Research Technical Completion Report

MICROCOMPUTER PROGRAM DEVELOPMENT FOR ON-FARM IRRIGATION SYSTEMS PLANNING

by

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WATER for IDAHO

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ABSTRACT

A simulation modeling package has been developed for the purpose of critically evaluating on-farm irrigation water supply and application systems under Pacific Northwest conditions. The entire package is designed to be executed on a microcomputer. The modeling package incorporates climatic, farm layout and management factors in conjunction with irrigation systems information. The modeling procedure can consider up to 6 different application systems supplied from a common water source applying water to a total of 11 fields. The crop rotation pattern for each field can be up to 9 years with 2 crops per year.

The entire modeling process consists of (1) constructon of a data file by specifying the site-specific information and the irrigation system(s) to be evaluated, (2) an analysis of irrigation system components and (3) a simulation of system operation. To perform these three steps, the modeling package consists of two electronic spreadsheet templates for data file building and two main FORTRAN 77 computer routines -- SYSTEM and SIMULATE. The electronic spreadsheet routine used for data file building provides an easy method of entering and editing data. After a data file is constructed, the SYSTEM routine is used to summarize the numerous data and calculate the costs and operating characteristics of components in the water supply and irrigation application systems. The SIMULATE routine is then used to combine all the information by simulating the operation of the complete on-farm irrigation system over a period of time. The results show how the complete on-farm irrigation system would function over a period of time and associated costs.

The procedure is designed to be used as a planning tool for determining the projected operation of an irrigation system on a given farm under site-specific conditions. Output generated from the model includes (1) the adequacy of irrigation for all crops grown in rotation, (2) any system limitations causing shortfalls in irrigation and (3) the capital and operational costs involved including the effects of inflation. The modeling package can be used by planners, consultants and related professionals knowledgeable in microcomputer use and irrigation system design. The results obtained from use of the modeling package can be used by planners, consultants, equipment suppliers and farmers in making objective comparisons between different systems and/or the effects of different cropping and irrigation-related management practices. Alternative plans can be quickly developed and evaluated, and the "best" plan selected for final detailed design.

CHAPTER 1

INTRODUCTION

BACKGROUND

Production from much of the agricultural land in the Pacific Northwest is limited because of inadequate or off-season occurrence of rainfall. Irrigation has been used in many parts of the Pacific Northwest to overcome the deficit rainfall conditions and create opportunities for more diversified agriculture and intensive land use. Such development is important to a region whose economy depends upon agricultural production.

The Pacific Northwest is a region with generally abundant water resources. Historically there has been enough water for all users. However, water resources are finite, and they must be used effectively to provide adequately for various competing uses. The need for planning water resources systems to spread the limited resource among the competing uses has brought about various computer modeling and systems analysis techniques.

Many models have been developed for water resources and irrigation systems. Some models deal with long range planning while others are used for day-to-day management. This project deals with a planning model; the following discussion centers on related planning models.

The objective of some irrigation system models is to determine the optimal allocation of irrigation water in a geographic area (Schmisseur and Conklin, 1973; Windsor and Chow, 1971) or the optimal timing of irrigation application (Hall and Butcher, 1968). For these models it is necessary to make assumptions regarding the configuration and performance of irrigation systems.

Considerable effort has gone into modeling irrigation system components. These efforts include optimal sizing of pipelines for sprinkler system supply (Keller and Watters, 1980) and the performance of sprinkler systems (Stillmunkes and James, 1982; Longley, 1984). Models describing gravity irrigation systems are those for furrow systems (SCS, 1983; Walker, 1984) and for border systems (Strelkoff and Clemmens, 1984; SCS, 1974).

Busch (1975) has developed a procedure for determining the optimal arrangement of irrigation distribution and application system components in a project area. This procedure has been used by the Bureau of Reclamation (Galinato and others, 1977). Yoo and others (1982) describe irrigation system planning techniques for rehabilitation of a large irrigated area. A procedure based on a linear-programming model has been used to specify irrigation system plans and water allocation for maximum profit (Allen, 1983). Khanjani (1980) has used a linear-programming model to optimize an irrigation supply system with internal storage reservoirs.

In the planning and design of effective on-farm irrigation systems it may be necessary to consider many alternative components that may be used to convey and apply water in a given situation. A systems analysis type of approach can be used to consider the myriad of physical, institutional and management factors that affect the design and operation of an irrigation system. Such an approach can provide the means of rapidly evaluating the effects of changing conditions and combining individual components so that the "best" system can be selected for the given set of conditions.

As each farm unit is unique in a physical sense as well as in its management, there is a need for matching the proper irrigation system and associated water management practices to a particular farm unit. To accomplish this goal, alternative irrigation systems must be evaluated critically to determine their operational characteristics as to how effectively they can be used to apply the proper amounts of water at the proper times in a given set of circumstances. In addition it is also necessary to consider both the capital and operating costs of a system. A suitable analysis procedure should incorporate all pertinent inputs and produce output describing how well a given system functions along with associated costs.

To improve the accuracy in which a model represents an actual on-farm irrigation system, Busch (1982) developed a model for simulating the actual operation of an on-farm irrigation system for site-specific conditions. This model, developed for use in New Zealand, has been accepted for use in that country (Busch and McBride, 1984).

OBJECTIVES

The overall objective of the work reported is to develop and test a procedure for critically evaluating on-farm irrigation system plans and water management practices for site-specific conditions.

Specific objectives are:

1. To develop means of determining the operating characteristics and costs of irrigation system components including various application systems -- surface and sprinkler. Factors to be considered include pumping energy requirements and costs of system components operating under site-specific conditions along with soils information, climatic conditions and irrigation practices including management practices.

2. To develop and test a simulation model for on-farm irrigation systems using appropriate systems analysis techniques. Output from the model will consist of detailed analysis of irrigation system operating characteristics and costs for a farm unit as influenced by the farm and system layout, water supply, legal factors, energy cost and availability and other pertinent factors.

An analysis technique for irrigation systems would provide for proper planning of irrigation systems and accurately determining their operating characteristics. The need for this information has increased dramatically due to increased competition for water. Estimates for irrigation growth such as presented by Hamilton and Lyman (1983) and their effects on competing uses must be documented through the use of more accurate planning models.

CHAPTER 2

SYSTEMS ANALYSIS PROCEDURES

IRRIGATION SYSTEM PLANNING

The effectiveness of an irrigation system to increase farm production and income is influenced by many factors. These factors include system design and configuration, crops grown, water availability and cost, and system management in conjunction with other resources such as labor and capital. In addition, the cost and availability of various resources including water, energy, labor and capital affect system design and performance. A properly planned and designed irrigation system is one that functions well with the resources available to produce beneficial results.

The design process for irrigation systems should include a planning phase for all but the simplest of systems. The planning phase usually occurs prior to final design and is important in that the relative merits of alternative preliminary plans and designs can be considered, compared and evaluated quantitatively. Irrigation system planning allows for objective comparisons between system alternatives and results in a final detailed design that includes only the "best" option(s) for a particular situation.

The existence of unique climatic conditions, types of crops grown, irrigation systems used, costs and constraints make it necessary to analyze irrigation systems and their operation under site-specific conditions. A system design that is successfully used for one application may not necessarily be best for the unique conditions present for another application. Introducing an effective planning phase in the design process allows for the critical evaluation of system design and operation, and systems analysis procedures can be used effectively for this purpose. System analysis procedures can be used to evaluate various aspects of an irrigation system such as the adequacy of irrigation throughout a season and the cost of operation per year or throughout the life of the system. The effects that numerous inputs such as labor, water and energy constraints, costs, inflation, crop rotation and field layout have on system performance can be evaluated as well.

IRRIGATION SYSTEM PLANNING MODELS

An irrigation system can be modeled such that the model accurately represents the actual system. Models may be scaled down physical models or more commonly used mathematical models. Mathematical models have become very popular due to the development and use of digital computers including microcomputers. Computerized models are generally relatively easy to construct and can accurately represent certain aspects of the actual system. In addition, mathematical models can be constructed for flexibility and used for a wide variety of applications.

Mathematical models of on-farm irrigation systems can be used for different purposes. A planning model may be used to simulate the operation of an irrigation system over a period of time. The results from an accurate model would therefore describe how a system would function in a particular situation. Using this approach, alternative systems can be compared for their suitability in a given situation. In contrast to planning models, management models are used to make real time management decisions. This type of model is designed for use as a management aid for a particular type of system.

A planning model for on-farm irrigation systems should incorporate as many influencing factors as possible. The major factors considered are those describing the farm and water supply in addition to the irrigation system as shown in Figure 2-1. The analysis procedures must incorporate the physical aspects of irrigation systems in conjunction with costs, various management aspects and institutional factors such as water rights.

To provide a thorough analysis, the effects of variations in the different inputs must be considered. For example, irrigation water requirements can vary quite markedly within an irrigation season and from season to season especially in an area where rainfall can be substantial.

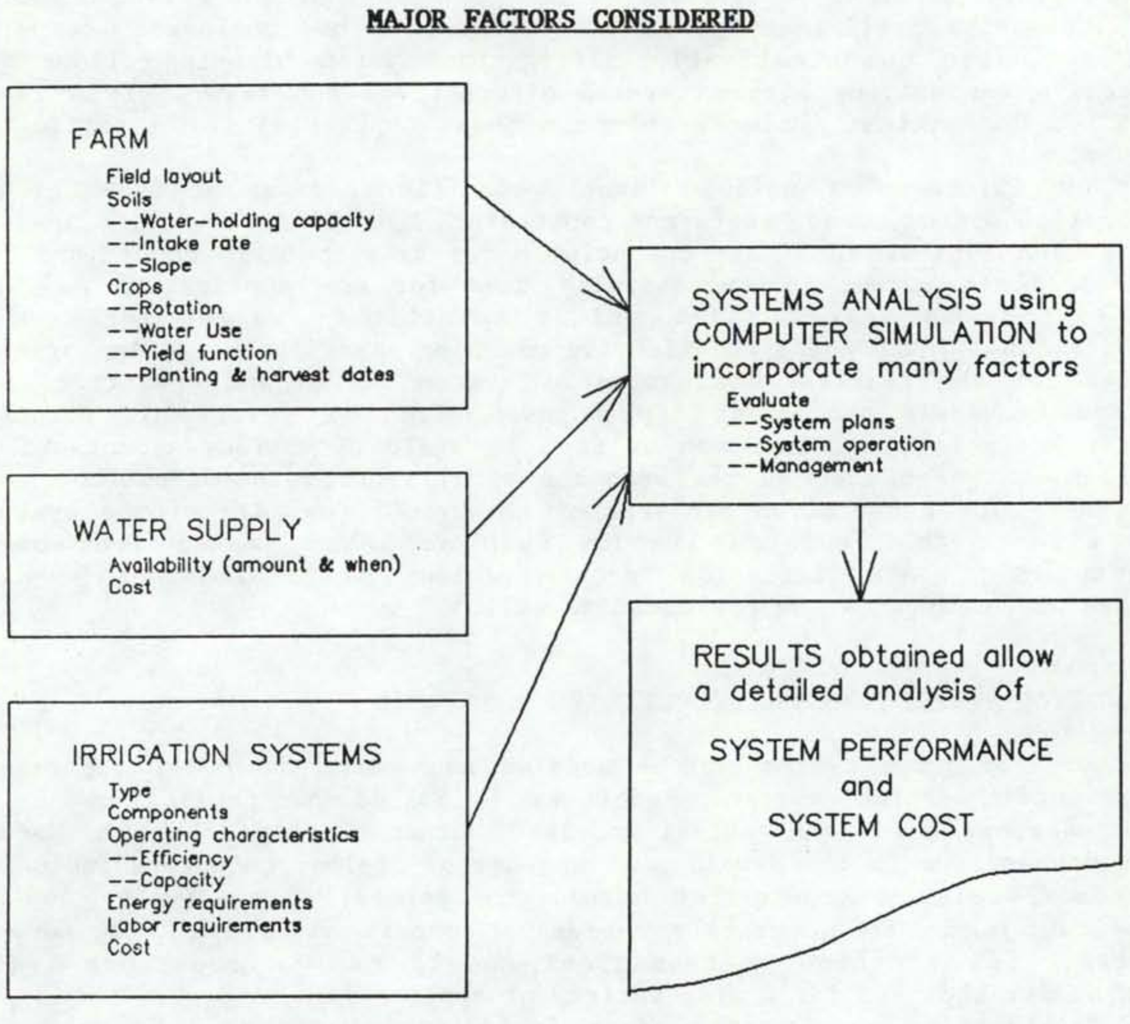

Figure 2-1 Major factors considered in irrigation system analysis.

Other variations to be considered are the time value of money in the form of interest rates and rate of return (discount rate) and the rate of inflation all of which can be expected to influence operation and maintenance costs. These variables must be considered in conjunction with the irrigation system under consideration as well as farm layout and projected crop rotations.

The main purpose of the systems analysis is to incorporate site-specific information, to perform necessary computations and to produce meaningful and understandable results. Results that provide adequate information describing necessary details of system performance and cost can be used by farmers and/or consultants in determining what system would be "best" for a given situation. Systems analysis procedures can also be used by planners to determine the effects of the availability of resources such as water and energy as well as variations in costs, interest rates and inflation factors.

ON-FARM IRRIGATION SYSTEM ANALYSIS (FISA)

Procedures for irrigation system analysis are used to provide a thorough analysis of the cost and operation of on-farm irrigation systems for planning purposes. These procedures consist of digital computer routines designed to model on-farm irrigation systems incorporating the necessary ingredients to produce meaningful and accurate results. The routines are designed to provide useful information at each step of the analysis process to allow for intermediate analysis. The use of several separate routines also provides more control and flexibility in the entire process.

The basic functions and interrelationships of the two spreadsheet templates and two separate computer routines are shown in Figure 2-2. All of the crop rotation, field layout, plant-soil-water relationships, supply system components and costs, application system components and costs, and water and labor availability and costs are assembled into a data file using the two spreadsheet templates. The SYSTEM routine is then used to summarize the numerous data and compute the operating characteristics and costs of the components in the water supply and irrigation application systems. All necessary information is combined in the SIMULATE routine which simulates how an irrigation system functions over a period of time to determine how well the system can supply irrigation water requirements and to compute the associated costs. The entire process is referred to as FISA.

DATA FILE CONSTRUCTION

A suitable data file containing required site-specific information is constructed using two linked electronic spreadsheet templates, referred to herein as FISAI and FISAII, respectively. The templates utilize macros to guide the user through the inputs necessary to construct a complete site-specific data file for use by the SYSTEM and SIMULATE routines. Since macros were used in construction of the electronic spreadsheet templates, they require the same brand of electronic spreadsheet software to run them as was used in their construction. The templates were constructed using

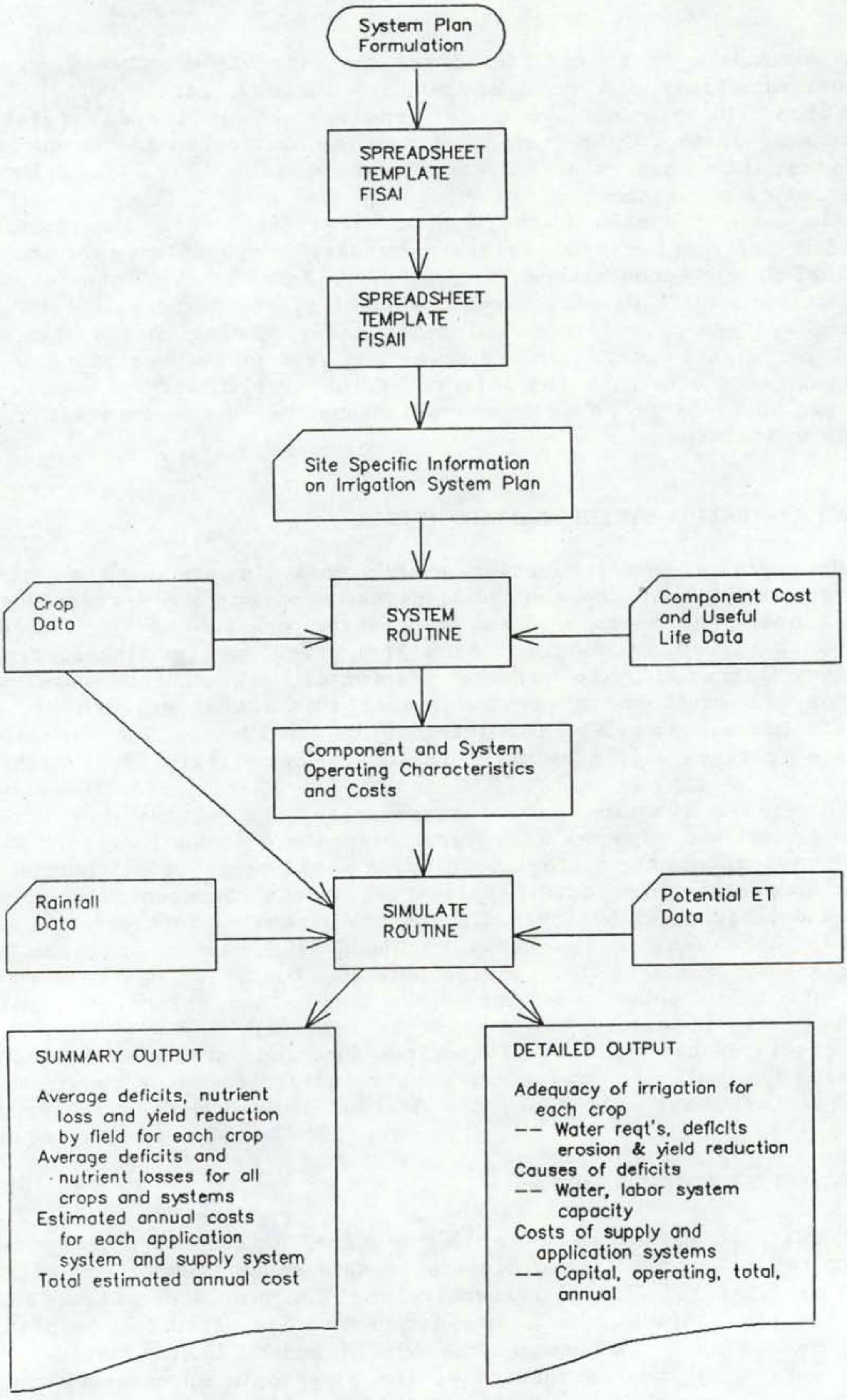

Figure 2-2 Computer routines of FISA.

LOTUS SYMPHONY*. The major inputs include site-specific data such as the number of fields to be irrigated, along with the size of each field and crop rotation; information concerning the irrigation water supply and all components in the supply system; and information concerning the selected application system(s). For each crop in each field the total depth of water held in the root zone for plant use and the allowable deficit when irrigation is required are computed from soil and crop data stored in the template once the soil type and crop type are entered. Water supply information includes the flow rate delivered to the system, water availability, and water cost. In the analysis procedure, the supply system is considered as that portion of the system used to supply all application systems used.

Financing information is entered for two finance terms, one for attached items and one for unattached items, as lending institutions may have different loan rates for these two items. Attached items are generally items considered to be part of the real property and unattached items are those which can be removed from the real property. Cost data entered for each component in the supply system and application system(s) include total capital cost, amount financed, type of loan, salvage value, annual maintenance expense and miscellaneous expenses (for taxes, insurance, contingencies, etc). Specific components for which data may be entered are canals, structures, pipelines, and pumps. If one or more pumps are used, data are also entered to compute the flow rate pumped and the pump energy requirements. Costs of land smoothing and preparation and any required subsurface drainage can be entered. In addition, provision is made to enter cost information for any additional components needed in the system.

Data can be entered for up to 6 separate application systems each supplying one or more fields, up to a total of 11 fields. The application system types for which data may be entered are: border, furrow, solid-set sprinkler, hand-move sprinkler, side-roll sprinkler, center-pivot sprinkler and linear-move sprinkler.

ANALYSIS OF IRRIGATION SYSTEM COMPONENTS

The SYSTEM routine uses models of individual irrigation application systems and components to compute the application efficiency and labor requirement for each system on each field, the conveyance efficiency for the supply system and application system(s), pumping energy requirements and the capital costs for a 20-year period using inflation, salvage values and like-kind replacement at the end of each component's useful life.

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*Trade names and company names are included for the benefit of the reader and do not imply any endorsement of preferential treatment of the product listed by the University of Idaho.

SYSTEM SIMULATION

The SIMULATE routine is used to determine the performance of the complete on-farm irrigation system and the operational costs involved. Inputs to the SIMULATE routine are from the site-specific data file describing the farm, the output of the SYSTEM routine and rainfall and crop water use data.

The SIMULATE routine computes crop water requirements for each field on a half-monthly time step throughout the irrigation season. The irrigation priority of each crop is computed for each half-monthly period based on the estimated loss in income if the crop is not irrigated during that period. Irrigation water is then allocated to each field in the simulation process according to the irrigation priority of the crop involved, the system capacity and efficiency, and the total amount of water available along with the requirements for and the availability of labor. If the system involved is unable to supply the water requirements of any crop during any half-monthly period, the cause is flagged and displayed in the final output.

The output from the SIMULATE routine is used to evaluate the irrigation system plan and system performance. The output consists of three main components: (1) the adequacy of irrigation for each crop in the rotation, (2) system requirements and causes of irrigation shortfalls and (3) irrigation costs. These three main components are shown in both a brief summary and a detailed output. The brief summary can be used to quickly view how the proposed system will perform, and the detailed output can be used to evaluate details of system operation and provide some insight as to appropriate adjustments in the system plan.

Specific output data for each crop in the rotation for each half-monthly period include average irrigation requirement, percent of time irrigation is required, average requirement when irrigation is required, average irrigation application when water is required, percent of time requirement exceeds application, average and maximum deficits, and the amount of water that must be applied before irrigation is actually needed to make full use of system capacity and water supply. Also shown are estimates of average annual soil loss (sprinkler systems only), average annual nitrogen loss and potential average yield reduction.

The second component of the SIMULATE output shows the causes of irrigation shortfalls. Irrigation shortfalls can be caused by three factors; (1) a shortage of water at the supply, (2) a limitation in the amount of labor available and (3) a limitation of application system capacity. These results are shown for each half-monthly period during the irrigation season and are based upon the percentage of time that <u>irrigation water is required</u>. The percentage of time application system capacity is limiting is shown for each system.

Irrigation system costs are based upon the cost data obtained from the SYSTEM routine in addition to operating costs computed by the SIMULATE routine. Cost summaries are given for each application system and the supply system. The costs summaries show the amount of capital not financed along with the amount of repayment and the interest for financed capital for each year over a 20-year period. Operating costs are also shown for each year during the 20-year period. Yearly operating costs reflect the influence of inflation. Yearly costs as affected by the amount of irrigation water applied are based on an average application determined in the simulation process. The yearly costs shown, therefore, do not reflect the variation that might occur due to various amounts of water applied in different years.

The overall annual cost is the annual cost of the system based upon the specified rate of return (discount rate). This number takes into account the various inflation rates for operating costs. The overall annual cost is useful in comparing the costs of systems while taking into account the desired rates of return and inflation.

HARDWARE REQUIREMENTS

In order to run the system analysis package outlined in this report, certain software and hardware requirements must be met. These include:

MS-DOS Version 2.1 or later

LOTUS SYMPHONY Version 1.1 or later

IBM or compatible personal computer with a minimum of 640 kilobytes of random access memory. A hard storage disk is recommended but not necessary. A mathematical coprocessor is also recommended to speed up program execution.

CHAPTER 3

CREATING AND EDITING A SITE-SPECIFIC DATA FILE FOR FISA

CREATING A DATA FILE FOR FISA

The first step in using the on-Farm Irrigation System Analysis Program (FISA) is to create a data file containing site-specific information. This data file is created using a spreadsheet template written for LOTUS SYMPHONY. A spreadsheet program is used to create the data file in order to give the user the capability of viewing, entering, and editing blocks (screens) of related input information. In addition, creating the data file in block form gives the user the ability to quickly work through sections of the information requiring no changes when editing a data file.

The amount of information required to run FISA can be quite extensive depending on the size of the irrigation system being considered. For this reason the data file building template is composed of two parts. The first part requests information pertaining to farm layout, soils, crops grown, water availability and cost, electric energy usage and cost, and supply system components. The second part requests information pertaining to the components of the irrigation application system(s). Part One of the spreadsheet template must be completed before going to Part Two. A flow chart of the data file building process is shown in Figure 3-1.

The first step to constructing a site-specific data file is to gather the pertinent information and formulate the irrigation system plan. This includes determining the soils and crops to be irrigated, location of the water source, field sizes and layout with respect to the water source, desired slope and leveling cost, desired system layout and specifics and the supply system layout. For system analysis purposes, the supply system is considered to be those components used to convey water from the source to the individual application system(s).

After the site-specific information is gathered, the data file building process is started by loading the LOTUS SYMPHONY program and retrieving the worksheet file FISAI. The data file building spreadsheet requires that the user enter the requested information in each screen before going on to the next one. After a screen of information has been entered, simultaneously pressing ALT-S brings up the next screen of inputs. This process is continued throughout the data file building process until all the information about a particular irrigation system has been entered. It is the user's responsibility to check the validity and completeness of the data in the current input screen before preceding to the next one as no provision is made for going back to a particular screen. If an error is detected in a previous screen, the only recourse is to start over at the beginning by simultaneously pressing ALT-R. This does invoke default values in the application system inputs screens, so some of these data will need to be reentered. However, the information previously entered in all other input screens reappear, thus, all that is required is to work through the screens (using ALT-S) to get to the place where changes are required.

There are other special key stroke combinations that invoke special features throughout the data file building process. These are noted later as needed as each screen of inputs is explained. The data file building

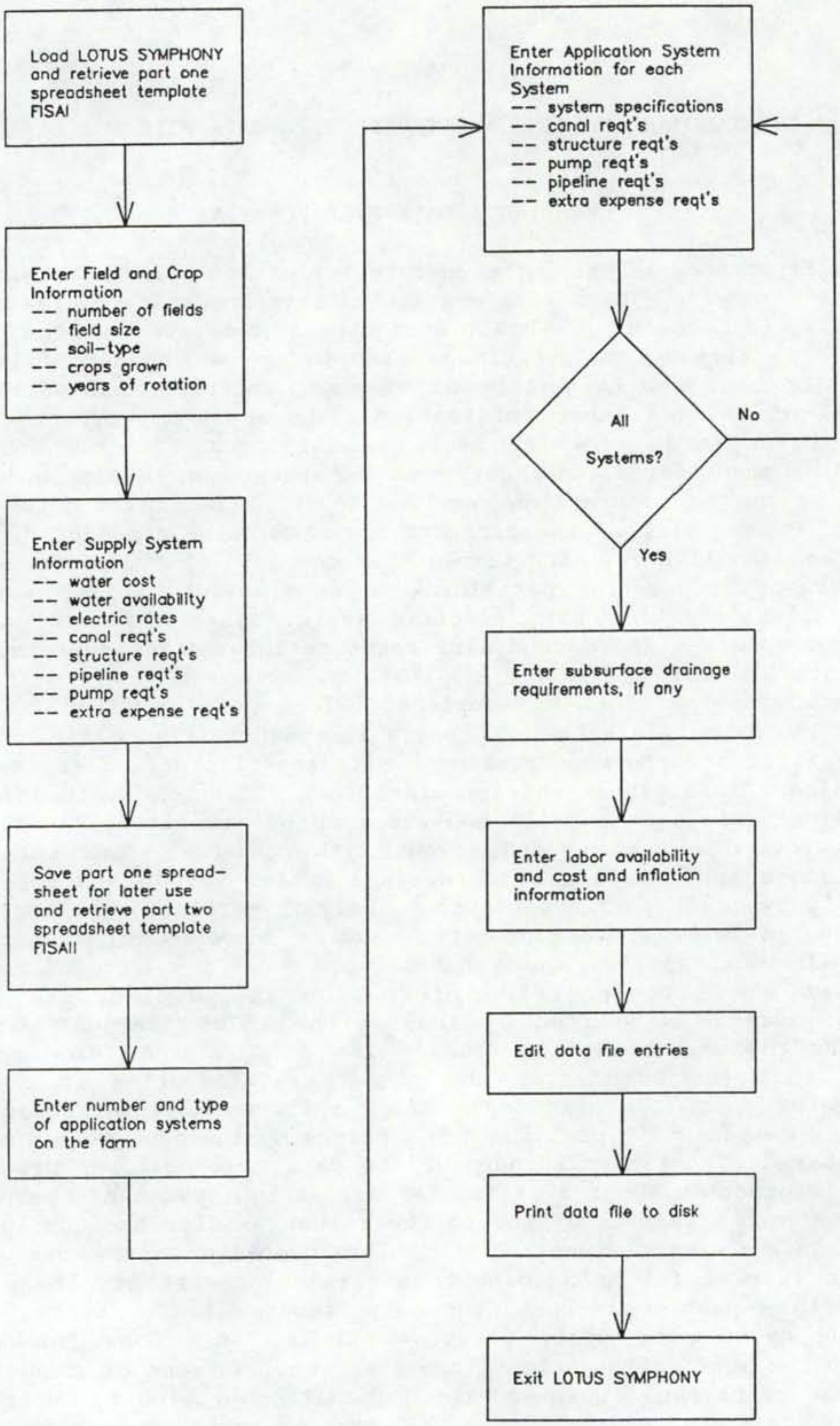

Figure 3-1 Flow chart of the data file building process.

spreadsheet contains brief instructions in each screen describing the required inputs. After running the data file building spreadsheet once or twice the user should be able to do it without referring to these written instructions.

As previously discussed, simultaneously pressing ALT-S causes the next screen of inputs to appear. This process can take up to a minute or two for some screens. For the longer periods between screens, a message will appear informing the user to please be patient (Figure 3-2). When the MACRO indicator on the bottom of the screen is on, the spreadsheet is operating and no other keys should be pressed. When this indicator is off, the user is in control of the cursor and the spreadsheet program. Cursor movement in the data file building spreadsheet is the same as with the regular LOTUS SYMPHONY program.

The following paragraphs describe the screens in the order in which they appear. Each screen has a name which appears at the lower left corner of the screen border. The screen name is used in the following discussion to identify the screen being described.

When the data file building spreadsheet is retrieved, the first screen to appear is the WAIT screen. This screen is shown in Figure 3-2. Its purpose is to inform the user that the spreadsheet program is working and to be patient until it has completed its task.

PLEASE WAIT

I AM DIGESTING THE DATA YOU HAVE FED ME AND PREPARING FOR THE NEXT INPUTS

Figure 3-2 The WAIT screen.

The next screen to appear is the INTRO screen shown in Figure 3-3. The INTRO screen contains a brief explanation of what the spreadsheet program does, what to expect, and how to use it. Simultaneously pressing Alt-S begins data entry and brings up the first screen requiring input.

The first screen requiring user input is the FILEINFO screen shown in Figure 3-4. The user is to enter YES or NO to the question as to whether printouts of the crop and soil menus are desired. If the answer is YES, the printer must be ready before pressing ALT-S. The second user input is a descriptive name for the data file. This name can be up to 45 characters in length. After the correct responses to the two prompts have been entered, simultaneously pressing ALT-S continues to the next screen. If the answer to the prompt for printouts of the crop and soil menus is YES, they will be printed before the next screen appears.

The FIELD screen appears next. An example FIELD screen is shown in Figure 3-5. The FIELD screen requests information on farm layout. The first input is the number of fields to be considered on the farm. A maximum of 11 fields can be considered by FISA. After entering the number of fields on the farm, the irrigated area in acres, years of rotation, and

```
              WELCOME TO THE DATA FILE BUILDING ROUTINE OF FISA

    THIS ROUTINE GUIDES YOU THROUGH THE STEPS NECESSARY TO CONSTRUCT A
FISA DATA FILE.  IT CONSISTS OF TWO PARTS.  PART ONE REQUESTS INFORMATION
ON FARM  LAYOUT, CROP ROTATION,  WATER AVAILABILITY AND COST,  AND SUPPLY
SYSTEM COMPONENTS.   PART TWO REQUESTS  INFORMATION ON THE  COMPONENTS OF
EACH APPLICATION SYSTEM.
    THIS ROUTINE  IS SETUP SUCH THAT  EACH SCREEN CONSTITUTES A  SET OF
CLOSELY  RELATED INPUTS.   ONCE  THE INPUT  DATA FOR  A  SCREEN HAS  BEEN
ENTERED, PRESSING ALT-S  WILL MOVE YOU TO THE NEXT  SCREEN.  THIS PROCESS
CONTINUES UNTIL THE  DATA FILE BUILDING PROCESS IS COMPLETE.   BE SURE OF
YOUR INPUTS BEFORE GOING  TO THE NEXT SCREEN AS NO  PROVISION IS MADE FOR
BACKING UP.  IN  THE CASE OF SUCH A MISTAKE,  PRESSING ALT-R WILL RESTART
THE DATA FILE BUILDING PROCESS AT THE BEGINNING.
    YOUR RESPONSES  TO THE  REQUESTED DATA  ARE TO  BE ENTERED  TO THE
RIGHT OF THE DOTS(.   .   .   .   .) OR IN THE INDICATED COLUMN.
    CURSOR CONTROL AND DATA ENTRY ARE  ACHIEVED IN THE SAME FASHION AS
IN THE REGULAR SYMPHONY WORKSHEET.

                      PRESS ALT-S TO START DATA ENTRY
```

Figure 3-3 The INTRO screen.

```
DO YOU WANT A PRINTOUT OF THE CURRENT SOIL AND CROP MENUS
 (YES OR NO) (IF YES, BE SURE PRINTER IS READY). . . . . . .       NO


ENTER A DESCRIPTIVE NAME FOR THIS DATA SET (MAXIMUM OF 45
 CHARACTERS). . . . . . .EXAMPLE RUN


                       PRESS ALT-S TO CONTINUE
```

Figure 3-4 Example FILEINFO screen.

ENTER NUMBER FIELDS ON THE FARM (MAXIMUM OF 11)   6

ENTER THE INFORMATION LISTED IN THE COLUMNS BELOW FOR EACH FIELD. MAXIMUM ROTATION DURATION IS 9 YEARS. PRESS ALT-M TO VIEW SOIL TYPE MENU.

FIELD NUMBER	IRRIGATED AREA (ac)	YEARS IN ROTATION	PREDOMINANT SOIL TYPE No.
1	40	7	12
2	40	2	10
3	30	1	7
4	40	2	14
5	132	2	3
6	80	2	18
7			
8			
9			
10			
11			

PRESS ALT-S TO CONTINUE

Figure 3-5 Example Field screen.

predominant soil type number must be entered for each field. The maximum number of years in rotation is 9. An on-screen menu of soil type numbers can be obtained by simultaneously pressing ALT-M while viewing this screen. Figure 3-6 shows a portion of an example SOILMENU screen. The soils listed in Figure 3-6 are for model testing purposes only. The user is required to develop an appropriate list of soils for the area of interest and incorporate them into FISAI using the procedures presented in Chapter 4 of this report. Pressing ALT-L will return the FIELD screen. A printout of the soil menu can be obtained by pressing the F7 function key, typing PSM and pressing ENTER.

The number of entries in each of the three input columns in the FIELD screen must match the number of fields entered for the farm or the spreadsheet program will not continue to the next screen. To attempt to go to the next screen when the number of entries in any one of the three input columns does not equal the number of fields on the farm, will cause a message to appear telling of the need to erase the extra entries or enter the missing data. Provided the correct number of entries are made, simultaneously pressing ALT-S will make the next screen appear.

Following the FIELD screen is the CROP screen. An example CROP screen is shown in Figure 3-7. The CROP screen requests information about the crops grown on each field. The spreadsheet program lists the information in order of field and year of rotation based upon data entered in the preceding FIELD screen. Data must be entered for each line appearing in the table. Two Crop Nos. must be entered for each year of rotation as FISA allows for two crops to be grown in any one year. Crop No. 1 is entered

SOIL MENU

PRESS ALTERNATE-L TO LEAVE THIS MENU
AND RETURN TO THE FIELD INFORMATION
SCREEN. PRESS PgDn & PgUp TO VIEW MENU.

(To obtain a hard copy, press F7,
type PSM, and press RETURN)

SOIL No.	SOIL SERIES	TEXTURE
1	ADKINS	VF SANDY LOAM
2	ADKINS	FSL
3	ASHUE	LOAM
4	ASHUE	GR LOAM
5	BAGDAD	SILT LOAM
6	BURBANK	L & LF SAND
7	BURBANK	FINE SAND
8	BURKE	SILT LOAM
9	BURKE	VF SANDY LOAM
10	ELLISFORDE	SIL & LOAM
11	ELLISFORDE	F SANDY LOAM
12	EPHRATA	F SANDY LOAM
13	EPHRATA	GR SANDY LOAM
14	ESQUATZEL	SIL & LOAM
15	ESQUATZEL	F SANDY LOAM
16	ESQUATZEL	VF SANDY LOAM

Figure 3-6 Portion of an example SOILMENU screen.

for fallow conditions. Crop No. 1 is also entered for a second crop when no second crop is grown. FISA can handle a maximum of 11 fields, each with a 9-year rotation and 2 crops per year, meaning there could be up to 198 crop numbers to enter in this screen. Since no more than 20 lines at a time can be shown on the computer display, the Page Up (PgUp) and Page Down (PgDn) keys can be used to view the entire table of inputs.

A menu of available crops and their identifying numbers can be obtained by pressing ALT-M while viewing the CROP screen. Figure 3-8. shows a portion of an example CROPMENU screen. The crops listed in Figure 3-8 are for model testing purposes only. The user is required to develop an appropriate list of crops for the area of interest and incorporate them into FISAI using the procedures presented in Chapter 4 of this report. Pressing ALT-L returns the CROP screen. A printout of the crop menu can be obtained by pressing the F7 function key, typing PCM and pressing RETURN.

The number of entries in each of the crop columns in the CROP screen must match the number of entries in the Field No. and Rotation Year columns or the spreadsheet program will not continue to the next screen. Attempting to go to the next screen when the number of entries in any one of the Crop No. columns does not equal the number field-rotation entries on

ENTER TWO CROPS FOR EACH FIELD AND YEAR OF ROTATION IN THE TABLE BELOW. ENTER CROP No. 1 (FALLOW) FOR SECOND CROP IF ONLY ONE CROP IS GROWN PER YEAR.

USE PgUp AND PgDn KEYS TO VIEW THE WHOLE TABLE. PRESS ALT-M TO VIEW CROP No. MENU. PRESS ALT-S TO CONTINUE AFTER DATA ENTRY IS COMPLETE.

FIELD No.	ROTATION YEAR	FIRST CROP No.	SECOND CROP No.
1	1	2	1
1	2	2	1
1	3	2	1
1	4	2	1
1	5	2	1
1	6	4	1
1	7	5	1
2	1	7	1
2	2	8	1
3	1	9	1
4	1	10	1
4	2	8	1
5	1	9	1
5	2	6	1
6	1	2	1
6	2	2	1

Figure 3-7 Example CROP screen.

the screen, causes a message to appear telling the user to enter the missing data. Provided the correct number of entries are made, pressing ALT-S simultaneously will make the next screen appear.

The next screen to appear is the DEFICIT screen shown in Figure 3-9. This screen requests information on the use of an application deficit. An application deficit, as defined for use in FISA, is the difference in the amount (depth) of water applied per irrigation and amount (depth) of water required to fill the soil moisture reservoir to field capacity. The use of an application deficit allows the FISA simulation process to store effective precipitation to help meet crop water requirements.

The DEFICIT screen requires that two questions be answered before pressing ALT-S. YES or NO must be entered as to whether the use of an application deficit is desired. If NO is entered, the second question on the screen need not be answered. The application deficit is set to zero when ALT-S is pressed. If the answer to the first question is YES, the second question as to whether the application deficit is the same for all crops must be answered as well. If the response to the second question is YES, the MESSAGE screen shown in Figure 3-10 appears when ALT-S is pressed. The desired application deficit as a percentage of the moisture available for plant use must be entered. The DEFICIT2 screen shown in Figure 3-11.

CROP MENU INFORMATION

PRESS ALTERNATE-L TO LEAVE THIS MENU
AND RETURN TO THE CROP INFORMATION
SCREEN. PRESS PgDn & PgUp TO VIEW MENU.

(To obtain a hard copy, press F7,
type PCM, and press RETURN)

CROP No.	CROP NAME	PLANTING DATE	HARVEST DATE
1	FALLOW	1-JAN	31-DEC
2	ALFALFA HAY	23-APR	1-NOV
4	SPRING GRAIN	20-MAR	30-AUG
5	FIELD CORN	15-MAY	20-OCT
6	SWEET CORN	15-MAY	15-SEP
7	DRY PEAS	27-MAR	15-JUL
8	POTATOES	15-MAY	10-OCT
9	WINTER WHEAT	1-OCT	1-AUG
10	PASTURE	23-APR	1-NOV

Figure 3-8 A portion of an example CROPMENU screen.

AN APPLICATION DEFICIT IS THE DIFFERENCE IN SOIL MOISTURE BETWEEN WHAT IS REQUIRED TO FILL THE SOIL MOISTURE RESERVOIR TO FIELD CAPACITY AND THAT WHICH IS ACTUALLY ADDED BY AN IRRIGATION. FISA ALLOWS YOU TO SPECIFY AN APPLICATION DEFICIT WHICH CAN BE CROP DEPENDENT. BELOW YOU ARE ASKED IF YOU DESIRE TO HAVE AN APPLICATION DEFICIT AND IF SO, WHETHER OR NOT IT IS THE SAME FOR EACH CROP.

DO YOU WISH FISA TO UTILIZE AN APPLICATION DEFICIT AS DESCRIBED ABOVE?
(YES or NO) . . . . YES

IF YES, IS THE APPLICATION DEFICIT THE SAME FOR EACH CROP?
(YES or NO) . . . . NO

PRESS ALTERNATE-S TO CONTINUE.

Figure 3-9 The DEFICIT screen.

ENTER THE APPLICATION DEFICIT AS A PERCENTAGE OF AVAILABLE MOISTURE FOR ALL CROPS AT THE PROMPT LOCATED AT THE TOP OF THE SCREEN.

Figure 3-10 The MESSAGE screen.

YOU MAY EDIT THE INFORMATION IN THE TABLE BELOW FOR EACH CROP LISTED. VALUES SHOWN FOR NORMAL CROP YIELD AND EXPECTED NET RETURN ARE DEFAULT VALUES WHICH YOU MAY WISH TO CHANGE. PRESS PgUp & PgDn TO VIEW WHOLE TABLE. PRESS ALT-S TO CONTINUE AFTER DATA ENTRY IS COMPLETE.

9 -- DIFFERENT CROPS GROWN BASED ON ROTATION DATA

CROPS GROWN CROP NO.	CROP NAME	APPLICATION DEFICIT (%)	NORMAL YIELD	EXPECTED NET RETURN ($/UNIT YIELD)
1	FALLOW	0.0	0	0.00
2	ALFALFA HAY	30.0	5.6	82.50
4	SPRING GRAIN	20.0	85.0	2.85
5	FIELD CORN	0.63	141.5	2.62
6	SWEET CORN	0.63	8.9	81.00
7	DRY PEAS	0.63	29.6	0.20
8	POTATOES	0.63	485	3.05
9	WINTER WHEAT	0.63	95	3.00
10	PASTURE	20.0	10.4	13.00

Figure 3-11 Example DEFICIT2 screen.

then appears. If the response to the second question is NO, the DEFICIT2 screen shown in Figure 3-11 appears following the DEFICIT screen when ALT-S is pressed.

The DEFICIT2 screen is shown in Figure 3-11. Many of the values appearing in this screen are dependent on responses entered in previous screens. If an application deficit is to be used and is different for each crop, this value must be entered for each crop shown. Application deficits greater than or equal to 100% should not be entered for any crop, including fallow, as this will cause errors in the SYSTEM and SIMULATE programs. The maximum number of different crops grown on the farm that can be handled by this spreadsheet program is 30. Since more than 10 crops cannot be listed on the computer display at one time, PgUp and PgDn may need to be used to view the entire table.

The crops listed in the table are based on those entered in the CROP screen. The number of different crops grown on the farm is shown above the table heading. The values shown in the Normal Yield and Expected Net Return columns are default values which may be changed. Normal Yield is expressed in the units customary for the particular crop although the actual units are not important as long as Expected Net Return is expressed on the same unit basis. The values shown in Figure 3-11 for Expected Net Return do not take variations in production costs of different crops into account. These values are used, however, because they are more readily available than actual net return values. The purpose of entering Expected Net Return is to calculate the irrigation priority of the crops according to an estimated amount of revenue lost if the crop is not irrigated on time. Provided that the ranking of the crops according to Expected Net Return is the same as that for the values entered, the resulting priorities will be essentially the same and will not affect the results obtained from the SIMULATE routine. Once the data in the DEFICIT2 screen has been determined to be correct, simultaneously pressing ALT-S brings up the next screen.

The SEASON screen shown in Figure 3-12 is the next screen to appear. This screen requires the user to enter the beginning and ending months of the irrigation season. The months are designated by number with 1 for January, 2 for February, etc. Simultaneously pressing ALT-S causes the next screen to appear after a short waiting period.

Following the SEASON screen is the SUPPLY screen shown in Figure 3-13. The SUPPLY screen requires the user to enter information about the cost of capital, cost of loans, and expected inflation rate for system components. Cost of Opportunity Capital is the interest rate expected if money were invested rather than used to buy an irrigation system. The interest rate and time of loan for each of two loans must be entered. Two loans are considered, one for attached items and one for unattached items, as lending institutions may have different loan rates for these two items. Simultaneously pressing ALT-S brings up the next screen.

```
ENTER THE NUMBER OF THE MONTH IN THE YEAR WHEN THE IRRIGATION SEASON
 STARTS.  (MARCH - 3 , APRIL - 4 , MAY - 5 , ETC.) . . . . .        4


ENTER THE NUMBER OF THE MONTH IN THE YEAR WHEN THE IRRIGATION SEASON
 STOPS.  (AUGUST - 8 , SEPTEMBER - 9 , OCTOBER - 10 , ETC) . . .    10

                        PRESS ALT-S TO CONTINUE
```

Figure 3-12 The SEASON screen.

The next screen to appear is the ELECTRICRATES screen shown in Figure 3-14. The first question is whether any electrically driven pumps are used in the irrigation system. If the response is NO, then the user can disregard the remaining inputs and go to the next screen by simultaneously pressing ALT-S. If the response to the first question is YES, the remaining inputs must be answered before going to the next screen. Electrical Service Installation Charge is a one-time charge for initial installation and includes any hardware and labor costs to get the electricity to the pump location. Billing Period Length is the time

CAPITAL COST AND LOAN INFORMATION

COST OF OPPORTUNITY CAPITAL (%). 13

EXPECTED INFLATION RATE ON SYSTEM HARDWARE (%) 8

SEPARATE LOAN TERMS ARE CONSIDERED FOR ATTACHED ITEMS AND UNATTATCHED ITEMS. ENTER THE INTEREST RATE AND DURATION OF EACH LOAN IN THE TABLE BELOW.

	(ATTACHED ITEMS) LOAN No. 1	(UNATTACHED ITEMS) LOAN No. 2
INTEREST RATE IN PERCENT.	9	14
TIME OF LOAN IN YEARS.	15	7

PRESS ALTERNATE-S TO CONTINUE

Figure 3-13 The SUPPLY screen.

ARE DATA TO BE ENTERED FOR ANY ELECTRICALLY DRIVEN PUMPS IN THE IRRIGATION SYSTEM (YES or NO)? . . . . YES

IF YES, FILL IN THE INFORMATION BELOW FOR ELECTRICAL USAGE RATES.

ELECTRICAL SERVICE INSTALLATION CHARGE ($). 1500
ANNUAL LUMP ELECTRICAL CHARGE ($) 1000
ANNUAL $/KILOWATT CHARGE 0
BILLING PERIOD LENGTH (MONTHS). 1
START OF SUMMER RATES (4 = APRIL, 5 = MAY, ETC.). 5
END OF SUMMER RATES (8 = AUGUST, 9 = SEPTEMBER, ETC.) 10
EXPECTED ANNUAL INFLATION RATE FOR ENERGY (%) 9

	SUMMER	WINTER
BILLING PERIOD LUMP CHARGE ($).	0	0
BILLING PERIOD $/KILOWATT CHARGE.	0	0
AVERAGE CHARGE ($/KWH).	0.045	0.039

PRESS ALT-S TO CONTINUE

Figure 3-14 The ELECTRICRATES screen.

interval in months between billings. FISA allows for two different electric rate schedules during the year, summer and winter. If the summer and winter rates are the same, all electric rate values should be entered identically for each season. Rather than consider the many different rate structures in use, FISA only requires one value to represent an Average Charge per kilowatt-hour. The authors feel that a single rate structure is sufficient for comparing alternative systems. In addition, projecting the current rate structure over a 20-year analysis period could lead to greater errors in predicting energy costs.

The next screen to appear is the WATER screen shown in Figure 3-15. The WATER screen requires the user to input information regarding the cost and availability of water. The value entered for Maximum Flow Rate Entering the System sets the limit for the SIMULATE routine when determining if capacity is limiting. This value also becomes the design flow rate for supply system components when the actual design flow rate is unknown. Seasonal Volume Available sets the upper limit for the amount of water available in the SIMULATE routine for determining when water is short. Days Per Week Flow Rate is Available, regulates the allocation of water to the fields in the SIMULATE routine.

Water costs should not include any costs for pumping of water, as such costs are covered under pumping requirements. Water costs are considered on a basic allotment basis or on a cost per acre-foot per acre basis. A zero value should be entered for one of the cost categories as water costs are computed only one of two ways. Volume of Basic Allotment, sets the limit on the volume of water that is available at the Basic Allotment cost. Cost of Additional Water is the cost of water used in excess of the Basic Allotment Volume.

```
                WATER SUPPLY AVAILABILITY AND COST INFORMATION

ENTER THE WATER SUPPLY DATA REQUESTED BELOW:

MAXIMUM FLOW RATE ENTERING THE SYSTEM (CFS). . . .        5.6
MAXIMUM SEASONAL VOLUME AVAILABLE (AC-FT/YR) . . .        7.6
DAYS PER WEEK THIS FLOW RATE IS AVAILABLE. . . . .          7


ENTER THE WATER COST DATA REQUESTED BELOW (ENTER ZERO FOR THE COSTS
THAT DO NOT APPLY). DO NOT INCLUDE ANY POWER CHARGES.

  COST OF BASIC ALLOTMENT ($/AC-FT). . . . . . . . .     19.98
  VOLUME OF BASIC ALLOTMENT (AC-FT/AC) . . . . . . .       3.5
OR COST PER AC-FT/AC . . . . . . . . . . . . . . . .      0.00
  COST OF ADDITIONAL WATER ($/AC-FT/AC). . . . . . .     23.00


                    PRESS ALT-S TO CONTINUE
```

Figure 3-15 The WATER screen.

The next screen to appear is the SUPPLYMESSAGE screen shown in Figure 3-16. The SUPPLYMESSAGE screen informs the user that the next five screens to appear pertain to supply system hardware. The supply system as considered by FISA includes any hardware components required to convey the water from the source to the individual application system(s). The user is required to enter information about any required open channels, open channel structures, pumps, pipelines, or extra expense items in the supply system. Simultaneously pressing ALT-S brings up the next screen.

The first screen to appear requiring information about the supply system is the SUPPLYCANAL screen. An example SUPPLYCANAL screen is shown in Figure 3-17. The first question is whether there are any open channels required in the supply system. If the response is NO, the remaining inputs are disregarded, and ALT-S can be pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question in the SUPPLYCANAL screen is how many open channels are required. The maximum number is 5. If more than five open channels are required, each application system also has provisions for up to five canals. Thus, with the supply system and application system combined there should be no problem entering data for all open channel sections into FISA.

The remaining inputs for each canal are in table form, some of which may need additional explanation. Flow Rate is the flow rate for which the channel will be sized in the SYSTEM routine to compute its initial cost. If this flow rate is unknown, zero can be entered, and the Maximum Flow Rate Entering the System that was entered in the preceding WATER screen will be used to size the open channel. Suggested values for Seepage Loss can be viewed by simultaneously pressing ALT-M. The seepage menu is shown in Figure 3-18. Simultaneously pressing ALT-L while viewing the SEEPAGE screen will return the SUPPLYCANAL screen. Loan number refers to the loan under which the open channel is financed if any of the cost is financed. Loan number 1 is for attached items and loan number 2 is for unattached items. **Even if none of the cost is financed, the value entered for Loan No. <u>must</u> be either 1 or 2.**

```
THE FOLLOWING FIVE SCREENS OF REQUESTED INFORMATION REFER TO THE SUPPLY

SYSTEM ONLY.  THE SUPPLY SYSTEM CONSISTS OF COMPONENTS USED TO CONVEY

FROM THE SOURCE TO THE APPLICATION SYSTEM(S).  YOU WILL BE ASKED TO

ENTER DATA FOR ANY CANALS, STRUCTURES, PUMPS, PIPELINES OR MISCELLANEOUS

EXPENSE ITEMS REQUIRED IN THE SUPPLY SYSTEM.


                         PRESS ALT-S TO CONTINUE
```

Figure 3-16 The SUPPLYMESSAGE screen.

```
ARE DATA TO BE ENTERED FOR ANY OPEN CHANNELS IN THE SUPPLY SYSTEM
(YES or NO)? . . . . . . . . . . . . . . . . . . . . . . . .     YES
IF YES, FILL IN THE TABLE BELOW FOR EACH OPEN CHANNEL.

NUMBER OF CHANNELS (MAXIMUM OF 5). . . . . . . . . . . . . .       1

CHANNEL ID No.                  1         2         3         4         5
-------------------------------------------------------------------------
LINED ? (YES OR NO) . . . .    YES
LENGTH IN FEET. . . . . . .   1000
PERCENT SLOPE . . . . . . .    0.1
FLOW RATE (CFS)(0-UNKNOWN).      0
SEEPAGE LOSS (ALT-M = MENU)    0.1
SALVAGE VALUE (% OF COST) .      0
PERCENT OF COST FINANCED. .     50
LOAN No. (1 OR 2) . . . . .      1
ANNUAL MAINTENANCE COST (%)      5
TOTAL ANNUAL MISC. COST ($)    120
-------------------------------------------------------------------------
                        PRESS ALT-S TO CONTINUE
```

Figure 3-17 Example SUPPLYCANAL screen.

```
PRESS ALTERNATE-L TO LEAVE THIS MENU AND RETURN
TO THE OPEN CHANNEL INFORMATION SCREEN.

ESTIMATED LOSS
CU FT/SQ FT/DAY)                      CONVEYANCE MATERIAL
-------------------------------------------------------------
          4.5 -- GRAVEL
          2.5 -- GRAVELLY SAND
          1.8 -- SAND, GRAVELLY SANDY LOAM
          1.3 -- LOAM, SANDY LOAM
          0.8 -- GRAVELLY CLAY & SANDY LOAM, SANDY CLAY LOAM
          0.6 -- CLAY LOAM, SILT LOAM, ASH LOAM
          0.4 -- CLAY LOAM 2-3 FT. OVER HARDPAN
          0.3 -- CEMENTED GRAVEL, HARDPAN, IMPERVIOUS CLAY LOAM
          0.2 -- DETERIORATED CONCRETE DITCH
          0.1 -- WELL MAINTAINED CONCRETE DITCH
```

Figure 3-18 Seepage loss menu.

The next screen requiring information about supply system components is the SUPPLYSTRUCTS screen. An example SUPPLYSTRUCTS screen is shown in Figure 3-19. This screen is similar to the previous SUPPLYCANAL screen. The first question asks if there are any open channel structures required in the supply system. If the response is NO, the remaining inputs are disregarded and ALT-S can be pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question in the SUPPLYSTRUCTS screen asks how many structures are required. The maximum number is 5. If more than five structures are required, each application system also has provisions for up to five structures. Thus, with the supply system and application system combined there should be no problem entering data for all open channel structures into FISA.

```
ARE DATA TO BE ENTERED FOR ANY STRUCTURES IN THE SUPPLY SYSTEM
(YES or NO)? . . . . . . . . . . . . . . . . . . . . . . . . .      YES

IF YES, FILL IN THE TABLE BELOW FOR EACH STRUCTURE

NUMBER OF STRUCTURES (MAXIMUM OF 5). . . . . . . . . . . . . .        1

STRUCTURE ID No.                 1         2         3         4         5
--------------------------------------------------------------------------
TOTAL COST. . . . . . . . .   3100
SALVAGE VALUE (% OF COST) .      0
PERCENT OF COST FINANCED. .     50
LOAN No. (1 OR 2) . . . . .      1
ANNUAL MAINTENANCE COST (%)      2
TOTAL ANNUAL MISC. COST ($)     10
--------------------------------------------------------------------------

                      PRESS ALT-S TO CONTINUE
```

Figure 3-19 An example SUPPLYSTRUCTS screen.

