAT = 9
     GOTO 2
1000 CLS : ' help
     SCREEN 1
     LOCATE 10, 15: PRINT "             HELP"
     LOCATE 23, 1: PRINT "PUSH ANY KEY TO CONTINUE";
1005 A$ = INKEY$: IF A$ = "" THEN 1005
     IF A$ = "Y" OR A$ = "y" THEN 1
1500 LOCATE 25, 3: PRINT "YOUR OUTPUT  IS IN *** HYD.DAT ***"
     PRINT
     CLOSE #3
    END

HYDRA:

   ' ---------------------------------------------
   '  SUBROUTINE HYDRA FOR HYDRAULIC ANALYSIS
   '         USING HAZEL WILLIAMS EQ.
   '---------------------------------------------
 FOR IT = 1 TO 5
 N = 1.852
 RN = 1 / N
 R1 = RN - 1
 FOR I = 1 TO NP
 QQ(I) = 0
 K(I) = (4.77 * L(I)) / ((D(I) ^ 4.87) * (CHW(I) ^ N))
 R(I) = 1 / (K(I) ^ RN)
 NEXT I
 FOR K = NP TO 1 STEP -1
 FOR L = 1 TO 3
 QQ(K) = QQ(K) + QQ(PD(K, L))
 NEXT L
 QQ(K) = QQ(K) + QV(K)
 NEXT K
 G = 32.2
 PHI = 3.142
 HE = ((8 * KM(0))/(G * PHI ^ 2)) * (QQ(1) ^ 2 / D(1) ^ 4)
                    'Head loss due to entrance
 HH(0) = HH0 - HE
 FOR M = 1 TO NP
 HM = ((8 * KM(M))/(G * PHI ^ 2)) * (QQ(M) ^ 2 / D(M) ^ 4)
```

```
                    'minor loss
HH(M) = HH(PU(M)) - K(M) * QQ(M) ^ N - HM
OH(M) = HH(M) - EL(M)          ' lateral inlet head, ft
NEXT M
FOR I = 1 TO NS
IF CT$(I) = "CORN/SL" AND LEFT$(SY$(I), 1) = "H" THEN
HRS = 8                        ' HRS=riser height in corn
ELSE
HRS = 4.5                      ' wheel move risers usually
                               ' 18 inches above lateral.
END IF
LDIA = VAL(MID$(SY$(I), 3, 1))  ' lateral pipe diameter
FOR M = 1 TO LT
IF LD(M) = LDIA THEN
JA = LC(M) * ((453 * QV(SP(I))) ^ LNN(M))     'head loss
                                              'gradient
F = (1 / (LNN(M) + 1)) + (1 / (2 * SPN(I))) + (SQR(LNN(M)
 - 1) / (6 * SPN(I) ^ 2))
IF LEFT$(SY$(I), 1) = "W" THEN AL = .5
F = (SPN(I) * F - (1 - AL)) / (SPN(I) - (1 - AL))
END IF
END IF
NEXT M
L = VAL(RIGHT$(SY$(I), 4))
HF = JA * F * (L / 100)
DELHE = 0              ' assuming delta Pe=0, i.e. no elev
                       ' change between inlet and close end
    HAV = OH(SP(I)) - (.75 * HF + .5 * DELHE + HRS)
    PAV(I) = HAV / 2.31  ' av. pressure at the sprinkler, psi
    DS(I) = SDC(Y(I)) * SQR(PAV(I))    'disch./sprinkler, gpm
    QV(SP(I)) = DS(I) * SPN(I) / 453
    APRT(I) = 96.3 * DS(I) / ASP(I)    ' applic. rate, in/hr.
    NEXT I
    NEXT IT
    QVFN = 0
    FOR I = 1 TO NS
    QVFN = QVFN + QV(SP(I))
    NEXT I
    QVDIFF = QVIN - QVFN     'initial - final (Q-sum of qa's)
    RETURN

NOTIS:
    CLS
    LOCATE 12, 20: PRINT "        ANALYSIS IN PROGRESS- WAIT A
MOMENT"
    LOCATE 13, 35: PRINT "Please...."
    RETURN


AUT:
    '-------------------------------------------------
    '     SUBROUTINE AUT FOR THE OUTPUT FILE HYD.DAT
```

```
    '-------------------------------------------------
     PRINT #3, "JULIAN DATE"; JD
     PRINT #3,
     PRINT #3, "USERS IRRIGATING"
     PRINT #3,
     Z           E           T           $                          =
"                                                                   "
     PR$ = "\        \###       ##.#   ##.##   ####   ###.##  ### ## ###
##"
     PRINT #3,
     PRINT #3, "USER/  SPRINKLER  NOZZLE  IRR    TOTAL    FIELD   ARRV
DEP"
     PRINT #3, "FIELD  PRESSURE   DISCH.  DEPTH  SERVICE  DEMAND  TIME
TIME"
     PRINT #3, "CODE      psi      gpm/S    in.   TIME,hr  ac-ft   JD hr
JD hr"
     PRINT #3, ZET$
     IF DSPLY$ = "Y" OR DSPLY$ = "y" THEN
     PRINT
     PRINT "JULIAN DATE"; JD
     PRINT
     PRINT "USERS IRRIGATING "
     PRINT
     PRINT
     PRINT "USER/   SPRINKLER   NOZZLE   IRR     TOTAL     FIELD    ARRV
DEP"
     PRINT "FIELD   PRESSURE    DISCH.   DEPTH   SERVICE   DEMAND   TIME
TIME"
     PRINT "CODE      psi       gpm/S     in.   TIME,hr  ac-ft   JD hr  JD
hr"
     PRINT ZET$
     END IF
     FOR U = 1 TO NS
     IF JDPL(U) <= JD AND JD <= JDPLM(U) THEN
     IF VOL(U) <> 0 THEN
     IF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT = 7 OR
      STRAT = 9 THEN
     IF STRAT = 9 THEN
     BY = U
     ELSE
     BY = BLK(U)
     END IF
     IRRG(U) = IRG(U, COUNTER(BY))
     END IF
     PRINT #3, USING PR$; N$(U); PAV(U); DS(U); IRRG(U);SVT(U, NIRR(U));
      VOL(U); ARRDT(U); TARR(U); JDDEP(U); HRDEP(U)
     IF DSPLY$ = "Y" OR DSPLY$ = "y" THEN
     PRINT USING PR$; N$(U); PAV(U); DS(U); IRRG(U); SVT(U, NIRR(U));
      VOL(U); ARRDT(U); TARR(U); JDDEP(U); HRDEP(U)
     END IF
     END IF
     END IF
```

```
     NEXT U
     PRINT #3, ZET$
     IF DSPLY$ = "Y" OR DSPLY$ = "y" THEN PRINT ZET$
     GH$ = "###.##"
     PRINT #3, "AVAILABLE FLOW RATE ="; USING GH$; HQ(JD)
     PRINT #3,
     PRINT #3, "COMPUTED FLOW RATE ="; USING GH$; DQ(JD)
     PRINT #3, : PRINT #3,
     IF DSPLY$ = "Y" OR DSPLY$ = "y" THEN
     PRINT "AVAILABLE FLOW RATE ="; USING GH$; HQ(JD)
     PRINT
     PRINT "COMPUTED FLOW RATE ="; USING GH$; DQ(JD)
     PRINT : PRINT
     END IF
     RETURN

INFO:
     CLS
     PRINT "                        PROJECTS ARE MADE UP OF "
     PRINT "                           ROTATION BLOCKS"
     PRINT "                                AND"
     PRINT : PRINT
     PRINT "               ROTATION BLOCKS ARE MADE UP OF       ROTATION
UNITS"
     PRINT : PRINT
     PRINT "         INDIVIDUAL FIELDS (USERS) OR GROUPS OF       FIELDS
CAN MAKE "
     PRINT : PRINT
     PRINT "                                ROTATION UNITS"
     PRINT : PRINT :
     PRINT "FOR EXAMPLE:"
     PRINT
     PRINT "ROTATION BLOCK #1 HAS TWO ROTATION UNITS"
     PRINT "ROTATION BLOCK #2 HAS THREE ROTATION UNITS"
     PRINT "ROTATION BLOCK #3 HAS THREE ROTATION UNITS"
     PRINT : PRINT : PRINT
     PRINT "TO MAKE CHANGES ALTER STRING ARRAY BN$ IN DATA FILE"
     PRINT
     PRINT "WISH TO RETURN ?";
2002 A$ = INKEY$: IF A$ = "" THEN 2002
     IF A$ = "Y" OR A$ = "y" THEN
     RETURN
     ELSE
     END IF

UPDATE:

     '-----------------------------------------------
     '    SUBROUTINE UPDATE FOR ALL ROTATION
     '              STRATEGIES
     '-----------------------------------------------
     '
```

```
CLS
PRINT "DO YOU NEED INFORMATION ON ROTATION BLOCKS ?"
PRINT : INPUT A$
IF A$ = "Y" OR A$ = "y" THEN
GOSUB INFO
END IF
PRINT
PRINT "ENTER MONTH AND DAY OF BEGINING ROTATION,"
PRINT "SEPARATE BY A COMMA"
PRINT
INPUT MN, DY
PRINT : PRINT : PRINT
INPUT "ROTATION INTERVALS, AND NUMBER OF DAYS ON"; RI,D2
ISUM = 0
FOR L = 1 TO MN - 1
IF MN = 1 THEN DM(L) = 0
ISUM = ISUM + DM(L)
NEXT L
J1 = ISUM + DY
IF STRAT = 2 THEN
FOR I = 1 TO NS
BLK(I) = BN(I)
NEXT I
MBL = 3
ELSEIF STRAT = 4 THEN
FOR I = 1 TO NS
BLK(I) = PG(I)
NEXT I
MBL = 3
ELSEIF STRAT = 5 THEN
FOR I = 1 TO NS
BLK(I) = STK(I)
NEXT I
MBL = 3
ELSEIF STRAT = 6 THEN
FOR I = 1 TO NS
BLK(I) = SEM(I)
NEXT I
MBL = 2
ELSEIF STRAT = 7 THEN
FOR I = 1 TO NS
BLK(I) = LL(I)
NEXT I
MBL = 2
END IF
PRINT
PRINT : INPUT "ENTER NUMBER OF DAYS TO STAGGER"; STAG
FOR BL = 1 TO MBL
COUNTER(BL) = (BL - 1) * STAG + 1
IF COUNTER(BL) >= RI THEN COUNTER(BL) = 1
NEXT BL
RETURN
```

```
APPEFF:

    ' ------------------------------------------------
    '        APPLICATION EFFICIENCY SUBROUTINE
    '------------------------------------------------
     UPVAL = 65
     LOWVAL = 45
     GOSUB NOMDIST
     P = GENV

   ' wind conditions are low, moderate, or high

     IF WS(JD) <= 4 THEN
      WCOND$ = "L"
     ELSEIF WS(JD) > 4 AND WS(JD) <= 15 THEN
      WCOND$ = "M"
     ELSEIF WS(JD) > 15 THEN
      WCOND$ = "H"
     END IF
     FOR N = 1 TO NSP
     IF Y(U) = Y2(N) THEN
     B = NZD(N)
     END IF
     NEXT N
     K = .015625                        ' 1/64 for English units.
     CI = (K * (P) ^ 1.3) / B           ' coarseness index
     FOR J = 1 TO WC
     IF WINDC$(J) = WCOND$ THEN
     IF CI < 7 THEN RE = KF(J) * EXP(AF(J) * ETR(JD))
     ELSEIF CI > 17 THEN RE = KCS(J) * EXP(ACS(J) * ETR(JD))
     ELSEIF CI >= 7 AND CI <= 17 THEN
     RE = ((CI - 7) / 10) * KF(J) * EXP(AF(J) * ETR(JD)) +
       ((17 - CI) / 10) * KCS(J) * EXP(ACS(J) * ETR(JD))
     END IF
     NEXT J
     UPVAL = .86
     LOWVAL = .75                       'upper and lower range of CU's
     GOSUB NOMDIST
     CU = GENV
     UPVAL = 1!
     LOWVAL = .95
     GOSUB NOMDIST
     QE = GENV                          'losses at sprinklers
     EFF(U) = CU * RE * QE
   RETURN

TREV:

    ' ------------------------------------------------
    ' SUBROUTINE FOR ESTIMATING EVAPORATION AND
    ' TRANSPIRATION FROM ETR.
```

```
' ------------------------------------------------
'
  DESCR$ = MID$(PRF$(U), 5, 4)        'layer description
  IF DESCR$ = "LOAM" OR DESCR$ = "CLLO" OR DESCR$ =
    "STLO" OR DESCR$ = "STCL" THEN
  TD = 5              ' td for loam soils in Kimberly
  ELSEIF DESCR$ = "LMSN" THEN
  TD = 3
  ELSEIF DESCR$ = "LMCL" OR DESCR$ = "CLAY" THEN
  TD = 7
  END IF
  KE = 1! - KCT(U)
  EP = KE * ETR(JD)
  TP = KCT(U) * ETR(JD)                ' potential transpiration
  IF TP < 0 THEN TP = 0
  IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
  RTO = TW(U) / TD
  IF RTO > 1 THEN RTO = 1
  EV = EP * (1! - RTO) ^ .5
  EVT(U) = EVT(U) + EV
  TTP(U) = TTP(U) + TP       ' summing pot. transpiration seasonal.
  TP(U) = TP(U) + TP         ' summing pot. transpi. for  growth
                             ' stages.
  IF SWS(U, JD) / AVW(U) >= .5 THEN
   T = TP
  ELSEIF SWS(U, JD) / AVW(U) < .5 THEN
   T = (TP / .5) * (SWS(U, JD) / AVW(U))
  END IF
  IF T < 0 THEN T = 0
  TT(U) = TT(U) + T          ' summing actual transpi. for
                               growth stages
  TST(U) = TST(U) + T        ' summing actual transpi. for
                               the season
  ELSEIF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6
    OR STRAT = 7 OR STRAT = 9 THEN
  FOR XY = 1 TO D2
  RTO = TWR(U, XY) / TD
  IF RTO > 1 THEN RTO = 1
  EV = EP * (1 - RTO) ^ .5
  EVTR(U, XY) = EVTR(U, XY) + EV
  TTPR(U, XY) = TTPR(U, XY) + TP
  TPR(U, XY) = TPR(U, XY) + TP
  IF SWC(U, XY) / AVW(U) >= .5 THEN
   T = TP
  ELSEIF SWC(U, XY) / AVW(U) < .5 THEN
   T = (TP / .5) * (SWC(U, XY) / AVW(U))
  END IF
  IF T < 0 THEN T = 0
  TTR(U, XY) = TTR(U, XY) + T
  TSTR(U, XY) = TSTR(U, XY) + T
  NEXT XY
  END IF
```

```
IF CT$(U) = "CORN/SL" OR CT$(U) = "S/GRAIN" THEN
IF CT$(U) = "CORN/SL" THEN
CN = 2
MT = 6
ELSEIF CT$(U) = "S/GRAIN" THEN
CN = 3
MT = 7
END IF
IF TH(JD) > 86 THEN TH(JD) = 86
IF TL(JD) < 50 THEN TL(JD) = 50
GDD = (TH(JD) / 2 + TL(JD) / 2) - 50
IF GDD < 0 THEN GDD = 0
GDDT(U) = GDDT(U) + GDD                          ' GDD accumulator
FOR GS = 2 TO MT
IF GDDT(U) >= GDD(CN, GS - 1) AND GDDT(U) <= GDD(CN, GS) THEN
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
TRT(U, GS) = TT(U)
TPT(U, GS) = TP(U)
ELSEIF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT =
 7 OR STRAT = 9 THEN
FOR XY = 1 TO D2
TRTR(U, XY, GS) = TTR(U, XY)
TPTR(U, XY, GS) = TPR(U, XY)
NEXT XY
END IF
END IF
NEXT GS
END IF
    RETURN

YIELD:

     ' ------------------------------------------
     '       YIELD ESTIMATE SUBROUTINE
     ' ------------------------------------------

       FOR K = 1 TO NS
       IF CT$(K) = "ALFALFA" OR CT$(K) = "PASTURE" THEN
       IF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR  STRAT = 7
        OR STRAT = 9 THEN
       TSTR2 = 0: TTPR2 = 0
       FOR XY = 1 TO D2
       TSTR2 = TSTR2 + TSTR(K, XY)
       TTPR2 = TTPR2 + TTPR(K, XY)
       NEXT XY
       TST(K) = TSTR2 / D2
       TTP(K) = TTPR2 / D2
       END IF
       ELSEIF CT$(K) = "CORN/SL" OR CT$(K) = "S/GRAIN" THEN
       IF CT$(K) = "CORN/SL" THEN
       MT = 5
       ELSEIF CT$(K) = "S/GRAIN" THEN
```

```
MT = 6
END IF
IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
FOR GS = 2 TO MT
ZA(K, GS) = TRT(K, GS + 1) - TRT(K, GS)
ZP(K, GS) = TPT(K, GS + 1) - TPT(K, GS)
NEXT GS
ELSEIF STRAT = 2 OR STRAT = 4 OR STRAT = 5 OR STRAT = 6 OR STRAT
 = 7 OR STRAT = 9 THEN
FOR GS = 2 TO MT
ZA(K, GS) = 0
ZP(K, GS) = 0
FOR XY = 1 TO D2
ZAR(K, XY, GS) = TRTR(K, XY, GS + 1) - TRTR(K, XY, GS)
ZPR(K, XY, GS) = TPTR(K, XY, GS + 1) - TPTR(K, XY, GS)
ZA(K, GS) = ZA(K, GS) + ZAR(K, XY, GS)
ZP(K, GS) = ZP(K, GS) + ZPR(K, XY, GS)
NEXT XY
ZA(K, GS) = ZA(K, GS) / D2        'mean for all strips
ZP(K, GS) = ZP(K, GS) / D2
NEXT GS
END IF
IF CT$(K) = "CORN/SL" THEN
ZPT(K) = ZP(K, 4) + ZP(K, 5)
ELSEIF CT$(K) = "S/GRAIN" THEN
ZPT(K) = ZP(K, 5) + ZP(K, 6)
END IF
END IF
  NEXT K

  PROJBEN = 0

  FOR I = 1 TO NS
  IF CT$(I) = "ALFALFA" OR CT$(I) = "PASTURE" THEN
 IF CT$(I) = "ALFALFA" THEN
     CN = 1
ELSEIF CT$(I) = "PASTURE" THEN
     CN = 4
 END IF
 IF STRAT = 1 OR STRAT = 3 OR STRAT = 8 THEN
 IF TST(I) < 0 THEN TST(I) = 0
     YLD(I) = YP(CN) * (TST(I) / TTP(I))   'DM yield
     ELSE
     YLD(I) = 0
     FOR XY = 1 TO D2
     YLD(I) = YLD(I) + YP(CN) * (TSTR(I, XY) / TTPR(I, XY))
     NEXT XY
     YLD(I) = YLD(I) / D2
     END IF
     ELSEIF CT$(I) = "CORN/SL" OR CT$(I) = "S/GRAIN" THEN
     IF CT$(I) = "CORN/SL" THEN
     CN = 2
```

```
      MT = 5
      ELSEIF CT$(I) = "S/GRAIN" THEN
      CN = 3
      MT = 6
      END IF
      TY1 = 1
      FOR GS = 2 TO MT
      TY1 = TY1 * (ZA(I, GS) / ZP(I, GS)) ^ LAMBDA(CN, GS)
      NEXT GS

    IF ZPT(I) >= TPTH(CN) THEN
    SLF = 1!
    ELSEIF ZPT(I) < TPTH(CN) THEN
    SLF = (ZPT(I) / TPTH(CN)) ^ ALP(CN)
    END IF
    YLD(I) = YP(CN) * TY1 * SLF       ' DM yield in ton/ac.
    IF CT$(I) = "CORN/SL" THEN
    'Potential yield YP estimated at 15.5% moisture content.
    'DM yield is about 30% silage yield
    'Grain yield is about 42% DM yield
    YLD(I) = YLD(I) / (1.155 * .42 * .3)  'silage yield in ton/ac.
    END IF
    END IF

  ' Returns per acre                    ' in $/acre
    RTUN(I) = INT(RETN(CN) * YLD(I) + BYPR(CN))

  ' Costs per acre                      ' in $/acre
      IF LEFT$(SY$(I), 1) = "W" THEN
      STY = 1
      ELSEIF LEFT$(SY$(I), 1) = "H" THEN
      STY = 2
      END IF
      F = (1 + INTR(STY)) ^ YEAR(STY)
      CRF = INTR(STY) * F / (F - 1)
      CK = (CRF * INVCOST(STY)) / AR(I)    ' capital cost per
                    acre (standard 1/4 mile)
      L = VAL(RIGHT$(SY$(I), 4))
      CK = CK * (L / 1320)                  'adjusted capital cost
      TC(I) = INT(YDCOST(CN) + CC(CN) + NIRR(I) *
      IRRCOST(CN) + CK + (ARDCOST(CN) * S(I) / AR(I)))
      BENF(I) = INT((RTUN(I) - TC(I)) * AR(I))
      PROJBEN = INT(PROJBEN + BENF(I))       ' benefit accruing to
                                              project
      NEXT I
    RETURN

NOMDIST:

    '--------------------------------
    '     RANDOM VARIATES GENERATOR
    '--------------------------------
```

```
'
  N = 12
  SUM = 0
  TRSQ = 0
  TRND = 0
  RANDOMIZE TIMER
  FOR II = 1 TO N
  R2 = (UPVAL - LOWVAL) * RND + LOWVAL
  TRND = TRND + RND
  SUM = SUM + R2
  RSQ = R2 ^ 2
  TRSQ = TRSQ + RSQ
  NEXT II
  EX = SUM / N
  VX = (TRSQ - N * (EX ^ 2)) / (N - 1)
  SIGMA = SQR(VX)
  GENV = ((TRND - 6!) * (SIGMA)) + EX  'normally distr. random
                                        variates
  IF GENV < LOWVAL THEN
  GENV = LOWVAL
  ELSEIF GENV > UPVAL THEN
  GENV = UPVAL
  END IF
RETURN

ARRGNT:
' ---------------------------------
'    TIME OF ARRIVAL GENERATOR
' ---------------------------------
' Read in ratio of arrivals for two segments
  RESTORE
  READ X, Y          ' x:y ratio in the two segments
  IF STRAT = 2 OR STRAT=4 OR STRAT=5 OR STRAT=6 OR STRAT=7
    OR STRAT=9 THEN
  X = 1
  Y = 0
  END IF
  US(1) = INT((X / (X + Y)) * NUI(JD))
  US(2) = NUI(JD) - US(1)              'NUI = # of users irrigating
  S = 0
  FOR I8 = 1 TO 2
  READ UPVAL, LOWVAL
  FOR K = 1 TO US(I8)
  GOSUB NOMDIST
  IF S < NUI(JD) THEN
  S = S + 1
  BARR(S) = GENV                        ' time for a user arrival
  END IF
  NEXT K
  NEXT I8
```

```
  RETURN
PRIO:
  ' ---------------------------------
  '     FIELD SERVICE PRIORITY
  ' ---------------------------------
  '
    FOR J = 1 TO NS
    IF CT$(J) = "ALFALFA" THEN
    CN = 1
    IF JD <= 150 THEN
    KPR = 1.8221
    ALPHA = .3338
    ELSEIF JD > JDPL(J) + 76 AND JD <= JDPL(J) + 122 THEN
    KPR = 1.4333
    ALPHA = .095
    ELSEIF JD > JDPL(J) + 122 THEN
    KPR = 1.3499
    ALPHA = .0417
    END IF
    ELSEIF CT$(J) = "CORN/SL" THEN       ' CN is a crop code
    CN = 2
    KPR = 1.284
    ALPHA = .1875
    ELSEIF CT$(J) = "S/GRAIN" THEN
    CN = 3
    KPR = 1.2523
    ALPHA = .0896
    ELSEIF CT$(J) = "PASTURE" THEN
    CN = 4
    KPR = 1.2214
    ALPHA = .025
    END IF
    PFS(J) = 0
    IF JD >= JDPL(J) AND JD <= JDPLM(J) THEN
    IF JDDEP(J) >= JD THEN
    TIME2(J) = 0
    PFS(J) = 0
    ELSE
    PFS(J) = KPR * EXP(ALPHA * TIME2(J))   'priority in queue
    END IF
    PFS2(J) = PFS(J)
    END IF
    NEXT J
    FOR J = 1 TO NS - 1
    FOR H = J + 1 TO NS
    IF PFS(J) >= PFS(H) THEN 70          ' bubble sort
    TMPR = PFS(J)
    PFS(J) = PFS(H)
    PFS(H) = TMPR
70  NEXT H
    NEXT J
    MSJ = 1
```

```
    TUQ = 0
    FOR I = 1 TO NS
    IF ARRDT(I) < JD AND JDDEP(I) >= JD THEN
    TUQ = TUQ + UQ(I)
    END IF
    NEXT I
    UQDEF = HQ(JD) - TUQ
    IF UQDEF <= 0 THEN
    FOR I = 1 TO NS
    IF ARRDT(I) = JD THEN
    JDDEP(I) = JD
    UQ(I) = 0
    VOL(I) = 0
    END IF
    NEXT I
    XPRIO = PFS(MSJ)
    ELSEIF UQDEF > 0 THEN
75  FOR I = 1 TO NS
    IF JDPL(I) <= JD AND JD <= JDPLM(I) THEN
    IF ARRDT(I) = JD AND PFS2(I) = XPRIO THEN
    IF UQ(I) <= UQDEF THEN
    UQDEF = UQDEF - UQ(I)
    TIME2(I) = 0
    PFS2(I) = 0
    ELSEIF ARRDT(I) = JD AND PFS2(I) = XPRIO AND UQ(I) > UQDEF THEN
    UQ(I) = 0
    VOL(I) = 0
    JDDEP(I) = JD
    END IF
    END IF
    END IF
    NEXT I
    UQDEF = HQ(JD) - TUQ
    IF UQDEF > 0 AND MSJ <= NS - 1 THEN
77  MSJ = MSJ + 1
    XPRIO = PFS(MSJ)
    IF XPRIO = PFS(MSJ - 1) AND MSJ <= NS - 1 THEN 77
    GOTO 75
    END IF
    END IF
    DQ(JD) = 0
    FOR I = 1 TO NS
    IF JDPL(I) <= JD AND JD <= JDPLM(I) THEN
    IF VOL(I) > 0 THEN DQ(JD) = DQ(JD) + UQ(I)
    IF ARRDT(I) = JD AND JDDEP(I) = JD THEN
    SWS(I, JD) = SWS(I, JD) - IRRG(I) * EFF(I)
    IRT(I) = IRT(I) - IRRG(I) * EFF(I)
    NUI(JD) = NUI(JD) - 1
    NIRR(I) = NIRR(I) - 1
    IF IRT(I) < 0 THEN IRT(I) = 0
    END IF
    END IF
```

```
    NEXT I
    RETURN


MLOSS:

    '---------------------------------
    '     MINOR LOSS SUBROUTINE
    '---------------------------------
    '
    OPEN "I", #4, "C:MINLOSS.DAT"
    INPUT #4, NFT
    DIM YM(NFT)
    FOR I = 1 TO NFT
    INPUT #4, YM(I)
    NEXT I
    CLOSE #4
    CLS
    PRINT
    PRINT "         ENTRANCE CONDITION:"
    PRINT "          1. square cornered"
    PRINT "          2. rounded        "
    PRINT "          3. re-entrant     "
    PRINT "         GATE VALVE:        "
    PRINT "          4. fully open     "
    PRINT "          5. 3/4 open       "
    PRINT "          6. 1/2 open       "
    PRINT "         GLOBE VALVE:       "
    PRINT "          7. fully open     "
    PRINT "         ANGLE VALVE        "
    PRINT "          8. fully open     "
    PRINT "         BALL CHECK VALVE   "
    PRINT "          9. fully open     "
    PRINT "         FOOT VALVE         "
    PRINT "         10. fully open     "
    PRINT "         11. TEE, THROUGH SIDE OUTLET"
    PRINT "         12. ELBOW (STANDARD) "
    PRINT "         13. ELBOW (45 DEGREE) "
    LOCATE 22, 9
    INPUT "ENTRANCE CONDITION AT THE INTAKE "; CE
    IF CE = 1 THEN
    KM(0) = .5
    ELSEIF CE = 2 THEN
    KM(0) = .05
    ELSEIF CE = 3 THEN
    KM(0) = 1!
    END IF
    FOR I = 1 TO NP
    LOCATE 22, 9
    PRINT "ENTER NUMBER OF THE FITTING ON PIPE"; I;
    INPUT CF
    KM(I) = YM(CF)
```

```
    NEXT I
    RETURN

BENCOMP:

  ' ------------------------------------------
  '         FIELD SPECIFIC DATA ON
  '      YIELD, COSTS, RETURN, BENEFIT
  ' ------------------------------------------
  '
    ZET$ = "_____________________________________________________________-
  "
—   PRINT #3,
    PRINT #3, "FIELD/           CUMMULATIVE    CROP  TOTAL  TOTAL BENE-
BENE-"
    PRINT #3, "USER              TRANSPIRATION YIELD RETURN COSTS FIT
FIT/A"
    PRINT #3, "CODE      CROP    POT.    ACTUAL t/ac.    $       $     $
$/AC"
    FM$ = "\      \\     \ ##.#   ##.#   ##.#  ##### #####  #####  ####"
    PRINT #3, ZET$
    FOR I = 1 TO NS
    IF CT$(I) = "CORN/SL" OR CT$(I) = "S/GRAIN" THEN
    IF CT$(I) = "CORN/SL" THEN
    MT = 5
    ELSEIF CT$(I) = "S/GRAIN" THEN
    MT = 6
    END IF
    FOR K = 2 TO MT
    IF K > 2 THEN
    PRINT #3, TAB(16); USING "###.#  ###.#"; ZP(I, K); ZA(I, K)
    ELSE
    PRINT #3, USING FM$; N$(I); CT$(I); ZP(I, K); ZA(I, K);
     YLD(I); RTUN(I) * AR(I); TC(I) * AR(I); BENF(I); BENF(I) / AR(I)
    END IF
    NEXT K
    ELSE
    PRINT #3, USING FM$; N$(I); CT$(I); TTP(I); TST(I);
     YLD(I); RTUN(I) * AR(I); TC(I) * AR(I); BENF(I); BENF(I) / AR(I)
    END IF
    NEXT I
    PRINT #3, ZET$
    PRINT #3, "Cummulative transpiration at 1st growth stage
              for Corn and"
    PRINT #3, "Small grain, which are zeros, are left out for clarity."
    PRINT #3,
    PRINT #3,
    RETURN