The next screen to appear is the SUPPLYPUMPS screen. An example SUPPLYPUMPS screen is shown in Figure 3-20. The first question is if there are any pumps required in the supply system. If the response is NO, the remaining inputs are disregarded and ALT-S is pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question in the SUPPLYPUMPS screen is how many pumps are required. The maximum number is 5. If more than five pumps are required, each application system also has provisions for up to five pumps. Thus, with the supply system and application system combined there should be no problem getting your pump requirements entered into FISA.

The remaining inputs for each pump are in table form, some of which may need additional explanation. Discharge is the flow rate of the pump. If this flow rate is unknown, zero can be entered, and the SYSTEM routine will use the value entered in the WATER screen for Maximum Flow Rate Entering the System as the pump flow rate. Discharge Pressure is the pressure required at the pump discharge. Inlet Pressure, is the pressure at the inlet end of the suction pipe. If water is being pumped from a well or sump, the Inlet Pressure should be entered as zero. Vertical Lift is the vertical distance from the water surface to the outlet of the pump. In the case of a booster pump, the Vertical Lift should be entered as zero. Zero can be entered for the value of Pump Efficiency in which case a default value of 75 percent will be used. Zero may also be entered for the value of Motor Efficiency in which case a default value of 95 percent will be used. Zero may be also entered for the value of Pump Cost in which case the SYSTEM routine will provide an approximate cost based on Discharge and Discharge Pressure. Head losses within pumps are assumed negligible.

```
ARE DATA TO BE ENTERED FOR ANY PUMPS IN THE SUPPLY SYSTEM
(YES or NO)? . . . . . . . . . . . . . . . . . . . . . . . . .       YES
IF YES, FILL IN THE TABLE BELOW FOR EACH PUMP (PRESS PgDn FOR TABLE).

NUMBER OF PUMPS  (MAXIMUM OF 5). . . . . . . . . . . . . . . .         2

PUMP ID No.                      1        2        3        4        5
----------------------------------------------------------------------
DISCHARGE (GPM)(0-UNKNOWN).      0        0
DISCHARGE PRESSURE (PSI). .      5        5
INLET PRESSURE (PSI). . . .      0        0
VERTICAL LIFT (FT). . . . .     20       20
PUMP EFF (%)(0-UNKNOWN) . .      0        0
MOTOR EFF (%) (0-UNKNOWN) .      0        0
PUMP COST ($) (0-UNKNOWN) .      0        0
SALVAGE VALUE (% OF COST) .     12       12
PERCENT OF COST FINANCED. .     80       80
LOAN No. (1 OR 2) . . . . .      2        2
ANNUAL MAINTENANCE COST (%)     10       10
TOTAL ANNUAL MISC. COST ($)     50       50
----------------------------------------------------------------------
                     PRESS ALT-S TO CONTINUE
```

Figure 3-20 An example SUPPLYPUMPS screen.

The next screen to appear requiring information about the supply system is the SUPPLYPIPES screen. An example SUPPLYPIPES screen is shown in Figure 3-21. Again the first question to be answered is whether there are any pipelines required in the supply system. If the response is NO, the remaining inputs are disregarded, and ALT-S is pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question in the SUPPLYPIPES screen is how many pipelines are required. The maximum number is 5. If more than five pipelines are required, each application system also has provisions for up to five pipelines. Thus, with the supply system and application system combined there should be no problem entering data for all pipelines into FISA.

The remaining inputs for each pipeline are in table form, some of which may need additional explanation. Material, refers to the type of pipeline to be installed. The choices are: S for steel, P for PVC, and A for aluminum. Costs, including installation, are computed by the SYSTEM routine, and pipelines of steel or PVC are assumed to be buried. Percent Slope, is a negative value for pipelines going downhill in the direction of flow and positive for pipelines going uphill in the direction of flow. The value entered for Flow Rate may be zero if the actual value is unknown, in which case the value for Maximum Flow Rate Entering the System entered in the WATER screen is used for the design flowrate.

```
ARE DATA TO BE ENTERED FOR ANY PIPELINES IN THE SUPPLY SYSTEM
(YES or NO)? . . . . . . . . . . . . . . . . . . . . . . . . .      NO
IF YES, FILL IN THE TABLE BELOW FOR EACH PIPELINE.

NUMBER OF PIPELINES (MAXIMUM OF 5). . . . . . . . . . . . . .        1

PIPELINE ID No.                1       2       3       4       5
-----------------------------------------------------------------
MAT'L(S-STEEL,P-PVC,A-ALUM)    S
LENGTH (FT) . . . . . . . .  3100
PERCENT SLOPE . . . . . . .   0.2
FLOW RATE (CFS)(0-UNKNOWN).     0
SALVAGE VALUE (% OF COST) .     0
PERCENT OF COST FINANCED. .    80
LOAN No. (1 OR 2) . . . . .     1
ANNUAL MAINTENANCE COST (%)     8
TOTAL ANNUAL MISC. COST ($)    10
-----------------------------------------------------------------
                    PRESS ALT-S TO CONTINUE
```

Figure 3-21 An example SUPPLYPIPES screen.

The last screen requiring information about the components of the supply system is the SUPPLYEXTRAS screen. An example SUPPLYEXTRAS screen is shown in Figure 3-22. The first question to be answered is whether there are any extra expenses for other components required in the supply system. Typical examples might be wells, pump houses, electrical panels, fencing, bridges, etc. Extra expenses are essentially costs for any items associated with the supply system. If the response is NO, the remaining inputs in the screen are disregarded, and ALT-S is pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question in the SUPPLYEXTRAS screen is how many extra expense items are required. The maximum number is 5. If more than five extra expense items are required, each application system also has provisions for up to five extra expense items. Thus, with the supply system and application system combined there should be no problem entering data for extra expenses into FISA.

The next three screens to appear pertain to managing the data file being constructed. The first of these is the SAVEWORKSHEETI screen shown in Figure 3-23. This screen informs the user that part one of the data file building process is complete and to save the part one worksheet for later editing sessions. If the part one worksheet is saved, it can be retrieved and used later for subsequent runs of FISA. The biggest advantage to saving the part one worksheet is that all of the new inputs are saved which can speed up the data file building process on subsequent runs.

```
ARE DATA TO BE ENTERED FOR ANY EXTRA EXPENSES IN THE SUPPLY SYSTEM i.e.
WELLS, FENCING, PUMP HOUSE, BRIDGES, ETC. (YES or NO)?. . . .       YES
IF YES, FILL IN THE TABLE BELOW FOR EACH ITEM.

NUMBER OF ITEMS (MAXIMUM OF 5). . . . . . . . . . . . . . . .         2

ITEM ID No.                    1       2       3       4       5

-----------------------------------------------------------------------
ITEM NAME . . . . . . . . . .ELEC PANEPUMPHOUSE
COST ($). . . . . . . . . .   1500    2000
USEFUL LIFE (YRS) . . . . .     15      15
SALVAGE VALUE (% OF COST) .      5       5
PERCENT OF COST SUBSIDIZED.      0       0
PERCENT OF COST FINANCED. .    100     100
LOAN No. (1 OR 2) . . . . .      2       2
ANNUAL MAINTENANCE COST (%)      2      13
TOTAL ANNUAL MISC. COST ($)     12      50
-----------------------------------------------------------------------

                    PRESS ALT-S TO CONTINUE
```

Figure 3-22 An example SUPPLYEXTRAS screen.

```
    YOU HAVE JUST COMPLETED PART ONE OF THE FISA DATA FILE BUILDING
    PROCESS.

    YOU MAY WISH TO SAVE THIS PART ONE WORKSHEET FOR LATER USE WHEN
    EDITING DATA FILES. TO SAVE THIS WORKSHEET, PRESS THE F9
    FUNCTION KEY FOLLOWED BY THE KEYS 'FS'. THEN ENTER A SUITABLE
    SYMPHONY WORKSHEET FILENAME.

                  PRESS ALT-S TO BEGIN PART TWO
```

Figure 3-23 The SAVEWORKSHEETI screen.

Part one of the worksheet is saved by pressing the F9 function key followed by F then S, and entering a suitable filename. **Be sure not to save the file as FISAI.**

The next screen to appear is the DATAFILE screen shown in Figure 3-24. This screen informs the user that part one of the data file is being assembled and to wait. This process can take up to two minutes, **BE PATIENT!** The next screen will appear and the computer will beep twice when it has completed building part one of the site-specific data file.

```
PLEASE WAIT WHILE PART ONE OF THE DATA FILE IS BEING ASSEMBLED.

THIS MAY TAKE UP TO TWO MINUTES.  YOU WILL BE NOTIFIED WHEN

THIS PROCESS IS COMPLETE.
```

Figure 3-24 The DATAFILE screen.

The next screen to appear is the RECOVERMEM screen shown in Figure 3-25. The purpose of this screen is to have the user temporarily save the current worksheet and then retrieve it to recover usable memory. **NOTE: The worksheet at this point is <u>not</u> the same as that previously saved in the SAVEWORKSHEETI screen and thus must be saved again.** This memory problem is characteristic of LOTUS SYMPHONY. This action of saving and retrieving the worksheet will allow room for combining the second part the file building template and its static data.

```
YOU NEED TO TEMPORARILY SAVE THE CURRENT WORKSHEET AT THIS TIME AND

IMMEDIATELY RETRIEVE IT TO REGAIN SOME FREE MEMORY BEFORE PROCEEDING

TO PART TWO OF THE DATA FILE BUILDING PROCESS.  BE SURE TO SAVE THE CURRENT

WORKSHEET UNDER A TEMPORARY FILENAME, NOT THE SAME NAME USED TO SAVE THE

PART ONE WORKSHEET WHICH WILL APPEAR AS THE DEFAULT FILENAME.  AFTER

SAVING AND RETRIEVING THE CURRENT WORKSHEET, PRESS ALT-S TO CONTINUE.
```

Figure 3-25 The RECOVERMEM screen.

The next screen displayed is the LOADWORKSHEETII screen shown in Figure 3-26. This screen informs the user that it is time to load part two of the worksheet and finish building the data file. The part two worksheet is loaded by entering the file name of the part two worksheet at the prompt located at the top of the screen. This file name can be any part two worksheet created and saved earlier or FISAII if a part two worksheet has not been previously created. It will take a minute or so for the part two worksheet to load and appear on the screen.

```
IT IS NOW TIME TO LOAD IN PART TWO OF THE DATA FILE BUILDING WORKSHEET.


ENTER THE FILENAME OF THE PART TWO WORKSHEET TO LOAD AT THE PROMPT ABOVE.


ENTER 'FISAII' IF A PREVIOUSLY SAVED PART TWO WORKSHEET IS NOT AVAILABLE.
```

Figure 3-26 The LOADWORKSHEETII screen.

The first screen of the part two worksheet to appear is the CHECKMEM screen shown in Figure 3-27. The purpose of this screen is to have the user check the amount of free memory remaining by pressing the F9 function key followed by S. If the remaining memory is less than 20%, the current worksheet should be temporarily saved and retrieved as was done previously. If the remaining memory is greater than 20%, then this step is optional. Once the amount of remaining memory has been checked and the appropriate action taken, simultaneously pressing ALT-S will start the part two data file building process.

The first screen of the part two worksheet to appear requiring data entry is the SYSTEM screen shown in Figure 3-28. The SYSTEM screen contains a menu of the types of irrigation application systems that can be considered by FISA. The user is required to input the number of separate irrigation application systems on the farm. The maximum number is 6. Only one application system is allowed per field. Thus, the number of application systems cannot be greater than the number of fields on the farm. Attempting to go to the next screen when the number of application systems is greater than number of fields on the farm, results in a message telling the user to correct the data. After the correct number of systems is entered, pressing ALT-S will bring up the next screen.

```
                                  WARNING

IN SOME CASES YOU MAY NOT HAVE ENOUGH FREE MEMORY TO COMPLETE THE PART

TWO WORKSHEET.  CHECK REMAINING MEMORY BY PRESSING THE F9 FUNCTION KEY

FOLLOWED BY S.  IF THE REMAINING MEMORY IS LESS THAN 20%, YOU SHOULD TRY

TO REGAIN SOME FREE MEMORY BY SAVING THE WORKSHEET AND RETRIEVING IT.

BE SURE TO SAVE THE CURRENT WORKSHEET UNDER A TEMPORARY FILE NAME NOT THE

ONE THAT AUTOMATICALLY APPEARS DURING THE SAVE FUNCTION.

                       PRESS ALT-S TO BEGIN PART TWO
```

Figure 3-27 The CHECKMEM screen.

```
THE FOLLOWING LIST OF IRRIGATION SYSTEMS ARE SUPPORTED BY FISA:

TYPE No.    DESCRIPTION                  TYPE No.    DESCRIPTION
------------------------------------------------------------------------
   1    -- GRADED BORDER                     5    -- SIDE-ROLL SPRINKLER
   2    -- FURROW OR CORRUGATE               6    -- CENTER-PIVOT
   3    -- SOLID SET SPRINKLER               7    -- LINEAR-MOVE
   4    -- HAND-MOVE SPRINKLER
------------------------------------------------------------------------

ENTER THE NUMBER OF SEPARATE APPLICATION SYSTEMS TO BE CONSIDERED
ON THE FARM (THERE CAN BE ONE OR MORE FIELDS PER SYSTEM) . . .        6

                         PRESS ALT-S TO CONTINUE
```

Figure 3-28 Example SYSTEM screen.

The next screen to appear is the SYSTEM2 screen. This screen partially overlays the preceding SYSTEM screen such that the application system type menu remains visible. Figure 3-29 shows an example SYSTEM2 screen. Not all of the SYSTEM2 screen can be shown at one time on the computer display. Therefore, PgDn and PgUp may need to be used to view the entire screen. The number of application systems listed in the table appearing in the SYSTEM2 screen is dependent upon the value entered for the number of systems on the farm in the previous screen. For each application system, the user is required to enter an application System Type No. from the menu that remains visible on the computer display, the Number Of Fields served by the system, and the Field ID# of each field served. The sum of the values in the table entered for Number Of Fields served by each system must equal the number of fields on the farm. Attempting to go to the next screen when the number of fields served by the application systems is greater than number of fields on the farm, results in a message telling the user to correct the data. After the correct data are entered, simultaneously pressing ALT-S brings up the next screen.

```
ENTER THE SYSTEM TYPE No. FROM THE MENU ABOVE AND NUMBER OF FIELDS AND
FIELD ID#'S SERVED BY EACH SYSTEM IN THE TABLE BELOW.  PRESS PgUp AND PgDn
TO VIEW TABLE BELOW.  PRESS ALT-S AFTER DATA ENTRY TO CONTINUE.

SYSTEM No.              1       2       3       4       5       6
------------------------------------------------------------------------
SYSTEM TYPE No.         1       2       3       5       6       7
NUMBER OF FIELDS        1       1       1       1       1       1
------------------------------------------------------------------------
FIELD  1 ID#            1       2       3       4       5       6
FIELD  2 ID#
FIELD  3 ID#
FIELD  4 ID#
FIELD  5 ID#
FIELD  6 ID#
FIELD  7 ID#
FIELD  8 ID#
FIELD  9 ID#
FIELD 10 ID#
FIELD 11 ID#
```

Figure 3-29 An example SYSTEM2 screen.

The next screen to appear is the SYSTEMONE screen. The purpose of the SYSTEMONE screen is to have the user enter site-specific information regarding the first application system. The exact inputs required in this screen depend upon the type of application system chosen. A different set of inputs appears for each of the seven possible application system types. The inputs for each application system are explained in the following paragraphs.

Each set of inputs for an application system is broken down into two groups, those which are system dependent and those which are field dependent. The system dependent inputs are located above those that are field dependent. The field dependent inputs must be entered for each field listed. This could be up to 11 fields. Since no more than four fields can be shown on the computer display at once, the left and right arrow keys may have to be used to scroll the screen to the left and right to enter and view field data.

In the case of a graded border application system, the inputs that would appear in the SYSTEMONE screen are shown in Figure 3-30. Some of the inputs have default values provided that can be changed by simply entering the desired value in the appropriate cell. Flow Rate Entering the System is the normal flow rate expected to operate the system. This flow rate is used to determine the number of sets per irrigation and border width. Hours per Day System Operates is the hours per day the system would normally operate if water where available 24 hours per day. The input, Open End Border, is YES (default) for open ended borders and NO for closed-end borders. Additional Hours Labor per Season, is used to account for labor requirements which occur over the season. Such requirements could be cleaning head gates and/or ditches, checking soil moisture, etc. Annual Maintenance Costs include costs for such things as repairs to head gates, automatic gates and smoothing and rebordering the field. An Application Efficiency and Deep Percolation Percentage may be entered if these are known. The advantage to entering these two inputs is that it greatly decreases the time required to run the SYSTEM routine as these values are then not computed. If an Application Efficiency and Deep Percolation Percentage are entered, the Unit Flow Rate of the border must also be entered. The default values for Application Efficiency, Deep Percolation Percentage and Unit Flow Rate are zero, as they are typically unknown.

```
ENTER THE INFORMATION LIST BELOW FOR APPLICATION SYSTEM NUMBER
     1    -- GRADED BORDER.

 FLOW RATE ENTERING THE SYSTEM (CFS). . . . . . . . . . . . .      1
 HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE . . . .    24

INFORMATION FOR EACH FIELD:

 FIELD No.                                1
--------------------------------------------
 FIELD LENGTH (FT). . . . . . . . .     800
 FIELD WIDTH (FT) . . . . . . . . .    2178
 FIELD SLOPE (%). . . . . . . . . .     0.1
 BORDER LENGTH (FT) . . . . . . . .     800
 MAXIMUM BORDER WIDTH (FT). . . . .      80
 OPEN END BORDER (YES OR NO). . . .     YES
 LABOR REQUIRED (HRS/AC/IRR). . . .     0.6
 HOURS ADD'L LABOR PER SEASON . . .       0
 COST OF LAND GRADING & BORDERING .    3000
   PERCENT OF COST FINANCED . . . .      50
   LOAN No. (1 OR 2). . . . . . . .       1
 ANNUAL MAINTENANCE COST ($). . . .     300
 APPLICATION EFF (%) (0-UNKNOWN). .       0
 DEEP PERCOLATION (%) (0-UNKNOWN) .       0
 UNIT FLOW RATE (CFS/FT)(0-UNKNOWN)       0
--------------------------------------------
                       PRESS ALT-S TO CONTINUE
```

Figure 3-30 An example SYSTEMONE screen for a graded border system.

In the case of a furrow or corrugate application system, the inputs that would appear in the SYSTEMONE screen are shown in Figure 3-31. Some of the inputs have default values provided that can be changed by simply entering the desired value in the appropriate cell. The Flow Rate Entering the System is the normal flow rate expected to operate the system. This flow rate is used to determine the number of furrows per set and number of sets per irrigation. A Maximum Furrow Flow can be entered if the user wants to specify one. Otherwise zero can be entered (default) and the SYSTEM routine will compute a value based on the standard furrow or corrugate spacing of the crop.

```
ENTER THE INFORMATION LIST BELOW FOR APPLICATION SYSTEM NUMBER
    2  --  FURROW OR CORRUGATE

 FLOW RATE ENTERING THE SYSTEM (CFS). . . . . . . . . . . . .        1
 HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE . . .        24

INFORMATION FOR EACH FIELD:

 FIELD No.                                  2
--------------------------------------------------
 FIELD LENGTH (FT). . . . . . . . .      1000
 FIELD WIDTH (FT) . . . . . . . . .      1745
 FIELD SLOPE (%). . . . . . . . . .       0.2
 FURROW LENGTH (FT) . . . . . . . .      1000
 MAX FURROW FLOW (GPM) (0-UNKNOWN).         0
 SET TIME INCREMENT (HRS) . . . . .        12
 MAXIMUM SET TIME (HRS) . . . . . .        72
 LABOR REQUIRED (HRS/AC/IRR). . . .       0.8
 HOURS ADD'L LABOR PER SEASON . . .         0
 TOTAL COST OF LAND GRADING . . . .      3000
   PERCENT OF COST FINANCED . . . .        50
   LOAN No. (1 OR 2). . . . . . . .         1
 ANNUAL MAINTENANCE COST ($). . . .       200
 APPLICATION EFF (%) (0-UNKNOWN). .         0
 DEEP PERCOLATION (%) (0-UNKNOWN) .         0
 FURROW FLOW RATE (GPM)(0-UNKNOWN).         0
--------------------------------------------------
                        PRESS ALT-S TO CONTINUE
```

Figure 3-31 An example SYSTEMONE screen for a furrow or corrugate system.

Set Time Increment is the expected minimum time interval for which the irrigator will be willing to tend to irrigation duties. Total irrigation set time is a multiple of the Set Time Increment, with the minimum total irrigation set time being one Set Time Increment. For example, if the Set Time increment is 6 hours then the total irrigation set time could be 6, 12, 18, 24, or any other multiple of 6 hours depending upon how long it takes the system to apply the irrigation requirement. Maximum Set Time is the maximum time the water will be applied in one field location. Additional Hours Labor per Season, is used to account for labor requirements which occur over the season. Such requirements could be cleaning head gates and/or ditches, picking up siphon tubes, etc. Annual Maintenance Costs include costs for such things as repairs to the head gates, and smoothing and furrowing or corrugating the field. An Application Efficiency and Deep Percolation Percentage may be entered if these are known. The advantage to entering these two inputs is that it greatly decreases the time required to run the SYSTEM routine as these values are then not computed. If an Application Efficiency and Deep Percolation Percentage are entered, the Furrow Flow Rate must also be entered. The default values for Application Efficiency, Deep Percolation Percentage and Furrow Flow Rate are zero, as they are typically unknown.

In the case of a solid-set sprinkler system, the inputs that would appear in the SYSTEMONE screen are shown in Figure 3-32. Several of the inputs have default values provided that can be changed by simply entering the desired value in the appropriate cell. Basin Tillage Practice refers to soil erosion and runoff control measures which might be taken. Block Width is the width of field section that is irrigated at one time. Set Time increment is the expected minimum time interval for which the irrigator will be willing to tend to irrigation duties. Total irrigation set time is a multiple of the Set Time Increment, with the minimum total irrigation set time being one Set Time Increment. For example, if the Set Time increment is 6 hours then the total irrigation set time could be 6, 12, 18, 24, or any other multiple of 6 hours depending upon how long it takes the system to supply the irrigation requirement. Gross APP. or EST. CU (consumptive use) is the daily depth of water that must be applied by the sprinkler system to meet crop needs, leaching requirements, and any losses such as evaporation, runoff, etc. Additional Hours Labor per Season, is used to account for labor requirements which occur over the season. Annual Maintenance Costs include costs for such things as repairs to valves, risers, mainline, lateral lines, sprinkler heads, etc.

In the case of a side-roll sprinkler system or a hand move sprinkler system, the inputs that would appear in the SYSTEMONE screen are shown in Figure 3-33. Several of the inputs have default values provided. These default values can be changed by simply entering the desired value in the appropriate cell. Hours Per Week Additional Down Time is the expected time in hours per week that the system will be non-operational due to moving, or regular maintenance. Gross Application Depth or Estimated Consumptive Use is the daily depth of water that must be applied by the sprinkler system to meet crop needs, leaching requirements, and any losses such as evaporation, runoff, etc. Annual Maintenance Costs include costs for such things as repairs to valves, risers, mainline, lateral lines, sprinkler heads, etc. Lateral Travel Distance is the length along the mainline that one lateral is expected to cover during a complete irrigation. Set Time increment is the expected minimum time interval for which the irrigator will be willing to tend to irrigation duties. Total irrigation set time is a multiple of the Set Time Increment, with the minimum total irrigation set time being one Set Time Increment. For example, if the Set Time increment is 6 hours then the total irrigation set time could be 6, 12, 18, 24, or any other multiple of 6 hours depending upon how long it takes the system to supply the irrigation requirement. Hours Additional Labor per Season, is used to

```
ENTER THE INFORMATION LISTED BELOW FOR APPLICATION SYSTEM NUMBER
     3  --  SOLID SET SPRINKLER

 HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE . . . .    24
 WIND RANGE NUMBER AT NOZZLE HEIGHT (1 = 0-4 MPH, 2 = 4-10 MPH,
 3 = 10-14 MPH). . . . . . . . . . . . . . . . . . . . . . .      2

INFORMATION FOR EACH FIELD:

 FIELD No.                                3
--------------------------------------------
 BASIN TILLAGE PRACTICE (YES OR NO)      NO
 LATERAL LENGTH (FT). . . . . . . .    1100
 LATERAL SPACING (FT) . . . . . . .      50
 LATERAL DIAMETER (IN). . . . . . .       4
 SPRINKLER SPACING (FT) . . . . . .      40
 SPRINKLER TYPE NUMBER
 (1 = HIGH PRESSURE IMPACTS
  2 = LOW PRESS IMPACTS-STD NOZZLE
  3 = LOW PRESS IMPACTS-CD NOZZLE
  4 = LOW PRESS IMPACTS-FC NOZZLE).       1
 BLOCK WIDTH (FT) . . . . . . . . .     200
 NUMBER OF BLOCKS . . . . . . . . .       6
 SET TIME INCREMENT (HRS) . . . . .       2
 GROSS APP. OR EST. CU (IN/DAY) . .    0.45
 AVERAGE FIELD SLOPE (%). . . . . .       2
 LABOR REQUIRED (HRS/AC/IRR). . . .    0.05
 HOURS ADD'L LABOR PER SEASON . . .       2
 COST PER LATERAL LINE ($). . . . .    1269
   PERCENT OF COST FINANCED . . . .      50
   LOAN No. (1 OR 2). . . . . . . .       2
 SALVAGE VALUE (%). . . . . . . . .      15
 TOTAL COST OF LAND GRADING . . . .     500
   PERCENT OF COST FINANCED . . . .      50
   LOAN No. (1 OR 2). . . . . . . .       1
 ANNUAL COST FOR LAND SMOOTHING . .      50
 ANNUAL MAINTENANCE COST (%). . . .      12
 TOTAL ANNUAL MISC. COST ($). . . .     100
--------------------------------------------
                        PRESS ALT-S TO CONTINUE
```

Figure 3-32 An example SYSTEMONE screen for a solid set sprinkler system.

account for labor requirements which occur over the season.

For a center-pivot sprinkler system, the inputs in the SYSTEMONE screen are as shown in Figure 3-34. Some of the inputs have default values provided that can be changed by simply entering the desired value in the appropriate cell. Gross Application Depth or Estimated Consumptive use is the daily depth of water that must be applied by the sprinkler system to

```
ENTER THE INFORMATION LISTED BELOW FOR APPLICATION SYSTEM NUMBER
     4  --  SIDE-ROLL SPRINKLER

 HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE . . . .     24
 HOURS PER WEEK ADD'L DOWN TIME WHEN WATER IS AVAILABLE. . . .      3
 WIND RANGE NUMBER AT NOZZLE HEIGHT (1 = 0-4 MPH, 2 = 4-10 MPH,
  3 = 10-14 MPH). . . . . . . . . . . . . . . . . . . . . . . .     3
 LATERAL LENGTH (FT) . . . . . . . . . . . . . . . . . . . . . .  1320
 LATERAL SPACING (FT). . . . . . . . . . . . . . . . . . . . . .    50
 LATERAL DIAMETER (IN) . . . . . . . . . . . . . . . . . . . . .     5
 SPRINKLER SPACING (FT). . . . . . . . . . . . . . . . . . . . .    40
 SPRINKLER TYPE NUMBER (1 = HIGH PRESSURE IMPACTS,
  2 = LOW PRESS IMPACTS-STD NOZZLE, 3 = LOW PRESS IMPACTS-CD NOZZLE
  4 = LOW PRESS IMPACTS-FC NOZZLE) . . . . . . . . . . . . . . .     2
 NUMBER OF LATERAL LINES . . . . . . . . . . . . . . . . . . . .     3
 GROSS APPLICATION DEPTH OR ESTIMATED CONSUMPTIVE USE (IN/DAY)     0.51
 COST PER LATERAL LINE ($) . . . . . . . . . . . . . . . . . . .  2689
   PERCENT OF COST FINANCED. . . . . . . . . . . . . . . . . . .    50
   LOAN No. (1 OR 2) . . . . . . . . . . . . . . . . . . . . . .     2
 SALVAGE VALUE (%) . . . . . . . . . . . . . . . . . . . . . . .    12
 ANNUAL MAINTENANCE COST (%) . . . . . . . . . . . . . . . . . .    11
 TOTAL ANNUAL MISC. COST ($) . . . . . . . . . . . . . . . . . .    59

INFORMATION FOR EACH FIELD:

 FIELD No.                              4
-------------------------------------------
 AVERAGE FIELD SLOPE (%). . . . . .     2
 LATERAL TRAVEL DISTANCE (FT) . . .   475
 SET TIME INCREMENT (HRS) . . . . .     8
 BASIN TILLAGE PRACTICE (YES OR NO)    NO
 LABOR REQUIRED (HRS/AC/IRR). . . .   0.3
 HOURS ADD'L LABOR PER SEASON . . .     2
 TOTAL COST OF LAND GRADING . . . .   500
   PERCENT OF COST FINANCED . . . .   100
   LOAN No. (1 OR 2). . . . . . . .     1
 ANNUAL COST FOR LAND SMOOTHING . .    34
-------------------------------------------
                         PRESS ALT-S TO CONTINUE
```

Figure 3-33 An example SYSTEMONE screen for a side roll sprinkler system.

meet crop needs, leaching requirements, and any losses such as evaporation, runoff, etc. Annual Maintenance Costs include costs for such things as repairs to valves, mainline, lateral line, sprinkler heads, etc. Wetted Radius is the distance in a radial direction from the pivot that is effectively irrigated.

```
ENTER THE INFORMATION LISTED BELOW FOR APPLICATION SYSTEM NUMBER
     5  --  CENTER PIVOT SPRINKLER

 HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE . . . .    24
 LATERAL LENGTH (FT) . . . . . . . . . . . . . . . . . . . . .  1300
 LATERAL DIAMETER (IN) . . . . . . . . . . . . . . . . . . . .  6.63
 GROSS APPLICATION DEPTH OR ESTIMATED CONSUMPTIVE USE (IN/DAY)  0.43
 SPRINKLER TYPE NUMBER (1 = HIGH PRESS IMPACT,
  2 = LOW PRESS IMPACT-STD NOZZLE, 3 = LOW PRESS IMPACTS-CD NOZZLE
  4 = LOW PRESS IMPACTS-FC NOZZLE, 5 = SPRAYS-TOP MOUNTED
  6 = SPRAYS-DROP TUBES,  7 = SPRAYS-BOOMS . . . . . . . . . .     7
 PRESSURE REGULATORS USED (YES OR NO). . . . . . . . . . . . .   YES
 ENDGUN USED (YES OR NO) . . . . . . . . . . . . . . . . . . .   YES
 AVERAGE WIND SPEED GREATER THAN 5 MPH (YES OR NO) . . . . . .    NO
 LABOR REQUIRED (HRS/AC/IRR) . . . . . . . . . . . . . . . . .   0.1
 TOTAL COST ($). . . . . . . . . . . . . . . . . . . . . . . . 63789
   PERCENT OF COST FINANCED. . . . . . . . . . . . . . . . . .    50
   LOAN No. (1 OR 2) . . . . . . . . . . . . . . . . . . . . .     2
 SALVAGE VALUE (%) . . . . . . . . . . . . . . . . . . . . . .    15
 ANNUAL MAINTENANCE COST (%) . . . . . . . . . . . . . . . . .    12
 TOTAL ANNUAL MISC. COST ($) . . . . . . . . . . . . . . . . .   300

INFORMATION FOR EACH FIELD:

 FIELD No.                                 5
--------------------------------------------
 AVERAGE FIELD SLOPE (%). . . . . .        5
 WETTED RADIUS (FT) . . . . . . . .     1350
 BASIN TILLAGE PRACTICE (YES OR NO)      YES
 TOTAL COST OF LAND GRADING . . . .     1200
   PERCENT OF COST FINANCED . . . .       50
   LOAN No. (1 OR 2). . . . . . . .        1
 ANNUAL COST FOR LAND SMOOTHING . .      300
--------------------------------------------
                          PRESS ALT-S TO CONTINUE
```

Figure 3-34 An example SYSTEMONE screen for a center pivot sprinkler system.

The inputs appearing in the SYSTEMONE screen for a linear-move sprinkler system are shown in Figure 3-35. Gross Application Depth or Estimated Consumptive Use is the daily depth of water that must be applied by the sprinkler system to meet crop needs, leaching requirements, and any losses such as evaporation, runoff, etc. Annual Maintenance Costs include costs for such things as repairs to valves, mainline, lateral line, sprinkler heads, etc.

```
ENTER THE INFORMATION LISTED BELOW FOR APPLICATION SYSTEM NUMBER
      6  --  LINEAR MOVE SPRINKLER

 HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE . . . .    24
 LATERAL LENGTH (FT) . . . . . . . . . . . . . . . . . . . . .  1867
 LATERAL DIAMETER (IN) . . . . . . . . . . . . . . . . . . . .  6.63
 GROSS APPLICATION DEPTH OR ESTIMATED CONSUMPTIVE USE (IN/DAY)  0.43
 SPRINKLER TYPE NUMBER (1 = HIGH PRESS IMPACT,
 2 = LOW PRESS IMPACT-STD NOZZLE, 3 = LOW PRESS IMPACTS-CD NOZZLE
 4 = LOW PRESS IMPACTS-FC NOZZLE, 5 = SPRAYS-TOP MOUNTED
 6 = SPRAYS-DROP TUBES,  7 = SPRAYS-BOOMS . . . . . . . . . . .    6
 PRESSURE REGULATORS USED (YES OR NO). . . . . . . . . . . . .   YES
 SUPPLY IN CENTER OF LATERAL (YES OR NO) . . . . . . . . . . .   YES
 AVERAGE WIND SPEED GREATER THAN 5 MPH (YES OR NO) . . . . . .   YES
 LABOR REQUIRED (HRS/AC/IRR) . . . . . . . . . . . . . . . . .   0.1
 TOTAL COST ($). . . . . . . . . . . . . . . . . . . . . . . . 67893
   PERCENT OF COST FINANCED. . . . . . . . . . . . . . . . . .    50
   LOAN No. (1 OR 2) . . . . . . . . . . . . . . . . . . . . .     2
 SALVAGE VALUE (%) . . . . . . . . . . . . . . . . . . . . . .    15
 ANNUAL MAINTENANCE COST (%) . . . . . . . . . . . . . . . . .    12
 TOTAL ANNUAL MISC. COST ($) . . . . . . . . . . . . . . . . .   356

INFORMATION FOR EACH FIELD:

 FIELD No.                                  6
--------------------------------------------
 AVERAGE FIELD SLOPE (%). . . . . . .       2
 FIELD LENGTH(FT)(TRAVEL DIRECTION)      1867
 BASIN TILLAGE PRACTICE (YES OR NO)        NO
 TOTAL COST OF LAND GRADING . . . .      1200
   PERCENT OF COST FINANCED . . . .        50
   LOAN No. (1 OR 2). . . . . . . .         1
 ANNUAL COST FOR LAND SMOOTHING . .       234
--------------------------------------------
                         PRESS ALT-S TO CONTINUE
```

Figure 3-35 An example SYSTEMONE screen for a linear move sprinkler system.

After the appropriate values have been entered for application system number one, pressing ALT-S brings up the SYSONECANAL screen. An example SYSONECANAL screen is shown in Figure 3-36. This screen requests the user to enter the open channel requirements of application system number one. The first question asks if any open channels are required. If the response is NO, the remaining inputs are disregarded, and ALT-S can be pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question in the SYSONECANAL screen is how many open channels are required. The maximum number is 5. The remaining inputs for each canal are in table form. Flow Rate, is the flow rate for which the channel will be sized in the SYSTEM routine to compute initial cost. If this flow rate is unknown, then zero can be entered and the SYSTEM program will either use the Flow Rate Entering System value entered in the SYSTEMONE screen or use a flow rate computed using the Gross Application Depth or Estimated Consumptive Use value entered in the SYSTEMONE screen. Suggested values for Seepage Loss can be viewed by simultaneously pressing ALT-M. The seepage menu is shown in Figure 3-18. After viewing the seepage menu, simultaneously pressing ALT-L will return the SYSONECANAL screen. Loan number refers to the loan under which the open channel is financed, if any of the cost is financed. Loan number 1 is for attached items and loan number 2 is for unattached items. **Even if none of the cost is financed, the value entered for Loan No. _must_ be either 1 or 2.**

```
ARE DATA TO BE ENTERED FOR ANY OPEN CHANNELS IN SYSTEM NUMBER 1
(YES or NO)? . . . . . . . . . . . . . . . . . . . . . . . . . .   YES
IF YES, FILL IN THE TABLE BELOW FOR EACH OPEN CHANNEL.

NUMBER OF CHANNELS (MAXIMUM OF 5). . . . . . . . . . . . . . . .     1

CHANNEL ID No.                    1         2         3         4         5
-----------------------------------------------------------------------------
LINED ? (YES OR NO) . . . .      NO
LENGTH IN FEET. . . . . . .    2178
PERCENT SLOPE . . . . . . .     0.1
FLOW RATE (CFS)(0-UNKNOWN).       1
SEEPAGE LOSS (ALT-M = MENU)     0.3
SALVAGE VALUE (% OF COST) .       0
PERCENT OF COST FINANCED. .      30
LOAN No. (1 OR 2) . . . . .       1
ANNUAL MAINTENANCE COST (%)      10
TOTAL ANNUAL MISC. COST ($)      60
-----------------------------------------------------------------------------
                        PRESS ALT-S TO CONTINUE
```

Figure 3-36 An example SYSONECANAL screen.

The next screen requiring information about application system one components is the SYSONESTRUCTS screen. An example SYSONESTRUCTS screen is shown in Figure 3-37. The first question asks if there are any open channel structure requirements. If the response is NO, the remaining inputs are disregarded and ALT-S, can be pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S. The second question in the SYSONESTRUCTS screen is how many structures are required. The maximum number is 5.

ARE DATA TO BE ENTERED FOR ANY STRUCTURES IN SYSTEM NUMBER 1 (YES or NO)? . . . . YES

IF YES, FILL IN THE TABLE BELOW FOR EACH STRUCTURE.

NUMBER OF STRUCTURES (MAXIMUM OF 5). 1

STRUCTURE ID No.	1	2	3	4	5
TOTAL COST.	300				
SALVAGE VALUE (% OF COST) .	0				
PERCENT OF COST FINANCED. .	80				
LOAN No. (1 OR 2)	2				
ANNUAL MAINTENANCE COST (%)	2				
TOTAL ANNUAL MISC. COST ($)	0				

PRESS ALT-S TO CONTINUE

Figure 3-37 An example SYSONESTRUCTS screen.

The next screen requiring information about application system one components is the SYSONEPUMPS screen. An example SYSONEPUMPS screen is shown in Figure 3-38. The first question to be answered is if any pumps are required for application system one. If the response is NO, the remaining inputs are disregarded, and ALT-S is pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question in the SYSONEPUMPS screen asks how many pumps are required. The maximum number is 5. The remaining inputs for each pump are in table form. Discharge is the flow rate of the pump. If this flow rate is unknown, then zero can be entered and the SYSTEM routine will either use the Flow Rate Entering System value entered in the SYSTEMONE screen or use the Gross Application Depth or Estimated Consumptive Use value entered in the SYSTEMONE screen to compute a flow rate. Discharge Pressure is the pressure required at the pump outlet. Inlet Pressure is the pressure at the inlet end of the suction pipe. If water is being pumped from a well or sump, the Inlet Pressure should be zero. Vertical Lift is the vertical distance from the water surface to the outlet of the pump. In the case of a booster pump, the Vertical Lift should be zero. Zero can be entered for the value of Pump Efficiency, in which case a default value of 75 percent will be used by the SYSTEM routine. Zero may also be entered for the value of Motor Efficiency in which case a default value of 95 percent will be used by the SYSTEM routine. Zero may be entered for the value of Pump Cost in which case the SYSTEM routine will provide an approximate cost based on the Discharge Pressure and flow rate. Head losses within pumps are assumed negligible.

The next screen requiring information about application system one components is the SYSONEPIPES screen. An example SYSONEPIPES screen is shown in Figure 3-39. Again, the first question to be answered is whether

```
ARE DATA TO BE ENTERED FOR ANY PUMPS IN SYSTEM NUMBER 1 (DO NOT INCLUDE
PUMPS ENTERED AS PART OF THE SUPPLY SYSTEM) (YES or NO)? . . .        NO
IF YES, FILL IN THE TABLE BELOW FOR EACH PUMP (PRESS PgDn FOR TABLE).

NUMBER OF PUMPS  (MAXIMUM OF 5). . . . . . . . . . . . . . . . .        1

PUMP ID No.                   1          2          3          4          5
--------------------------------------------------------------------------
DISCHARGE (GPM)(0-UNKNOWN).
DISCHARGE PRESSURE (PSI). .
INLET PRESSURE (PSI). . . .
VERTICAL LIFT (FT). . . . .
PUMP EFF (%)(0-UNKNOWN) . .
MOTOR EFF (%)(0-UNKNOWN). .
PUMP COST ($)(0-UNKNOWN). .
SALVAGE VALUE (% OF COST) .
PERCENT OF COST FINANCED. .
LOAN No. (1 OR 2) . . . . .
ANNUAL MAINTENANCE COST (%)
TOTAL ANNUAL MISC. COST ($)
--------------------------------------------------------------------------
                        PRESS ALT-S TO CONTINUE
```

Figure 3-38 An example SYSONEPUMPS screen.

```
ARE DATA TO BE ENTERED FOR ANY PIPELINES IN SYSTEM NUMBER 1
(YES or NO)? . . . . . . . . . . . . . . . . . . . . . . . . .        NO
IF YES, FILL IN THE TABLE BELOW FOR EACH PIPELINE.

NUMBER OF PIPELINES (MAXIMUM OF 5). . . . . . . . . . . . . .          1

PIPELINE ID No.               1          2          3          4          5
--------------------------------------------------------------------------
MAT'L(S-STEEL,P-PVC,A-ALUM)
LENGTH (FT) . . . . . . . .
PERCENT SLOPE . . . . . . .
FLOW RATE (CFS)(0-UNKNOWN).
SALVAGE VALUE (% OF COST) .
PERCENT OF COST FINANCED. .
LOAN No. (1 OR 2) . . . . .
ANNUAL MAINTENANCE COST (%)
TOTAL ANNUAL MISC. COST ($)
--------------------------------------------------------------------------
                        PRESS ALT-S TO CONTINUE
```

Figure 3-39 An example SYSONEPIPES screen.

any pipelines required for application system one. If the response is NO, the remaining inputs are disregarded, and ALT-S is pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question in the SYSONEPIPES screen asks how many pipelines are required. The maximum number is 5. The remaining inputs for each pipeline are in table form. Material refers to the type of pipeline to be installed. The choices are: S for steel, P for PVC, and A for aluminum. Pipelines of steel or PVC are assumed to be buried when their installation costs are computed by the SYSTEM routine. Percent Slope, is a negative value for pipelines going downhill in the direction of flow and positive for pipelines going uphill in the direction of flow. The value entered for Flow Rate may be zero if the actual value is unknown, in which case the SYSTEM routine will either use the Flow Rate Entering System value entered in the SYSTEMONE screen or use a flow rate computed from the Gross Application Depth or Estimated Consumptive Use value entered in the SYSTEMONE screen.

The last screen requiring information about the components of the application system one is the SYSONEEXTRAS screen. An example SYSONEEXTRAS screen is shown in Figure 3-40. The first question to be answered is whether there are any extra expenses for other components required for application system one. Typical examples might be wells, pump houses, electrical panels, fencing, bridges, etc. Extra expenses are essentially costs for any items associated with the application system. If the response is NO, the remaining inputs are disregarded, and ALT-S is pressed to bring up the next screen. If the response to the first question is YES,

```
ARE DATA TO BE ENTERED FOR ANY EXTRA EXPENSES IN SYSTEM NUMBER 1 i.e.
WELLS, FENCING, PUMP HOUSE, BRIDGES, ETC. (YES or NO)?. . . .      YES
IF YES, FILL IN THE TABLE BELOW FOR EACH ITEM.

NUMBER OF ITEMS (MAXIMUM OF 5). . . . . . . . . . . . . . . .        1

ITEM ID No.                  1        2        3        4        5
----------------------------------------------------------------------
ITEM NAME . . . . . . . . . OUTLETS
COST ($). . . . . . . . . .    1000
USEFUL LIFE (YRS) . . . . .      15
SALVAGE VALUE (% OF COST) .      20
PERCENT OF COST FINANCED. .     100
LOAN No. (1 OR 2) . . . . .       2
ANNUAL MAINTENANCE COST (%)      10
TOTAL ANNUAL MISC. COST ($)      35
----------------------------------------------------------------------

                    PRESS ALT-S TO CONTINUE
```

Figure 3-40 An example SYSONEEXTRAS screen.

then the remaining inputs in the screen must be answered before pressing ALT-S. The second question in the SYSONEXTRAS screen asks how many extra expense items are required. The maximum number is 5.

The next screen to appear depends upon how many application systems there are on the farm. If there is more than one, the next screen to appear is the SYSTEMTWO screen. This screen serves the same purpose as the SYSTEMONE screen except it requests information regarding the second application system. As with the SYSTEMONE screen, the particular inputs depend on the type of application system selected. Once this information has been entered, the next five screens request information about any open channel, structure, pump, pipeline, and extra expense items required for application system two. These screens are named SYSTWOCANALS, SYSTWOSTRUCTS, SYSTWOPUMPS, SYSTWOPIPES, and SYSTWOEXTRAS, respectively. The inputs in these screens are the same as those for application system one except they are for application system two. This process of entering information for each application system continues until the information for each system on the farm has been entered. The respective screen names change slightly to refer to the system number to which data are being entered.

After the required information regarding each application system has been entered, the DRAINAGE screen appears. An example DRAINAGE screen is shown in Figure 3-41. The first question to be answered is whether any field on the farm requires subsurface drainage. If the response is NO, the remaining inputs are disregarded, and ALT-S is pressed to bring up the next screen. If the response to the first question is YES, then the remaining inputs in the screen must be answered before pressing ALT-S.

The second question to be answered is how many fields require subsurface drainage. The remainder of the inputs are in table form. The field ID#'s of the fields requiring drainage must be entered at the top of the table above the dashed line. Then in each column under the field ID#, field-specific information is entered. Days Between Irrigations is an estimate of the average number of days. Contingency Cost is an estimated possible cost over run based on a percentage of the new cost.

The last screen to appear requesting information about the on-farm irrigation system is the SIMULATE screen. An example SIMULATE screen is shown in Figure 3-42. The inputs in this screen pertain to some of the economic conditions to be expected over the life of the system. The first input is the Maximum Labor Input Available. This value controls the distribution of water on the farm in the FISA simulation routine. When the Maximum Labor Input Available has been used up, irrigation stops. The values entered for Inflation Rate of Labor Costs and Inflation Rate of Operating and Maintenance Costs are estimates over the life of the system.

The next screen to appear is the DATAFILE2 screen shown in Figure 3-43. This screen informs the user that part two of the data file is being assembled and to wait. This process can take up to three minutes, **BE PATIENT!** The next screen will appear and the computer will beep twice when it has completed building part one of the data file.

After part two of the site-specific data file has been constructed, the SAVEWORKSHEET2 screen shown in Figure 3-44 appears. This screen informs the user that Part Two of the data file building process is complete and to save the Part Two worksheet for later editing sessions.

```
IS SUBSURFACE DRAINAGE REQUIRED BY ANY OF THE FIELDS IN THE FARM
(YES OR NO). . . . . . . . . . . . . . . . . . . . . . . . . . YES
IF YES, FILL IN THE TABLE BELOW FOR EACH FIELD REQUIRING DRAINAGE.

NUMBER OF FIELDS REQUIRING SUBSURFACE DRAINAGE . . . . . . . .      2

FIELD IDENTIFICATION NUMBER. . . . .         1        3
-----------------------------------------------------
DAYS BETWEEN IRRIGATIONS . . . . . . .      10       10
ROOT ZONE DEPTH (FT) . . . . . . . . .       3        3
DRAIN DEPTH (FT) . . . . . . . . . . .       8        8
DEPTH TO LOWER BARRIER (FT). . . . . .       9        9
CONDUCTIVITY OF DRAIN LAYER (FT/DAY)       0.3      0.3
MINIMUM DEPTH TO WATER TABLE (FT). .         4        4
SLOPE OF DRAIN LATERALS (%). . . . .       0.1      0.1
CONTINGENCY COST (% OF NEW COST) . .        13       13
PERCENT OF COST FINANCED . . . . . .         0        0
LOAN No. (1 OR 2). . . . . . . . . .         1        1
ANNUAL MAINTENANCE COST (%). . . . .        15       15
SALVAGE VALUE (%). . . . . . . . . .         0        0
TOTAL ANNUAL MISCELLANEOUS COST ($).        30       30
-----------------------------------------------------

                    PRESS ALT-S TO CONTINUE
```

Figure 3-41 An example DRAINAGE screen.

```
ENTER THE INFORMATION REQUESTED BELOW:

MAXIMUM LABOR INPUT AVAILABLE IN HOURS PER WEEK . . . . . . .     250


LABOR WAGE RATE ($/HR). . . . . . . . . . . . . . . . . . . .    5.45


EXPECTED ANNUAL INFLATION RATE FOR LABOR (%). . . . . . . . .       8


EXPECTED ANNUAL INFLATION RATE FOR OPERATING AND MAINTENANCE
COSTS (%) . . . . . . . . . . . . . . . . . . . . . . . . . .      10



                    PRESS ALT-S TO CONTINUE
```

Figure 3-42 An example SIMULATE screen.

Part Two of the worksheet is saved by pressing the F9 function key followed by FS, and entering a suitable filename. Be sure not to save the file as FISAII. Pressing ALT-S causes the next screen to appear.

```
PLEASE WAIT WHILE PART TWO OF THE DATA FILE IS BEING CREATED.

THIS MAY TAKE UP TO THREE MINUTES.  YOU WILL BE NOTIFIED WHEN

THIS PROCESS IS COMPLETE.
```

Figure 3-43 The DATAFILE2 screen.

```
YOU HAVE JUST COMPLETED PART TWO THE FISA DATA FILE BUILDING
PROCESS.

YOU MAY WISH TO SAVE THIS PART TWO WORKSHEET FOR LATER USE TO MAKE
SUBSEQUENT DATA FILES.  TO SAVE THIS WORKSHEET, PRESS THE F9
FUNCTION KEY FOLLOWED BY THE KEYS 'FS'.  THEN ENTER A SUITABLE
SYMPHONY WORKSHEET FILENAME.


                  PRESS ALT-S TO CONTINUE
```

Figure 3-44 The SAVEWORKSHEET2 screen.

The next screen to appear is the EDITDATA screen shown in Figure 3-45. This screen informs the user that he has the option of viewing and editing the data file just constructed. Simultaneously pressing ALT-E will make the data file appear on the screen and provide full editing capability. Care must be taken when the data file contents are changed because only certain inputs can be changed without making the data file inoperable for SYSTEM and Simulate routines. See Editing Data Files in the following section of this manual for a list of things that can be changed in the data file.

The EDITDATA screen also informs the user how to save the data file on disk so that it can be used by the SYSTEM and SIMULATE routines. This is accomplished by simultaneously pressing ALT-P. When ALT-P is pressed, the PRINTDATAFILE screen shown in Figure 3-46 appears along with a prompt at the top screen to enter the desired name of the data file. If a filename extension is not entered for the data file, SYMPHONY will attach the extension 'PRN'. It is suggested that the user enter a file name extension

```
THE DATA FILE BUILDING PROCESS IS COMPLETE.  YOU MAY VIEW THE DATAFILE
BY PRESSING ALT-E.  YOU WILL HAVE THE CAPABILITY OF CHANGING THE
INFORMATION CONTAINED IN THE DATA FILE.  HOWEVER, BE CAREFUL OF WHAT YOU
CHANGE AS YOU CAN EASILY MAKE THE DATA INCONSISTENT CAUSING FISA TO
TERMINATE DUE TO CONFLICTING INPUT DATA.  IF YOU MAKE ANY CHANGES BE SURE
TO SAVE THE WORKSHEET AGAIN USING THE F9 FUNCTION KEY.

SAVE THE DATA FILE TO THE DISK BY PRESSING ALT-P AND ENTERING A
SUITABLE FILE NAME WHEN PROMPTED.  IF YOU DON'T INCLUDE A FILENAME
EXTENSION, SYMPHONY WILL ADD ONE (.PRN).  IT IS SUGGESTED THAT YOU USE
THE FILE NAME EXTENSION '.DAT'.

END THIS SYMPHONY DATA FILE BUILDING WORKSHEET IN THE SAME MANNER AS
OTHER SYMPHONY WORK SESSION (PRESS F9 AND E).
```

Figure 3-45 The EDITDATA screen.

```
ENTER A SUITABLE FILENAME FOR THE DATAFILE AT THE PROMPT ABOVE.

NOTE:  IF THE FILENAME YOU SPECIFY ALREADY EXISTS, SYMPHONY WILL
       APPEND THE INFORMATION TO THE END OF THE EXISTING FILE.
       THEREFORE MAKE SURE THE FILE YOU SPECIFY DOES NOT ALREADY
       EXIST ON THE DISK (USE F9 'FE' TO ERASE AN EXISTING FILE).
```

Figure 3-46 The PRINTDATAFILE screen.

of 'DAT'. Also, if a file already exists with the same name as that entered at the prompt, SYMPHONY will append the current data file to the end of the file that already exists. Thus, a file with the desired name must not exist on the disk when saving a data file. If such a file exists, it can be erased by pressing the F9 function key, pressing 'FE', entering the filename to be erased and confirming the entered filename.

Once the data file has been saved to disk, the SYMPHONY work session is ended in the usual manner by pressing the F9 function key, pressing 'E', and confirming you wish to exit SYMPHONY.

Appendix B contains a detailed discussion of the macro-language programming for the two SYMPHONY templates, FISAI and FISAII.

EDITING A DATA FILE CREATED FOR FISA

There are two ways to edit a FISA data file. One approach allows the user to view the completed data file and directly edit its contents. This approach has some major drawbacks in that only minor things can be changed without making the data file unusable. A basic rule for determining which items can be changed is that the change must not affect any subsequent entries as far as their location in the data file is concerned. For instance, the number of fields on the farm could not be changed by directly editing the data file. If the number of fields were increased or decreased, there would be too many or too few lines in the file for the number of fields indicated causing the SYSTEM and SIMULATE programs to crash. On the other hand, the size of a field could be changed in the appropriate place without damage to the data file.

In Table 3-1, listed in the order in which they appear in the data file are the data items which may be changed. The statement that "EXISTENCE OF _________ REQUIREMENT CANNOT BE CHANGED" means that a particular irrigation system component cannot be added or deleted, only the entries pertaining to the particular irrigation system component can be changed.

The safest way to change entries in a FISA data file is to go through the data file building process again, using the part one and part two worksheet files that were saved (providing that they were) when the original data file was created. This process is the same as using the two worksheet files FISAI and FISAII, however, the inputs will now be the same as those entered in the original data file and the only editting is for those inputs with desired changes.

To edit a data file directly, retrieve into SYMPHONY the part two worksheet that was saved when the data file to be edited was created. The EDITDATA screen shown in Figure 3-45 will appear. Press ALT-E simultaneously to have the data file appear on the screen. The data file is quite large, therefore the PgUp, PgDn, and left and right arrow keys will need to be used to view the entire data file. When finished editing, simultaneously press ALT-P to print the data file to disk for use by FISA. The user may wish to save the part two worksheet under a new filename for later editing of the new data file just saved.

Table 3-1 Data file entries which can be changed and conditions which must be met to make the change if any.