GRAPH:
```

```
TYPE TITLETYPE
  MainTitle AS STRING * 40
  XTitle AS STRING * 40
  YTitle AS STRING * 18
END TYPE


CONST GRTOP = 23, GRBTT = 170
CONST GRLEFT = 50, GRRIGHT = 450
CONST YLENGTH = GRBTT - GRTOP
BTTM = GRBTT - 3

SCREEN 2
CLS
LOCATE 12, 8
PRINT "Press Shift PrtSc to print the graph screen"
LOCATE 25, 2: PRINT
BEGIN$ = INPUT$(1)
CLS

'Draw y axis:
LINE (GRLEFT, GRTOP)-(GRLEFT, GRBTT), 1

'Draw y-axis title:
XTYL$ = "USER #"
START% = 4 - (LEN(XTYL$) / 2)
LOCATE 4, START%
PRINT RTRIM$(XTYL$);

'Put tic marks on x-axis:
FOR K = 1 TO 5
LINE (GRLEFT + XSTEP, BTTM)-STEP(0, 2)
XSTEP = 100 * K
IF K = 1 THEN G = 5
LOCATE 23, 13 * (K - 1) + G
PRINT USING "###"; 50 * (K + 1)
NEXT K

'Draw x-axis title:
YTYL$ = "JULIAN DATE"
START% = 33 - (LEN(YTYL$) / 2)
LOCATE 24, START%
PRINT RTRIM$(YTYL$);

'Put tic marks on y-axis:
J = 0
FOR I = 1 TO NS
YSTEP = 6 * I
IF I = 5 OR I = 10 OR I = 15 OR I = 20 THEN
S = 4
ELSE
```

```
S = 1
END IF
LINE (GRLEFT, BTTM - YSTEP)-STEP(S, 0)
IF I = 5 OR I = 10 OR I = 15 OR I = 20 THEN
LOCATE 18 - J, 4
J = J + 4
PRINT USING "##"; I
END IF
NEXT I

'Draw main graph title:
MAINTYL$ = "ALLOCATIONS SUMMARY"
START% = 34 - (LEN(MAINTYL$) / 2)
LOCATE 3, START%
PRINT RTRIM$(MAINTYL$);


'Draw x axis:
LINE (GRLEFT - 3, BTTM)-(GRRIGHT, BTTM)

DRAW "L400"
OPEN "I", #11, "C:GR.DAT"
FOR U = 1 TO NS
DRAW "U6"
S2 = 2
TT = 0: TOT(U, 0) = 100
INPUT #11, NIRR(U)
FOR I = 1 TO NIRR(U)
INPUT #11, NNSVT(U, I), SVT(U, I)
NNSVT(U, I) = S2 * NNSVT(U, I)
SVT(U, I) = INT(SVT(U, I) / 24)     'hours to days of
                                    'service time
SVT(U, I) = S2 * SVT(U, I)
IF TOT(U, I) > 288 THEN SVT(U, I) = 288 - TOT(U, I)
TOT(U, I) = TOT(U, I) + NNSVT(U, I) + SVT(U, I)
T = NNSVT(U, I)
DRAW "BR=" + VARPTR$(T)
SVT = SVT(U, I)
DRAW "R=" + VARPTR$(SVT)
TI = NNSVT(U, I) + SVT(U, I)
TT = TT + TI
NEXT I
DRAW "BL=" + VARPTR$(TT)
NEXT U
BEGIN$ = INPUT$(1)
CLOSE #11
RETURN

AUG:

OPEN "I", #12, "C:AUGMENT.DAT"
INPUT #12, WELLCOST, WELLNO, PUMPCOST, SHLTCOST,
```

```
  ATTDCOST, LUBREPCOST
INPUT #12, DPUMPING, PEFF, COSTPKW(1), COSTPKW(2), IRATE
FOR M33 = 1 TO 3
INPUT #12, YEARS(M33)     '(Lives of Well, Pump, and  Shelter)
NEXT M33
FOR CY = 1 TO 3
INPUT #12, COSTPEN(CY)
COSTPEN(CY) = COSTPEN(CY) / 100       ' in dollars
NEXT CY
INPUT #12, TERMPERC, SERVCHG
FOR CY = 1 TO 2
INPUT #12, VOLTDCOST(CY)               ' in dollars
NEXT CY

'FIXED COST
   IRATE = IRATE / 100                  ' APR to decimal
FOR JM = 1 TO 3
   ZY = (1 + IRATE) ^ YEARS(JM)
   CRF2(JM) = (IRATE * ZY) / (ZY - 1)
   NEXT JM
   INVCOST = WELLCOST * CRF2(1) * WELLNO + PUMPCOST * CRF2(2) +
   SHLTCOST * CRF2(3)
   FXCOST = INVCOST / 12
RETURN
```

Appendix 2: Sample Input Files

CROP.DAT

CT	Number of crops in the file
CTY$	Crop Name
RDMAX	Maximum Root Depth of the Crop
RDMIN	Minimum Root Depth of the Crop
KCMAX	Maximum value of Crop Coefficient for the Crop
KCMIN	Minimum value of Crop Coefficient for the Crop
EC	Number of days from planting or begin growth to effective cover.
JDM	Number of days from planting or begin growth to physiologic maturity
A0..A3	Coefficients for estimating Crop Coefficients, Kc, before effective cover
B0..B3	Coefficients for estimating Crop Coefficients, Kc, after effective cover
AT0..AT3	Coefficients for estimating Crop transpiration factor, Kct, for use between crop emergence and effective cover
BT0..BT3	Coefficients for estimating Crop transpiration factor, Kct, for use after effective cover
LAMBDA	Exponent to allow for weighting of growth period
ALP	a constant weighting factor
TPTH	Threshold transpiration for adequate total dry matter prediction
YP	Potential yield
GDD	Growing Degree Days
A5	Coefficients used in the 5th power polynomial for estimating reference crop evapotranspiration, Etr, as a function of julian date.

```
4
ALFALFA,5,2,1,.3,51,168,0.3113,1.248,-.5599,0,.245,.0378,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,7.56,0,0,0,0,0,0,0
CORN/SL,4,.5,.95,.2,72,142,.2010,-.7520,2.476,-.9615,.9740
-.2157E-2,.8648E-4,-.1741E-5,-0.2630E-1,0.3493,-0.1199E+1
0.1808E+1,0.9108-0.6512E-3,-0.2496E-4,-0.3164E-6
0,.5,.22,.65,.65,0,1.7,10,3.6,0,86,258,1218,1622,2186,0
S/GRAIN,3,.5,1,.2,80,135,.1580,-.3084,2.966,-1.756,1.004
.02925,-0.1100E-2,0.7079E-5,-0.4792E-1,0.2142,0.7545,0.5422
0.2123E+1,-0.7377E-1,0.8643E-3,-0.3537E-5,0,.1,.1,.1,.6,1.29
4.9,9.5,3.8,0,64,162,391,746,946,1790
PASTURE,2.5,2.5,.8,.8,76,168,.8,.8,.8,.8,.8,.8,.8,.8,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,2.67,0,0,0,0,0,0,0,5.3699E-2
-2.7443E-3,5.6347E-5,-2.3162E-7,1.6664E-10,2.7704E-13
```

SOIL.DAT

ST Number of soil types based on textural classification
STY$ Soil type code used:
LMSN Loamy sands
LOAM Loam
STLO Silt loam
STCL Silty clay loam
LMCL Loamy clay
INFL Soil infiltration rate, in/hr.
WHC water holding capacity, in/ft.

```
5
LMSN,2.5,1
LOAM,1.32,1.98
STLO,0.87,2.04
STCL,0.16,2.10
LMCL,0.2,2.75
```

ECON.DAT

S7 Number of sprinkle irrigation system types
CT Number of crop types
SYST$ System type: W-M for wheel move system, and H-M for hand system.
INVCOST System investment cost
INTR Interest rate, on annual basis, in percentage
YEAR Pay-back period, in year
CTY$ Crop type
RETN Financial returns from the sale of crop, in $/ton
BYPR Financial returns from the sale of crop by-product, in $/acre
YDCOST Yield dependent costs, $/acre
CC Constant costs, $/acre
ARDCOST Area dependent costs, $/acre
IRRCOST Irrigation labor costs, $/acre

```
2,4
W-M,6000,12,15
H-M,3000,12,15
ALFALFA,60,2.25,100.07,6.30,6,3
CORN/SL,22,0,121.22,46.09,6,3
S/GRAIN,73,4.45,88.62,42.94,6,3
PASTURE,15.76,0,15.46,10.21,6,3
```

MINLOSS.DAT

NFT Number of fittings
YM Minor loss coefficient for the fitting

13
1,0.5,0.05,0.19,1,5.60,10,5,70,15,1.8,0.9,.4

SPRK.DAT

NSP Number of sprinkler head types in file
Y2 Sprinkler ID number
SNS$ Sprinkler description
NZD Sprinkler nozzle diameter, in inches
SDC Sprinkler discharge coefficient for use with the sprinkler discharge, q_a versus P, equation

LT Number of lateral sizes
LD Lateral pipe size (diameter), in inches
LC Coefficients for use with the Friction Loss Gradient equation
LNN index for use with the Friction Loss Gradient equation

WC Number of wind conditions

WINDC$ Wind conditions:
L for Low wind (wind speed <= 4 mph)
M for Medium wind (4 mph < wind speed <= 15 mph)
H for High wind (wind speed > 15 mph)

KF Coefficient, K, for fine spray for use with equation for estimating effective portion of applied water, Re, for a specific wind condition
AF an exponent, a, for fine spray, used in the equation for estimating Re
KCS Coefficient, K, for coarse spray for use with the equation for estimating effective portion of applied water, Re, for specific wind condition
ACS an exponent, a, for coarse spray, used in the equation for estimating Re
DM number of days in each month (non-leap year)

```
28
1,1/16,0.0625,0.1107
2,5/64,0.0781,0.176
3,3/32,0.0938,0.255
4,7/64,0.1094,0.346
5,1/8,0.125,0.453
6,9/64,0.1406,0.575
7,5/32,0.1563,0.71
8,9/64x3/32,0.2344,0.825
9,11/64,0.1719,0.849
10,5/32x3/32,0.25,0.966
11,3/16,0.1875,1.016
12,11/64x3/32,0.2656,1.10
13,13/64,0.2031,1.12
14,7/32,0.2188,1.40
15,3/16x1/8,0.3125,1.483
16,1/4,0.25,1.833
17,7/32x1/8,0.3438,1.883
18,9/32,0.2813,2.33
19,1/4x11/64,0.4219,2.60
20,5/16,0.3125,2.81
21,9/32x3/16,0.4688,3.28
22,11/32,0.3438,3.36
23,3/8,0.3750,3.93
24,5/16x7/32,0.5313,4.08
25,3/8x7/32,0.5938,5.0
26,7/16,0.4375,5.33
27,1/2,0.5,6.75
28,9/16,0.5625,8.5
4
2,0.005631,1.8509
3,0.000699,1.856508
4,0.000168,1.852934
5,0.0000554,1.85242
3
L,0.968,-0.117,0.954,-0.333
M,0.965,-0.236,0.988,-0.068
H,0.980,-0.084,0.989,-0.041
31,28,31,30,31,30,31,31,30,31,30,31
```

UZAS.DAT

NS	Number of users/fields
N$	User/field name or code
AR	Field area, in acres
S	Share of water irrigation water stock assigned to the field
SP	Supply/Delivery pipe number
BN$	Users in rotation block allocation code

PG$ Allocation among crop category code
STK$ Code associated with allocations based on stock ranks
SEM$ Code associated with allocations baed on system types
LL$ Code associated with low labor cost scheme allocations
SY$ User system type
Y User sprinkler type code
SPN Number of sprinklers on user's lateral
ASP Area under each sprinkler based on (S_m x S_l)
CT$ User's Crop
PLD$ Planting or begin growth date, if specified
PRF$ Field soil profile, layer description and thickness

```
23
CARI430,40,40,29,1,1,3,1,1,W 4 1320,11,33,2400,ALFALFA,MAR 22,"1 60STCL"
CARI593,40,51,28,1,1,3,1,1,W 5 1120,11,28,1600,ALFALFA,MAR 24,"1 60STCL"
CARI688,40,40,27,1,2,3,2,2,H 5 1400,14,28,1500,S/GRAIN,APR 20,"1 36STCL"
CARI836,50,39,25,1,3,3,2,2,H 4 2500,9,50,1500,PASTURE,MAR 25,"1 30STCL"
CARI525,10,12.5,26,1,3,1,2,2,H 4 600,9,12,1500,PASTURE,MAR 19,"1 30STCL"
CARI750,20,15,19,2,2,2,2,2,H 4 600,14,15,1200,S/GRAIN,APR 15,"1 36STCL"
CARI142,20,26,20,2,3,2,1,2,W 4 1040,11,26,2400,PASTURE,MAR 26,"1 30STCL"
CARI950,80,12,21,2,1,1,2,1,H 4 1080,9,27,1600,ALFALFA,MAR 19,"2 36LOAM
24LMCL"
CARI011,15,19,16,2,1,2,1,1,W 4 1040,11,26,2400,ALFALFA,MAR ,"1 60STCL"
CARI066,30,38,15,2,1,3,1,1,W 4 1040,11,26,2400,ALFALFA,MAR ,"1 60STLO"
CARI122,15,19,17,2,1,2,1,1,W 4 1040,11,26,2400,ALFALFA,MAR 28,"1 60STCL"
CARI474,30,38,14,2,1,3,1,1,W 4 1040,11,26,2400,ALFALFA,MAR 29,"1 60STCL"
CARI299,30,38,13,2,1,3,1,1,W 4 1040,14,26,2400,ALFALFA,MAR 25,"1 60STCL"
CARI869,35,23,22,1,1,2,2,1,H 4 1760,9,44,1200,ALFALFA,MAR ,"1 60STCL"
CARI958,25,20,23,1,2,2,2,2,H 4 1520,11,38,1200,CORN/SL,MAY 17,"1 48STCL"
CARI481,30,27,7,3,1,2,1,1,W 4 1500,13,30,1500,ALFALFA,MAR ,"1 60LOAM"
CARI986,10,19,6,3,2,2,2,2,H 4 1400,14,35,1200,S/GRAIN,APR 25,"1 36STCL"
CARI399,10,8,5,3,2,1,2,2,H 4 1400,14,35,1200,CORN/SL,MAY 15,"1 48LOAM"
CARI640,10,8,8,3,1,1,2,1,H 4 1400,14,35,1200,ALFALFA,MAR 19,"1 60STCL"
CARI059,25,14,10,3,1,2,2,1,H 4 1500,14,30,1500,ALFALFA,MAR 31,"1 60STCL"
CARI618,50,41,3,3,1,3,1,1,W 4 1200,9,44,1200,ALFALFA,MAR 15,"2 15STLO
45STCL"
CARI181,7,7,2,3,1,1,2,1,H 4 750,9,18,1200,ALFALFA,MAR 22,"2 15STLO
45STCL"
CARI714,5,6.25,9,3,1,1,2,1,H 4 600,9,15,1200,ALFALFA,MAR 26,"2 15STLO
45STCL"
```

NETWK.DAT

NP Number of pipe sections in the hydraulic network
I Pipe section ID
D Diameter of pipe section, in inches
L Length of the pipe section, in feet
M$ Pipe material

```
       PVC  polyvinyl chloride
       WS   welded steel
CHW  Hazen-Williams coefficient for the pipe material
EL   Pipe elevation at the delivery point
QV   Estimated user demand (initial guess), in cfs
ND   node number
PU   Number for the pipe upstream
PD   Number for the pipe(s) downstream, zero if none


29
1,18,890,WS,130,842,0,2,0,2,3,4
2,6,1626,PVC,150,793,.15,3,1,0,0,0
3,4,964,PVC,150,820,.41,4,1,0,0,0
4,18,940,WS,130,799.2,0,5,1,5,0,0
5,18,450,WS,130,776.6,.7,7,4,6,8,11
6,8,270,PVC,150,775,.7,8,5,7,0,0
7,6,996,PVC,150,772,.51,9,6,0,0,0
8,8,665,PVC,150,773.2,.71,10,5,9,10,0
9,4,148,PVC,150,784.5,.15,11,8,0,0,0
10,6,579,PVC,150,760.4,.79,12,8,0,0,0
11,16,1347,WS,130,736,0,13,5,12,22,24
12,12,332,PVC,150,740.5,0,16,11,13,0,0
13,12,1674,PVC,150,738,.67,17,12,14,0,0
14,10,1256,PVC,150,734,.37,18,13,15,16,0
15,6,407,PVC,150,743,.37,19,14,0,0,0
16,10,793,PVC,150,724,.37,20,14,17,0,0
17,10,643,PVC,150,714.9,.37,21,16,18,0,0
18,8,744,PVC,150,709,0,22,17,20,21,19
19,4,902,PVC,150,707,.37,23,18,0,0,0
20,8,1985,PVC,150,723.2,.46,24,18,0,0,0
21,6,585,PVC,150,715,.41,25,18,0,0,0
22,8,424,PVC,150,734.4,.64,14,11,23,0,0
23,6,715,PVC,150,736.2,.64,15,22,0,0,0
24,10,1681,PVC,150,714,0,26,11,25,27,0
25,6,242,PVC,150,716,.72,27,24,26,0,0
26,4,720,PVC,150,718.6,.23,28,25,0,0,0
27,10,1277,PVC,150,706.5,.51,29,24,28,0,0
28,8,1455,PVC,150,698,.51,30,27,29,0,0
29,8,1304,PVC,150,692,.55,31,28,0,0,0
```

CLIM.DRY (beginning March 15, ending Oct. 15)

TH Maximum temperature in degree Farenheit

47	40	42	44	50	40	48	50	52	51	55	54	56	53	55	47	42	40
41	44	41	46	62	68	59	63	58	37	47	48	59	65	68	74	69	62
47	58	68	72	67	58	60	64	68	68	69	69	66	54	66	70	73	66
47	47	53	56	61	66	73	78	81	79	76	73	76	80	82	84	87	79

81 85 86 75 58 58 66 72 79 82 87 84 80 67 63 73 83 90
93 93 86 85 84 69 62 68 79 83 81 85 91 91 91 94 95 97
96 88 88 88 87 91 88 89 91 96 93 91 89 87 90 94 98 99
96 97 95 87 75 82 88 93 94 96 93 91 91 92 96 93 95 100
100 94 92 90 89 92 92 88 82 84 83 83 84 79 77 75 83 89
90 86 87 90 86 86 89 87 76 88 89 89 87 89 93 95 94 91
77 78 75 76 85 87 89 92 84 85 86 87 85 86 87 79 76 80
83 85 85 83 76 79 80 81 85 81 73 77 81 79 78 74 67 63
59 60 53 47 47 55 69 66 71 64 56 53 47 47 47

TL Minimum temperature in degree Farenheit

30 28 32 30 29 15 28 25 31 26 26 35 29 39 36 32 25 25
28 23 25 32 38 33 33 27 32 29 28 30 35 29 38 39 52 30
27 23 29 37 44 30 31 29 33 40 32 35 40 44 34 37 51 37
30 32 26 31 40 32 37 39 41 49 43 41 36 38 42 44 45 48
48 46 48 53 32 29 31 34 37 38 42 47 52 37 35 33 39 43
49 58 60 42 43 43 40 44 43 50 46 43 49 53 55 56 50 55
70 45 52 46 49 54 53 48 50 54 53 55 47 53 48 52 54 54
54 56 53 62 58 56 48 52 57 63 55 51 48 48 47 50 50 50
60 60 68 59 59 53 54 62 59 53 50 52 48 53 55 54 48 48
48 53 47 48 50 50 50 51 45 49 57 47 45 46 49 50 52 65
47 37 38 49 41 41 44 47 48 51 44 46 47 59 50 51 51 38
41 42 43 46 37 36 37 41 43 43 41 38 39 39 38 44 43 37
34 34 38 34 27 30 30 35 36 43 27 35 28 22 22

PN Precipitation, in inches

0 0 .22 .05 0 0 0 0 0 0 0 0 0 .03 .12 .05 .35 0 .01 0
.02 .02 0 0 .02 0 .51 .11 .02 .07 0 0 0 0 0 0 .03 0 0
0 0 .02 .01 0 0 .04 0 0 .02 .34 .04 0 0 .35 .36 .38 .03
0 0 0 0 0 0 0 0 0 0 0 0 0 0 .01 0 0 0 .14 .32 0 0
0 0 0 0 0 .01 .07 .08 0 0 0 0 0 .02 0 0 0 .52 .19 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 .11 .39 .07 .01 0 .01 0 0 0 0 0 0 0 0 0 0
0 0 0 .11 .06 0 0 0 .13 .02 0 .02 0 .03 .08 0 0 0 0 0
0 0 0 0 0 0 .03 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 .13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 .12 0 0 .03 1.23 .5 .02 0 0 0 0 .06 0 0 0 0

HQ Streamflow, in cfs

21 22 18 15 14 13 12 12 14 15 18 18 17 16 15 14 13 12
12 11 10 10 12 19 25 30 25 21 19 18 19 29 46 58 56 43
35 35 43 50 47 44 44 50 53 58 62 62 60 60 64 71 85 72
64 56 53 51 50 51 56 71 92 110 124 128 134 138 162 160
167 165 167 167 171 152 112 89 79 75 76 80 88 92 89 74

65 60 62 67 71 75 70 65 64 60 55 50 49 49 49 48 48 46
46 44 43 42 41 39 36 35 34 32 31 29 27 27 26 25 24 23
22 21 21 20 20 20 20 20 19 18 17 17 16 16 15 15 15 14
14 14 14 13 13 13 14 13 13 12 12 12 12 12 12 12 13 12
12 12 11 11 11 11 11 10 10 10 10 10 10 10 9.8 9.8 9.8
9.8 9.8 9.8 9.8 9.8 9.8 9.8 9.8 9.8 9.8 9.4 9.4 9.4 9.4
9.4 9.4 9.4 9.4 9.4 9.4 9.1 9.1 9.1 9.1 9.1 8.7 8.7 8.7
8.7 8.7 8.4 8.4 8.4 8.4 8.4 8.4 8.4 8 8 8 8 8 8 12 11
9.1 8.4 8.4 8 8 8 8 7.8 7.8 7.8 7.8

WS Wind run over a 24 hour period, in miles/day

199 228 21 10 43 76 112 64 88 108 91 58 93 89 93 140 175
91 121 150 179 117 144 74 55 76 66 57 45 28 159 54 83 84
27 121 70 80 37 46 67 160 78 48 41 79 70 85 60 69 85 74
70 59 56 107 50 33 47 33 60 55 102 8 63 52 55 57 86 48
63 52 62 44 57 45 42 90 84 49 54 68 36 37 50 48 60 41
46 38 49 42 47 40 9 123 45 37 36 38 66 12 124 27 64 55
38 42 32 66 44 60 39 41 72 136 182 36 50 58 67 58 99 47
43 83 111 68 17 64 54 79 65 46 78 70 79 30 48 81 114
150 31 44 38 46 37 61 48 57 54 42 10 89 54 99 9 4 78
41 60 53 65 61 67 67 53 89 94 59 65 72 77 43 63 59 41
78 89 49 33 40 51 43 49 47 56 42 123 108 10 41 31 69 11
90 62 65 33 39 52 66 66 35 51 39 53 43 47 72 60 47 43
45 45 29 40 33 53 41 36 37 51 66 72 28 33 29 35 36 36

AUGMENT.DAT

WELLCOST	Cost of each irrigation well.
WELLNO	Number of wells.
PUMPCOST	Cost of four pumps
SHLTCOST	Pump and equipment shelter cost.
ATTDCOST	Cost of attending to pumps per 100 hr.
LUBREPCOST	Lubrication and repair cost per 100 hr.
DPUMPING	Depth of pumping, ft.
PEFF	Pump efficiency, in decimal.
COSTPKW(1)	Cost per KW, first 100 KW.
COSTPKW(2)	Cost per KW, all additional KW.
IRATE	Interest rate, in %.
YEARS(1)	Life of Wells.
YEARS(2)	Life of Pumps.
YEARS(3)	Life of Shelter.
COSTPEN(1)	Cost per KWh first 100 KWh per KW.
COSTPEN(2)	Cost per KWh, next 25,000 KWh.
COSTPEN(3)	Cost per KWh, all additional KWh.
TERMPERC	Term percentage.
SERVCHG	Service charge, per service connection.

VOLTDCOST(1) Voltage discount, per KW first 100 KW.
VOLTDCOST(2) Voltage discount, all additional KW.

```
5824,4,36754.68,450,8.30,15.70
110,.82,8.04,5.33,12
25,15,10
10.0345,5.3803,3.5702
0,9.89
1.17,0.62
```

Appendix 3: Description of Soils Classification

Soils Description

Airport siltv clav loam, (Ak)- This soil occurs at a slightly lower elevation than Airport silt loam, 0-3% slopes. Its surface layer is silty clay loam and the subsoil and substratum range to heavy silty clay loam.

In places, water-table is at or near the surface all the time. About 25 percent of the acreage is drained and is used for irrigated crops of alfalfa, barley, corn for silage, sugar beets and for improved pasture. The remaining 75 percent is in native pasture.

Trenton siltv clav loam, (TrA)- This soil is in the north-central part of Cache Valley on low lake terraces that are broken in places by deep gullies which serve as drainageways. The soil is moderately difficult to till and compacts if cultivated when wet. It is moderately well drained and slowly permeable. Runoff is slow and hazard to erosion slight, water-table is commonly below the depth of 40 inches. Most roots penetrate to a depth of about 2 feet and only a few penetrate to 3-4 feet depth.

About 70 percent of the acreage is used for dry-farmed crops of alfalfa, small grains, sugar beet, and pasture.

Niblev siltv clav loam, NcA- This soil is on broad, low lake terraces, generally east of College Ward and north of Hyrum. The soil is fairly difficult to till. Permeability is slow. Runoff is very slow to slow, and hazard to erosion is slight to none. Most plant roots are within a depth of 20 inches, but some penetrate to a depth of more than 5 feet.

The soil is mostly drained. It is used mainly for irrigated crops such as alfalfa, small grain, sugar beet, and corn for silage, some area is in native pasture.

Greenson loam. 0-3% slopes- This soil is on broad, smooth or slightly undulating, low lake terraces. It's texture is loam to silt loam. It is easy to till. Premeability is moderate. Runoff is slow and erosion hazard is slight to none.

Depth to water-table for this soil ranges from 30-60 inches. Much of the acreage is artificially drained. Roots extend to a depth of 5 feet where the soils are drained. In the un-drained areas, most roots are above the water-table. This soil is used for irrigating most crops of the valley including alfalfa, small grain, corn for silage, sugar beet, and pasture.

Greenson loam, over deep clay. 0-1% slopes- This soil is similar to Greenson loam, 0-3% slopes, except that the substratum is silty clay or heavy silty clay loam that is slowly permeable. The soil is on low lake terraces adjacent to Collett, Logan, and Nibley soils. An area of this soil in the vicinity of the Utah State University Drainage and Reclamation Farm is moderately saline and alkali affected.

The soil is somewhat poorly drained, and its permeability is slow. Runoff is slow, and hazards to erosion slight. Depth to the under-lying, fine-textured material ranges from 32-40 inches. Water-table is commonly above the fine textured material.

The soil is mostly used for irrigated crops of alfalfa, small grain, corn, and pasture.

Mendon silt loam, 0-3% slopes- This slightly undulating soil is on medium lake terraces. The surface layer is 10-17 inches thick. Runoff is slow, and hazard to erosion is slight, it is mainly used for dryfarmed crops of alfalfa, winter wheats, and safflower. Small areas are irrigated. Sugar beet, alfalfa, and small grains are grown in these areas.

Mendon silt loam, 3-6% slopes- This soil is on the gently undulating intermediate lake terraces, it is mainly along the west side of Cache Valley and on the east side between the towns of Richmond and Smithfield. Slightly steeper than Mendon silt loam on 0-3% slope, it is easier to till. Permeability is moderately slow. Runoff is slow to medium, and hazards to erosion is slight to moderate.

The soil is mainly for dryfarmed crops of alfalfa, winter wheats and safflower. Small areas are irrigated.

Roshe springs silt loam, 0-3% slopes- This soil is poorly drained depressions on low lake terraces and fans near the bottom of Cache valley. The soil is moderately permeable. Runoff is slow and hazard to erosion is none to slight. Depth to water-table is normally at 10-36 inches, but some areas are ponded part of the year. In some drained areas, water-table has been lowered to a depth of 60 inches, which makes it easier for roots to penetrate.

Roshe springs soils is used mainly for range, about 25 percent of its acreage is drained and used for irrigated crops of small grain, corn for silage, improved pasture, and sugar beet.

Appendix 4: A Printout of On-Demand Strategy Output

JULIAN DATE 148

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 0.00

JULIAN DATE 149

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 0.00

JULIAN DATE 150

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.20

JULIAN DATE 151

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.20

JULIAN DATE 152

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.20

JULIAN DATE 153

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.20

JULIAN DATE 154

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.20

JULIAN DATE 155

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.20

JULIAN DATE 156

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3
CARI950	52	6.1	8.04	1763	53.62	156 20	230 7

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.56

JULIAN DATE 157

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3
CARI950	52	6.1	8.04	1763	53.62	156 20	230 7

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.56

JULIAN DATE 158

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5
CARI142	48	7.0	3.55	175	5.91	150 20	158 3
CARI950	52	6.1	8.04	1763	53.62	156 20	230 7

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.56

JULIAN DATE 159

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI836	44	5.6	3.45	277	14.37	150 6	161 20
CARI525	57	6.4	3.80	223	3.17	150 22	160 5

CARI950	52	6.1	8.04	1763	53.62	156	20	230	7

AVAILABLE FLOW RATE = 6.30

COMPUTED FLOW RATE = 1.16

JULIAN DATE 160

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr		DEP TIME JD hr	
CARI836	44	5.6	3.45	277	14.37	150	6	161	20
CARI525	57	6.4	3.80	223	3.17	150	22	160	5
CARI950	52	6.1	8.04	1763	53.62	156	20	230	7

AVAILABLE FLOW RATE = 5.80

COMPUTED FLOW RATE = 1.16

JULIAN DATE 161

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr		DEP TIME JD hr	
CARI836	44	5.6	3.45	277	14.37	150	6	161	20
CARI950	52	6.1	8.04	1763	53.62	156	20	230	7

AVAILABLE FLOW RATE = 5.26

COMPUTED FLOW RATE = 0.99

JULIAN DATE 162

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr		DEP TIME JD hr	
CARI950	52	6.1	8.04	1763	53.62	156	20	230	7
CARI481	36	6.8	6.62	443	16.54	162	19	181	6

CARI640	32	8.0	7.28	118	6.07	162	20	167	18

AVAILABLE FLOW RATE = 5.26

COMPUTED FLOW RATE = 1.43

JULIAN DATE 163

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD	hr	DEP TIME JD	hr
CARI950	52	6.1	8.04	1763	53.62	156	20	230	7
CARI066	43	6.7	6.75	529	16.86	163	8	185	9
CARI481	36	6.8	6.62	443	16.54	162	19	181	6
CARI640	32	7.9	7.28	118	6.07	162	20	167	18
CARI618	18	3.6	7.34	1053	30.59	163	19	207	15

AVAILABLE FLOW RATE = 5.38

COMPUTED FLOW RATE = 2.16

JULIAN DATE 164

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD	hr	DEP TIME JD	hr
CARI430	59	7.8	7.23	508	24.10	164	8	185	12
CARI593	63	8.0	6.66	535	22.20	164	6	186	12
CARI950	52	6.1	8.04	1763	53.62	156	20	230	7
CARI011	50	7.2	7.09	258	8.87	164	7	175	2
CARI066	43	6.6	6.75	529	16.86	163	8	185	9
CARI122	53	7.4	6.59	233	8.24	164	20	174	14
CARI299	46	9.5	7.78	426	19.44	164	21	182	15
CARI869	46	5.8	6.92	432	20.19	164	19	182	19
CARI481	36	6.7	6.62	443	16.54	162	19	181	6
CARI640	32	7.9	7.28	118	6.07	162	20	167	18
CARI618	18	3.6	7.34	1053	30.59	163	19	207	15
CARI181	36	5.1	7.16	246	4.18	164	18	175	0
CARI714	36	5.1	7.15	212	2.98	164	19	173	15

AVAILABLE FLOW RATE = 5.49

COMPUTED FLOW RATE = 5.54

JULIAN DATE 165

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI430	59	7.8	7.23	508	24.10	164 8	185 12
CARI593	63	8.0	6.66	535	22.20	164 6	186 12
CARI950	52	6.1	8.04	1763	53.62	156 20	230 7
CARI011	50	7.2	7.09	258	8.87	164 7	175 2
CARI066	43	6.6	6.75	529	16.86	163 8	185 9
CARI122	53	7.4	6.59	233	8.24	164 20	174 14
CARI474	47	6.9	7.31	549	18.27	165 18	188 15
CARI299	46	9.5	7.78	426	19.44	164 21	182 15
CARI869	46	5.8	6.92	432	20.19	164 19	182 19
CARI481	36	6.7	6.62	443	16.54	162 19	181 6
CARI640	32	7.9	7.28	118	6.07	162 20	167 18
CARI059	37	8.5	7.19	318	14.98	165 20	179 2
CARI618	18	3.6	7.34	1053	30.59	163 19	207 15
CARI181	36	5.1	7.16	246	4.18	164 18	175 0
CARI714	36	5.1	7.15	212	2.98	164 19	173 15

AVAILABLE FLOW RATE = 5.60

COMPUTED FLOW RATE = 6.51

JULIAN DATE 166

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI430	59	7.8	7.23	508	24.10	164 8	185 12
CARI593	62	8.0	6.66	535	22.20	164 6	186 12
CARI836	43	5.6	3.75	306	15.64	166 7	179 0
CARI525	57	6.4	3.66	216	3.05	166 7	175 7
CARI750	52	10.1	3.78	226	6.29	166 6	175 16
CARI142	47	7.0	3.85	191	6.41	166 8	174 7
CARI950	51	6.1	8.04	1763	53.62	156 20	230 7
CARI011	49	7.1	7.09	258	8.87	164 7	175 2
CARI066	42	6.6	6.75	529	16.86	163 8	185 9

CARI122	52	7.4	6.59	233	8.24	164	20	174	14
CARI474	46	6.9	7.31	549	18.27	165	18	188	15
CARI299	46	9.5	7.78	426	19.44	164	21	182	15
CARI869	46	5.8	6.92	432	20.19	164	19	182	19
CARI481	36	6.7	6.62	443	16.54	162	19	181	6
CARI640	32	7.9	7.28	118	6.07	162	20	167	18
CARI059	37	8.5	7.19	318	14.98	165	20	179	2
CARI618	18	3.6	7.34	1053	30.59	163	19	207	15
CARI181	36	5.1	7.16	246	4.18	164	18	175	0
CARI714	36	5.1	7.15	212	2.98	164	19	173	15

AVAILABLE FLOW RATE = 5.66

COMPUTED FLOW RATE = 8.03

JULIAN DATE 167

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD	ARRV TIME hr	DEP TIME JD	DEP TIME hr
CARI430	59	7.8	7.23	508	24.10	164	8	185	12
CARI593	62	8.0	6.66	535	22.20	164	6	186	12
CARI836	43	5.6	3.75	306	15.64	166	7	179	0
CARI525	57	6.4	3.66	216	3.05	166	7	175	7
CARI750	52	10.1	3.78	226	6.29	166	6	175	16
CARI142	47	7.0	3.85	191	6.41	166	8	174	7
CARI950	51	6.1	8.04	1763	53.62	156	20	230	7
CARI011	49	7.1	7.09	258	8.87	164	7	175	2
CARI066	42	6.6	6.75	529	16.86	163	8	185	9
CARI122	52	7.4	6.59	233	8.24	164	20	174	14
CARI474	46	6.9	7.31	549	18.27	165	18	188	15
CARI299	46	9.5	7.78	426	19.44	164	21	182	15
CARI869	46	5.8	6.92	432	20.19	164	19	182	19
CARI481	36	6.7	6.62	443	16.54	162	19	181	6
CARI640	32	7.9	7.28	118	6.07	162	20	167	18
CARI059	37	8.5	7.19	318	14.98	165	20	179	2
CARI618	18	3.6	7.34	1053	30.59	163	19	207	15
CARI181	36	5.1	7.16	246	4.18	164	18	175	0
CARI714	36	5.1	7.15	212	2.98	164	19	173	15

AVAILABLE FLOW RATE = 5.64

COMPUTED FLOW RATE = 8.03

JULIAN DATE 168

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI430	59	7.8	7.23	508	24.10	164 8	185 12
CARI593	62	8.0	6.66	535	22.20	164 6	186 12
CARI836	43	5.6	3.75	306	15.64	166 7	179 0
CARI525	57	6.4	3.66	216	3.05	166 7	175 7
CARI750	52	10.1	3.78	226	6.29	166 6	175 16
CARI142	48	7.0	3.85	191	6.41	166 8	174 7
CARI950	51	6.1	8.04	1763	53.62	156 20	230 7
CARI011	49	7.1	7.09	258	8.87	164 7	175 2
CARI066	43	6.6	6.75	529	16.86	163 8	185 9
CARI122	53	7.4	6.59	233	8.24	164 20	174 14
CARI474	47	6.9	7.31	549	18.27	165 18	188 15
CARI299	46	9.5	7.78	426	19.44	164 21	182 15
CARI869	46	5.8	6.92	432	20.19	164 19	182 19
CARI481	36	6.7	6.62	443	16.54	162 19	181 6
CARI059	37	8.5	7.19	318	14.98	165 20	179 2
CARI618	18	3.6	7.34	1053	30.59	163 19	207 15
CARI181	36	5.1	7.16	246	4.18	164 18	175 0
CARI714	36	5.1	7.15	212	2.98	164 19	173 15

AVAILABLE FLOW RATE = 5.60

COMPUTED FLOW RATE = 7.41

JULIAN DATE 169

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD hr	DEP TIME JD hr
CARI430	59	7.8	7.23	508	24.10	164 8	185 12
CARI593	62	8.0	6.66	535	22.20	164 6	186 12
CARI688	59	10.8	3.60	217	12.02	169 7	178 8
CARI836	43	5.6	3.75	306	15.64	166 7	179 0
CARI525	57	6.4	3.66	216	3.05	166 7	175 7
CARI750	52	10.1	3.78	226	6.29	166 6	175 16
CARI142	47	7.0	3.85	191	6.41	166 8	174 7
CARI950	51	6.1	8.04	1763	53.62	156 20	230 7
CARI011	49	7.1	7.09	258	8.87	164 7	175 2

CARI066	42	6.6	6.75	529	16.86	163	8	185	9
CARI122	53	7.4	6.59	233	8.24	164	20	174	14
CARI474	46	6.9	7.31	549	18.27	165	18	188	15
CARI299	46	9.5	7.78	426	19.44	164	21	182	15
CARI869	46	5.8	6.92	432	20.19	164	19	182	19
CARI481	36	6.7	6.62	443	16.54	162	19	181	6
CARI059	37	8.5	7.19	318	14.98	165	20	179	2
CARI618	18	3.6	7.34	1053	30.59	163	19	207	15
CARI181	36	5.1	7.16	246	4.18	164	18	175	0
CARI714	36	5.1	7.15	212	2.98	164	19	173	15

AVAILABLE FLOW RATE = 5.56

COMPUTED FLOW RATE = 8.08

JULIAN DATE 170

USERS IRRIGATING

USER/ FIELD CODE	SPRINKLER PRESSURE psi	NOZZLE DISCH. gpm/S	IRR DEPTH in.	TOTAL SERVICE TIME,hr	FIELD DEMAND ac-ft	ARRV TIME JD	ARRV TIME hr	DEP TIME JD	DEP TIME hr
CARI430	59	7.8	7.23	508	24.10	164	8	185	12
CARI593	62	8.0	6.66	535	22.20	164	6	186	12
CARI688	59	10.8	3.60	217	12.02	169	7	178	8
CARI836	43	5.6	3.75	306	15.64	166	7	179	0
CARI525	57	6.4	3.66	216	3.05	166	7	175	7
CARI750	52	10.1	3.78	226	6.29	166	6	175	16
CARI142	47	7.0	3.85	191	6.41	166	8	174	7
CARI950	51	6.1	8.04	1763	53.62	156	20	230	7
CARI011	49	7.1	7.09	258	8.87	164	7	175	2
CARI066	42	6.6	6.75	529	16.86	163	8	185	9
CARI122	53	7.4	6.59	233	8.24	164	20	174	14
CARI474	46	6.9	7.31	549	18.27	165	18	188	15
CARI299	46	9.5	7.78	426	19.44	164	21	182	15
CARI869	46	5.8	6.92	432	20.19	164	19	182	19
CARI481	36	6.7	6.62	443	16.54	162	19	181	6
CARI059	37	8.5	7.19	318	14.98	165	20	179	2
CARI618	18	3.6	7.34	1053	30.59	163	19	207	15
CARI181	36	5.1	7.16	246	4.18	164	18	175	0
CARI714	36	5.1	7.15	212	2.98	164	19	173	15

AVAILABLE FLOW RATE = 5.56

COMPUTED FLOW RATE = 8.08

Appendix 5: Codings for Rotation Irrigation Strategies

Table 36.--Allocation Codings for the Modified Rotation Irrigation Strategies.

User/ Field Code	Field size (acres)	Codes for the Rotation Block	
		Users in Rotation Block	Among crop Category
CARI430	40	1	1
CARI593	40	1	1
CARI688	40	1	2
CARI836	50	1	3
CARI525	10	1	3
CARI750	20	2	2
CARI142	20	2	3
CARI950	80	2	1
CARI011	15	2	1
CARI066	30	2	1
CARI122	15	2	1
CARI474	30	2	1
CARI299	30	2	1
CARI869	35	1	1
CARI958	25	1	2
CARI481	30	3	1
CARI986	10	3	2
CARI399	10	3	2
CARI640	10	3	1
CARI059	25	3	1
CARI618	50	3	1
CARI181	7	3	1
CARI714	5	3	1

Area of each block:

Block #1	240 acres	Block #1	442 acres
Block #2	240 acres	Block #2	105 acres
Block #3	147 acres	block #3	80 acres

Table 36.--Allocation Codings for the Modified Rotation Irrigation Strategies (Continued).

Codes for the Rotation Block		
Ranking of Stocks	System Types	Low labor cost scheme
3	1	1
3	1	1
3	2	2
3	2	2
1	2	2
2	2	2
2	1	2
1	2	1
2	1	1
3	1	1
2	1	1
3	1	1
3	1	1
2	2	1
2	2	2
2	1	1
2	2	2
1	2	2
1	2	1
1	2	2
3	1	1
1	2	1
1	2	1

Block #1 147 acres	Block #1 300 acres	Block #1 442 acres
Block #2 170 acres	Block #2 327 acres	Block #2 185 acres
Block #3 310 acres		

Appendix 6: Summaries of Results for Other Strategies

Summary of Water Use by Field/User During a DryYear Using On-Demand Strategy with No Cost Augmentation.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	5	25.5	0.0	5.4	-1.2	29.7
CARI593	ALFALFA	40	5	26.3	0.0	5.4	-2.0	29.6
CARI688	S/GRAIN	40	6	18.6	0.7	4.0	1.0	23.0
CARI836	PASTURE	50	8	21.6	0.1	5.4	2.0	28.8
CARI525	PASTURE	10	8	21.9	0.0	5.4	1.0	28.3
CARI750	S/GRAIN	20	6	18.5	0.3	4.0	0.9	23.0
CARI142	PASTURE	20	8	21.7	0.3	5.4	2.1	28.9
CARI950	ALFALFA	80	2	14.0	0.0	5.4	5.2	24.6
CARI011	ALFALFA	15	5	25.9	0.0	4.8	-1.1	29.6
CARI066	ALFALFA	30	5	25.4	0.0	4.8	-0.6	29.6
CARI122	ALFALFA	15	5	25.5	0.0	5.4	-1.4	29.6
CARI474	ALFALFA	30	5	25.9	0.0	5.4	-1.7	29.6
CARI299	ALFALFA	30	5	25.7	0.0	5.4	-1.5	29.6
CARI869	ALFALFA	35	5	25.9	0.0	4.8	-1.1	29.6
CARI958	CORN/SL	25	4	16.5	0.0	2.6	1.4	20.4
CARI481	ALFALFA	30	5	24.4	0.0	4.8	0.4	29.6
CARI986	S/GRAIN	10	6	18.8	0.7	4.0	0.8	22.9
CARI399	CORN/SL	10	4	15.4	0.0	2.6	2.7	20.7
CARI640	ALFALFA	10	5	25.6	0.3	5.4	-1.0	29.8
CARI059	ALFALFA	25	5	25.3	0.0	5.2	-1.0	29.5
CARI618	ALFALFA	50	3	21.8	0.0	5.6	2.4	29.8
CARI181	ALFALFA	7	5	25.2	0.0	5.4	-0.9	29.7
CARI714	ALFALFA	5	5	25.3	0.0	5.4	-1.1	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre Using On-Demand at No Cost Augmentation, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	5960	12240	306
CARI593	ALFALFA	28.9	28.9	7.6	18200	5880	12320	308
CARI688	S/GRAIN	0.1	0.1	3.8	11240	6160	5080	127
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	8.9					
CARI836	PASTURE	27.4	27.4	2.7	2100	3550	-1450	-29
CARI525	PASTURE	26.9	26.9	2.7	420	770	-350	-35
CARI750	S/GRAIN	0.1	0.1	3.8	5620	3020	2600	130
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	8.6					
CARI142	PASTURE	27.5	27.5	2.7	840	1840	-1000	-50
CARI950	ALFALFA	29.0	21.4	5.6	26960	9360	17600	220
CARI011	ALFALFA	29.0	29.0	7.6	6825	2625	4200	280
CARI066	ALFALFA	29.0	29.0	7.6	13650	4560	9090	303
CARI122	ALFALFA	28.9	28.9	7.6	6825	2625	4200	280
CARI474	ALFALFA	28.9	28.9	7.6	13650	4560	9090	303
CARI299	ALFALFA	28.9	28.9	7.6	13650	4560	9090	303
CARI869	ALFALFA	29.0	29.0	7.6	15925	4970	10955	313
CARI958	CORN/SL	0.0	0.0	24.2	13300	4875	8425	337
		3.6	3.6					
		4.3	4.3					
		5.6	5.6					
CARI481	ALFALFA	29.0	29.0	7.6	13650	4800	8850	295
CARI986	S/GRAIN	0.1	0.1	3.8	2810	1950	860	86
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	9.5					
CARI399	CORN/SL	0.0	0.0	23.9	5250	2220	3030	303
		3.9	3.9					
		4.3	4.3					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1720	2830	283
CARI059	ALFALFA	28.9	28.9	7.6	11375	3600	7775	311
CARI618	ALFALFA	28.7	27.0	7.1	21350	6800	14550	291
CARI181	ALFALFA	28.9	28.9	7.6	3185	1141	2044	292
CARI714	ALFALFA	28.9	28.9	7.6	2275	840	1435	287

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages Using On-Demand at No Cost Augmentation, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	110.5	7.3
CARI593	51.0	9.1	115.1	7.6
CARI688	40.0	7.1	81.1	5.4
CARI836	39.0	7.0	115.4	7.6
CARI525	12.5	2.2	24.1	1.6
CARI750	15.0	2.7	40.6	2.7
CARI142	26.0	4.6	47.2	3.1
CARI950	12.0	2.1	122.8	8.1
CARI011	19.0	3.4	43.3	2.9
CARI066	38.0	6.8	85.4	5.7
CARI122	19.0	3.4	43.4	2.9
CARI474	38.0	6.8	86.6	5.7
CARI299	38.0	6.8	83.6	5.5
CARI869	23.0	4.1	96.6	6.4
CARI958	20.0	3.6	44.7	3.0
CARI481	27.0	4.8	80.0	5.3
CARI986	19.0	3.4	20.8	1.4
CARI399	8.0	1.4	16.8	1.1
CARI640	8.0	1.4	28.4	1.9
CARI059	14.0	2.5	66.9	4.4
CARI618	41.0	7.3	121.2	8.0
CARI181	7.0	1.2	19.8	1.3
CARI714	6.3	1.1	13.9	0.9

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 845.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 143,464.00

AVERAGE WAITING TIME (DAYS) = 11

TOTAL WATER ALLOCATED (ACRE-FT) = 1508.2

RESOURCE UTILIZATION RATIO = 1.84

Summary of Water Use by Field/User During a Normal Year,
Using On-Demand Strategy with No Cost Augmentation.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	3	16.4	0.0	11.1	2.2	29.7
CARI593	ALFALFA	40	3	16.3	0.2	11.1	2.4	29.6
CARI688	S/GRAIN	40	6	18.3	3.3	7.4	0.6	23.0
CARI836	PASTURE	50	7	19.5	2.2	11.4	0.1	28.8
CARI525	PASTURE	10	6	16.4	1.8	11.1	2.6	28.3
CARI750	S/GRAIN	20	6	18.6	3.6	7.9	0.1	23.0
CARI142	PASTURE	20	7	19.2	2.3	11.4	0.6	28.9
CARI950	ALFALFA	80	2	17.2	0.0	11.1	0.8	29.1
CARI011	ALFALFA	15	3	16.1	0.1	11.1	2.5	29.6
CARI066	ALFALFA	30	3	16.4	0.4	11.1	2.6	29.6
CARI122	ALFALFA	15	3	16.0	0.6	11.4	2.7	29.6
CARI474	ALFALFA	30	3	16.5	0.7	11.4	2.4	29.6
CARI299	ALFALFA	30	3	16.1	0.3	11.4	2.4	29.6
CARI869	ALFALFA	35	3	16.1	0.1	11.1	2.5	29.6
CARI958	CORN/SL	25	3	12.5	0.2	6.8	1.3	20.4
CARI481	ALFALFA	30	4	20.1	0.7	11.1	-0.9	29.6
CARI986	S/GRAIN	10	6	18.4	3.0	6.9	0.6	22.9
CARI399	CORN/SL	10	4	15.6	2.0	6.8	0.2	20.7
CARI640	ALFALFA	10	3	16.0	0.0	11.1	2.7	29.8
CARI059	ALFALFA	25	3	16.2	0.9	11.5	2.8	29.5
CARI618	ALFALFA	50	2	13.8	0.4	11.7	4.7	29.8
CARI181	ALFALFA	7	3	15.9	0.1	11.1	2.7	29.7
CARI714	ALFALFA	5	3	15.8	0.5	11.4	2.8	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre Using On-Demand at No Cost Augmentation, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	CUMULATIVE TRANSPIRATION ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	5720	12480	312
CARI593	ALFALFA	28.9	28.9	7.6	18200	5640	12560	314
CARI688	S/GRAIN	0.2	0.2	3.8	11240	6160	5080	127
		0.9	0.9					
		3.3	3.3					
		2.5	2.5					
		9.2	9.2					
CARI836	PASTURE	27.4	27.4	2.7	2100	3400	-1300	-26
CARI525	PASTURE	26.9	26.9	2.7	420	710	-290	-29
CARI750	S/GRAIN	0.4	0.4	3.8	5620	3020	2600	130
		1.1	1.1					
		3.8	3.8					
		2.5	2.5					
		8.7	8.7					
CARI142	PASTURE	27.5	27.5	2.7	840	1780	-940	-47
CARI950	ALFALFA	29.0	26.6	6.9	33440	9360	24080	301
CARI011	ALFALFA	28.9	28.9	7.6	6825	2535	4290	286
CARI066	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI122	ALFALFA	28.9	28.9	7.6	6825	2535	4290	286
CARI474	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI299	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI869	ALFALFA	28.9	28.9	7.6	15925	4760	11165	319
CARI958	CORN/SL	0.0	0.0	24.7	13600	4800	8800	352
		3.2	3.2					
		4.6	4.6					
		5.6	5.6					
CARI481	ALFALFA	28.9	28.9	7.6	13650	4710	8940	298
CARI986	S/GRAIN	0.2	0.2	3.8	2810	1950	860	86
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	9.6					
CARI399	CORN/SL	0.0	0.0	24.7	5440	2220	3220	322
		3.4	3.4					
		4.8	4.8					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1660	2890	289
CARI059	ALFALFA	28.9	28.9	7.6	11375	3450	7925	317