Data Entry	Conditions if any
DATA DESCRIPTIVE NAME	
IRRIGATION SEASON	
FIRST MONTH OF SEASON	
LAST MONTH OF SEASON	
IRRIGATED AREA	
INTAKE FAMILY	
SPRINKLER INTAKE RATE	
EROSIVITY FACTOR	
CROP No.	OKAY IF ORIGINAL CROP IS STILL GROWN IN SOME FIELD AND NEW CROP ALREADY IS GROWN IN SOME FIELD.
TAM	
MAD	
AD	
NORMAL YIELD	
EXPECTED NET RETURN	
COST OF OPPORTUNITY CAPITAL	
INFLATION RATE OF SYSTEM COMPONENTS	
MAXIMUM SUBSIDY AMOUNT	
LOAN INTEREST RATE	
LOAN PERIOD	
CFS ENTERING SYSTEM	
AC-FT AVAILABLE	
DAY PER WEEK FLOW IS AVAILABLE	
COST OF BASIC ALLOTMENT	
VOLUME OF BASIC ALLOTMENT	
COST PER AC-FT/AC	
COST OF ADDITIONAL WATER	
ALL ENTRIES UNDER ELECTRICAL USAGE	EXISTENCE OF ELECTRICAL USAGE CANNOT BE CHANGED.
SUPPLY SYSTEM OPEN CHANNEL ENTRIES	EXISTENCE OF AN OPEN CHANNEL REQUIREMENT CANNOT BE CHANGED.
SUPPLY SYSTEM STRUCTURE ENTRIES	EXISTENCE OF A STRUCTURE REQUIREMENT CANNOT BE CHANGED.
SUPPLY SYSTEM PUMP ENTRIES	EXISTENCE OF A PUMP REQUIREMENT CANNOT BE CHANGED.
SUPPLY SYSTEM PIPELINE ENTRIES	EXISTENCE OF A PIPELINE REQUIREMENT CANNOT BE CHANGED.
SUPPLY SYSTEM EXTRA EXPENSE ENTRIES	EXISTENCE OF AN EXTRA EXPENSE REQUIREMENT CANNOT BE CHANGED.
ANY APPLICATION SYSTEM ENTRIES	EXISTENCE OF AN APPLICATION SYSTEM CANNOT BE CHANGED NOR CAN THE SYSTEM TYPE.
APPLICATION SYSTEM OPEN CHANNEL ENTRIES	EXISTENCE OF AN OPEN CHANNEL REQUIREMENT CANNOT BE CHANGED.
APPLICATION SYSTEM STRUCTURE ENTRIES	EXISTENCE OF A STRUCTURE REQUIREMENT CANNOT BE CHANGED.
APPLICATION SYSTEM PUMP ENTRIES	EXISTENCE OF A PUMP REQUIREMENT CANNOT BE CHANGED.
APPLICATION SYSTEM PIPELINE ENTRIES	EXISTENCE OF A PIPELINE REQUIREMENT CANNOT BE CHANGED.
APPLICATION SYSTEM EXTRA EXPENSE ENTRIES	EXISTENCE OF AN EXTRA EXPENSE CANNOT BE CHANGED.
ALL ENTRIES UNDER DRAINAGE REQUIRED	EXISTENCE OF A DRAINAGE REQUIREMENT CANNOT BE CHANGED.
MAXIMUM LABOR INPUT	
LABOR WAGE RATE	
INFLATION RATE ON LABOR COSTS	
INFLATION RATE ON O&M COSTS	

CHAPTER 4

DATA FILES REQUIRED TO RUN FISA

The information required by FISA to evaluate an on-farm irrigation system plan is contained in five separate data files. They are the ON-FARM, RAINFALL, PET, CROPDATA, and COSTDATA files. An brief explanation of each data file is presented in the following paragraphs

The On-farm Data file is the most comprehensive. This file is created using two LOTUS SYMPHONY worksheets, FISAI and FISAII, which guide the user through the necessary inputs and steps to assemble this data file. Detailed instructions on assembling an On-farm data file and its contents are presented in Chapter 3.

The Rainfall and PET (Potential Evapotranspiration) data files make up two of the data files required by FISA. These files are used by the simulate routine of FISA. The simulation program is driven on a semi-monthly time step. Thus, for each year of record, the Rainfall and PET data files contain date information followed by 24 half-monthly values of rainfall and potential evapotranspiration, respectively. The data in each of the files must appear in a specific format to be read by the simulate routine. The required format for both files in terms of a FORTRAN 77 Format statement is: (1X,I4,3X,12F7.2/8X,12F7.2) (which translates into: one blank space, year of record expressed in four digits, three blank spaces, a series of twelve-seven digit numbers in the form XXXX.XX, skip to next line, eight blank spaces, and another series of twelve-seven digit number expressed in the form XXXX.XX). The values of rainfall and PET are expressed in units of inches.

The fourth data file required by FISA is the CROPDATA file. This file contains growth stage, evapotranspiration crop coefficients, and miscellaneous information for each crop of interest. This file is created using a LOTUS SYMPHONY worksheet called CROPDATA. The layout of an example CROPDATA worksheet is shown in Figure 4-1. The CROPDATA worksheet is divided into two parts. The top portion of the worksheet is the input area for crop data. The lower portion of the worksheet is a simple manipulation of the input data to get the important crop growth dates in a form suitable for FISA. This process involves converting the crop growth dates from a day-month format to the number of days from the beginning of the year. The crops are listed in no particular order with the exception of FALLOW which must always appear as CROP No. 1. However, the ordering of the crops must match that of the crops listed in the CROPMENU screen of the FISAI worksheet.

A short explanation of the information appearing in the CROPDATA file is in order. Appearing from left to right is: Crop No., a one or two digit number used to index a crop; Crop Name, up to 15 characters in length; planting date, harvest date, effective cover date, flowering date, yield formation date and ripening date all expressed in day-month format; 24 values of crop coefficients for each half-monthly period in the year in X.XX format; four values of the yield response factor for the vegetative, flowering, yield formation, and ripening stage of growth, respectively; Manning's n value for border irrigation, zero or blank if border irrigation is not suitable for the crop; typical furrow or corrugate spacing of the

CROP No.	CROP NAME	PLANT DATE	HARVEST DATE	EFFECTIVE COVER DATE	FLWR DATE	YIELD FORM DATE	RIPE DATE	Kc 1ST	Kc 2ND	Kc 3RD	Kc 4TH	Kc 5TH	Kc 6TH	Kc 7TH	Kc 8TH	Kc 9TH	Kc 10TH	Kc 11TH	Kc 12TH
1	FALLOW	1-JAN	31-DEC	1-JAN	1-JAN	1-JAN	1-JAN	0	0	0	0	0	0	0	0	0	0	0	0
2	ALFALFA HAY	1-APR	30-OCT	15-MAY	31-MAY	5-JUN	15-JUN	0	0	0	0	0	0	0.75	0.93	1	0.97	0.95	0.55
3	DRY BEANS	22-MAY	30-AUG	15-JUL	5-JUL	25-JUL	15-AUG	0	0	0	0	0	0	0	0	0	0.15	0.32	0.55
4	SUGAR BEETS	14-APR	15-OCT	10-JUL	10-JUL	15-AUG	15-OCT	0	0	0	0	0	0	0	0.3	0.3	0.31	0.5	0.9
5	SPRING WHEAT	4-APR	10-AUG	20-JUN	20-JUN	25-JUN	15-JUL	0	0	0	0	0	0	0.3	0.36	0.75	0.95	1	1
6	SPRING BARLEY	4-APR	10-AUG	20-JUN	20-JUN	25-JUN	15-JUL	0	0	0	0	0	0	0.3	0.36	0.75	0.95	1	1
7	FIELD CORN	5-MAY	20-SEP	15-JUL	30-JUL	15-AUG	10-SEP	0	0	0	0	0	0	0	0	0.3	0.3	0.35	0.7
8	SWEET CORN	5-MAY	15-AUG	15-JUL	20-JUL	30-JUL	15-AUG	0	0	0	0	0	0	0	0	0.3	0.3	0.35	0.7
9	DRY PEAS	10-APR	25-JUL	5-JUN	15-JUN	20-JUN	5-JUL	0	0	0	0	0	0	0.15	0.3	0.55	0.85	0.9	0.6
10	POTATOES	25-APR	10-OCT	10-JUL	1-JUL	15-JUL	20-SEP	0	0	0	0	0	0	0	0.1	0.3	0.37	0.63	0.78
11	WINTER WHEAT	15-FEB	10-AUG	5-JUN	5-JUN	20-JUN	15-JUL	0	0	0	0.3	0.35	0.55	0.75	0.9	0.95	1	1	1

CROP No.	CROP NAME	Kc 13TH	Kc 14TH	Kc 15TH	Kc 16TH	Kc 17TH	Kc 18TH	Kc 19TH	Kc 20TH	Kc 21ST	Kc 22ND	Kc 23ND	Kc 24ND	Ky 1ST	Ky 2ND	Ky 3RD	Ky 4th	BORD "n"	FUR'W SP'C (in)	SS OK	SH OK	CH OK	MAX CROP COVER	AVE RE'DUE YIELD
1	FALLOW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	30	Y	Y	Y	0	0
2	ALFALFA HAY	0.98	0.97	0.55	0.98	0.97	0.5	0.55	0.35	0	0	0	0	0.85	0.85	0.85	0.85	0.15	26	Y	Y	Y	100	2000
3	DRY BEANS	0.9	0.9	0.55	0.1	0	0	0	0	0	0	0	0	0.2	1.1	0.75	0.2		28	Y	Y	Y	85	1000
4	SUGAR BEETS	1	1	0.96	0.9	0.87	0.7	0.6	0	0	0	0	0	0.8	0.8	0.8	0.8		30	Y	Y	Y	85	200
5	SPRING WHEAT	0.75	0.3	0.15	0	0	0	0	0	0	0	0	0	0.2	0.65	0.55	0.1	0.1	22	Y	Y	Y	100	1200
6	SPRING BARLEY	0.75	0.3	0.15	0	0	0	0	0	0	0	0	0	0.2	0.65	0.55	0.1	0.1	22	Y	Y	Y	100	1200
7	FIELD CORN	0.9	0.95	0.91	0.85	0.65	0.15	0	0	0	0	0	0	0.4	1.5	0.5	0.2		30	N	N	Y	90	1000
8	SWEET CORN	0.9	0.93	0.83	0.65	0	0	0	0	0	0	0	0	0.4	1.5	0.5	0		30	N	N	Y	90	1500
9	DRY PEAS	0.35	0.1	0	0	0	0	0	0	0	0	0	0	0.2	0.9	0.7	0.2	0.3	22	Y	Y	Y	100	1400
10	POTATOES	0.85	0.85	0.8	0.75	0.68	0.5	0.3	0	0	0	0	0	0.45	0.8	0.7	0.2		30	Y	Y	Y	85	600
11	WINTER WHEAT	0.95	0.8	0.3	0	0	0	0	0	0	0	0	0	0.2	0.6	0.5	0.1	0.1	22	Y	Y	Y	100	1400

CROP No.	CROP NAME	PLANT DATE	HARVEST DATE	EFFECTIVE COVER DATE	FLWR DATE	YIELD FORM DATE	RIPE DATE	Kc 1ST	Kc 2ND	Kc 3RD	Kc 4TH	Kc 5TH	Kc 6TH	Kc 7TH	Kc 8TH	Kc 9TH	Kc 10TH	Kc 11TH	Kc 12TH
1	FALLOW	1	365	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2	ALFALFA HAY	91	303	135	151	156	166	0	0	0	0	0	0	0.75	0.93	1	0.97	0.95	0.55
3	DRY BEANS	142	242	196	186	206	227	0	0	0	0	0	0	0	0	0	0.15	0.32	0.55
4	SUGAR BEETS	104	288	191	191	227	288	0	0	0	0	0	0	0	0.3	0.3	0.31	0.5	0.9
5	SPRING WHEAT	94	222	171	171	176	196	0	0	0	0	0	0	0.3	0.36	0.75	0.95	1	1
6	SPRING BARLEY	94	222	171	171	176	196	0	0	0	0	0	0	0.3	0.36	0.75	0.95	1	1
7	FIELD CORN	125	263	196	211	227	253	0	0	0	0	0	0	0	0	0.3	0.3	0.35	0.7
8	SWEET CORN	125	227	196	201	211	227	0	0	0	0	0	0	0	0	0.3	0.3	0.35	0.7
9	DRY PEAS	100	206	156	166	171	186	0	0	0	0	0	0	0.15	0.3	0.55	0.85	0.9	0.6
10	POTATOES	115	283	191	182	196	263	0	0	0	0	0	0	0	0.1	0.3	0.37	0.63	0.78
11	WINTER WHEAT	46	222	156	156	171	196	0	0	0	0.3	0.35	0.55	0.75	0.9	0.95	1	1	1

CROP No.	CROP NAME	Kc 13TH	Kc 14TH	Kc 15TH	Kc 16TH	Kc 17TH	Kc 18TH	Kc 19TH	Kc 20TH	Kc 21ST	Kc 22ND	Kc 23ND	Kc 24ND	Ky 1ST	Ky 2ND	Ky 3RD	Ky 4th	BORD "n"	FUR'W SP'C (in)	SS OK	SH OK	CH OK	MAX CROP COVER	AVE RE'DUE YIELD
1	FALLOW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	30	Y	Y	Y	0	0
2	ALFALFA HAY	0.98	0.97	0.55	0.98	0.97	0.5	0.55	0.35	0	0	0	0	0.85	0.85	0.85	0.85	0.15	26	Y	Y	Y	100	2000
3	DRY BEANS	0.9	0.9	0.55	0.1	0	0	0	0	0	0	0	0	0.2	1.1	0.75	0.2	0	28	Y	Y	Y	85	1000
4	SUGAR BEETS	1	1	0.96	0.9	0.87	0.7	0.6	0	0	0	0	0	0.8	0.8	0.8	0.8	0	30	Y	Y	Y	85	200
5	SPRING WHEAT	0.75	0.3	0.15	0	0	0	0	0	0	0	0	0	0.2	0.65	0.55	0.1	0.1	22	Y	Y	Y	100	1200
6	SPRING BARLEY	0.75	0.3	0.15	0	0	0	0	0	0	0	0	0	0.2	0.65	0.55	0.1	0.1	22	Y	Y	Y	100	1200
7	FIELD CORN	0.9	0.95	0.91	0.85	0.65	0.15	0	0	0	0	0	0	0.4	1.5	0.5	0.2	0	30	N	N	Y	90	1000
8	SWEET CORN	0.9	0.93	0.83	0.65	0	0	0	0	0	0	0	0	0.4	1.5	0.5	0	0	30	N	N	Y	90	1500
9	DRY PEAS	0.35	0.1	0	0	0	0	0	0	0	0	0	0	0.2	0.9	0.7	0.2	0.3	22	Y	Y	Y	100	1400
10	POTATOES	0.85	0.85	0.8	0.75	0.68	0.5	0.3	0	0	0	0	0	0.45	0.8	0.7	0.2	0	30	Y	Y	Y	85	600
11	WINTER WHEAT	0.95	0.8	0.3	0	0	0	0	0	0	0	0	0	0.2	0.6	0.5	0.1	0.1	22	Y	Y	Y	100	1400

Figure 4-1 Example CROPDATA spreadsheet.

crop, zero or blank if furrow or corrugate irrigation is not suitable for the crop; SS, whether solid-set sprinkler systems are suitable for the crop(Y or N); SM, whether set-move sprinkler systems are suitable for the crop (Y or N); CM, whether continuous-move sprinkler systems are suitable for the crop (Y or N); Maximum Crop Cover, maximum percent ground cover the crop achieves during the growing season; Average Residue Yield, the average amount of residue remaining on the ground surface in units of ton/acre after the crop is harvested and the ground has been tilled in preparation for following crops. The crop coefficient values appearing in the CROPDATA file are dependent upon the particular equation used to compute potential evapotranspiration in the PET file. Any method can be used so long as the crop coefficients are appropriate for the method used to estimate potential evaporation. The crop response factors used here are the same as those described by Doorenbos and Kassam (1979).

The planting, harvesting, etc. dates are converted to days from the beginning of the year using the @DATE function of SYMPHONY. For the @DATE function to work the correct date must be entered into the computer before using the CROPDATA worksheet as the @DATE function uses this date.

The lower portion of the CROPDATA worksheet starting with CROP No. 1 is all that is used to actually setup the CROPDATA file. This lower portion is printed to a disk file with margins set to no-margins. This disk file can be given any name. Its a good idea to save the worksheet file as well for later editing and creation of other CROPDATA files.

After the required crop information has been entered and saved on disk using the CROPDATA worksheet file, this disk file containing the crop information must be converted to a direct access file. The direct access file converts the CROP No. to the record number in the file. The crop information file from the worksheet CROPDATA is converted to a direct access file using the program CRFILGEN. This program requires two inputs, the name of the disk file printed from the worksheet CROPDATA and the name given to the final CROPDATA file. A listing of this program is provided in Appendix F.

The last file required by FISA is the COSTDATA file. This file contains the information needed to compute costs over the life of the irrigation system. This file is again created using a LOTUS SYMPHONY worksheet called COSTDATA. The layout of the information and an example COSTDATA worksheet file are shown in Figure 4-2. Once the necessary data have been entered into the worksheet, the information starting with STEEL PIPE, LOW PRESS is printed to a disk file with margins set to no-margins. This disk file can have any name you choose. It is a good idea to save the worksheet file as well for later editing and creation of additional COSTDATA files. After the required cost information has been entered and printed on disk with margins set to no-margins using the COSTDATA worksheet file, this disk file containing the cost information must be converted to a direct access file. The direct access file assigns each line of the data file a record number. The cost information file from the worksheet COSTDATA is converted to a direct access file using the program COFILGEN. This program requires two inputs, the name of the disk file printed from the worksheet COSTDATA and the name given to the final COSTDATA file. A listing of this program is provided in Appendix G.

In addition to the potential evapotranspiration, rainfall, crop data

LISTED BELOW IS THE STRUCTURE OF THE COST-USEFUL LIFE DATA FILE FOR FISA

ITEM NAME	MISCELLANEOUS INFORMATION (NOTE: PIPE COST IN $/100 FT)
STEEL PIPE, LOW PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
STEEL PIPE, MED PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
STEEL PIPE, HIGH PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
PVC PIPE, LOW PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
PVC PIPE, MED PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
PVC PIPE, HIGH PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
ALUM PIPE, LOW PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
ALUM PIPE, MED PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
ALUM PIPE, HIGH PRESS	# SIZES HW COEFF USEFUL LIFE DIA COST DIA COST DIA COST DIA COST DIA COST . . . .
DRAIN TILE	# SIZES USEFUL LIFE EXCAV COST($/CU.YD.) BACKFILL($/CU.YD.) GRAVEL($/CU.YD.) DIA COST DIA COST . . . .
UNLINED CANAL	COST($/FT) USEFUL LIFE
LINED CANAL	COST($/FT) USEFUL LIFE
PUMPS	USEFUL LIFE
LAND LEVELING	USEFUL LIFE
APPLICATION SYSTEMS	SOLIDSET USEFUL LIFE HANDMOVE USEFUL LIFE SIDEROLL USEFUL LIFE CENTERPIVOT USEFUL LIFE LINEARMOVE USEFUL LIFE

ITEM NAME	MISCELLANEOUS INFORMATION																						
STEEL PIPE, LOW PRESS	10	120	20	3.85	460.23	5.85	692.06	7.85	923.90	9.85	1155.73	11.85	1387.57	13.85	1619.40	15.85	1851.24	17.85	2083.07	19.85	2314.91	21.85	2546.74
STEEL PIPE, MED PRESS	10	120	20	3.85	460.23	5.85	692.06	7.85	923.90	9.85	1155.73	11.85	1387.57	13.85	1619.40	15.85	1851.24	17.85	2083.07	19.79	2678.94	21.79	2947.51
STEEL PIPE, HIGH PRESS	10	120	20	3.85	460.23	5.85	692.06	7.85	923.90	9.85	1155.73	11.85	1387.57	13.85	1619.40	15.67	2134.09	17.79	2410.37	19.79	2678.94	21.79	2947.51
PVC PIPE, LOW PRESS	10	140	25	3.28	64.17	4.36	66.04	5.29	121.01	6.00	94.65	7.99	141.14	9.99	198.60	11.98	270.17	14.97	392.47	17.96	542.72	19.95	658.33
PVC PIPE, MED PRESS	10	140	25	3.28	64.17	3.93	80.79	5.29	121.01	5.84	154.74	7.76	247.74	9.70	366.53	11.64	504.02	14.55	731.06	17.79	1040.97	19.40	1247.83
PVC PIPE, HIGH PRESS	9	140	25	3.23	73.87	4.15	114.10	5.14	165.78	6.12	226.46	7.96	366.22	9.92	548.49	11.77	755.49	13.18	941.00	14.77	1166.71		
ALUM PIPE, LOW PRESS	6	130	15	3.90	94.91	4.90	118.94	5.90	142.97	7.90	191.04	9.90	239.11	11.90	287.17								
ALUM PIPE, MED PRESS	6	130	15	3.90	94.91	4.90	118.94	5.90	142.97	7.90	191.04	9.87	299.66	11.87	359.98								
ALUM PIPE, HIGH PRESS	6	130	15	3.90	94.91	4.90	118.94	5.87	179.03	7.84	302.27	9.80	475.76	11.75	699.49								
DRAIN TILE	3	20	0.50	0.50	3.00	4.00	35.00	6.00	42.00	8.00	65.00												
UNLINED CANAL	0.65	5																					
LINED CANAL	2.68	15																					
PUMPS	15																						
LAND LEVELING	20																						
APPLICATION SYSTEMS	20	12	12	12	12																		

Figure 4-2 Example COSTDATA spreadsheet.

and cost data files required to run the on-farm irrigation system planning programs, some crop data and all soil data must appear in the data file building worksheet, FISAI.

The crop data appearing in the part one worksheet are shown in Figure 4-3. The upper left corner of the crop data is located in cell N13 and continues through column V. The first five columns of crop information are the same as those appearing in the CROPDATA worksheet and can be obtained from this worksheet by printing the five columns of information to a disk file and importing the information into the FISAI worksheet. The remaining four columns of information must be entered from the keyboard. After the crop information is entered into the FISAI worksheet, the rows included in the worksheet ranges CROPMENU and CROPLOOKUPCOL **must** be increased or decreased to include all of the rows of crop information. **The number of columns included in the ranges must not be changed**. The range CROPMENU includes only columns N through Q and the range CROPLOOKUPCOL only includes column N.

One other adjustment to the FISAI worksheet must be done to incorporate the addition or deletion of crop data. The restrict range of the window named CROPMENU must be expanded or reduced to include the rows of crop data appearing in the worksheet. This is done using the window-setting-restrict command while in the CROPMENU window.

CROP No.	CROP NAME	PLANTING DATE	HARVEST DATE	EFFECTIVE COVER DATE	ROOT ZONE DEPTH(ft)	MAD (%)	NORMAL YIELD	NET RETURN ($/UNIT YIELD)
1	FALLOW	1-JAN	31-DEC	1-JAN	5.0	100	0.0	$0.00
2	ALFALFA HAY	23-APR	1-NOV	20-MAY	5.0	50	5.6	$82.50
3	DRY BEANS	5-JUN	30-SEP	20-Jun	2.0	50	23.1	$17.50
4	SPRING GRAIN	20-MAR	30-AUG	14-Apr	3.0	50	85.0	$2.85
5	FIELD CORN	15-MAY	20-OCT	09-Jun	3.0	50	141.5	$2.62
6	SWEET CORN	15-MAY	15-SEP	04-Jun	2.0	40	8.9	$81.00
7	DRY PEAS	27-MAR	15-JUL	11-APR	2.0	50	29.6	$10.20
8	POTATOES	15-MAY	10-OCT	9-JUN	2.0	25	485.0	$3.05
9	WINTER WHEAT	1-OCT	1-AUG	6-MAR	3.0	50	95.0	$3.00
10	PASTURE	23-APR	1-NOV	20-MAY	2.5	50	10.4	$13.00

FIGURE 4-3 Sample crop data appearing in the FISAI worksheet.

All of the soil data required by the on-farm irrigation system planning program are stored in the FISAI worksheet. Figure 4-4 shows the soil data which must appear in the FISAI worksheet. The upper left corner of the soil data are located in cell X13 and continues through column AE. The soil data are entered from the keyboard. After the soil information is entered into the FISAI worksheet, the rows included in the worksheet ranges SOILMENU and SOILLOOKUPCOL **must** be increased or decreased to include all of the rows of crop information. **The number of columns included in the ranges must not be changed**. The range SOILMENU includes only columns X through Z and the range SOILLOOKUPCOL only includes column X.

One other adjustment to the FISAI worksheet must be made to incorporate the addition or deletion of soil data. The restrict range of the window named SOILMENU must be expanded or reduced to include the rows of soil data appearing in the worksheet. This is done using the window-setting-restrict command while in the SOILMENU window.

SOIL No.	SOIL SERIES	TEXTURE	WHC (IN/FT)	DEPTH (FT)	INTAKE FAMILY	SPRINKLER INTAKE (IN/HR)	EROSIVITY FACTOR
1	ADKINS	VF SANDY LOAM	1.80	5.0	0.30	0.35	0.49
2	ADKINS	FSL	1.80	5.0	0.40	0.50	0.32
3	ASHUE	LOAM	0.96	3.0	0.36	0.35	0.37
4	ASHUE	GR LOAM	0.84	3.0	0.36	0.35	0.24
5	BAGDAD	SILT LOAM	2.35	5.0	0.25	0.30	0.43
6	BURBANK	L & LF SAND	0.80	3.0	0.60	1.00	0.24
7	BURBANK	FINE SAND	1.96	3.0	0.80	0.80	0.17
8	BURKE	SILT LOAM	2.40	2.0	0.23	0.30	0.43
9	BURKE	VF SANDY LOAM	3.24	2.0	0.17	0.30	0.49
10	ELLISFORDE	SIL & LOAM	2.35	5.0	0.30	0.25	0.49
11	ELLISFORDE	F SANDY LOAM	2.30	5.0	0.40	0.50	0.32
12	EPHRATA	F SANDY LOAM	1.44	3.0	0.40	0.50	0.32
13	EPHRATA	GR SANDY LOAM	1.43	3.0	0.26	0.40	0.15
14	ESQUATZEL	SIL & LOAM	3.48	5.0	0.18	0.35	0.43
15	ESQUATZEL	F SANDY LOAM	2.42	5.0	0.50	0.60	0.24
16	ESQUATZEL	VF SANDY LOAM	2.45	5.0	0.35	0.40	0.49
17	FARRELL	VF SANDY LOAM	1.49	5.0	0.30	0.35	0.49
18	FARRELL	F SANDY LOAM	1.42	5.0	0.40	0.50	0.24
19	FARRELL	SILT LOAM	1.51	5.0	0.30	0.35	0.43
20	FINLEY	SIL & LOAM	0.86	5.0	0.30	0.35	0.43
21	HEZEL	LF, L, LVF SAND	1.99	5.0	0.60	0.80	0.24
22	HEZEL	FINE SAND	2.02	5.0	0.80	0.80	0.17
23	KENNEWICK	SILT LOAM	2.30	5.0	0.15	0.25	0.55
24	KENNEWICK	LFS & FSL	2.11	5.0	0.30	0.46	0.32
25	NACHES	LOAM	1.42	4.0	0.24	0.25	0.32
26	NEPPEL	F SANDY LOAM	1.40	3.0	0.40	0.50	0.32
27	NEPPEL	SILT LOAM	1.40	3.0	0.27	0.35	0.43
28	PROSSER	SILT LOAM	2.04	2.5	0.25	0.30	0.43
29	PROSSER	SANDY LOAM	1.90	2.5	0.40	0.50	0.28
30	QUINCY	FS & SAND	0.89	5.0	4.00	0.91	0.17
31	QUINCY	LF & L SAND	1.10	5.0	4.00	0.91	0.17
32	RENSLOW	SILT LOAM	2.40	5.0	0.25	0.30	0.49
33	RITZVILLE	SILT LOAM	2.76	5.0	0.25	0.27	0.43
34	RITZVILLE	VF SANDY LOAM	2.40	5.0	0.25	0.30	0.49
35	ROYAL	LF & L SAND	1.80	5.0	0.60	0.80	0.32
36	ROYAL	F&VF SANDY LOAM	1.87	5.0	0.43	0.60	0.37
37	ROYAL	SILT LOAM	1.51	5.0	0.50	0.60	0.49
38	SAGEHILL	VF SANDY LOAM	2.71	5.0	0.36	0.40	0.49
39	SAGEHILL	F SANDY LOAM	2.57	5.0	0.50	0.60	0.32
40	SAGEHILL	LV FINE SAND	2.28	5.0	0.35	0.40	0.43

Figure 4-4 Sample soil data appearing in the FISAI worksheet.

CHAPTER 5

DESCRIPTION OF SYSTEM ROUTINE

OVERVIEW

The main purpose of the SYSTEM program is to provide information about the supply and application systems with enough detail for proper irrigation system simulation and analysis. The program is written to be compatable with the standard FORTRAN 77 programming language.

Data for the program are obtained from several data files. Data for the crop rotations and individual system characteristics is obtained from the file created using the FISA (crop rotation/irrigation system) data file building program which utilizes Lotus SYMPHONY. Also required are data files containing system component costs as well as a file containing crop information pertaining to the suitability of various types of irrigation systems for particular crops.

SYSTEM has the capability of modeling the irrigation performance of seven types of irrigation systems: border, furrow or corrugate, solid-set sprinklers, hand-move sprinklers, side-roll sprinklers, center-pivot and lateral-move sprinkler systems. The program also estimates economical sizes for pipes and open channels within the system, initial system costs, and annual capital cash flows for a particular economic analysis period.

System performance and cost data obtained from SYSTEM are then appended to the FISA On-farm data file used as input for this program. The entire data set can then be used by the SIMULATE program to analyze actual system operation.

INPUT DATA

The majority of the data required for SYSTEM are obtained from the SYMPHONY-created FISA data file. Crop rotation data, the fields' soil characteristics and individual irrigation and supply system component characteristics are read. Also, a file containing information on system component life and costs is required and a crop information file which contains information on border irrigation roughness (Manning's n) values and typical furrow spacing for various crops as well as information about the compatibility of the individual crops to various methods of irrigation.

The user will receive prompts on the screen to enter the names of the appropriate data files. The prompts are shown in Figure 5-1.

```
ENTER THE NAME OF THE CROP ROTATION/SYSTEM DATA FILE TO BE USED

ENTER THE NAME OF THE CROP DATA FILE TO BE USED

ENTER THE NAME OF THE COST DATA FILE TO BE USED
```

Figure 5-1 User prompts for SYSTEM program.

The program uses formatted input statements to be compatible with the input data files.

PROGRAM COMPONENTS

MAIN Program

The function of the main SYSTEM program is to call all of the data entry and modeling subroutines and append the program output to the FISA data file. A flowchart of the SYSTEM program is provided in Figure 5-2 and a program listing in Appendix C. The main program prompts the user to supply the file names and opens the FISA, crop and cost data files. From the FISA data file, the main routine reads crop rotation, power and water cost, and general irrigation system data that apply to all systems. The length of the economic analysis period (currently 20 years) is set in this portion of the program as well.

The main SYSTEM routine checks the input data to prevent the assignment of the same field to more than one irrigation system and also checks for any incompatibility between the irrigation systems specified in the data file and the crops in their respective rotations (e.g. corn specified in a rotation for a field under side-roll irrigation).

The main routine calls the SUPPLY, SPNKLR, SURFCE, and SDRAIN subroutines, the functions of which are discussed individually. These subroutines are called as required by flags in the input data file.

The main SYSTEM routine appends the program output data to the FISA data file. These data are discussed in detail in the section of this report describing the SYSTEM program output.

SUPPLY subroutine

The SUPPLY subroutine, called from the main SYSTEM routine, computes the costs and conveyance efficiency for the farm water supply system. The farm is assumed to be supplied by a single source and a single supply system. In this routine, costs of various components which make up the supply system are obtained, and seepage losses are estimated.

Depending on the components specified, SUPPLY calls the subroutines CANAL, PIPES, PUMP, STRUCT, and OTHER. Any conveyance losses for the supply system are assumed to occur in open channels and are computed in the CANAL subroutine. For purposes of estimating canal losses and pipe costs, it is assumed that supply system canals and pipes contain water for 75% of the irrigation season. This adjustment is made because of the periodic nature of irrigations and lower irrigation requirements near the beginning and end of the irrigation season. If any pumps are specified for the supply system, the maximum pressure in the system is assumed to be the maximum outlet pressure of any of the pumps. Pipe materials are selected based on this pressure requirement.

SURFCE subroutine

The SURFCE subroutine computes the costs and irrigation efficiencies associated with individual surface irrigation systems. This subroutine

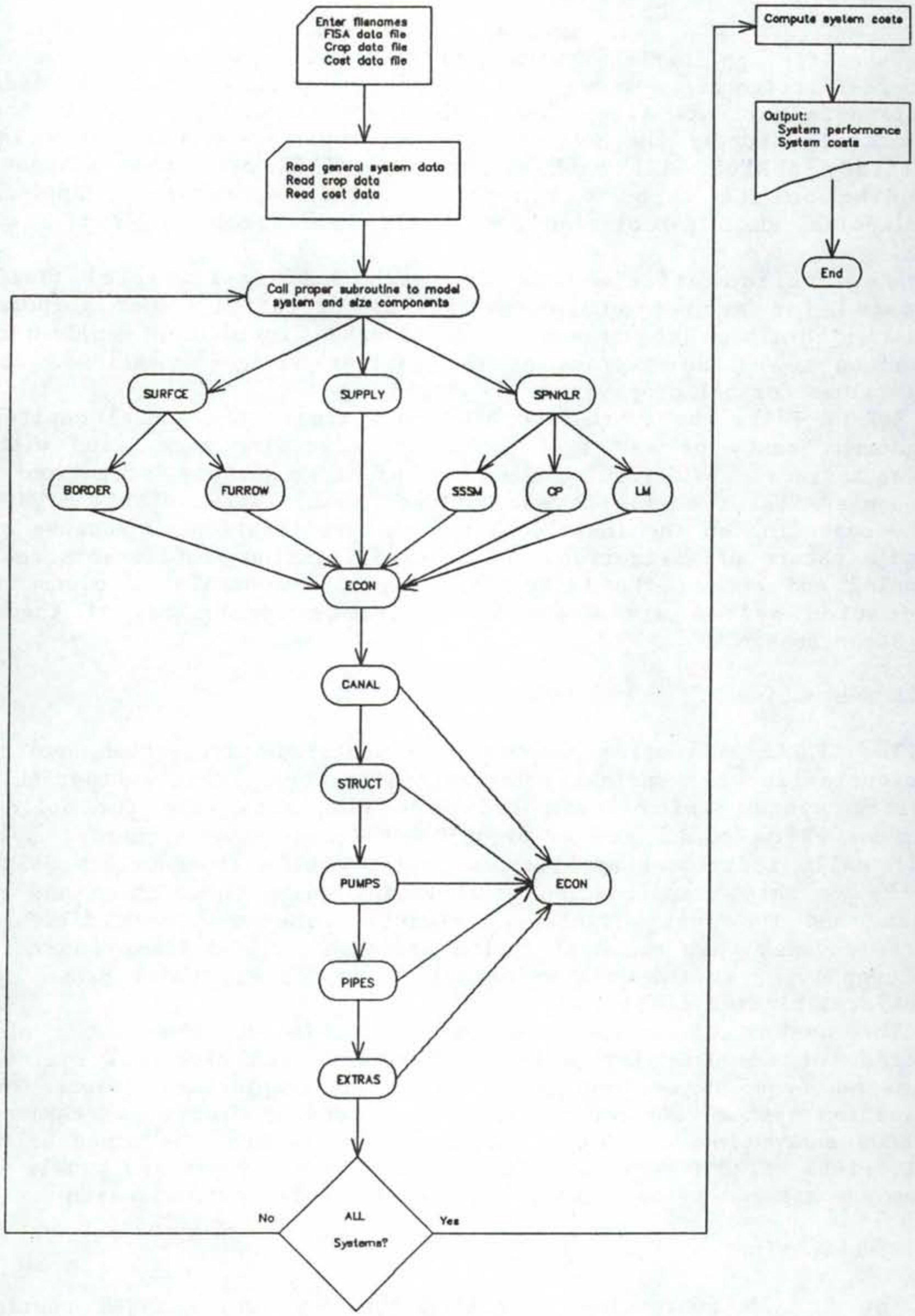

Figure 5-2 Flowchart for SYSTEM program.

reads specific application system data from the FISA data file for furrow and border irrigation systems. If irrigation application efficiencies are specified in the data file, these values are assumed to be valid for all crops irrigated by the system. If an application efficiency is not specified, SURFCE will call either the BORDER or FURROW subroutines, depending on the type of system specified, to determine application efficiencies, deep percolation and runoff loss fractions, and unit flow rate.

Application efficiencies for each surface-irrigated field are estimated for each crop in the field's rotation. For purposes of estimating drainage requirements, the average irrigation application is determined to be the average of the various Management Allowed Deficit (MAD) values for all crops grown the field.

SURFCE calls the subroutine ECON to estimate the annual capital and replacement costs of any land leveling or grading associated with the surface systems. To determine the costs of other surface irrigation system components, SURFCE calls the subroutines CANAL, PIPES, STRUCT, PUMP, and OTHER, depending on the individual system specifications. Because of the periodic nature of irrigations and lower irrigation requirements near the beginning and end of the irrigation season, any canals or pipes in the application system are assumed to operate during 50% of the total irrigation season.

SPNKLR subroutine

The SPNKLR subroutine computes the costs and irrigation application efficiencies for all sprinkler irrigation systems. This subroutine reads specific system information from the FISA data file for solid set, set-move, side-roll, center-pivot, and linear-move sprinkler systems. SPNKLR calls individual application system models (subroutines SSSM, CP, and LM) to obtain application efficiencies, deep percolation and runoff losses, and the most efficient irrigation times for each field. The program assumes that the application efficiencies and losses do not vary with crop type, so the same values are used for all crops grown in each sprinkler-irrigated field.

The number of solid-set systems laterals and the number of sets required for adequate irrigation by hand-move and side-roll systems are estimated from system data. Capital and replacement costs for the application system components and for any land grading are determined by the ECON subroutine. Costs of other components are determined using the CANAL, PIPES, STRUCT PUMP, and OTHER subroutines. Pipes and canals in the system are assumed to operate during 50% of the irrigation season.

SDRAIN subroutine

The SDRAIN subroutine is called from the main SYSTEM routine to estimate the spacing and costs of subsurface drainage. For each field requiring drainage, the routine uses data from the FISA data file and computes the drain spacing using the Donnan method, and the drain outflow using a technique developed by the U. S. Bureau of Reclamation. Data from the cost file are used to economically size the drainage components and determine a cost estimate. The subroutine ECON is called to calculate the capital cash flow and replacement costs for drainage system components. The drainage system for each field is designed for a capacity equal to the average MAD of the crops in the field's rotation.

CANAL subroutine

The subroutine CANAL is used to estimate the cost and conveyance efficiency of any canals specified for a particular system. An iterative procedure is used to determine the most economical channel size for either lined or unlined channels. The economic comparisons are made on the basis of installation costs, maintenance costs (assumed to be a fraction of installation costs), and the costs of water lost to seepage. If the particular channel capacity is not specified in the input data, the capacity of the application or supply system of which the channel is a component is used. While these channel dimensions provide suitable planning-stage estimates of system costs and performance, because of assumptions made in the sizing process, **THESE SPECIFIED DIMENSIONS SHOULD NOT BE USED FOR SYSTEM DESIGN**. This subroutine assumes uniform slope, soil, and flow conditions along the length of each reach, not necessarily the actual operating conditions. Therefore, these dimensions should be evaluated before being used in the actual system design.

Lined channels are assumed to have a standard bottom width to conform with typical slip-form standards (ASAE, 1984). A total of seven standard bottom width and side slope combinations for lined channels are evaluated. For unlined channels, a series of incremental bottom widths are evaluated. The recommended side slopes, maximum flow velocities and channel roughness estimates for unlined canals are determined from the soil classification inferred from the seepage rate. If a channel of sufficient capacity cannot be found, a message to the user is displayed on the screen.

Costs are estimated using data from the component cost file for both types of canals. Seepage losses for the canals are estimated using seepage rates and canal lining specified in the FISA data file. The expected seepage rates for various soil types and channel linings are outlined in the SCS Irrigation Guide for the State of Washington (USDA-SCS,1985b). Annual maintenance costs for lined and unlined channels are assumed to be 2.5% and 7.5% of the initial installation costs, respectively. Costs for the most economical channel size are passed to the ECON subroutine to obtain estimates for the annual capital and replacement costs.

PIPES subroutine

The subroutine PIPES is used to estimate the cost of the required pipe(s) specified for a particular system. A procedure similar to that used by the Soil Conservation Service (USDA-SCS, 1985a) is used to select the most economical pipe size and estimate the total costs involved, including pipe installation and annual energy costs. Cost data for various pipe materials and sizes are obtained from the component cost file and energy costs from the FISA data file.

In the sizing procedure, annual energy costs of pumping water through a particular size pipe are estimated using estimates for the required pipe flow and pressure loss due to friction in the pipe. Unless the pipe flow is specified in the FISA data file, the entire application or supply system capacity is assumed. The head loss in pipes is computed using this estimated flow rate and the Hazen-Williams equation for head loss. Using the assumed flow rate, the estimated annual period of use, and a 70% estimated pumping plant efficiency, the annual energy cost of friction losses for a specific pipe size is determined.

The material for a pipe is specified in the FISA data file, and the thickness selected is based on the system pressure. The pressure head in a pipe is assumed to be the maximum output pressure of any pumps in the particular system, or if no pumps are specified, the maximum pressure required by the particular system. The routine uses three design pressures for pipes: 50, 100, and 160 psi.

The subroutine computes installation, energy, and maintenance costs for each pipe size under consideration. The maximum flow velocity is limited to 5 ft/sec. The most economical pipe size is selected for the particular application and these cost numbers are passed to the ECON subroutine to calculate annual capital and replacement costs. The selected pipe size is saved for the SYSTEM program output. As with the channel dimensions determined in the CANAL subroutine, because of the assumptions made in the sizing process, **THESE SPECIFIED DIMENSIONS SHOULD NOT BE USED FOR SYSTEM DESIGN** without further evaluation. If a pipe of sufficient size is not found, the program displays a message on the screen.

PUMP subroutine

The subroutine PUMP is used to estimate the power requirements and costs of any pumps. Data for each pump are read from the FISA data file. If the pump discharge is not specified for a system having a single pump, its discharge is assumed to be the flow of the particular system (supply or application). If the pump discharge rates in a system with multiple pumps are not specified, the flow rate assumed for each is the total system flow divided by the number of pumps. If efficiencies are not specified for the pump and/or motor, values of 75% and 95% are used, respectively. Pump costs may be specified in the data file. If they are not, a linear relationship between the required pump power and cost (Spofford, 1986) is used to estimate a cost. PUMP calls the ECON subroutine to calculate annual capital costs and replacement costs for the pumps.

In the PUMP subroutine, power requirements are estimated from each pump's lift, flow, and efficiency. The Total Dynamic Head (TDH) for a pump, used to calculate its power requirement, is the difference between the inlet and outlet pump pressures plus the pump lift. The lift term is primarily used for well pumps having a substantial elevation difference between the inlet and outlet. The PUMP subroutine also tabulates the maximum pumping heads (pump outlet pressures) for each supply or application system for use in selecting the materials in the pipe sizing subroutine, PIPES.

STRUCT and OTHER subroutines

The STRUCT and OTHER subroutines read cost data from the FISA data file pertaining to any specified structures (STRUCT) and other system components not classified as pipes, canals, pumps or structures (OTHER). The data read by STRUCT is primarily cost information. The economic life of a structure is obtained from the cost data file. The data read from the FISA file by the OTHER subroutine include the same type of economic data but also includes the name and expected economic life of the component. Both STRUCT and OTHER call the subroutine ECON to estimate annual capital and replacement costs.

ECON subroutine

The subroutine ECON is used to determine the annual capital recovery and annual capital cash flow for irrigation system components. ECON is called from all of the other SYSTEM routines which compute component costs or read them directly from the FISA data file. The economic analysis is done for the period specified in the main SYSTEM program (currently 20 years). The cost of a replacement component is determined utilizing its initial cost, the estimated component life, and the expected inflation rate. Salvage values are also determined. The annual capital recovery includes all replacements during the period and uses the expected return on capital (discount rate) specified in the FISA data file.

For the annual capital cash flow calculations, the capital costs for each component are determined, taking into account the amount of capital cost financed and the specified loan rates and periods. The annual capital cash flow for a financed component is based on the interest rate and length of the loan specified for the component in the FISA data file. The ECON subroutine also divides the annual capital cash flow into separate principle and interest components. Subsidized capital costs are not included in the most recent version of the SYSTEM program. Please see Appendix C for further comments on capital cost subsidies.

For all replacement components, the same percentage of the cost financed in the initial capital outlay is assumed for the replacement. Any capital costs that are not financed are assumed to be applied to the beginning of the year in which they were incurred. Since capital costs are based on end-of-year payments, cash transactions for purchasing initial system components are assumed to occur at the end of year 0. Cash transactions for replacement components are applied to the end of the year prior to replacement. If the life of a component, either initial or replacement, extends beyond the end of the economic analysis period, its salvage value is assumed to be its worth at the end of the period. This value is computed using straight-line depreciation.

The annual capital cash flow is broken into three components, the principle, interest and cash costs. The capital cash flow for the supply system and each irrigation application system is computed for each year in the analysis period to be used in the SIMULATE program.

For each component, the annual maintenance cost and annual miscellaneous cost are also computed. The maintenance cost is computed as a percentage of the initial cost of the component and reflects the inflated costs of any replacements. The annual miscellaneous cost of a component is obtained directly from the FISA data file and is also adjusted for inflation during the analysis period.

BORDER subroutine

The BORDER subroutine contains the model for irrigation systems using graded borders. This simulation model is based on the zero-inertia model developed by Katopodes and Strelkoff (1977) and the kinematic wave model of Sherman and Singh (1978). The routine models the performance of either closed or open-ended borders, based on a unit width. As with most numeric models, certain generalizations about the system must be made. Specific model assumptions are noted in comment lines within the program listing of the two main subroutines in the model.

A two-parameter optimization technique is used to determine the most efficient combination of irrigation time and unit stream size (flow per unit border width) if an irrigation application efficiency is not provided with the input data for the routine. The model provides estimates of application efficiency and deep percolation and runoff losses. The optimization procedure is contained in the main BORDER subroutine while the second subroutine, BORDR, contains the actual hydraulic model.

The border irrigation model requires data from the FISA data file. Also, crop-specific data, including each crop's resistance to irrigation flow (Manning's n coefficient) are obtained from the crop data file. This information is passed to BORDER from the SURFCE subroutine.

FURROW subroutine

The subroutine FURROW contains a model for simulating the performance of furrow or corrugate irrigation systems. The model is based on the kinematic wave model of Walker and Humpherys (1983). The routine models the performance of a single irrigation furrow to determine the application efficiency and deep percolation loss fraction for a particular crop under irrigation.

An optimizing search technique is utilized to select the furrow stream size which will result in the most efficient irrigation application. The irrigation set time based on this stream size, the application efficiency, and the deep percolation and runoff loss fractions for each crop are estimated. The main subroutine FURROW contains the search routine and calls the subroutine WAVE which contains the actual kinematic wave model.

Data for this routine are obtained from the FISA data file. Also, crop-specific data, such as the typical furrow spacing, are obtained from the crop data file. Typical furrow and corrugate shapes are assumed for all crops, based on the furrow or corrugate spacing. These data are supplied by the calling subroutine, SURFCE.

CP subroutine

The subroutine CP models the performance of center pivot irrigation systems. This center pivot model assumes that irrigation performance is not crop-dependent. Data pertaining to the application system characteristics are obtained from the FISA data file, and cost data for the application system are obtained from the cost information file. All data needed for the model are passed from the calling SPNKLR subroutine.

The CP routine models the performance of a center-pivot system operating with three different slope conditions (level, and uphill and downhill flow) (James, 1982) and uses an average performance to determine the application efficiency and deep percolation amounts. The model determines the slowest rotational speed for the lateral which minimizes surface runoff at a point 3/4 of the lateral radius from the pivot point. Characteristics of the type of sprinkler specified for the system (Kincaid, 1982) are determined in the SPCHR subroutine.

Runoff amounts are estimated from application rates and soil infiltration characteristics (Gilley, 1984) in the subroutine RUNOFF. The subroutine USLECP is called to compute the system- and field-specific components necessary to estimate soil erosion losses due to sprinkle irrigation. This is based on a method developed by the U.S. Soil Conservation Service (Koluvek, 1985). Deep percolation amounts are estimated from system application uniformities normally associated with center pivot systems (James and Blair, 1983). The expected wind regime is used to estimate wind and evaporation losses. Other model assumptions are noted as comments within the program code listed in Appendix C.

LM subroutine

The subroutine LM models the performance of linear-move irrigation systems. This model has many of the same features and assumptions as the center pivot model used in SYSTEM. This system model assumes that irrigation performance is not crop-dependent. Data pertaining to the application system characteristics are obtained from the FISA data file and cost data for the application system are obtained from the cost information file. All data needed for the model are passed from the calling SPNKLR subroutine.

The LM routine models the performance of a linear-move system operating with three different slope conditions (level, and uphill and downhill flow) (James, 1982) and uses an average performance to determine the application efficiency and deep percolation amounts. The model determines the slowest travel speed for the lateral which minimizes surface runoff at the midpoint of the lateral. Characteristics of the type of sprinkler specified for the system (Kincaid, 1982) are determined in the SPCHR subroutine.

Runoff amounts are estimated from application rates and soil infiltration characteristics (Gilley, 1984) in the subroutine RUNOFF. The subroutine USLE is called to compute the system- and field-specific components necessary to estimate soil losses due to sprinkle irrigation. This procedure is based on a method developed by the U.S. Soil Conservation Service (Koluvek, 1985). The expected wind regime is used to estimate wind and evaporation losses. Deep percolation amounts are estimated from system application uniformities normally associated with center-pivot and linear-move systems (James and Blair, 1983). Other model assumptions are noted as comments within the program code.

SSSM subroutine

The subroutine SSSM contains the models for solid set, hand move, and side roll irrigation systems. This routine determines the irrigation performance of the system by modeling a single irrigation lateral. Data pertaining to the application system characteristics are obtained from the FISA data file and cost data for the application system are obtained from the cost information file. All data needed for the model are passed from the calling SPNKLR subroutine.

The SSSM routine models the performance of the lateral operating with three slope conditions (level, and uphill and downhill flow) and uses an average performance to determine application efficiency and deep percolation amounts. Irrigation losses due to wind and evaporation are estimated using a method developed by the Soil Conservation Service (USDA-SCS, 1983). Runoff estimates are made from soil infiltration data (Gilley, 1984) in the subroutine SSSMRO.

Deep percolation losses are estimated from application uniformity which is computed using the wind-affected sprinkler pattern data of Seginer and Kostrinsky (1975). The subroutine TRP is used to linearly interpolate from a table of sprinkler pattern values to estimate the actual sprinkler patterns. The application efficiency is also based on the longest set time that can be used to minimize surface runoff while applying an irrigation depth equal to an average MAD value for all of the crops irrigated by the system.

OUTPUT

Output from SYSTEM is appended onto the FISA data file used as input for the program. Included in the output is:

1. Supply system information -
   - Estimated conveyance losses
   - Summary of initial capital costs for each of the two specified loans
   - Annual capital cash flow for the economic analysis period
   - Costs for individual components and replacements over the economic period
   - Capacity and power information for included pumps
   - Estimated sizes for any included open channels and/or pipes included in the system

(Samples of supply system output data are provided in Figure 5-3 and Figure 5-4.)

2. Individual application system information-
   - Maximum flow entering system
   - Percentage of time the system can operate
   - Fields served by system and labor required to irrigate each
   - Application efficiency and deep percolation loss percentage for each crop grown on each field served by the system
   - Summary of initial capital costs for each of the two specified loans
   - Annual capital cash flow for the economic analysis period
   - Costs for individual components and replacements over the economic period
   - Capacity and power information for included pumps

(Samples of application system output data are provided in Figure 5-5 and Figure 5-6.)

SUMMARY OF INITIAL SYSTEM COSTS AND FINANCING ---

	ATTACHED COMPONENTS (LOAN NO. 1)	UNATTACHED COMPONENTS (LOAN NO.2)
TOTAL CAPITAL COST ($)	96864.59	10291.28
CAPITAL NOT FINANCED ($)	17368.77	339.56
FINANCED CAPITAL ($)	79495.82	9951.71
INTEREST RATE (%)	8.00	12.00
TIME OF LOAN (YEARS)	15.	7.
SALVAGE VALUE ($)	.00	989.95
ANNUAL MAINTENANCE EXPENSE ($) . . .	7400.96	969.13
ANNUAL MISCELLANEOUS EXPENSE ($) .	150.00	162.00

ANNUAL CAPITAL CASH FLOW

YEAR	PRINCPLE	INTREST	CASH	TOTAL
0	0	0	17708	17708
1	3914	7554	0	11468
2	4267	7201	0	11468
3	4652	6816	0	11468
4	5074	6394	0	11468
5	5535	5933	0	11468
6	6042	5426	0	11468
7	6593	4875	0	11468
8	5017	4270	0	9287
9	5419	3868	0	9287
10	5853	3434	0	9287
11	6320	2967	0	9287
12	6826	2461	0	9287
13	7372	1915	0	9287
14	7962	1325	0	9287
15	8599	688	704	9991
16	2816	4150	0	6966
17	3123	3843	0	6966
18	3465	3501	0	6966
19	3846	3120	0	6966
20	4268	2698	0	6966

ANNUAL CAPITAL RECOVERY ($) . . . 14028.71

ECONOMIC INFORMATION FOR SYSTEM COMPONENTS

15 COMPONENTS PURCHASED (R = REPLACEMENT ITEM)

ITEM		YR	LIFE	TOTAL COST	SALVAGE VALUE	ANNUAL COST	LOAN RATE(%)	ANNUAL MAINT($)	ANNUAL MISC($)
LINED CANAL		0	15	3821	0	449	8	267	120
LINED CANAL	R	15	15	7943	5295	841	8	555	249
STRUCTURE		0	15	3100	0	364	8	93	10
STRUCTURE	R	15	15	6445	4296	682	8	193	20
STRUCTURE		0	15	3100	0	364	8	93	10
STRUCTURE	R	15	15	6445	4296	682	8	193	20
PUMP		0	15	3396	407	399	12	340	50
PUMP	R	15	15	7059	4989	742	12	706	103
PUMP		0	15	3396	407	399	12	340	50
PUMP	R	15	15	7059	4989	742	12	706	103
STEEL PIPE, LOW PRESS		0	20	86844	0	10201	8	6948	10
ELEC PANE		0	15	1500	75	176	12	30	12
ELEC PANE	R	15	15	3118	2131	329	12	62	24
PUMPHOUSE		0	15	2000	100	235	12	260	50
PUMPHOUSE	R	15	15	4158	2841	439	12	540	103

Figure 5-3 Supply system economic output data.

```
ESTIMATED SEEPAGE LOSSES        .053 %

      1 CHANNEL(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED CHANNEL(S)
          CHANNEL NO.       BOTTOM WIDTH*        DEPTH*
                                (FT)              (FT)
------------------------------------------------------
               1                1.0               2.2

* ESTIMATES ONLY.  DO NOT USE IN DESIGNING SYSTEM


      2 PUMP(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PUMP(S)
          PUMP ID NO.        FLOW RATE       INPUT POWER
                               (GPM)            (KW)
------------------------------------------------------
               1              2917.2            24.3
               2              2917.2            24.3


      1 PIPE(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PIPE(S)
          PIPE NUMBER       NOMINAL DIA.*
                                (IN)
-------------------------------------------
               1                22.

* ESTIMATES ONLY.  DO NOT USE IN DESIGNING SYSTEM
```

Figure 5-4 Other supply system output data.