CARI618	ALFALFA	28.7	28.5	7.5	22600	6650	15950	319
CARI181	ALFALFA	28.9	28.9	7.6	3185	1099	2086	298
CARI714	ALFALFA	28.9	28.9	7.6	2275	810	1465	293

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages Using On-Demand at No Cost Augmentation, Normal Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	73.1	6.4
CARI593	51.0	9.1	70.2	6.1
CARI688	40.0	7.1	81.1	7.1
CARI836	39.0	7.0	105.1	9.2
CARI525	12.5	2.2	18.1	1.6
CARI750	15.0	2.7	41.3	3.6
CARI142	26.0	4.6	42.2	3.7
CARI950	12.0	2.1	142.2	12.4
CARI011	19.0	3.4	26.4	2.3
CARI066	38.0	6.8	53.5	4.7
CARI122	19.0	3.4	26.4	2.3
CARI474	38.0	6.8	52.3	4.6
CARI299	38.0	6.8	55.3	4.8
CARI869	23.0	4.1	61.7	5.4
CARI958	20.0	3.6	34.4	3.0
CARI481	27.0	4.8	64.8	5.7
CARI986	19.0	3.4	20.3	1.8
CARI399	8.0	1.4	17.3	1.5
CARI640	8.0	1.4	18.1	1.6
CARI059	14.0	2.5	45.3	4.0
CARI618	41.0	7.3	72.7	6.4
CARI181	7.0	1.2	12.0	1.1
CARI714	6.3	1.1	8.5	0.7

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 551.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 153,961.00

AVERAGE WAITING TIME (DAYS) = 7

TOTAL WATER ALLOCATED (ACRE-FT) = 1142.2

RESOURCE UTILIZATION RATIO = 1.00

Summary of Water Use by Field/User During a Wet Year Using On-Demand Strategy with No Cost Augmentation.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	3	16.0	0.0	17.5	-3.7	29.7
CARI593	ALFALFA	40	3	16.1	1.5	17.0	-2.0	29.6
CARI688	S/GRAIN	40	4	12.3	5.0	14.3	1.4	23.0
CARI836	PASTURE	50	5	13.6	4.2	17.3	2.2	28.8
CARI525	PASTURE	10	5	13.6	4.6	17.8	1.6	28.3
CARI750	S/GRAIN	20	4	12.5	4.4	14.0	1.0	23.0
CARI142	PASTURE	20	5	13.6	4.1	17.1	2.3	28.9
CARI950	ALFALFA	80	2	15.5	0.1	17.8	-3.4	29.8
CARI011	ALFALFA	15	2	10.6	0.5	19.3	0.1	29.5
CARI066	ALFALFA	30	3	15.5	3.8	19.3	-1.5	29.5
CARI122	ALFALFA	15	3	16.1	1.5	16.9	-1.9	29.6
CARI474	ALFALFA	30	3	16.2	1.5	16.7	-1.8	29.6
CARI299	ALFALFA	30	3	16.0	1.5	17.3	-2.2	29.6
CARI869	ALFALFA	35	2	10.6	0.5	19.3	0.1	29.5
CARI958	CORN/SL	25	2	8.6	2.9	14.5	0.2	20.4
CARI481	ALFALFA	30	3	15.3	4.0	19.3	-1.2	29.5
CARI986	S/GRAIN	10	4	12.2	5.2	14.2	1.8	22.9
CARI399	CORN/SL	10	2	7.8	2.2	14.9	0.1	20.7
CARI640	ALFALFA	10	3	16.0	0.0	17.8	-4.0	29.8
CARI059	ALFALFA	25	3	16.0	0.0	16.7	-3.1	29.5
CARI618	ALFALFA	50	2	11.8	0.0	17.4	0.6	29.8
CARI181	ALFALFA	7	3	15.9	1.6	17.5	-2.2	29.7
CARI714	ALFALFA	5	3	16.0	1.5	17.1	-2.0	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre Using On-Demand at No Cost Augmentation, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	5720	12480	312
CARI593	ALFALFA	28.9	28.9	7.6	18200	5640	12560	314
CARI688	S/GRAIN	0.5	0.5	3.8	11240	5920	5320	133
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.7					
CARI836	PASTURE	27.4	27.4	2.7	2100	3100	-1000	-20
CARI525	PASTURE	26.9	26.9	2.7	420	680	-260	-26
CARI750	S/GRAIN	0.7	0.7	2.9	4340	2900	1440	72
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.0	6.0					
CARI142	PASTURE	27.5	27.5	2.7	840	1660	-820	-41
CARI950	ALFALFA	29.0	27.9	7.3	35120	9360	25760	322
CARI011	ALFALFA	30.9	30.9	7.6	6825	2490	4335	289
CARI066	ALFALFA	30.9	30.9	7.6	13650	4380	9270	309
CARI122	ALFALFA	28.9	28.9	7.6	6825	2535	4290	286
CARI474	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI299	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI869	ALFALFA	30.9	30.9	7.6	15925	4655	11270	322
CARI958	CORN/SL	0.0	0.0	23.0	12625	4725	7900	316
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	30.9	7.6	13650	4620	9030	301
CARI986	S/GRAIN	0.2	0.2	3.8	2810	1890	920	92
		1.5	1.5					
		4.4	4.4					
		2.7	2.7					
		7.4	7.4					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2160	2830	283
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1660	2890	289
CARI059	ALFALFA	28.9	28.9	7.6	11375	3450	7925	317
CARI618	ALFALFA	28.7	28.7	7.6	22750	6650	16100	322
CARI181	ALFALFA	28.9	28.9	7.6	3185	1099	2086	298
CARI714	ALFALFA	28.9	28.9	7.6	2275	810	1465	293

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation received and in Percentages Using On-Demand at No Cost Augmentation, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	70.6	7.4
CARI593	51.0	9.1	68.6	7.2
CARI688	40.0	7.1	53.7	5.6
CARI836	39.0	7.0	72.5	7.6
CARI525	12.5	2.2	15.1	1.6
CARI750	15.0	2.7	26.5	2.8
CARI142	26.0	4.6	29.7	3.1
CARI950	12.0	2.1	132.0	13.9
CARI011	19.0	3.4	17.2	1.8
CARI066	38.0	6.8	51.8	5.4
CARI122	19.0	3.4	26.8	2.8
CARI474	38.0	6.8	52.8	5.5
CARI299	38.0	6.8	51.4	5.4
CARI869	23.0	4.1	40.8	4.3
CARI958	20.0	3.6	23.6	2.5
CARI481	27.0	4.8	50.5	5.3
CARI986	19.0	3.4	13.2	1.4
CARI399	8.0	1.4	8.4	0.9
CARI640	8.0	1.4	17.8	1.9
CARI059	14.0	2.5	43.2	4.5
CARI618	41.0	7.3	64.9	6.8
CARI181	7.0	1.2	12.2	1.3
CARI714	6.3	1.1	8.7	0.9

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 237.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 154,331.00

AVERAGE WAITING TIME (DAYS) = 5

TOTAL WATER ALLOCATED (ACRE-FT) = 952.0

RESOURCE UTILIZATION RATIO = 0.79

Summary of Water Use by Field/User During a Dry Year Using On-Demand Strategy with Augmentation Costed.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	5	25.5	0.0	5.4	-1.2	29.7
CARI593	ALFALFA	40	5	26.3	0.0	5.4	-2.0	29.6
CARI688	S/GRAIN	40	6	18.6	0.7	4.0	1.0	23.0
CARI836	PASTURE	50	8	21.6	0.1	5.4	2.0	28.8
CARI525	PASTURE	10	8	21.9	0.0	5.4	1.0	28.3
CARI750	S/GRAIN	20	6	18.5	0.3	4.0	0.9	23.0
CARI142	PASTURE	20	8	21.7	0.3	5.4	2.1	28.9
CARI950	ALFALFA	80	2	14.1	0.0	5.4	5.2	24.6
CARI011	ALFALFA	15	5	25.9	0.0	4.8	-1.1	29.6
CARI066	ALFALFA	30	5	25.2	0.0	4.8	-0.3	29.6
CARI122	ALFALFA	15	5	25.5	0.0	5.4	-1.4	29.6
CARI474	ALFALFA	30	5	26.1	0.2	5.4	-1.7	29.6
CARI299	ALFALFA	30	5	25.7	0.0	5.4	-1.5	29.6
CARI869	ALFALFA	35	5	25.9	0.0	4.8	-1.1	29.6
CARI958	CORN/SL	25	4	16.5	0.0	2.6	1.4	20.4
CARI481	ALFALFA	30	5	24.4	0.0	4.8	0.4	29.6
CARI986	S/GRAIN	10	6	18.8	0.7	4.0	0.8	22.9
CARI399	CORN/SL	10	4	15.4	0.0	2.6	2.7	20.7
CARI640	ALFALFA	10	5	25.6	0.3	5.4	-1.0	29.8
CARI059	ALFALFA	25	5	25.3	0.0	5.2	-1.0	29.5
CARI618	ALFALFA	50	3	21.8	0.1	5.6	2.5	29.8
CARI181	ALFALFA	7	5	25.2	0.0	5.4	-0.9	29.7
CARI714	ALFALFA	5	5	25.3	0.0	5.4	-1.1	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre Using On-Demand with Augmentation Costed, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	5960	12240	306
CARI593	ALFALFA	28.9	28.9	7.6	18200	5880	12320	308
CARI688	S/GRAIN	0.1	0.1	3.8	11240	6160	5080	127
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	8.9					
CARI836	PASTURE	27.4	27.4	2.7	2100	3550	-1450	-29
CARI525	PASTURE	26.9	26.9	2.7	420	770	-350	-35
CARI750	S/GRAIN	0.1	0.1	3.8	5620	3020	2600	130
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	8.6					
CARI142	PASTURE	27.5	27.5	2.7	840	1840	-1000	-50
CARI950	ALFALFA	29.0	21.4	5.6	27040	9360	17680	221
CARI011	ALFALFA	29.0	29.0	7.6	6825	2625	4200	280
CARI066	ALFALFA	29.0	29.0	7.6	13650	4560	9090	303
CARI122	ALFALFA	28.9	28.9	7.6	6825	2625	4200	280
CARI474	ALFALFA	28.9	28.9	7.6	13650	4560	9090	303
CARI299	ALFALFA	28.9	28.9	7.6	13650	4560	9090	303
CARI869	ALFALFA	29.0	29.0	7.6	15925	4970	10955	313
CARI958	CORN/SL	0.0	0.0	24.2	13300	4875	8425	337
		3.6	3.6					
		4.3	4.3					
		5.6	5.6					
CARI481	ALFALFA	29.0	29.0	7.6	13650	4800	8850	295
CARI986	S/GRAIN	0.1	0.1	3.8	2810	1950	860	86
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	9.5					
CARI399	CORN/SL	0.0	0.0	23.9	5250	2220	3030	303
		3.9	3.9					
		4.3	4.3					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1720	2830	283
CARI059	ALFALFA	28.9	28.9	7.6	11375	3600	7775	311
CARI618	ALFALFA	28.7	27.2	7.2	21550	6800	14750	295
CARI181	ALFALFA	28.9	28.9	7.6	3185	1141	2044	292
CARI714	ALFALFA	28.9	28.9	7.6	2275	840	1435	287

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, On-Demand, Augmentation Costed, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	108.8	7.2
CARI593	51.0	9.1	113.5	7.5
CARI688	40.0	7.1	81.1	5.4
CARI836	39.0	7.0	116.7	7.7
CARI525	12.5	2.2	24.7	1.6
CARI750	15.0	2.7	40.0	2.7
CARI142	26.0	4.6	47.7	3.2
CARI950	12.0	2.1	124.0	8.2
CARI011	19.0	3.4	42.4	2.8
CARI066	38.0	6.8	80.3	5.3
CARI122	19.0	3.4	41.7	2.8
CARI474	38.0	6.8	87.5	5.8
CARI299	38.0	6.8	84.2	5.6
CARI869	23.0	4.1	99.0	6.6
CARI958	20.0	3.6	46.1	3.1
CARI481	27.0	4.8	77.8	5.2
CARI986	19.0	3.4	21.0	1.4
CARI399	8.0	1.4	17.4	1.2
CARI640	8.0	1.4	28.0	1.9
CARI059	14.0	2.5	70.6	4.7
CARI618	41.0	7.3	120.8	8.0
CARI181	7.0	1.2	19.6	1.3
CARI714	6.3	1.1	14.3	0.9

MONTH	AUG. VOLUME (acre-ft)	AUG. HR (hour)	ENERGY (kwh)	COSTS $	DISCOUNTS $	NET BILL $
APRIL	2.27	72	567	1182.80	27.62	1155.19
MAY	29.87	456	7447	6257.20	247.39	6009.81
JUNE	56.88	552	14180	10952.33	421.31	10531.02
JULY	335.94	744	83748	58216.69	2218.49	55998.20
AUGUST	340.79	744	84956	59033.45	2249.71	56783.75
SEPTEMBER	79.46	408	19808	14823.77	566.70	14257.07

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 845.2
TOTAL AUGMENTATION COST = $ 144,735.00

TOTAL BENEFIT TO PROJECT = $ -5,214.00
AVERAGE WAITING TIME (DAYS) = 11

TOTAL WATER ALLOCATED (ACRE-FT) = 1507.3
RESOURCE UTILIZATION RATIO = 1.84

Summary of Water Use by Field/User During a Wet Year Using On-Demand Strategy with Augmentation Costed.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	3	16.0	0.0	17.5	-3.7	29.7
CARI593	ALFALFA	40	3	16.1	1.5	17.0	-2.0	29.6
CARI688	S/GRAIN	40	4	12.3	5.0	14.3	1.4	23.0
CARI836	PASTURE	50	5	13.6	4.2	17.3	2.2	28.8
CARI525	PASTURE	10	5	13.6	4.6	17.8	1.6	28.3
CARI750	S/GRAIN	20	4	12.5	4.4	14.0	1.0	23.0
CARI142	PASTURE	20	5	13.6	4.1	17.1	2.3	28.9
CARI950	ALFALFA	80	2	16.1	0.8	17.8	-3.4	29.8
CARI011	ALFALFA	15	2	10.6	0.5	19.3	0.1	29.5
CARI066	ALFALFA	30	3	15.5	3.8	19.3	-1.5	29.5
CARI122	ALFALFA	15	3	16.1	1.5	16.9	-1.9	29.6
CARI474	ALFALFA	30	3	16.2	1.5	16.7	-1.8	29.6
CARI299	ALFALFA	30	3	16.0	1.5	17.3	-2.2	29.6
CARI869	ALFALFA	35	2	10.6	0.5	19.3	0.1	29.5
CARI958	CORN/SL	25	2	8.6	2.9	14.5	0.2	20.4
CARI481	ALFALFA	30	3	15.3	4.0	19.3	-1.2	29.5
CARI986	S/GRAIN	10	4	12.2	5.2	14.2	1.8	22.9
CARI399	CORN/SL	10	2	7.8	2.2	14.9	0.1	20.7
CARI640	ALFALFA	10	3	16.0	0.0	17.8	-4.0	29.8
CARI059	ALFALFA	25	3	16.0	0.0	16.7	-3.1	29.5
CARI618	ALFALFA	50	2	12.4	0.0	17.4	0.0	29.8
CARI181	ALFALFA	7	3	15.9	1.6	17.5	-2.2	29.7
CARI714	ALFALFA	5	3	16.0	1.5	17.1	-2.0	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre Using On-Demand with Augmentation Costed, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	5720	12480	312
CARI593	ALFALFA	28.9	28.9	7.6	18200	5640	12560	314
CARI688	S/GRAIN	0.5	0.5	3.8	11240	5920	5320	133
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.7					
CARI836	PASTURE	27.4	27.4	2.7	2100	3100	-1000	-20
CARI525	PASTURE	26.9	26.9	2.7	420	680	-260	-26
CARI750	S/GRAIN	0.7	0.7	2.9	4340	2900	1440	72
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.9	6.0					
CARI142	PASTURE	27.5	27.5	2.7	840	1660	-820	-41
CARI950	ALFALFA	29.0	28.0	7.3	35200	9360	25840	323
CARI011	ALFALFA	30.9	30.9	7.6	6825	2490	4335	289
CARI066	ALFALFA	30.9	30.9	7.6	13650	4380	9270	309
CARI122	ALFALFA	28.9	28.9	7.6	6825	2535	4290	286
CARI474	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI299	ALFALFA	28.9	28.9	7.6	13650	4380	9270	309
CARI869	ALFALFA	30.9	30.9	7.6	15925	4655	11270	322
CARI958	CORN/SL	0.0	0.0	23.0	12625	4725	7900	316
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	30.9	7.6	13650	4620	9030	301
CARI986	S/GRAIN	0.2	0.2	3.8	2810	1890	920	92
		1.5	1.5					
		4.4	4.4					
		2.7	2.7					
		7.4	7.4					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2160	2830	283
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1660	2890	289
CARI059	ALFALFA	28.9	28.9	7.6	11375	3450	7925	317
CARI618	ALFALFA	28.7	28.7	7.6	22750	6650	16100	322
CARI181	ALFALFA	28.9	28.9	7.6	3185	1099	2086	298
CARI714	ALFALFA	28.9	28.9	7.6	2275	810	1465	293

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, On-Demand, Augmentation Costed, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	67.2	6.9
CARI593	51.0	9.1	68.3	7.1
CARI688	40.0	7.1	53.8	5.6
CARI836	39.0	7.0	73.8	7.6
CARI525	12.5	2.2	14.8	1.5
CARI750	15.0	2.7	26.7	2.8
CARI142	26.0	4.6	28.7	3.0
CARI950	12.0	2.1	144.1	14.9
CARI011	19.0	3.4	17.4	1.8
CARI066	38.0	6.8	49.6	5.1
CARI122	19.0	3.4	27.4	2.8
CARI474	38.0	6.8	54.2	5.6
CARI299	38.0	6.8	53.7	5.6
CARI869	23.0	4.1	40.6	4.2
CARI958	20.0	3.6	23.3	2.4
CARI481	27.0	4.8	51.1	5.3
CARI986	19.0	3.4	13.3	1.4
CARI399	8.0	1.4	8.7	0.9
CARI640	8.0	1.4	17.7	1.8
CARI059	14.0	2.5	42.6	4.4
CARI618	41.0	7.3	68.7	7.1
CARI181	7.0	1.2	12.2	1.3
CARI714	6.3	1.1	8.8	0.9

MONTH	AUG. VOLUME (acre-ft)	AUG. HR (hour)	ENERGY (kwh)	COSTS $	DISCOUNTS $	NET BILL $
APRIL	0.00	0	0	713.75	0.00	713.75
MAY	0.00	0	0	713.75	0.00	713.75
JUNE	0.00	0	0	713.75	0.00	713.75
JULY	115.45	720	28781	21059.53	798.52	20261.01
AUGUST	113.34	744	28256	20709.89	784.93	19924.95
SEPTEMBER	8.60	72	2145	2456.08	104.55	2351.53

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 237.4
TOTAL AUGMENTATION COST = $ 44,679.00

TOTAL BENEFIT TO PROJECT = $ 105,509.00
AVERAGE WAITING TIME (DAYS) = 5

TOTAL WATER ALLOCATED (ACRE-FT) = 966.7
RESOURCE UTILIZATION RATIO = 0.80

Summary of Water Use by Field/User in Rotation Blocks in Dry Year.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	12.7	0.0	5.4	5.2	23.2
CARI593	ALFALFA	40	10	16.1	0.0	5.4	5.1	26.6
CARI688	S/GRAIN	40	10	11.3	5.3	4.0	5.9	15.9
CARI836	PASTURE	50	10	9.9	0.7	5.4	5.1	19.7
CARI525	PASTURE	10	10	15.8	3.1	5.4	5.1	23.3
CARI750	S/GRAIN	20	10	9.1	3.7	4.0	6.0	15.4
CARI142	PASTURE	20	10	16.7	3.7	5.4	5.0	23.4
CARI950	ALFALFA	80	10	1.9	0.0	5.4	5.2	12.4
CARI011	ALFALFA	15	11	17.4	0.8	4.8	5.3	26.8
CARI066	ALFALFA	30	11	17.6	1.0	4.8	5.3	26.6
CARI122	ALFALFA	15	11	16.4	0.0	5.4	4.9	26.7
CARI474	ALFALFA	30	11	16.3	0.0	5.4	5.0	26.6
CARI299	ALFALFA	30	10	16.2	0.0	5.4	5.0	26.6
CARI869	ALFALFA	35	11	9.1	0.0	4.8	5.9	19.7
CARI958	CORN/SL	25	10	11.1	2.0	2.6	3.7	15.5
CARI481	ALFALFA	30	11	13.9	0.0	4.8	5.7	24.4
CARI986	S/GRAIN	10	10	23.7	14.6	4.0	5.6	18.8
CARI399	CORN/SL	10	9	12.4	3.4	2.6	3.6	15.2
CARI640	ALFALFA	10	9	11.3	0.0	5.4	5.1	21.8
CARI059	ALFALFA	25	10	8.1	0.0	5.2	5.0	18.3
CARI618	ALFALFA	50	9	11.4	0.0	5.6	5.2	22.1
CARI181	ALFALFA	7	9	14.2	0.0	5.4	5.0	24.6
CARI714	ALFALFA	5	10	17.8	0.0	5.4	5.1	28.3

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre for Users in Rotation Blocks, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	18.7	4.9	11840	6560	5280	132
CARI593	ALFALFA	28.9	23.3	6.1	14680	6480	8200	205
CARI688	S/GRAIN	0.1	0.1	0.8	2600	6640	-4040	-101
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	2.7					
CARI836	PASTURE	27.4	15.6	1.5	1200	3850	-2650	-53
CARI525	PASTURE	26.9	19.4	1.9	300	830	-530	-53
CARI750	S/GRAIN	0.1	0.1	0.6	1020	3260	-2240	-112
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	2.2					
CARI142	PASTURE	27.5	19.3	1.9	580	1960	-1380	-69
CARI950	ALFALFA	29.0	6.6	1.7	8400	11280	-2880	-36
CARI011	ALFALFA	29.0	23.7	6.2	5595	2895	2700	180
CARI066	ALFALFA	29.0	23.6	6.1	11130	5100	6030	201
CARI122	ALFALFA	28.9	23.4	6.1	5550	2895	2655	177
CARI474	ALFALFA	28.9	23.3	6.1	11010	5100	5910	197
CARI299	ALFALFA	28.9	23.3	6.1	11010	5010	6000	200
CARI869	ALFALFA	29.0	15.1	3.9	8330	5600	2730	78
CARI958	CORN/SL	0.0	0.0	3.2	1750	5325	-3575	-143
		3.6	3.6					
		4.3	3.7					
		5.6	0.3					
CARI481	ALFALFA	29.0	20.7	5.4	9780	5340	4440	148
CARI986	S/GRAIN	0.1	0.1	2.3	1710	2070	-360	-36
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	6.4					
CARI399	CORN/SL	0.0	0.0	1.5	330	2370	-2040	-204
		3.9	3.9					
		4.3	3.4					
		5.5	0.1					
CARI640	ALFALFA	29.0	16.6	4.3	2610	1840	770	77
CARI059	ALFALFA	28.9	13.4	3.5	5275	3975	1300	52
CARI618	ALFALFA	28.7	16.9	4.4	13450	7700	5750	115
CARI181	ALFALFA	28.9	20.5	5.4	2268	1225	1043	149
CARI714	ALFALFA	28.9	25.4	6.6	2005	915	1090	218

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, with Users in Rotation Blocks, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	55.2	8.0
CARI593	51.0	9.1	70.5	10.2
CARI688	40.0	7.1	49.5	7.2
CARI836	39.0	7.0	54.2	7.9
CARI525	12.5	2.2	17.2	2.5
CARI750	15.0	2.7	19.6	2.8
CARI142	26.0	4.6	36.6	5.3
CARI950	12.0	2.1	12.0	1.7
CARI011	19.0	3.4	28.7	4.2
CARI066	38.0	6.8	55.9	8.1
CARI122	19.0	3.4	26.9	3.9
CARI474	38.0	6.8	49.6	7.2
CARI299	38.0	6.8	45.6	6.6
CARI869	23.0	4.1	25.7	3.7
CARI958	20.0	3.6	23.6	3.4
CARI481	27.0	4.8	26.2	3.8
CARI986	19.0	3.4	22.0	3.2
CARI399	8.0	1.4	11.7	1.7
CARI640	8.0	1.4	9.7	1.4
CARI059	14.0	2.5	8.7	1.3
CARI618	41.0	7.3	19.7	2.9
CARI181	7.0	1.2	10.3	1.5
CARI714	6.3	1.1	9.6	1.4

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 34,203.00

AVERAGE WAITING TIME (DAYS) = 79

TOTAL WATER ALLOCATED (ACRE-FT) = 688.8

RESOURCE UTILIZATION RATIO = 0.84

Summary of Water Use by Fields/Users in Rotation Blocks
During a Wet Year.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	17.9	3.8	17.5	-1.9	29.7
CARI593	ALFALFA	40	10	22.6	7.3	17.0	-2.7	29.6
CARI688	S/GRAIN	40	10	16.6	11.3	14.3	3.4	23.0
CARI836	PASTURE	50	10	14.1	5.5	17.3	2.9	28.8
CARI525	PASTURE	10	10	22.2	12.4	17.8	0.7	28.3
CARI750	S/GRAIN	20	10	13.4	8.9	14.0	4.2	22.7
CARI142	PASTURE	20	10	24.5	13.5	17.1	0.9	28.9
CARI950	ALFALFA	80	10	2.7	0.0	17.8	5.7	26.2
CARI011	ALFALFA	15	11	26.9	14.6	19.3	-1.8	29.8
CARI066	ALFALFA	30	11	26.9	14.9	19.3	-1.5	29.8
CARI122	ALFALFA	15	11	24.3	8.2	16.9	-3.4	29.6
CARI474	ALFALFA	30	11	24.2	8.0	16.7	-3.3	29.6
CARI299	ALFALFA	30	10	23.9	8.4	17.3	-3.2	29.6
CARI869	ALFALFA	35	12	13.7	3.3	19.3	-0.3	29.5
CARI958	CORN/SL	25	10	14.0	8.5	14.5	0.4	20.4
CARI481	ALFALFA	30	11	21.4	9.8	19.3	-1.2	29.7
CARI986	S/GRAIN	10	10	35.0	26.5	14.2	0.3	23.0
CARI399	CORN/SL	10	9	15.9	10.1	14.9	0.1	20.8
CARI640	ALFALFA	10	9	15.9	2.3	17.8	-1.6	29.8
CARI059	ALFALFA	25	10	11.7	0.2	16.7	1.4	29.5
CARI618	ALFALFA	50	9	15.9	2.6	17.4	-1.0	29.8
CARI181	ALFALFA	7	9	20.2	5.3	17.5	-2.7	29.7
CARI714	ALFALFA	5	10	25.2	9.5	17.1	-3.2	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre Fields/Users in Rotation Blocks, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	6560	11640	291
CARI593	ALFALFA	28.9	28.9	7.6	18200	6480	11720	293
CARI688	S/GRAIN	0.5	0.5	3.7	11120	6640	4480	112
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.7					
CARI836	PASTURE	27.4	27.3	2.7	2050	3850	-1800	-36
CARI525	PASTURE	26.9	26.9	2.7	420	830	-410	-41
CARI750	S/GRAIN	0.7	0.7	2.4	3600	3260	340	17
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.0	5.2					
CARI142	PASTURE	27.5	27.5	2.7	840	1960	-1120	-56
CARI950	ALFALFA	29.0	17.9	4.7	22560	11280	11280	141
CARI011	ALFALFA	30.9	30.9	7.6	6825	2895	3930	262
CARI066	ALFALFA	30.9	30.9	7.6	13650	5100	8550	285
CARI122	ALFALFA	28.9	28.9	7.6	6825	2895	3930	262
CARI474	ALFALFA	28.9	28.9	7.6	13650	5100	8550	285
CARI299	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI869	ALFALFA	30.9	30.9	7.6	15925	5705	10220	292
CARI958	CORN/SL	0.0	0.0	23.0	12625	5325	7300	292
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	30.9	7.6	13650	5340	8310	277
CARI986	S/GRAIN	0.2	0.2	3.8	2810	2070	740	74
		1.5	1.5					
		4.4	4.4					
		2.7	2.7					
		7.4	7.4					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2370	2620	262
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1840	2710	271
CARI059	ALFALFA	28.9	28.9	7.6	11375	3975	7400	296
CARI618	ALFALFA	28.7	28.7	7.6	22750	7700	15050	301
CARI181	ALFALFA	28.9	28.9	7.6	3185	1225	1960	280
CARI714	ALFALFA	28.9	28.9	7.6	2275	915	1360	272

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, with Users in Rotation Blocks, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	78.0	7.3
CARI593	51.0	9.1	99.8	9.3
CARI688	40.0	7.1	73.2	6.9
CARI836	39.0	7.0	75.8	7.1
CARI525	12.5	2.2	24.4	2.3
CARI750	15.0	2.7	28.5	2.7
CARI142	26.0	4.6	53.9	5.0
CARI950	12.0	2.1	20.5	1.9
CARI011	19.0	3.4	44.1	4.1
CARI066	38.0	6.8	88.2	8.3
CARI122	19.0	3.4	39.9	3.7
CARI474	38.0	6.8	79.5	7.4
CARI299	38.0	6.8	74.4	7.0
CARI869	23.0	4.1	44.6	4.2
CARI958	20.0	3.6	29.8	2.8
CARI481	27.0	4.8	53.7	5.0
CARI986	19.0	3.4	37.3	3.5
CARI399	8.0	1.4	16.8	1.6
CARI640	8.0	1.4	15.3	1.4
CARI059	14.0	2.5	17.9	1.7
CARI618	41.0	7.3	43.9	4.1
CARI181	7.0	1.2	15.4	1.4
CARI714	6.3	1.1	13.8	1.3

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 127,400.00

AVERAGE WAITING TIME (DAYS) = 29

TOTAL WATER ALLOCATED (ACRE-FT) = 1068.9

RESOURCE UTILIZATION RATIO = 0.89

Summary of Water Use by Fields/Users On Request During a Dry Year.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	4	20.5	0.0	5.4	3.8	29.7
CARI593	ALFALFA	40	4	23.8	0.0	5.4	0.5	29.6
CARI688	S/GRAIN	40	0	0.0	0.5	4.0	6.0	9.5
CARI836	PASTURE	50	2	6.7	0.4	5.4	5.2	16.8
CARI525	PASTURE	10	4	13.3	0.0	5.4	5.2	23.9
CARI750	S/GRAIN	20	2	5.5	0.3	4.0	6.0	15.2
CARI142	PASTURE	20	3	8.6	0.2	5.4	5.2	18.9
CARI950	ALFALFA	80	2	15.2	0.0	5.4	5.2	25.8
CARI011	ALFALFA	15	2	9.7	0.0	4.8	7.4	21.9
CARI066	ALFALFA	30	2	9.6	0.0	4.8	7.4	21.8
CARI122	ALFALFA	15	2	9.6	0.0	5.4	5.2	20.1
CARI474	ALFALFA	30	2	9.9	0.0	5.4	5.2	20.4
CARI299	ALFALFA	30	2	9.7	0.0	5.4	5.2	20.3
CARI869	ALFALFA	35	2	10.0	0.0	4.8	7.4	22.3
CARI958	CORN/SL	25	1	10.8	0.0	2.6	-1.7	11.7
CARI481	ALFALFA	30	2	10.8	0.0	4.8	7.4	23.1
CARI986	S/GRAIN	10	0	0.0	0.7	4.0	6.0	9.3
CARI399	CORN/SL	10	0	0.0	0.0	2.6	8.9	11.5
CARI640	ALFALFA	10	2	12.8	0.0	5.4	5.2	23.3
CARI059	ALFALFA	25	1	5.6	0.0	5.2	5.4	16.2
CARI618	ALFALFA	50	2	10.5	0.0	5.6	5.2	21.3
CARI181	ALFALFA	7	4	21.2	0.0	5.4	3.1	29.7
CARI714	ALFALFA	5	3	16.0	0.0	5.4	5.2	26.5

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre with Fields/Users On Request, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.5	7.5	18000	5840	12160	304
CARI593	ALFALFA	28.9	28.8	7.5	18160	5760	12400	310