SUMMARY OF INITIAL SYSTEM COSTS AND FINANCING ---

	ATTACHED COMPONENTS (LOAN NO. 1)	UNATTACHED COMPONENTS (LOAN NO.2)
TOTAL CAPITAL COST ($)	5637.18	29662.80
CAPITAL NOT FINANCED ($)	770.00	550.00
FINANCED CAPITAL ($)	4867.18	29112.80
INTEREST RATE (%)	8.00	12.00
TIME OF LOAN (YEARS)	15.	7.
SALVAGE VALUE ($)	.00	6875.70
ANNUAL MAINTENANCE EXPENSE ($) . .	820.58	2427.56
ANNUAL MISCELLANEOUS EXPENSE ($) .	25.00	40.00

ANNUAL CAPITAL CASH FLOW

YEAR	PRINCPLE	INTREST	CASH	TOTAL
0	0	0	17708	17708
1	3064	3884	0	6948
2	3427	3521	0	6948
3	3829	3119	0	6948
4	4280	2668	0	6948
5	4785	2163	0	6948
6	5349	1599	0	6948
7	5981	967	773	7721
8	384	354	0	738
9	417	321	0	738
10	454	284	0	738
11	494	244	0	738
12	537	201	0	738
13	4591	5001	0	9592
14	5124	4468	1088	10680
15	5657	4004	1600	11261
16	6888	4819	0	11707
17	7712	3995	0	11707
18	8631	3076	0	11707
19	9662	2045	0	11707
20	1965	888	0	2853

ANNUAL CAPITAL RECOVERY ($) 7228.40

ECONOMIC INFORMATION FOR SYSTEM COMPONENTS

17 COMPONENTS PURCHASED (R = REPLACEMENT ITEM)

ITEM		YR	LIFE	TOTAL COST	SALVAGE VALUE	ANNUAL COST	LOAN RATE(%)	ANNUAL MAINT($)	ANNUAL MISC($)
APPLICATION SYSTEM		0	12	22500	5625	2643	12	1125	15
APPLICATION SYSTEM	R	12	12	40407	20203	4393	12	2020	26
LAND GRADING		0	20	1000	0	117	12	100	0
STRUCTURE		0	15	500	0	59	8	50	0
STRUCTURE	R	15	15	1039	693	110	8	103	0
PUMP		0	15	3063	766	360	12	613	10
PUMP	R	15	15	6367	4776	665	12	1274	20
PVC PIPE, MED PRESS		0	25	3597	0	423	8	540	10
PUMP PAD		0	15	500	0	59	12	50	0
PUMP PAD	R	15	15	1039	693	110	12	103	0
RISERS		0	15	1540	0	181	8	231	15
RISERS	R	15	15	3202	2134	339	8	480	31
GAGES		0	7	1100	110	129	12	165	0
GAGES	R	7	7	1548	155	179	12	232	0
GAGES	R	14	7	2178	498	247	12	326	0
ELEC PANEL		0	15	1500	375	176	12	375	15
ELEC PANEL	R	15	15	3118	2339	325	12	779	31

Figure 5-5 Application system output data.

SYSTEM NO 4 -- SIDE-ROLL SPRINKLER

FLOW ENTERING SYSTEM (CFS) 1.11

ESTIMATED SEEPAGE LOSSES .000 %

MAX. TIME SYSTEM OPERATES 100.00 %

PROJECTED APPLICATION SYSTEM LIFE (YRS) 12.0

FIELDS SERVED AND LABOR REQUIREMENTS

FIELD NO.	LABOR REQT. (HR/IRRIG)	ADDITIONAL (HR/SEASON)
3	24.0	.0

OVERALL SYSTEM EFFICIENCIES FOR CROPS IN EACH FIELD

FIELD NO.	- CROP - NO.	NAME	APPLIC EFF(%)	DEEP PERC(%)	RUN-OFF(%)	HRS/SET OR HRS/PASS
3						
	2	ALFALFA HAY	40.4	49.6	.0	12.0
	5	SPRING WHEAT	40.4	49.6	.0	12.0
	10	POTATOES	40.4	49.6	.0	12.0
	11	WINTER WHEAT	40.4	49.6	.0	12.0

0 CHANNEL(S) INCLUDED IN THIS SYSTEM

1 PUMP(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PUMP(S)

PUMP ID NO.	FLOW RATE (GPM)	INPUT POWER (KW)
4	497.8	21.1

1 PIPE(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PIPE(S)

PIPE NUMBER	NOMINAL DIA.* (IN)
1	8.

* ESTIMATES ONLY. DO NOT USE IN DESIGNING SYSTEM

Figure 5-6 Other application system output data.

3. Intermediate values used in soil erosion calculations

(An example of this is found in Figure 5-7)

```
THE FOLLOWING DATA ARE USED TO CALCULATE SOIL LOSSES

THE VALUES HAVE NO PHYSICAL MEANING

      3      .000 -582.034   15.325
      4      .000   44.403   15.301
      5      .000  -37.044   15.305
      6      .000     .000     .000
```

Figure 5-7 Intermediate soil loss calculations.

Upon completion of the program, the message displayed in Figure 5-8 is displayed on the terminal.

```
>>> THE PROGRAM HAS SUCCESSFULLY EXECUTED!! <<<


-- A LISTING OF INPUT DATA AND SUMMARY OUTPUT IS IN FILE C:EXAMPLE.DAT

-- DATA FOR THE SIMULATION PROGRAM IS INCLUDED
Stop - Program terminated.
```

Figure 5-8 SYSTEM program completion message.

The data file is then completed for use by the SIMULATE program and/or for examining irrigation system efficiency and cost estimates.

CHAPTER 6

SIMULATE ROUTINE

OVERVIEW

As implied by the program name, the program SIMULATE simulates the operation of an irrigation system. Agronomic and system data are used in conjunction with climatic data to determine the ability of a particular irrigation system to supply crop irrigation requirements for a particular crop rotation, as well as estimating the total costs of owning and operating the system. Crop rotation and irrigation system data are obtained from the input/output file created by the FISA and SYSTEM routines. Agronomic data are obtained from the random access crop data file also used by the SYSTEM program and climatic data are obtained from files containing rainfall and potential evapotranspiration (PET) information.

Output from SIMULATE consists of four main categories: 1) the adequacy of irrigation for each crop, 2) irrigation system performance and the causes of inadequacies in irrigation, 3) annual water use summaries for the years in the simulation period, and 4) system cost information.

The SIMULATE program presented here is based on an irrigation systems analysis project done in New Zealand (Busch, 1982). The program is written to be compatible with the standard FORTRAN 77 language.

INPUT DATA

Upon the initiation of SIMULATE, general information regarding data file names appears on the screen. The user is then asked to answer the series of prompts shown in Figure 6-1 to identify the appropriate data files.

```
INPUT DATA FOR THE OPERATION SIMULATION MODULE

-THE MAXIMUM NUMBER OF CHARACTERS IN ANY TITLE IS 20
WITH NO EMBEDDED BLANKS AND ONLY ALPHANUMERIC CHARACTERS

-ALL NUMERIC DATA ARE ENTERED IN FREE FORMAT (LIST DIRECTED)


ENTER THE NAME OF THE CROP ROTATION/SYSTEM DATA FILE TO BE USED

ENTER THE NAME OF THE CROP DATA FILE TO BE USED

ENTER THE NAME OF THE RAINFALL FILE

ENTER THE NAME OF THE PET FILE
```

Figure 6-1 Data file prompts for SIMULATE.

```
ENTER THE NAME FOR THIS SIMULATION RUN.

REMEMBER, NO BLANKS ARE ALLOWED IN THIS NAME!

(OUTPUT FILE(S) FOR THIS RUN WILL HAVE THE SAME NAME)
```

Figure 6-2 User prompt for SIMULATE output name.

The user is then asked for an identifying name for the simulation run as shown in Figure 6-2. The file or files containing the output information of SIMULATE will have the same name with an appropriate DOS extension.

```
SELECT THE FOLLOWING OUTPUT FORMAT:
1 -- DETAILED OUTPUT ONLY
2 -- CONDENSED OUTPUT ONLY
3 -- BOTH DETAILED AND CONDENSED OUTPUTS
```

Figure 6-3 SIMULATE output format menu.

The user will then be asked to select the desired output format from the menu shown in Figure 6-3. The detailed output file contains extensive data from the simulation and has a '.LNG' DOS extension. The condensed output file is a short summary of the simulation data and has a '.SHT' DOS extension.

The file names specified are then displayed as shown in Figure 6-4.

```
RESULTS FROM THE SIMULATE ROUTINE IN FILE C:EXAMPLE

  INPUT DATA ARE FROM THE FOLLOWING FILES:

    IRRIG. SYSTEMS/CROP ROTATION FILE --- C:SYSOUT.DAT

    CROP DATA FILE ---------------------- C:CROP.DAT

    RAINFALL FILE ----------------------- C:PRECIP.DAT

    POTENTIAL ET (PET) FILE ------------- C:PET.DAT
```

Figure 6-4 Display of specified SIMULATE data files.

Lastly, the first and last years of the simulation period are required. Weather data must be provided for this period, and the program will check the rainfall and PET files to ascertain that they contain adequate data. The prompt for this input is displayed in Figure 6-5.

```
ENTER BEGINNING AND ENDING YEARS FOR SIMULATION RUN
```

Figure 6-5 User prompt for SIMULATE simulation period.

PROGRAM OPERATION

General

After the data input is completed, the following message then appears and the simulation procedure begins.

```
I AM NOW THINKING, COMPUTING AND TRYING TO DIGEST ALL
THE DATA YOU HAVE FED ME.  I WILL TELL YOU WHEN I HAVE
SUCCESSFULLY COMPLETED ALL DETAILS ----- PROVIDED YOU
HAVE NOT FED ME BAD DATA THAT WILL RESULT IN INDIGESTION!!
```

Figure 6-6 SIMULATE run message.

The program then reads the required data from the files and simulates the operation of the irrigation system for the years specified. Each year is divided into 24 semi-monthly periods, and the system operation is modeled and evaluated for each period. The flow of the program is as follows with the main subroutines for each procedure in parentheses:

1. Read required data from input files (MAIN, LOCAT, AGRON)

2. For each year in the simulation:

   a. For each semi-monthly period:

      i. Compute water requirement for period (WTREQT)

      ii. Determine irrigation priorities for each field (PRIOR)

      iii. Allocate irrigation water in order of priorities and determine soil water balance (ALOCAT)

      iv. Adjust water balance for stress if necessary (STRESS)

v. Forecast any irrigation shortfalls in subsequent period and apply additional water in present period if feasible (FORCST)

b. Summarize yearly irrigation performance (YERSUM)

3. Print summary of simulation results to data file(s) (SUMOUT)

These and other subroutines are discussed in greater detail in the Program Components section of this report. A flowchart for SIMULATE is provided in Figure 6-8 and a program listing in Appendix D.

Upon completion of the data output, the program is finished and the message shown in Figure 6-7 is displayed.

```
THE JOB IS FINISHED AND OUTPUT DATA ARE IN FILE(S) C:EXAMPLE.LNG
                                                   C:EXAMPLE.SHT

INPUT DATA ARE IN FILE C:SYSOUT.DAT

Stop - Program terminated.
```

Figure 6-7 SIMULATE program completion message.

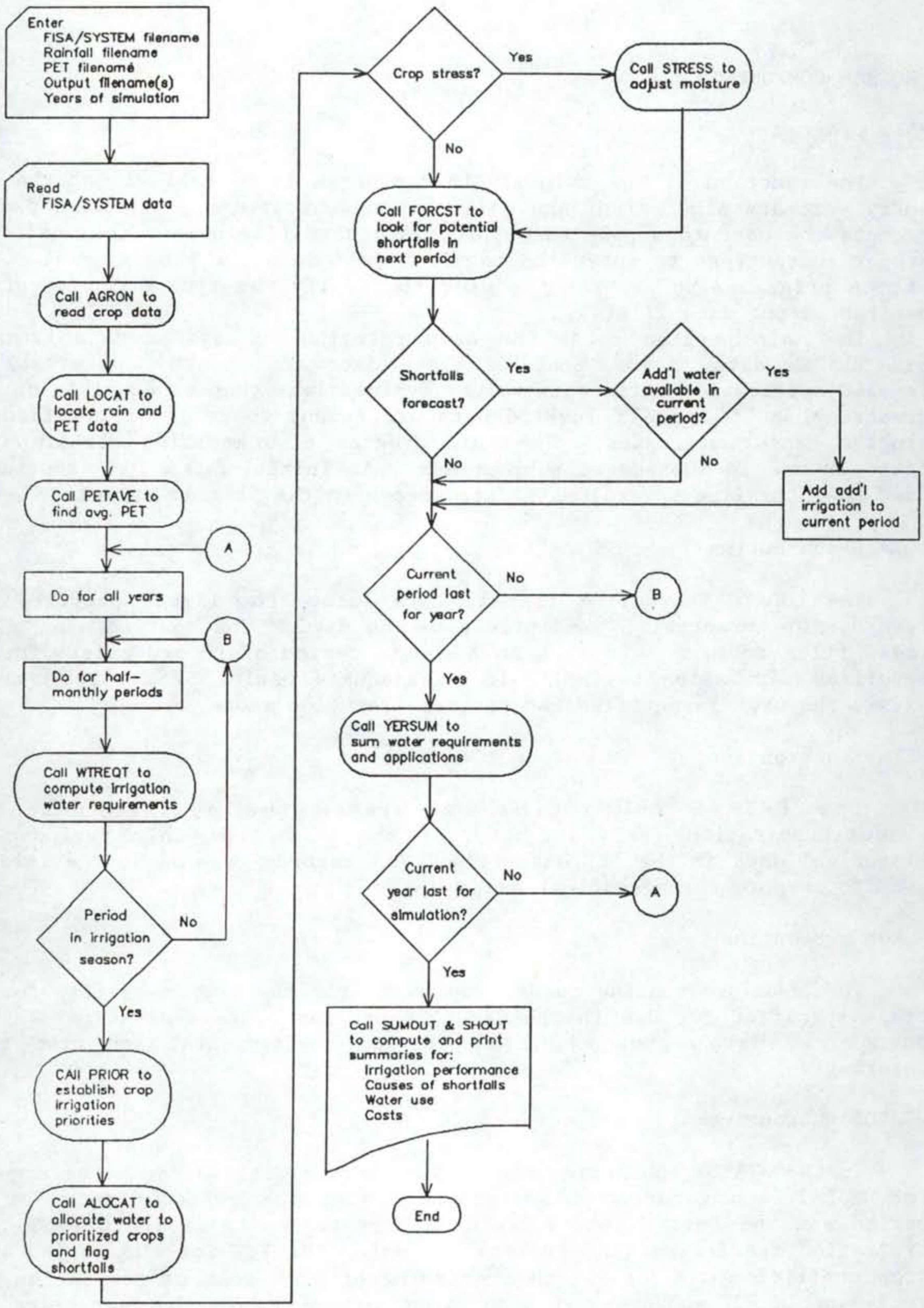

Figure 6-8 Flowchart for SIMULATE.

PROGRAM COMPONENTS

MAIN program

The function of the main SIMULATE program is to call all of the data entry, primary simulation, and data output subroutines. The main program prompts the user to supply the appropriate data file names, then calls the proper subroutines to enter the required data into the program. This part of the program also prompts the user to specify the type and name of the desired output data file(s).

The main program reads the crop rotation and system data from the FISA/SYSTEM data file. Some of these data are checked, primarily for invalid application efficiency values (values less than or equal to zero or greater than 100%). If invalid data are found, the user is notified and program execution ceases. The main program also modifies certain input data for use in subsequent subroutines. An initial BLOCK DATA routine is used to initialize several main data arrays in the program as well.

LOCATE subroutine

The LOCATE subroutine is called to locate the first specified file records for potential ET and precipitation data. The routine also checks these files to make sure that an adequate period of record exists for the specified simulation period. If an adequate period of record does not exist, the user is notified and program execution stops.

PETAVE subroutine

The PETAVE subroutine calculates the average potential evapotranspiration (PET) for each of the 24 half-monthly periods from historical data in the PET data file. All records (years) in the file are used to compute the historical average.

AGRON subroutine

The AGRON subroutine reads crop data from the crop data file for all crops specified for use in the SIMULATE program. These data include crop phenologic data, crop evapotranspiration coefficients, and crop yield information.

WTREQT subroutine

In the WTREQT subroutine the total amount of irrigation water required for a half-month period is determined using the climatic data for the period and the soil moisture status at the beginning of the period. The irrigation requirements are determined using the PET for the period and a crop coefficient (Kc). At the beginning of each year of simulation, the semi-monthly PET and precipitation values are read from the respective data files. WTREQT uses a soil water balance equation to adjust the soil moisture conditions (deficit) for the ET in the period.

In order to estimate the crop water requirements, the crop growth characteristics including the crop coefficient, root zone depth and percent canopy cover are evaluated at the midpoint of the half-month period. A linear increase of canopy cover and root zone depth is assumed between planting and the time of maximum cover.

The ET rate is assumed to be unaffected by soil moisture conditions until the soil moisture deficit reaches the specified Management Allowed Deficit (MAD) for the crop and then decreases linearly to zero as the deficit approaches the Total Available Moisture (TAM) value. The effective precipitation for the period is estimated from measured values (USDA-SCS, 1967) and subtracted from the irrigation requirements. The estimated effective precipitation for a period is assumed to be no greater than the estimated ET or the measured precipitation for the period.

Also in this routine, the irrigation requirement for the next period is estimated for use in the FORCST routine. This forecast estimate is obtained by multiplying the historic PET for the next period by the ratio of the actual PET to historic PET for the current period (Kottwitz, et al., 1984) to obtain a forecast PET for the period. This PET value is then multiplied by the crop coefficient for the next period to obtain the forecast irrigation requirement.

PRIOR subroutine

Irrigation priorities for each period are established in the PRIOR subroutine. They are established utilizing the FAO yield reduction function (Doorenbos and Kassam, 1979) and specified maximum yields and prices from the agronomic data file. The field having the crop with the largest potential for monetary loss from lack of irrigation is given the highest priority and the remainder of the fields are ranked in descending order, based on their individual potential losses.

The rankings are computed by estimating the number of days of moisture stress for the crop and estimating the ET reduction due to moisture stress. Fields reaching critical moisture levels (soil moisture below the MAD) are ranked higher in priority for the period than fields having higher moisture levels. Priorities are also established for all fields for the subsequent half-monthly period for use in the FORCST subroutine.

ALOCAT subroutine

The ALOCAT subroutine allocates irrigation water available for each period among the various fields. The gross volume of water required is estimated for each field by dividing the net water requirement for the field (from WTREQT) by the application efficiency of the irrigation system and the overall conveyance efficiency. Labor requirements for the field are estimated by using the water requirements to calculate the number of irrigations required during the period.

Starting with the field having the highest irrigation priority, water is allocated to supply the irrigation requirement for the period. As the water is allocated to each field, several constraints are checked. The total irrigation water and total labor allocated are checked against the total irrigation water and total labor available to the farm. Also, the total amount required during the period is checked against the total capacity of the individual application system.

If the total water or labor limits are reached, no more irrigation water is allocated for the period. If an individual system capacity limit is reached, no more water is allocated to the fields irrigated by that system for the period. Should any of these limits be reached and the water requirements for the period are not completely supplied, the causes and magnitudes of the shortfalls are tabulated for use in the final irrigation performance summary.

After allocation of the irrigation water, a soil water balance is used to estimate the soil moisture conditions of each field. If the irrigation requirements of any fields are not met and the soil moisture deficit becomes greater than the MAD, the subroutine STRESS is called to adjust the soil water balance to account for reduced ET rates induced by moisture stress. If all water and labor available for a period are not allocated, the ALOCAT subroutine calls the FORCST subroutine to examine the possibility of using additional irrigation to preclude any irrigation deficits in the subsequent period.

STRESS subroutine

The STRESS subroutine is called by the ALOCAT subroutine to adjust the soil moisture conditions for reduced ET due to moisture stress. It is assumed that ET is not affected by the soil moisture level until it drops below the MAD level. Below the MAD level, this rate is assumed to decrease linearly from the maximum ET rate to zero as the soil moisture drops between the MAD to the TAM level. The soil water balance adjustment is made by estimating the number of days with and without moisture stress and adjusting the ET rate accordingly. Also, this ET reduction is tabulated for use in the yield estimation calculations.

FORCST subroutine

The FORCST subroutine is called to examine the possibility of using additional irrigation to preclude any irrigation deficits in subsequent, half-monthly periods. When periods of insufficient irrigation are forecast, many farmers apply extra irrigation water when feasible to utilize storage available in the soil reservoir. The subroutine FORCST is used to model this management practice.

After allocating irrigation water for a period in the ALOCAT subroutine, the irrigation requirements forecast for the next period are used in a procedure similar to the one used in ALOCAT to determine the likelihood of any shortfalls occurring in that subsequent period. If shortfalls are forecast for the next period, and if sufficient water, labor, and system capacities exist in the current period, water is allocated in the current period for those fields having an Application Deficit (AD) greater than zero. This essentially fills the soil moisture reservoir. This extra application, however, is limited by the same labor and water availability and system capacity constraints as in ALOCAT. If additional water is applied to any fields, the soil moisture status of each is updated.

YERSUM subroutine

The subroutine YERSUM summarizes the annual irrigation performance and tabulates the data for each of the 24 periods within the year. The data include information on the adequacy of irrigation and irrigation priority for each crop, any irrigation shortfalls and their causes, total irrigation water requirements, potential soil erosion losses and nitrogen leaching, and estimated crop yields.

Estimates of annual soil loss and nitrogen leaching are made in the USLE subroutine called by YERSUM. Yield estimates are made by tabulating both actual ET and maximum ET for each crop and each of four growth stages and utilizing an additive yield reduction function (Vaux and Pruitt, 1983.) and the yield reduction factors of Doorenbos and Kassam (1979).

USLE subroutine

The USLE subroutine is called to estimate annual soil losses due to sprinkle irrigation as well as potential nutrient losses from soil water leaching. The system-specific soil loss values from the SYSTEM program and agronomic data (residue from the previous crop and the maximum canopy cover of the current crop) are used to estimate annual soil erosion for sprinkle-irrigated fields (Koluvek and Spofford, 1986). A modified form of a formula developed by Pfeiffer and Whittlesey (1978) is used to estimate the percentage of applied nitrogen lost to leaching. The estimated deep percolation losses for particular systems and crops are used in this computation.

SUMOUT subroutine

The SUMOUT subroutine computes the results of the simulation and prints the detailed output summary to the specified file. For each half-monthly period, crop irrigation summaries are tabulated, as well as average annual values for crop water requirements, soil erosion, nutrient leaching and yield reduction due to moisture stress. Also, for each period, the frequency of irrigation shortfalls due to water and labor constraints is computed, as is the amount of time each application system is required and the amount of time that its capacity is limiting.

For each year of the simulation, a water use summary is computed, detailing the net irrigation requirement, the net irrigation application and the gross water requirement for the farm for each period. Also, for each crop, the average irrigation priority for each period is computed.

SUMOUT also computes an economic summary for each application system and the supply system. This summary includes the capital costs computed in the SYSTEM program as well as average operating costs obtained from the system simulation. SUMOUT prints this detailed simulation summary to the appropriate file and calls the subroutine SHOUT if a condensed simulation summary is required. The program output is discussed in greater detail in the Program Output section of this report.

SHOUT subroutine

The SHOUT subroutine tabulates data for the condensed output summary and prints it in the specified file. For each field, the average irrigation deficit, labor deficit, nutrient loss and yield reduction are computed for each crop in the field rotation. A summary of average irrigation deficit, labor deficit and nutrient loss is also tabulated for each field and for the entire farm. For each system (application and supply), an annual cost summary is also prepared as is an annual cost summary for the entire farm. The program output is discussed in greater detail in the Program Output section of this report.

PROGRAM OUTPUT

Detailed Output Summary

Adequacy of Irrigation for Each Crop

The SIMULATE program supplies information describing the adequacy of irrigation for each crop in the simulated rotation. These data are influenced by the rotation in different fields, irrigation system capacity and efficiency, limitations of water and labor, and the crop water requirements and rainfall during the simulation period. This information allows the user to analyze patterns of water requirements and irrigation applications.

Results included in this section of the output are:

Average irrigation requirement - the average irrigation requirement expected during the period of simulation.

Percent of time irrigation is required - the percentage of time at least one irrigation is required during each half-monthly period within the entire simulation time period. Irrigation may not be required during a particular period every year, especially near the beginning or end of the irrigation season. This is <u>not</u> a measure of the total hours of irrigation during each period.

Average requirement when required - the irrigation amount required whenever irrigation is required. This is often greater than the average requirement because irrigation may not be required in all years during a simulation period, and when it is required, the required amount may be larger than the average amount.

Average applied when irrigation is required - net irrigation amount applied to the crop. This amount is the average applied by all systems used to irrigate the particular crop.

Percent of time requirement is greater than the amount applied - an indication of the amount of time the irrigation demands are not met relative to the time that irrigation is required.

Average shortfall - (required minus applied) the average shortfall only when shortfalls occur.

Maximum shortfall - the maximum shortfall occurring during the simulation period.

Standard deviation of the shortfalls - computed only for those shortfalls greater than zero and can be used for frequency analysis.

Percent of time readjustment is required - percent of time relative to the time irrigation is required that shortfalls are anticipated and additional water is stored in the soil reservoir above the AD level.

Average readjustment - the average additional amount applied above the AD level whenever additional irrigation is applied.

Maximum readjustment - the maximum amount of additional water applied during the simulation period.

An example of the program output for this crop information is displayed in Figure 6-9.

For each crop, average annual totals are also displayed for 1) average irrigation requirement, 2) average requirement when required, 3) average application when required, 4) average shortfall, and 5) average readjustment.

In addition, data for each crop are provided for the following:

Estimated annual soil loss - the estimated soil erosion losses occurring when the crop is sprinkle irrigated.

Estimated annual nitrogen percolation loss - percent of nitrogen leached from the root zone, based on deep percolation losses.

Estimated average yield reduction by growth stage - estimated yield reduction (percent of maximum yield)incurred by the crop due to moisture stress in the specified growth stages and an estimated average annual total.

An example of this annual crop summary information is provided in Figure 6-10.

CROP SUMMARY RESULTS FOR ALFALFA HAY

---- MONTH ----->	JAN		FEB		MAR		APR		MAY		JUN	
--- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	.0	.0	.0	.0	.0	.0	1.6	2.2	3.1	3.7	3.0	2.3
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	100	100	100	100	100	100
AVE REQUIREMENT WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	1.6	2.2	3.1	3.7	3.0	2.3
AVE APPLIED WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	1.6	2.1	2.7	3.2	2.4	2.1
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	30	40	60	50	70	60
AVERAGE SHORTFALL WHEN OCCURRING (IN)	.0	.0	.0	.0	.0	.0	.1	.5	.7	1.2	1.0	.3
MAXIMUM SHORTFALL - - (IN)	.0	.0	.0	.0	.0	.0	.2	1.1	1.9	2.4	2.4	.7
STD. DEVIATION OF SHORTFALLS (IN)	.0	.0	.0	.0	.0	.0	.1	.4	.6	.9	.9	.3
PERCENT OF TIME READJSTMNT REQD (%)	0	0	0	0	0	0	10	20	0	0	10	0
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.3	.1	.0	.0	.1	.0
MAXIMUM READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.1	.1	.1	.1	.1	.1

CROP SUMMARY RESULTS FOR ALFALFA HAY --- CONTINUED

---- MONTH ----->	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	4.6	4.7	2.7	4.1	3.3	1.5	.9	.2	.0	.0	.0	.0
PERCENT OF TIME IRRIG IS REQD (%)	100	100	100	100	100	100	100	50	0	0	0	0
AVE REQUIREMENT WHEN REQUIRED (IN)	4.6	4.7	2.7	4.1	3.3	1.5	.9	.4	.0	.0	.0	.0
AVE APPLIED WHEN REQUIRED (IN)	3.1	3.5	2.1	3.3	2.8	1.5	.9	.4	.0	.0	.0	.0
PERCENT OF TIME REQT > APPLIED (%)	80	80	70	70	80	10	0	0	0	0	0	0
AVERAGE SHORTFALL WHEN OCCURRING (IN)	1.9	1.5	.8	1.1	.6	.1	.0	.0	.0	.0	.0	.0
MAXIMUM SHORTFALL - - (IN)	5.1	3.3	2.3	1.8	1.3	.1	.0	.0	.0	.0	.0	.0
STD. DEVIATION OF SHORTFALLS (IN)	1.5	1.3	.7	.7	.4	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME READJSTMNT REQD (%)	0	0	0	0	0	0	0	0	0	0	0	0
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

Figure 6-9 Irrigation summary data by half-monthly period.

```
SEASONAL TOTALS FOR ALFALFA HAY
==================================

AVERAGE IRRIG    AVERAGE REQT      AVE APPLIED    AVE SHORTFALLS     AVERAGE
REQUIREMENT(IN)  WHEN REQD(IN)   WHEN REQD(IN)   OCCURRING(IN) READJUSTMENT(IN)
-------------------------------------------------------------------------------

      38.0            38.2            31.6             9.8              .5


ESTIMATED ANNUAL SOIL LOSS       .03 T/ACRE (Sprinkle irrig. only)

ESTIMATED ANNUAL NITROGEN PERCOLATION LOSS      36.48 % OF APPLIED


ESTIMATED AVERAGE YIELD REDUCTION BY GROWTH STAGE
GROWTH STAGE        1      2      3      4          TOTAL
                 ------ ------ ------ ------        ------
REDUCTION  (%)      .8     .4     .0    3.2           4.3
```

Figure 6-10 Annual irrigation summary data.

System Requirements and Causes of Irrigation Shortfalls

Irrigation shortfalls are caused by three factors in SIMULATE. They are: 1) a shortage of water at the supply, 2) a limitation in the available labor, and 3) a limitation of the application system capacity. The values presented are based upon the time that irrigation water is required. These data are:

Water supply limitation - the percentage of time when irrigation is required that the water supply is limiting.

Labor limitation - the percentage of time when irrigation is required that a shortage of labor causes irrigation shortfalls to occur.

System limitations - for each system, the percentage of time that an irrigation application system is required and the percentage of time that its capacity is limiting.

The first two causes are based on the supply of water and labor available to the whole farm, while system capacity limitations are specific to individual irrigation application systems. Examples of these two data tables are in Figures 6-11 and 6-12.

PERCENT OF TIME SHORTFALLS OCCUR WHEN
WATER IS REQUIRED DUE TO VARIOUS CONSTRAINTS

---- MONTH ------>	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
WATER AS LIMITING - - - (%)	0	0	0	0	0	0	0	0	0	0	0	0
LABOR AS LIMITING - - - (%)	0	0	0	0	0	0	0	0	10	20	40	20

PERCENT OF TIME SHORTFALLS OCCUR WHEN WATER
IS REQUIRED DUE TO VARIOUS CONSTRAINTS -- CONTINUED

---- MONTH ------>	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
WATER AS LIMITING - - - (%)	0	0	0	0	0	0	0	0	0	0	0	0
LABOR AS LIMITING - - - (%)	90	90	30	50	0	0	0	0	0	0	0	0

Figure 6-11 Frequency of water and labor limitations.

=== SIDE-ROLL SPRINKLER===

---- MONTH ------>	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
--TIME REQUIRED (%)	0	0	0	0	0	0	60	80	100	100	100	100
--CAP. LIMITING (%)	0	0	0	0	0	0	30	40	70	50	50	90

---- MONTH ------>	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
--TIME REQUIRED (%)	100	100	100	70	70	70	50	40	0	0	0	0
--CAP. LIMITING (%)	50	50	70	50	70	30	0	0	0	0	0	0

Figure 6-12 Application system requirements and limitation frequencies.

Irrigation Water Use Summary

This portion of the output summarizes, for each year in the simulation, the water requirements for each period and for the entire year. In addition, average values for the simulation period are provided. The values displayed are for the entire farm. These data are:

Total net irrigation requirement - the average amount of water required for the farm in the period.

Total net irrigation application - the net amount of water applied on the farm in the period.

Total gross water requirement - The amount of water supplied to the farm during the period to support the irrigation application.

Sample data output for this information is provided in Figures 6-13, 6-14 and 6-15.

Irrigation Priorities

As part of the irrigation water allocation procedure, SIMULATE determines the priority of the crops grown during each half-monthly period. The crop having the highest priority has a rank of 1, the crop with the next highest priority, a rank of 2, and so forth. The priority of a particular crop will depend upon the soil moisture conditions and the other crops grown during the period. The average rankings for particular crops are computed and tabulated for each period. An example of this output is shown in Figure 6-16.

Irrigation System Costs

Irrigation system capital costs are based upon the cost data supplied by the SYSTEM program. Variable costs for water, energy, and labor are determined utilizing data from the SIMULATE program and the FISA data file. Cost summaries are printed for the water supply system and each application system.

The first part of the system cost output is similar to the economic output of the SYSTEM program. This output lists general system data and economic information for system components purchased with the two specified loans for attached and unattached components. Also included in this section of output are the expected return on investment (discount rate) and the various inflation rates used in the economic evaluation.

Values are also supplied for the expected costs for the system over its life. The overall annual cost is the annual cost of the system based upon the specified rate of return. This takes into account the various inflation rates for operating costs and average operating requirements. The overall annual capital cost is also based upon the specified rate of return and accounts for the capital cost portion of the overall annual cost. These values are useful in comparing the costs of various systems while taking into account the desired rate of return and inflation. They should **not**, however, be used as an indication of annual cash flow.

TOTAL NET IRRIGATION REQUIREMENT (IN)

YEAR	JAN 1ST	JAN 2ND	FEB 1ST	FEB 2ND	MAR 1ST	MAR 2ND	APR 1ST	APR 2ND	MAY 1ST	MAY 2ND	JUN 1ST	JUN 2ND
1	.0	.0	.0	.0	.0	.0	1.0	1.7	3.0	3.6	3.4	3.7
2	.0	.0	.0	.0	.0	.0	1.0	.3	2.0	3.9	.8	2.7
3	.0	.0	.0	.0	.0	.0	1.0	1.9	2.2	3.4	2.7	4.8
4	.0	.0	.0	.0	.0	.0	1.4	2.1	3.0	4.0	4.0	3.0
5	.0	.0	.0	.0	.0	.0	1.8	1.4	1.7	3.6	2.9	3.3
6	.0	.0	.0	.0	.0	.0	1.8	.7	3.2	2.2	2.8	2.9
7	.0	.0	.0	.0	.0	.0	1.2	2.5	2.8	4.1	2.4	3.5
8	.0	.0	.0	.0	.0	.0	.6	1.2	2.6	2.8	1.9	2.1
9	.0	.0	.0	.0	.0	.0	.9	1.8	2.8	3.2	3.2	2.4
10	.0	.0	.0	.0	.0	.0	.2	.6	.8	2.3	3.8	2.7
MEAN	.0	.0	.0	.0	.0	.0	1.1	1.4	2.4	3.3	2.8	3.1

TOTAL NET IRRIGATION REQUIREMENT (IN) --- CONTINUED

YEAR	JUL 1ST	JUL 2ND	AUG 1ST	AUG 2ND	SEP 1ST	SEP 2ND	OCT 1ST	OCT 2ND	NOV 1ST	NOV 2ND	DEC 1ST	DEC 2ND	ANNUAL TOTAL
1	4.6	3.7	1.9	2.8	1.9	1.1	.5	.4	.0	.0	.0	.0	33.4
2	4.1	3.7	2.9	2.3	1.5	.8	.3	.0	.0	.0	.0	.0	26.5
3	4.4	4.1	1.4	.6	1.7	.7	.3	.2	.0	.0	.0	.0	29.5
4	4.1	4.5	2.9	2.4	1.5	.8	.5	.0	.0	.0	.0	.0	34.2
5	4.3	4.0	3.3	2.8	1.8	1.0	.8	.0	.0	.0	.0	.0	32.8
6	4.6	4.4	2.3	3.0	2.3	.8	.7	.0	.0	.0	.0	.0	31.6
7	4.5	3.7	1.7	2.9	1.6	.8	.1	.0	.0	.0	.0	.0	31.8
8	3.2	3.0	2.0	2.4	1.8	.7	.6	.3	.0	.0	.0	.0	25.2
9	3.0	3.0	1.9	2.1	1.7	.9	.4	.0	.0	.0	.0	.0	27.3
10	3.9	3.3	2.5	1.7	1.6	1.0	.1	.0	.0	.0	.0	.0	24.6
MEAN	4.0	3.7	2.3	2.3	1.7	.9	.4	.1	.0	.0	.0	.0	29.7

Figure 6-13 Net irrigation requirement summary.

TOTAL NET IRRIGATION APPLICATION (IN)

YEAR	JAN 1ST	JAN 2ND	FEB 1ST	FEB 2ND	MAR 1ST	MAR 2ND	APR 1ST	APR 2ND	MAY 1ST	MAY 2ND	JUN 1ST	JUN 2ND
1	.0	.0	.0	.0	.0	.0	1.1	1.7	2.8	3.4	1.9	1.8
2	.0	.0	.0	.0	.0	.0	1.0	.3	2.1	3.6	.9	2.5
3	.0	.0	.0	.0	.0	.0	1.1	1.9	2.3	3.1	2.4	2.7
4	.0	.0	.0	.0	.0	.0	1.3	1.8	1.4	1.3	1.5	2.5
5	.0	.0	.0	.0	.0	.0	1.7	1.4	1.6	2.5	2.4	3.1
6	.0	.0	.0	.0	.0	.0	1.7	.8	2.8	1.9	2.4	2.8
7	.0	.0	.0	.0	.0	.0	1.3	2.3	2.5	3.2	2.2	3.0
8	.0	.0	.0	.0	.0	.0	.6	1.3	2.4	2.8	2.0	2.0
9	.0	.0	.0	.0	.0	.0	.9	1.9	2.8	2.9	2.8	2.1
10	.0	.0	.0	.0	.0	.0	.2	.7	.9	2.3	2.2	2.4
MEAN	.0	.0	.0	.0	.0	.0	1.1	1.4	2.2	2.7	2.1	2.5

TOTAL NET IRRIGATION APPLICATION (IN) --- CONTINUED

YEAR	JUL 1ST	JUL 2ND	AUG 1ST	AUG 2ND	SEP 1ST	SEP 2ND	OCT 1ST	OCT 2ND	NOV 1ST	NOV 2ND	DEC 1ST	DEC 2ND	ANNUAL TOTAL
1	1.8	3.3	1.8	1.9	1.8	1.1	.5	.4	.0	.0	.0	.0	25.3
2	2.9	2.4	1.7	2.0	1.4	.8	.3	.0	.0	.0	.0	.0	21.8
3	2.6	1.4	1.1	.6	1.5	.7	.3	.2	.0	.0	.0	.0	21.8
4	1.6	1.8	2.6	1.9	1.2	.8	.5	.0	.0	.0	.0	.0	20.2
5	1.7	2.1	3.0	1.9	1.3	1.0	.8	.0	.0	.0	.0	.0	24.6
6	2.3	1.7	2.1	1.9	1.5	.8	.7	.0	.0	.0	.0	.0	23.4
7	3.1	2.9	1.4	2.1	1.4	.8	.1	.0	.0	.0	.0	.0	26.4
8	2.4	2.9	1.4	2.3	1.6	.7	.6	.3	.0	.0	.0	.0	23.3
9	2.6	2.5	1.6	1.8	1.5	.9	.4	.0	.0	.0	.0	.0	24.8
10	2.0	2.1	2.2	1.5	1.4	1.0	.1	.0	.0	.0	.0	.0	19.0
MEAN	2.3	2.3	1.9	1.8	1.4	.9	.4	.1	.0	.0	.0	.0	23.1

Figure 6-14 Net irrigation application summary.

TOTAL GROSS WATER REQUIREMENT (AC-FT)

YEAR	JAN 1ST	JAN 2ND	FEB 1ST	FEB 2ND	MAR 1ST	MAR 2ND	APR 1ST	APR 2ND	MAY 1ST	MAY 2ND	JUN 1ST	JUN 2ND
1	0	0	0	0	0	0	71	114	229	289	249	372
2	0	0	0	0	0	0	76	20	168	286	86	232
3	0	0	0	0	0	0	101	169	201	251	204	292
4	0	0	0	0	0	0	146	187	172	222	236	217
5	0	0	0	0	0	0	168	139	161	215	218	243
6	0	0	0	0	0	0	159	73	241	161	204	225
7	0	0	0	0	0	0	102	180	206	268	172	262
8	0	0	0	0	0	0	44	92	202	232	190	211
9	0	0	0	0	0	0	67	150	228	246	226	199
10	0	0	0	0	0	0	17	66	81	194	231	214
MEAN	0	0	0	0	0	0	95	119	189	236	202	247

TOTAL GROSS WATER REQUIREMENT (AC-FT) --- CONTINUED

YEAR	JUL 1ST	JUL 2ND	AUG 1ST	AUG 2ND	SEP 1ST	SEP 2ND	OCT 1ST	OCT 2ND	NOV 1ST	NOV 2ND	DEC 1ST	DEC 2ND	ANNUAL TOTAL
1	399	284	223	174	161	126	47	30	0	0	0	0	2768
2	188	213	178	113	84	55	18	1	0	0	0	0	1720
3	346	245	107	59	137	74	33	19	0	0	0	0	2238
4	315	319	224	185	123	77	52	6	0	0	0	0	2482
5	237	297	256	189	141	96	83	0	0	0	0	0	2442
6	230	347	192	180	119	76	70	0	0	0	0	0	2278
7	216	213	107	141	95	64	9	0	0	0	0	0	2036
8	207	281	139	247	152	91	58	19	0	0	0	0	2164
9	208	194	129	104	88	60	24	0	0	0	0	0	1924
10	238	190	198	143	134	100	13	0	0	0	0	0	1820
MEAN	258	258	175	154	124	82	41	8	0	0	0	0	2187

Figure 6-15 Gross water requirement summary.

AVERAGE IRRIGATION PRIORITY

---- MONTH ----->	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
ALFALFA HAY	0	0	0	0	0	0	2	2	2	2	2	2
SPRING WHEAT	0	0	0	0	0	0	2	2	4	4	3	3
SPRING BARLEY	0	0	0	0	0	0	2	2	2	1	1	2
POTATOES	0	0	0	0	0	0	0	0	1	2	2	2
WINTER WHEAT	0	0	0	0	0	0	2	3	3	3	3	3

---- MONTH ----->	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
ALFALFA HAY	3	2	3	2	2	1	2	1	0	0	0	0
SPRING WHEAT	3	3	2	0	0	0	0	0	0	0	0	0
SPRING BARLEY	1	1	3	0	0	0	0	0	0	0	0	0
POTATOES	2	2	3	1	1	2	1	0	0	0	0	0
WINTER WHEAT	3	3	1	0	0	0	2	2	0	0	0	0

Figure 6-16 Average irrigation system priorities.

The second part of the economic output consists of an annual cash flow table for the length of the economic analysis period. This period is currently set within the SYSTEM and SIMULATE programs to be 20 years. The cash flow components are assumed to be end-of-year payments. Any unfinanced capital costs are assumed to be payments made before the actual irrigation season and are added to the cash flow at the end of the previous year. The yearly cost data reflect the influence of the various inflation factors. The items in the cash flow table are divided into capital and operating costs, and each of these main categories are further divided.

The annual capital costs are split into three categories, loan repayment (principle), interest, and cash payments and the annual total is also tabulated. Operating costs shown for each year include costs for energy, maintenance and miscellaneous expenses. Labor expenses are added to the annual operating costs of irrigation application systems, and the costs for irrigation water are added to the operating costs of the supply system. These costs are based on average operating conditions. They are affected by the amount of irrigation water applied and are based on an average annual application determined in the simulation process. The annual operating costs, therefore, do not reflect the variations that might occur due to yearly variations in irrigation application amounts. They do, however, reflect the effects of inflation of the various component costs.

Examples of system cost summaries for an application system are given in Figure 6-17 and Figure 6-18 and for a supply system in Figure 6-19 and Figure 6-20.

IRRIGATION SYSTEM SUMMARY FOR SIDE-ROLL SPRINKLER

TOTAL AREA SERVED (ACRES) - - - - - - -	80.0
FLOW ENTERING SYSTEM (CFS) - - - - - - -	1.11
PERCENT OF TIME SYSTEM OPERATES (%) - -	100
SYSTEM LIFE (YEARS) - - - - - - - - - -	12

INPUT DATA FOR ATTACHED COMPONENTS
-- (LOAN NO. 1)

TOTAL CAPITAL COST ($) - - - - - - - -	5637
CAPITAL NOT FINANCED ($) - - - - - - -	770
FINANCED CAPITAL ($) - - - - - - - - -	4867
FINANCE INTEREST RATE (%) - - - - - -	8.0
TIME OF LOAN (YEARS) - - - - - - - - -	15
SALVAGE VALUE ($) - - - - - - - - - -	0
ANNUAL MAINTENANCE EXPENSE ($) - - - -	821
ANNUAL MISCELLANEOUS EXPENSE ($) - - -	25

INPUT DATA FOR NON-ATTACHED COMPONENTS
-- (LOAN NO. 2)

TOTAL CAPITAL COST ($) - - - - - - - -	29663
CAPITAL NOT FINANCED ($) - - - - - - -	550
FINANCED CAPITAL ($) - - - - - - - - -	29113
FINANCE INTEREST RATE (%) - - - - - -	12.0
TIME OF LOAN (YEARS) - - - - - - - - -	7
SALVAGE VALUE ($) - - - - - - - - - -	6876
ANNUAL MAINTENANCE EXPENSE ($) - - - -	2428
ANNUAL MISCELLANEOUS EXPENSE ($) - - -	40

RETURN ON INVESTMENT (%) - - - - - - - -	10.0
LABOR WAGE RATE ($/HR) - - - - - - - -	4.00
INFLATION FOR LABOR (%) - - - - - - - -	5.0
INFLATION FOR OPERATION AND MAINT. (%) -	5.0
INFLATION FOR ENERGY (%) - - - - - - - -	3.0

EXPECTED COSTS FOR IRRIGATION FOR SIDE-ROLL SPRINKLER
OVER THE LIFE OF THE SYSTEM

THE SYSTEM SUPPLIES 80.0 ACRES

TOTAL OVERALL ANNUAL COST ($) - - - - - - - -	20648
OVERALL ANNUAL CAPITAL COST ($) - - - - - - -	7228

(NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)

SYSTEM POWER ESTIMATES FOR AVERAGE SEASON

HOURS OF OPERATION PER SEASON - - - - - -	3976
SEASONAL KILOWATT-HOURS - - - - - - - - -	83900

TOTAL CAPITAL COST NOT FINANCED ($) - - - - -	1320

Figure 6-17 Cost summary for irrigation application system.

	- - - CAPITAL COSTS - - -				OPERATING COSTS FOR AVERAGE CONDITIONS					OVERALL
YR	REPYMNT	INTRST	CASH	TOTAL	LABOR	ENERGY	MAINT	MISC	TOTAL	TOTAL
0	0	0	17708	17708	0	0	0	0	0	17708
1	3064	3884	0	6948	1414	5453	3248	65	10180	17128
2	3427	3521	0	6948	1485	5617	3411	68	10581	17529
3	3829	3119	0	6948	1559	5786	3581	72	10998	17946
4	4280	2668	0	6948	1637	5959	3760	75	11431	18379
5	4785	2163	0	6948	1719	6138	3948	79	11884	18832
6	5349	1599	0	6948	1805	6322	4146	83	12356	19304
7	5981	967	773	7721	1895	6512	4353	87	12847	20568
8	384	354	0	738	1990	6707	4570	91	13358	14096
9	417	321	0	738	2090	6908	4799	96	13893	14631
10	454	284	0	738	2194	7116	5039	101	14450	15188
11	494	244	0	738	2304	7329	5291	106	15030	15768
12	537	201	0	738	2419	7549	5555	111	15634	16372
13	4591	5001	0	9592	2540	7775	5833	117	16265	25857
14	5124	4468	1088	10680	2667	8009	6125	123	16924	27604
15	5657	4004	1600	11261	2800	8249	6431	129	17609	28870
16	6888	4819	0	11707	2940	8496	6753	135	18324	30031
17	7712	3995	0	11707	3087	8751	7090	142	19070	30777
18	8631	3076	0	11707	3242	9014	7445	149	19850	31557
19	9662	2045	0	11707	3404	9284	7817	156	20661	32368
20	1965	888	0	2853	3574	9563	8208	164	21509	24362

Figure 6-18 Annual cash flow for irrigation application system.

```
SUMMARY FOR WATER SUPPLY SYSTEM --

TOTAL AREA SERVED (ACRES) - - - - - - - -      480.0
SYSTEM CAPACITY
   MAX VOLUME DELIVERED (ACRE-IN/24 HR)      309
   MAX FLOW RATE (CFS) - - - - - - - - - -     13.00
CONVEYANCE EFFICIENCY (%) - - - - - - - -    100

INPUT DATA FOR ATTACHED COMPONENTS
  -- (LOAN NO. 1)
  TOTAL CAPITAL COST ($) - - - - - - - - -  96865
  CAPITAL NOT FINANCED ($) - - - - - - - -  17369
  FINANCED CAPITAL ($) - - - - - - - - - -  79496
  FINANCE INTEREST RATE (%) - - - - - - -     8.0
  TIME OF LOAN (YEARS) - - - - - - - - - -    15
  SALVAGE VALUE ($) - - - - - - - - - - -      0
  ANNUAL MAINTENANCE EXPENSE ($) - - - -    7401
  ANNUAL MISCELLANEOUS EXPENSE ($) - - -     150

INPUT DATA FOR NON-ATTACHED COMPONENTS
  -- (LOAN NO. 2)
  TOTAL CAPITAL COST ($) - - - - - - - - -  10291
  CAPITAL NOT FINANCED ($) - - - - - - - -    340
  FINANCED CAPITAL ($) - - - - - - - - - -   9952
  FINANCE INTEREST RATE (%) - - - - - - -    12.0
  TIME OF LOAN (YEARS) - - - - - - - - - -     7
  SALVAGE VALUE ($) - - - - - - - - - - -    990
  ANNUAL MAINTENANCE EXPENSE ($) - - - -     969
  ANNUAL MISCELLANEOUS EXPENSE ($) - - -     162

RETURN ON INVESTMENT (%) - - - - - - - - -   10.0
INFLATION FOR OPERATION AND MAINT. (%) -      5.0
INFLATION FOR ENERGY (%) - - - - - - - - -    3.0


EXPECTED COSTS FOR IRRIGATION FOR SUPPLY SYSTEM
OVER THE LIFE OF THE SYSTEM

THE SYSTEM SUPPLIES  480.0 ACRES

TOTAL OVERALL ANNUAL COST ($) - - - - - - - - -   51778
OVERALL ANNUAL CAPITAL COST ($) - - - - - - - -   14029
  (NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)

SYSTEM POWER ESTIMATES FOR AVERAGE SEASON
  HOURS OF OPERATION PER SEASON - - - - - - -      4073
  SEASONAL KILOWATT-HOURS - - - - - - - - - -     98986

TOTAL CAPITAL COST NOT FINANCED ($) - - - - - -   17708
```

Figure 6-19 Cost summary for irrigation supply system

	- - - CAPITAL COSTS - - -				OPERATING COSTS FOR AVERAGE CONDITIONS					OVERALL
YR	REPYMNT	INTRST	CASH	TOTAL	WATER	ENERGY	MAINT	MISC	TOTAL	TOTAL
0	0	0	17708	17708	0	0	0	0	0	17708
1	4211	7914	0	12125	12053	6434	8370	312	27169	39294
2	4600	7525	0	12125	12655	6627	8789	328	28399	40524
3	5025	7100	0	12125	13288	6826	9228	344	29686	41811
4	5492	6634	0	12125	13953	7031	9689	361	31034	43159
5	6003	6122	0	12125	14650	7242	10174	379	32445	44570
6	6566	5559	0	12125	15383	7459	10683	398	33923	46048
7	6593	4875	0	11468	16152	7683	11217	418	35470	46938
8	5017	4270	0	9287	16959	7913	11778	439	37089	46376
9	5419	3868	0	9287	17807	8150	12366	461	38784	48071
10	5853	3434	0	9287	18698	8395	12985	484	40562	49849
11	6320	2967	0	9287	19633	8647	13634	508	42422	51709
12	6826	2461	0	9287	20614	8906	14316	534	44370	53657
13	7372	1915	0	9287	21645	9173	15031	560	46409	55696
14	7962	1325	0	9287	22727	9449	15783	588	48547	57834
15	8599	688	704	9991	23864	9732	16572	618	50786	60777
16	2816	4150	0	6966	25057	10024	17401	649	53131	60097
17	3123	3843	0	6966	26310	10325	18271	681	55587	62553
18	3465	3501	0	6966	27625	10635	19184	715	58159	65125
19	3846	3120	0	6966	29006	10954	20144	751	60855	67821
20	4268	2698	0	6966	30457	11282	21151	788	63678	70644

Figure 6-20 Annual cash flow for supply system.

Condensed Output Summary

Seasonal System Performance by Crop

These data are tabulated from the simulated irrigation performance of each irrigation system on each field. For the period of simulation, the average values of irrigation deficit, labor deficit, nutrient loss, and yield reduction are computed for each crop in the field rotation. The output format displays the field number and the type of irrigation system on the field. An example of this output is shown in Figure 6-21.

FIELD # 3 (SIDE-ROLL SPRINKLER IRRIGATION SYSTEM)

CROP	AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)	AVG YIELD REDUCTION(%)
ALFALFA HAY	1287.52	111.86	45.57	8.27
SPRING WHEAT	268.70	5.04	16.44	1.03
POTATOES	766.93	.00	21.98	9.33
WINTER WHEAT	2021.73	420.04	13.32	5.80

Figure 6-21 Seasonal performance by crop.

Seasonal System Performance For All Crops

The performance of each irrigation system is determined for each crop grown in the rotation for a particular field. The values of irrigation deficit, labor deficit, and nutrient loss are averaged for all crops grown in each field. An example of this information is given in Figure 6-22.

FIELD # 3 (SIDE-ROLL SPRINKLER IRRIGATION SYSTEM)

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
1086.22	134.24	24.33

Figure 6-22 Seasonal performance for all crops.

Seasonal Performance For All Systems

If more than one irrigation application system is used on a farm, the average seasonal performance for all systems on the farm can be computed by summing the total irrigation deficits for all fields on the farm and computing an average nutrient loss fraction for all fields. An example of this information is given in Figure 6-23.

SEASONAL PERFORMANCE SUMMARY FOR ALL SYSTEMS

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
3428.81	726.28	18.31

Figure 6-23 Seasonal performance summary for all systems.

Annual Costs For Irrigation Systems

Annual costs for each irrigation application system and the water supply system are computed from the cost data from the SYSTEM program and data from the SIMULATE program and the FISA data file. The condensed output summary displays the average annual costs for capital expenses and energy, maintenance, and miscellaneous costs for each application system and the irrigation supply system. For each application system the annual labor cost is also computed, and the annual water cost is calculated for the supply system. The costs for labor, water, and energy are based on average operating conditions, and all of these costs are based on the expected rate of return (discount rate). The annual costs for each application system and the supply system are summed to obtain the total annual costs for the entire farm.

Examples of the annual cost summaries are given in Figure 6-24.

ESTIMATED ANNUAL COSTS FOR IRRIGATION SYSTEMS

SIDE-ROLL SPRINKLER

CAPITAL	LABOR	ENERGY	MAINT	MISC	TOTAL
7228	2011	6693	4620	91	20643

SUPPLY SYSTEM

CAPITAL	ENERGY	MAINT	MISC	WATER	TOTAL
14029	7897	11907	443	17146	37393

ESTIMATED ANNUAL COST TOTALS

CAPITAL	LABOR	ENERGY	MAINT	MISC	WATER	TOTAL
69712	24663	28790	63599	1145	17146	205055

Figure 6-24 Annual cost summaries for application and supply systems and total annual cost summary.

CHAPTER 7

EXAMPLE FARM SIMULATION

FARM DESCRIPTION AND SYSTEM COMPONENTS

To further explain the operation of the irrigation system planning model, an example of the FISA, SYSTEM and SIMULATE output files for a farm are provided in Appendix A. By examining these data files, one can see the types of data that are required for the planning model and the types of modeling procedures done by the SYSTEM and SIMULATE programs.

As stated previously, it is important that preliminary planning for the farm irrigation system is done before the planning model is used to evaluate the system. The preliminary steps include obtaining information about the farm field layout, the location and capacity of the irrigation water supply, the expected crop rotation, the types of irrigation systems to be evaluated, and the basic system components and costs.