CARI688	S/GRAIN	0.1	0.1	0.0	160	5440	-5280	-132
		0.7	0.7					
		3.8	3.8					
		2.5	0.5					
		8.9	0.0					
CARI836	PASTURE	27.4	14.2	1.4	1050	2650	-1600	-32
CARI525	PASTURE	26.9	21.2	2.1	330	650	-320	-32
CARI750	S/GRAIN	0.1	0.1	1.0	1580	2780	-1200	-60
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	3.1					
CARI142	PASTURE	27.5	16.2	1.6	480	1540	-1060	-53
CARI950	ALFALFA	29.0	21.8	5.7	27520	9360	18160	227
CARI011	ALFALFA	29.0	18.1	4.7	4260	2490	1770	118
CARI066	ALFALFA	29.0	18.0	4.7	8490	4290	4200	140
CARI122	ALFALFA	28.9	17.0	4.4	4035	2490	1545	103
CARI474	ALFALFA	28.9	17.4	4.5	8220	4290	3930	131
CARI299	ALFALFA	28.9	17.1	4.5	8100	4290	3810	127
CARI869	ALFALFA	29.0	18.5	4.8	10185	4655	5530	158
CARI958	CORN/SL	0.0	0.0	0.0	0	4650	-4650	-186
		3.6	3.2					
		4.3	0.1					
		5.6	0.0					
CARI481	ALFALFA	29.0	19.6	5.1	9240	4530	4710	157
CARI986	S/GRAIN	0.1	0.1	0.0	40	1770	-1730	-173
		0.7	0.7					
		3.1	3.1					
		2.4	1.1					
		9.5	0.0					
CARI399	CORN/SL	0.0	0.0	0.0	0	2100	-2100	-210
		3.9	3.2					
		4.3	0.1					
		5.5	0.0					
CARI640	ALFALFA	29.0	20.3	5.3	3190	1630	1560	156
CARI059	ALFALFA	28.9	13.0	3.4	5125	3300	1825	73
CARI618	ALFALFA	28.7	17.8	4.7	14100	6650	7450	149
CARI181	ALFALFA	28.9	28.8	7.5	3178	1120	2058	294
CARI714	ALFALFA	28.9	24.2	6.3	1910	810	1100	220

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, with Users On Request, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	88.1	11.8
CARI593	51.0	9.1	103.4	13.9
CARI688	40.0	7.1	0.0	0.0
CARI836	39.0	7.0	35.6	4.8
CARI525	12.5	2.2	14.9	2.0
CARI750	15.0	2.7	11.7	1.6
CARI142	26.0	4.6	18.2	2.4
CARI950	12.0	2.1	136.3	18.3
CARI011	19.0	3.4	16.1	2.2
CARI066	38.0	6.8	30.9	4.2
CARI122	19.0	3.4	16.3	2.2
CARI474	38.0	6.8	31.3	4.2
CARI299	38.0	6.8	30.6	4.1
CARI869	23.0	4.1	37.3	5.0
CARI958	20.0	3.6	29.3	3.9
CARI481	27.0	4.8	35.0	4.7
CARI986	19.0	3.4	0.0	0.0
CARI399	8.0	1.4	0.0	0.0
CARI640	8.0	1.4	13.8	1.8
CARI059	14.0	2.5	15.5	2.1
CARI618	41.0	7.3	54.9	7.4
CARI181	7.0	1.2	16.4	2.2
CARI714	6.3	1.1	8.8	1.2

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 64,268.00

AVERAGE WAITING TIME (DAYS) = 74

TOTAL WATER ALLOCATED (ACRE-FT) = 744.4

RESOURCE UTILIZATION RATIO = 0.91

Summary of Water Use by Fields/Users on Request, Normal Year.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	2	13.2	0.0	11.1	5.3	29.7
CARI593	ALFALFA	40	3	20.8	0.2	11.1	-2.1	29.6
CARI688	S/GRAIN	40	3	17.0	3.3	7.4	1.5	22.5
CARI836	PASTURE	50	3	9.3	2.2	11.4	5.4	24.0
CARI525	PASTURE	10	4	16.0	1.8	11.1	1.7	27.0
CARI750	S/GRAIN	20	1	5.7	3.6	7.9	6.8	16.8
CARI142	PASTURE	20	2	8.0	2.3	11.4	5.5	22.7
CARI950	ALFALFA	80	1	5.7	0.0	11.1	8.2	25.0
CARI011	ALFALFA	15	2	11.5	0.1	11.1	7.1	29.6
CARI066	ALFALFA	30	1	5.2	0.4	11.1	8.3	24.2
CARI122	ALFALFA	15	1	5.3	0.6	11.4	8.5	24.6
CARI474	ALFALFA	30	1	10.5	0.7	11.4	8.4	29.6
CARI299	ALFALFA	30	1	5.3	0.3	11.4	8.2	24.6
CARI869	ALFALFA	35	1	5.4	0.1	11.1	8.3	24.7
CARI958	CORN/SL	25	1	9.5	1.2	6.8	0.4	15.4
CARI481	ALFALFA	30	1	5.0	0.7	11.1	8.3	23.7
CARI986	S/GRAIN	10	0	0.0	3.0	6.9	6.4	10.3
CARI399	CORN/SL	10	0	0.0	0.1	6.8	7.8	14.5
CARI640	ALFALFA	10	1	5.4	0.0	11.1	8.2	24.7
CARI059	ALFALFA	25	0	0.0	0.9	11.5	8.8	19.4
CARI618	ALFALFA	50	1	5.3	0.0	11.7	9.6	26.5
CARI181	ALFALFA	7	2	10.6	0.1	11.1	8.0	29.7
CARI714	ALFALFA	5	3	21.2	0.9	11.4	-2.1	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre with Users On Request, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	28.8	7.5	18200	5600	12600	315
CARI593	ALFALFA	28.9	28.8	7.5	18200	5640	12560	314
CARI688	S/GRAIN	0.2	0.2	2.4	7240	5800	1440	36
		0.9	0.9					
		3.3	3.2					
		2.5	1.3					
		9.2	8.8					
CARI836	PASTURE	27.4	20.8	2.0	1550	2800	-1250	-25
CARI525	PASTURE	26.9	24.0	2.4	370	650	-280	-28
CARI750	S/GRAIN	0.4	0.4	0.8	1280	2720	-1440	-72
		1.1	1.1					
		3.8	3.4					
		2.5	2.0					
		8.7	2.9					
CARI142	PASTURE	27.5	18.7	1.8	560	1480	-920	-46
CARI950	ALFALFA	29.0	21.6	5.6	27280	9120	18160	227
CARI011	ALFALFA	28.9	28.4	7.4	6705	2490	4215	281
CARI066	ALFALFA	28.9	20.8	5.4	9840	4200	5640	188
CARI122	ALFALFA	28.9	21.0	5.5	4980	2445	2535	169
CARI474	ALFALFA	28.9	25.6	6.7	12090	4200	7890	263
CARI299	ALFALFA	28.9	21.3	5.6	10110	4200	5910	197
CARI869	ALFALFA	28.9	21.5	5.6	11865	4550	7315	209
CARI958	CORN/SL	0.0	0.0	0.0	0	4650	-4650	-186
		3.2	3.2					
		4.6	2.1					
		5.6	0.0					
CARI481	ALFALFA	28.9	20.1	5.3	9510	4440	5070	169
CARI986	S/GRAIN	0.2	0.2	0.0	40	1770	-1730	-173
		0.7	0.7					
		2.9	2.9					
		2.4	0.5					
		9.6	0.0					
CARI399	CORN/SL	0.0	0.0	0.0	0	2100	-2100	-210
		3.4	3.4					
		4.8	1.6					
		5.5	0.0					
CARI640	ALFALFA	29.0	21.3	5.5	3350	1600	1750	175
CARI059	ALFALFA	28.9	14.0	3.7	5525	3225	2300	92
CARI618	ALFALFA	28.7	21.7	5.7	17250	6500	10750	215
CARI181	ALFALFA	28.9	27.5	7.2	3031	1078	1953	279
CARI714	ALFALFA	28.9	28.9	7.6	2275	810	1465	293

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, with Users On Request, Normal Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	56.2	9.5
CARI593	51.0	9.1	92.3	15.6
CARI688	40.0	7.1	74.7	12.6
CARI836	39.0	7.0	52.9	8.9
CARI525	12.5	2.2	17.5	3.0
CARI750	15.0	2.7	12.5	2.1
CARI142	26.0	4.6	18.5	3.1
CARI950	12.0	2.1	51.2	8.7
CARI011	19.0	3.4	20.0	3.4
CARI066	38.0	6.8	16.7	2.8
CARI122	19.0	3.4	8.6	1.5
CARI474	38.0	6.8	34.8	5.9
CARI299	38.0	6.8	17.5	3.0
CARI869	23.0	4.1	20.8	3.5
CARI958	20.0	3.6	26.6	4.5
CARI481	27.0	4.8	16.0	2.7
CARI986	19.0	3.4	0.0	0.0
CARI399	8.0	1.4	0.0	0.0
CARI640	8.0	1.4	5.9	1.0
CARI059	14.0	2.5	0.0	0.0
CARI618	41.0	7.3	28.8	4.9
CARI181	7.0	1.2	7.7	1.3
CARI714	6.3	1.1	11.7	2.0

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 89,183.00

AVERAGE WAITING TIME (DAYS) = 58

TOTAL WATER ALLOCATED (ACRE-FT) = 591.0

RESOURCE UTILIZATION RATIO = 0.52

Summary of Water Use by Fields/Users On Request During a Wet Year.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	2	10.7	0.0	17.5	1.5	29.7
CARI593	ALFALFA	40	3	16.1	1.5	17.0	-2.0	29.6
CARI688	S/GRAIN	40	3	9.8	4.7	14.3	3.7	23.0
CARI836	PASTURE	50	3	8.2	1.3	17.3	4.6	28.8
CARI525	PASTURE	10	4	12.0	3.0	17.8	1.6	28.3
CARI750	S/GRAIN	20	3	10.7	4.4	14.0	2.7	23.0
CARI142	PASTURE	20	4	12.5	1.5	17.1	0.8	28.9
CARI950	ALFALFA	80	2	16.4	1.1	17.8	-3.4	29.8
CARI011	ALFALFA	15	2	10.8	0.5	19.3	-0.1	29.5
CARI066	ALFALFA	30	2	10.9	0.8	19.3	0.0	29.5
CARI122	ALFALFA	15	2	12.2	0.0	16.9	0.4	29.6
CARI474	ALFALFA	30	2	12.6	0.0	16.7	0.3	29.6
CARI299	ALFALFA	30	1	5.3	0.0	17.3	5.9	28.5
CARI869	ALFALFA	35	1	5.5	0.5	19.3	5.2	29.5
CARI958	CORN/SL	25	1	6.9	1.1	14.5	0.2	20.4
CARI481	ALFALFA	30	2	14.6	3.3	19.3	-1.2	29.5
CARI986	S/GRAIN	10	1	2.7	4.4	14.2	6.2	18.6
CARI399	CORN/SL	10	0	0.0	1.4	14.9	7.2	20.7
CARI640	ALFALFA	10	1	5.4	0.0	17.8	5.7	28.9
CARI059	ALFALFA	25	1	5.5	0.0	16.7	6.6	28.6
CARI618	ALFALFA	50	2	12.4	0.0	17.4	0.0	29.8
CARI181	ALFALFA	7	3	16.0	0.5	17.5	-3.2	29.7
CARI714	ALFALFA	5	3	16.6	0.1	17.1	-4.0	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre with the Users On Request, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	5600	12600	315
CARI593	ALFALFA	28.9	28.9	7.6	18200	5640	12560	314
CARI688	S/GRAIN	0.5	0.5	3.8	11160	5800	5360	134
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.7					
CARI836	PASTURE	27.4	26.9	2.6	2050	2800	-750	-15
CARI525	PASTURE	26.9	26.9	2.7	420	650	-230	-23
CARI750	S/GRAIN	0.7	0.7	2.7	4080	2840	1240	62
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.0	5.7					
CARI142	PASTURE	27.5	27.3	2.7	820	1600	-780	-39
CARI950	ALFALFA	29.0	27.4	7.2	34480	9360	25120	314
CARI011	ALFALFA	30.9	30.9	7.6	6825	2490	4335	289
CARI066	ALFALFA	30.9	30.9	7.6	13650	4290	9360	312
CARI122	ALFALFA	28.9	28.9	7.6	6825	2490	4335	289
CARI474	ALFALFA	28.9	28.9	7.6	13650	4290	9360	312
CARI299	ALFALFA	28.9	22.9	6.0	10830	4200	6630	221
CARI869	ALFALFA	30.9	29.6	7.2	15260	4550	10710	306
CARI958	CORN/SL	0.0	0.0	13.0	7150	4650	2500	100
		4.7	4.7					
		4.0	4.0					
		5.6	2.3					
CARI481	ALFALFA	30.9	29.3	7.2	12960	4530	8430	281
CARI986	S/GRAIN	0.2	0.2	0.2	160	1800	-1640	-164
		1.5	1.5					
		4.4	4.4					
		2.7	2.6					
		7.4	0.6					
CARI399	CORN/SL	0.0	0.0	7.7	1690	2100	-410	-41
		5.2	5.2					
		4.0	3.4					
		5.5	1.2					
CARI640	ALFALFA	29.0	23.8	6.2	3750	1600	2150	215
CARI059	ALFALFA	28.9	22.8	6.0	9000	3300	5700	228
CARI618	ALFALFA	28.7	28.7	7.6	22750	6650	16100	322
CARI181	ALFALFA	28.9	28.9	7.6	3185	1099	2086	298
CARI714	ALFALFA	28.9	28.9	7.6	2275	810	1465	293

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, with the Users On Request, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	47.5	6.3
CARI593	51.0	9.1	73.6	9.7
CARI688	40.0	7.1	42.2	5.6
CARI836	39.0	7.0	46.4	6.1
CARI525	12.5	2.2	13.4	1.8
CARI750	15.0	2.7	23.6	3.1
CARI142	26.0	4.6	27.5	3.6
CARI950	12.0	2.1	150.2	19.8
CARI011	19.0	3.4	16.8	2.2
CARI066	38.0	6.8	35.6	4.7
CARI122	19.0	3.4	18.8	2.5
CARI474	38.0	6.8	43.2	5.7
CARI299	38.0	6.8	17.1	2.3
CARI869	23.0	4.1	22.5	3.0
CARI958	20.0	3.6	18.7	2.5
CARI481	27.0	4.8	49.4	6.5
CARI986	19.0	3.4	2.9	0.4
CARI399	8.0	1.4	0.0	0.0
CARI640	8.0	1.4	6.1	0.8
CARI059	14.0	2.5	15.4	2.0
CARI618	41.0	7.3	66.6	8.8
CARI181	7.0	1.2	12.0	1.6
CARI714	6.3	1.1	9.3	1.2

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 136,231.00

AVERAGE WAITING TIME (DAYS) = 34

TOTAL WATER ALLOCATED (ACRE-FT) = 758.9

RESOURCE UTILIZATION RATIO = 0.63

Summary of Water Use by Field/User During a Dry Year, with Allocations Rotated Among Crop Categories.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	10.1	0.0	5.4	5.2	20.7
CARI593	ALFALFA	40	10	13.0	0.0	5.4	5.1	23.5
CARI688	S/GRAIN	40	9	18.1	11.0	4.0	6.0	17.2
CARI836	PASTURE	50	10	15.1	3.9	5.4	5.1	21.7
CARI525	PASTURE	10	9	22.5	8.3	5.4	5.0	24.5
CARI750	S/GRAIN	20	10	13.7	7.1	4.0	6.0	16.6
CARI142	PASTURE	20	10	23.5	9.0	5.4	4.9	24.8
CARI950	ALFALFA	80	10	1.5	0.0	5.4	5.2	12.1
CARI011	ALFALFA	15	11	13.9	0.0	4.8	5.8	24.5
CARI066	ALFALFA	30	11	14.0	0.0	4.8	5.8	24.6
CARI122	ALFALFA	15	10	13.2	0.0	5.4	5.0	23.6
CARI474	ALFALFA	30	10	13.3	0.0	5.4	4.9	23.6
CARI299	ALFALFA	30	10	13.0	0.0	5.4	5.1	23.5
CARI869	ALFALFA	35	11	7.2	0.0	4.8	5.9	17.9
CARI958	CORN/SL	25	9	15.4	4.7	2.6	3.2	16.5
CARI481	ALFALFA	30	11	9.9	0.0	4.8	5.9	20.6
CARI986	S/GRAIN	10	9	28.0	17.0	4.0	5.0	20.1
CARI399	CORN/SL	10	10	14.6	5.0	2.6	3.9	16.0
CARI640	ALFALFA	10	10	8.1	0.0	5.4	5.1	18.7
CARI059	ALFALFA	25	10	6.0	0.0	5.2	5.1	16.3
CARI618	ALFALFA	50	9	8.2	0.0	5.6	5.2	19.0
CARI181	ALFALFA	7	10	10.2	0.0	5.4	5.2	20.7
CARI714	ALFALFA	5	10	12.9	0.0	5.4	5.0	23.3

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre Allocations Among Crop Categories, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	15.4	4.0	9760	6560	3200	80
CARI593	ALFALFA	28.9	19.1	5.0	12040	6480	5560	139
CARI688	S/GRAIN	0.1	0.1	1.4	4280	6520	-2240	-56
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	4.1					
CARI836	PASTURE	27.4	17.5	1.7	1300	3850	-2550	-51
CARI525	PASTURE	26.9	20.9	2.1	320	800	-480	-48
CARI750	S/GRAIN	0.1	0.1	1.1	1700	3260	-1560	-78
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	3.3					
CARI142	PASTURE	27.5	21.1	2.1	640	1960	-1320	-66
CARI950	ALFALFA	29.0	6.5	1.7	8240	11280	-3040	-38
CARI011	ALFALFA	29.0	21.0	5.5	4935	2895	2040	136
CARI066	ALFALFA	29.0	21.1	5.5	9960	5100	4860	162
CARI122	ALFALFA	28.9	19.4	5.1	4605	2850	1755	117
CARI474	ALFALFA	28.9	19.4	5.1	9150	5010	4140	138
CARI299	ALFALFA	28.9	19.1	5.0	9030	5010	4020	134
CARI869	ALFALFA	29.0	13.4	3.5	7385	5600	1785	51
CARI958	CORN/SL	0.0	0.0	7.5	4075	5250	-1175	-47
		3.6	3.6					
		4.3	3.9					
		5.6	1.0					
CARI481	ALFALFA	29.0	16.0	4.2	7530	5340	2190	73
CARI986	S/GRAIN	0.1	0.1	2.7	2040	2040	0	0
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	7.3					
CARI399	CORN/SL	0.0	0.0	5.3	1160	2400	-1240	-124
		3.9	3.9					
		4.3	3.6					
		5.5	0.6					
CARI640	ALFALFA	29.0	12.3	3.2	1950	1870	80	8
CARI059	ALFALFA	28.9	10.7	2.8	4250	3975	275	11
CARI618	ALFALFA	28.7	12.6	3.3	10000	7700	2300	46
CARI181	ALFALFA	28.9	15.5	4.1	1722	1246	476	68
CARI714	ALFALFA	28.9	18.9	4.9	1490	915	575	115

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Among Crop Categories, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	44.5	6.5
CARI593	51.0	9.1	57.0	8.3
CARI688	40.0	7.1	73.5	10.7
CARI836	39.0	7.0	76.6	11.2
CARI525	12.5	2.2	25.9	3.8
CARI750	15.0	2.7	27.8	4.1
CARI142	26.0	4.6	54.0	7.9
CARI950	12.0	2.1	10.2	1.5
CARI011	19.0	3.4	22.7	3.3
CARI066	38.0	6.8	45.2	6.6
CARI122	19.0	3.4	21.4	3.1
CARI474	38.0	6.8	41.5	6.1
CARI299	38.0	6.8	35.8	5.2
CARI869	23.0	4.1	20.1	2.9
CARI958	20.0	3.6	32.3	4.7
CARI481	27.0	4.8	18.8	2.7
CARI986	19.0	3.4	30.0	4.4
CARI399	8.0	1.4	11.2	1.6
CARI640	8.0	1.4	7.2	1.1
CARI059	14.0	2.5	5.0	0.7
CARI618	41.0	7.3	9.5	1.4
CARI181	7.0	1.2	7.6	1.1
CARI714	6.3	1.1	7.0	1.0

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 19,651.00

AVERAGE WAITING TIME (DAYS) = 91

TOTAL WATER ALLOCATED (ACRE-FT) = 685.0

RESOURCE UTILIZATION RATIO = 0.83

Summary of Water Use by Field/User During a Normal Year, Allocations Among Crop Categories Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	14.4	3.7	11.1	7.8	29.5
CARI593	ALFALFA	40	10	18.4	6.3	11.1	6.4	29.6
CARI688	S/GRAIN	40	9	24.7	16.6	7.4	5.3	20.8
CARI836	PASTURE	50	10	20.6	10.7	11.4	4.5	25.9
CARI525	PASTURE	10	9	28.7	16.2	11.1	4.0	27.6
CARI750	S/GRAIN	20	10	18.7	12.4	7.9	5.9	20.0
CARI142	PASTURE	20	10	29.7	16.9	11.4	3.6	27.9
CARI950	ALFALFA	80	10	2.2	0.0	11.1	8.2	21.5
CARI011	ALFALFA	15	10	18.4	6.3	11.1	6.5	29.6
CARI066	ALFALFA	30	10	18.1	6.4	11.1	6.7	29.6
CARI122	ALFALFA	15	10	19.1	6.7	11.4	5.8	29.6
CARI474	ALFALFA	30	10	19.6	7.0	11.4	5.5	29.6
CARI299	ALFALFA	30	10	18.5	6.4	11.4	6.1	29.6
CARI869	ALFALFA	35	10	9.5	2.4	11.1	8.2	26.4
CARI958	CORN/SL	25	9	21.9	9.6	6.8	1.2	20.3
CARI481	ALFALFA	30	10	12.9	4.0	11.1	8.2	28.2
CARI986	S/GRAIN	10	9	35.3	23.2	6.9	3.5	22.4
CARI399	CORN/SL	10	10	21.1	8.8	6.8	1.0	20.0
CARI640	ALFALFA	10	10	11.5	2.6	11.1	8.2	28.2
CARI059	ALFALFA	25	10	10.1	2.9	11.5	6.5	25.1
CARI618	ALFALFA	50	9	11.7	2.8	11.7	8.2	28.7
CARI181	ALFALFA	7	10	14.3	3.8	11.1	7.9	29.5
CARI714	ALFALFA	5	10	18.5	6.5	11.4	6.1	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre Allocations Among Crop Categories, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	CUMULATIVE TRANSPIRATION ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	27.3	7.1	17200	6560	10640	266
CARI593	ALFALFA	28.9	28.6	7.5	18080	6480	11600	290
CARI688	S/GRAIN	0.2	0.2	2.7	7920	6520	1400	35
		0.9	0.9					
		3.3	3.3					
		2.5	2.5					
		9.2	7.0					
CARI836	PASTURE	27.4	22.4	2.2	1700	3850	-2150	-43
CARI525	PASTURE	26.9	25.1	2.5	390	800	-410	-41
CARI750	S/GRAIN	0.4	0.4	1.9	2880	3260	-380	-19
		1.1	1.1					
		3.8	3.8					
		2.5	2.5					
		8.7	5.1					
CARI142	PASTURE	27.5	25.3	2.5	760	1960	-1200	-60
CARI950	ALFALFA	29.0	16.2	4.2	20480	11280	9200	115
CARI011	ALFALFA	28.9	28.6	7.5	6765	2850	3915	261
CARI066	ALFALFA	28.9	28.5	7.5	13500	5010	8490	283
CARI122	ALFALFA	28.9	28.5	7.5	6750	2850	3900	260
CARI474	ALFALFA	28.9	28.5	7.5	13470	5010	8460	282
CARI299	ALFALFA	28.9	28.6	7.5	13530	5010	8520	284
CARI869	ALFALFA	28.9	22.9	6.0	12635	5495	7140	204
CARI958	CORN/SL	0.0	0.0	20.3	11175	5250	5925	237
		3.2	3.2					
		4.6	4.6					
		5.6	4.2					
CARI481	ALFALFA	28.9	25.1	6.6	11850	5250	6600	220
CARI986	S/GRAIN	0.2	0.2	3.7	2760	2040	720	72
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	9.4					
CARI399	CORN/SL	0.0	0.0	18.7	4100	2400	1700	170
		3.4	3.4					
		4.8	4.8					
		5.5	3.5					
CARI640	ALFALFA	29.0	24.7	6.4	3880	1870	2010	201
CARI059	ALFALFA	28.9	21.0	5.5	8275	3975	4300	172
CARI618	ALFALFA	28.7	25.2	6.6	20000	7700	12300	246
CARI181	ALFALFA	28.9	27.1	7.1	2996	1246	1750	250
CARI714	ALFALFA	28.9	28.5	7.5	2245	915	1330	266

Cummulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Among Crop Categories, Normal Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	63.0	6.2
CARI593	51.0	9.1	80.7	8.0
CARI688	40.0	7.1	102.0	10.0
CARI836	39.0	7.0	107.6	10.6
CARI525	12.5	2.2	35.3	3.5
CARI750	15.0	2.7	38.6	3.8
CARI142	26.0	4.6	74.9	7.4
CARI950	12.0	2.1	15.3	1.5
CARI011	19.0	3.4	29.9	2.9
CARI066	38.0	6.8	59.8	5.9
CARI122	19.0	3.4	31.4	3.1
CARI474	38.0	6.8	63.0	6.2
CARI299	38.0	6.8	57.6	5.7
CARI869	23.0	4.1	30.3	3.0
CARI958	20.0	3.6	51.1	5.0
CARI481	27.0	4.8	32.8	3.2
CARI986	19.0	3.4	44.7	4.4
CARI399	8.0	1.4	20.9	2.1
CARI640	8.0	1.4	9.9	1.0
CARI059	14.0	2.5	17.8	1.8
CARI618	41.0	7.3	27.3	2.7
CARI181	7.0	1.2	11.0	1.1
CARI714	6.3	1.1	10.0	1.0

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 105,760.00

AVERAGE WAITING TIME (DAYS) = 43

TOTAL WATER ALLOCATED (ACRE-FT) = 1015.1

RESOURCE UTILIZATION RATIO = 0.89

Summary of Water Use by Field/User During a Wet Year,
Allocations Rotated Among Crop Categories.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	14.5	1.8	17.5	-0.6	29.7
CARI593	ALFALFA	40	10	18.7	4.0	17.0	-2.1	29.6
CARI688	S/GRAIN	40	9	26.2	20.4	14.3	3.0	23.0
CARI836	PASTURE	50	10	22.0	12.9	17.3	2.5	28.8
CARI525	PASTURE	10	9	30.1	20.4	17.8	0.9	28.4
CARI750	S/GRAIN	20	10	19.9	14.3	14.0	2.8	22.3
CARI142	PASTURE	20	10	31.5	20.7	17.1	1.0	28.9
CARI950	ALFALFA	80	10	2.2	0.0	17.8	5.7	25.7
CARI011	ALFALFA	15	12	21.2	9.3	19.3	-1.8	29.5
CARI066	ALFALFA	30	12	21.1	9.5	19.3	-1.5	29.5
CARI122	ALFALFA	15	10	19.1	4.1	16.9	-2.4	29.6
CARI474	ALFALFA	30	10	19.3	3.9	16.7	-2.5	29.6
CARI299	ALFALFA	30	10	18.6	4.0	17.3	-2.3	29.6
CARI869	ALFALFA	35	12	11.1	2.6	19.3	1.7	29.5
CARI958	CORN/SL	25	9	23.5	17.4	14.5	0.7	21.2
CARI481	ALFALFA	30	12	15.1	4.2	19.3	-0.7	29.5
CARI986	S/GRAIN	10	9	38.5	30.3	14.2	0.8	23.2
CARI399	CORN/SL	10	10	21.9	16.2	14.9	0.6	21.3
CARI640	ALFALFA	10	10	11.6	0.3	17.8	0.6	29.8
CARI059	ALFALFA	25	10	8.7	0.0	16.7	4.2	29.5
CARI618	ALFALFA	50	9	11.8	0.5	17.4	1.1	29.8
CARI181	ALFALFA	7	10	14.4	1.7	17.5	-0.5	29.7
CARI714	ALFALFA	5	10	18.6	3.9	17.1	-2.2	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Allocations Among Crop Categories, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	6560	11640	291
CARI593	ALFALFA	28.9	28.9	7.6	18200	6480	11720	293
CARI688	S/GRAIN	0.5	0.5	3.6	10600	6520	4080	102
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.4					
CARI836	PASTURE	27.4	26.7	2.6	2000	3850	-1850	-37
CARI525	PASTURE	26.9	26.9	2.7	420	800	-380	-38
CARI750	S/GRAIN	0.7	0.7	2.1	3180	3260	-80	-4
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.0	4.7					
CARI142	PASTURE	27.5	27.5	2.7	840	1960	-1120	-56
CARI950	ALFALFA	29.0	17.2	4.5	21680	11280	10400	130
CARI011	ALFALFA	30.9	30.9	7.6	6825	2940	3885	259
CARI066	ALFALFA	30.9	30.9	7.6	13650	5190	8460	282
CARI122	ALFALFA	28.9	28.9	7.6	6825	2850	3975	265
CARI474	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI299	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI869	ALFALFA	30.9	30.9	7.6	15925	5705	10220	292
CARI958	CORN/SL	0.0	0.0	23.0	12625	5250	7375	295
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	30.9	7.6	13650	5430	8220	274
CARI986	S/GRAIN	0.2	0.2	3.8	2810	2040	770	77
		1.5	1.5					
		4.4	4.4					
		2.7	2.7					
		7.4	7.4					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2400	2590	259
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1870	2680	268
CARI059	ALFALFA	28.9	28.4	7.4	11175	3975	7200	288
CARI618	ALFALFA	28.7	28.7	7.6	22750	7700	15050	301
CARI181	ALFALFA	28.9	28.9	7.6	3185	1246	1939	277
CARI714	ALFALFA	28.9	28.9	7.6	2275	915	1360	272

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Rotated Among Crop Categories, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	64.0	6.1
CARI593	51.0	9.1	82.0	7.8
CARI688	40.0	7.1	110.0	10.5
CARI836	39.0	7.0	112.1	10.7
CARI525	12.5	2.2	37.1	3.6
CARI750	15.0	2.7	41.1	3.9
CARI142	26.0	4.6	79.6	7.6
CARI950	12.0	2.1	15.7	1.5
CARI011	19.0	3.4	34.9	3.3
CARI066	38.0	6.8	69.8	6.7
CARI122	19.0	3.4	31.3	3.0
CARI474	38.0	6.8	61.8	5.9
CARI299	38.0	6.8	53.2	5.1
CARI869	23.0	4.1	31.7	3.0
CARI958	20.0	3.6	53.5	5.1
CARI481	27.0	4.8	27.6	2.6
CARI986	19.0	3.4	51.5	4.9
CARI399	8.0	1.4	20.5	2.0
CARI640	8.0	1.4	11.3	1.1
CARI059	14.0	2.5	10.1	1.0
CARI618	41.0	7.3	25.0	2.4
CARI181	7.0	1.2	11.1	1.1
CARI714	6.3	1.1	10.2	1.0

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 125,414.00

AVERAGE WAITING TIME (DAYS) = 37

TOTAL WATER ALLOCATED (ACRE-FT) = 1045.2

RESOURCE UTILIZATION RATIO = 0.87

Summary of Water Use by Fields/Users During a Dry Year,
with User Allocations Rotated Among Stock Ranks.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	9	11.2	0.0	5.4	5.1	21.7
CARI593	ALFALFA	40	10	14.4	0.0	5.4	5.1	24.9
CARI688	S/GRAIN	40	9	10.2	4.8	4.0	5.9	15.5
CARI836	PASTURE	50	10	8.7	0.3	5.4	5.2	19.0
CARI525	PASTURE	10	10	21.0	6.9	5.4	5.1	24.6
CARI750	S/GRAIN	20	10	10.8	4.8	4.0	5.9	15.9
CARI142	PASTURE	)	10	19.9	6.6	5.4	5.0	23.7
CARI950	ALFALFA	80	10	2.5	0.0	5.4	5.2	13.1
CARI011	ALFALFA	15	11	20.4	4.0	4.8	5.3	26.5
CARI066	ALFALFA	30	11	16.2	0.3	4.8	4.8	25.5
CARI122	ALFALFA	15	11	19.5	3.2	5.4	4.2	26.0
CARI474	ALFALFA	30	10	14.3	0.0	5.4	5.0	24.6
CARI299	ALFALFA	30	10	14.1	0.0	5.4	5.1	24.6
CARI869	ALFALFA	35	11	10.6	0.0	4.8	5.9	21.2
CARI958	CORN/SL	25	9	11.9	3.1	2.6	3.9	15.4
CARI481	ALFALFA	30	11	14.7	1.6	4.8	5.7	23.5
CARI986	S/GRAIN	10	9	25.4	16.4	4.0	5.8	18.8
CARI399	CORN/SL	10	10	15.9	4.4	2.6	1.8	15.9
CARI640	ALFALFA	10	10	13.3	0.0	5.4	5.1	23.8
CARI059	ALFALFA	25	11	8.7	0.0	5.2	5.2	19.1
CARI618	ALFALFA	50	9	9.0	0.0	5.6	5.2	19.8
CARI181	ALFALFA	7	10	17.0	0.8	5.4	5.1	26.6
CARI714	ALFALFA	5	10	21.7	3.3	5.4	4.4	28.2

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Allocations Among Stock Ranks, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	16.6	4.3	10480	6440	4040	101
CARI593	ALFALFA	28.9	20.8	5.4	13120	6480	6640	166
CARI688	S/GRAIN	0.1	0.1	0.7	2280	6520	-4240	-106
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	2.5					
CARI836	PASTURE	27.4	14.7	1.4	1100	3850	-2750	-55
CARI525	PASTURE	26.9	20.9	2.1	320	830	-510	-51
CARI750	S/GRAIN	0.1	0.1	0.8	1320	3260	-1940	-97
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	2.7					
CARI142	PASTURE	27.5	19.8	1.9	600	1960	-1360	-68
CARI950	ALFALFA	29.0	7.0	1.8	8960	11280	-2320	-29
CARI011	ALFALFA	29.0	23.7	6.2	5580	2895	2685	179
CARI066	ALFALFA	29.0	22.2	5.8	10470	5100	5370	179
CARI122	ALFALFA	28.9	23.0	6.0	5430	2895	2535	169
CARI474	ALFALFA	28.9	20.8	5.4	9840	5010	4830	161
CARI299	ALFALFA	28.9	20.5	5.4	9690	5010	4680	156
CARI869	ALFALFA	29.0	17.4	4.5	9555	5600	3955	113
CARI958	CORN/SL	0.0	0.0	3.9	2125	5250	-3125	-125
		3.6	3.6					
		4.3	3.8					
		5.6	0.4					
CARI481	ALFALFA	29.0	19.8	5.2	9330	5340	3990	133
CARI986	S/GRAIN	0.1	0.1	2.2	1680	2040	-360	-36
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	6.3					
CARI399	CORN/SL	0.0	0.0	3.3	720	2400	-1680	-168
		3.9	3.9					
		4.3	3.6					
		5.5	0.3					
CARI640	ALFALFA	29.0	19.4	5.1	3050	1870	1180	118
CARI059	ALFALFA	28.9	13.9	3.6	5500	4050	1450	58
CARI618	ALFALFA	28.7	13.8	3.6	10950	7700	3250	65
CARI181	ALFALFA	28.9	23.1	6.0	2548	1246	1302	186
CARI714	ALFALFA	28.9	26.0	6.8	2050	915	1135	227

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Among Stock Ranks, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	48.8	6.9
CARI593	51.0	9.1	62.4	8.8
CARI688	40.0	7.1	43.3	6.1
CARI836	39.0	7.0	46.1	6.5
CARI525	12.5	2.2	23.0	3.3
CARI750	15.0	2.7	22.6	3.2
CARI142	26.0	4.6	43.8	6.2
CARI950	12.0	2.1	19.0	2.7
CARI011	19.0	3.4	33.6	4.8
CARI066	38.0	6.8	51.0	7.2
CARI122	19.0	3.4	32.2	4.6
CARI474	38.0	6.8	44.1	6.3
CARI299	38.0	6.8	42.1	6.0
CARI869	23.0	4.1	29.3	4.2
CARI958	20.0	3.6	21.1	3.0
CARI481	27.0	4.8	28.9	4.1
CARI986	19.0	3.4	25.6	3.6
CARI399	8.0	1.4	16.7	2.4
CARI640	8.0	1.4	12.1	1.7
CARI059	14.0	2.5	10.5	1.5
CARI618	41.0	7.3	24.3	3.5
CARI181	7.0	1.2	12.8	1.8
CARI714	6.3	1.1	11.7	1.7

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 28,757.00

AVERAGE WAITING TIME (DAYS) = 81

TOTAL WATER ALLOCATED (ACRE-FT) = 704.9

RESOURCE UTILIZATION RATIO = 0.86

Summary of Water Use by Field/User During a Normal Year, Allocation Among Stock Ranks.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	9	15.2	4.1	11.1	7.2	29.3
CARI593	ALFALFA	40	10	19.4	6.7	11.1	5.8	29.6
CARI688	S/GRAIN	40	9	14.4	9.0	7.4	6.2	19.1
CARI836	PASTURE	50	10	12.0	5.3	11.4	5.1	23.2
CARI525	PASTURE	10	10	29.6	17.1	11.1	4.5	28.1
CARI750	S/GRAIN	20	10	14.8	9.6	7.9	6.1	19.1
CARI142	PASTURE	20	10	28.0	16.0	11.4	4.1	27.5
CARI950	ALFALFA	80	10	3.6	0.0	11.1	8.2	22.9
CARI011	ALFALFA	15	10	27.4	13.6	11.1	4.7	29.6
CARI066	ALFALFA	30	10	19.1	6.7	11.1	6.1	29.6
CARI122	ALFALFA	15	11	29.0	14.4	11.4	3.5	29.6
CARI474	ALFALFA	30	10	19.7	7.2	11.4	5.6	29.6
CARI299	ALFALFA	30	10	19.2	6.7	11.4	5.7	29.6
CARI869	ALFALFA	35	10	14.2	4.9	11.1	7.3	27.7
CARI958	CORN/SL	25	9	20.0	7.4	6.8	0.6	19.9
CARI481	ALFALFA	30	10	19.3	8.3	11.1	6.3	28.5
CARI986	S/GRAIN	10	9	33.3	22.8	6.9	4.9	22.3
CARI399	CORN/SL	10	10	23.9	11.1	6.8	0.5	20.0
CARI640	ALFALFA	10	10	19.1	6.6	11.1	6.0	29.8
CARI059	ALFALFA	25	11	12.7	4.8	11.5	7.4	26.9
CARI618	ALFALFA	50	9	12.3	2.8	11.7	7.7	28.8
CARI181	ALFALFA	7	10	23.9	10.1	11.1	4.7	29.7
CARI714	ALFALFA	5	10	30.6	15.7	11.4	3.2	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Allocation Among Stock Ranks, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	27.3	7.1	17240	6440	10800	270
CARI593	ALFALFA	28.9	28.6	7.5	18040	6480	11560	289
CARI688	S/GRAIN	0.2	0.2	2.1	6240	6520	-280	-7
		0.9	0.9					
		3.3	3.3					
		2.5	2.5					
		9.2	5.8					
CARI836	PASTURE	27.4	18.1	1.8	1350	3850	-2500	-50
CARI525	PASTURE	26.9	26.0	2.6	400	830	-430	-43
CARI750	S/GRAIN	0.4	0.4	1.7	2580	3260	-680	-34
		1.1	1.1					
		3.8	3.8					
		2.5	2.5					
		8.7	4.7					
CARI142	PASTURE	27.5	24.8	2.4	760	1960	-1200	-60
CARI950	ALFALFA	29.0	17.6	4.6	22160	11280	10880	136
CARI011	ALFALFA	28.9	28.6	7.5	6765	2850	3915	261
CARI066	ALFALFA	28.9	28.5	7.5	13470	5010	8460	282
CARI122	ALFALFA	28.9	28.5	7.5	6735	2895	3840	256
CARI474	ALFALFA	28.9	28.5	7.5	13500	5010	8490	283
CARI299	ALFALFA	28.9	28.6	7.5	13500	5010	8490	283
CARI869	ALFALFA	28.9	25.4	6.6	14035	5495	8540	244
CARI958	CORN/SL	0.0	0.0	19.1	10475	5250	5225	209
		3.2	3.2					
		4.6	4.6					
		5.6	3.8					
CARI481	ALFALFA	28.9	26.4	6.9	12480	5250	7230	241
CARI986	S/GRAIN	0.2	0.2	3.6	2700	2040	660	66
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	9.2					
CARI399	CORN/SL	0.0	0.0	19.9	4370	2400	1970	197
		3.4	3.4					
		4.8	4.8					
		5.5	3.9					
CARI640	ALFALFA	29.0	28.4	7.4	4460	1870	2590	259
CARI059	ALFALFA	28.9	23.7	6.2	9325	4050	5275	211
CARI618	ALFALFA	28.7	26.2	6.9	20800	7700	13100	262
CARI181	ALFALFA	28.9	28.8	7.5	3178	1246	1932	276
CARI714	ALFALFA	28.9	28.9	7.6	2275	915	1360	272

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Among Stock Ranks, Normal Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	66.7	6.4
CARI593	51.0	9.1	85.2	8.2
CARI688	40.0	7.1	62.2	5.9
CARI836	39.0	7.0	63.9	6.1
CARI525	12.5	2.2	32.8	3.1
CARI750	15.0	2.7	30.5	2.9
CARI142	26.0	4.6	62.9	6.0
CARI950	12.0	2.1	24.9	2.4
CARI011	19.0	3.4	44.8	4.3
CARI066	38.0	6.8	63.0	6.0
CARI122	19.0	3.4	47.2	4.5
CARI474	38.0	6.8	63.9	6.1
CARI299	38.0	6.8	59.8	5.7
CARI869	23.0	4.1	45.7	4.4
CARI958	20.0	3.6	47.5	4.5
CARI481	27.0	4.8	49.5	4.7
CARI986	19.0	3.4	37.9	3.6
CARI399	8.0	1.4	32.8	3.1
CARI640	8.0	1.4	19.6	1.9
CARI059	14.0	2.5	24.8	2.4
CARI618	41.0	7.3	45.1	4.3
CARI181	7.0	1.2	18.3	1.8
CARI714	6.3	1.1	16.7	1.6

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 109,227.00

AVERAGE WAITING TIME (DAYS) = 40

TOTAL WATER ALLOCATED (ACRE-FT) = 1045.7

RESOURCE UTILIZATION RATIO = 0.92

Summary of Water Use by Field/User During a Wet Year,
Allocations Rotated Among Stock Ranks.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	9	15.7	2.2	17.5	-1.4	29.7
CARI593	ALFALFA	40	10	20.3	5.0	17.0	-2.7	29.6
CARI688	S/GRAIN	40	9	15.1	10.4	14.3	4.0	23.0
CARI836	PASTURE	50	10	12.5	4.7	17.3	3.8	28.8
CARI525	PASTURE	10	10	29.6	19.7	17.8	0.6	28.3
CARI750	S/GRAIN	20	10	15.7	10.5	14.0	3.2	22.4
CARI142	PASTURE	20	10	28.5	17.6	17.1	1.0	29.0
CARI950	ALFALFA	80	10	3.7	0.0	17.8	5.7	27.1
CARI011	ALFALFA	15	11	30.3	18.2	19.3	-1.8	29.7
CARI066	ALFALFA	30	11	26.3	14.4	19.3	-1.5	29.7
CARI122	ALFALFA	15	11	29.3	13.4	16.9	-3.1	29.7
CARI474	ALFALFA	30	10	20.4	4.8	16.7	-2.5	29.7
CARI299	ALFALFA	30	10	20.0	4.9	17.3	-2.8	29.6
CARI869	ALFALFA	35	11	15.8	5.9	19.3	0.3	29.5
CARI958	CORN/SL	25	9	17.2	11.0	14.5	0.4	21.1
CARI481	ALFALFA	30	11	21.6	10.9	19.3	-0.6	29.5
CARI986	S/GRAIN	10	9	35.7	27.8	14.2	0.8	22.9
CARI399	CORN/SL	10	10	19.4	13.7	14.9	0.1	20.7
CARI640	ALFALFA	10	10	19.3	5.3	17.8	-2.0	29.8
CARI059	ALFALFA	25	11	13.0	1.9	16.7	1.8	29.5
CARI618	ALFALFA	50	9	12.5	0.8	17.4	0.6	29.8
CARI181	ALFALFA	7	10	24.6	9.8	17.5	-2.6	29.7
CARI714	ALFALFA	5	10	31.1	15.2	17.1	-3.4	29.7

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Allocations Among Stock Ranks, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	6440	11760	294
CARI593	ALFALFA	28.9	28.9	7.6	18200	6480	11720	293
CARI688	S/GRAIN	0.5	0.5	3.6	10720	6520	4200	105
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.5					
CARI836	PASTURE	27.4	25.7	2.5	1950	3850	-1900	-38
CARI525	PASTURE	26.9	26.9	2.7	420	830	-410	-41
CARI750	S/GRAIN	0.7	0.7	2.0	3040	3260	-220	-11
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.0	4.5					
CARI142	PASTURE	27.5	27.5	2.7	840	1960	-1120	-56
CARI950	ALFALFA	29.0	19.3	5.0	24400	11280	13120	164
CARI011	ALFALFA	30.9	30.9	7.6	6825	2895	3930	262
CARI066	ALFALFA	30.9	30.9	7.6	13650	5100	8550	285
CARI122	ALFALFA	28.9	28.9	7.6	6825	2895	3930	262
CARI474	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI299	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI869	ALFALFA	30.9	30.9	7.6	15925	5600	10325	295
CARI958	CORN/SL	0.0	0.0	23.0	12625	5250	7375	295
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	30.9	7.6	13650	5340	8310	277
CARI986	S/GRAIN	0.2	0.2	3.8	2810	2040	770	77
		1.5	1.5					
		4.4	4.4					
		2.7	2.7					
		7.4	7.4					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2400	2590	259
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1870	2680	268
CARI059	ALFALFA	28.9	28.3	7.4	11125	4050	7075	283
CARI618	ALFALFA	28.7	28.7	7.6	22750	7700	15050	301
CARI181	ALFALFA	28.9	28.9	7.6	3185	1246	1939	277
CARI714	ALFALFA	28.9	28.9	7.6	2275	915	1360	272

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Among Stock Ranks, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	69.2	6.4
CARI593	51.0	9.1	88.5	8.2
CARI688	40.0	7.1	63.2	5.8
CARI836	39.0	7.0	66.0	6.1
CARI525	12.5	2.2	33.3	3.1
CARI750	15.0	2.7	32.6	3.0
CARI142	26.0	4.6	64.9	6.0
CARI950	12.0	2.1	26.3	2.4
CARI011	19.0	3.4	50.0	4.6
CARI066	38.0	6.8	86.3	8.0
CARI122	19.0	3.4	48.1	4.4
CARI474	38.0	6.8	65.9	6.1
CARI299	38.0	6.8	62.1	5.7
CARI869	23.0	4.1	50.8	4.7
CARI958	20.0	3.6	39.1	3.6
CARI481	27.0	4.8	55.2	5.1
CARI986	19.0	3.4	42.2	3.9
CARI399	8.0	1.4	20.5	1.9
CARI640	8.0	1.4	19.1	1.8
CARI059	14.0	2.5	24.1	2.2
CARI618	41.0	7.3	39.9	3.7
CARI181	7.0	1.2	18.6	1.7
CARI714	6.3	1.1	16.9	1.6

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 128,314.00

AVERAGE WAITING TIME (DAYS) = 35

TOTAL WATER ALLOCATED (ACRE-FT) = 1082.8

RESOURCE UTILIZATION RATIO = 0.90

Summary of Water Use by Fields/Users, Allocations Based on System Types Strategy, Dry Year.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	11.3	0.0	5.4	5.2	21.8
CARI593	ALFALFA	40	10	14.5	0.0	5.4	5.1	25.0
CARI688	S/GRAIN	40	9	14.8	8.4	4.0	6.0	16.3
CARI836	PASTURE	50	10	12.2	2.1	5.4	5.1	20.5
CARI525	PASTURE	10	10	18.7	5.9	5.4	5.1	23.3
CARI750	S/GRAIN	20	10	11.1	5.2	4.0	6.0	15.9
CARI142	PASTURE	20	10	14.9	2.9	5.4	5.1	22.4
CARI950	ALFALFA	80	10	2.3	0.0	5.4	5.2	12.8
CARI011	ALFALFA	15	11	15.7	0.9	4.8	5.6	25.3
CARI066	ALFALFA	30	11	15.7	0.9	4.8	5.6	25.1
CARI122	ALFALFA	15	10	14.7	0.1	5.4	5.0	25.0
CARI474	ALFALFA	30	10	14.8	0.1	5.4	4.9	25.0
CARI299	ALFALFA	30	10	14.5	0.0	5.4	5.1	25.0
CARI869	ALFALFA	35	11	11.1	0.0	4.8	5.5	21.4
CARI958	CORN/SL	25	9	12.5	3.2	2.6	4.1	16.0
CARI481	ALFALFA	30	11	11.0	0.0	4.8	5.9	21.7
CARI986	S/GRAIN	10	9	25.1	15.4	4.0	5.3	18.9
CARI399	CORN/SL	10	10	11.8	3.7	2.6	4.8	15.4
CARI640	ALFALFA	10	10	12.1	0.0	5.4	5.1	22.6
CARI059	ALFALFA	25	11	8.8	0.0	5.2	5.2	19.2
CARI618	ALFALFA	50	9	9.2	0.0	5.6	5.2	20.0
CARI181	ALFALFA	7	10	15.5	1.2	5.4	4.7	24.4
CARI714	ALFALFA	5	10	19.5	3.5	5.4	4.1	25.4

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Allocations Based on System Types, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	16.8	4.4	10640	6560	4080	102
CARI593	ALFALFA	28.9	21.1	5.5	13320	6480	6840	171
CARI688	S/GRAIN	0.1	0.1	1.1	3360	6520	-3160	-79
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	3.4					
CARI836	PASTURE	27.4	16.3	1.6	1250	3850	-2600	-52
CARI525	PASTURE	26.9	19.5	1.9	300	830	-530	-53
CARI750	S/GRAIN	0.1	0.1	0.8	1260	3260	-2000	-100
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	2.6					
CARI142	PASTURE	27.5	18.5	1.8	560	1960	-1400	-70
CARI950	ALFALFA	29.0	6.8	1.8	8720	11280	-2560	-32
CARI011	ALFALFA	29.0	21.7	5.7	5115	2895	2220	148
CARI066	ALFALFA	29.0	21.6	5.6	10200	5100	5100	170
CARI122	ALFALFA	28.9	21.2	5.5	5025	2850	2175	145
CARI474	ALFALFA	28.9	21.2	5.5	10020	5010	5010	167
CARI299	ALFALFA	28.9	21.1	5.5	10020	5010	5010	167
CARI869	ALFALFA	29.0	17.6	4.6	9660	5600	4060	116
CARI958	CORN/SL	0.0	0.0	5.1	2775	5250	-2475	-99
		3.6	3.6					
		4.3	3.8					
		5.6	0.6					
CARI481	ALFALFA	29.0	17.6	4.6	8310	5340	2970	99
CARI986	S/GRAIN	0.1	0.1	2.4	1780	2040	-260	-26
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	6.6					
CARI399	CORN/SL	0.0	0.0	2.8	620	2400	-1780	-178
		3.9	3.9					
		4.3	3.4					
		5.5	0.3					
CARI640	ALFALFA	29.0	17.7	4.6	2780	1870	910	91
CARI059	ALFALFA	28.9	14.0	3.7	5550	4050	1500	60
CARI618	ALFALFA	28.7	13.8	3.6	11000	7700	3300	66
CARI181	ALFALFA	28.9	20.5	5.4	2261	1246	1015	145
CARI714	ALFALFA	28.9	22.4	5.9	1770	915	855	171

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Based on System Types, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	49.7	7.4
CARI593	51.0	9.1	63.6	9.4
CARI688	40.0	7.1	59.7	8.8
CARI836	39.0	7.0	61.7	9.1
CARI525	12.5	2.2	20.6	3.1
CARI750	15.0	2.7	23.0	3.4
CARI142	26.0	4.6	32.7	4.8
CARI950	12.0	2.1	13.4	2.0
CARI011	19.0	3.4	25.7	3.8
CARI066	38.0	6.8	51.5	7.6
CARI122	19.0	3.4	24.1	3.6
CARI474	38.0	6.8	47.7	7.1
CARI299	38.0	6.8	42.8	6.3
CARI869	23.0	4.1	24.4	3.6
CARI958	20.0	3.6	25.7	3.8
CARI481	27.0	4.8	21.6	3.2
CARI986	19.0	3.4	23.7	3.5
CARI399	8.0	1.4	9.7	1.4
CARI640	8.0	1.4	9.2	1.4
CARI059	14.0	2.5	6.6	1.0
CARI618	41.0	7.3	17.9	2.6
CARI181	7.0	1.2	11.0	1.6
CARI714	6.3	1.1	10.1	1.5

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 28,280.00

AVERAGE WAITING TIME (DAYS) = 83

TOTAL WATER ALLOCATED (ACRE-FT) = 676.2

RESOURCE UTILIZATION RATIO = 0.82

Summary of Water Use by Fields/Users During a Normal Year, Allocations Based on System Types Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	16.0	5.1	11.1	6.8	28.9
CARI593	ALFALFA	40	10	20.4	7.7	11.1	5.8	29.6
CARI688	S/GRAIN	40	9	20.1	13.3	7.4	6.0	20.2
CARI836	PASTURE	50	10	16.8	8.3	11.4	4.9	24.7
CARI525	PASTURE	10	10	25.5	14.3	11.1	4.3	26.6
CARI750	S/GRAIN	20	10	15.1	10.0	7.9	6.1	19.1
CARI142	PASTURE	20	10	21.0	10.5	11.4	4.9	26.9
CARI950	ALFALFA	80	10	3.2	0.0	11.1	8.2	22.5
CARI011	ALFALFA	15	10	20.2	7.5	11.1	5.9	29.6
CARI066	ALFALFA	30	10	20.2	7.8	11.1	6.1	29.6
CARI122	ALFALFA	15	10	20.9	8.1	11.4	5.3	29.6
CARI474	ALFALFA	30	10	21.6	8.4	11.4	4.9	29.6
CARI299	ALFALFA	30	10	20.4	7.8	11.4	5.6	29.6
CARI869	ALFALFA	35	10	14.1	4.4	11.1	6.7	27.4
CARI958	CORN/SL	25	9	19.0	7.2	6.8	1.4	20.0
CARI481	ALFALFA	30	10	14.3	4.9	11.1	7.5	28.1
CARI986	S/GRAIN	10	9	31.9	21.1	6.9	4.1	21.8
CARI399	CORN/SL	10	10	18.1	6.6	6.8	1.3	19.5
CARI640	ALFALFA	10	10	16.8	5.7	11.1	6.1	28.3
CARI059	ALFALFA	25	11	12.2	4.3	11.5	7.5	26.8
CARI618	ALFALFA	50	9	13.1	3.5	11.7	7.3	28.5
CARI181	ALFALFA	7	10	21.3	8.7	11.1	5.2	28.9
CARI714	ALFALFA	5	10	26.9	13.0	11.4	4.3	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Allocations Based on System Types, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	26.9	7.0	16960	6560	10400	260
CARI593	ALFALFA	28.9	28.2	7.4	17800	6480	11320	283
CARI688	S/GRAIN	0.2	0.2	2.3	6840	6520	320	8
		0.9	0.9					
		3.3	3.3					
		2.5	2.5					
		9.2	6.2					
CARI836	PASTURE	27.4	20.4	2.0	1550	3850	-2300	-46
CARI525	PASTURE	26.9	23.8	2.4	370	830	-460	-46
CARI750	S/GRAIN	0.4	0.4	1.7	2500	3260	-760	-38
		1.1	1.1					
		3.8	3.8					
		2.5	2.5					
		8.7	4.6					
CARI142	PASTURE	27.5	23.6	2.3	720	1960	-1240	-62
CARI950	ALFALFA	29.0	17.2	4.5	21760	11280	10480	131
CARI011	ALFALFA	28.9	28.2	7.4	6675	2850	3825	255
CARI066	ALFALFA	28.9	28.1	7.4	13290	5010	8280	276
CARI122	ALFALFA	28.9	28.1	7.4	6645	2850	3795	253
CARI474	ALFALFA	28.9	28.1	7.4	13290	5010	8280	276
CARI299	ALFALFA	28.9	28.2	7.4	13320	5010	8310	277
CARI869	ALFALFA	28.9	25.1	6.6	13860	5495	8365	239
CARI958	CORN/SL	0.0	0.0	19.0	10425	5250	5175	207
		3.2	3.2					
		4.6	4.6					
		5.6	3.8					
CARI481	ALFALFA	28.9	25.8	6.7	12210	5250	6960	232
CARI986	S/GRAIN	0.2	0.2	3.5	2590	2040	550	55
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	9.0					
CARI399	CORN/SL	0.0	0.0	16.8	3680	2400	1280	128
		3.4	3.4					
		4.8	4.8					
		5.5	3.0					
CARI640	ALFALFA	29.0	26.1	6.8	4100	1870	2230	223
CARI059	ALFALFA	28.9	23.7	6.2	9300	4050	5250	210
CARI618	ALFALFA	28.7	26.1	6.9	20650	7700	12950	259
CARI181	ALFALFA	28.9	26.8	7.0	2961	1246	1715	245
CARI714	ALFALFA	28.9	28.0	7.3	2205	915	1290	258

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Based on System Types, Normal Year

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	69.8	6.7
CARI593	51.0	9.1	89.4	8.6
CARI688	40.0	7.1	87.2	8.4
CARI836	39.0	7.0	88.9	8.6
CARI525	12.5	2.2	28.6	2.8
CARI750	15.0	2.7	32.2	3.1
CARI142	26.0	4.6	46.2	4.5
CARI950	12.0	2.1	23.7	2.3
CARI011	19.0	3.4	33.2	3.2
CARI066	38.0	6.8	66.0	6.4
CARI122	19.0	3.4	34.3	3.3
CARI474	38.0	6.8	69.9	6.7
CARI299	38.0	6.8	63.9	6.2
CARI869	23.0	4.1	46.4	4.5
CARI958	20.0	3.6	45.6	4.4
CARI481	27.0	4.8	39.5	3.8
CARI986	19.0	3.4	36.2	3.5
CARI399	8.0	1.4	17.9	1.7
CARI640	8.0	1.4	16.0	1.5
CARI059	14.0	2.5	23.2	2.2
CARI618	41.0	7.3	48.7	4.7
CARI181	7.0	1.2	15.8	1.5
CARI714	6.3	1.1	14.6	1.4

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 106,015.00

AVERAGE WAITING TIME (DAYS) = 42

TOTAL WATER ALLOCATED (ACRE-FT) = 1037.1

RESOURCE UTILIZATION RATIO = 0.91

Summary of Water Use by Fields/Users During a Wet Year,
Allocations Based on System Types Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	16.1	2.7	17.5	-1.2	29.7
CARI593	ALFALFA	40	10	20.8	6.2	17.0	-2.0	29.6
CARI688	S/GRAIN	40	9	21.4	16.1	14.3	3.3	22.9
CARI836	PASTURE	50	10	17.9	9.4	17.3	2.7	28.5
CARI525	PASTURE	10	10	26.7	17.5	17.8	1.4	28.4
CARI750	S/GRAIN	20	10	16.2	11.2	14.0	3.0	22.0
CARI142	PASTURE	20	10	21.4	11.0	17.1	1.5	28.9
CARI950	ALFALFA	80	10	3.3	0.0	17.8	5.7	26.7
CARI011	ALFALFA	15	12	23.8	11.8	19.3	-1.8	29.5
CARI066	ALFALFA	30	12	23.9	12.3	19.3	-1.5	29.5
CARI122	ALFALFA	15	10	21.0	6.1	16.9	-2.2	29.6
CARI474	ALFALFA	30	10	21.3	6.0	16.7	-2.3	29.6
CARI299	ALFALFA	30	10	20.7	6.2	17.3	-2.2	29.6
CARI869	ALFALFA	35	11	17.2	7.4	19.3	0.6	29.7
CARI958	CORN/SL	25	9	18.5	12.6	14.5	0.9	21.2
CARI481	ALFALFA	30	12	16.9	6.7	19.3	-0.1	29.5
CARI986	S/GRAIN	10	9	35.1	27.2	14.2	1.0	23.2
CARI399	CORN/SL	10	10	16.9	11.7	14.9	0.8	21.0
CARI640	ALFALFA	10	10	17.5	5.1	17.8	-0.5	29.8
CARI059	ALFALFA	25	11	12.8	1.7	16.7	1.7	29.5
CARI618	ALFALFA	50	9	13.2	1.4	17.4	0.6	29.8
CARI181	ALFALFA	7	10	22.6	8.8	17.5	-1.6	29.7
CARI714	ALFALFA	5	10	28.7	13.7	17.1	-2.5	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, and Benefit, Allocations Based on System Types, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	CUMULATIVE TRANSPIRATION ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	6560	11640	291
CARI593	ALFALFA	28.9	28.9	7.6	18200	6480	11720	293
CARI688	S/GRAIN	0.5	0.5	3.3	9760	6520	3240	81
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.0					
CARI836	PASTURE	27.4	25.6	2.5	1950	3850	-1900	-38
CARI525	PASTURE	26.9	26.9	2.7	420	830	-410	-41
CARI750	S/GRAIN	0.7	0.7	1.9	2860	3260	-400	-20
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.0	4.3					
CARI142	PASTURE	27.5	27.5	2.7	840	1960	-1120	-56
CARI950	ALFALFA	29.0	18.9	4.9	23760	11280	12480	156
CARI011	ALFALFA	30.9	30.9	7.6	6825	2940	3885	259
CARI066	ALFALFA	30.9	30.9	7.6	13650	5190	8460	282
CARI122	ALFALFA	28.9	28.9	7.6	6825	2850	3975	265
CARI474	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI299	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI869	ALFALFA	30.9	30.8	7.5	15855	5600	10255	293
CARI958	CORN/SL	0.0	0.0	23.0	12625	5250	7375	295
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	30.9	7.6	13650	5430	8220	274
CARI986	S/GRAIN	0.2	0.2	3.8	2810	2040	770	77
		1.5	1.5					
		4.4	4.4					
		2.7	2.7					
		7.4	7.4					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2400	2590	259
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1870	2680	268
CARI059	ALFALFA	28.9	27.6	7.2	10850	4050	6800	272
CARI618	ALFALFA	28.7	28.7	7.6	22750	7700	15050	301
CARI181	ALFALFA	28.9	28.9	7.6	3185	1246	1939	277
CARI714	ALFALFA	28.9	28.9	7.6	2275	915	1360	272

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Allocations Based on System Types, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	71.0	6.6
CARI593	51.0	9.1	90.8	8.5
CARI688	40.0	7.1	91.4	8.5
CARI836	39.0	7.0	91.5	8.5
CARI525	12.5	2.2	30.1	2.8
CARI750	15.0	2.7	33.1	3.1
CARI142	26.0	4.6	46.7	4.4
CARI950	12.0	2.1	23.3	2.2
CARI011	19.0	3.4	39.2	3.7
CARI066	38.0	6.8	78.4	7.3
CARI122	19.0	3.4	34.6	3.2
CARI474	38.0	6.8	69.8	6.5
CARI299	38.0	6.8	60.4	5.6
CARI869	23.0	4.1	55.6	5.2
CARI958	20.0	3.6	42.8	4.0
CARI481	27.0	4.8	42.0	3.9
CARI986	19.0	3.4	41.0	3.8
CARI399	8.0	1.4	15.8	1.5
CARI640	8.0	1.4	16.8	1.6
CARI059	14.0	2.5	21.0	2.0
CARI618	41.0	7.3	45.7	4.3
CARI181	7.0	1.2	17.2	1.6
CARI714	6.3	1.1	15.7	1.5

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 125,889.00

AVERAGE WAITING TIME (DAYS) = 38

TOTAL WATER ALLOCATED (ACRE-FT) = 1073.8

RESOURCE UTILIZATION RATIO = 0.89

Summary of Water Use by Field/User During a Dry Year, with Water Rotated Based on Low Labor Cost Scheme.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	10.5	0.0	5.4	5.2	21.1
CARI593	ALFALFA	40	10	13.5	0.0	5.4	5.1	24.0
CARI688	S/GRAIN	40	9	17.6	10.8	4.0	6.0	16.8
CARI836	PASTURE	50	10	14.4	3.8	5.4	5.1	21.0
CARI525	PASTURE	10	10	21.2	7.7	5.4	5.1	24.0
CARI750	S/GRAIN	20	10	13.1	6.7	4.0	6.0	16.4
CARI142	PASTURE	20	10	22.5	8.4	5.4	4.8	24.3
CARI950	ALFALFA	80	10	1.6	0.0	5.4	5.2	12.1
CARI011	ALFALFA	15	11	14.3	0.0	4.8	5.8	24.8
CARI066	ALFALFA	30	11	14.4	0.2	4.8	5.8	24.8
CARI122	ALFALFA	15	10	13.6	0.0	5.4	5.0	24.0
CARI474	ALFALFA	30	10	13.7	0.0	5.4	5.0	24.0
CARI299	ALFALFA	30	10	13.4	0.0	5.4	5.1	23.9
CARI869	ALFALFA	35	11	7.4	0.0	4.8	5.9	18.1
CARI958	CORN/SL	25	9	14.8	4.3	2.6	3.3	16.4