The farm in the example consists of six 80-acre fields. A schematic diagram of the field layout and the main irrigation system components is provided in Figure 7.1. The six fields are irrigated by three separate irrigation systems of different types. These are a furrow irrigation system, a side-roll sprinkler system and a center pivot system, with each system irrigating two adjacent fields. Water is supplied to the application systems by a main supply system. There are three soil types on the farm, and the expected crop rotations for each field are shown in Table 7.1.

The listing of the FISA data file in Appendix A shows information regarding the six fields and their associated soil types and characteristics. Also shown is the crop rotation information that is presented in Table 7.1 as well as the total available moisture (TAM), management-allowed moisture deficit (MAD), and irrigation application deficit (AD) for each crop. It should be noted that fallow is entered as a second crop for all years in the rotation, unless a second crop, such as winter wheat, is actually planted in that year. Even with perennial crops such as alfalfa, fallow is listed as a second crop. Fall planted crops harvested the following year (like winter wheat) should be entered as the second crop for the year in which it is planted. These fall planted crops must also be entered as the first crop for the following year in the rotation.

After the crop information, data regarding the water supply and the water supply system are given. This information includes the supply system capacity and the cost structures for irrigation water and electric power. The example FISA data file in Appendix A shows a supply system capacity of 13 cfs, a total seasonal availability of 1920 acre-ft, and water available every day of the irrigation season. The price structure for the irrigation water includes a basic annual allotment of 3.5 acre-feet of water for each acre of land at a cost of $25 per acre. Additional water can be purchased at a cost of $50 for each additional acre-foot per acre of land.

The charge for electric energy includes a one-time service installation charge of $1500. In addition, there are monthly billing period

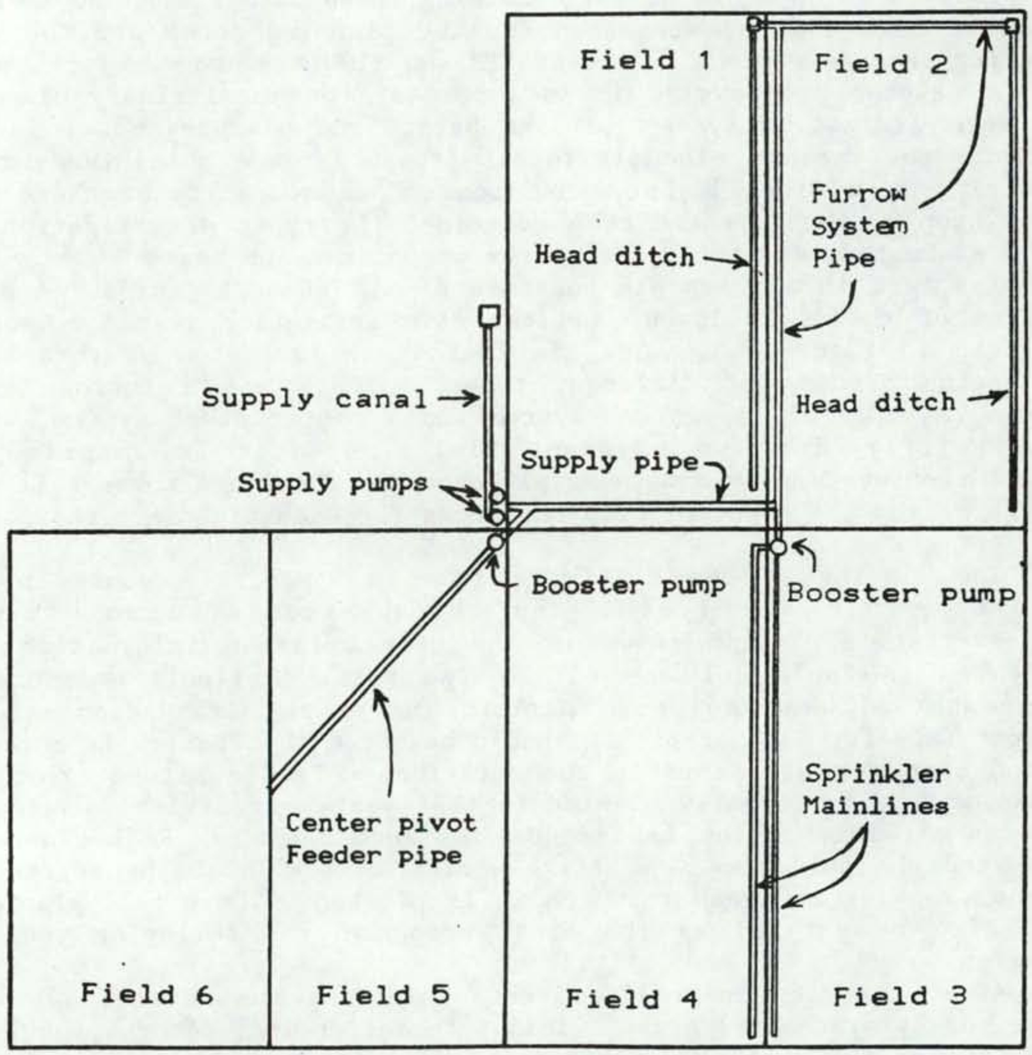

Figure 7-1 Example farm layout.

Table 7-1 Crop rotations for example farm.

Field number	Year:	1	2	3	4	5	6	7
1	First crop	10	11	2	2	2	2	5
	Second crop	11	1				1	1
2	First crop	5	10	11	2	2	2	2
	Second crop	1	11	1				1
3	First crop	2	5	10	11	2	2	2
	Second crop	1	1	11	1			
4	First crop	2	2	5	10	11	2	2
	Second crop		1	1	11	1		
5	First crop	2	2	2	5	10	11	2
	Second crop			1	1	11	1	
6	First crop	5	11	6				
	Second crop	11	1	1				

1 = Fallow 2 = Alfalfa hay 5 = Spring wheat
6 = Spring barley 10 = Potatoes 11 = Winter wheat

charges which vary seasonally. For power used in the summer (April through September), a demand charge of \$25 for each kilowatt of maximum demand during the billing period and a use charge of \$0.045 per kilowatt-hour are assessed. During the remainder of the year, only a charge of \$0.065 per kilowatt-hour is assessed for the power used.

The next segment of the FISA file in Appendix A contains data pertaining to the individual system components of the main irrigation supply system. One of these components is a 1000-ft lined canal. Since no flow rate is specified for the canal in the example, the CANAL routine in the SYSTEM program assumes that the capacity of the canal is 13 cfs, the maximum supply system capacity, for estimating the canal size and cost. Two structures are required in the supply system, each costing \$3100.

The supply system also requires two pumps to lift water from the canal, approximately a 20-ft lift. No pump discharges, efficiencies, or costs are given, so several assumptions are made in the PUMP routine of the SYSTEM program. Each pump is assumed to have a discharge of half of the total supply system capacity, and this discharge value is used to estimate the cost of each pump. Default values for the pump and motor efficiencies (75% and 95%, respectively) are assumed when estimating power requirements.

In addition, the supply system requires 1320 feet of steel pipeline. Since a flow rate for the pipe was not specified in the FISA data file, the PIPE routine in the SYSTEM program will size the pipe to convey the entire

13-cfs supply system capacity and estimate the total costs. The supply system also requires an electric panel and a pumphouse.

Following the supply system information, the example FISA data file contains data regarding the individual irrigation application systems. A table is included in the file, which outlines the type of irrigation system found on each field. This is followed by specific data pertaining to the individual application systems.

Specific data is provided for each field irrigated by the furrow system. Since no irrigation efficiency value is provided for either field, the SYSTEM program will use the furrow irrigation simulation model to compute the irrigation efficiency, the deep percolation losses and the most efficient furrow flow rate for each crop grown in Fields 1 and 2. The model uses the data provided for each field, including the soil characteristics and the furrow length.

The furrow system includes two 2640-ft lined head ditches. Since no flow rates are specified for these channels, the CANAL routine sizes each for the entire 5-cfs system capacity and uses these dimensions to estimate costs. Two structures, costing $300 each, are specified for the furrow system as well as two PVC pipes. These two pipes each are sized to convey the entire system flow rate. Other components specified in the FISA data file for the system include siphon tubes, structures (head ditch check dams, etc.) and tail water ditches.

Following the first irrigation system, data are provided for the side-roll irrigation system. General specifications are given for the system, including 1320-ft, 5-inch diameter laterals, high pressure impact sprinklers with a 40x60-ft spacing, and a gross application rate of 0.33 inches per day. The number of laterals required for the system is not specified, but is computed by the SSSM routine of the SYSTEM program. Additional field-specific data are also provided for the system. The side-roll system also requires one structure and a single pump. No discharge is specified for this pump so this is assumed to be the entire 5-cfs system capacity. This information will then be used to estimate a pump cost. Default values for pump and motor efficiencies are used to estimate pump power requirements.

The side-roll system also requires two 2540-ft PVC mainlines. These are sized to carry the entire system flow rate, since no flow rate is specified for either pipe. This system configuration provides extra system flexibility but, depending upon the intended system operation, by specifying each pipe to carry half of the total system flow, costs could possibly be reduced. Other cost reductions may have been realized by splitting mainline pipes into multiple reaches with decreasing flow rates. The pipe material is assumed to have a pressure rating greater than the 65-psi outlet pressure of the system's pump. In addition, cost data are provided for other system components including a pump pad, risers, gages and an electric panel.

The third application system in the example is a center-pivot sprinkler system. Unlike the side-roll system specifications, a single lateral is assumed to irrigate both of the fields. The lateral specified in the example is 1320 feet in length, 6.36 inches in diameter, with a gross daily application of 0.4 inches per day. It is equipped with low pressure spray sprinklers on booms as well as an endgun. Even though pressure regulators are specified, they are assumed to be used for this system and all other low pressure sprinkler systems. In addition, performance and cost data are provided for each field irrigated by the system.

The center-pivot system requires a single structure and a single pump. This pump is assumed to have a discharge equal to the system flow, which is computed from the gross application rate of the system and the irrigated area. The default efficiency values are used to estimate the power requirements for this pump.

A 1900-ft PVC pipe is required to convey water from the pump to the system's pivot point. It is sized to convey the entire system flow rate and has a pressure rating greater than the 55-psi pump outlet pressure. A pump pad, pivot pad, electric panel and gages are also specified for this system.

The information in Appendix A shows that no drainage is required for this farm. Other general data provided for the simulation indicate the maximum labor available on the farm is 300 hours per week at an average rate of $5.45 per hour. The cost of labor is expected to increase at 5% per year and the cost of general operating expenses at 8% per year.

SYSTEM Output

Following the FISA data file information, the listing in Appendix A contains the output appended onto the FISA file by the SYSTEM program. The first information is regarding the supply system for the farm.

Seepage losses for the main supply system are estimated to be very small, less than 1% of the total water conveyed. This should be expected since the supply system canal is rather short and has a concrete lining. A cost summary for the supply system is then displayed, with the costs being split between the two loans for attached and unattached system components. A table of the estimated annual capital cash flow for the supply system follows, with annual capital expenses divided into principle, interest and cash payments. The initial cash payment for year 0 represents the unfinanced capital expense for the supply system. The annual capital recovery is also shown for the 20-year economic analysis period.

Economic information for the various supply system components is supplied. The table provided in the SYSTEM output indicates the name of each major system component, the year in which it is purchased, and the component life. The letter R next to the component name indicates a replacement item. Listed for each component purchased are: the initial purchase cost, salvage value, annual capital cost, annual maintenance cost, and annual miscellaneous cost. The loan rate used when computing the annual capital cost is also listed in the table. If loan numbers other than 1 or 2 appear in the data file, an interest rate of 0% is assumed. It should be noted that the salvage value listed for each component is the salvage value at the end of its useful life or at the end of the economic period if the useful life extends beyond the 20-year analysis period.

Data pertaining to canals, pumps, and pipes in the supply system follow the economic data for the supply system. Outputs from the open channel and pipe sizing subroutines are shown. The lined channel used to estimate the supply system costs has a 1-foot bottom width and a depth of 2.2 feet, and the pipe for the system has an assumed diameter of 22 inches.

While these values are determined using standard design methods, because of assumptions made about the systems, **these values should <u>not</u> be used for system design**. Also, the discharge capacities of the two pumps specified for the supply system are assumed to be half of the total supply system capacity, or approximately 2900 gpm each. The power requirements for the pumps are computed based on this 2900 gpm flow rate, the lift and discharge pressures specified for the pumps, and the default motor and pump efficiency values.

Following the detailed supply system output in the example are similar data for each of the three irrigation application systems. The data for each will be discussed briefly.

The data for the furrow irrigation system show the specified system capacity to be 5 cfs and indicate that nearly 1% of the total water entering the system will be lost due to conveyance losses, primarily in the channels specified for the system. The labor required for a complete irrigation of each of the two fields covered by the system is estimated to be 64 hours. Other than the labor required for irrigation (moving siphon tubes, etc.), no other labor is indicated for the operation of this system.

The irrigation performance of the system as computed by the furrow system model is displayed for each field and for each crop in the rotation in tabular form. The example indicates that for the same crops, the irrigation application efficiencies are considerably lower for Field 1 than for Field 2. This may be due to different moisture-holding characteristics of the soils of the two fields. Along with the irrigation efficiency for each crop, information regarding the runoff and deep percolation losses for each crop and field is listed. For this example, most of the irrigation losses are the result of deep percolation. Also, for the most efficient irrigation performance, a 12-hour irrigation set time for each crop and field has been determined.

The detailed application system output includes tables listing initial irrigation system costs, annual capital cash flow, and the system component economic information for the furrow irrigation system. These tables are in the same format as is used for the water supply system. Also, the information for the two channels and pipes in this system is provided. As noted in the earlier discussion, the channels and pipes have been sized to carry the entire system capacity of 5 cfs.

Data for the side-roll sprinkler system are listed next in the data file. The flow rate for this system is computed based on the design application rate of 0.33 inches per day. Since no open channels are included in this system, seepage losses are considered negligible. A total of 24 hours of labor are required for a complete irrigation of either field. The irrigation efficiencies for the two fields differ, most likely due to the different moisture-holding characteristics of the individual soils. Most of the irrigation losses are shown to be deep percolation losses. The large amounts of deep percolation are probably caused by using relatively long (12-hour) irrigation set time increment on a soil with low moisture-holding capability. The balance of the losses, not displayed in the data file, are due to wind drift and evaporation. For each field and crop, these wind losses are approximately 10%, and can be obtained by subtracting the sum of the application efficiency and deep percolation and runoff losses from 100%. In order to minimize surface runoff, a maximum irrigation time of 12 hours per set is specified.

The economic information provided for this system is similar to that provided for the furrow irrigation system. One notable difference is the application system (sprinkler lateral units) component costs. The total cost of the sprinkler laterals is split between each field irrigated by the system. Since two fields are irrigated by this system, the cost for each field is assumed to be half of the total application system cost. These costs are listed separately for each field in the economic information table. The cost of $31701 for each field is determined assuming that three laterals are required for each field, at a cost of $10567 each. The land grading costs for each field are also listed separately, but the rest of the component costs are listed for the entire system. The estimated pump power requirements and pipe sizes for this system are based on a flow rate of 2.22 cfs, the entire system capacity, computed from the design application rate of 0.33 inches per acre.

The information supplied by the SYSTEM program for the center pivot irrigation system indicates a system capacity of 2.69 cfs, determined by the total area irrigated by the system, 160 acres, and the design application rate of 0.4 inches per day. The labor required for a complete irrigation of each field is approximately 8 hours.

The application efficiency for each field and each crop irrigated by the system is estimated to be approximately 86%. As with the side-roll system, the application losses due to wind drift and evaporation can be obtained by subtracting the total of the irrigation application efficiency and deep percolation and runoff losses from 100%. The maximum time for one irrigation or one 'pass' over the field for this system is 77 hours. This means that surface runoff will result if the system speed is adjusted to require a longer time to make a complete revolution. This time value will usually vary for soils with different sprinkler intake rates.

The economic information for this system is similar to that of the side-roll system. Like the other system, the application system (center pivot unit) cost is distributed between the two fields and listed separately for each. The land grading costs associated with each field are also separated.

The pump power requirements are determined using the system capacity, the pump discharge pressure, and the default motor and pump efficiency values. The specified pipe is assumed to convey the entire system capacity.

The last items added to the data file by the SYSTEM program are intermediate values, computed for each of the sprinkler irrigated fields, for soil erosion loss calculations. These values have no physical meaning but are contained in this file for the purpose of transferring these data to the SIMULATE routine.

SIMULATE Output

Following the example FISA data file and the SYSTEM output, Appendix A displays the output of the SIMULATE program. The SIMULATE output data shown are the results of a 10-year simulation using the example FISA and SYSTEM data as inputs. Examples of both the detailed SIMULATE output and the short SIMULATE output summary are provided for the example farm.

The first portion of the detailed output contains information pertaining to the adequacy of irrigation for each crop in the farm's rotation. Average values are provided for each of the semi-monthly periods, as detailed in the SIMULATE output section of Chapter 6 of this report. Also provided for each crop are seasonal totals for some of these irrigation performance data.

The seasonal totals for potatoes indicate an average annual irrigation requirement of 25.0 inches. The sum of the average irrigation requirements for all periods in which irrigation was required is 25.4 inches and the average amount applied for these periods is 23.3 inches per year. The average annual shortfall for years in which potatoes experienced irrigation deficits is 5.7 inches. On the average, 0.2 inches of water is added to potato fields each year for the purpose of reducing forecast irrigation deficits. These data are computed from the irrigation system performance for all fields having crop rotations with potatoes during the 10-year simulation.

The average annual soil erosion occurring for sprinkle irrigated potatoes was small, 0.05 tons per acre, but the average annual nutrient loss to deep percolation was assumed to be approximately 22% of the amount applied. The irrigation deficits resulted in an estimated 2.3% average yield reduction. Similar data are provided for all other crops in the rotation.

The next section of the SIMULATE output delineates the causes and frequencies of irrigation shortfalls. This information indicates that irrigation deficits are caused by labor shortages but not by shortages of available water. Irrigation deficits caused by labor occurred during the first period of July 90% of the time during the 10-year simulation when irrigation was required in this period. The frequency of irrigation deficits could probably be reduced by increasing the supply of available labor for the farm.

The next portion of the output indicates the frequency with which each irrigation application system is required and the number of time when required that the system capacity limited the irrigation application. Examination of the data for the side-roll irrigation system shows it to be required in all years for all periods between the middle of April and the end of September. This system was also needed three out of every five years in which some irrigation was required during the final period of October. The side-roll system capacity frequently limited the irrigation application. For example, 60% of the time that irrigation was required during early July, the irrigation amount was constrained by the system capacity.

Total farm water use for all fields and crops for each year of the simulation is tabulated. The net irrigation requirements, the net irrigation applications and the gross water requirements are tabulated for each year in the simulation and averaged over the simulation period. For the farm, the 10-year average annual net irrigation water requirement is 27.9 inches, the average net annual irrigation application is 22.1 inches, and the average annual gross water requirement is 2649 acre-ft. This gross requirement includes the net application amount plus any application or conveyance losses, essentially the total amount that must be supplied to the farm at the entrance of the supply system.

The next data table in the example SIMULATE output shows the average irrigation priority for each crop for each period of the year. This information shows how the various crops compare with each other when irrigation water is allocated for each period. Potatoes have a high irrigation priority throughout most of the season, while spring wheat has a comparatively low priority when compared with other crops.

Economic data for the three application systems and the supply system are listed next in the SIMULATE output file. This economic information contains much of the same general information regarding capital costs also present in the SYSTEM output for these individual systems. Information relative to the average operating costs for each system is added to these data by the SIMULATE program. Operating costs, such as labor and energy, that are dependent upon the irrigation application amount are computed using average annual irrigation amounts for the system.

The economic data for the side-roll system include the same capital cost information that was displayed in the SYSTEM output for the system. The total overall annual costs are provided in addition to the overall annual capital costs for the 20-year economic analysis period. These two values should **not**, however, be used as estimates of annual capital cash flows. The power cost estimates for the side-roll system are based on the average annual irrigation application, the number of hours of operation required to apply this amount, and the power requirements of the pump in the system. To operate the system's pump, with a power input of 42.1 kilowatts, for 5445 hours requires 229,225 kilowatt-hours of power.

A table provides annual cost estimates for cash flow, adjusted for the inflation rates specified for the costs of the various inputs. The annual capital cash flow and annual maintenance and miscellaneous costs for each system are obtained from the SYSTEM output, and the annual operating costs are obtained using the average annual labor and power requirements. Based on the economic information from the FISA data file, the SYSTEM program data outputs, and the average irrigation amounts from the SIMULATE program, the side-roll system has a total annual cost of approximately $61,000 during the tenth year of operation.

The economic information presented for the supply system is essentially the same as that for the individual irrigation application systems. The only difference between the two is found in the operating costs in the annual cash flow table. No labor costs are listed for the supply system, but the estimated water costs for the average annual gross water requirement for the farm are included.

In the example output, it may be noted that the seasonal hours of pump operation used to compute the annual power requirement for the supply system is less that the hours used to compute the annual power requirement for the side-roll system. This result does not imply that the side-roll system can be operated without utilizing the supply system. The amount of water supplied by each system is divided by the total pump discharge capacity to obtain the hours of operation per season. This assumes that all pumps are operating at full capacity whenever they are running.

In the output listed in Appendix A, the detailed SIMULATE output is followed by a summarized SIMULATE output for the same 10-year simulation period. This summary includes the irrigation performance for each crop for each field on the farm. This enables an analysis of the interaction between the crop rotation, soil characteristics, and irrigation system for each field.

The example output indicates that alfalfa has the greatest yield reduction when grown in fields irrigated by the side-roll system, perhaps indicating that the system capacity or the crop rotations for these two fields may be altered in subsequent system plans. Winter wheat grown in field 1 has a lower average yield reduction than the same crop grown in field 2, even though both fields are irrigated by the same system. This difference may be the result of the different weather conditions for the specific years in the simulation when winter wheat was grown on the respective fields or differences in the irrigation priorities due different crop mixes on the farm. It could also be a result of the differences in the soil characteristics between the two fields.

Following the performance summary for the various crops, the average irrigation performance for all crops grown in each field and for the entire farm is displayed. While this information is useful for comparing the various application systems, it is greatly dependent upon the crop rotation. Care should be taken so that the user does not try to derive too much specific information from any of this summarized output. Short simulation periods are affected greatly by year to year variations in the weather conditions and crop rotations. Longer periods of simulation and changes in the order of the crop rotation can improve the utility of the simulation results for evaluating system planning decisions.

A brief summary of the economic data for the supply and application systems and for the entire farm is provided in this output. The values displayed are average annual costs for the various cost components based on a uniform annual payment over the 20-year simulation period. The annual capital cost and annual total cost for each system should agree with the values in the detailed SIMULATE output file. These costs should only be used for comparing different systems and should **not** be used as an indication of the annual cash flow. As with much of the data in this summarized output, there is a great deal of dependence upon the specified crop rotations and varying weather conditions of the different years of the simulation period.

Further Analysis

The data illustrated in this example are the results of the simulation of a single combination of farm layout, system design, crop rotations and econimic information. The FISA modeling package enables the user to evaluate different combinations of the these and other considerations according to his own preferences and priorities.

In this example, the next step may be to use the package on the same farm, only with a single type of application system (furrow, for example) for all fields. This will require the user to make some preliminary plans for the farm layout and basic system design, based on the farm topography. If the user was concerned about the effects of energy prices on the particular irrigation system plan, he might evaluate the original farm plan using an inflation rates for energy other than the example's 9% value.

Effects of other factors on the overall farm plan could be evaluated as well, including changes in the crop rotation, irrigation management, water availability, water costs, system components and interest rates. Based on these kinds of trials, the user can then determine the most suitable irrigation system plan by comparing different simulation results.

CHAPTER 8

CONCLUSIONS

Systems analysis can be used effectively for planning irrigation systems. The analysis procedure developed provides a means of analyzing the different aspects of an on-farm irrigation system along with the effects of many external factors that affect system performance. The on-farm irrigation system analysis procedure (FISA) provides a means of critically evaluating on-farm irrigation system plans and water management practices under site-specific conditions. A computer routine called SYSTEM is used in the procedure for computing the operating characteristics and providing cost summaries of system components. A computer routine called SIMULATE is then used to obtain a detailed analysis of system operational characteristics and costs.

The computer routines used provide for a great deal of flexibility in the FISA procedure. This flexibility is necessary for the procedure to be useful for on-farm system planning purposes as site-specific conditions can vary quite markedly. The FISA procedure is designed to utilize available site-specific data to the fullest extent.

Irrigation system operations can be accurately represented by simulation modeling. The simulation model developed is capable of estimating irrigation water requirements based upon crop water use, rainfall, and soil moisture holding characteristics. Simulation of water application and irrigation priorities for each crop are considered for each field. Management factors such as maintaining adequate soil moisture levels in anticipation of system capacity limitations are included in the simulation process. Results from the simulation process satisfactorily represent how a system would operate under conditions defined by input data.

The results obtained using FISA show the following:

-- the effectiveness of irrigation operation throughout the irrigation season.
-- the effects of inflation and loan terms.
-- the interactive effects of physical parameters, costs, loan terms, inflation and management factors.
-- trade-offs, useful for multiple objective planning.
-- output suitable as inputs for a cash flow and economic analysis and other planning models.

An important feature of the FISA procedure is the relative ease with which alternative system plans can be evaluated. Plans involving different field layouts and cropping patterns can be considered along with alternative application systems. Developing these plans can be accomplished quite rapidly, with the primary task being the modification and/or recreation of the FISA data file. Developing and evaluating alternatives in the planning phase allows alternatives to be objectively evaluated and decisions to be made prior to detailed system design.

The FISA procedures can be used by planners, consultants and related professionals knowledgeable in microcomputer use and irrigation system design. The results obtained from use FISA can be used by planners, consultants, equipment suppliers and farmers in making objective comparisons between different systems and/or the effects of different cropping and irrigation-related management practices. It can be used for planning new systems, for evaluating existing systems or for determining the effects of system modifications. Alternative plans can be quickly developed and evaluated, and the "best" plan selected for final detailed design.

CHAPTER 9

RECOMMENDATIONS

Although the on-farm irrigation system analysis procedure developed is an effective planning tool, several recommendations are offered for effective use and possible extensions.

An understanding of input data and computational processes used is necessary to understand and effectively interpret the results as well as assure the results obtained are free of errors. The procedure is not fool proof as incorrect input can surely return incorrect output. The user should also be familiar with the computer system used, and the LOTUS SYMPHONY 1.1 package.

Continued verification of all elements in the procedure should be an item of top priority. Considerable effort was made to eliminate "BUGS" from the computer routines, but there are undoubtedly some remaining to be found by unsuspecting users!

Extensions of the present procedure would provide added dimensions to the applications and results. The following extensions may prove effective:

1. Provide a stand-alone windowing program for creating the site-specific data file. This would eliminate the requirement that the user have LOTUS SYMPHONY 1.1 software and increase the portability of the entire procedure.

2. Provide for a non-steady water supply that would closely resemble the supply from a run-of-the-river supply.

3. Include a more detailed analysis of the simulation results that could incorporate a probability distribution for irrigation requirements, water application and/or deficits for each crop, field, or system.

4. Provide information pertaining to the expected variation of operating costs based upon variations in the irrigation water applications obtained from the simulation process.

It is hoped that the entire procedure will be improved, modified, expanded and adopted as a effective tool for planning on-farm irrigation systems.

REFERENCES

Allen, R.G. 1983. Optimizing irrigation system design. Unpublished PhD Dissertation, Civil Engineering Department, University of Idaho, Moscow. 572p.

ASAE. 1984. Agricultural Engineering Yearbook, S289: Concrete slip-form canal and ditch lining. pp. 445-447.

Busch, J.R. 1975. Obtaining specifications for minimum cost irrigation systems. Proceedings, ASCE I&D Specialty Conference. pp. 456-475.

Busch, J.R. 1982. Systems analysis of on-farm irrigation systems. Report submitted to the New Zealand National Research Advisory Council through Ministry of Agriculture and Fisheries, Agricultural Research Division.

Busch, J.R. and S.D. McBride. 1984. A user's manual for the Farm Irrigation System Analysis (FISA). Technical Report 18, Winchmore Irrigation Research Station, Private Bag, Ashburton, New Zealand. 42p.

Doorenbos J., and A.H. Kassam. 1979. Yield Response to Water. Food and Agriculture Organization of the United Nations, Irrigation and Drainage Paper no. 33. Rome.

Galinato, G.D., J.R. Busch and C.E. Brockway. 1977. Optimizing irrigation system design. Research Technical Completion Report, Idaho Water Resources Research Institute, University of Idaho, Moscow. 266p.

Gilley, J. R. 1984. Suitability of reduced pressure center pivots. ASCE J. Irrig. and Drain. Div. 110(IR1), 22-34.

Hall, W.A. and W.S. Butcher. 1968. Optimal timing of irrigation. ASCE Irrigation and Drainage Journal. 94:267-275.

Hamilton, J.R. and R.A. Lyman. 1983. An investigation into the economic impacts of subordinating the swan falls hydroelectric water right to upstream irrigation. Idaho Water and Energy Resources Research Institute, Moscow.

James, L. G. 1982. Modeling the performance of center pivot irrigation systems operating on variable topography. Trans ASAE 11(1), 11-15.

James, L. G. and S. K. Blair. 1983. Performance of low pressure center pivot systems. ASAE paper 83-2021.

Katopodes, A. M. and T. Strelkoff. 1977. Dimensionless solutions of border-irrigation advance. ASCE J. Irrig. and Drain. Div. 103(IR4), 401-417.

REFERENCES (continued)

Keller J. and G.Z. Watters. 1980. Computer-aided irrigation pipe network design program. Keller Engineering, Logan, UT. 113p.

Khanjani, M.J. 1980. Methodology for optimization of an irrigation system with storage reservoirs. Unpublished PhD Dissertation, Agricultural Engineering Department, University of Idaho, Moscow. 313p.

Kincaid, D.C. 1982. Sprinkler pattern radius. Trans ASAE 25(6), 1668-1672.

Koluvek, P. 1985. Modeling Sprinkler Erosion. Presentation at the Idaho Water Resources Research Institute Irrigation Research Workshop, November 7-8, 1985. Kennewick, Washington.

Koluvek, P. and T. S. Spofford. 1986. Personal communication.

Kottwitz, A. E., L. G. James, B. W. Sauer, and K. R. Best. 1984. Forecasting climatic data for irrigation scheduling. ASAE paper no. 84-2620.

Longley, T.S. 1984. Reservoir tillage for center pivot irrigation. ASAE paper PNR84-209 presented at the PNR Annual Meeting of the ASAE, Kennewick, WA. September 26-28, 1984.

Pfeiffer, G.H., and N.K. Whittlesey. 1978. Economic Impacts of Controlling Concentration and Other Water Quality Determinants in the Yakima River Basin. Management of Nitrogen in Irrigated Agriculture edited by P.F. Pratt, published by the Department of Soil and Environment Sciences, University of California, Riverside, CA. May 1978 pp. 415-442.

Schmisseur, W.E. and F.S. Conklin. 1973. The economics of water conservation investments and practices: a general methodology and its application to selected irrigation units in Oregon. Dept. of Agricultural Economics, Oregon State University, Corvallis. 88p.

Seginer, I. and M. Kostrinsky. 1975. Wind, sprinkler patterns and system design. Jour. Irrig. and Drain. Div. ASCE 101(IR4), pp. 251-264.

Sherman, B. and V. P. Singh. 1978. A kinematic model for surface irrigation. Water Resources Res. 14(2), 357-364.

Soil Conservation Service. 1967. Irrigation water requirements. Engineering Division Technical Release no. 21. 88p.

Soil Conservation Service. 1974. Border irrigation. USDA SCS National Engineering Handbook, Section 15, Chapter 4. 73p.

REFERENCES (continued)

Soil Conservation Service. 1983. Furrow irrigation. USDA SCS National Engineering Handbook, Section 15, Chapter 5. 50p.

Soil Conservation Service. 1983. Sprinkler irrigation. USDA SCS National Engineering Handbook, Section 15, Chapter 11. 121p.

Soil Conservation Service. 1985a. Idaho irrigation guide, Title 210 Chapter VI. 386p.

Soil Conservation Service. 1985b. State of Washington irrigation guide. 704p.

Spofford, T. L. 1986. Personal communication

Strelkoff, T. and A.J. Clemmens. 1984. Current status of irrigation modeling. Proceedings of the ASCE I&D Specialty Conference. pp 93-103.

Vaux, H. J. and W. O. Pruitt. 1983. Crop-water production functions. In: Hillel, Daniel (ed.),Advances in irrigation, vol. 2., AcademicPress, New York. pp. 61-97.

Walker, W.R. 1984. Optimizing surface irrigation system performance. Proceedings of the ASCE I&D Specialty Conference. pp. 104-111.

Walker, W. R. and A. S. Humpherys. 1983. Kinematic-wave furrow irrigation model. ASCE J. Irrig. and Drain. Div. 109(IR4), pp. 377-392.

Windsor, J.S. and C.T. Chow. 1971. Model for farm irrigation in humid areas. ASCE Irrigation and Drainage Journal. 97:369-385.

Yoo K.H., J.R. Busch and C.E. Brockway. 1982. Optimal planning of irrigation distribution and application systems for a large irrigated area. Research Technical Completion Report, Idaho Water Resources Research Institute, University of Idaho, Moscow. 235p.

APPENDIX A

EXAMPLE OUTPUT FILES

CONTENTS

FISA DATA FILE

DATA DESCRIPTIVE NAME: Example

8 -MONTH IRRIGATION SEASON

3 -FIRST MONTH OF THE SEASON

10 -LAST MONTH OF THE SEASON

6 -TOTAL NUMBER OF FIELDS

FIELD DATA:

FIELD NUMBER	IRRIGATED AREA (ac)	YEARS IN ROTATION	PREDOMINANT SOIL TYPE No.	INTAKE FAMILY	SPRINKLER INTAKE (IN/HR)	EROSIVITY FACTOR
1	80	7	2	0.4	0.34	0.78
2	80	7	6	0.4	0.34	0.78
3	80	7	6	0.4	0.34	0.78
4	80	7	2	0.4	0.34	0.78
5	80	7	2	0.4	0.34	0.78
6	80	3	13	0.4	0.34	0.78

CROP - ROTATION DATA:

38 - CROP-ROTATION COMBINATIONS

			- - - - FIRST CROP - - -				- - - SECOND CROP - - -			
FIELD No.	SOIL No.	ROTATION YEAR	CROP No.	TAM (inches)	MAD (%)	AD (%)	CROP No.	TAM (inches)	MAD (%)	AD (%)
1	2	1	10	0.82	35	10	11	1.23	60	20
1	2	2	11	1.23	60	20	1	1.23	100	10
1	2	3	2	1.23	50	15	1	1.23	100	10
1	2	4	2	1.23	50	15	1	1.23	100	10
1	2	5	2	1.23	50	15	1	1.23	100	10
1	2	6	2	1.23	50	15	1	1.23	100	10
1	2	7	5	1.23	60	24	1	1.23	100	10
2	6	1	5	2.28	60	24	1	2.28	100	10
2	6	2	10	1.52	35	10	11	2.28	60	20
2	6	3	11	2.28	60	20	1	2.28	100	10
2	6	4	2	2.28	50	15	1	2.28	100	10
2	6	5	2	2.28	50	15	1	2.28	100	10
2	6	6	2	2.28	50	15	1	2.28	100	10
2	6	7	2	2.28	50	15	1	2.28	100	10
3	6	1	2	2.28	50	15	1	2.28	100	10
3	6	2	5	2.28	60	24	1	2.28	100	10
3	6	3	10	1.52	35	10	11	2.28	60	20
3	6	4	11	2.28	60	20	1	2.28	100	10

3	6	5	2	2.28	50	15	1	2.28	100	10
3	6	6	2	2.28	50	15	1	2.28	100	10
3	6	7	2	2.28	50	15	1	2.28	100	10
4	2	1	2	1.23	50	15	1	1.23	100	10
4	2	2	2	1.23	50	15	1	1.23	100	10
4	2	3	5	1.23	60	24	1	1.23	100	10
4	2	4	10	0.82	35	10	11	1.23	60	20
4	2	5	11	1.23	60	20	1	1.23	100	10
4	2	6	2	1.23	50	15	1	1.23	100	10
4	2	7	2	1.23	50	15	1	1.23	100	10
5	2	1	2	1.23	50	15	1	1.23	100	10
5	2	2	2	1.23	50	15	1	1.23	100	10
5	2	3	2	1.23	50	15	1	1.23	100	10
5	2	4	5	1.23	60	24	1	1.23	100	10
5	2	5	10	0.82	35	10	11	1.23	60	20
5	2	6	11	1.23	60	20	1	1.23	100	10
5	2	7	2	1.23	50	15	1	1.23	100	10
6	13	1	5	6.03	60	24	11	6.03	60	20
6	13	2	11	6.03	60	20	1	6.03	100	10
6	13	3	6	6.03	60	20	1	6.03	100	10

6 - CROPS GROWN AS LISTED BELOW

CROP No.	CROP NAME	NORMAL YIELD	EXPECTED NET RETURN ($/UNIT YIELD)
1	FALLOW	0.0	0.00
2	ALFALFA HAY	5.0	70.00
5	SPRING WHEAT	80.0	3.00
6	SPRING BARLEY	2.5	61.00
10	POTATOES	25.0	48.00
11	WINTER WHEAT	100.0	3.10

SUPPLY INFORMATION:

10 -- PERCENT COST OF OPPORTUNITY CAPITAL

5 -- EXPECTED INFLATION RATE FOR SYSTEM COMPONENTS

LOAN TERMS:

	(ATTACHED ITEMS) LOAN No. 1	(UNATTACHED ITEMS) LOAN No. 2
INTEREST RATE IN PERCENT.	8	12
TIME OF LOAN IN YEARS.	15	7

FLOW DATA:

13	-- CFS ENTERING SYSTEM MAXIMUM
1920	-- AC-FT AVAILABLE MAXIMUM
7	-- DAYS PER WEEK FLOW IS AVAILABLE

WATER COST DATA:

25.00	-- COST OF BASIC ALLOTMENT ($/AC)
3.5	-- VOLUME OF BASIC ALLOTMENT (AC-FT/AC)
0.00	-- COST PER AC-FT/AC
50.00	-- COST OF ADDITIONAL WATER ($/AC-FT/AC)

ELECTRICAL RATE INFORMATION:

YES -- ELECTRIC USAGE IS REQUIRED

ELECTRICAL SERVICE INSTALLATION CHARGE ($).	1500
ANNUAL LUMP ELECTRICAL CHARGE ($)	0
ANNUAL $/KILOWATT CHARGE	0
BILLING PERIOD LENGTH (MONTHS).	1
START OF SUMMER RATES (4 = APRIL, 5 = MAY, ETC.).	4
END OF SUMMER RATES (8 = AUGUST, 9 = SEPTEMBER, ETC.)	9
EXPECTED ANNUAL INFLATION RATE FOR ENERGY (%)	9

	SUMMER	WINTER
BILLING PERIOD LUMP CHARGE ($).	0	0
BILLING PERIOD $/KILOWATT CHARGE.	25	0
AVERAGE CHARGE ($/KWH).	0.045	0.065

SUPPLY SYSTEM OPEN CHANNEL REQUIREMENTS:

yes -- OPEN CHANNELS ARE REQUIRED

NUMBER OF CHANNELS (MAXIMUM OF 5). 1

CHANNEL ID No.	1	2	3	4	5
LINED ? (YES OR NO)	yes				
LENGTH IN FEET.	1000				
PERCENT SLOPE	0.1				
FLOWRATE (CFS) (0-UNKNOWN).	0				
SEEPAGE LOSS (ALT-M = MENU)	0.1				
SALVAGE VALUE (% OF COST) .	0				
PERCENT OF COST FINANCED. .	100				
LOAN No. (1 OR 2)	1				
ANNUAL MAINTENANCE COST (%)	7				
TOTAL ANNUAL MISC. COST ($)	120				

SUPPLY SYSTEM STRUCTURE REQUIREMENTS:

YES -- STRUCTURES ARE REQUIRED

NUMBER OF STRUCTURES (MAXIMUM OF 5). 2

STRUCTURE ID No.	1	2	3	4	5
TOTAL COST.	3100	3100			
SALVAGE VALUE (% OF COST) .	0	0			
PERCENT OF COST FINANCED. .	100	100			
LOAN No. (1 OR 2)	1	1			
ANNUAL MAINTENANCE COST (%)	3	3			
TOTAL ANNUAL MISC. COST ($)	10	10			

SUPPLY SYSTEM PUMP REQUIREMENTS:

yes -- PUMPS ARE REQUIRED

NUMBER OF PUMPS (MAXIMUM OF 5). 2

PUMP ID No.	1	2	3	4	5
DISCHARGE (GPM)(0-UNKNOWN).	0	0			
DISCHARGE PRESSURE (PSI). .	5	5			
INLET PRESSURE (PSI). . . .	0	0			
VERTICAL LIFT (FT).	20	20			
PUMP EFF (%)(0-UNKNOWN) . .	0	0			
MOTOR EFF (%) (0-UNKNOWN) .	0	0			
PUMP COST ($) (0-UNKNOWN) .	0	0			
SALVAGE VALUE (% OF COST) .	12	12			
PERCENT OF COST FINANCED. .	95	95			
LOAN No. (1 OR 2)	2	2			
ANNUAL MAINTENANCE COST (%)	10	10			
TOTAL ANNUAL MISC. COST ($)	50	50			

SUPPLY SYSTEM PIPELINE REQUIREMENTS:

yes -- PIPELINES ARE REQUIRED

NUMBER OF PIPELINES (MAXIMUM OF 5). 1

PIPELINE ID No.	1	2	3	4	5
MAT'L(S-STEEL,P-PVC,A-ALUM)	S				
LENGTH (FT)	3100				
PERCENT SLOPE	-2				
FLOWRATE (CFS)(0-UNKNOWN) .	0				
SALVAGE VALUE (% OF COST) .	0				
PERCENT OF COST FINANCED. .	80				
LOAN No. (1 OR 2)	1				
ANNUAL MAINTENANCE COST (%)	8				
TOTAL ANNUAL MISC. COST ($)	10				

SUPPLY SYSTEM EXTRA EXPENSE REQUIREMENTS:

YES -- EXTRA EXPENSES ARE REQUIRED

NUMBER OF ITEMS (MAXIMUM OF 5). 2

ITEM ID No.	1	2	3	4	5
ITEM NAME	ELEC PANL	PUMPHOUSE			
COST ($).	1500	2000			
USEFUL LIFE (YRS)	15	15			
SALVAGE VALUE (% OF COST) .	5	5			
PERCENT OF COST FINANCED. .	100	100			
LOAN No. (1 OR 2)	2	2			
ANNUAL MAINTENANCE COST (%)	2	13			
TOTAL ANNUAL MISC. COST ($)	12	50			

APPLICATION SYSTEMS INFORMATION:

3 -- SEPARATE APPLICATION SYSTEMS ARE TO BE CONSIDERED

SYSTEM No.	1	2	3
SYSTEM TYPE No.	2	5	6
NUMBER OF FIELDS	2	2	2
1st Field ID#	1	3	5
2nd Field ID#	2	4	6

SYSTEM No 1 -- FURROW OR CORRUGATE

FLOW RATE ENTERING THE SYSTEM (CFS). 5
HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE 24

INFORMATION FOR EACH FIELD:

FIELD No.	1	2
FIELD LENGTH (FT).	1320	1320
FIELD WIDTH (FT)	2640	2640
FIELD SLOPE (%).	1	1
FURROW LENGTH (FT)	1320	1320
MAX FURROW FLOW (GPM) (0-UNKNOWN).	0	0
SET TIME INCREMENT (HRS)	12	12
MAXIMUM SET TIME (HRS)	72	72
LABOR REQUIRED (HRS/AC/IRR). . . .	0.8	0.8
HOURS ADD'L LABOR PER SEASON . . .	0	0
TOTAL COST OF LAND GRADING	8000	7500
PERCENT OF COST FINANCED	100	100
LOAN No. (1 OR 2).	2	2
ANNUAL MAINTENANCE COST ($). . . .	100	100
APPLICATION EFF (%) (0-UNKNOWN). .	0	0
DEEP PERCOLATION (%) (0-UNKNOWN) .	0	0
FURROW FLOW RATE (GPM)(0-UNKNOWN).	0	0

APPLICATION SYSTEM No. 1 OPEN CHANNEL REQUIREMENTS:

YES -- OPEN CHANNELS ARE REQUIRED

NUMBER OF CHANNELS (MAXIMUM OF 5). 2

CHANNEL ID No.	1	2	3	4	5
LINED ? (YES OR NO)	YES	YES			
LENGTH IN FEET.	2640	2640			
PERCENT SLOPE	0.05	0.05			
FLOWRATE (CFS) (0-UNKNOWN).	0	0			
SEEPAGE LOSS (ALT-M = MENU)	0.15	0.15			
SALVAGE VALUE (% OF COST) .	0	0			
PERCENT OF COST FINANCED. .	100	100			
LOAN No. (1 OR 2)	1	1			
ANNUAL MAINTENANCE COST (%)	15	15			
TOTAL ANNUAL MISC. COST ($)	25	25			

APPLICATION SYSTEM No. 1 STRUCTURE REQUIREMENTS:

YES -- STRUCTURES ARE REQUIRED

NUMBER OF STRUCTURES (MAXIMUM OF 5). 2

STRUCTURE ID No.	1	2	3	4	5
TOTAL COST.	300	300			
SALVAGE VALUE (% OF COST) .	0	0			
PERCENT OF COST FINANCED. .	100	100			
LOAN No. (1 OR 2)	2	2			
ANNUAL MAINTENANCE COST (%)	15	15			
TOTAL ANNUAL MISC. COST ($)	10	10			

APPLICATION SYSTEM No. 1 PUMP REQUIREMENTS:

NO -- PUMPS ARE REQUIRED

APPLICATION SYSTEM No. 1 PIPELINE REQUIREMENTS:

YES -- PIPELINES ARE REQUIRED

NUMBER OF PIPELINES (MAXIMUM OF 5). 2

PIPELINE ID No.	1	2	3	4	5
MAT'L(S-STEEL,P-PVC,A-ALUM)	P	P			
LENGTH (FT)	1320	2640			
PERCENT SLOPE	2	2.5			
FLOWRATE (CFS)(0-UNKNOWN) .	0	0			
SALVAGE VALUE (% OF COST) .	0	0			
PERCENT OF COST FINANCED. .	100	100			
LOAN No. (1 OR 2)	1	1			
ANNUAL MAINTENANCE COST (%)	10	15			
TOTAL ANNUAL MISC. COST ($)	10	10			

APPLICATION SYSTEM No. 1 EXTRA EXPENSE REQUIREMENTS:

YES -- EXTRA EXPENSES ARE REQUIRED

NUMBER OF ITEMS (MAXIMUM OF 5). 3

ITEM ID No.	1	2	3	4	5
ITEM NAME	tubes	structs	tail ditch		
COST ($).	2400	300	400		
USEFUL LIFE (YRS)	7	15	2		
SALVAGE VALUE (% OF COST) .	5	0	0		
PERCENT OF COST FINANCED. .	100	100	0		
LOAN No. (1 OR 2)	2	2	2		
ANNUAL MAINTENANCE COST (%)	10	15	50		
TOTAL ANNUAL MISC. COST ($)	10	20	0		

SYSTEM No 2 -- SIDE-ROLL SPRINKLER

HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE 24
HOURS PER WEEK ADD'L DOWN TIME WHEN WATER IS AVAILABLE. . . . 7
WIND RANGE NUMBER AT NOZZLE HEIGHT (1 = 0-4 MPH, 2 = 4-10 MPH,
3 = 10-14 MPH). 2
LATERAL LENGTH (FT) 1320
LATERAL SPACING (FT). 60
LATERAL DIAMETER (IN) 5
SPRINKLER SPACING (FT). 40
SPRINKLER TYPE NUMBER (1 = HIGH PRESSURE IMPACTS,
2 = LOW PRESS IMPACTS-STD NOZZLE, 3 = LOW PRESS IMPACTS-CD NOZZLE
4 = LOW PRESS IMPACTS-FC NOZZLE) 1
NUMBER OF LATERAL LINES 6
GROSS APPLICATION DEPTH (IN/DAY). 0.33
COST PER LATERAL LINE ($) 10567
PERCENT OF COST FINANCED. 100
LOAN No. (1 OR 2) 2
SALVAGE VALUE (%) 25
ANNUAL MAINTENANCE COST (%) 12
TOTAL ANNUAL MISC. COST ($) 15

INFORMATION FOR EACH FIELD:

FIELD No.	3	4
AVERAGE FIELD SLOPE (%).	1	1
LATERAL TRAVEL DISTANCE (FT) . . .	840	840
SET TIME INCREMENT (HRS)	12	12
BASIN TILLAGE PRACTICE (YES OR NO)	NO	NO
LABOR REQUIRED (HRS/AC/IRR). . . .	0.3	0.3
HOURS ADD'L LABOR PER SEASON . . .	0	0
TOTAL COST OF LAND GRADING	1000	1000
PERCENT OF COST FINANCED	100	100
LOAN No. (1 OR 2).	2	2
ANNUAL COST FOR LAND SMOOTHING . .	100	100

APPLICATION SYSTEM No. 2 OPEN CHANNEL REQUIREMENTS:

NO -- OPEN CHANNELS ARE REQUIRED

APPLICATION SYSTEM No. 2 STRUCTURE REQUIREMENTS:

YES -- STRUCTURES ARE REQUIRED

NUMBER OF STRUCTURES (MAXIMUM OF 5). 1

STRUCTURE ID No.	1	2	3	4	5
TOTAL COST.	300				
SALVAGE VALUE (% OF COST) .	0				
PERCENT OF COST FINANCED. .	100				
LOAN No. (1 OR 2)	2				
ANNUAL MAINTENANCE COST (%)	15				
TOTAL ANNUAL MISC. COST ($)	10				

APPLICATION SYSTEM No. 2 PUMP REQUIREMENTS:

YES -- PUMPS ARE REQUIRED

NUMBER OF PUMPS (MAXIMUM OF 5). 1

PUMP ID No.	1	2	3	4	5
DISCHARGE (GPM)(0-UNKNOWN).	0				
DISCHARGE PRESSURE (PSI). .	65				
INLET PRESSURE (PSI). . . .	0				
VERTICAL LIFT (FT).	10				
PUMP EFF (%)(0-UNKNOWN) . .	0				
MOTOR EFF (%)(0-UNKNOWN). .	0				
PUMP COST ($)(0-UNKNOWN). .	0				
SALVAGE VALUE (% OF COST) .	25				
PERCENT OF COST FINANCED. .	80				
LOAN No. (1 OR 2)	1				
ANNUAL MAINTENANCE COST (%)	20				
TOTAL ANNUAL MISC. COST ($)	10				

APPLICATION SYSTEM No. 2 PIPELINE REQUIREMENTS:

YES -- PIPELINES ARE REQUIRED

NUMBER OF PIPELINES (MAXIMUM OF 5). 2

PIPELINE ID No.	1	2	3	4	5
MAT'L(S-STEEL,P-PVC,A-ALUM)	P	P			
LENGTH (FT)	3960	3960			
PERCENT SLOPE	2	2.5			
FLOWRATE (CFS)(0-UNKNOWN) .	0	0			
SALVAGE VALUE (% OF COST) .	0	0			
PERCENT OF COST FINANCED. .	100	100			
LOAN No. (1 OR 2)	1	1			
ANNUAL MAINTENANCE COST (%)	10	10			
TOTAL ANNUAL MISC. COST ($)	20	20			

APPLICATION SYSTEM No. 2 EXTRA EXPENSE REQUIREMENTS:

YES -- EXTRA EXPENSES ARE REQUIRED

NUMBER OF ITEMS (MAXIMUM OF 5). 4

ITEM ID No.	1	2	3	4	5
ITEM NAME	PUMP PAD	RISERS	GAGES	ELEC PANL	
COST ($).	500	3000	1100	1500	
USEFUL LIFE (YRS)	15	15	7	15	
SALVAGE VALUE (% OF COST) .	0	0	10	25	
PERCENT OF COST FINANCED. .	100	50	50	100	
LOAN No. (1 OR 2)	2	1	2	2	
ANNUAL MAINTENANCE COST (%)	10	15	15	25	
TOTAL ANNUAL MISC. COST ($)	0	15	0	15	

SYSTEM No 3 -- CENTER PIVOT SPRINKLER

HOURS PER DAY SYSTEM OPERATES WHEN WATER IS AVAILABLE	24
LATERAL LENGTH (FT)	1270
LATERAL DIAMETER (IN)	6.36
GROSS APPLICATION DEPTH (IN/DAY).	0.4
SPRINKLER TYPE NUMBER (1 = HIGH PRESS IMPACT, 2 = LOW PRESS IMPACT-STD NOZZLE, 3 = LOW PRESS IMPACTS-CD NOZZLE 4 = LOW PRESS IMPACTS-FC NOZZLE, 5 = SPRAYS-TOP MOUNTED 6 = SPRAYS-DROP TUBES, 7 = SPRAYS-BOOMS	7
PRESSURE REGULATORS USED (YES OR NO).	YES
ENDGUN USED (YES OR NO)	YES
AVERAGE WIND SPEED GREATER THAN 5 MPH (YES OR NO)	YES
LABOR REQUIRED (HRS/AC/IRR)	0.1
TOTAL COST ($).	70000
PERCENT OF COST FINANCED.	100
LOAN No. (1 OR 2)	1
SALVAGE VALUE (%)	25
ANNUAL MAINTENANCE COST (%)	15
TOTAL ANNUAL MISC. COST ($)	25

INFORMATION FOR EACH FIELD:

FIELD No.	5	6
AVERAGE FIELD SLOPE (%).	1	1
WETTED RADIUS (FT)	1320	1320
BASIN TILLAGE PRACTICE (YES OR NO)	NO	NO
TOTAL COST OF LAND GRADING	1000	1000
PERCENT OF COST FINANCED	100	100
LOAN No. (1 OR 2).	2	2
ANNUAL COST FOR LAND SMOOTHING . .	100	100

APPLICATION SYSTEM No. 3 OPEN CHANNEL REQUIREMENTS:

NO -- OPEN CHANNELS ARE REQUIRED

APPLICATION SYSTEM No. 3 STRUCTURE REQUIREMENTS:

YES -- STRUCTURES ARE REQUIRED

NUMBER OF STRUCTURES (MAXIMUM OF 5). 1

STRUCTURE ID No.	1	2	3	4	5
TOTAL COST.	500				
SALVAGE VALUE (% OF COST) .	0				
PERCENT OF COST FINANCED. .	100				
LOAN No. (1 OR 2)	1				
ANNUAL MAINTENANCE COST (%)	10				
TOTAL ANNUAL MISC. COST ($)	0				

APPLICATION SYSTEM No. 3 PUMP REQUIREMENTS:

YES -- PUMPS ARE REQUIRED

NUMBER OF PUMPS (MAXIMUM OF 5). 1

PUMP ID No.	1	2	3	4	5
DISCHARGE (GPM)(0-UNKNOWN).	0				
DISCHARGE PRESSURE (PSI). .	55				
INLET PRESSURE (PSI). . . .	0				
VERTICAL LIFT (FT).	10				
PUMP EFF (%)(0-UNKNOWN) . .	0				
MOTOR EFF (%)(0-UNKNOWN). .	0				
PUMP COST ($)(0-UNKNOWN). .	0				
SALVAGE VALUE (% OF COST) .	25				
PERCENT OF COST FINANCED. .	100				
LOAN No. (1 OR 2)	2				
ANNUAL MAINTENANCE COST (%)	15				
TOTAL ANNUAL MISC. COST ($)	25				

APPLICATION SYSTEM No. 3 PIPELINE REQUIREMENTS:

YES -- PIPELINES ARE REQUIRED

NUMBER OF PIPELINES (MAXIMUM OF 5). 1

PIPELINE ID No.	1	2	3	4	5
MAT'L(S-STEEL,P-PVC,A-ALUM)	P				
LENGTH (FT)	1600				
PERCENT SLOPE	2.5				
FLOWRATE (CFS)(0-UNKNOWN) .	0				
SALVAGE VALUE (% OF COST) .	0				
PERCENT OF COST FINANCED. .	100				
LOAN No. (1 OR 2)	1				
ANNUAL MAINTENANCE COST (%)	10				
TOTAL ANNUAL MISC. COST ($)	15				

APPLICATION SYSTEM No. 3 EXTRA EXPENSE REQUIREMENTS:

YES -- EXTRA EXPENSES ARE REQUIRED

NUMBER OF ITEMS (MAXIMUM OF 5). 4

ITEM ID No.	1	2	3	4	5
ITEM NAME	PUMP PAD	PIV PAD	ELEC PANL	GAGES	
COST ($).	500	250	1500	700	
USEFUL LIFE (YRS)	15	15	15	15	
SALVAGE VALUE (% OF COST) .	0	0	25	0	
PERCENT OF COST FINANCED. .	100	100	100	50	
LOAN No. (1 OR 2)	2	2	2	1	
ANNUAL MAINTENANCE COST (%)	10	10	25	10	
TOTAL ANNUAL MISC. COST ($)	0	0	15	25	

FARM DRAINAGE REQUIREMENTS:

no -- DRAINAGE IS REQUIRED ON THE FARM

SIMULATE INFORMATION:

MAXIMUM LABOR INPUT AVAILABLE IN HOURS PER WEEK 400

LABOR WAGE RATE ($/HR). 5.45

EXPECTED ANNUAL INFLATION RATE FOR LABOR (%). 5

EXPECTED ANNUAL INFLATION RATE FOR OPERATING AND MAINTENANCE COSTS (%) 8

SYSTEM OUTPUT DATA

SUMMARY OF SUPPLY SYSTEM INFORMATION

ESTIMATED SEEPAGE LOSSES .053 %

SUMMARY OF INITIAL SYSTEM COSTS AND FINANCING ---

	ATTACHED COMPONENTS (LOAN NO. 1)	UNATTACHED COMPONENTS (LOAN NO.2)
TOTAL CAPITAL COST ($)	96864.59	10291.28
CAPITAL NOT FINANCED ($)	17368.77	339.56
FINANCED CAPITAL ($)	79495.82	9951.71
INTEREST RATE (%)	8.00	12.00
TIME OF LOAN (YEARS)	15.	7.
SALVAGE VALUE ($)	.00	989.95
ANNUAL MAINTENANCE EXPENSE ($) . .	7400.96	969.13
ANNUAL MISCELLANEOUS EXPENSE ($) .	150.00	162.00

ANNUAL CAPITAL CASH FLOW

YEAR	PRINCIPLE	INTREST	CASH	TOTAL
0	0	0	17708	17708
1	3914	7554	0	11468
2	4267	7201	0	11468
3	4652	6816	0	11468
4	5074	6394	0	11468
5	5535	5933	0	11468
6	6042	5426	0	11468
7	6593	4875	0	11468
8	5017	4270	0	9287
9	5419	3868	0	9287
10	5853	3434	0	9287
11	6320	2967	0	9287
12	6826	2461	0	9287
13	7372	1915	0	9287
14	7962	1325	0	9287
15	8599	688	704	9991
16	2816	4150	0	6966
17	3123	3843	0	6966
18	3465	3501	0	6966
19	3846	3120	0	6966
20	4268	2698	0	6966

ANNUAL CAPITAL RECOVERY ($) . . . 14012.25

ECONOMIC INFORMATION FOR SYSTEM COMPONENTS

15 COMPONENTS PURCHASED (R = REPLACEMENT ITEM)

ITEM		YR	LIFE	TOTAL COST	SALVAGE VALUE	ANNUAL COST	LOAN RATE(%)	ANNUAL MAINT($)	ANNUAL MISC($)
LINED CANAL		0	15	3821	0	449	8	267	120
LINED CANAL	R	15	15	7943	5295	841	8	555	249
STRUCTURE		0	15	3100	0	364	8	93	10
STRUCTURE	R	15	15	6445	4296	682	8	193	20
STRUCTURE		0	15	3100	0	364	8	93	10
STRUCTURE	R	15	15	6445	4296	682	8	193	20
PUMP		0	15	3396	407	392	12	340	50
PUMP	R	15	15	7059	4989	742	12	706	103
PUMP		0	15	3396	407	392	12	340	50
PUMP	R	15	15	7059	4989	742	12	706	103
STEEL PIPE, LOW PRESS		0	20	86844	0	10201	8	6948	10
ELEC PANL		0	15	1500	75	175	12	30	12
ELEC PANL	R	15	15	3118	2131	329	12	62	24
PUMPHOUSE		0	15	2000	100	233	12	260	50
PUMPHOUSE	R	15	15	4158	2841	439	12	540	103

1 CHANNEL(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED CHANNEL(S)

CHANNEL NO.	BOTTOM WIDTH* (FT)	DEPTH* (FT)
1	1.0	2.2

* ESTIMATES ONLY. DO NOT USE IN DESIGNING SYSTEM

2 PUMP(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PUMP(S)

PUMP ID NO.	FLOW RATE (GPM)	INPUT POWER (KW)
1	2917.2	24.3
2	2917.2	24.3

1 PIPE(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PIPE(S)

PIPE NUMBER	NOMINAL DIA.* (IN)
1	22.