CARI481	ALFALFA	30	11	10.2	0.0	4.8	5.9	20.9
CARI986	S/GRAIN	10	9	26.8	16.2	4.0	5.1	19.7
CARI399	CORN/SL	10	10	14.2	4.7	2.6	3.8	15.9
CARI640	ALFALFA	10	10	8.4	0.0	5.4	5.1	18.9
CARI059	ALFALFA	25	10	6.1	0.0	5.2	5.1	16.4
CARI618	ALFALFA	50	9	8.5	0.0	5.6	5.2	19.3
CARI181	ALFALFA	7	10	10.6	0.0	5.4	5.2	21.1
CARI714	ALFALFA	5	10	13.3	0.0	5.4	5.1	23.7

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Low Labor Cost Scheme Strategy, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE- FIT $	BENE- FIT/A $/AC
CARI430	ALFALFA	28.9	15.8	4.1	9960	6560	3400	85
CARI593	ALFALFA	28.9	19.8	5.2	12520	6480	6040	151
CARI688	S/GRAIN	0.1	0.1	1.3	3920	6520	-2600	-65
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	3.8					
CARI836	PASTURE	27.4	16.8	1.6	1250	3850	-2600	-52
CARI525	PASTURE	26.9	20.5	2.0	320	830	-510	-51
CARI750	S/GRAIN	0.1	0.1	1.0	1580	3260	-1680	-84
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	3.1					
CARI142	PASTURE	27.5	20.7	2.0	620	1960	-1340	-67
CARI950	ALFALFA	29.0	6.5	1.7	8320	11280	-2960	-37
CARI011	ALFALFA	29.0	21.2	5.5	4995	2895	2100	140
CARI066	ALFALFA	29.0	21.3	5.5	10020	5100	4920	164
CARI122	ALFALFA	28.9	20.0	5.2	4725	2850	1875	125
CARI474	ALFALFA	28.9	19.9	5.2	9420	5010	4410	147
CARI299	ALFALFA	28.9	19.8	5.2	9390	5010	4380	146
CARI869	ALFALFA	29.0	13.6	3.5	7490	5600	1890	54
CARI958	CORN/SL	0.0	0.0	7.3	4000	5250	-1250	-50
		3.6	3.6					
		4.3	3.8					
		5.6	1.0					
CARI481	ALFALFA	29.0	16.7	4.3	7860	5340	2520	84
CARI986	S/GRAIN	0.1	0.1	2.5	1890	2040	-150	-15
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	6.9					
CARI399	CORN/SL	0.0	0.0	5.3	1160	2400	-1240	-124
		3.9	3.9					
		4.3	3.5					
		5.5	0.7					
CARI640	ALFALFA	29.0	12.7	3.3	2000	1870	130	13
CARI059	ALFALFA	28.9	10.9	2.8	4325	3975	350	14
CARI618	ALFALFA	28.7	13.0	3.4	10300	7700	2600	52
CARI181	ALFALFA	28.9	15.9	4.2	1757	1246	511	73
CARI714	ALFALFA	28.9	19.6	5.1	1545	915	630	126

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Based on Low Labor Cost Scheme, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	46.1	6.6
CARI593	51.0	9.1	59.0	8.5
CARI688	40.0	7.1	73.3	10.6
CARI836	39.0	7.0	76.2	11.0
CARI525	12.5	2.2	24.6	3.5
CARI750	15.0	2.7	27.0	3.9
CARI142	26.0	4.6	50.8	7.3
CARI950	12.0	2.1	10.0	1.4
CARI011	19.0	3.4	23.7	3.4
CARI066	38.0	6.8	47.3	6.8
CARI122	19.0	3.4	22.4	3.2
CARI474	38.0	6.8	43.8	6.3
CARI299	38.0	6.8	41.1	5.9
CARI869	23.0	4.1	22.1	3.2
CARI958	20.0	3.6	28.6	4.1
CARI481	27.0	4.8	21.0	3.0
CARI986	19.0	3.4	27.9	4.0
CARI399	8.0	1.4	9.5	1.4
CARI640	8.0	1.4	7.8	1.1
CARI059	14.0	2.5	5.7	0.8
CARI618	41.0	7.3	11.2	1.6
CARI181	7.0	1.2	8.1	1.2
CARI714	6.3	1.1	7.3	1.0

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 21,426.00

AVERAGE WAITING TIME (DAYS) = 90

TOTAL WATER ALLOCATED (ACRE-FT) = 694.3

RESOURCE UTILIZATION RATIO = 0.85

Summary of Water Use by Field/User During a Normal Year, with the Low Labor Cost Scheme Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	14.8	4.3	11.1	7.2	28.9
CARI593	ALFALFA	40	10	19.0	6.7	11.1	6.2	29.6
CARI688	S/GRAIN	40	9	23.7	16.2	7.4	5.3	20.3
CARI836	PASTURE	50	10	20.0	10.8	11.4	4.3	24.9
CARI525	PASTURE	10	10	27.1	15.7	11.1	4.0	26.5
CARI750	S/GRAIN	20	10	18.1	12.1	7.9	5.8	19.7
CARI142	PASTURE	20	10	28.7	16.5	11.4	3.3	26.9
CARI950	ALFALFA	80	10	2.2	0.0	11.1	8.2	21.5
CARI011	ALFALFA	15	10	18.7	6.5	11.1	6.3	29.6
CARI066	ALFALFA	30	10	18.8	6.9	11.1	6.5	29.6
CARI122	ALFALFA	15	10	19.4	7.1	11.4	5.8	29.6
CARI474	ALFALFA	30	10	19.9	7.3	11.4	5.5	29.6
CARI299	ALFALFA	30	10	18.9	6.9	11.4	6.1	29.6
CARI869	ALFALFA	35	10	9.8	2.4	11.1	8.2	26.7
CARI958	CORN/SL	25	9	21.5	9.4	6.8	1.2	20.1
CARI481	ALFALFA	30	10	13.4	4.2	11.1	7.9	28.1
CARI986	S/GRAIN	10	9	33.3	21.9	6.9	3.5	21.9
CARI399	CORN/SL	10	10	20.2	8.3	6.8	1.1	19.7
CARI640	ALFALFA	10	10	11.9	2.6	11.1	7.8	28.3
CARI059	ALFALFA	25	10	10.1	2.9	11.5	6.6	25.3
CARI618	ALFALFA	50	9	12.0	2.8	11.7	7.7	28.5
CARI181	ALFALFA	7	10	15.0	4.5	11.1	7.3	28.9
CARI714	ALFALFA	5	10	18.9	6.9	11.4	6.1	29.5

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Low Labor Cost Scheme, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	26.7	7.0	16880	6560	10320	258
CARI593	ALFALFA	28.9	28.3	7.4	17880	6480	11400	285
CARI688	S/GRAIN	0.2	0.2	2.3	7000	6520	480	12
		0.9	0.9					
		3.3	3.3					
		2.5	2.5					
		9.2	6.3					
CARI836	PASTURE	27.4	21.3	2.1	1600	3850	-2250	-45
CARI525	PASTURE	26.9	23.7	2.4	370	830	-460	-46
CARI750	S/GRAIN	0.4	0.4	1.8	2740	3260	-520	-26
		1.1	1.1					
		3.8	3.8					
		2.5	2.5					
		8.7	4.9					
CARI142	PASTURE	27.5	24.1	2.3	720	1960	-1240	-62
CARI950	ALFALFA	29.0	16.3	4.3	20560	11280	9280	116
CARI011	ALFALFA	28.9	28.3	7.4	6690	2850	3840	256
CARI066	ALFALFA	28.9	28.0	7.3	13260	5010	8250	275
CARI122	ALFALFA	28.9	28.1	7.4	6645	2850	3795	253
CARI474	ALFALFA	28.9	28.1	7.3	13260	5010	8250	275
CARI299	ALFALFA	28.9	28.2	7.4	13320	5010	8310	277
CARI869	ALFALFA	28.9	23.1	6.0	12740	5495	7245	207
CARI958	CORN/SL	0.0	0.0	19.4	10625	5250	5375	215
		3.2	3.2					
		4.6	4.6					
		5.6	3.9					
CARI481	ALFALFA	28.9	25.5	6.7	12060	5250	6810	227
CARI986	S/GRAIN	0.2	0.2	3.5	2610	2040	570	57
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	9.0					
CARI399	CORN/SL	0.0	0.0	17.5	3840	2400	1440	144
		3.4	3.4					
		4.8	4.8					
		5.5	3.2					
CARI640	ALFALFA	29.0	25.4	6.6	4000	1870	2130	213
CARI059	ALFALFA	28.9	21.0	5.5	8275	3975	4300	172
CARI618	ALFALFA	28.7	25.8	6.8	20450	7700	12750	255
CARI181	ALFALFA	28.9	26.7	7.0	2954	1246	1708	244
CARI714	ALFALFA	28.9	28.0	7.3	2205	915	1290	258

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Low Labor Cost Scheme Strategy, Normal Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	64.9	6.3
CARI593	51.0	9.1	83.0	8.1
CARI688	40.0	7.1	102.1	9.9
CARI836	39.0	7.0	102.5	9.9
CARI525	12.5	2.2	34.0	3.3
CARI750	15.0	2.7	36.9	3.6
CARI142	26.0	4.6	72.8	7.1
CARI950	12.0	2.1	16.0	1.5
CARI011	19.0	3.4	30.8	3.0
CARI066	38.0	6.8	61.6	6.0
CARI122	19.0	3.4	32.1	3.1
CARI474	38.0	6.8	65.6	6.4
CARI299	38.0	6.8	60.6	5.9
CARI869	23.0	4.1	32.1	3.1
CARI958	20.0	3.6	49.2	4.8
CARI481	27.0	4.8	34.3	3.3
CARI986	19.0	3.4	43.0	4.2
CARI399	8.0	1.4	20.1	1.9
CARI640	8.0	1.4	11.9	1.2
CARI059	14.0	2.5	19.6	1.9
CARI618	41.0	7.3	36.5	3.5
CARI181	7.0	1.2	11.3	1.1
CARI714	6.3	1.1	10.3	1.0

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 103,073.00

AVERAGE WAITING TIME (DAYS) = 43

TOTAL WATER ALLOCATED (ACRE-FT) = 1031.1

RESOURCE UTILIZATION RATIO = 0.90

Summary of Water Use by Field/User During a Wet Year,
with Low Labor Cost Scheme Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	10	15.0	2.1	17.5	-0.8	29.7
CARI593	ALFALFA	40	10	19.2	4.7	17.0	-1.9	29.6
CARI688	S/GRAIN	40	9	25.3	20.0	14.3	3.3	22.8
CARI836	PASTURE	50	10	21.2	12.5	17.3	2.6	28.5
CARI525	PASTURE	10	10	28.7	19.4	17.8	1.4	28.4
CARI750	S/GRAIN	20	10	19.2	14.1	14.0	2.8	21.9
CARI142	PASTURE	20	10	30.4	19.7	17.1	1.1	28.9
CARI950	ALFALFA	80	10	2.3	0.0	17.8	5.7	25.7
CARI011	ALFALFA	15	12	21.7	9.8	19.3	-1.8	29.5
CARI066	ALFALFA	30	12	21.8	10.2	19.3	-1.5	29.5
CARI122	ALFALFA	15	10	19.6	4.7	16.9	-2.2	29.6
CARI474	ALFALFA	30	10	19.6	4.5	16.7	-2.2	29.6
CARI299	ALFALFA	30	10	19.3	4.9	17.3	-2.2	29.6
CARI869	ALFALFA	35	12	11.3	2.7	19.3	1.6	29.5
CARI958	CORN/SL	25	9	22.8	16.9	14.5	0.9	21.2
CARI481	ALFALFA	30	12	15.5	5.2	19.3	-0.1	29.5
CARI986	S/GRAIN	10	9	36.5	28.6	14.2	1.1	23.2
CARI399	CORN/SL	10	10	21.0	15.5	14.9	0.8	21.3
CARI640	ALFALFA	10	10	12.0	0.6	17.8	0.5	29.8
CARI059	ALFALFA	25	10	8.9	0.0	16.7	3.9	29.5
CARI618	ALFALFA	50	9	12.2	0.8	17.4	0.9	29.8
CARI181	ALFALFA	7	10	15.1	2.2	17.5	-0.7	29.7
CARI714	ALFALFA	5	10	19.3	4.7	17.1	-2.1	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Low Labor Cost Scheme Strategy, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	6560	11640	291
CARI593	ALFALFA	28.9	28.9	7.6	18200	6480	11720	293
CARI688	S/GRAIN	0.5	0.5	3.2	9640	6520	3120	78
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.0					
CARI836	PASTURE	27.4	25.7	2.5	1950	3850	-1900	-38
CARI525	PASTURE	26.9	26.9	2.7	420	830	-410	-41
CARI750	S/GRAIN	0.7	0.7	1.9	2840	3260	-420	-21
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.0	4.3					
CARI142	PASTURE	27.5	27.5	2.7	840	1960	-1120	-56
CARI950	ALFALFA	29.0	17.2	4.5	21680	11280	10400	130
CARI011	ALFALFA	30.9	30.9	7.6	6825	2940	3885	259
CARI066	ALFALFA	30.9	30.9	7.6	13650	5190	8460	282
CARI122	ALFALFA	28.9	28.9	7.6	6825	2850	3975	265
CARI474	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI299	ALFALFA	28.9	28.9	7.6	13650	5010	8640	288
CARI869	ALFALFA	30.9	30.8	7.5	15855	5705	10150	290
CARI958	CORN/SL	0.0	0.0	23.0	12625	5250	7375	295
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	30.9	7.6	13650	5430	8220	274
CARI986	S/GRAIN	0.2	0.2	3.8	2810	2040	770	77
		1.5	1.5					
		4.4	4.4					
		2.7	2.7					
		7.4	7.4					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2400	2590	259
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	1870	2680	268
CARI059	ALFALFA	28.9	27.6	7.2	10850	3975	6875	275
CARI618	ALFALFA	28.7	28.7	7.6	22750	7700	15050	301
CARI181	ALFALFA	28.9	28.9	7.6	3185	1246	1939	277
CARI714	ALFALFA	28.9	28.9	7.6	2275	915	1360	272

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, Low Labor Cost Scheme Strategy, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	66.0	6.1
CARI593	51.0	9.1	84.4	7.8
CARI688	40.0	7.1	109.4	10.2
CARI836	39.0	7.0	108.4	10.1
CARI525	12.5	2.2	35.7	3.3
CARI750	15.0	2.7	39.4	3.7
CARI142	26.0	4.6	77.3	7.2
CARI950	12.0	2.1	15.6	1.5
CARI011	19.0	3.4	35.8	3.3
CARI066	38.0	6.8	71.6	6.6
CARI122	19.0	3.4	32.2	3.0
CARI474	38.0	6.8	64.9	6.0
CARI299	38.0	6.8	57.2	5.3
CARI869	23.0	4.1	35.9	3.3
CARI958	20.0	3.6	49.3	4.6
CARI481	27.0	4.8	35.7	3.3
CARI986	19.0	3.4	48.7	4.5
CARI399	8.0	1.4	20.9	1.9
CARI640	8.0	1.4	12.7	1.2
CARI059	14.0	2.5	15.0	1.4
CARI618	41.0	7.3	38.7	3.6
CARI181	7.0	1.2	11.5	1.1
CARI714	6.3	1.1	10.5	1.0

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 123,639.00

AVERAGE WAITING TIME (DAYS) = 38

TOTAL WATER ALLOCATED (ACRE-FT) = 1076.6

RESOURCE UTILIZATION RATIO = 0.90

Summary of Water Use by Field/User During a Dry Year,
One-Time Delivery Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	1	10.5	0.0	5.4	5.2	21.0
CARI593	ALFALFA	40	1	10.5	0.0	5.4	5.2	21.0
CARI688	S/GRAIN	40	1	3.1	0.5	4.0	6.0	12.6
CARI836	PASTURE	50	1	5.3	0.0	5.4	5.2	15.8
CARI525	PASTURE	10	1	4.7	0.0	5.4	5.2	15.3
CARI750	S/GRAIN	20	1	3.8	0.3	4.0	6.0	13.5
CARI142	PASTURE	20	1	5.1	0.0	5.4	5.2	15.7
CARI950	ALFALFA	80	1	9.1	0.0	5.4	5.2	19.6
CARI011	ALFALFA	15	1	10.5	0.0	4.8	6.0	21.3
CARI066	ALFALFA	30	1	7.4	0.0	4.8	6.0	18.1
CARI122	ALFALFA	15	1	10.5	0.0	5.4	5.2	21.0
CARI474	ALFALFA	30	1	10.5	0.0	5.4	5.2	21.0
CARI299	ALFALFA	30	1	10.5	0.0	5.4	5.2	21.0
CARI869	ALFALFA	35	1	9.9	0.0	4.8	6.0	20.7
CARI958	CORN/SL	25	1	8.4	0.0	2.6	6.6	17.5
CARI481	ALFALFA	30	1	9.9	0.3	4.8	6.0	20.4
CARI986	S/GRAIN	10	1	2.6	0.7	4.0	6.0	11.9
CARI399	CORN/SL	10	1	7.9	0.0	2.6	6.6	17.1
CARI640	ALFALFA	10	1	10.2	0.0	5.4	5.2	20.7
CARI059	ALFALFA	25	1	10.3	0.0	5.2	5.2	20.6
CARI618	ALFALFA	50	1	10.4	0.0	5.6	5.2	21.2
CARI181	ALFALFA	7	1	10.4	0.0	5.4	5.2	21.0
CARI714	ALFALFA	5	1	10.4	0.0	5.4	5.2	21.0

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Benefit, and Benefit/Acre, One-Time Delivery Strategy, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	16.5	4.3	10440	5480	4960	124
CARI593	ALFALFA	28.9	16.3	4.3	10320	5400	4920	123
CARI688	S/GRAIN	0.1	0.1	0.2	800	5560	-4760	-119
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	1.0					
CARI836	PASTURE	27.4	12.6	1.2	950	2500	-1550	-31
CARI525	PASTURE	26.9	12.1	1.2	180	560	-380	-38
CARI750	S/GRAIN	0.1	0.1	0.4	680	2720	-2040	-102
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	1.5					
CARI142	PASTURE	27.5	12.6	1.2	380	1420	-1040	-52
CARI950	ALFALFA	29.0	15.8	4.1	20000	9120	10880	136
CARI011	ALFALFA	29.0	17.5	4.6	4140	2445	1695	113
CARI066	ALFALFA	29.0	15.4	4.0	7290	4200	3090	103
CARI122	ALFALFA	28.9	16.7	4.4	3960	2445	1515	101
CARI474	ALFALFA	28.9	16.8	4.4	7950	4200	3750	125
CARI299	ALFALFA	28.9	16.5	4.3	7860	4200	3660	122
CARI869	ALFALFA	29.0	17.4	4.5	9555	4550	5005	143
CARI958	CORN/SL	0.0	0.0	15.1	8300	4650	3650	146
		3.6	3.2					
		4.3	2.7					
		5.6	4.6					
CARI481	ALFALFA	29.0	16.9	4.4	7950	4440	3510	117
CARI986	S/GRAIN	0.1	0.1	0.3	220	1800	-1580	-158
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	1.2					
CARI399	CORN/SL	0.0	0.0	14.1	3090	2130	960	96
		3.9	3.2					
		4.3	2.8					
		5.5	4.0					
CARI640	ALFALFA	29.0	16.1	4.2	2530	1600	930	93
CARI059	ALFALFA	28.9	16.1	4.2	6350	3300	3050	122
CARI618	ALFALFA	28.7	16.2	4.3	12900	6500	6400	128
CARI181	ALFALFA	28.9	16.5	4.3	1820	1057	763	109
CARI714	ALFALFA	28.9	16.6	4.4	1315	780	535	107

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, One-Time delivery Strategy, Dry Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	43.6	7.5
CARI593	51.0	9.1	47.0	8.1
CARI688	40.0	7.1	13.0	2.2
CARI836	39.0	7.0	31.8	5.5
CARI525	12.5	2.2	4.9	0.8
CARI750	15.0	2.7	8.4	1.4
CARI142	26.0	4.6	10.6	1.8
CARI950	12.0	2.1	82.5	14.2
CARI011	19.0	3.4	17.3	3.0
CARI066	38.0	6.8	23.8	4.1
CARI122	19.0	3.4	16.6	2.9
CARI474	38.0	6.8	35.8	6.2
CARI299	38.0	6.8	34.6	6.0
CARI869	23.0	4.1	35.7	6.1
CARI958	20.0	3.6	22.5	3.9
CARI481	27.0	4.8	33.4	5.8
CARI986	19.0	3.4	2.8	0.5
CARI399	8.0	1.4	8.9	1.5
CARI640	8.0	1.4	10.5	1.8
CARI059	14.0	2.5	28.7	4.9
CARI618	41.0	7.3	55.1	9.5
CARI181	7.0	1.2	7.6	1.3
CARI714	6.3	1.1	6.0	1.0

MONTH	AUG. VOLUME (acre-ft)	AUG. HR (hour)	ENERGY (kwh)	COSTS $	DISCOUNTS $	NET BILL $
APRIL	0.00	0	0	713.75	0.00	713.75
MAY	0.00	0	0	713.75	0.00	713.75
JUNE	70.09	360	17473	13192.21	506.40	12685.81
JULY	84.90	744	21165	15846.58	601.78	15244.81
AUGUST	43.48	696	10839	8668.52	335.01	8333.51
SEPTEMBER	0.00	0	0	713.75	0.00	713.75

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 198.5
TOTAL AUGMENTATION COST = $ 38,405.00

TOTAL BENEFIT TO PROJECT = $ 5,294.00
AVERAGE WAITING TIME (DAYS) = 101

TOTAL WATER ALLOCATED (ACRE-FT) = 580.8
RESOURCE UTILIZATION RATIO = 0.71

Summary of Water Use by Fields/Users During a Normal Year, One-Time Delivery Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	1	5.4	0.0	11.1	8.2	24.7
CARI593	ALFALFA	40	1	6.2	0.2	11.1	8.2	25.3
CARI688	S/GRAIN	40	1	5.6	3.3	7.4	6.3	16.1
CARI836	PASTURE	50	1	2.8	2.2	11.4	5.1	17.1
CARI525	PASTURE	10	1	2.8	1.8	11.1	5.3	17.4
CARI750	S/GRAIN	20	1	4.5	3.6	7.9	6.3	15.1
CARI142	PASTURE	20	1	2.8	2.3	11.4	5.2	17.2
CARI950	ALFALFA	80	1	6.7	0.0	11.1	8.2	26.0
CARI011	ALFALFA	15	1	5.4	0.1	11.1	8.2	24.6
CARI066	ALFALFA	30	1	5.2	0.4	11.1	8.2	24.1
CARI122	ALFALFA	15	1	7.6	0.6	11.4	8.2	26.6
CARI474	ALFALFA	30	1	5.4	0.7	11.4	8.2	24.3
CARI299	ALFALFA	30	1	5.3	0.3	11.4	8.0	24.4
CARI869	ALFALFA	35	1	10.5	0.1	11.1	6.3	27.8
CARI958	CORN/SL	25	1	4.9	0.2	6.8	6.9	18.5
CARI481	ALFALFA	30	1	8.8	0.7	11.1	8.2	27.4
CARI986	S/GRAIN	10	1	3.2	3.0	6.9	6.3	13.4
CARI399	CORN/SL	10	1	6.5	0.1	6.8	6.3	19.5
CARI640	ALFALFA	10	1	10.5	0.0	11.1	6.0	27.6
CARI059	ALFALFA	25	1	5.4	0.9	11.5	8.2	24.1
CARI618	ALFALFA	50	1	5.3	0.0	11.7	8.2	25.1
CARI181	ALFALFA	7	1	5.4	0.1	11.1	8.2	24.6
CARI714	ALFALFA	5	1	5.3	0.5	11.4	8.1	24.3

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Benefit, and Benefit/Acre, One-Time Delivery Strategy, Normal Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	21.6	5.7	13680	5480	8200	205
CARI593	ALFALFA	28.9	22.4	5.9	14160	5400	8760	219
CARI688	S/GRAIN	0.2	0.2	1.0	3040	5560	-2520	-63
		0.9	0.9					
		3.3	3.2					
		2.5	1.5					
		9.2	4.0					
CARI836	PASTURE	27.4	13.3	1.3	1000	2500	-1500	-30
CARI525	PASTURE	26.9	13.6	1.4	210	560	-350	-35
CARI750	S/GRAIN	0.4	0.4	0.4	700	2720	-2020	-101
		1.1	1.1					
		3.8	3.7					
		2.5	2.5					
		8.7	1.6					
CARI142	PASTURE	27.5	13.2	1.3	400	1420	-1020	-51
CARI950	ALFALFA	29.0	22.8	6.0	28720	9120	19600	245
CARI011	ALFALFA	28.9	21.6	5.6	5100	2445	2655	177
CARI066	ALFALFA	28.9	20.9	5.5	9900	4200	5700	190
CARI122	ALFALFA	28.9	23.5	6.2	5565	2445	3120	208
CARI474	ALFALFA	28.9	21.3	5.6	10080	4200	5880	196
CARI299	ALFALFA	28.9	21.4	5.6	10140	4200	5940	198
CARI869	ALFALFA	28.9	25.5	6.7	14070	4550	9520	272
CARI958	CORN/SL	0.0	0.0	16.2	8900	4650	4250	170
		3.2	3.2					
		4.6	4.6					
		5.6	2.9					
CARI481	ALFALFA	28.9	24.1	6.3	11400	4440	6960	232
CARI986	S/GRAIN	0.2	0.2	0.3	270	1800	-1530	-153
		0.7	0.7					
		2.9	2.9					
		2.4	2.4					
		9.6	1.4					
CARI399	CORN/SL	0.0	0.0	18.9	4160	2130	2030	203
		3.4	3.4					
		4.8	4.7					
		5.5	3.7					
CARI640	ALFALFA	29.0	25.3	6.6	3970	1600	2370	237
CARI059	ALFALFA	28.9	21.1	5.5	8300	3300	5000	200
CARI618	ALFALFA	28.7	21.8	5.7	17300	6500	10800	216
CARI181	ALFALFA	28.9	21.6	5.6	2380	1057	1323	189
CARI714	ALFALFA	28.9	21.2	5.6	1675	780	895	179

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, One-Time Delivery Strategy, Normal Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	23.9	6.0
CARI593	51.0	9.1	28.8	7.2
CARI688	40.0	7.1	22.7	5.7
CARI836	39.0	7.0	15.4	3.9
CARI525	12.5	2.2	3.0	0.7
CARI750	15.0	2.7	9.5	2.4
CARI142	26.0	4.6	6.0	1.5
CARI950	12.0	2.1	61.7	15.5
CARI011	19.0	3.4	9.0	2.3
CARI066	38.0	6.8	17.3	4.3
CARI122	19.0	3.4	12.7	3.2
CARI474	38.0	6.8	17.9	4.5
CARI299	38.0	6.8	16.6	4.2
CARI869	23.0	4.1	39.9	10.0
CARI958	20.0	3.6	13.0	3.3
CARI481	27.0	4.8	29.3	7.3
CARI986	19.0	3.4	3.4	0.9
CARI399	8.0	1.4	7.4	1.8
CARI640	8.0	1.4	11.5	2.9
CARI059	14.0	2.5	15.0	3.8
CARI618	41.0	7.3	28.1	7.0
CARI181	7.0	1.2	4.4	1.1
CARI714	6.3	1.1	2.9	0.7

MONTH	AUG. VOLUME (acre-ft)	AUG. HR (hour)	ENERGY (kwh)	COSTS $	DISCOUNTS $	NET BILL $
APRIL	0.00	0	0	713.75	0.00	713.75
MAY	0.00	0	0	713.75	0.00	713.75
JUNE	4.74	144	1182	1696.54	57.61	1638.93
JULY	0.11	48	27	737.15	1.30	735.86
AUGUST	2.18	120	543	1175.13	26.46	1148.67
SEPTEMBER	0.00	0	0	713.75	0.00	713.75

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 7.0
TOTAL AUGMENTATION COST = $ 5,665.00

TOTAL BENEFIT TO PROJECT = $ 84,175.00
AVERAGE WAITING TIME (DAYS) = 67

TOTAL WATER ALLOCATED (ACRE-FT) = 399.3
RESOURCE UTILIZATION RATIO = 0.35

Summary of Water Use by Fields/Users During a Wet Year,
One-Time Delivery Strategy.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	1	9.1	0.0	17.5	3.1	29.7
CARI593	ALFALFA	40	1	5.4	0.0	17.0	6.1	28.5
CARI688	S/GRAIN	40	1	4.3	4.7	14.3	6.1	20.0
CARI836	PASTURE	50	1	2.6	1.3	17.3	5.1	23.8
CARI525	PASTURE	10	1	2.6	1.6	17.8	4.8	23.6
CARI750	S/GRAIN	20	1	6.2	4.7	14.0	5.8	21.2
CARI142	PASTURE	20	1	2.6	1.1	17.1	5.3	23.8
CARI950	ALFALFA	80	1	7.6	0.0	17.8	4.4	29.8
CARI011	ALFALFA	15	1	5.3	0.5	19.3	5.4	29.5
CARI066	ALFALFA	30	1	5.1	0.8	19.3	5.6	29.2
CARI122	ALFALFA	15	1	5.9	0.0	16.9	6.3	29.1
CARI474	ALFALFA	30	1	9.8	0.0	16.7	3.1	29.6
CARI299	ALFALFA	30	1	5.3	0.0	17.3	5.9	28.5
CARI869	ALFALFA	35	1	5.3	0.5	19.3	5.4	29.5
CARI958	CORN/SL	25	1	5.2	1.1	14.5	1.8	20.4
CARI481	ALFALFA	30	1	5.1	1.1	19.3	5.6	28.9
CARI986	S/GRAIN	10	1	2.7	4.4	14.2	6.2	18.6
CARI399	CORN/SL	10	1	4.4	1.4	14.9	2.8	20.7
CARI640	ALFALFA	10	1	9.9	0.0	17.8	2.1	29.8
CARI059	ALFALFA	25	1	5.9	0.0	16.7	6.3	28.9
CARI618	ALFALFA	50	1	5.4	0.0	17.4	6.3	29.1
CARI181	ALFALFA	7	1	5.3	0.0	17.5	5.9	28.7
CARI714	ALFALFA	5	1	5.6	0.1	17.1	6.0	28.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, One-Time Delivery Strategy, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	CUMULATIVE TRANSPIRATION ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.6	7.5	18000	5480	12520	313
CARI593	ALFALFA	28.9	23.0	6.0	14520	5400	9120	228
CARI688	S/GRAIN	0.5	0.5	0.8	2520	5560	-3040	-76
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	2.0					
CARI836	PASTURE	27.4	17.8	1.7	1350	2500	-1150	-23
CARI525	PASTURE	26.9	18.1	1.8	280	560	-280	-28
CARI750	S/GRAIN	0.7	0.7	1.8	2760	2720	40	2
		1.7	1.7					
		5.3	3.5					
		3.0	3.0					
		6.0	4.3					
CARI142	PASTURE	27.5	17.7	1.7	540	1420	-880	-44
CARI950	ALFALFA	29.0	28.2	7.4	35520	9120	26400	330
CARI011	ALFALFA	30.9	29.3	7.2	6480	2445	4035	269
CARI066	ALFALFA	30.9	28.6	7.0	12660	4200	8460	282
CARI122	ALFALFA	28.9	24.2	6.3	5715	2445	3270	218
CARI474	ALFALFA	28.9	27.9	7.3	13200	4200	9000	300
CARI299	ALFALFA	28.9	22.9	6.0	10830	4200	6630	221
CARI869	ALFALFA	30.9	29.3	7.2	15120	4550	10570	302
CARI958	CORN/SL	0.0	0.0	23.0	12625	4650	7975	319
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	28.3	6.9	12480	4440	8040	268
CARI986	S/GRAIN	0.2	0.2	0.4	320	1800	-1480	-148
		1.5	1.5					
		4.4	4.4					
		2.7	2.6					
		7.4	1.3					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2130	2860	286
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	28.0	7.3	4400	1600	2800	280
CARI059	ALFALFA	28.9	24.2	6.3	9525	3300	6225	249
CARI618	ALFALFA	28.7	23.9	6.3	18950	6500	12450	249
CARI181	ALFALFA	28.9	23.4	6.1	2590	1057	1533	219
CARI714	ALFALFA	28.9	23.1	6.1	1825	780	1045	209

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock Relative to Allocation Received and in Percentages, One-Time Delivery Strategy, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	40.0	10.3
CARI593	51.0	9.1	22.6	5.8
CARI688	40.0	7.1	19.0	4.9
CARI836	39.0	7.0	15.7	4.0
CARI525	12.5	2.2	2.9	0.7
CARI750	15.0	2.7	13.3	3.4
CARI142	26.0	4.6	5.7	1.5
CARI950	12.0	2.1	65.2	16.7
CARI011	19.0	3.4	8.8	2.3
CARI066	38.0	6.8	16.0	4.1
CARI122	19.0	3.4	8.9	2.3
CARI474	38.0	6.8	32.8	8.4
CARI299	38.0	6.8	17.2	4.4
CARI869	23.0	4.1	21.3	5.5
CARI958	20.0	3.6	13.4	3.4
CARI481	27.0	4.8	16.3	4.2
CARI986	19.0	3.4	2.9	0.7
CARI399	8.0	1.4	5.1	1.3
CARI640	8.0	1.4	10.7	2.7