* ESTIMATES ONLY. DO NOT USE IN DESIGNING SYSTEM

SUMMARY OF APPLICATION SYSTEMS INFORMATION

SYSTEM NO 1 -- FURROW OR CORRUGATE

FLOW ENTERING SYSTEM (CFS) 5.00

ESTIMATED SEEPAGE LOSSES .862 %

MAX. TIME SYSTEM OPERATES 100.00 %

PROJECTED APPLICATION SYSTEM LIFE (YRS) 20.0

FIELDS SERVED AND LABOR REQUIREMENTS

FIELD NO.	LABOR REQT. (HR/IRRIG)	ADDITIONAL (HR/SEASON)
1	64.0	.0
2	64.0	.0

OVERALL SYSTEM EFFICIENCIES FOR CROPS IN EACH FIELD

FIELD NO.	- CROP - NO.	NAME	APPLIC EFF(%)	DEEP PERC(%)	RUN-OFF(%)	HRS/SET OR HRS/PASS
1						
	2	ALFALFA HAY	27.0	66.3	6.7	12.0
	5	SPRING WHEAT	26.5	60.6	12.8	12.0
	10	POTATOES	14.7	78.6	6.6	12.0
	11	WINTER WHEAT	26.5	60.6	12.8	12.0
2						
	2	ALFALFA HAY	45.6	44.6	9.8	12.0
	5	SPRING WHEAT	43.4	37.1	19.5	12.0
	10	POTATOES	27.3	66.1	6.6	12.0
	11	WINTER WHEAT	43.4	37.1	19.5	12.0

SUMMARY OF INITIAL SYSTEM COSTS AND FINANCING ---

	ATTACHED COMPONENTS (LOAN NO. 1)	UNATTACHED COMPONENTS (LOAN NO.2)
TOTAL CAPITAL COST ($)	33267.20	19200.00
CAPITAL NOT FINANCED ($)	.00	400.00
FINANCED CAPITAL ($)	33267.20	18800.00
INTEREST RATE (%)	8.00	12.00
TIME OF LOAN (YEARS)	15.	7.
SALVAGE VALUE ($)	.00	120.00
ANNUAL MAINTENANCE EXPENSE ($) . .	4705.15	775.00
ANNUAL MISCELLANEOUS EXPENSE ($) .	70.00	50.00

ANNUAL CAPITAL CASH FLOW

YEAR	PRINCPLE	INTREST	CASH	TOTAL
0	0	0	400	400
1	3090	4918	0	8008
2	3414	4594	441	8449
3	3771	4237	0	8008
4	4164	3844	486	8494
5	4603	3405	0	8008
6	5088	2920	536	8544
7	5624	2384	0	8008
8	2437	2191	590	5218
9	2646	1982	0	4628
10	2872	1756	651	5279
11	3119	1509	0	4628
12	3387	1241	718	5346
13	3679	949	0	4628
14	3997	631	791	5419
15	4074	855	0	4929
16	1951	3429	873	6253
17	2139	3241	0	5380
18	2339	3041	962	6342
19	2562	2818	0	5380
20	2808	2572	0	5380

ANNUAL CAPITAL RECOVERY ($) . . . 8461.18

ECONOMIC INFORMATION FOR SYSTEM COMPONENTS

27 COMPONENTS PURCHASED (R = REPLACEMENT ITEM)

ITEM		YR	LIFE	TOTAL COST	SALVAGE VALUE	ANNUAL COST	LOAN RATE(%)	ANNUAL MAINT($)	ANNUAL MISC($)
LAND LEVELING		0	20	8000	0	940	12	100	0
LAND LEVELING		0	20	7500	0	881	12	100	0
LINED CANAL		0	15	8086	0	950	8	1213	25
LINED CANAL	R	15	15	16809	11206	1779	8	2521	51
LINED CANAL		0	15	8086	0	950	8	1213	25
LINED CANAL	R	15	15	16809	11206	1779	8	2521	51
STRUCTURE		0	15	300	0	35	12	45	10
STRUCTURE	R	15	15	624	416	66	12	93	20
STRUCTURE		0	15	300	0	35	12	45	10
STRUCTURE	R	15	15	624	416	66	12	93	20
PVC PIPE, LOW PRESS		0	25	5699	0	649	8	570	10
PVC PIPE, LOW PRESS		0	25	11397	0	1299	8	1710	10
tubes		0	7	2400	120	280	12	240	10
tubes	R	7	7	3377	169	394	12	337	14
tubes	R	14	7	4752	882	543	12	475	19
structs		0	15	300	0	35	12	45	20

structs	R	15	15	624	416	66	12	93	41
tail ditc		0	2	400	0	47	12	200	0
tail ditc	R	2	2	441	0	52	12	220	0
tail ditc	R	4	2	486	0	57	12	243	0
tail ditc	R	6	2	536	0	63	12	268	0
tail ditc	R	8	2	591	0	69	12	295	0
tail ditc	R	10	2	652	0	77	12	325	0
tail ditc	R	12	2	718	0	84	12	359	0
tail ditc	R	14	2	792	0	93	12	395	0
tail ditc	R	16	2	873	0	103	12	436	0
tail ditc	R	18	2	963	0	113	12	481	0

2 CHANNEL(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED CHANNEL(S)

CHANNEL NO.	BOTTOM WIDTH* (FT)	DEPTH* (FT)
1	1.0	1.7
2	1.0	1.7

* ESTIMATES ONLY. DO NOT USE IN DESIGNING SYSTEM

0 PUMP(S) INCLUDED IN THIS SYSTEM

2 PIPE(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PIPE(S)

PIPE NUMBER	NOMINAL DIA.* (IN)
1	15.
2	15.

* ESTIMATES ONLY. DO NOT USE IN DESIGNING SYSTEM

SYSTEM NO 2 -- SIDE-ROLL SPRINKLER

FLOW ENTERING SYSTEM (CFS) 2.22

ESTIMATED SEEPAGE LOSSES .000 %

MAX. TIME SYSTEM OPERATES 100.00 %

PROJECTED APPLICATION SYSTEM LIFE (YRS) 12.0

FIELDS SERVED AND LABOR REQUIREMENTS

FIELD NO.	LABOR REQT. (HR/IRRIG)	ADDITIONAL (HR/SEASON)
3	24.0	.0
4	24.0	.0

OVERALL SYSTEM EFFICIENCIES FOR CROPS IN EACH FIELD

FIELD NO.	- CROP - NO.	NAME	APPLIC EFF(%)	DEEP PERC(%)	RUN-OFF(%)	HRS/SET OR HRS/PASS
3						
	2	ALFALFA HAY	40.4	49.6	.0	12.0
	5	SPRING WHEAT	40.4	49.6	.0	12.0
	10	POTATOES	40.4	49.6	.0	12.0
	11	WINTER WHEAT	40.4	49.6	.0	12.0
4						
	2	ALFALFA HAY	21.8	68.2	.0	12.0
	5	SPRING WHEAT	21.8	68.2	.0	12.0
	10	POTATOES	21.8	68.2	.0	12.0
	11	WINTER WHEAT	21.8	68.2	.0	12.0

SUMMARY OF INITIAL SYSTEM COSTS AND FINANCING ---

	ATTACHED COMPONENTS (LOAN NO. 1)	UNATTACHED COMPONENTS (LOAN NO.2)
TOTAL CAPITAL COST ($)	40150.50	68802.00
CAPITAL NOT FINANCED ($)	2543.68	550.00
FINANCED CAPITAL ($)	37606.82	68252.00
INTEREST RATE (%)	8.00	12.00
TIME OF LOAN (YEARS)	15.	7.
SALVAGE VALUE ($)	1304.60	16335.50
ANNUAL MAINTENANCE EXPENSE ($) . .	4686.89	4639.12
ANNUAL MISCELLANEOUS EXPENSE ($) .	65.00	40.00

ANNUAL CAPITAL CASH FLOW

YEAR	PRINCPLE	INTREST	CASH	TOTAL
0	0	0	3094	3094
1	8151	11198	0	19349
2	9074	10275	0	19349
3	10103	9246	0	19349
4	11247	8102	0	19349
5	12532	6817	0	19349
6	13958	5391	0	19349
7	15552	3797	773	20122
8	2449	2114	0	4563
9	2649	1914	0	4563
10	2865	1698	0	4563
11	3098	1465	0	4563
12	3350	1213	0	4563
13	14906	14605	0	29511
14	16556	12955	1088	30599
15	18331	11249	5287	34867
16	16884	10729	0	27613
17	18893	8720	0	27613
18	21142	6471	0	27613
19	23657	3956	0	27613
20	1529	1136	0	2665

ANNUAL CAPITAL RECOVERY ($) . . . 19644.86

ECONOMIC INFORMATION FOR SYSTEM COMPONENTS

21 COMPONENTS PURCHASED (R = REPLACEMENT ITEM)

ITEM		YR	LIFE	TOTAL COST	SALVAGE VALUE	ANNUAL COST	LOAN RATE(%)	ANNUAL MAINT($)	ANNUAL MISC($)
APPLICATION SYSTEM		0	12	31701	7925	3585	12	1902	8
APPLICATION SYSTEM	R	12	12	56930	28465	6190	12	3415	14
LAND GRADING		0	20	1000	0	117	12	100	0
APPLICATION SYSTEM		0	12	31701	7925	3585	12	1902	8
APPLICATION SYSTEM	R	12	12	56930	28465	6190	12	3415	14
LAND GRADING		0	20	1000	0	117	12	100	0
STRUCTURE		0	15	300	0	35	12	45	10
STRUCTURE	R	15	15	624	416	66	12	93	20
PUMP		0	15	5218	1305	590	8	1044	10
PUMP	R	15	15	10849	8137	1132	8	2170	20
PVC PIPE, MED PRESS		0	25	15966	0	1820	8	1597	20
PVC PIPE, MED PRESS		0	25	15966	0	1820	8	1597	20
PUMP PAD		0	15	500	0	59	12	50	0
PUMP PAD	R	15	15	1039	693	110	12	103	0
RISERS		0	15	3000	0	352	8	450	15
RISERS	R	15	15	6237	4158	660	8	935	31

GAGES		0	7	1100	110	127	12	165	0
GAGES	R	7	7	1548	155	179	12	232	0
GAGES	R	14	7	2178	498	247	12	326	0
ELEC PANL		0	15	1500	375	170	12	375	15
ELEC PANL	R	15	15	3118	2339	325	12	779	31

0 CHANNEL(S) INCLUDED IN THIS SYSTEM

1 PUMP(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PUMP(S)

PUMP ID NO.	FLOW RATE (GPM)	INPUT POWER (KW)
3	995.7	42.1

2 PIPE(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PIPE(S)

PIPE NUMBER	NOMINAL DIA.* (IN)
1	10.
2	10.

* ESTIMATES ONLY. DO NOT USE IN DESIGNING SYSTEM

SYSTEM NO 3 -- CENTER PIVOT

FLOW ENTERING SYSTEM (CFS) 2.69

ESTIMATED SEEPAGE LOSSES .000 %

MAX. TIME SYSTEM OPERATES 100.00 %

PROJECTED APPLICATION SYSTEM LIFE (YRS) 12.0

FIELDS SERVED AND LABOR REQUIREMENTS

FIELD NO.	LABOR REQT. (HR/IRRIG)	ADDITIONAL (HR/SEASON)
5	8.0	.0
6	8.0	.0

OVERALL SYSTEM EFFICIENCIES FOR CROPS IN EACH FIELD

FIELD NO.	- CROP - NO.	NAME	APPLIC EFF(%)	DEEP PERC(%)	RUN-OFF(%)	HRS/SET OR HRS/PASS
5						
	2	ALFALFA HAY	85.9	8.5	.0	77.0
	5	SPRING WHEAT	85.9	8.5	.0	77.0
	10	POTATOES	85.9	8.5	.0	77.0
	11	WINTER WHEAT	85.9	8.5	.0	77.0
6						
	5	SPRING WHEAT	85.9	8.5	.0	77.0
	6	SPRING BARLEY	85.9	8.5	.0	77.0
	11	WINTER WHEAT	85.9	8.5	.0	77.0

SUMMARY OF INITIAL SYSTEM COSTS AND FINANCING ---

	ATTACHED COMPONENTS (LOAN NO. 1)	UNATTACHED COMPONENTS (LOAN NO.2)
TOTAL CAPITAL COST ($)	80070.75	9629.15
CAPITAL NOT FINANCED ($)	350.00	.00
FINANCED CAPITAL ($)	79720.75	9629.15
INTEREST RATE (%)	8.00	12.00
TIME OF LOAN (YEARS)	15.	7.
SALVAGE VALUE ($)	17500.00	1719.79
ANNUAL MAINTENANCE EXPENSE ($) . .	6257.08	1456.87
ANNUAL MISCELLANEOUS EXPENSE ($) .	65.00	40.00

ANNUAL CAPITAL CASH FLOW

YEAR	PRINCIPLE	INTREST	CASH	TOTAL
0	0	0	350	350
1	3891	7533	0	11424
2	4240	7184	0	11424
3	4621	6803	0	11424
4	5040	6384	0	11424
5	5498	5926	0	11424
6	5995	5429	0	11424
7	6542	4882	0	11424
8	5030	4283	0	9313
9	5433	3880	0	9313
10	5868	3445	0	9313
11	6337	2976	0	9313
12	6843	2470	0	9313
13	12022	11977	0	23999
14	12983	11016	0	23999
15	14021	9978	727	24726
16	7469	10898	0	18367
17	8129	10238	0	18367
18	8849	9518	0	18367
19	9637	8730	0	18367
20	10496	7871	0	18367

ANNUAL CAPITAL RECOVERY ($) . . . 17814.24

ECONOMIC INFORMATION FOR SYSTEM COMPONENTS

19 COMPONENTS PURCHASED (R = REPLACEMENT ITEM)

ITEM		YR	LIFE	TOTAL COST	SALVAGE VALUE	ANNUAL COST	LOAN RATE(%)	ANNUAL MAINT($)	ANNUAL MISC($)
APPLICATION SYSTEM		0	12	35000	8750	3958	8	2625	13
APPLICATION SYSTEM	R	12	12	62855	31427	6834	8	4714	23
LAND GRADING		0	20	1000	0	117	12	100	0
APPLICATION SYSTEM		0	12	35000	8750	3958	8	2625	13
APPLICATION SYSTEM	R	12	12	62855	31427	6834	8	4714	23
LAND GRADING		0	20	1000	0	117	12	100	0
STRUCTURE		0	15	500	0	59	8	50	0
STRUCTURE	R	15	15	1039	693	110	8	103	0
PUMP		0	15	5379	1345	608	12	807	25
PUMP	R	15	15	11183	8387	1167	12	1677	51
PVC PIPE, MED PRESS		0	25	8871	0	1011	8	887	15
PUMP PAD		0	15	500	0	59	12	50	0
PUMP PAD	R	15	15	1039	693	110	12	103	0
PIV PAD		0	15	250	0	29	12	25	0
PIV PAD	R	15	15	520	346	55	12	51	0
ELEC PANL		0	15	1500	375	170	12	375	15

ELEC PANL	R	15	15	3118	2339	325	12	779	31
GAGES		0	15	700	0	82	8	70	25
GAGES	R	15	15	1455	970	154	8	145	51

0 CHANNEL(S) INCLUDED IN THIS SYSTEM

1 PUMP(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PUMP(S)

PUMP ID NO.	FLOW RATE (GPM)	INPUT POWER (KW)
4	1206.9	43.7

1 PIPE(S) INCLUDED IN THIS SYSTEM

SUMMARY INFORMATION FOR INCLUDED PIPE(S)

PIPE NUMBER	NOMINAL DIA.* (IN)
1	12.

* ESTIMATES ONLY. DO NOT USE IN DESIGNING SYSTEM

THE FOLLOWING DATA ARE USED TO CALCULATE SOIL LOSSES

THE VALUES HAVE NO PHYSICAL MEANING

3	.000	-582.034	15.325
4	.000	-582.034	15.325
5	.000	44.403	15.301
6	.000	44.403	15.301

DETAILED SIMULATE OUTPUT DATA

IRRIGATION SIMULATION OUTPUT FOR
Example

SUMMARIES ARE GIVEN FOR:

1. ADEQUACY OF IRRIGATION FOR ALL CROPS
2. IRRIGATION WATER USE
3. IRRIGATION SYSTEM PERFORMANCE AND COST
4. RESULTS ARE BASED ON 10 YEARS RECORDS FOR RAINFALL AND PET DATA

CROP SUMMARY RESULTS FOR ALFALFA HAY
=====================================

---- MONTH ----->	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	.0	.0	.0	.0	.0	.0	1.5	2.2	3.1	3.6	2.9	1.9
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	100	100	100	100	100	100
AVE REQUIREMENT WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	1.5	2.2	3.1	3.6	2.9	1.9
AVE APPLIED WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	1.4	2.0	2.5	3.0	2.3	1.9
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	30	40	60	70	50	30
AVERAGE SHORTFALL WHEN OCCURRING (IN)	.0	.0	.0	.0	.0	.0	.4	.5	1.1	.8	1.1	.3
MAXIMUM SHORTFALL - - (IN)	.0	.0	.0	.0	.0	.0	.5	.7	2.0	1.4	2.0	.6
STD. DEVIATION OF SHORTFALLS (IN)	.0	.0	.0	.0	.0	.0	.2	.3	.6	.4	.5	.3
PERCENT OF TIME READJSTMNT REQD (%)	0	0	0	0	0	40	30	50	70	50	30	60
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.1	.1	.0	.1	.1

CROP SUMMARY RESULTS FOR ALFALFA HAY --- CONTINUED

---- MONTH ----->	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	4.4	4.3	2.4	3.6	3.1	1.3	.9	.2	.0	.0	.0	.0
PERCENT OF TIME IRRIG IS REQD (%)	100	100	100	100	100	100	100	50	0	0	0	0
AVE REQUIREMENT WHEN REQUIRED (IN)	4.4	4.3	2.4	3.6	3.1	1.3	.9	.5	.0	.0	.0	.0
AVE APPLIED WHEN REQUIRED (IN)	3.0	3.3	1.7	2.9	2.5	1.3	.9	.5	.0	.0	.0	.0
PERCENT OF TIME REQT > APPLIED (%)	70	70	70	60	60	10	0	0	0	0	0	0
AVERAGE SHORTFALL WHEN OCCURRING (IN)	2.0	1.5	1.0	1.1	1.0	.1	.0	.0	.0	.0	.0	.0
MAXIMUM SHORTFALL - - (IN)	5.1	2.9	2.6	1.6	1.6	.1	.0	.0	.0	.0	.0	.0
STD. DEVIATION OF SHORTFALLS (IN)	1.5	.6	.8	.4	.4	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME READJSTMNT REQD (%)	10	0	30	0	0	0	0	0	0	0	0	0
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM READJUSTMENT (IN)	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0

SEASONAL TOTALS FOR ALFALFA HAY

AVERAGE IRRIG REQUIREMENT(IN)	AVERAGE REQT WHEN REQD(IN)	AVE APPLIED WHEN REQD(IN)	AVE SHORTFALLS OCCURRING(IN)	AVERAGE READJUSTMENT(IN)
35.4	35.6	29.1	11.0	.6

ESTIMATED ANNUAL SOIL LOSS .04 T/ACRE (Sprinkle irrig. only)

ESTIMATED ANNUAL NITROGEN PERCOLATION LOSS 20.28 % OF APPLIED

ESTIMATED AVERAGE YIELD REDUCTION BY GROWTH STAGE

GROWTH STAGE	1	2	3	4	TOTAL
REDUCTION (%)	1.6	.5	.0	3.4	5.5

CROP SUMMARY RESULTS FOR SPRING WHEAT
=====================================

---- MONTH ----->	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	.0	.0	.0	.0	.0	.0	.1	.7	2.0	3.1	2.7	3.4
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	63	88	100	100	100	100
AVE REQUIREMENT WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	.2	.8	2.0	3.1	2.7	3.4
AVE APPLIED WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	.3	1.0	1.7	1.8	2.2	2.0
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	25	63	38	75
AVERAGE SHORTFALL WHEN OCCURRING (IN)	.0	.0	.0	.0	.0	.0	.0	.0	2.2	2.1	1.8	2.0
MAXIMUM SHORTFALL - - (IN)	.0	.0	.0	.0	.0	.0	.0	.0	2.8	3.9	3.9	5.5
STD. DEVIATION OF SHORTFALLS (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.8	1.4	1.9	2.2
PERCENT OF TIME READJSTMNT REQD (%)	0	0	0	0	0	0	25	50	50	25	50	25
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.3	.4	.5	.4	.3	.5
MAXIMUM READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.3	.5	.6	.5	.5	.5

CROP SUMMARY RESULTS FOR SPRING WHEAT --- CONTINUED

---- MONTH ----->	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	2.5	1.6	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME IRRIG IS REQD (%)	100	100	86	0	0	0	0	0	0	0	0	0
AVE REQUIREMENT WHEN REQUIRED (IN)	2.5	1.6	1.2	.0	.0	.0	.0	.0	.0	.0	.0	.0
AVE APPLIED WHEN REQUIRED (IN)	1.0	.9	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME REQT > APPLIED (%)	75	50	17	0	0	0	0	0	0	0	0	0
AVERAGE SHORTFALL WHEN OCCURRING (IN)	2.2	1.6	2.5	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM SHORTFALL - - (IN)	4.0	3.0	2.5	.0	.0	.0	.0	.0	.0	.0	.0	.0
STD. DEVIATION OF SHORTFALLS (IN)	1.4	1.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME READJSTMNT REQD (%)	13	0	14	0	0	0	0	0	0	0	0	0
AVERAGE READJUSTMENT (IN)	.5	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM READJUSTMENT (IN)	.5	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0

SEASONAL TOTALS FOR SPRING WHEAT

AVERAGE IRRIG REQUIREMENT(IN)	AVERAGE REQT WHEN REQD(IN)	AVE APPLIED WHEN REQD(IN)	AVE SHORTFALLS OCCURRING(IN)	AVERAGE READJUSTMENT(IN)
17.3	17.6	11.9	14.3	3.5

ESTIMATED ANNUAL SOIL LOSS .04 T/ACRE (Sprinkle irrig. only)

ESTIMATED ANNUAL NITROGEN PERCOLATION LOSS 8.69 % OF APPLIED

ESTIMATED AVERAGE YIELD REDUCTION BY GROWTH STAGE

GROWTH STAGE	1	2	3	4	TOTAL
REDUCTION (%)	.6	.0	.9	.1	1.6

CROP SUMMARY RESULTS FOR SPRING BARLEY

---- MONTH ----->	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	.0	.0	.0	.0	.0	.0	.0	.5	2.6	2.5	2.7	4.1
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	0	67	100	100	100	100
AVE REQUIREMENT WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	.0	.8	2.6	2.5	2.7	4.1
AVE APPLIED WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	.0	.8	3.3	3.0	2.7	2.5
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	0	0	0	33
AVERAGE SHORTFALL WHEN OCCURRING (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	5.7
MAXIMUM SHORTFALL - - (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	5.7
STD. DEVIATION OF SHORTFALLS (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME READJSTMNT REQD (%)	0	0	0	0	0	0	0	0	100	67	33	33
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.7	.7	.1	.7
MAXIMUM READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.7	.7	.1	.7

CROP SUMMARY RESULTS FOR SPRING BARLEY --- CONTINUED

---- MONTH ----->	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	3.0	1.5	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME IRRIG IS REQD (%)	100	100	100	0	0	0	0	0	0	0	0	0
AVE REQUIREMENT WHEN REQUIRED (IN)	3.0	1.5	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0
AVE APPLIED WHEN REQUIRED (IN)	3.0	1.5	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	0	0	0	0
AVERAGE SHORTFALL WHEN OCCURRING (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM SHORTFALL - - (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
STD. DEVIATION OF SHORTFALLS (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME READJSTMNT REQD (%)	0	0	50	0	0	0	0	0	0	0	0	0
AVERAGE READJUSTMENT (IN)	.0	.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM READJUSTMENT (IN)	.0	.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0

SEASONAL TOTALS FOR SPRING BARLEY

AVERAGE IRRIG REQUIREMENT(IN)	AVERAGE REQT WHEN REQD(IN)	AVE APPLIED WHEN REQD(IN)	AVE SHORTFALLS OCCURRING(IN)	AVERAGE READJUSTMENT(IN)
17.5	17.8	17.7	5.7	3.0

ESTIMATED ANNUAL SOIL LOSS .04 T/ACRE (Sprinkle irrig. only)

ESTIMATED ANNUAL NITROGEN PERCOLATION LOSS 4.91 % OF APPLIED

ESTIMATED AVERAGE YIELD REDUCTION BY GROWTH STAGE

GROWTH STAGE	1	2	3	4	TOTAL
REDUCTION (%)	.7	.0	.0	.0	.7

CROP SUMMARY RESULTS FOR POTATOES

---- MONTH ----->	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.6	1.4	1.8	2.9
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	0	0	13	88	100	100	100
AVE REQUIREMENT WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	.0	.2	.7	1.4	1.8	2.9
AVE APPLIED WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.0	.0	.3	.7	1.4	1.8	2.7
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	0	0	0	0	13	38
AVERAGE SHORTFALL WHEN OCCURRING (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	.5
MAXIMUM SHORTFALL - - (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	1.1
STD. DEVIATION OF SHORTFALLS (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.5
PERCENT OF TIME READJSTMNT REQD (%)	0	0	0	0	0	0	0	25	38	25	25	13
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

CROP SUMMARY RESULTS FOR POTATOES --- CONTINUED

---- MONTH ----->	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	3.8	3.9	3.7	3.0	2.2	1.3	.4	.0	.0	.0	.0	.0
PERCENT OF TIME IRRIG IS REQD (%)	100	100	100	100	100	100	86	0	0	0	0	0
AVE REQUIREMENT WHEN REQUIRED (IN)	3.8	3.9	3.7	3.0	2.2	1.3	.5	.0	.0	.0	.0	.0
AVE APPLIED WHEN REQUIRED (IN)	3.5	3.2	3.1	2.7	2.2	1.3	.5	.0	.0	.0	.0	.0
PERCENT OF TIME REQT > APPLIED (%)	38	50	38	38	0	0	0	0	0	0	0	0
AVERAGE SHORTFALL WHEN OCCURRING (IN)	1.0	1.4	1.4	1.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM SHORTFALL - - (IN)	1.7	2.2	3.1	1.4	.0	.0	.0	.0	.0	.0	.0	.0
STD. DEVIATION OF SHORTFALLS (IN)	.6	.8	1.5	.4	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME READJSTMNT REQD (%)	0	0	13	0	0	0	0	0	0	0	0	0
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

SEASONAL TOTALS FOR POTATOES

AVERAGE IRRIG REQUIREMENT(IN)	AVERAGE REQT WHEN REQD(IN)	AVE APPLIED WHEN REQD(IN)	AVE SHORTFALLS OCCURRING(IN)	AVERAGE READJUSTMENT(IN)
25.0	25.4	23.3	5.7	.2

ESTIMATED ANNUAL SOIL LOSS .05 T/ACRE (Sprinkle irrig. only)

ESTIMATED ANNUAL NITROGEN PERCOLATION LOSS 22.48 % OF APPLIED

ESTIMATED AVERAGE YIELD REDUCTION BY GROWTH STAGE

GROWTH STAGE	1	2	3	4	TOTAL
REDUCTION (%)	.4	.0	1.9	.0	2.3

CROP SUMMARY RESULTS FOR WINTER WHEAT

---- MONTH ----->	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	.0	.0	.0	.0	.0	.3	.9	1.2	2.5	3.5	3.1	3.8
PERCENT OF TIME IRRIG IS REQD (%)	0	0	0	0	0	63	75	88	100	100	100	100
AVE REQUIREMENT WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.4	1.2	1.4	2.5	3.5	3.1	3.8
AVE APPLIED WHEN REQUIRED (IN)	.0	.0	.0	.0	.0	.5	1.2	1.5	2.5	3.0	2.3	3.3
PERCENT OF TIME REQT > APPLIED (%)	0	0	0	0	0	0	17	14	25	25	50	38
AVERAGE SHORTFALL WHEN OCCURRING (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.6	2.7	1.8	1.7
MAXIMUM SHORTFALL - - (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.8	3.1	5.2	4.3
STD. DEVIATION OF SHORTFALLS (IN)	.0	.0	.0	.0	.0	.0	.0	.0	.3	.7	2.3	2.3
PERCENT OF TIME READJSTMNT REQD (%)	0	0	0	0	0	13	0	25	50	50	13	50
AVERAGE READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.3	.3	.4	.7	.4
MAXIMUM READJUSTMENT (IN)	.0	.0	.0	.0	.0	.0	.0	.3	.7	.7	.7	.7

CROP SUMMARY RESULTS FOR WINTER WHEAT --- CONTINUED

---- MONTH ----->	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
AVERAGE IRRIG REQUIREMENT - (IN)	4.3	4.1	1.8	.0	.0	.0	.7	.0	.0	.0	.0	.0
PERCENT OF TIME IRRIG IS REQD (%)	100	100	86	0	0	0	20	11	0	0	0	0
AVE REQUIREMENT WHEN REQUIRED (IN)	4.3	4.1	2.1	.0	.0	.0	3.6	.1	.0	.0	.0	.0
AVE APPLIED WHEN REQUIRED (IN)	1.5	2.0	2.1	.0	.0	.0	3.6	.1	.0	.0	.0	.0
PERCENT OF TIME REQT > APPLIED (%)	88	63	0	0	0	0	0	0	0	0	0	0
AVERAGE SHORTFALL WHEN OCCURRING (IN)	3.2	3.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM SHORTFALL - - (IN)	5.4	5.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
STD. DEVIATION OF SHORTFALLS (IN)	1.9	1.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
PERCENT OF TIME READJSTMNT REQD (%)	0	0	29	0	0	0	0	0	0	0	0	0
AVERAGE READJUSTMENT (IN)	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0
MAXIMUM READJUSTMENT (IN)	.0	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0

SEASONAL TOTALS FOR WINTER WHEAT

AVERAGE IRRIG REQUIREMENT(IN)	AVERAGE REQT WHEN REQD(IN)	AVE APPLIED WHEN REQD(IN)	AVE SHORTFALLS OCCURRING(IN)	AVERAGE READJUSTMENT(IN)
26.1	30.0	23.6	13.3	2.4

ESTIMATED ANNUAL SOIL LOSS .04 T/ACRE (Sprinkle irrig. only)

ESTIMATED ANNUAL NITROGEN PERCOLATION LOSS 12.40 % OF APPLIED

ESTIMATED AVERAGE YIELD REDUCTION BY GROWTH STAGE

GROWTH STAGE	1	2	3	4	TOTAL
REDUCTION (%)	.2	.2	.4	.0	.9

PERCENT OF TIME SHORTFALLS OCCUR WHEN
WATER IS REQUIRED DUE TO VARIOUS CONSTRAINTS

---- MONTH ------>	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
WATER AS LIMITING - - - (%)	0	0	0	0	0	0	0	0	0	0	0	0
LABOR AS LIMITING - - - (%)	0	0	0	0	0	0	0	0	0	30	20	20

PERCENT OF TIME SHORTFALLS OCCUR WHEN WATER
IS REQUIRED DUE TO VARIOUS CONSTRAINTS -- CONTINUED

---- MONTH ------>	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
WATER AS LIMITING - - - (%)	0	0	0	0	0	0	0	0	0	0	0	0
LABOR AS LIMITING - - - (%)	90	70	20	30	0	0	0	0	0	0	0	0

PERCENT OF TIME EACH SYSTEM IS REQUIRED
AND PERCENT OF TIME ITS CAPACITY IS LIMITING

=== FURROW OR CORRUGATE===

---- MONTH ------>	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
--TIME REQUIRED (%)	0	0	0	0	0	40	100	100	100	100	100	100
--CAP. LIMITING (%)	0	0	0	0	0	0	0	0	0	10	20	30

---- MONTH ------>	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
--TIME REQUIRED (%)	100	100	100	100	100	100	100	60	0	0	0	0
--CAP. LIMITING (%)	20	0	10	0	0	0	0	0	0	0	0	0

=== SIDE-ROLL SPRINKLER===

---- MONTH ------>	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
--TIME REQUIRED (%)	0	0	0	0	0	40	90	100	100	100	100	100
--CAP. LIMITING (%)	0	0	0	0	0	0	40	50	90	80	70	90

---- MONTH ------>	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
--TIME REQUIRED (%)	100	100	100	100	100	100	80	60	0	0	0	0
--CAP. LIMITING (%)	60	100	70	60	60	10	0	0	0	0	0	0

=== CENTER PIVOT ===

---- MONTH ------>	JAN		FEB		MAR		APR		MAY		JUN	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
--TIME REQUIRED (%)	0	0	0	0	0	60	100	100	100	100	100	100
--CAP. LIMITING (%)	0	0	0	0	0	0	0	0	0	0	0	0

---- MONTH ------>	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------->	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
--TIME REQUIRED (%)	100	100	100	80	80	80	80	80	0	0	0	0
--CAP. LIMITING (%)	0	0	0	0	0	0	0	0	0	0	0	0

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IRRIGATION WATER USE SUMMARY
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TOTAL NET IRRIGATION REQUIREMENT (IN)

YEAR	JAN 1ST	JAN 2ND	FEB 1ST	FEB 2ND	MAR 1ST	MAR 2ND	APR 1ST	APR 2ND	MAY 1ST	MAY 2ND	JUN 1ST	JUN 2ND
1	.0	.0	.0	.0	.0	.0	1.0	1.7	3.2	3.8	3.8	3.2
2	.0	.0	.0	.0	.0	.0	.5	.3	2.0	3.4	.8	2.7
3	.0	.0	.0	.0	.0	.0	.9	1.8	2.1	3.3	2.2	4.6
4	.0	.0	.0	.0	.0	.2	1.1	2.0	2.7	3.9	3.7	2.5
5	.0	.0	.0	.0	.0	.1	1.4	1.3	1.7	3.5	2.8	2.8
6	.0	.0	.0	.0	.0	.0	1.6	.7	3.2	2.0	2.4	2.4
7	.0	.0	.0	.0	.0	.0	1.1	2.6	2.9	3.5	2.6	3.0
8	.0	.0	.0	.0	.0	.0	.5	.8	2.9	2.7	2.1	2.1
9	.0	.0	.0	.0	.0	.0	.5	1.7	2.9	2.8	3.6	2.2
10	.0	.0	.0	.0	.0	.0	.1	.6	.8	2.2	3.4	2.4
MEAN	.0	.0	.0	.0	.0	.0	.9	1.3	2.4	3.1	2.7	2.8

TOTAL NET IRRIGATION REQUIREMENT (IN) --- CONTINUED

YEAR	JUL 1ST	JUL 2ND	AUG 1ST	AUG 2ND	SEP 1ST	SEP 2ND	OCT 1ST	OCT 2ND	NOV 1ST	NOV 2ND	DEC 1ST	DEC 2ND	ANNUAL TOTAL
1	4.6	4.1	2.7	2.6	2.1	1.0	1.1	.4	.0	.0	.0	.0	35.3
2	4.1	3.7	2.9	2.2	1.5	.7	.3	.0	.0	.0	.0	.0	25.1
3	4.1	4.0	1.4	.6	1.7	.5	.3	.2	.0	.0	.0	.0	27.6
4	3.9	4.2	2.5	2.2	1.2	.6	.4	.0	.0	.0	.0	.0	31.1
5	3.8	3.8	2.7	2.2	1.5	.6	.8	.0	.0	.0	.0	.0	29.1
6	4.2	3.1	2.0	2.2	2.4	.5	.7	.0	.0	.0	.0	.0	27.7
7	4.5	3.2	1.5	2.5	1.5	.7	.2	.0	.0	.0	.0	.0	29.9
8	3.5	3.0	2.0	2.5	1.7	.7	.6	.3	.0	.0	.0	.0	25.3
9	2.8	3.1	1.8	1.6	1.6	.9	.4	.0	.0	.0	.0	.0	25.9
10	3.4	3.3	1.6	1.7	1.5	.9	.1	.0	.0	.0	.0	.0	22.1
MEAN	3.9	3.5	2.1	2.0	1.7	.7	.5	.1	.0	.0	.0	.0	27.9

TOTAL NET IRRIGATION APPLICATION (IN)

YEAR	JAN 1ST	JAN 2ND	FEB 1ST	FEB 2ND	MAR 1ST	MAR 2ND	APR 1ST	APR 2ND	MAY 1ST	MAY 2ND	JUN 1ST	JUN 2ND
1	.0	.0	.0	.0	.0	.0	.8	1.3	2.4	2.2	2.4	1.5
2	.0	.0	.0	.0	.0	.0	.5	.3	1.7	3.1	.8	2.5
3	.0	.0	.0	.0	.0	.0	.9	1.9	2.3	3.1	2.2	2.7
4	.0	.0	.0	.0	.0	.2	1.1	2.3	2.7	1.9	3.0	2.0
5	.0	.0	.0	.0	.0	.2	1.4	1.3	1.5	2.8	2.4	2.6
6	.0	.0	.0	.0	.0	.0	1.3	.7	2.7	2.0	1.9	2.6
7	.0	.0	.0	.0	.0	.0	1.0	2.3	2.3	3.2	2.0	3.1
8	.0	.0	.0	.0	.0	.0	.5	.8	2.3	2.4	1.8	2.1
9	.0	.0	.0	.0	.0	.0	.6	1.4	2.3	2.4	2.6	2.1
10	.0	.0	.0	.0	.0	.0	.1	.6	.8	2.2	3.2	2.2
MEAN	.0	.0	.0	.0	.0	.0	.8	1.3	2.1	2.5	2.2	2.3

TOTAL NET IRRIGATION APPLICATION (IN) --- CONTINUED

YEAR	JUL 1ST	JUL 2ND	AUG 1ST	AUG 2ND	SEP 1ST	SEP 2ND	OCT 1ST	OCT 2ND	NOV 1ST	NOV 2ND	DEC 1ST	DEC 2ND	ANNUAL TOTAL
1	.6	1.9	1.0	1.8	1.3	1.0	1.1	.4	.0	.0	.0	.0	19.8
2	2.7	2.1	2.7	1.8	1.3	.7	.3	.0	.0	.0	.0	.0	20.6
3	3.0	2.9	1.3	.6	1.7	.5	.3	.2	.0	.0	.0	.0	23.5
4	1.5	1.2	2.2	1.4	1.2	.6	.4	.0	.0	.0	.0	.0	21.7
5	2.6	3.3	2.6	2.2	1.5	.6	.8	.0	.0	.0	.0	.0	25.8
6	2.2	2.4	1.7	1.9	1.6	.5	.7	.0	.0	.0	.0	.0	22.4
7	3.3	2.4	1.1	2.0	1.1	.7	.2	.0	.0	.0	.0	.0	24.8
8	1.9	2.3	.7	1.8	1.1	.7	.6	.3	.0	.0	.0	.0	19.5
9	2.7	2.4	1.7	1.6	1.4	.9	.4	.0	.0	.0	.0	.0	22.5
10	2.6	3.2	1.5	1.7	1.5	.9	.1	.0	.0	.0	.0	.0	20.8
MEAN	2.3	2.4	1.7	1.7	1.4	.7	.5	.1	.0	.0	.0	.0	22.1

TOTAL GROSS WATER REQUIREMENT (AC-FT)

YEAR	JAN 1ST	JAN 2ND	FEB 1ST	FEB 2ND	MAR 1ST	MAR 2ND	APR 1ST	APR 2ND	MAY 1ST	MAY 2ND	JUN 1ST	JUN 2ND
1	0	0	0	0	0	6	94	117	294	265	347	283
2	0	0	0	0	0	7	65	40	200	334	104	277
3	0	0	0	0	0	6	87	192	233	295	208	467
4	0	0	0	0	0	16	117	217	266	307	367	253
5	0	0	0	0	0	30	160	155	172	365	217	224
6	0	0	0	0	0	8	165	90	321	201	242	213
7	0	0	0	0	0	6	115	197	286	291	261	293
8	0	0	0	0	0	0	61	89	269	231	248	264
9	0	0	0	0	0	0	73	162	286	245	338	240
10	0	0	0	0	0	0	13	61	91	215	297	203
MEAN	0	0	0	0	0	8	95	132	242	275	263	272

TOTAL GROSS WATER REQUIREMENT (AC-FT) --- CONTINUED

YEAR	JUL 1ST	JUL 2ND	AUG 1ST	AUG 2ND	SEP 1ST	SEP 2ND	OCT 1ST	OCT 2ND	NOV 1ST	NOV 2ND	DEC 1ST	DEC 2ND	ANNUAL TOTAL
1	527	271	267	220	260	146	97	46	0	0	0	0	3240
2	239	264	278	200	147	94	40	7	0	0	0	0	2295
3	289	290	124	54	167	53	33	19	0	0	0	0	2516
4	323	389	199	208	164	83	58	10	0	0	0	0	2978
5	377	283	240	221	146	59	78	0	0	0	0	0	2728
6	355	215	240	232	275	67	93	0	0	0	0	0	2717
7	378	218	161	170	154	78	20	0	0	0	0	0	2627
8	351	254	323	222	216	98	83	33	0	0	0	0	2742
9	282	256	222	185	154	112	43	0	0	0	0	0	2598
10	301	293	158	169	149	83	13	0	0	0	0	0	2045
MEAN	342	273	221	188	183	87	56	11	0	0	0	0	2649

AVERAGE IRRIGATION PRIORITY

---- MONTH -----> ---- HALF ------>	JAN 1ST	JAN 2ND	FEB 1ST	FEB 2ND	MAR 1ST	MAR 2ND	APR 1ST	APR 2ND	MAY 1ST	MAY 2ND	JUN 1ST	JUN 2ND
ALFALFA HAY	0	0	0	0	0	0	2	2	2	2	2	2
SPRING WHEAT	0	0	0	0	0	0	2	2	4	4	4	3
SPRING BARLEY	0	0	0	0	0	0	2	2	2	2	1	3
POTATOES	0	0	0	0	0	0	0	0	1	2	1	2
WINTER WHEAT	0	0	0	0	1	1	2	3	3	3	3	4

---- MONTH ----->	JUL		AUG		SEP		OCT		NOV		DEC	
---- HALF ------>	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND	1ST	2ND
ALFALFA HAY	2	2	3	2	2	1	2	1	0	0	0	0
SPRING WHEAT	4	3	3	0	0	0	0	0	0	0	0	0
SPRING BARLEY	1	2	2	0	0	0	0	0	0	0	0	0
POTATOES	2	2	2	1	1	2	1	0	0	0	0	0
WINTER WHEAT	3	3	1	0	0	0	2	2	0	0	0	0

IRRIGATION SYSTEM ECONOMIC SUMMARY

IRRIGATION SYSTEM SUMMARY FOR FURROW OR CORRUGATE

TOTAL AREA SERVED (ACRES) - - - - - - -	160.0
FLOW ENTERING SYSTEM (CFS) - - - - - - -	5.00
PERCENT OF TIME SYSTEM OPERATES (%) - -	100
SYSTEM LIFE (YEARS) - - - - - - - - - -	20

INPUT DATA FOR ATTACHED COMPONENTS
-- (LOAN NO. 1)

TOTAL CAPITAL COST ($) - - - - - - - -	33267
CAPITAL NOT FINANCED ($) - - - - - - -	0
FINANCED CAPITAL ($) - - - - - - - - -	33267
FINANCE INTEREST RATE (%) - - - - - -	8.0
TIME OF LOAN (YEARS) - - - - - - - - -	15
SALVAGE VALUE ($) - - - - - - - - - -	0
ANNUAL MAINTENANCE EXPENSE ($) - - - -	4705
ANNUAL MISCELLANEOUS EXPENSE ($) - - -	70

INPUT DATA FOR NON-ATTACHED COMPONENTS
-- (LOAN NO. 2)

TOTAL CAPITAL COST ($) - - - - - - - -	19200
CAPITAL NOT FINANCED ($) - - - - - - -	400
FINANCED CAPITAL ($) - - - - - - - - -	18800
FINANCE INTEREST RATE (%) - - - - - -	12.0
TIME OF LOAN (YEARS) - - - - - - - - -	7
SALVAGE VALUE ($) - - - - - - - - - -	120
ANNUAL MAINTENANCE EXPENSE ($) - - - -	775
ANNUAL MISCELLANEOUS EXPENSE ($) - - -	50

RETURN ON INVESTMENT (%) - - - - - - - -	10.0
LABOR WAGE RATE ($/HR) - - - - - - - -	5.45
INFLATION FOR LABOR (%) - - - - - - - -	5.0
INFLATION FOR OPERATION AND MAINT. (%) -	8.0
INFLATION FOR ENERGY (%) - - - - - - - -	9.0

EXPECTED COSTS FOR IRRIGATION FOR FURROW OR CORRUGATE
OVER THE LIFE OF THE SYSTEM

THE SYSTEM SUPPLIES 160.0 ACRES

TOTAL OVERALL ANNUAL COST ($) - - - - - - - - - 36981
OVERALL ANNUAL CAPITAL COST ($) - - - - - - - - 8461
(NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)

SYSTEM POWER ESTIMATES FOR AVERAGE SEASON
HOURS OF OPERATION PER SEASON - - - - - - 0
SEASONAL KILOWATT-HOURS - - - - - - - - - 0

TOTAL CAPITAL COST NOT FINANCED ($) - - - - - 400

	- - - CAPITAL COSTS - - -				OPERATING COSTS FOR AVERAGE CONDITIONS					OVERALL
YR	REPYMNT	INTRST	CASH	TOTAL	LABOR	ENERGY	MAINT	MISC	TOTAL	TOTAL
0	0	0	400	400	0	0	0	0	0	400
1	3090	4918	0	8008	12945	0	5480	120	18545	26553
2	3414	4594	441	8449	13592	0	5919	130	19641	28090
3	3771	4237	0	8008	14272	0	6392	140	20804	28812
4	4164	3844	486	8494	14986	0	6903	151	22040	30534
5	4603	3405	0	8008	15735	0	7456	163	23354	31362
6	5088	2920	536	8544	16522	0	8052	176	24750	33294
7	5624	2384	0	8008	17348	0	8696	190	26234	34242
8	2437	2191	590	5218	18215	0	9392	206	27813	33031
9	2646	1982	0	4628	19126	0	10143	222	29491	34119
10	2872	1756	651	5279	20082	0	10955	240	31277	36556
11	3119	1509	0	4628	21086	0	11831	259	33176	37804
12	3387	1241	718	5346	22141	0	12778	280	35199	40545
13	3679	949	0	4628	23248	0	13800	302	37350	41978
14	3997	631	791	5419	24410	0	14904	326	39640	45059
15	4074	855	0	4929	25631	0	16096	352	42079	47008
16	1951	3429	873	6253	26912	0	17384	381	44677	50930
17	2139	3241	0	5380	28258	0	18775	411	47444	52824
18	2339	3041	962	6342	29671	0	20277	444	50392	56734
19	2562	2818	0	5380	31154	0	21899	480	53533	58913
20	2808	2572	0	5380	32712	0	23651	518	56881	62261

IRRIGATION SYSTEM SUMMARY FOR SIDE-ROLL SPRINKLER

TOTAL AREA SERVED (ACRES) - - - - - - - -	160.0
FLOW ENTERING SYSTEM (CFS) - - - - - - - -	2.22
PERCENT OF TIME SYSTEM OPERATES (%) - -	100
SYSTEM LIFE (YEARS) - - - - - - - - - - -	12
INPUT DATA FOR ATTACHED COMPONENTS	
-- (LOAN NO. 1)	
TOTAL CAPITAL COST ($) - - - - - - - - -	40151
CAPITAL NOT FINANCED ($) - - - - - - - -	2544
FINANCED CAPITAL ($) - - - - - - - - - -	37607
FINANCE INTEREST RATE (%) - - - - - - -	8.0
TIME OF LOAN (YEARS) - - - - - - - - - -	15
SALVAGE VALUE ($) - - - - - - - - - - -	1305
ANNUAL MAINTENANCE EXPENSE ($) - - - -	4687
ANNUAL MISCELLANEOUS EXPENSE ($) - - -	65
INPUT DATA FOR NON-ATTACHED COMPONENTS	
-- (LOAN NO. 2)	
TOTAL CAPITAL COST ($) - - - - - - - - -	68802
CAPITAL NOT FINANCED ($) - - - - - - - -	550
FINANCED CAPITAL ($) - - - - - - - - - -	68252
FINANCE INTEREST RATE (%) - - - - - - -	12.0
TIME OF LOAN (YEARS) - - - - - - - - - -	7
SALVAGE VALUE ($) - - - - - - - - - - -	16336
ANNUAL MAINTENANCE EXPENSE ($) - - - -	4639
ANNUAL MISCELLANEOUS EXPENSE ($) - - -	40
RETURN ON INVESTMENT (%) - - - - - - - -	10.0
LABOR WAGE RATE ($/HR) - - - - - - - - -	5.45
INFLATION FOR LABOR (%) - - - - - - - - -	5.0
INFLATION FOR OPERATION AND MAINT. (%) -	8.0
INFLATION FOR ENERGY (%) - - - - - - - -	9.0

EXPECTED COSTS FOR IRRIGATION FOR SIDE-ROLL SPRINKLER
OVER THE LIFE OF THE SYSTEM

THE SYSTEM SUPPLIES 160.0 ACRES

TOTAL OVERALL ANNUAL COST ($) - - - - - - - - 70624
OVERALL ANNUAL CAPITAL COST ($) - - - - - - - 19645
(NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)

SYSTEM POWER ESTIMATES FOR AVERAGE SEASON
HOURS OF OPERATION PER SEASON - - - - - - 5445
SEASONAL KILOWATT-HOURS - - - - - - - - - 229225

TOTAL CAPITAL COST NOT FINANCED ($) - - - - - 3094

	- - - CAPITAL COSTS - - -				OPERATING COSTS FOR AVERAGE CONDITIONS					OVERALL
YR	REPYMNT	INTRST	CASH	TOTAL	LABOR	ENERGY	MAINT	MISC	TOTAL	TOTAL
0	0	0	3094	3094	0	0	0	0	0	3094
1	8151	11198	0	19349	3338	14900	9326	105	27669	47018
2	9074	10275	0	19349	3505	16241	10072	113	29931	49280
3	10103	9246	0	19349	3681	17702	10878	122	32383	51732
4	11247	8102	0	19349	3865	19295	11748	132	35040	54389
5	12532	6817	0	19349	4058	21032	12688	143	37921	57270
6	13958	5391	0	19349	4261	22925	13703	154	41043	60392
7	15552	3797	773	20122	4474	24988	14799	167	44428	64550
8	2449	2114	0	4563	4697	27237	15983	180	48097	52660
9	2649	1914	0	4563	4932	29688	17262	194	52076	56639
10	2865	1698	0	4563	5179	32360	18643	210	56392	60955
11	3098	1465	0	4563	5438	35273	20134	227	61072	65635
12	3350	1213	0	4563	5710	38447	21745	245	66147	70710
13	14906	14605	0	29511	5995	41908	23484	264	71651	101162
14	16556	12955	1088	30599	6295	45679	25363	286	77623	108222
15	18331	11249	5287	34867	6610	49790	27392	308	84100	118967
16	16884	10729	0	27613	6940	54272	29584	333	91129	118742
17	18893	8720	0	27613	7287	59156	31950	360	98753	126366
18	21142	6471	0	27613	7652	64480	34506	389	107027	134640
19	23657	3956	0	27613	8034	70283	37267	420	116004	143617
20	1529	1136	0	2665	8436	76609	40248	453	125746	128411

IRRIGATION SYSTEM SUMMARY FOR CENTER PIVOT

TOTAL AREA SERVED (ACRES) - - - - - - -	160.0
FLOW ENTERING SYSTEM (CFS) - - - - - - -	2.69
PERCENT OF TIME SYSTEM OPERATES (%) - -	100
SYSTEM LIFE (YEARS) - - - - - - - - - -	12

INPUT DATA FOR ATTACHED COMPONENTS
-- (LOAN NO. 1)

TOTAL CAPITAL COST ($) - - - - - - - - -	68802
CAPITAL NOT FINANCED ($) - - - - - - -	100
FINANCED CAPITAL ($) - - - - - - - - - -	68252
FINANCE INTEREST RATE (%) - - - - - -	8.0
TIME OF LOAN (YEARS) - - - - - - - - -	7
SALVAGE VALUE ($) - - - - - - - - - -	16336
ANNUAL MAINTENANCE EXPENSE ($) - - - -	4639
ANNUAL MISCELLANEOUS EXPENSE ($) - - -	40

INPUT DATA FOR NON-ATTACHED COMPONENTS
-- (LOAN NO. 2)

TOTAL CAPITAL COST ($) - - - - - - - - -	68802
CAPITAL NOT FINANCED ($) - - - - - - -	100
FINANCED CAPITAL ($) - - - - - - - - - -	68252
FINANCE INTEREST RATE (%) - - - - - -	12.0
TIME OF LOAN (YEARS) - - - - - - - - -	7
SALVAGE VALUE ($) - - - - - - - - - -	16336
ANNUAL MAINTENANCE EXPENSE ($) - - - -	4639
ANNUAL MISCELLANEOUS EXPENSE ($) - - -	40

RETURN ON INVESTMENT (%) - - - - - - - -	10.0
LABOR WAGE RATE ($/HR) - - - - - - - -	5.45
INFLATION FOR LABOR (%) - - - - - - - -	5.0
INFLATION FOR OPERATION AND MAINT. (%) -	8.0
INFLATION FOR ENERGY (%) - - - - - - - -	9.0

EXPECTED COSTS FOR IRRIGATION FOR CENTER PIVOT
OVER THE LIFE OF THE SYSTEM

THE SYSTEM SUPPLIES 160.0 ACRES

TOTAL OVERALL ANNUAL COST ($) - - - - - - - -	44946
OVERALL ANNUAL CAPITAL COST ($) - - - - - - -	17814

(NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)

SYSTEM POWER ESTIMATES FOR AVERAGE SEASON

HOURS OF OPERATION PER SEASON - - - - - -	1965
SEASONAL KILOWATT-HOURS - - - - - - - - -	85890

TOTAL CAPITAL COST NOT FINANCED ($) - - - - - 350

	- - - CAPITAL COSTS - - -				OPERATING COSTS FOR AVERAGE CONDITIONS					OVERALL
YR	REPYMNT	INTRST	CASH	TOTAL	LABOR	ENERGY	MAINT	MISC	TOTAL	TOTAL
0	0	0	350	350	0	0	0	0	0	350
1	3891	7533	0	11424	1461	5583	7714	105	14863	26287
2	4240	7184	0	11424	1534	6085	8331	113	16063	27487
3	4621	6803	0	11424	1611	6633	8998	122	17364	28788
4	5040	6384	0	11424	1691	7230	9717	132	18770	30194
5	5498	5926	0	11424	1776	7881	10495	143	20295	31719
6	5995	5429	0	11424	1864	8590	11334	154	21942	33366
7	6542	4882	0	11424	1958	9363	12241	167	23729	35153
8	5030	4283	0	9313	2056	10206	13220	180	25662	34975
9	5433	3880	0	9313	2158	11124	14278	194	27754	37067
10	5868	3445	0	9313	2266	12125	15420	210	30021	39334
11	6337	2976	0	9313	2380	13217	16654	227	32478	41791
12	6843	2470	0	9313	2499	14406	17986	245	35136	44449
13	12022	11977	0	23999	2623	15703	19425	264	38015	62014
14	12983	11016	0	23999	2755	17116	20979	286	41136	65135
15	14021	9978	727	24726	2892	18656	22657	308	44513	69239
16	7469	10898	0	18367	3037	20335	24470	333	48175	66542
17	8129	10238	0	18367	3189	22166	26428	360	52143	70510
18	8849	9518	0	18367	3348	24161	28542	389	56440	74807
19	9637	8730	0	18367	3516	26335	30825	420	61096	79463
20	10496	7871	0	18367	3691	28705	33291	453	66140	84507

SUMMARY FOR WATER SUPPLY SYSTEM --

TOTAL AREA SERVED (ACRES) - - - - - - - -	480.0
SYSTEM CAPACITY	
MAX VOLUME DELIVERED (ACRE-IN/24 HR)	309
MAX FLOW RATE (CFS) - - - - - - - - - -	13.00
CONVEYANCE EFFICIENCY (%) - - - - - - - -	100

INPUT DATA FOR ATTACHED COMPONENTS
-- (LOAN NO. 1)

TOTAL CAPITAL COST ($) - - - - - - - - -	96865
CAPITAL NOT FINANCED ($) - - - - - - - -	17369
FINANCED CAPITAL ($) - - - - - - - - - -	79496
FINANCE INTEREST RATE (%) - - - - - - -	8.0
TIME OF LOAN (YEARS) - - - - - - - - - -	15
SALVAGE VALUE ($) - - - - - - - - - - -	0
ANNUAL MAINTENANCE EXPENSE ($) - - - - -	7401
ANNUAL MISCELLANEOUS EXPENSE ($) - - - -	150

INPUT DATA FOR NON-ATTACHED COMPONENTS
-- (LOAN NO. 2)

TOTAL CAPITAL COST ($) - - - - - - - - -	10291
CAPITAL NOT FINANCED ($) - - - - - - - -	340
FINANCED CAPITAL ($) - - - - - - - - - -	9952
FINANCE INTEREST RATE (%) - - - - - - -	12.0
TIME OF LOAN (YEARS) - - - - - - - - - -	7
SALVAGE VALUE ($) - - - - - - - - - - -	990
ANNUAL MAINTENANCE EXPENSE ($) - - - - -	969
ANNUAL MISCELLANEOUS EXPENSE ($) - - - -	162

RETURN ON INVESTMENT (%) - - - - - - - -	10.0
INFLATION FOR OPERATION AND MAINT. (%) -	8.0
INFLATION FOR ENERGY (%) - - - - - - - -	9.0

EXPECTED COSTS FOR IRRIGATION FOR SUPPLY SYSTEM
OVER THE LIFE OF THE SYSTEM

THE SYSTEM SUPPLIES 480.0 ACRES

TOTAL OVERALL ANNUAL COST ($) - - - - - - - -	67136
OVERALL ANNUAL CAPITAL COST ($) - - - - - - -	14012

(NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)

SYSTEM POWER ESTIMATES FOR AVERAGE SEASON

HOURS OF OPERATION PER SEASON - - - - - -	4933
SEASONAL KILOWATT-HOURS - - - - - - - - -	119870

TOTAL CAPITAL COST NOT FINANCED ($) - - - - -	17708

	- - - CAPITAL COSTS - - -				OPERATING COSTS FOR AVERAGE CONDITIONS					OVERALL
YR	REPYMNT	INTRST	CASH	TOTAL	WATER	ENERGY	MAINT	MISC	TOTAL	TOTAL
0	0	0	17708	17708	0	0	0	0	0	17708
1	4211	7914	0	12125	12101	7792	8370	312	28575	40700
2	4600	7525	0	12125	13069	8493	9040	337	30939	43064
3	5025	7100	0	12125	14114	9257	9763	364	33498	45623
4	5492	6634	0	12125	15243	10090	10544	393	36270	48395
5	6003	6122	0	12125	16463	10998	11387	424	39272	51397
6	6566	5559	0	12125	17780	11988	12298	458	42524	54649
7	6593	4875	0	11468	19202	13067	13282	495	46046	57514
8	5017	4270	0	9287	20739	14243	14345	535	49862	59149
9	5419	3868	0	9287	22398	15525	15492	577	53992	63279
10	5853	3434	0	9287	24189	16922	16732	624	58467	67754
11	6320	2967	0	9287	26125	18445	18070	674	63314	72601
12	6826	2461	0	9287	28215	20106	19516	727	68564	77851
13	7372	1915	0	9287	30472	21915	21077	786	74250	83537
14	7962	1325	0	9287	32909	23887	22763	849	80408	89695
15	8599	688	704	9991	35542	26037	24585	916	87080	97071
16	2816	4150	0	6966	38386	28381	26551	990	94308	101274
17	3123	3843	0	6966	41456	30935	28675	1069	102135	109101
18	3465	3501	0	6966	44773	33719	30969	1154	110615	117581
19	3846	3120	0	6966	48355	36754	33447	1247	119803	126769
20	4268	2698	0	6966	52223	40062	36123	1346	129754	136720

CONDENSED SIMULATE OUTPUT DATA

SUMMARIZED IRRIGATION SIMULATION OUTPUT FOR
Example

RESULTS ARE BASED ON 10 YEARS OF RAINFALL AND PET DATA

SIMULATED SEASONAL PERFORMANCE BY CROP

FIELD # 1 (FURROW OR CORRUGATE IRRIGATION SYSTEM)

CROP	AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)	AVG YIELD REDUCTION(%)
ALFALFA HAY	51.10	66.47	33.62	.52
SPRING WHEAT	38.37	.00	20.85	.00
POTATOES	259.73	686.32	28.20	5.51
WINTER WHEAT	378.08	367.72	20.98	.00

FIELD # 2 (FURROW OR CORRUGATE IRRIGATION SYSTEM)

CROP	AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)	AVG YIELD REDUCTION(%)
ALFALFA HAY	188.57	117.92	25.23	2.25
SPRING WHEAT	443.88	154.06	9.72	1.00
POTATOES	.00	.00	26.92	.00
WINTER WHEAT	467.76	257.87	15.27	1.43

FIELD # 3 (SIDE-ROLL SPRINKLER IRRIGATION SYSTEM)

CROP	AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)	AVG YIELD REDUCTION(%)
ALFALFA HAY	1161.68	68.84	17.34	11.27
SPRING WHEAT	484.81	4.50	10.38	2.11
POTATOES	97.78	.00	20.74	.00
WINTER WHEAT	1932.47	68.92	13.22	4.82

FIELD # 4 (SIDE-ROLL SPRINKLER IRRIGATION SYSTEM)

CROP	AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)	AVG YIELD REDUCTION(%)
ALFALFA HAY	1427.13	97.67	22.44	15.65
SPRING WHEAT	492.40	25.77	10.54	.00
POTATOES	708.53	.00	22.11	8.75
WINTER WHEAT	865.37	22.13	15.88	.00

FIELD # 5 (CENTER PIVOT IRRIGATION SYSTEM)

CROP	AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)	AVG YIELD REDUCTION(%)
ALFALFA HAY	86.89	16.62	8.17	.87
SPRING WHEAT	664.93	118.55	3.44	.00
POTATOES	.00	.00	6.00	.00
WINTER WHEAT	365.79	61.96	5.24	.00

FIELD # 6 (CENTER PIVOT IRRIGATION SYSTEM)

CROP	AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)	AVG YIELD REDUCTION(%)
SPRING WHEAT	792.42	28.82	4.69	4.26
SPRING BARLEY	151.47	5.23	4.91	1.22
WINTER WHEAT	338.99	11.71	5.73	.31

SIMULATED SEASONAL PERFORMANCE FOR ALL CROPS

FIELD # 1 (FURROW OR CORRUGATE IRRIGATION SYSTEM)

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
181.82	280.13	25.91

FIELD # 2 (FURROW OR CORRUGATE IRRIGATION SYSTEM)

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
275.05	132.46	19.29

FIELD # 3 (SIDE-ROLL SPRINKLER IRRIGATION SYSTEM)

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
919.19	35.57	15.42

FIELD # 4 (SIDE-ROLL SPRINKLER IRRIGATION SYSTEM)

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
873.36	36.39	17.74

FIELD # 5 (CENTER PIVOT IRRIGATION SYSTEM)

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
279.40	49.28	5.71

FIELD # 6 (CENTER PIVOT IRRIGATION SYSTEM)

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
427.63	15.25	5.11

SEASONAL PERFORMANCE SUMMARY FOR ALL SYSTEMS

AVG IRRIGATION DEFICIT(AC-IN)	AVG LABOR DEFICIT(HRS)	AVG NUTRIENT LOSS(% APPLD)
2956.45	549.08	14.86

ESTIMATED ANNUAL COSTS FOR IRRIGATION SYSTEMS

FURROW OR CORRUGATE

CAPITAL	LABOR	ENERGY	MAINT	MISC	TOTAL
8461	18416	0	9885	215	36977

SIDE-ROLL SPRINKLER

CAPITAL	LABOR	ENERGY	MAINT	MISC	TOTAL
19645	4748	29215	16823	188	70619

CENTER PIVOT

CAPITAL	LABOR	ENERGY	MAINT	MISC	TOTAL
17814	2077	10946	13915	188	44940

ESTIMATED ANNUAL COSTS FOR SUPPLY SYSTEM

SUPPLY SYSTEM

CAPITAL	ENERGY	MAINT	MISC	WATER	TOTAL
14012	15277	15099	562	21829	66779

ESTIMATED ANNUAL COST TOTALS

CAPITAL	LABOR	ENERGY	MAINT	MISC	WATER	TOTAL
59932	25241	55438	55722	1153	21829	219315

APPENDIX B

PROGRAMMING OF THE FISA DATA ENTRY SPREADSHEETS

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PROGRAM OPERATION AND MACRO LISTING

The purpose of the information presented here is provide an explanation of the inner workings of the FISA data file building spreadsheets. This presentation is written assuming the reader has a working knowledge of LOTUS Symphony 1.1 and its programming language. It is also assumed that the reader has run the data file building spreadsheet a few times to become familiar with its data requirements and program flow.

A spreadsheet program was used rather than a Fortran program to build the data file to give the user the capability of viewing, entering, and editing blocks (screens) of related information. Inaddition, creating the data file in block form gives the user the ability to quickly work through the information requiring no changes when editing an existing data file.

Each screen of information is contained in a Symphony window. The data file building process (macros) essentially guide the user through the necessary windows to construct a data file and save it on disk. Each window has a macro associated with it that performs any needed tasks in the window and moves the spreadsheet to the next window. The range name \S is moved from macro to macro in the order needed to construct the data file. This approach requires the user to remember only one keystroke sequence (ALT-S) to move from one screen of information to the next.

The data file building process is started by retrieving the part one spreadsheet, FISAI, into Symphony. The first window to appear is the Intro window. This window gives a brief explanation of how to use the program. The \R macro is a start/restart routine. It brings up the WAIT window, resets the range name \S to the first macro of the data file building sequence and brings up the INTRO window. The \R macro is the macro executed automatically when the part one spreadsheet is retrieved. The \R macro begins in cell J1 and listed in Figure B-1.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{ONERROR NO\S}{S}WUINTRO~
{TYPE}S
{M}RND\S~
{PANELOFF}{WINDOWSOFF}
{M}RNC\S~START~
{HOME}{TYPE}D
{PANELON}{WINDOWSON}
```

Figure B-1 \R macro.

The first macro of the data file building sequence is named START. The START macro begins in cell J11 and listed in Figure B-2. This macro calls up the FILEINFO window, reassigns the range name \S to next macro to be executed and locates the cursor on the first input in the FILEINFO screen.

```
{WINDOWSOFF}{PANELOFF}
{S}WUFILEINFO~
{M}RND\S~
{M}RNC\S~FILEINFO~
{HOME}{GOTO}PRINTOUTANS~
{PANELON}{WINDOWSON}
```

Figure B-2 START macro.

The next macro in the data file building sequence is named FILEINFO. The FILEINFO macro begins in cell J21 and listed in Figure B-3. This macro performs several functions one of which is based on user input in the FILEINFO screen. It brings up the WAIT window, checks to see if the user desires a printout of the soil and crop menus and provides them if needed by calling the submacros PRINTCM and PRINTSM. It then assigns the range names \M and \L to the SMMACRO and LEAVEMENU macros respectively, brings up the FIELD window, reassigns the range name \S to the next macro to be executed and locates the cursor on the first input in the window.

```
{PANELOFF}
{S}WUWAIT~{WINDOWSOFF}
{IF PRINTOUTANS="YES"#OR#PRINTOUTANS="yes"}{PRINTSM}{PRINTCM}
{M}RND\S~
{M}RNC\S~FIELD~
{M}RNC\L~LEAVEMENU~
{ONERROR NO\M}
{M}RND\M~
{PANELOFF}{WINDOWSOFF}
{M}RNC\M~SMMACRO~
{S}WUFIELD~
{HOME}{GOTO}NO.FIELDS~
{PANELON}{WINDOWSON}{QUIT}
```

Figure B-3 FILEINFO macro.

The PRINTSM, PRINTCM, SMMACRO, and LEAVEMENU macros referenced in the FILEINFO macro are listed in Figure B-4. The PRINTSM macro produces a printout of the soil menu. It is located in cell L36. The PRINTCM macro produces a printout of the crop menu. It is located in cell J36. The SMMACRO produces a list of available soils on the screen by bringing up the window SOILMENU. It is located in cell J41. The LEAVEMENU macro returns the user to the original screen after viewing a soil menu, crop menu or seepage rate menu. It is located in cell J79.

The next macro in the data file building sequence is named FIELD. The FIELD macro begins in cell J44 and listed in Figure B-5. The **** in Figure B-5 means that line is part of the line above it in the actual spreadsheet. The Field macro performs a number of functions. First it checks the number of entries for irrigated area, years in rotation and soil type to make sure they all match the number of fields on the farm. If the numbers of entries in each column do not equal the number of fields on the farm, the macro displays the FIELDWARNING window explaining the problem, returns to the FIELD screen and quits. If the number of entries are correct, the FIELD macro brings up the WAIT screen, enters the next window, reassigns the range name \S to the next macro to be executed and reassigns the range name \M to the CMMACRO. The remainder of the FIELD macro deals with formatting the next window so the user can input the field-crop rotation information. This formatting process involves marking a row in the CROP window for each field on the farm and year of crop rotation for the field. This is done by using the looping features provided by the Symphony programming language. Three counters are used to accomplish the looping process, each of which has a range name. They are: Increment, cell J71; Counter1, cell J72; and Counter2, cell J73. There are two loops with

```
PRINTCM MACRO                    PRINTSM MACRO
{S}PSSRCROPMENU~                 {S}PSSRSOILMENU~
I{ESC}QGPQ{RETURN}               I{ESC}QGPQ{RETURN}

SOIL MENU MACRO                  LEAVE MENU MACRO
{PANELOFF}                       {PANELOFF}
{S}WUSOILMENU~                   {S}WU{RIGHT}~
```

Figure B-4 PRINTCM, PRINTSM, SOILMENU, and LEAVEMENU macros.

```
{PANELOFF}
{IF @COUNT(IRRAREA)<>NO.FIELDS#OR#@COUNT(YEARSROT)<>NO.FIELDS#OR#@COUNT(SOILTYPENO.)<>NO.FIELDS}
 **** {S}WUFIELDWARNING~{PANELON}{?}{S}WUFIELD~{QUIT}
{S}WUWAIT~{WINDOWSOFF}{S}SGNQ
{S}WUCROP~
{M}RND\S~
{M}RNC\S~CROP~
{M}RND\M~{M}RNC\M~CMMACRO~
{LET INCREMENT,0:VALUE}
{FOR COUNTER1,1,No.FIELDS,1,FLOOP}
{GOTO}FIELDCOL~
{DOWN INCREMENT}
{M}E{RIGHT 6}{DOWN 99-INCREMENT}~
{HOME}{GOTO}CROP1COL~{S}SGYQ{PANELON}{WINDOWSON}

FLOOP STARTS HERE
{FOR COUNTER2,1,@INDEX(ROTATIONS,0,COUNTER1-1),1,CLOOP}
{RETURN}

CLOOP STARTS HERE
{PUT FIELDCOL,0,INCREMENT,COUNTER1}
{PUT ROTATIONCOL,0,INCREMENT,COUNTER2}
{LET INCREMENT,INCREMENT+1:VALUE}
{RETURN}
```

Figure B-5 FIELD macro.

range names of Floop and Cloop. Floop is the field loop and begins in cell J62. Cloop is the crop rotation loop nested within the Floop. Cloop begins in cell J66. After the CROP window is formatted, the cursor is located on the first input in the window and the macro terminates.

The CMMACRO addressed in the FIELD macro is located in cell J99 andlisted in Figure B-6. This macro produces a listing of available crops onthe screen by bringing up the window CROPMENU.

```
CROP MENU MACRO
{PANELOFF}
{S}WUCROPMENU~
```

Figure B-6 CMMACRO macro.

```
{PANELOFF}
{IF @COUNT(FIELDCOL)<>@COUNT(CROP1COL)#OR#@COUNT(FIELDCOL)<>@COUNT(CROP2COL)}{S}WUWARNING~
 **** {PANELON}{?}{S}WUCROP~{QUIT}
{S}WUWAIT~{WINDOWSOFF}{S}WU{RIGHT}~{S}SGNQ
{M}RND\M~{M}RND\S~
{M}ECROPCOL~{GOTO}SORTCOL~\-~
{M}CCROP1COL~CROPCOL~
{M}QSBDSORTCOL~D{ESC}{TAB}{END}{DOWN}~QS1SORTCOL~A~QRUQ
{GOTO}SORTCOL~
{END}{DOWN}{DOWN}
{M}CCROP2COL~~
{M}QSBDSORTCOL~D{ESC}{TAB}{END}{DOWN}~QS1SORTCOL~A~QRUQ
{M}RNCSORTCOL~{ESC}{TAB}{END}{DOWN}~
{S}WUMAIN~
{GOTO}CROPGROWN~{UP}
{M}ECROPGROWN~
{M}RVSORTCOL~~
{M}ESORTCOL~{M}RPPCROPGROWN~
{LET No.CROPS,@COUNT(CROPGROWN):VALUE}
{S}WUDEFICIT2~
{GOTO}CROPGROWN~{RIGHT}{M}E{DOWN 30}~
@VLOOKUP({LEFT},CROPLOOKUPCOL,1)~
{M}C~{DOWN}{TAB}{DOWN NO.CROPS}~
{GOTO}NORMYIELD~
{M}E{DOWN 30}{RIGHT}~
@VLOOKUP({LEFT 5},$CROPLOOKUPCOL,7)~
{M}C~{DOWN}{TAB}{DOWN NO.CROPS}~
{GOTO}EXPNETRETURN~
@VLOOKUP({LEFT 6},$CROPLOOKUPCOL,8)~
{M}C~{DOWN}{TAB}{DOWN NO.CROPS}~
{GOTO}CROPGROWN~{DOWN NO.CROPS}{M}E{DOWN 30-NO.CROPS}{RIGHT 6}~{S}WUDEFICIT~
{M}RNC\S~DEFICIT~
{HOME}{GOTO}DEFANS1~{S}SGYQ
{PANELON}{WINDOWSON}
```

Figure B-7 CROP macro.

The next macro in the file building sequence is CROP. The CROP macro begins in cell J103 and listed in Figure B-7. The **** in Figure B-7 mean that line is part of the line above it in the actual spreadsheet. This macro performs several functions. First this macro checks to see if the number of entries for first crop and second crop are equal to the number of required field-crop rotation combinations. If not, the WARNING window is displayed explaining the problem and the macro terminates. If the correct number of entries have been made, the CROP macro displays the WAIT window, returns to the CROP window and deletes the range names \S and \M. The CROP macro uses SYMPHONY's data base features to sort out the number of different crops grown on the farm. The macro then uses this information to produce the entries seen in the window DEFICIT2. Lastly, the macro reassigns the range name \S to the next macro to be executed, brings up the DEFICIT window and places the cursor at the location of the first input in the window.

The next macro in the data file building sequence is DEFICIT. The DEFICIT macro begins in cell J174 and listed in Figure B-8. This macro fills in the appropriate value for application deficit seen in the DEFICIT2 window based on user input in the DEFICIT window. The application deficit can be zero, the same for each crop grown, or different for the various crops grown. The DEFICIT macro branches to other macros based on the type of application deficit to be entered. The macro ZEROAD takes over when the application deficit is to be zero. The macro EQUALAD takes over when the application deficit is to be the same for each crop grown. For the case where the application deficit is different among the crops grown, the DEFICIT macro reassigns the range name \S to the next macro to be excuted, brings up the DEFICIT2 window and locates the cursor on the first input in the window.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{IF DEFANS1="NO"#OR#DEFANS1="no"}{BRANCH ZEROAD}
{IF DEFANS2="YES"#OR#DEFANS2="yes"}{BRANCH EQUALAD}
{M}RND\S~
{M}RNC\S~DEFICIT2~
{S}WUDEFICIT2~{HOME}{GOTO}CROPDEFICIT~
{DOWN NO.CROPS}{M}E{DOWN 30-NO.CROPS}~{GOTO}CROPDEFICIT~{PANELON}{WINDOWSON}
```

Figure B-8 DEFICIT macro.

The ZEROAD macro referenced in the DEFICIT macro is listed in Figure B-9. This macro begins in cell J183. Its sole function is to fill in zero for the application deficit seen in the DEFICIT2 window. At the end it reassigns the range name \S to the next macro to be executed, brings up the DEFICIT2 window and locates the cursor at the location of the first input in the window screen.

The EQUALAD macro referenced in the DEFICIT macro is listed in Figure B-10. This macro begins in cell J195. The EQUALAD macro prompts the user for the application deficit and fills in the value for the crops listed in the DEFICIT2 window. The macro uses the window named MESSAGE to prompt the user and read in the value for application deficit. The input value for application deficit is stored in a holding cell named INPUTAD (J215) and copied to the correct locations in the window DEFICIT2. Lastly, the macro reassigns the range name \S to the next macro to be executed, brings up the DEFICIT2 window and locates the cursor on the first input in the window.

```
ZERO APPLICATION DEFICIT
{S}WUDEFICIT2~
{GOTO}CROPDEFICIT~
{M}E{TAB}{DOWN 29}~
{GOTO}CROPGROWN~{END}{DOWN}{RIGHT 3}
{M}RF{BS}{TAB}{END}{UP}{DOWN}~0~0~30~
{M}RND\S~
{M}RNC\S~DEFICIT2~
{S}WUDEFICIT2~{HOME}{GOTO}CROPDEFICIT~
{PANELON}{WINDOWSON}
```

Figure B-9 ZEROAD macro.

```
EQUAL APPLICATION DEFICIT
{S}WUMESSAGE~{S}SGNQ
{M}EMESSAGE~
{HOME}{DOWN 2}{RIGHT 2}
'ENTER THE APPLICATION DEFICIT AS A PERCENTAGE OF AVAILABLE MOISTURE~
{DOWN}
'FOR ALL CROPS AT THE PROMPT LOCATED AT THE TOP OF THE SCREEN.~
{WINDOWSON}
{GETNUMBER "APPLICATION DEFICIT (inches)......? ",INPUTAD}
{WINDOWSOFF}{S}WUWAIT~{WINDOWSON}{WINDOWSOFF}
{S}WUDEFICIT2~
{GOTO}CROPDEFICIT~
{M}E{TAB}{DOWN 29}~
{GOTO}CROPGROWN~{END}{DOWN}{RIGHT 3}
{M}RF{BS}{TAB}{END}{UP}{DOWN}~INPUTAD~0~30~
{M}RND\S~
{M}RNC\S~DEFICIT2~
{S}WUDEFICIT2~{HOME}{GOTO}CROPDEFICIT~{S}SGYQ
{PANELON}{WINDOWSON}
```

Figure B-10 EQUALAD macro.

The next macro to be executed in the data file building process is named DEFICIT2. The DEFICIT2 macro begins in cell J218 and listed in Figure B-11. This macro simply reassigns the range name \S to the next macro to be executed, brings up the SEASON window, and locates the cursor on the first input in the window.

The next macro to be executed in the data file building sequence is SEASON. The SEASON macro begins in cell J240 and listed in Figure B-12. The season macro simply displays the WAIT window, enters the FARMDATA window, turns off spreadsheet protection, deletes the range name \S and transfers program control to the FARMDATA macro.

```
UNEQUAL APPLICATION DEFICIT
{WINDOWSOFF}{PANELOFF}
{S}WUSEASON~
{M}RND\S~
{M}RNC\S~SEASON~
{HOME}{GOTO}BEGIRRMONTH~
{PANELON}{WINDOWSON}
```

Figure B-11 DEFICIT2 macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{S}WUFARMDATA~{S}SGNQ
{M}RND\S~
{BRANCH FARMDATA}
```

Figure B-12 SEASON macro.

The FARMDATA macro referenced by the SEASON macro begins in cell M260. The FARMDATA macro is listed in Figure B-13. The **** in Figure B-13 means that line is part of the line above it in the actual spreadsheet. The purpose of the FARMDATA macro is to construct the table of field information seen in the data file. The information includes field number, soil type number, rotation year and for each crop and year of rotation it includes crop number, total available moisture (TAM), management allowed deficit (MAD), and application deficit (AD). The FARMDATA macro works on the basic principle of entering the correct spreadsheet formula in the columns of the table, copying the formulas down the columns and forcing calculation of the spreadsheet. The table of field information has the range name TABLE and is located in the cell range A264..K339. The last thing the FARMDATA macro does is reassign the range name \S to the next macro to be executed, bring up the SUPPLY window, position the cursor on the first input in the window and turn on spreadsheet protection.

The next macro to be executed is named SUPPLY. The SUPPLY macro begins in cell J364 and listed in Figure B-14. The SUPPLY macro simply reassigns the range name \S to the next macro to be executed, brings up the ELECTRICRATES window and locates the cursor on the first input in the window.

The next macro to be executed is named ELECTRICRATES. The ELECTRICRATES macro begins in cell J404 and listed in Figure B-15. The ELECTRICRATES macro simply reassigns the range name \S to the next macro to be executed, brings up the WATER window and locates the cursor on the first input in the window.

```
{M}ETABLE~
{M}CFIELDCOL~TABLEFIELDCOL~
{GOTO}TABLESOILCOL~
@INDEX($FIELDDATA,6,TABLEFIELDCOL-1)~
{M}C~{DOWN}{TAB}{DOWN @COUNT(FIELDCOL)-2}~
{M}CROTATIONCOL~TABLEROTCOL~
{M}CCROP1COL~TABLECROP1COL~
{GOTO}TAM1COL~
@VLOOKUP(TABLESOILCOL,$SOILLOOKUPCOL,3)*@MIN(@VLOOKUP(TABLESOILCOL,$SOILLOOKUPCOL,4),
 **** @VLOOKUP(TABLECROP1COL,$CROPLOOKUPCOL,5))~
{M}C~{DOWN}{TAB}{DOWN @COUNT(FIELDCOL)-2}~
{GOTO}MAD1COL~
@VLOOKUP(TABLECROP1COL,$CROPLOOKUPCOL,6)~
{M}C~{DOWN}{TAB}{DOWN @COUNT(FIELDCOL)-2}~
{GOTO}TABLEAD1COL~
@VLOOKUP(TABLECROP1COL,$CROPGROWN,3)~
{M}C~{DOWN}{TAB}{DOWN @COUNT(FIELDCOL)-2}~
{M}CCROP2COL~TABLECROP2COL~
{GOTO}TAM2COL~
@VLOOKUP(TABLESOILCOL,$SOILLOOKUPCOL,3)*@MIN(@VLOOKUP(TABLESOILCOL,$SOILLOOKUPCOL,4),
 **** @VLOOKUP(TABLECROP2COL,$CROPLOOKUPCOL,5))~
{M}C~{DOWN}{TAB}{DOWN @COUNT(FIELDCOL)-2}~
{GOTO}MAD2COL~
@VLOOKUP(TABLECROP2COL,$CROPLOOKUPCOL,6)~
{M}C~{DOWN}{TAB}{DOWN @COUNT(FIELDCOL)-2}~
{GOTO}TABLEAD2COL~
@VLOOKUP(TABLECROP2COL,$CROPGROWN,3)~
{M}C~{DOWN}{TAB}{DOWN @COUNT(FIELDCOL)-2}~
{CALC}
{S}WUSUPPLY~
{M}RNC\S~SUPPLY~{HOME}{GOTO}CAPCOST~
{S}SGYQ{PANELON}{WINDOWSON}
```

Figure B-13 FARMDATA macro.

```
{WINDOWSOFF}{PANELOFF}
{M}RND\S~{M}RNC\S~ELECTRICRATES~
{S}WUELECTRICRATES~
{HOME}{GOTO}ELECTRICANS~
{PANELON}{WINDOWSON}
```

Figure B-14 SUPPLY macro.

```
{WINDOWSOFF}{PANELOFF}
{M}RND\S~{M}RNC\S~WATER~
{S}WUWATER~{HOME}{GOTO}FLOWRATE~
{PANELON}{WINDOWSON}
```

Figure B-15 ELECTRICRATES macro.

The next macro to be executed is named WATER. The WATER macro begins in cell J384 and listed in Figure B-16. The WATER macro simply reassigns the range name \S to the next macro to be executed and brings up the SUPPLYMESSAGE window on the display screen.

```
{PANELOFF}
{S}WUSUPPLYMESSAGE~{WINDOWSOFF}
{M}RND\S~{M}RNC\S~SUPPLYMESSAGE~
{PANELON}
```

Figure B-16 WATER macro.

The next macro to execute is the named SUPPLYMESSAGE. The SUPPLYMESSAGE macro begins in cell J394 and listed in Figure B-17. This macro reassigns the range name \S to the next macro to be executed, brings up the SUPPLYCANAL window and locates the cursor on the first input in the window.

```
{WINDOWSOFF}{PANELOFF}
{M}RND\S~{M}RNC\S~SUPPLYCANAL~
{S}WUSUPPLYCANAL~
{M}RNC\M~SEEPMMACRO~
{HOME}{GOTO}SUPCANANS~
{PANELON}{WINDOWSON}
```

Figure B-17 SUPPLYMESSAGE macro.

The next macro to execute is called SUPPLYCANAL. The SUPPLYCANAL macro begins in cell J444 and listed in Figure B-18. This macro erases extra data from the SUPPLYCANAL window based on the number of canals for which information was entered (value in range NO.SUPCANALS). The SUPPLYCANAL macro then reassigns the range name \S to the next macro to be executed, brings up the SUPPLYSTRUCTS window, and locates the cell pointer on the first input in the window.

```
{WINDOWSOFF}{PANELOFF}
{GOTO}SUPCANDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SUPCANALS}{M}E{RIGHT 5-NO.SUPCANALS}{DOWN 9}~
{M}RND\M~
{M}RND\S~{M}RNC\S~SUPPLYSTRUCTS~
{S}WUSUPPLYSTRUCTS~
{HOME}{GOTO}SUPSTRUCTANS~
{PANELON}{WINDOWSON}
```

Figure B-18 SUPPLYCANAL macro.

The next macro to execute is called SUPPLYSTRUCTS. The SUPPLYSTRUCTS macro begins in cell J464 and listed in Figure B-19. This macro erases extra data from the SUPPLYSTRUCTS window based on the number of structures for which information was entered (value in range NO.SUPSTRUCTS). The SUPPLYSTRUCTS macro then reassigns the range name \S to the next macro to be executed, brings up the SUPPLYPUMPS window, and locates the cell pointer on the first input in the window.

```
{WINDOWSOFF}{PANELOFF}
{GOTO}SUPSTRUCTDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SUPSTRUCTS}{M}E{RIGHT 5-NO.SUPSTRUCTS}{DOWN 5}~
{M}RND\S~{M}RNC\S~SUPPLYPUMPS~
{S}WUSUPPLYPUMPS~
{HOME}{GOTO}SUPPUMPANS~
{PANELON}{WINDOWSON}
```

Figure B-19 SUPPLYSTRUCTS macro.

The next macro to execute is called SUPPLYPUMPS. The SUPPLYPUMPS macro begins in cell J484 and listed in Figure B-20. This macro erases extra data from the SUPPLYPUMPS window based on the number of pumps for which information was entered (value in range NO.SUPPUMPS). The SUPPLYSPUMPS macro then reassigns the range name \S to the next macro to be executed, brings up the SUPPLYPIPES window, and locates the cell pointer on the first input in the window.

```
{WINDOWSOFF}{PANELOFF}
{GOTO}SUPPUMPDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SUPPUMPS}{M}E{RIGHT 5-NO.SUPPUMPS}{DOWN 11}~
{M}RND\S~{M}RNC\S~SUPPLYPIPES~
{S}WUSUPPLYPIPES~
{HOME}{GOTO}SUPPIPEANS~
{PANELON}{WINDOWSON}
```

Figure B-20 SUPPLYPUMPS macro.

The next macro to execute is called SUPPLYPIPES. The SUPPLYPIPES macro begins in cell J507 and listed in Figure B-21. This macro erases extra data from the SUPPLYPIPES window based on the number of pipes for which information was entered, value in range NO.SUPPIPES. The SUPPLYSPIPES macro then reassigns the range name \S to the next macro to be executed, brings up the SUPPLYEXTRAS window, and locates the cell pointer on the first input in the window.

The next macro to execute is called SUPPLYEXTRAS. The SUPPLYEXTRAS macro begins in cell J527 and listed in Figure B-22. This macro erases extra data from the SUPPLYEXTRAS window based on the number of miscellaneous items for which information was entered, value in range NO.SUPEXTRAS. The SUPPLYEXTRAS macro then reassigns the range name \S to the next macro to be executed, and brings up the SAVEWORKSHEETI window.

```
{WINDOWSOFF}{PANELOFF}
{GOTO}SUPPIPEDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SUPPIPES}{M}E{RIGHT 5-NO.SUPPIPES}{DOWN 8}~
{M}RND\S~{M}RNC\S~SUPPLYEXTRAS~
{S}WUSUPPLYEXTRAS~
{HOME}{GOTO}SUPEXTRASANS~
{PANELON}{WINDOWSON}
```

Figure B-21 SUPPLYPIPES macro.

```
{WINDOWSOFF}{PANELOFF}
{GOTO}SUPEXTRASDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SUPEXTRAS}{M}E{RIGHT 5-NO.SUPEXTRAS}{DOWN 7}~
{M}RND\S~{M}RNC\S~CREATEOUTPUTI~
{S}WUSAVEWORKSHEETI~{HOME}
{PANELON}{WINDOWSON}
```

Figure B-22 SUPPLYEXTRAS macro.

The SAVEWORKSHEETI window provides the user with the opportunity to save the part one spreadsheet which will contain the inputs just entered in the current session. The user can then use this part one spreadsheet at a later time for making subsequent data files, thus minimizing data entry.

The next macro to execute is named CREATEOUTPUTI. The CREATEOUTPUTI macro begins in cell BH2 and listed in Figure B-23. This macro turns off spreadsheet protection, displays the window DATAFILE on the display screen, enters the MAIN window and transfers control to the submacro PARTONEOUTPUT. After program control returns from the submacro, the spreadsheet area containing the windows of the part one spreadsheet is erased, the format reset and protection status set to protect. Next, the spreadsheet area containing the submacro PARTONEOUTPUT is erased, the range name \S reassigned to the next macro to execute and the RECOVERMEM window displayed on the screen.

```
{WINDOWSOFF}{PANELOFF}{S}SGNQ
{S}WUDATAFILE~
{WINDOWSON}{WINDOWSOFF}{S}WUMAIN~{PARTONEOUTPUT}
{M}EA1.AK608~{M}FRA1.AK608~{M}RPPA1.AK608~
{M}EBA1..BA81~
{M}RNC\S~BH15~
{S}WURECOVERMEM~{BEEP}{BEEP}
{PANELON}{WINDOWSON}
```

Figure B-23 CREATEOUTPUTI macro.

The PARTONEOUTPUT macro referenced in CREATEOUTPUTI macro begins in cell BA2 and listed in Figure B-24. The purpose of this macro is to copy and arrange the input information entered in the various windows of the part one spreadsheet to another portion of the spreadsheet. The input data is arranged in the spreadsheet as it appears in the data file. SYMPHONY

Range Values command is used instead of the Copy command to arrange the input information as only the values are desired not formulas, secondly it is quicker than the Copy command. Every data item appearing in the data file is referenced by a range name. After all data has been arranged, the macro erases all range names. This is because the FISAII file has its own range names and some are the same. A list of ranges names appearing in the part one spreadsheet is given at the end of this write up. After erasing all range names, two are redefined, OUTPUTCONT and NO.FIELDS. The range OUTPUTCONT marks the cell where the part two spreadsheet should continue building the data file using its input values. The range NO.FIELDS contains the number of fields on the farm. This value is used as a data check in the part two spreadsheet. Lastly, the PARTONEOUTPUT macro returns program control to the CREATEOUTPUTI macro.

```
{LET ORUNNAME,RUNNAME:VALUE}
{LET OMONTHSIRR,ENDIRRMONTH-BEGIRRMONTH+1:VALUE}
{LET OBEGIRRMONTH,BEGIRRMONTH:VALUE}
{LET OENDIRRMONTH,ENDIRRMONTH:VALUE}
{LET ONO.FIELDS,NO.FIELDS:VALUE}
{GOTO}ONO.FIELDS~{DOWN 7}
{M}E{PGDN 11}{RIGHT 10}~
{M}RVFIELDS~~
{RIGHT 2}
{M}RVIRRAREA~~
{RIGHT 2}
{M}RVYEARSROT~~
{RIGHT 2}
{M}RVSOILTYPENO.~~
{RIGHT 2}@VLOOKUP({LEFT 2},$SOILLOOKUPCOL,5)~
{M}C~{DOWN}{TAB}{DOWN NO.FIELDS-2}~
{RIGHT}@VLOOKUP({LEFT 3},$SOILLOOKUPCOL,6)~
{M}C~{DOWN}{TAB}{DOWN NO.FIELDS-2}~
{RIGHT}@VLOOKUP({LEFT 4},$SOILLOOKUPCOL,7)~
{M}C~{DOWN}{TAB}{DOWN NO.FIELDS-2}~
{LEFT 10}{DOWN NO.FIELDS}
{M}E{RIGHT 10}{DOWN 11}~
{DOWN 2}'CROP - ROTATION DATA:~{DOWN 2}
@COUNT(FIELDCOL)~
{RIGHT}'- CROP-ROTATION COMBINATIONS~{LEFT}{DOWN 2}
{M}CTABLEHEADING~~
{DOWN 4}
{M}RVFIELDDATATABLE~~
{DOWN @COUNT(FIELDCOL)}
{DOWN 2}
+NO.CROPS~{RIGHT}
'- CROPS GROWN AS LISTED BELOW~{DOWN 3}
{M}RVHEAD4~~{DOWN 3}
{M}RVCROPGROWN~~
{RIGHT}
```

Figure B-24 PARTONEOUTPUT macro.

```
@VLOOKUP({LEFT},$CROPLOOKUPCOL,1)~
{M}C~{DOWN}{TAB}{DOWN NO.CROPS-2}~
{RIGHT}{UP 4}{M}RVYIELDDATA~~
{LEFT 3}{DOWN NO.CROPS+6}'SUPPLY INFORMATION:~
{DOWN 2}+CAPCOST~{RIGHT}'-- PERCENT COST OF OPPORTUNITY CAPITAL~
{LEFT}{DOWN 2}+INFLRATE~{RIGHT}'-- EXPECTED INFLATION RATE FOR SYSTEM COMPONENTS~
{DOWN 2}{RIGHT 3}'   LOAN TERMS:~{LEFT 4}
{DOWN 2}{M}RVLOANTERMS~~
{DOWN 8}'    FLOW DATA:
{DOWN 2}+FLOWRATE~{RIGHT}'-- CFS ENTERING SYSTEM MAXIMUM~
{LEFT}{DOWN}+FLOWVOLUME~{RIGHT}'-- AC-FT AVAILABLE MAXIMUM~
{LEFT}{DOWN}+DAYSAVAIL~{RIGHT}'-- DAYS PER WEEK FLOW IS AVAILABLE~
{LEFT}{DOWN 3}'    WATER COST DATA:~
{DOWN 2}{M}RVWATERCOST~~
{RIGHT}'-- COST OF BASIC ALLOTMENT ($/AC)~
{DOWN}'-- VOLUME OF BASIC ALLOTMENT (AC-FT/AC)~
{DOWN}'-- COST PER AC-FT/AC~
{DOWN}'-- COST OF ADDITIONAL WATER ($/AC-FT/AC)~
{DOWN 3}{LEFT}'    ELECTRICAL RATE INFORMATION:
{DOWN 2}+ELECTRICANS~
{RIGHT}'-- ELECTRIC USAGE IS REQUIRED~{LEFT}
{IF ELECTRICANS="YES"#OR#ELECTRICANS="yes"}{DOWN 2}{M}RVELECTRICDATA~~{DOWN 12}
{DOWN 3}'    SUPPLY SYSTEM OPEN CHANNEL REQUIREMENTS:~
{DOWN 2}+SUPCANANS~
{RIGHT}'-- OPEN CHANNELS ARE REQUIRED~{LEFT}
{IF SUPCANANS="YES"#OR#SUPCANANS="yes"}{DOWN 2}{M}RVSUPCANDATA~~{DOWN 14}
{DOWN 3}'    SUPPLY SYSTEM STRUCTURE REQUIREMENTS:~
{DOWN 2}+SUPSTRUCTANS~
{RIGHT}'-- STRUCTURES ARE REQUIRED~{LEFT}
{IF SUPSTRUCTANS="YES"#OR#SUPSTRUCTANS="yes"}{DOWN 2}{M}RVSUPSTRUCTDATA~~{DOWN 10}
{DOWN 3}'    SUPPLY SYSTEM PUMP REQUIREMENTS:~
{DOWN 2}+SUPPUMPANS~
{RIGHT}'-- PUMPS ARE REQUIRED~{LEFT}
{IF SUPPUMPANS="YES"#OR#SUPPUMPANS="yes"}{DOWN 2}{M}RVSUPPUMPDATA~~{DOWN 16}
{DOWN 3}'    SUPPLY SYSTEM PIPELINE REQUIREMENTS:~
{DOWN 2}+SUPPIPEANS~
{RIGHT}'-- PIPELINES ARE REQUIRED~{LEFT}
{IF SUPPIPEANS="YES"#OR#SUPPIPEANS="yes"}{DOWN 2}{M}RVSUPPIPEDATA~~{DOWN 13}
{DOWN 3}'    SUPPLY SYSTEM EXTRA EXPENSE REQUIREMENTS:~
{DOWN 2}+SUPEXTRASANS~
{RIGHT}'-- EXTRA EXPENSES ARE REQUIRED~{LEFT}
{IF SUPEXTRASANS="YES"#OR#SUPEXTRASANS="yes"}{DOWN 2}{M}RVSUPEXTRASDATA~~{DOWN 12}
{DOWN 3}'APPLICATION SYSTEMS INFORMATION:~
{M}RNRY
{DOWN 2}{M}RNCOUTPUTCONT~~
{M}RNCNO.FIELDS~AM9~
{S}WUSYSTEM~
{S}SACQ
{RETURN}
```

Figure B-24 PARTONEOUTPUT macro (cont).

The next macro to execute is the named RECOVERMEM which is located in cell BH15 and shown in Figure B-25. This macro combines the part two spreadsheet with the part one spreadsheet. The MAIN window is entered, the cell pointer located in cell A1 and the file combine command initiated allowing the user to enter the name of the part two spreadsheet to be combined. Only a portion of the part two spreadsheet is combined, the range named WORKSHEET2. Lastly, spreadsheet protection is turn on, the name of the macro to automatically execute when the spreadsheet is loaded is erased, and program control is transferred to the setup macro, STARTPARTII, in the part two spreadsheet.

```
RECOVERMEN MACRO
{WINDOWSOFF}{PANELOFF}
{M}RND\S~
{S}WULOADWORKSHEETII~
{WINDOWSON}{WINDOWSOFF}
{S}WUMAIN~{HOME}
{PANELON}{S}FCCNWORKSHEET2~RF{?}~
{S}SGYACQ{BRANCH STARTPARTII}
```

Figure B-25 The RECOVERMEM macro.

The STARTPARTII macro referenced by the RECOVERMEM macro of the part one spreadsheet begins is cell N1 of the part two spreadsheet. The purpose of the STARTPARTII macro is to display the CHECKMEM window and assign the range name \S to the next macro to execute. The STARTPARTII macro is listed in Figure B-26. The submacro DELETE\S referenced by the STARTPARTII macro is also shown in Figure B-26. The purpose the DELETE\S macro is to delete the range name \S if it exists.

```
{PANELOFF}{S}WUCHECKMEM~{WINDOWSOFF}
{DELETE\S}
{M}RNC\S~\R~
{PANELON}{WINDOWSON}

DELETE\S MACRO
{ONERROR NO\S}
{M}RND\S~
{RETURN}
```

Figure B-26 STARTPARII and DELETE\S macro.

The next macro to execute is named \R. The \R macro is located in cell J15. The \R macro is again a start/restart routine and listed in Figure B-27. It displays the WAIT window, reassigns the range name \S to the next macro to be executed in the part two spreadsheet, brings up the SYSTEM window and locates the cell pointer on the first input in the window.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{DELETE\S}
{M}RNC\S~SYSTEM~
{S}WUSYSTEM~{GOTO}NO.SYSTEMS~
{PANELON}{WINDOWSON}
```

Figure B-27 \R macro of the part two spreadsheet.

The next macro to be executed in the part two spreadsheet is called SYSTEM. The SYSTEM macro is located in cell J1 and listed in Figure B-28. This macro displays the WAIT screen, reassigns the range name \S to the next macro to be executed, turns off spreadsheet protection, brings up the SYSTEM2 window, reformats the window and unprotects its input cells, turns on spreadsheet protection, and locates the cell pointer on the first input in the window.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{M}RND\S~{M}RNC\S~SYSTEM2~
{S}SGNQ
{S}WUSYSTEM2~
{M}ESYSTEMNO.~
{GOTO}SYSTEMNO.~
{M}RFSYSTEMNO.~1~1~NO.SYSTEMS~
{DOWN 2}{M}RPA{DOWN}{RIGHT 5}~
{DOWN 3}{M}RPA{DOWN 10}{RIGHT 5}~
{S}SGYQ
{GOTO}SYSTEMTYPE~
{PANELON}{WINDOWSON}
```

Figure B-28 SYSTEM macro.

The next macro to execute is called SYSTEM2. The SYSTEM2 macro begins in cell M21 and listed in Figure B-29. NOTE: The **** in Figure B-29 mean that line is part of the line directly above it in the actual spreadsheet. The SYSTEM2 macro displays the WAIT window, returns to the SYSTEM2 window, turns off spreadsheet protection and erases any extra information from the previous SYSTEM2 window. Then the number of inputs are checked to make sure it matches the number of fields specified for the farm. If these numbers do not match, the WARNING window is displayed explaining the problem and the macro terminates, allowing the user to enter the correct data. If the number of inputs is correct, the SYSTEMONE window is formatted to match the type of irrigation application system specified. Once the correct irrigation application system type is found, the window is filled with the correct input prompts for that system. Submacros, whose names are indicative of the types of application systems, are used to facilitate formatting the window. After the window has been formatted correctly, program control is transferred to the SYSTEMONE macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}WUSYSTEM2~
{S}SGNQ{GOTO}SYSTEMNO.~{RIGHT NO.SYSTEMS}
{M}E{RIGHT 8-NO.SYSTEMS}~{DOWN 2}
{M}E{RIGHT 8-NO.SYSTEMS}{DOWN}~{DOWN 3}
{M}E{RIGHT 8-NO.SYSTEMS}{DOWN 10}~
{IF @SUM(SYSTEMFIELDS)<>NO.FIELDS}{S}WUWARNING~{WINDOWSON}{QUIT}
{S}WUSYSTEMONE~{HOME}{M}ESYSTEMONEDATA~{LET NO.FIELDSINSYS,@INDEX(SYSTEMFIELDS,0,0):VALUE}
{IF @INDEX(SYSTEMTYPE,0,0)=1}{M}RVBORDERSCREEN~~{BORDER}{M}RTSYSTEMNO.1~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,0,0)}{BORDER1}{M}RPPSYSTEMONEDATA~{BORDERP}{SYSTEMONE}
{IF @INDEX(SYSTEMTYPE,0,0)=2}{M}RVFURROWSCREEN~~{FURROW}{M}RTSYSTEMNO.1~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,0,0)}{FURROW1}{M}RPPSYSTEMONEDATA~{FURROWP}{SYSTEMONE}
{IF @INDEX(SYSTEMTYPE,0,0)=3}{M}RVSOLIDSETSCREEN~~{SOLIDSET}{M}RTSYSTEMNO.1~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,0,0)}{SOLIDSET1}{M}RPPSYSTEMONEDATA~{SOLIDSETP}{SYSTEMONE}
{IF @INDEX(SYSTEMTYPE,0,0)=4}{M}RVHANDMOVESCREEN~~{SETMOVE}{M}RTSYSTEMNO.1~~
 ****{RIGHT @INDEX(SYSTEMFIELDS,0,0)}{SETMOVE1}{M}RPPSYSTEMONEDATA~{SETMOVEP}{SYSTEMONE}
{IF @INDEX(SYSTEMTYPE,0,0)=5}{M}RVSIDEROLLSCREEN~~{SETMOVE}{M}RTSYSTEMNO.1~~
 ****{RIGHT @INDEX(SYSTEMFIELDS,0,0)}{SETMOVE1}{M}RPPSYSTEMONEDATA~{SETMOVEP}{SYSTEMONE}
{IF @INDEX(SYSTEMTYPE,0,0)=6}{M}RVCENPIVOTSCREEN~~{CENTERPIVOT}{M}RTSYSTEMNO.1~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,0,0)}{CENTERPIVOT1}{M}RPPSYSTEMONEDATA~{CENTERPIVOTP}{SYSTEMONE}
{IF @INDEX(SYSTEMTYPE,0,0)=7}{M}RVLINMOVESCREEN~~{LINEARMOVE}{M}RTSYSTEMNO.1~~
 ****{RIGHT @INDEX(SYSTEMFIELDS,0,0)}{LINEARMOVE1}{M}RPPSYSTEMONEDATA~{LINEARMOVEP}{SYSTEMONE}
{QUIT}
```

Figure B-29 SYSTEM2 macro.

The submacros BORDER, FURROW, SOLIDSET, SETMOVE, CENTERPIVOT, and LINEARMOVE referenced in the SYSTEM2 macro are listed in Figure B-30. These macros begin in cells Q48, Q51, Q54, Q57, Q60 and Q63, respectively. The purpose of these macros is to locate the cell pointer at a certain location in each application system screen for subsequent formatting operations.

```
BORDER ROUTINE                     SETMOVE ROUTINE
{DOWN 8}{RIGHT 4}{RETURN}          {DOWN 25}{RIGHT 4}{RETURN}

FURROW ROUTINE                     CENTERPIVOT ROUTINE
{DOWN 8}{RIGHT 4}{RETURN}          {DOWN 24}{RIGHT 4}{RETURN}

SOLIDSET ROUTINE                   LINEARMOVE ROUTINE
{DOWN 9}{RIGHT 4}{RETURN}          {DOWN 24}{RIGHT 4}{RETURN}
```

Figure B-30 BORDER, FURROW, SOLIDSET, SETMOVE, CENTERPIVOT, and LINEARMOVE macros.

The submacros BORDER1, FURROW1, SOLIDSET1, SETMOVE1, CENTERPIVOT1, and LINEARMOVE1 referenced in the SYSTEM2 macro are listed in Figure B-31. These macros begin in cells S48, S51, S54, S57, S60, and S63, respectively. The purpose of these macros is to erase extra input prompts in each application system input screen as each input screen initially contains prompts for up to 11 fields.

```
BORDER1 ROUTINE                      SETMOVE1 ROUTINE
{M}E{DOWN 17}{END}{RIGHT}~{RETURN}  {M}E{DOWN 12}{END}{RIGHT}~{RETURN}

FURROW1 ROUTINE                      CENTERPIVOT1 ROUTINE
{M}E{DOWN 18}{END}{RIGHT}~{RETURN}  {M}E{DOWN 9}{END}{RIGHT}~{RETURN}

SOLIDSET1 ROUTINE                    LINEARMOVE1 ROUTINE
{M}E{DOWN 29}{END}{RIGHT}~{RETURN}  {M}E{DOWN 9}{END}{RIGHT}~{RETURN}
```

Figure B-31 BORDER1, FURROW1, SOLIDSET1, SETMOVE1, CENTERPIVOT1, and LINEARMOVE1 macros.