CARI059	14.0	2.5	16.1	4.1
CARI618	41.0	7.3	29.1	7.5
CARI181	7.0	1.2	4.1	1.1
CARI714	6.3	1.1	2.9	0.7

MONTH	AUG. VOLUME (acre-ft)	AUG. HR (hour)	ENERGY (kwh)	COSTS $	DISCOUNTS $	NET BILL $
APRIL	0.00	0	0	713.75	0.00	713.75
MAY	0.00	0	0	713.75	0.00	713.75
JUNE	0.01	24	3	720.47	0.13	720.33
JULY	0.85	144	212	913.82	10.32	903.49
AUGUST	0.00	0	0	713.75	0.00	713.75
SEPTEMBER	0.00	0	0	713.75	0.00	713.75

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.9
TOTAL AUGMENTATION COST = $ 4,479.00

TOTAL BENEFIT TO PROJECT = $ 117,441.00
AVERAGE WAITING TIME (DAYS) = 65

TOTAL WATER ALLOCATED (ACRE-FT) = 390.2
RESOURCE UTILIZATION RATIO = 0.32

Summary of Water Use by Field/User During a Dry Year, with Continuous Supply.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	16	13.0	0.0	5.4	5.1	23.5
CARI593	ALFALFA	40	16	16.5	0.0	5.4	5.1	26.9
CARI688	S/GRAIN	40	13	12.0	5.6	4.0	5.9	16.4
CARI836	PASTURE	50	16	10.2	0.3	5.4	5.1	20.4
CARI525	PASTURE	10	16	16.0	2.7	5.4	5.1	23.8
CARI750	S/GRAIN	20	13	9.3	3.8	4.0	6.0	15.6
CARI142	PASTURE	20	16	17.0	3.6	5.4	5.1	23.9
CARI950	ALFALFA	80	16	1.9	0.0	5.4	5.2	12.5
CARI011	ALFALFA	15	16	18.0	0.3	4.8	5.6	28.1
CARI066	ALFALFA	30	16	17.9	0.5	4.8	5.6	27.7
CARI122	ALFALFA	15	16	16.7	0.0	5.4	5.0	27.0
CARI474	ALFALFA	30	16	16.9	0.0	5.4	5.0	27.2
CARI299	ALFALFA	30	16	16.5	0.0	5.4	5.1	27.0
CARI869	ALFALFA	35	16	9.3	0.0	4.8	5.9	20.0
CARI958	CORN/SL	25	14	12.5	2.1	2.6	2.8	15.7
CARI481	ALFALFA	30	16	12.7	0.0	4.8	5.8	23.3
CARI986	S/GRAIN	10	13	22.0	13.1	4.0	5.8	18.8
CARI399	CORN/SL	10	14	11.9	2.7	2.6	3.5	15.2
CARI640	ALFALFA	10	16	10.3	0.0	5.4	5.1	20.8
CARI059	ALFALFA	25	16	7.5	0.0	5.2	5.1	17.8
CARI618	ALFALFA	50	16	10.5	0.0	5.6	5.2	21.3
CARI181	ALFALFA	7	16	12.9	0.0	5.4	5.1	23.4
CARI714	ALFALFA	5	16	16.4	0.0	5.4	5.1	26.8

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, with Continuous Supply, Dry Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	18.8	4.9	11840	7280	4560	114
CARI593	ALFALFA	28.9	23.6	6.2	14920	7200	7720	193
CARI688	S/GRAIN	0.1	0.1	1.0	3160	7000	-3840	-96
		0.7	0.7					
		3.8	3.8					
		2.5	2.5					
		8.9	3.2					
CARI836	PASTURE	27.4	16.2	1.6	1200	4750	-3550	-71
CARI525	PASTURE	26.9	20.2	2.0	310	1010	-700	-70
CARI750	S/GRAIN	0.1	0.1	0.7	1140	3440	-2300	-115
		0.8	0.8					
		4.1	4.1					
		2.5	2.5					
		8.6	2.4					
CARI142	PASTURE	27.5	20.1	2.0	600	2320	-1720	-86
CARI950	ALFALFA	29.0	6.7	1.7	8480	12720	-4240	-53
CARI011	ALFALFA	29.0	24.8	6.5	5850	3120	2730	182
CARI066	ALFALFA	29.0	24.5	6.4	11550	5550	6000	200
CARI122	ALFALFA	28.9	23.8	6.2	5640	3120	2520	168
CARI474	ALFALFA	28.9	24.0	6.3	11340	5550	5790	193
CARI299	ALFALFA	28.9	23.7	6.2	11220	5550	5670	189
CARI869	ALFALFA	29.0	15.2	4.0	8365	6125	2240	64
CARI958	CORN/SL	0.0	0.0	3.0	1625	5625	-4000	-160
		3.6	3.6					
		4.3	3.9					
		5.6	0.2					
CARI481	ALFALFA	29.0	19.3	5.0	9120	5790	3330	111
CARI986	S/GRAIN	0.1	0.1	2.4	1760	2160	-400	-40
		0.7	0.7					
		3.1	3.1					
		2.4	2.4					
		9.5	6.5					
CARI399	CORN/SL	0.0	0.0	1.0	220	2520	-2300	-230
		3.9	3.9					
		4.3	3.4					
		5.5	0.1					
CARI640	ALFALFA	29.0	15.4	4.0	2420	2050	370	37
CARI059	ALFALFA	28.9	12.7	3.3	5000	4425	575	23
CARI618	ALFALFA	28.7	15.8	4.2	12600	8750	3850	77
CARI181	ALFALFA	28.9	18.6	4.9	2058	1372	686	98
CARI714	ALFALFA	28.9	23.5	6.2	1855	1005	850	170

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Summary of Water Use by Field/User During a Dry Year, with Continuous Supply Strategy.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	56.6	7.7
CARI593	51.0	9.1	72.5	9.9
CARI688	40.0	7.1	52.5	7.1
CARI836	39.0	7.0	55.6	7.6
CARI525	12.5	2.2	17.6	2.4
CARI750	15.0	2.7	20.5	2.8
CARI142	26.0	4.6	37.2	5.1
CARI950	12.0	2.1	14.4	2.0
CARI011	19.0	3.4	29.4	4.0
CARI066	38.0	6.8	58.8	8.0
CARI122	19.0	3.4	27.4	3.7
CARI474	38.0	6.8	55.2	7.5
CARI299	38.0	6.8	54.0	7.3
CARI869	23.0	4.1	31.4	4.3
CARI958	20.0	3.6	29.5	4.0
CARI481	27.0	4.8	30.0	4.1
CARI986	19.0	3.4	20.8	2.8
CARI399	8.0	1.4	11.2	1.5
CARI640	8.0	1.4	9.3	1.3
CARI059	14.0	2.5	9.7	1.3
CARI618	41.0	7.3	22.8	3.1
CARI181	7.0	1.2	9.7	1.3
CARI714	6.3	1.1	8.8	1.2

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 23,841.00

AVERAGE WAITING TIME (DAYS) = 80

TOTAL WATER ALLOCATED (ACRE-FT) = 734.9

RESOURCE UTILIZATION RATIO = 0.89

Summary of Water Use by Field/User During a Wet Year, with Continuous Supply.

FIELD/ USER CODE	CROP	AREA (ac)	SEASONAL TOTAL # OF IRRG	NET IRRG (in)	DRAIN (in)	RAIN (in)	RT-Z DEPL (in)	CROP ET (in)
CARI430	ALFALFA	40	16	18.6	3.7	17.5	-2.8	29.7
CARI593	ALFALFA	40	16	23.8	8.0	17.0	-3.2	29.6
CARI688	S/GRAIN	40	13	17.6	11.5	14.3	2.6	23.0
CARI836	PASTURE	50	16	14.7	5.3	17.3	2.1	28.8
CARI525	PASTURE	10	16	22.9	13.1	17.8	0.8	28.3
CARI750	S/GRAIN	20	13	13.4	8.6	14.0	4.3	23.0
CARI142	PASTURE	20	16	24.4	13.6	17.1	1.0	28.9
CARI950	ALFALFA	80	16	2.8	0.0	17.8	5.7	26.2
CARI011	ALFALFA	15	16	27.4	15.2	19.3	-1.8	29.7
CARI066	ALFALFA	30	16	27.4	15.5	19.3	-1.5	29.7
CARI122	ALFALFA	15	16	24.0	7.9	16.9	-3.5	29.6
CARI474	ALFALFA	30	16	24.2	7.9	16.7	-3.4	29.6
CARI299	ALFALFA	30	16	23.8	8.1	17.3	-3.4	29.6
CARI869	ALFALFA	35	16	14.1	3.3	19.3	-0.7	29.5
CARI958	CORN/SL	25	14	14.3	8.6	14.5	0.2	20.4
CARI481	ALFALFA	30	16	19.4	7.9	19.3	-1.2	29.6
CARI986	S/GRAIN	10	13	32.8	24.5	14.2	0.4	23.0
CARI399	CORN/SL	10	14	14.5	8.8	14.9	0.1	20.8
CARI640	ALFALFA	10	16	14.8	1.5	17.8	-1.3	29.8
CARI059	ALFALFA	25	16	10.9	0.0	16.7	2.0	29.5
CARI618	ALFALFA	50	16	15.0	1.8	17.4	-0.8	29.8
CARI181	ALFALFA	7	16	18.7	3.8	17.5	-2.7	29.7
CARI714	ALFALFA	5	16	23.6	7.7	17.1	-3.4	29.6

RT-Z DEPL = Root Zone Depletion
NET IRRG = Applied water that infiltrated the soil surface

Cumulative Transpiration, Crop Yield, Cost, Return, Benefit, and Benefit/Acre, Continuous Supply, Wet Year.

FIELD/ USER CODE	CROP	CUMULATIVE TRANSPIRATION POT.	CUMULATIVE TRANSPIRATION ACTUAL	CROP YIELD t/ac.	TOTAL RETURN $	TOTAL COSTS $	BENE-FIT $	BENE-FIT/A $/AC
CARI430	ALFALFA	28.9	28.9	7.6	18200	7280	10920	273
CARI593	ALFALFA	28.9	28.9	7.6	18200	7200	11000	275
CARI688	S/GRAIN	0.5	0.5	3.8	11240	7000	4240	106
		1.5	1.5					
		5.1	5.1					
		2.8	2.8					
		6.7	6.7					
CARI836	PASTURE	27.4	27.4	2.7	2100	4750	-2650	-53
CARI525	PASTURE	26.9	26.9	2.7	420	1010	-590	-59
CARI750	S/GRAIN	0.7	0.7	2.7	3980	3440	540	27
		1.7	1.7					
		5.3	5.3					
		3.0	3.0					
		6.0	5.6					
CARI142	PASTURE	27.5	27.5	2.7	840	2320	-1480	-74
CARI950	ALFALFA	29.0	17.9	4.7	22480	12720	9760	122
CARI011	ALFALFA	30.9	30.9	7.6	6825	3120	3705	247
CARI066	ALFALFA	30.9	30.9	7.6	13650	5550	8100	270
CARI122	ALFALFA	28.9	28.9	7.6	6825	3120	3705	247
CARI474	ALFALFA	28.9	28.9	7.6	13650	5550	8100	270
CARI299	ALFALFA	28.9	28.9	7.6	13650	5550	8100	270
CARI869	ALFALFA	30.9	30.9	7.6	15925	6125	9800	280
CARI958	CORN/SL	0.0	0.0	23.0	12625	5625	7000	280
		4.7	4.7					
		4.0	4.0					
		5.6	5.6					
CARI481	ALFALFA	30.9	30.9	7.6	13650	5790	7860	262
CARI986	S/GRAIN	0.2	0.2	3.8	2810	2160	650	65
		1.5	1.5					
		4.4	4.4					
		2.7	2.7					
		7.4	7.4					
CARI399	CORN/SL	0.0	0.0	22.7	4990	2520	2470	247
		5.2	5.2					
		4.0	4.0					
		5.5	5.5					
CARI640	ALFALFA	29.0	29.0	7.6	4550	2050	2500	250
CARI059	ALFALFA	28.9	28.9	7.6	11375	4425	6950	278
CARI618	ALFALFA	28.7	28.7	7.6	22750	8750	14000	280
CARI181	ALFALFA	28.9	28.9	7.6	3185	1372	1813	259
CARI714	ALFALFA	28.9	28.9	7.6	2275	1005	1270	254

Cumulative transpiration at 1st growth stage for Corn and Small grain, which are zeros, are left out for clarity.

Field/User Stock relative to Allocation received and in Percentages, with Continuous Supply, Wet Year.

FIELD/ USER CODE	USER STOCK	USER STOCK AS AS A RATIO OF COMPANY STOCK (%)	USER ALLOCATION (ac-ft)	USER ALLOCATION AS A RATIO OF ALL ALLOCATIONS (%)
CARI430	40.0	7.1	81.5	7.3
CARI593	51.0	9.1	104.5	9.4
CARI688	40.0	7.1	77.3	7.0
CARI836	39.0	7.0	80.2	7.2
CARI525	12.5	2.2	25.2	2.3
CARI750	15.0	2.7	29.3	2.6
CARI142	26.0	4.6	53.7	4.8
CARI950	12.0	2.1	21.5	1.9
CARI011	19.0	3.4	44.9	4.0
CARI066	38.0	6.8	89.8	8.1
CARI122	19.0	3.4	39.7	3.6
CARI474	38.0	6.8	79.8	7.2
CARI299	38.0	6.8	76.7	6.9
CARI869	23.0	4.1	52.1	4.7
CARI958	20.0	3.6	40.1	3.6
CARI481	27.0	4.8	47.7	4.3
CARI986	19.0	3.4	34.9	3.1
CARI399	8.0	1.4	14.6	1.3
CARI640	8.0	1.4	15.3	1.4
CARI059	14.0	2.5	20.8	1.9
CARI618	41.0	7.3	54.7	4.9
CARI181	7.0	1.2	14.3	1.3
CARI714	6.3	1.1	12.9	1.2

TOTAL VOLUME OF AUGMENTATION (AC-FT) = 0.0

TOTAL AUGMENTATION COST = $ 0.00

TOTAL BENEFIT TO PROJECT = $ 117,763.00

AVERAGE WAITING TIME (DAYS) = 28

TOTAL WATER ALLOCATED (ACRE-FT) = 1111.6

RESOURCE UTILIZATION RATIO = 0.93

Appendix 7: Streamflow Data for High Creek, near Richmond, Utah.

Flow in High Creek, near Richmond, Utah, in a Dry Year
Represented by Data for Oct. 1978 to Sep. 1979. [in cfs.]

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	14	8.5	9	9	5.5	6.2	12	62	79	41	14	10
2	13	8.5	9	9	6	6.2	12	60	75	39	14	10
3	13	8.5	9	9	6	6.2	11	60	76	36	14	9.8
4	12	8	9	9	6	6.2	10	64	80	35	14	9.8
5	12	8	9	9	6	6.4	10	71	88	34	13	9.8
6	12	8	8	10	6	6.4	12	85	92	32	13	9.8
7	12	8	8	10	6	6.7	19	72	89	31	13	9.8
8	11	7.8	8	10	6	8.4	25	64	74	29	14	9.8
9	11	8	8	10	7	10	30	56	65	27	13	9.8
10	11	7.8	8	10	7	10	25	53	60	27	13	9.8
11	11	7.8	8	10	7	11	21	51	62	26	12	9.8
12	11	8	8	10	7	12	19	50	67	25	12	9.8
13	11	7.5	8	10	7	14	18	51	71	24	12	9.8
14	11	8	8	10	6.7	17	19	56	75	23	12	9.8
15	11	8	8	10	6.2	21	29	71	70	22	12	9.8
16	11	8	8	9	6.2	22	46	92	65	21	12	9.4
17	11	9	8	8	5.9	18	58	110	64	21	12	9.4
18	11	9	8	8	5.6	15	56	124	60	20	13	9.4
19	11	9	8	8	5.6	14	43	128	55	20	12	9.4
20	10	10	8	8	5.6	13	35	134	50	20	12	9.4
21	10	10	8	7	5.9	12	35	138	49	20	12	9.4
22	10	10	8	6	5.9	12	43	162	49	20	11	9.4
23	10	10	8	5.3	5.9	14	50	160	49	19	11	9.4
24	10	10	8	5.5	5.9	15	47	167	48	18	11	9.4
25	10	10	9	5.5	5.4	18	44	165	48	17	11	9.4
26	9.8	10	9	5.5	5.6	18	44	167	46	17	11	9.1
27	9.8	10	9	5.5	6.2	17	50	167	46	16	10	9.1
28	9.4	10	9	5.5	6.2	16	53	171	44	16	10	9.1
29	9	10	9	5.5	--	15	58	152	43	15	10	9.1
30	9	10	9	5.5	--	14	62	112	42	15	10	9.1
31	9	--	9	5.5	--	13	--	89	--	15	10	--

Flow in High Creek, near Richmond, Utah, in a Normal Year Represented by Data for Oct. 1985 to Sep. 1986. [in cfs.]

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	12	11	11	9.5	14	43	98	80	376	100	28	9.9
2	10	9.8	11	9.5	14	43	82	92	474	104	27	10
3	10	9.7	11	9.4	14	42	72	113	357	104	27	10
4	10	11	11	9.1	13	43	68	127	386	103	26	10
5	10	12	11	9.1	13	44	68	109	359	95	25	11
6	10	12	11	8.9	13	44	72	99	311	82	25	11
7	12	12	11	8.7	12	44	72	83	248	78	24	11
8	13	12	11	8.7	11	58	66	75	223	76	23	12
9	11	12	10	8.8	11	86	63	71	175	77	23	13
10	11	10	9.6	8.8	10	66	61	72	145	72	22	14
11	11	11	9.2	8.6	9.8	55	61	81	145	65	22	14
12	11	11	9	8.5	9.4	49	59	83	152	59	21	14
13	11	11	8.9	8.7	9.5	45	59	80	158	57	20	13
14	9.7	11	9.1	9	9.7	42	56	80	164	56	20	13
15	9.4	11	9.1	9.3	14	39	59	75	167	56	19	13
16	9.3	11	9.1	9.2	18	36	61	70	166	56	18	13
17	8.8	11	9.2	11	24	33	61	67	164	55	17	12
18	8.8	11	10	11	55	30	57	69	162	51	17	12
19	8.8	11	10	12	74	29	53	85	162	48	17	12
20	8.8	11	10	13	58	27	51	116	147	46	17	12
21	9.8	10	10	13	38	27	52	148	145	44	15	12
22	12	9.7	10	13	25	30	64	152	132	43	16	12
23	12	9.8	10	12	26	34	104	128	128	41	15	10
24	13	10	9.2	11	29	39	111	124	128	41	14	13
25	13	12	9.1	11	42	44	103	136	123	40	14	15
26	13	12	9.1	11	49	40	96	175	118	40	13	14
27	13	11	8.9	11	48	41	84	229	115	41	12	13
28	13	11	8.8	11	45	48	84	236	110	40	12	13
29	12	11	8.8	11	--	57	87	275	109	39	12	12
30	12	11	8.9	11	--	70	80	367	105	33	12	13
31	11	--	9.7	12	--	107	--	359	--	29	11	--

Flow in High Creek, near Richmond, Utah, in a Wet Year
Represented by Data for Oct. 1982 to Sep. 1983. [in cfs.]

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	28	22	14	10	11	16	25	75	266	118	39	19
2	28	22	14	10	11	16	24	75	225	123	38	19
3	28	21	14	10	11	19	22	70	206	119	37	20
4	27	21	14	10	11	21	21	68	210	114	35	19
5	25	20	14	11	11	20	20	83	198	109	34	18
6	23	20	14	11	11	20	19	91	190	111	33	18
7	22	19	14	11	12	19	18	81	206	113	31	17
8	21	18	14	11	12	18	18	80	222	117	30	17
9	21	18	14	11	12	17	18	94	241	114	32	17
10	20	17	14	11	12	19	19	80	204	108	30	17
11	19	17	14	11	11	27	20	68	230	92	29	16
12	19	16	14	11	11	37	20	58	225	83	28	16
13	19	16	13	11	12	35	20	53	169	78	27	16
14	19	16	13	11	12	36	20	50	143	75	27	16
15	19	16	13	11	12	34	19	49	143	73	26	15
16	20	16	13	11	12	30	20	49	153	67	25	15
17	20	15	13	11	12	27	24	49	169	63	25	15
18	19	15	13	11	12	26	32	51	223	59	27	15
19	18	16	13	11	12	24	38	66	225	57	26	15
20	16	16	13	11	12	22	48	76	192	55	27	15
21	16	16	13	11	11	21	49	82	172	53	26	15
22	16	15	13	11	11	21	52	90	175	51	25	14
23	16	14	13	11	11	20	58	101	183	50	24	15
24	16	14	13	11	13	19	73	117	190	48	23	15
25	16	14	13	11	14	19	83	137	174	51	22	14
26	18	14	13	11	16	18	70	201	163	48	22	14
27	20	14	12	11	16	18	60	295	165	45	21	15
28	20	14	11	11	16	18	55	302	151	46	21	15
29	20	14	10	11	--	18	55	351	127	44	21	15
30	20	14	10	11	--	19	60	391	118	41	20	15
31	22	--	10	11	--	25	--	317	--	40	20	--

Appendix 8: Estimation Procedure for
Augmentation Cost.

The general procedure used to estimate cost of augmentation, where flow augmentation was needed in the case of strategies 1 and 8, is summarized below. The energy source was electricity and a Utah Power and Light company, UPLC, schedule was used. Augmentation is estimated as:

$$Q_{aug} = DQ_{jd} - HQ_{jd} \quad (51)$$

if $Q_{aug} > 0$

and

$$V_{aug} = 1.983Q_{aug} \quad (52)$$

where Q_{aug} = the required flow augmentation, cfs.

DQ_{jd} = demand flow on a particular julian date, cfs.

HQ_{jd} = historical streamflow for the particular julian date, cfs.

V_{aug} = Volume of augmentation, acre-ft.

A pump installation consisting of four pumps is available. It is anticipated that augmentation in dry, normal, and wet years be in a range not exceeding 8 cfs. Based on experience and observation of a well and pump installation on a nearby farm by a dealer, Bullen's Inc., similar pumps and wells were envisaged for the study area. The pumps were rated 2 cfs. at 75 hp. run by 3-phase electric motors. The number of pumps operating to supply augmentation on any day is estimated by rounding up to next integer of:

$$PUMPN = Q_{aug}/2 \tag{53}$$

i.e. 1 pump if $0 < Q_{aug} <= 2$ cfs

2 pupms if 2 cfs $< Q_{aug} <= 4$ cfs

3 pumps if 4 cfs $< Q_{aug} <= 6$ cfs

and 4 pupms if 6 cfs $< Q_{aug} <= 8$ cfs

where PUMPN = number of pumps operating.

Power requirement is estimated:

$$Power = \frac{453 \times Q_{aug} \times DPUMPING}{3960 \times P_{eff} \times 0.745} \tag{54}$$

where Power is measured in KW.

Q_{aug} is as previously defined.

DPUMPING = depth of pumping in feet.

P_{eff} = Pump efficiency in decimal.

The energy requirement is estimated from:

$$Energy = Power \times Time \tag{55}$$

where Energy is measured in KWH

and Time in hours, usually 24 hours.

Both power and energy are tallied to obtain monthly and seasonal totals. Monthly power and energy costs were estimated using option A of the UPLC schedule attached. Monthly bills for augmentation were estimated by:

$$MNBILL = FXCOST+SERVCHG+(MISCOST + DEMCOST + ENECOST)_{mn} \quad (56)$$

where MNBILL = monthly bill, $

FXCOST = fixed cost representing amortized costs for well, pump and motor, and shelter; assuming lives of 30, 20, and 10 years respectively and 12 percent interest rate.

SERVCHG = service charge per connection by the utility company.

MISCOST = miscellaneous cost, which are associated with attendance, lubrication, and repairs on per 100 hour basis for the month.

DEMCOST = monthly power demand cost, using Power Rate in UPPLC Sheet 10.2

ENECOST = monthly energy cost, using Energy Rate in UPLC Sheet 10.2

mn = specific month.

Discounts were applied to the monthly bill to obtain the net monthly bill. The discounts were in respect to term and voltage. While term discounts may be discontinued, voltage discounts are rated based on power demand and are contingent upon the customer providing and maintaining transformer and necessary equipment. The discount rates are included in UPLC Sheet 10.2. Seasonal bill is a summation of monthly net bills minus off-season costs. The off-season costs are equipment costs for which payment must be made during and out of the irrigation season.

First Revised Sheet No. 10.2
Cancels Original Sheet No. 10.2

UTAH POWER & LIGHT COMPANY P.S.C.U. No. 33

MONTHLY BILL:

Monthly Customer Service Charge

All Customers:
$9.89 per Service Connection

The Monthly Customer Service Charge is for administrative costs including the cost of meter reading and billing. This charge is paid each month that the customer is connected for service.

IRRIGATION SEASON RATES:

Option A - Customers Not Participating in Load Control or Time-of-Day Program (Computer Code 38)

Power Rate:
$8.04 per kW first 100 kW
$5.33 per kW all additional kW

Energy Rate:
10.0345¢ per kWh first 100 kWh per kW
5.3803¢ per kWh next 25,000 kWh
3.5702¢ per kWh all additional kWh

Voltage Discount: Where customer provides and maintains all transformers and other necessary equipment, the voltage discount will be:
$1.17 per kW first 100 kW of power
$0.62 per kW all additional kW

Minimum Monthly Charge: The Monthly Customer Service Charge plus the Power and Energy charges.

Option B - Customers Participating in Load Control Program Designated Day (Computer Code 10)

Power Rate:
$6.06 per kW first 100 kW
$3.37 per kW all additional kW

Energy Rate:
10.0345¢ per kWh first 100 kWh per kW
5.3803¢ per kWh next 25,000 kWh
3.5702¢ per kWh all additional kWh

Voltage Discount: Where customer provides and maintains all transformers and other necessary equipment, the voltage discount will be:
$1.17 per kW first 100 kW of power
$0.62 per kW all additional kW

Minimum Monthly Charge: The Monthly Customer Service Charge plus the Power and Energy charges.

Option C - Customers Participating in Load Control Program Company's Option (Computer Code 39)

Power Rate:
$3.81 per kW first 100 kW
$1.10 per kW all additional kW

Energy Rate:
10.0345¢ per kWh first 100 kWh per kW
5.3803¢ per kWh next 25,000 kWh
3.5702¢ per kWh all additional kWh

Pullen's Inc.

DEEP WELL TURBINE PUMP

[illegible] MAIN PHONE (801) 752-7301
LOGAN, UTAH 84321

ESTIMATE ORDER **SHEET**

SOLD TO [illegible]
ADDRESS [illegible]
SHIP TO:
ADDRESS:
SHIP VIA: COLLECT PREPAID
CUSTOMER JOB NO. LOCATION [illegible]

DATE [illegible]
P.O. NO.
QUOTATION NO.
BID DATE
NO. OF PUMPS
ITEM NO.

Well Diameter (Inside	12"	Inches	Type 10" JKH		No. Stages 8			RPM 1500	
Well Depth	[illegible]	Feet	Impeller FULL					Curve No.	
Static Water Level	70	Feet	K. Value		Total Thrust				Lbs.
Drawdown	20'	Feet	GPM	HEAD	% Eff.	BHP			
Pumping Level	180'	Feet	900	260	.87	75			Laboratory
Disch. Pressure (65 psig)	150	Feet							Lower
Total Pumping Head	260	Feet							Field
Pump Capacity	[illegible] 900	GPM	Motor Eff.	% (full load)		%(3/4 load)	%(½ load)	Overall Eff.	%

	DESCRIPTION	PRICING SCHEDULE			Approx. Wgt.
1 MOTOR:	US Make 75 HP 1800 RPM 460 Volts				
	3 Phase 60 Cycle Type Frame No.				
	Special Features: N/R/R				
2 HEAD SIZE:	12 AL 8" Discharge				
	Companion Flanges				
	(Surface Dschg.) (Below Ground Dschg. "Base to Dschg.)				
3 DISCHARGE PIPE:	Ft. of "Std. Pipe			[illegible]	
4 COL. 120	Ft. 8 "Std. Pipe x 2 "Tube x 1" "Shaft per Ft. $				
5 BOWLS: Size 10" JKH	Type JKH No. Stages 8				
6 SUCTION PIPE:	5 Ft. of [illegible]" "Std. Pipe				
7 STRAINER:	10" Cast				
8 AIR LINE:					
9 ALTITUDE GAUGE & FITTINGS:					
10 STARTING EQUIPMENT					
11	1 Size 4 Fmtl - Base Sgn Block			[illegible]	
12	Phase Amt				
13	Lightning Arrester				
14					
15 ACCESSORIES, SPECIAL CONSTRUCTION, VARIATIONS:					
16	Wiring to Panel			[illegible]	
17					
18					
19					
20 ACCESSORIES, SPECIAL CONSTRUCTION, VARIATIONS:					
21					
22					
23					
24					
25					
26					
27					
28	TOTALS			8172	
INSTALLATION SERVICE	Setting Pump	[illegible]			
WIRING					
	NET TOTAL EACH			[illegible]	
	NET TOTAL UNITS				

REMARKS: 9188.67

QUOTED BY [illegible]

VITA

Aliyu Abubakar Ramalan

Candidate for the Degree of

Doctor of Philosophy

Dissertation: Management Strategies for Gravity Sprinkle Irrigation Systems.

Major field: Agricultural and Irrigation Engineering

Biographical Information:

Personal Data: Born in Lafia Town, Plateau State of Nigeria, September 25th, 1948; son of Hajiya Hauwa and Alhaji Abubakar Ramalan. Married to Hafsat Abubakar Agwai October 10th, 1975; has three children, two boys and one girl.

Education: Received early education in Nigeria and proceeded to England in 1970 and entered National College of Agricultural Engineering (now Silsoe College) in 1971 and graduating in 1974 with B.Sc. Degree in Agricultural Engineering. Earned an M.S. Degree in Irrigation Engineering from Utah State University in 1980. Completed the requirements for Doctor of Philosophy degree in Agricultural and Irrigation Engineering at Utah State University, Logan, Utah, in 1988.

Professional Experience: From 1974 to-date, has worked as an Extension Irrigation Engineer with Ahmadu Bello University, Zaria, Nigeria.

Affiliations: Member Nigerian Society of Agricultural Engineers; Graduate Member Society of Agricultural Engineers, England; Member Nigerian National Committee, Afro-Asian Region of the International Committee On Irrigation and Drainage, ICID.