The submacros BORDERP, FURROWP, SOLIDSETP, SETMOVEP, CENTERPIVOTP, and LINEARMOVEP referenced in the SYSTEM2 macro are listed in Figure B-32. These macros begin in cells Q75, Q80, Q86, Q93, Q100, and Q108, respectively. The purpose of these macros is to unprotect the input areas of the various application system screens.

The SYSTEMONE macro referenced in the SYSTEM2 macro is listed in Figure B-33. The SYSTEMONE macro begins in cell P41. This macro locates the cell pointer on the first input in the SYSTEMONE window, turns on spreadsheet protection, and reassigns the range name \S to the next macro to be executed.

The next macro to be executed is called SYSONEPARTII. The SYSONEPARTII macro begins in cell Q67 and listed in Figure B-34. This macro displays the WAIT window, reassigns the range name \S to the next macro to be executed, brings up the SYSONECANAL window, executes the submacro CANALP and terminates.

The submacro CANALP referenced in the SYSONEPARTII macro is located in cell Q115 and listed in Figure B-35. The purpose of this macro is to turn off spreadsheet protection, unprotect the input cells in the application system canal input screen, position the cell pointer on the first input in the screen and turn spreadsheet protection back on.

The next macro to be executed is called SYSONECANAL. The SYSONECANAL macro begins in cell J83 and listed in Figure B-36. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system one canal input screen, reassigns the range name \S to the next macro to execute, brings up the SYSONESTRUCTS window, executes the submacro STRUCTP and terminates.

The STRUCTP macro referenced in the SYSONECANAL macro is located in cell Q122 and listed in Figure B-37. The purpose of this macro is to turn off spreadsheet protection, unprotect the input cells in the application system structures input screen, position the cell pointer on the first input in the screen, and turn spreadsheet protection back on.

The next macro to be executed is called SYSONESTRUCTS. The SYSONESTRUCTS macro begins in cell J104 and listed in Figure B-38. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system one structure input screen, reassigns the range name \S to the next macro to execute, brings up the SYSONEPUMPS window, executes the submacro PUMPP and terminates.

```
BORDERP MACRO
{HOME}{DOWN 3}{RIGHT 7}{M}RPA{DOWN}~
{DOWN 7}{LEFT 3}{M}RPA{RIGHT NO.FIELDSINSYS-1}
{DOWN 14}~{RETURN}

FURROWP MACRO
{HOME}{DOWN 3}{RIGHT 7}{M}RPA{DOWN}~
{DOWN 7}{LEFT 3}{M}RPA{RIGHT NO.FIELDSINSYS-1}
{DOWN 15}~{RETURN}

SOLIDSETP MACRO
{HOME}{DOWN 3}{RIGHT 7}{M}RPA~
{DOWN 2}{M}RPA~
{DOWN 6}{LEFT 3}{M}RPA{RIGHT NO.FIELDSINSYS-1}
{DOWN 4}~{DOWN 9}{M}RPA{DOWN 17}{RIGHT NO.FIELDSINSYS-1}
{RETURN}

SETMOVEP MACRO
{HOME}{DOWN 3}{RIGHT 7}{M}RPA{DOWN}~
{DOWN 3}{M}RPA{DOWN 4}~{DOWN 7}
{M}RPA{DOWN 8}~
{DOWN 14}{LEFT 3}{M}RPA{RIGHT NO.FIELDSINSYS-1}
{DOWN 9}~{RETURN}

CENTERPIVOTP MACRO
{HOME}{DOWN 3}{RIGHT 7}{M}RPA{DOWN 3}~
{DOWN 7}{M}RPA{DOWN 10}~
{DOWN 16}{LEFT 3}{M}RPA{RIGHT NO.FIELDSINSYS-1}
{DOWN 6}~{RETURN}

LINEARMOVEP MACRO
{HOME}{DOWN 3}{RIGHT 7}{M}RPA{DOWN 3}~
{DOWN 7}{M}RPA{DOWN 10}~
{DOWN 16}{LEFT 3}{M}RPA{RIGHT NO.FIELDSINSYS-1}
{DOWN 6}~{RETURN}
```

Figure B-32 BORDERP, FURROWP, SOLIDSETP, SETMOVEP, CENTERPIVOTP, and LINEARMOVEP.

```
{HOME}{DOWN}1~{DOWN 2}{RIGHT 7}
{S}SGYQ
{M}RND\S~{M}RNC\S~SYSONEPARTII~
{PANELON}{WINDOWSON}{QUIT}
```

Figure B-33 SYSTEMONE macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{M}RND\S~{M}RNC\S~SYSONECANAL~
{S}WUSYSONECANAL~{CANALP}
{PANELON}{WINDOWSON}
```

Figure B-34 SYSONEPARTII macro.

```
CANALP MACRO
{S}SGNQ{HOME}{DOWN}{RIGHT 7}{M}RPA~
{DOWN 3}{M}RPA~
{DOWN 4}{LEFT 4}{M}RPA{RIGHT 4}{DOWN 9}~
{HOME}{DOWN}{RIGHT 7}{S}SGYQ{RETURN}
```

Figure B-35 CANALP macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSONECANALDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSONECANALS}{M}E{RIGHT 5-NO.SYSONECANALS}{DOWN 9}~
{M}RND\S~{M}RNC\S~SYSONESTRUCTS~
{S}WUSYSONESTRUCTS~{STRUCTP}
{PANELON}{WINDOWSON}
```

Figure B-36 SYSONECANAL macro.

```
STRUCTP MACRO
{S}SGNQ{HOME}{DOWN}{RIGHT 7}{M}RPA~
{DOWN 4}{M}RPA~
{DOWN 4}{LEFT 4}{M}RPA{RIGHT 4}{DOWN 5}~
{HOME}{DOWN}{RIGHT 7}{S}SGYQ{RETURN}
```

Figure B-37 STRUCTP macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSONESTRUCTDAT~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSONESTRUCT}{M}E{RIGHT 5-NO.SYSONESTRUCT}{DOWN 5}~
{M}RND\S~{M}RNC\S~SYSONEPUMPS~
{S}WUSYSONEPUMPS~{PUMPP}
{PANELON}{WINDOWSON}
```

Figure B-38 SYSONESTRUCTS macro.

The PUMPP macro referenced in the SYSONESTRUCTS macro is located in cell Q129 and listed in Figure B-39. The purpose of this macro is to turn off spreadsheet protection, unprotect the input cells in the application system pump input screen, position the cell pointer on the first input in the screen, and turn spreadsheet protection back on.

```
PUMPP MACRO
{S}SGNQ{HOME}{DOWN}{RIGHT 7}{M}RPA~
{DOWN 3}{M}RPA~
{DOWN 4}{LEFT 4}{M}RPA{RIGHT 4}{DOWN 11}~
{HOME}{DOWN}{RIGHT 7}{S}SGYQ{RETURN}
```

Figure B-39 PUMPP macro.

The next macro to be executed is called SYSONEPUMPS. The SYSONEPUMPS macro begins in cell J124 and listed in Figure B-40. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system one pump input screen, reassigns the range name \S to the next macro to execute, brings up the SYSONEPIPES window, executes the submacro PIPEP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSONEPUMPDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSONEPUMPS}{M}E{RIGHT 5-NO.SYSONEPUMPS}{DOWN 11}~
{M}RND\S~{M}RNC\S~SYSONEPIPES~
{S}WUSYSONEPIPES~{PIPEP}
{PANELON}{WINDOWSON}
```

Figure B-40 SYSONEPUMPS macro.

The PIPEP macro referenced in the SYSONEPUMPS macro is located in cell Q136 and listed in Figure B-41. The purpose of this macro is to turn off spreadsheet protection, unprotect the input cells in the application system pipe input screen, position the cell pointer on the first input in the screen and turn spreadsheet protection back on.

```
PIPEP MACRO
{S}SGNQ{HOME}{DOWN}{RIGHT 7}{M}RPA~
{DOWN 3}{M}RPA~
{DOWN 4}{LEFT 4}{M}RPA{RIGHT 4}{DOWN 8}~
{HOME}{DOWN}{RIGHT 7}{S}SGYQ{RETURN}
```

Figure B-41 PIPEP macro.

The next macro to be executed is called SYSONEPIPES. The SYSONEPIPES macro begins in cell J147 and listed in Figure B-42. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system one pipe input screen, reassigns the range name \S to the next macro to execute, brings up the SYSONEEXTRAS window, executes the submacro EXTRAP and terminates.

The EXTRAP macro referenced in the SYSONEPIPES macro is located in cell Q143 and listed in Figure B-43. The purpose of this macro is to turn off spreadsheet protection, unprotect the input cells in the application system extras input screen, position the cell pointer on the first input in the screen, and turn spreadsheet protection back on.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSONEPIPEDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSONEPIPES}{M}E{RIGHT 5-NO.SYSONEPIPES}{DOWN 8}~
{M}RND\S~{M}RNC\S~SYSONEEXTRAS~
{S}WUSYSONEEXTRAS~{EXTRAP}
{HOME}{GOTO}SYSONEEXTRAANS~
{PANELON}{WINDOWSON}
```

Figure B-42 SYSONEPIPES macro.

```
EXTRAP MACRO
{S}SGNQ{HOME}{DOWN}{RIGHT 7}{M}RPA~
{DOWN 3}{M}RPA~
{DOWN 4}{LEFT 4}{M}RPA{RIGHT 4}{DOWN 7}~
{HOME}{DOWN}{RIGHT 7}{S}SGYQ{RETURN}
```

Figure B-43 EXTRAP macro.

The next macro to be executed is called SYSONEEXTRAS. The SYSONEEXTRAS macro begins in cell J167 and listed in Figure B-44. NOTE: The **** in Figure B-44 means that line is part of the line directly above it in the actual spreadsheet. Initially, the SYSONEEXTRAS macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window and erases any extra information from the system one extra input screen. Next, the number of applications systems on the farm is checked to see if it is less than two. If the number of applications is less than two, program control branches to the macro ENDSYSTEMINPUT which is described later in this write up. If the number of applications systems on the farm is greater than or equal to two, the SYSTEMTWO window is formatted to match the type of irrigation application system specified for system two. Once the correct irrigation application system type is found, the window is filled with the correct input prompts for that system. Submacros, whose names are indicative of the types of application systems, are used to facilitate formatting the input screen. After the window has been formatted correctly, program control is transferred to the SYSTEMTWO macro.

The SYSTEMTWO macro referenced in the SYSONEEXTRAS macro is listed in Figure B-45. The SYSTEMTWO macro begins in cell Q187. This macro locates the cell pointer on the first input in the SYSTEMTWO window, turns on spreadsheet protection, and reassigns the range name \S to the next macro to be executed.

The next macro to be executed is called SYSTWOPARTII. The SYSTWOPARTII macro begins in cell Q195 and listed in Figure B-46. This macro displays the WAIT window, reassigns the range name \S to the next macro to be executed, brings up the SYSTWOCANAL window, executes the submacro CANALP and terminates.

The next macro to be executed is called SYSTWOCANAL. The SYSTWOCANAL macro begins in cell J230 and listed in Figure B-47. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system two canal input screen, reassigns the range name \S to the next macro to execute, brings up the SYSTWOSTRUCTS window, executes the submacro STRUCTP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}WUSYSONEEXTRAS~{S}SGNQ
{GOTO}SYSONEEXTRADATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSONEEXTRAS}{M}E{RIGHT 5-NO.SYSONEEXTRAS}{DOWN 7}~
{IF NO.SYSTEMS<2}{BRANCH ENDSYSTEMINPUT}
{S}WUSYSTEMTWO~{HOME}{M}ESYSTEMTWODATA~{LET NO.FIELDSINSYS,@INDEX(SYSTEMFIELDS,1,0):VALUE}
{IF @INDEX(SYSTEMTYPE,1,0)=1}{M}RVBORDERSCREEN~~{BORDER}{M}RTSYSTEMNO.2~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,1,0)}{BORDER1}{M}RPPSYSTEMTWODATA~{BORDERP}{SYSTEMTWO}
{IF @INDEX(SYSTEMTYPE,1,0)=2}{M}RVFURROWSCREEN~~{FURROW}{M}RTSYSTEMNO.2~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,1,0)}{FURROW1}{M}RPPSYSTEMTWODATA~{FURROWP}{SYSTEMTWO}
{IF @INDEX(SYSTEMTYPE,1,0)=3}{M}RVSOLIDSETSCREEN~~{SOLIDSET}{M}RTSYSTEMNO.2~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,1,0)}{SOLIDSET1}{M}RPPSYSTEMTWODATA~{SOLIDSETP}{SYSTEMTWO}
{IF @INDEX(SYSTEMTYPE,1,0)=4}{M}RVHANDMOVESCREEN~~{SETMOVE}{M}RTSYSTEMNO.2~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,1,0)}{SETMOVE1}{M}RPPSYSTEMTWODATA~{SETMOVEP}{SYSTEMTWO}
{IF @INDEX(SYSTEMTYPE,1,0)=5}{M}RVSIDEROLLSCREEN~~{SETMOVE}{M}RTSYSTEMNO.2~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,1,0)}{SETMOVE1}{M}RPPSYSTEMTWODATA~{SETMOVEP}{SYSTEMTWO}
{IF @INDEX(SYSTEMTYPE,1,0)=6}{M}RVCENPIVOTSCREEN~~{CENTERPIVOT}{M}RTSYSTEMNO.2~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,1,0)}{CENTERPIVOT1}{M}RPPSYSTEMTWODATA~{CENTERPIVOTP}{SYSTEMTWO}
{IF @INDEX(SYSTEMTYPE,1,0)=7}{M}RVLINMOVESCREEN~~{LINEARMOVE}{M}RTSYSTEMNO.2~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,1,0)}{LINEARMOVE1}{M}RPPSYSTEMTWODATA~{LINEARMOVEP}{SYSTEMTWO}
{QUIT}
```

Figure B-44 SYSONEEXTRAS macro.

```
{HOME}{DOWN}2~{DOWN 2}{RIGHT 7}
{S}SGYQ
{M}RND\S~{M}RNC\S~SYSTWOPARTII~
{PANELON}{WINDOWSON}{QUIT}
```

Figure B-45 SYSTEMTWO macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{M}RND\S~{M}RNC\S~SYSTWOCANAL~
{S}WUSYSTWOCANAL~{CANALP}
{PANELON}{WINDOWSON}
```

Figure B-46 SYSTWOPARTII macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSTWOCANALDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTWOCANALS}{M}E{RIGHT 5-NO.SYSTWOCANALS}{DOWN 9}~
{M}RND\S~{M}RNC\S~SYSTWOSTRUCTS~
{S}WUSYSTWOSTRUCTS~{STRUCTP}
{PANELON}{WINDOWSON}
```

Figure B-47 SYSTWOCANAL macro.

The next macro to be executed is called SYSTWOSTRUCTS. The SYSTWOSTRUCTS macro begins in cell J251 and listed in Figure B-48. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system two structure input screen, reassigns the range name \S to the next macro to execute, brings up the SYSTWOPUMPS window, executes the submacro PUMPP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSTWOSTRUCTDAT~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTWOSTRUCT}{M}E{RIGHT 5-NO.SYSTWOSTRUCT}{DOWN 5}~
{M}RND\S~{M}RNC\S~SYSTWOPUMPS~
{S}WUSYSTWOPUMPS~{PUMPP}
{PANELON}{WINDOWSON}
```

Figure B-48 SYSTWOSTRUCTS macro.

The next macro to be executed is called SYSTWOPUMPS. The SYSTWOPUMPS macro begins in cell J271 and listed in Figure B-49. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system two pump input screen, reassigns the range name \S to the next macro to execute, brings up the SYSTWOPIPES window, executes the submacro PIPEP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSTWOPUMPDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTWOPUMPS}{M}E{RIGHT 5-NO.SYSTWOPUMPS}{DOWN 11}~
{M}RND\S~{M}RNC\S~SYSTWOPIPES~
{S}WUSYSTWOPIPES~{PIPEP}
{PANELON}{WINDOWSON}
```

Figure B-49 SYSTWOPUMPS macro.

The next macro to be executed is called SYSTWOPIPES. The SYSTWOPIPES macro begins in cell J294 and listed in Figure B-50. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system two pipe input screen, reassigns the range name \S to the next macro to execute, brings up the SYSTWOEXTRAS window, executes the submacro EXTRAP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSTWOPIPEDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTWOPIPES}{M}E{RIGHT 5-NO.SYSTWOPIPES}{DOWN 8}~
{M}RND\S~{M}RNC\S~SYSTWOEXTRAS~
{S}WUSYSTWOEXTRAS~{EXTRAP}
{HOME}{GOTO}SYSTWOEXTRAANS~
{PANELON}{WINDOWSON}
```

Figure B-50 SYSTWOPIPES macro.

The next macro to be executed is called SYSTWOEXTRAS. The SYSTWOEXTRAS macro begins in cell J314 and listed in Figure B-51. NOTE: The **** in Figure B-51 means that line is part of the line directly above it in the actual spreadsheet. Initially, the SYSTWOEXTRAS macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window and erases any extra information from the system two extra input screen. Next, the number of applications systems on the farm is checked to see if it is less than three. If the number of applications is less than three, program control branches to the macro ENDSYSTEMINPUT which is described later in this write up. If the number of applications systems on the farm is greater than or equal to three, the SYSTEMTHR window is formatted to match the type of irrigation application system specified for system three. Once the correct irrigation application system type is found, the window is filled with the correct input prompts for that system. Submacros, whose names are indicative of the types of application systems, are again used to facilitate formatting the input screen. After the window has been formatted correctly, program control is transferred to the SYSTEMTHR macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}WUSYSTWOEXTRAS~{S}SGNQ
{GOTO}SYSTWOEXTRADATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTWOEXTRAS}{M}E{RIGHT 5-NO.SYSTWOEXTRAS}{DOWN 7}~
{IF NO.SYSTEMS<3}{BRANCH ENDSYSTEMINPUT}
{S}WUSYSTEMTHR~{HOME}{M}ESYSTEMTHRDATA~{LET NO.FIELDSINSYS,@INDEX(SYSTEMFIELDS,2,0):VALUE}
{IF @INDEX(SYSTEMTYPE,2,0)=1}{M}RVBORDERSCREEN~~{BORDER}{M}RTSYSTEMNO.3~~
 **** {RIGHT@INDEX(SYSTEMFIELDS,2,0)}{BORDER1}{M}RPPSYSTEMTHRDATA~{BORDERP}{SYSTEMTHR}
{IF @INDEX(SYSTEMTYPE,2,0)=2}{M}RVFURROWSCREEN~~{FURROW}{M}RTSYSTEMNO.3~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,2,0)}{FURROW1}{M}RPPSYSTEMTHRDATA~{FURROWP}{SYSTEMTHR}
{IF @INDEX(SYSTEMTYPE,2,0)=3}{M}RVSOLIDSETSCREEN~~{SOLIDSET}{M}RTSYSTEMNO.3~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,2,0)}{SOLIDSET1}{M}RPPSYSTEMTHRDATA~{SOLIDSETP}{SYSTEMTHR}
{IF @INDEX(SYSTEMTYPE,2,0)=4}{M}RVHANDMOVESCREEN~~{SETMOVE}{M}RTSYSTEMNO.3~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,2,0)}{SETMOVE1}{M}RPPSYSTEMTHRDATA~{SETMOVEP}{SYSTEMTHR}
{IF @INDEX(SYSTEMTYPE,2,0)=5}{M}RVSIDEROLLSCREEN~~{SETMOVE}{M}RTSYSTEMNO.3~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,2,0)}{SETMOVE1}{M}RPPSYSTEMTHRDATA~{SETMOVEP}{SYSTEMTHR}
{IF @INDEX(SYSTEMTYPE,2,0)=6}{M}RVCENPIVOTSCREEN~~{CENTERPIVOT}{M}RTSYSTEMNO.3~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,2,0)}{CENTERPIVOT1}{M}RPPSYSTEMTHRDATA~{CENTERPIVOTP}{SYSTEMTHR}
{IF @INDEX(SYSTEMTYPE,2,0)=7}{M}RVLINMOVESCREEN~~{LINEARMOVE}{M}RTSYSTEMNO.3~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,2,0)}{LINEARMOVE1}{M}RPPSYSTEMTHRDATA~{LINEARMOVEP}{SYSTEMTHR}
{QUIT}
```

Figure B-51 SYSTWOEXTRAS macro.

The SYSTEMTHR macro referenced in the SYSTWOEXTRAS macro is listed in Figure B-52. The SYSTEMTHR macro begins in cell Q341. This macro locates the cell pointer on the first input in the SYSTEMTHR window, turns on spreadsheet protection, and reassigns the range name \S to the next macro to be executed.

```
{HOME}{DOWN}3~{DOWN 2}{RIGHT 7}
{S}SGYQ
{M}RND\S~{M}RNC\S~SYSTHRPARTII~
{PANELON}{WINDOWSON}{QUIT}
```

Figure B-52 SYSTEMTHR macro.

The next macro to be executed is called SYSTHRPARTII. The SYSTHRPARTII macro begins in cell Q349 and listed in Figure B-53. This macro displays the WAIT window, reassigns the range name \S to the next macro to be executed, brings up the SYSTHRCANAL window, executes the submacro CANALP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{M}RND\S~{M}RNC\S~SYSTHRCANAL~
{S}WUSYSTHRCANAL~{CANALP}
{PANELON}{WINDOWSON}
```

Figure B-53 SYSTHRPARTII macro.

The next macro to be executed is called SYSTHRCANAL. The SYSTHRCANAL macro begins in cell J377 and listed in Figure B-54. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system three canal input screen, reassigns the range name \S to the next macro to execute, brings up the SYSTHRSTRUCTS window, executes the submacro STRUCTP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSTHRCANALDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTHRCANALS}{M}E{RIGHT 5-NO.SYSTHRCANALS}{DOWN 9}~
{M}RND\S~{M}RNC\S~SYSTHRSTRUCTS~
{S}WUSYSTHRSTRUCTS~{STRUCTP}
{PANELON}{WINDOWSON}
```

Figure B-54 SYSTHRCANAL macro.

The next macro to be executed is called SYSTHRSTRUCTS. The SYSTHRSTRUCTS macro begins in cell J398 and listed in Figure B-55. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system three structure input screen, reassigns the range name \S to the next macro to execute, brings up the SYSTHRPUMPS window, executes the submacro PUMPP and terminates.

The next macro to be executed is called SYSTHRPUMPS. The SYSTHRPUMPS macro begins in cell J418 and listed in Figure B-56. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system three pump input screen, reassigns the range name \S to the next macro to execute, brings up the SYSTHRPIPES window, executes the submacro PIPEP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSTHRSTRUCTDAT~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTHRSTRUCT}{M}E{RIGHT 5-NO.SYSTHRSTRUCT}{DOWN 5}~
{M}RND\S~{M}RNC\S~SYSTHRPUMPS~
{S}WUSYSTHRPUMPS~{PUMPP}
{PANELON}{WINDOWSON}
```

Figure B-55 SYSTHRSTRUCTS macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSTHRPUMPDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTHRPUMPS}{M}E{RIGHT 5-NO.SYSTHRPUMPS}{DOWN 11}~
{M}RND\S~{M}RNC\S~SYSTHRPIPES~
{S}WUSYSTHRPIPES~{PIPEP}
{PANELON}{WINDOWSON}
```

Figure B-56 SYSTHRPUMPS macro.

The next macro to be executed is called SYSTHRPIPES. The SYSTHRPIPES macro begins in cell J441 and listed in Figure B-57. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system three pipe input screen, reassigns the range name \S to the next macro to execute, brings up the SYSTHREXTRAS window, executes the submacro EXTRAP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSTHRPIPEDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTHRPIPES}{M}E{RIGHT 5-NO.SYSTHRPIPES}{DOWN 8}~
{M}RND\S~{M}RNC\S~SYSTHREXTRAS~
{S}WUSYSTHREXTRAS~{EXTRAP}
{PANELON}{WINDOWSON}
```

Figure B-57 SYSTHRPIPES macro.

The next macro to be executed is called SYSTHREXTRAS. The SYSTHREXTRAS macro begins in cell J461 and listed in Figure B-58. NOTE: The **** in Figure B-58 means that line is part of the line directly above it in the actual spreadsheet. Initially, the SYSTHREXTRAS macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window and erases any extra information from the system three extra input screen. Next, the number of applications systems on the farm is checked to see if it is less than four. If the number of applications is less than four, program control branches to the macro ENDSYSTEMINPUT which is described later in this write up. If the number of applications systems on the farm is greater than or equal to four, the SYSTEMFOR window is formatted to match the type of irrigation application system specified for system four. Once the correct irrigation application system type is found, the window is filled with the correct input prompts for that system. Submacros. whose names are indicative of the types of application systems, are again used to facilitate formatting the input screen. After the window has been formatted correctly, program control is transferred to the SYSTEMFOR macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}WUSYSTHREXTRAS~{S}SGNQ
{GOTO}SYSTHREXTRADATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSTHREXTRAS}{M}E{RIGHT 5-NO.SYSTHREXTRAS}{DOWN 7}~
{IF NO.SYSTEMS<4}{BRANCH ENDSYSTEMINPUT}
{S}WUSYSTEMFOR~{HOME}{M}ESYSTEMFORDATA~{LET NO.FIELDSINSYS,@INDEX(SYSTEMFIELDS,3,0):VALUE}
{IF @INDEX(SYSTEMTYPE,3,0)=1}{M}RVBORDERSCREEN~~{BORDER}{M}RTSYSTEMNO.4~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,3,0)}{BORDER1}{M}RPPSYSTEMFORDATA~{BORDERP}{SYSTEMFOR}
{IF @INDEX(SYSTEMTYPE,3,0)=2}{M}RVFURROWSCREEN~~{FURROW}{M}RTSYSTEMNO.4~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,3,0)}{FURROW1}{M}RPPSYSTEMFORDATA~{FURROWP}{SYSTEMFOR}
{IF @INDEX(SYSTEMTYPE,3,0)=3}{M}RVSOLIDSETSCREEN~~{SOLIDSET}{M}RTSYSTEMNO.4~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,3,0)}{SOLIDSET1}{M}RPPSYSTEMFORDATA~{SOLIDSETP}{SYSTEMFOR}
{IF @INDEX(SYSTEMTYPE,3,0)=4}{M}RVHANDMOVESCREEN~~{SETMOVE}{M}RTSYSTEMNO.4~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,3,0)}{SETMOVE1}{M}RPPSYSTEMFORDATA~{SETMOVEP}{SYSTEMFOR}
{IF @INDEX(SYSTEMTYPE,3,0)=5}{M}RVSIDEROLLSCREEN~~{SETMOVE}{M}RTSYSTEMNO.4~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,3,0)}{SETMOVE1}{M}RPPSYSTEMFORDATA~{SETMOVEP}{SYSTEMFOR}
{IF @INDEX(SYSTEMTYPE,3,0)=6}{M}RVCENPIVOTSCREEN~~{CENTERPIVOT}{M}RTSYSTEMNO.4~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,3,0)}{CENTERPIVOT1}{M}RPPSYSTEMFORDATA~{CENTERPIVOTP}{SYSTEMFOR}
{IF @INDEX(SYSTEMTYPE,3,0)=7}{M}RVLINMOVESCREEN~~{LINEARMOVE}{M}RTSYSTEMNO.4~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,3,0)}{LINEARMOVE1}{M}RPPSYSTEMFORDATA~{LINEARMOVEP}{SYSTEMFOR}
{QUIT}
```

Figure B-58 SYSTHREXTRAS macro.

The SYSTEMFOR macro referenced in the SYSTHREXTRAS macro is listed in Figure B-59. The SYSTEMFOR macro begins in cell Q483. This macro locates the cell pointer on the first input in the SYSTEMFOR window, turns on spreadsheet protection, and reassigns the range name \S to the next macro to be executed.

```
{HOME}{DOWN}4~{DOWN 2}{RIGHT 7}
{S}SGYQ
{M}RND\S~{M}RNC\S~SYSFORPARTII~
{PANELON}{WINDOWSON}{QUIT}
```

Figure B-59 SYSTEMFOR macro.

The next macro to be executed is called SYSFORPARTII. The SYSFORPARTII macro begins in cell Q491 and listed in Figure B-60. This macro displays the WAIT window, reassigns the range name \S to the next macro to be executed, brings up the SYSFORCANAL window, executes the submacro CANALP and terminates.

The next macro to be executed is called SYSFORCANAL. The SYSFORCANAL macro begins in cell J524 and listed in Figure B-61. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system four canal input screen, reassigns the range name \S to the next macro to execute, brings up the SYSFORSTRUCTS window, executes the submacro STRUCTP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{M}RND\S~{M}RNC\S~SYSFORCANAL~
{S}WUSYSFORCANAL~{CANALP}
{PANELON}{WINDOWSON}
```

Figure B-60 SYSFORPARTII macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSFORCANALDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFORCANALS}{M}E{RIGHT 5-NO.SYSFORCANALS}{DOWN 9}~
{M}RND\S~{M}RNC\S~SYSFORSTRUCTS~
{S}WUSYSFORSTRUCTS~{STRUCTP}
{PANELON}{WINDOWSON}
```

Figure B-61 SYSFORCANAL macro.

The next macro to be executed is called SYSFORSTRUCTS. The SYSFORSTRUCTS macro begins in cell J545 and listed in Figure B-62. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system four structure input screen, reassigns the range name \S to the next macro to execute, brings up the SYSFORPUMPS window, executes the submacro PUMPP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSFORSTRUCTDAT~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFORSTRUCT}{M}E{RIGHT 5-NO.SYSFORSTRUCT}{DOWN 5}~
{M}RND\S~{M}RNC\S~SYSFORPUMPS~
{S}WUSYSFORPUMPS~{PUMPP}
{PANELON}{WINDOWSON}
```

Figure B-62 SYSFORSTRUCTS macro.

The next macro to be executed is called SYSFORPUMPS. The SYSFORPUMPS macro begins in cell J565 and listed in Figure B-63. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system four pump input screen, reassigns the range name \S to the next macro to execute, brings up the SYSFORPIPES window, executes the submacro PIPEP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSFORPUMPDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFORPUMPS}{M}E{RIGHT 5-NO.SYSFORPUMPS}{DOWN 11}~
{M}RND\S~{M}RNC\S~SYSFORPIPES~
{S}WUSYSFORPIPES~{PIPEP}
{PANELON}{WINDOWSON}
```

Figure B-63 SYSFORPUMPS macro.

The next macro to be executed is called SYSFORPIPES. The SYSFORPIPES macro begins in cell J588 and listed in Figure B-64. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system four pipe input screen, reassigns the range name \S to the next macro to execute, brings up the SYSFOREXTRAS window, executes the submacro EXTRAP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSFORPIPEDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFORPIPES}{M}E{RIGHT 5-NO.SYSFORPIPES}{DOWN 8}~
{M}RND\S~{M}RNC\S~SYSFOREXTRAS~
{S}WUSYSFOREXTRAS~{EXTRAP}
{PANELON}{WINDOWSON}
```

Figure B-64 SYSFORPIPES macro.

The next macro to be executed is called SYSFOREXTRAS. The SYSFOREXTRAS macro begins in cell J608 and listed in Figure B-65. NOTE: The **** in Figure B-65 means that line is part of the line directly above it in the actual spreadsheet. Initially, the SYSFOREXTRAS macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window and erases any extra information from the system four extra input screen. Next, the number of applications systems on the farm is checked to see if it is less than five. If the number of applications is less than five, program control branches to the macro ENDSYSTEMINPUT which is described later in this write up. If the number of applications systems on the farm is greater than or equal to five, the SYSTEMFIV window is formatted to match the type of irrigation application system specified for system five. Once the correct irrigation application system type is found, the window is filled with the correct input prompts for that system. Submacros, whose names are indicative of the types of application systems, are again used to facilitate formatting the input screen. After the window has been formatted correctly, program control is transferred to the SYSTEMFIV macro.

The SYSTEMFIV macro referenced in the SYSFOREXTRAS macro is listed in Figure B-66. The SYSTEMFIV macro begins in cell Q625. This macro locates the cell pointer on the first input in the SYSTEMFIV window, turns on spreadsheet protection, and reassigns the range name \S to the next macro to be executed.

The next macro to be executed is called SYSFIVPARTII. The SYSFIVPARTII macro begins in cell Q625 and listed in Figure B-67. This macro displays the WAIT window, reassigns the range name \S to the next macro to be executed, brings up the SYSFIVCANAL window, executes the submacro CANALP and terminates.

The next macro to be executed is called SYSFIVCANAL. The SYSFIVCANAL macro begins in cell J671 and listed in Figure B-68. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system five canal input screen, reassigns the range name \S to the next macro to execute, brings up the SYSFIVSTRUCTS window, executes the submacro STRUCTP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}WUSYSFOREXTRAS~{S}SGNQ
{GOTO}SYSFOREXTRADATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFOREXTRAS}{M}E{RIGHT 5-NO.SYSFOREXTRAS}{DOWN 7}~
{IF NO.SYSTEMS<5}{BRANCH ENDSYSTEMINPUT}
{S}WUSYSTEMFIV~{HOME}{M}ESYSTEMFIVDATA~{LET NO.FIELDSINSYS,@INDEX(SYSTEMFIELDS,4,0):VALUE}
{IF @INDEX(SYSTEMTYPE,4,0)=1}{M}RVBORDERSCREEN~~{BORDER}{M}RTSYSTEMNO.5~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,4,0)}{BORDER1}{M}RPPSYSTEMFIVDATA~{BORDERP}{SYSTEMFIV}
{IF @INDEX(SYSTEMTYPE,4,0)=2}{M}RVFURROWSCREEN~~{FURROW}{M}RTSYSTEMNO.5~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,4,0)}{FURROW1}{M}RPPSYSTEMFIVDATA~{FURROWP}{SYSTEMFIV}
{IF @INDEX(SYSTEMTYPE,4,0)=3}{M}RVSOLIDSETSCREEN~~{SOLIDSET}{M}RTSYSTEMNO.5~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,4,0)}{SOLIDSET1}{M}RPPSYSTEMFIVDATA~{SOLIDSETP}{SYSTEMFIV}
{IF @INDEX(SYSTEMTYPE,4,0)=4}{M}RVHANDMOVESCREEN~~{SETMOVE}{M}RTSYSTEMNO.5~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,4,0)}{SETMOVE1}{M}RPPSYSTEMFIVDATA~{SETMOVEP}{SYSTEMFIV}
{IF @INDEX(SYSTEMTYPE,4,0)=5}{M}RVSIDEROLLSCREEN~~{SETMOVE}{M}RTSYSTEMNO.5~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,4,0)}{SETMOVE1}{M}RPPSYSTEMFIVDATA~{SETMOVEP}{SYSTEMFIV}
{IF @INDEX(SYSTEMTYPE,4,0)=6}{M}RVCENPIVOTSCREEN~~{CENTERPIVOT}{M}RTSYSTEMNO.5~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,4,0)}{CENTERPIVOT1}{M}RPPSYSTEMFIVDATA~{CENTERPIVOTP}{SYSTEMFIV}
{IF @INDEX(SYSTEMTYPE,4,0)=7}{M}RVLINMOVESCREEN~~{LINEARMOVE}{M}RTSYSTEMNO.5~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,4,0)}{LINEARMOVE1}{M}RPPSYSTEMFIVDATA~{LINEARMOVEP}{SYSTEMFIV}
{QUIT}
```

Figure B-65 SYSFOREXTRAS macro.

```
{HOME}{DOWN}5~{DOWN 2}{RIGHT 7}
{S}SGNQ
{M}RND\S~{M}RNC\S~SYSFIVPARTII~
{PANELON}{WINDOWSON}{QUIT}
```

Figure B-66 SYSTEMFIV macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{M}RND\S~{M}RNC\S~SYSFIVCANAL~
{S}WUSYSFIVCANAL~{CANALP}
{PANELON}{WINDOWSON}
```

Figure B-67 SYSFIVPARTII macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSFIVCANALDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFIVCANALS}{M}E{RIGHT 5-NO.SYSFIVCANALS}{DOWN 9}~
{M}RND\S~{M}RNC\S~SYSFIVSTRUCTS~
{S}WUSYSFIVSTRUCTS~{STRUCTP}
{PANELON}{WINDOWSON}
```

Figure B-68 SYSFIVCANAL macro.

The next macro to be executed is called SYSFIVSTRUCTS. The SYSFIVSTRUCTS macro begins in cell J692 and listed in Figure B-69. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system five structure input screen, reassigns the range name \S to the next macro to execute, brings up the SYSFIVPUMPS window, executes the submacro PUMPP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSFIVSTRUCTDAT~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFIVSTRUCT}{M}E{RIGHT 5-NO.SYSFIVSTRUCT}{DOWN 5}~
{M}RND\S~{M}RNC\S~SYSFIVPUMPS~
{S}WUSYSFIVPUMPS~{PUMPP}
{PANELON}{WINDOWSON}
```

Figure B-69 SYSFIVSTRUCTS macro.

The next macro to be executed is called SYSFIVPUMPS. The SYSFIVPUMPS macro begins in cell J712 and listed in Figure B-70. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system five pump input screen, reassigns the range name \S to the next macro to execute, brings up the SYSFIVPIPES window, executes the submacro PIPEP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSFIVPUMPDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFIVPUMPS}{M}E{RIGHT 5-NO.SYSFIVPUMPS}{DOWN 11}~
{M}RND\S~{M}RNC\S~SYSFIVPIPES~
{S}WUSYSFIVPIPES~{PIPEP}
{PANELON}{WINDOWSON}
```

Figure B-70 SYSFIVPUMPS macro.

The next macro to be executed is called SYSFIVPIPES. The SYSFIVPIPES macro begins in cell J735 and listed in Figure B-71. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system five pipe input screen, reassigns the range name \S to the next macro to execute, brings up the SYSFIVEXTRAS window, executes the submacro EXTRAP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSFIVPIPEDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFIVPIPES}{M}E{RIGHT 5-NO.SYSFIVPIPES}{DOWN 8}~
{M}RND\S~{M}RNC\S~SYSFIVEXTRAS~
{S}WUSYSFIVEXTRAS~{EXTRAP}
{PANELON}{WINDOWSON}
```

Figure B-71 SYSFIVPIPES macro.

The next macro to be executed is called SYSFIVEXTRAS. The SYSFIVEXTRAS macro begins in cell J755 and listed in Figure B-72. NOTE:

The **** in Figure B-72 means that line is part of the line directly above it in the actual spreadsheet. Initially, the SYSFIVEXTRAS macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window and erases any extra information from the system five extra input screen. Next, the number of applications systems on the farm is checked to see if it is less than six. If the number of applications is less than six, program control branches to the macro ENDSYSTEMINPUT which is described later in this write up. If the number of applications systems on the farm is greater than or equal to six, the SYSTEMSIX window is formatted to match the type of irrigation application system specified for system six. Once the correct irrigation application system type is found, the window is filled with the correct input prompts for that system. Submacros, whose names are indicative of the types of application systems, are again used to facilitate formatting the input screen. After the window has been formatted correctly, program control is transferred to the SYSTEMSIX macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}WUSYSFIVEXTRAS~{S}SGNQ
{GOTO}SYSFIVEXTRADATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSFIVEXTRAS}{M}E{RIGHT 5-NO.SYSFIVEXTRAS}{DOWN 7}~
{IF NO.SYSTEMS<6}{BRANCH ENDSYSTEMINPUT}
{S}WUSYSTEMSIX~{HOME}{M}ESYSTEMSIXDATA~{LET NO.FIELDSINSYS,@INDEX(SYSTEMFIELDS,5,0):VALUE}
{IF @INDEX(SYSTEMTYPE,5,0)=1}{M}RVBORDERSCREEN~~{BORDER}{M}RTSYSTEMNO.6~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,5,0)}{BORDER1}{M}RPPSYSTEMSIXDATA~{BORDERP}{SYSTEMSIX}
{IF @INDEX(SYSTEMTYPE,5,0)=2}{M}RVFURROWSCREEN~~{FURROW}{M}RTSYSTEMNO.6~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,5,0)}{FURROW1}{M}RPPSYSTEMSIXDATA~{FURROWP}{SYSTEMSIX}
{IF @INDEX(SYSTEMTYPE,5,0)=3}{M}RVSOLIDSETSCREEN~~{SOLIDSET}{M}RTSYSTEMNO.6~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,5,0)}{SOLIDSET1}{M}RPPSYSTEMSIXDATA~{SOLIDSETP}{SYSTEMSIX}
{IF @INDEX(SYSTEMTYPE,5,0)=4}{M}RVHANDMOVESCREEN~~{SETMOVE}{M}RTSYSTEMNO.6~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,5,0)}{SETMOVE1}{M}RPPSYSTEMSIXDATA~{SETMOVEP}{SYSTEMSIX}
{IF @INDEX(SYSTEMTYPE,5,0)=5}{M}RVSIDEROLLSCREEN~~{SETMOVE}{M}RTSYSTEMNO.6~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,5,0)}{SETMOVE1}{M}RPPSYSTEMSIXDATA~{SETMOVEP}{SYSTEMSIX}
{IF @INDEX(SYSTEMTYPE,5,0)=6}{M}RVCENPIVOTSCREEN~~{CENTERPIVOT}{M}RTSYSTEMNO.6~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,5,0)}{CENTERPIVOT1}{M}RPPSYSTEMSIXDATA~{CENTERPIVOTP}{SYSTEMSIX}
{IF @INDEX(SYSTEMTYPE,5,0)=7}{M}RVLINMOVESCREEN~~{LINEARMOVE}{M}RTSYSTEMNO.6~~
 **** {RIGHT @INDEX(SYSTEMFIELDS,5,0)}{LINEARMOVE1}{M}RPPSYSTEMSIXDATA~{LINEARMOVEP}{SYSTEMSIX}
{QUIT}
```

Figure B-72 SYSFIVEXTRAS macro.

The SYSTEMSIX macro referenced in the SYSFIVEXTRAS macro is listed in Figure B-73. The SYSTEMSIX macro begins in cell Q900. This macro locates the cell pointer on the first input in the SYSTEMSIX window, turns on spreadsheet protection, and reassigns the range name \S to the next macro to be executed.

The next macro to be executed is called SYSSIXPARTII. The SYSSIXPARTII macro begins in cell Q908 and listed in Figure B-74. This macro displays the WAIT window, reassigns the range name \S to the next macro to be executed, brings up the SYSSIXCANAL window, executes the submacro CANALP and terminates.

```
{HOME}{DOWN}6~{DOWN 2}{RIGHT 7}
{S}SGYQ
{M}RND\S~{M}RNC\S~SYSSIXPARTII~
{PANELON}{WINDOWSON}{QUIT}
```

Figure B-73 SYSTEMSIX macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}
{M}RND\S~{M}RNC\S~SYSSIXCANAL~
{S}WUSYSSIXCANAL~{CANALP}
{PANELON}{WINDOWSON}
```

Figure B-74 SYSSIXPARTII macro.

The next macro to be executed is called SYSSIXCANAL. The SYSSIXCANAL macro begins in cell J950 and listed in Figure B-75. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system six canal input screen, reassigns the range name \S to the next macro to execute, brings up the SYSSIXSTRUCTS window, executes the submacro STRUCTP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSSIXCANALDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSSIXCANALS}{M}E{RIGHT 5-NO.SYSSIXCANALS}{DOWN 9}~
{M}RND\S~{M}RNC\S~SYSSIXSTRUCTS~
{S}WUSYSSIXSTRUCTS~{STRUCTP}
{PANELON}{WINDOWSON}
```

Figure B-75 SYSSIXCANAL macro.

The next macro to be executed is called SYSSIXSTRUCTS. The SYSSIXSTRUCTS macro begins in cell J971 and listed in Figure B-76. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system six structure input screen, reassigns the range name \S to the next macro to execute, brings up the SYSSIXPUMPS window, executes the submacro PUMPP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSSIXSTRUCTDAT~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSSIXSTRUCT}{M}E{RIGHT 5-NO.SYSSIXSTRUCT}{DOWN 5}~
{M}RND\S~{M}RNC\S~SYSSIXPUMPS~
{S}WUSYSSIXPUMPS~{PUMPP}
{PANELON}{WINDOWSON}
```

Figure B-76 SYSSIXSTRUCTS macro.

The next macro to be executed is called SYSSIXPUMPS. The SYSSIXPUMPS macro begins in cell J991 and listed in Figure B-77. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system six pump input screen, reassigns the range name \S to the next macro to execute, brings up the SYSSIXPIPES window, executes the submacro PIPEP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSSIXPUMPDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSSIXPUMPS}{M}E{RIGHT 5-NO.SYSSIXPUMPS}{DOWN 11}~
{M}RND\S~{M}RNC\S~SYSSIXPIPES~
{S}WUSYSSIXPIPES~{PIPEP}
{PANELON}{WINDOWSON}
```

Figure B-77 SYSSIXPUMPS macro.

The next macro to be executed is called SYSSIXPIPES. The SYSSIXPIPES macro begins in cell J1014 and listed in Figure B-78. This macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window, erases any extra information from the system six pipe input screen, reassigns the range name \S to the next macro to execute, brings up the SYSSIXEXTRAS window, executes the submacro EXTRAP and terminates.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSSIXPIPEDATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSSIXPIPES}{M}E{RIGHT 5-NO.SYSSIXPIPES}{DOWN 8}~
{M}RND\S~{M}RNC\S~SYSSIXEXTRAS~
{S}WUSYSSIXEXTRAS~{EXTRAP}
{HOME}{GOTO}SYSSIXEXTRAANS~
{PANELON}{WINDOWSON}
```

Figure B-78 SYSSIXPIPES macro.

The next macro to be executed is called SYSSIXEXTRAS. The SYSSIXEXTRAS macro begins in cell J1034 and listed in Figure B-79. The SYSSIXEXTRAS macro displays the WAIT window, turns off spreadsheet protection, enters the MAIN window and erases any extra information from the system six extra input screen. Then program control transfers to the ENDSYSTEMINPUT macro.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}SYSSIXEXTRADATA~{DOWN 4}{RIGHT 3}
{RIGHT NO.SYSSIXEXTRAS}{M}E{RIGHT 5-NO.SYSSIXEXTRAS}{DOWN 7}~
{BRANCH ENDSYSTEMINPUT}
```

Figure B-79 SYSSIXEXTRAS macro.

The ENDSYSTEMINPUT macro referenced in all of the application system SYS___EXTRAS macros is listed in Figure B-80. The purpose of this macro is to branch out of the application system information input routine and request information on farm drainage system requirements. The macro formats the DRAINAGE window, unprotects the input areas of the window, reassigns the range name \S to the next macro to be executed, turns spreadsheet protection back on and displays the drainage system input screen.

```
{S}WUDRAINAGE~
{M}RND\S~{M}RNC\S~DRAINAGE~
{GOTO}DRAINAGEANS~
{M}RPA~{DOWN 3}{M}RPA~
{DOWN 2}{LEFT 3}{M}RPA{RIGHT 10}~
{DOWN 2}{M}RPA{DOWN 12}{RIGHT 10}~
{HOME}{DOWN 7}{RIGHT 3}{M}C~{RIGHT}{TAB}{RIGHT 10}~
{DOWN 14}{M}C~{RIGHT}{TAB}{RIGHT 10}~
{HOME}{GOTO}DRAINAGEANS~
{S}SGYQ{PANELON}{WINDOWSON}
```

Figure B-80 ENDSYSTEMINPUT macro.

The next macro to be executed is called DRAINAGE. The DRAINAGE macro begins in cell O771 and listed in Figure B-81. This macro turns off spreadsheet protection, erases any extra information from the drainage input screen, brings up the SIMULATE window, unprotects the input cells in the window, positions the cell pointer on the first input in the window, reassigns the range name \S to the next macro to be executed and turns spreadsheet protection back on.

```
{PANELOFF}{S}WUWAIT~{WINDOWSOFF}{S}SGNQ{S}WUMAIN~
{GOTO}DRAINAGEDATA~{DOWN 2}{RIGHT 4}
{RIGHT NO.DRAINFIELDS}{M}E{RIGHT 9-NO.DRAINFIELDS}{DOWN 16}~
{S}WUSIMULATE~{HOME}{DOWN 4}{RIGHT 7}{M}RPA~
{DOWN 3}{M}RPA~{DOWN 3}{M}RPA~{DOWN 4}{M}RPA~
{HOME}{DOWN 4}{RIGHT 7}
{M}RND\S~{M}RNC\S~SIMULATE~
{S}SGYQ{PANELON}{WINDOWSON}
```

Figure B-81 DRAINAGE macro.

The last macro dealing with data input is named SIMULATE. The SIMULATE macro is located in cell J799 and listed in Figure B-82. This macro displays the DATAFILE2 window, turns off spreadsheet protection, executes the submacro OUTPUT, turns spreadsheet protection back on, sets EDIT as the macro to automatically executed when the spreadsheet is loaded, brings up the SAVEWORKSHEET2 window, reassigns the range name \S to the next macro to execute and causes the computer to beep twice.

```
{WINDOWSOFF}{PANELOFF}
{S}WUDATAFILE2~
{WINDOWSON}{WINDOWSOFF}{S}WUMAIN~
{S}SGNQ{OUTPUT}{S}SGYQ
{M}RND\S~{S}SASEDIT~Q
{S}WUSAVEWORKSHEET2~
{M}RNC\S~EDITDATA~
{BEEP}{BEEP}{PANELON}{WINDOWSON}
```

Figure B-82 SIMULATE macro.

The OUTPUT macro referenced in the SIMULATE macro is located in cell Y314 and listed in Figure B-83. The purpose of this macro is to copy and arrange the input information entered in the various windows of the part two spreadsheet to the end of the data created in the part one spreadsheet. The input data is arranged in the spreadsheet as it appears in the data file. SYMPHONY's Range Values command is used instead of the Copy command to arrange the input information as only the values are desired not formulas, secondly it is quicker than the Copy command. Every data item appearing in the data file is referenced by a range name. A list of ranges names appearing in the part two spreadsheet is given at the end of this write up. When the data for the number of applications systems specified on the farm has been copied and arranged, the OUTPUT macro branches to the ENDSYSTEMOUTPUT macro.

```
{GOTO}OUTPUTCONT~
+NO.SYSTEMS~
{RIGHT}'-- SEPARATE APPLICATION SYSTEMS ARE TO BE CONSIDERED~
{LEFT}{DOWN 2}{M}RVSYSTEMDATA~~
{RIGHT 2}{RIGHT NO.SYSTEMS}{M}E{RIGHT 8-NO.SYSTEMS}{DOWN 14}~
{LEFT}{DOWN 4}{END}{LEFT}{DOWN 1+@MAX(SYSTEMFIELDS)}
{M}E{DOWN 8-@MAX(SYSTEMFIELDS)}{RIGHT 2+NO.SYSTEMS}~
\-~{M}C~{RIGHT}{TAB}{RIGHT NO.SYSTEMS}~
{DOWN 2}{M}RVSYSTEMONEDATA~~{M}E~~
{DOWN}{M}M{RIGHT}~{RIGHT}~SYSTEM No. 1~
{DOWN 40}{END}{UP}{DOWN}{M}E{RIGHT 5}~
{DOWN 2}    APPLICATION SYSTEM No. 1 OPEN CHANNEL REQUIREMENTS:~
{DOWN 2}+SYSONECANALANS~
{RIGHT}'-- OPEN CHANNELS ARE REQUIRED~{LEFT}
{IF SYSONECANALANS="YES"#OR#SYSONECANALANS="yes"}{DOWN 2}{M}RVSYSONECANALDATA~~{DOWN 14}
{DOWN 3}'    APPLICATION SYSTEM No. 1 STRUCTURE REQUIREMENTS:~
{DOWN 2}+SYSONESTRUCTANS~
{RIGHT}'-- STRUCTURES ARE REQUIRED~{LEFT}
{IF SYSONESTRUCTANS="YES"#OR#SYSONESTRUCTANS="yes"}{DOWN 2}{M}RVSYSONESTRUCTDAT~~{DOWN 10}
{DOWN 3}'    APPLICATION SYSTEM No. 1 PUMP REQUIREMENTS:~
{DOWN 2}+SYSONEPUMPANS~
{RIGHT}'-- PUMPS ARE REQUIRED~{LEFT}
{IF SYSONEPUMPANS="YES"#OR#SYSONEPUMPANS="yes"}{DOWN 2}{M}RVSYSONEPUMPDATA~~{DOWN 16}
```

Figure B-83 OUTPUT macro.

```
{DOWN 3}'     APPLICATION SYSTEM No. 1 PIPELINE REQUIREMENTS:~
{DOWN 2}+SYSONEPIPEANS~
{RIGHT}'-- PIPELINES ARE REQUIRED~{LEFT}
{IF SYSONEPIPEANS="YES"#OR#SYSONEPIPEANS="yes"}{DOWN 2}{M}RVSYSONEPIPEDATA~~{DOWN 13}
{DOWN 3}'     APPLICATION SYSTEM No. 1 EXTRA EXPENSE REQUIREMENTS:~
{DOWN 2}+SYSONEEXTRAANS~
{RIGHT}'-- EXTRA EXPENSES ARE REQUIRED~{LEFT}
{IF SYSONEEXTRAANS="YES"#OR#SYSONEEXTRAANS="yes"}{DOWN 2}{M}RVSYSONEEXTRADATA~~{DOWN 12}
{IF NO.SYSTEMS<2}{BRANCH ENDSYSTEMOUTPUT}
{DOWN 2}{M}RVSYSTEMTWODATA~~{M}E~~
{DOWN}{M}M{RIGHT}~{RIGHT}~SYSTEM No. 2~
{DOWN 40}{END}{UP}{DOWN}{M}E{RIGHT 5}~
{DOWN 2}    APPLICATION SYSTEM No. 2 OPEN CHANNEL REQUIREMENTS:~
{DOWN 2}+SYSTWOCANALANS~
{RIGHT}'-- OPEN CHANNELS ARE REQUIRED~{LEFT}
{IF SYSTWOCANALANS="YES"#OR#SYSTWOCANALANS="yes"}{DOWN 2}{M}RVSYSTWOCANALDATA~~{DOWN 14}
{DOWN 3}'     APPLICATION SYSTEM No. 2 STRUCTURE REQUIREMENTS:~
{DOWN 2}+SYSTWOSTRUCTANS~
{RIGHT}'-- STRUCTURES ARE REQUIRED~{LEFT}
{IF SYSTWOSTRUCTANS="YES"#OR#SYSTWOSTRUCTANS="yes"}{DOWN 2}{M}RVSYSTWOSTRUCTDAT~~{DOWN 10}
{DOWN 3}'     APPLICATION SYSTEM No. 2 PUMP REQUIREMENTS:~
{DOWN 2}+SYSTWOPUMPANS~
{RIGHT}'-- PUMPS ARE REQUIRED~{LEFT}
{IF SYSTWOPUMPANS="YES"#OR#SYSTWOPUMPANS="yes"}{DOWN 2}{M}RVSYSTWOPUMPDATA~~{DOWN 16}
{DOWN 3}'     APPLICATION SYSTEM No. 2 PIPELINE REQUIREMENTS:~
{DOWN 2}+SYSTWOPIPEANS~
{RIGHT}'-- PIPELINES ARE REQUIRED~{LEFT}
{IF SYSTWOPIPEANS="YES"#OR#SYSTWOPIPEANS="yes"}{DOWN 2}{M}RVSYSTWOPIPEDATA~~{DOWN 13}
{DOWN 3}'     APPLICATION SYSTEM No. 2 EXTRA EXPENSE REQUIREMENTS:~
{DOWN 2}+SYSTWOEXTRAANS~
{RIGHT}'-- EXTRA EXPENSES ARE REQUIRED~{LEFT}
{IF SYSTWOEXTRAANS="YES"#OR#SYSTWOEXTRAANS="yes"}{DOWN 2}{M}RVSYSTWOEXTRADATA~~{DOWN 12}
{IF NO.SYSTEMS<3}{BRANCH ENDSYSTEMOUTPUT}
{DOWN 2}{M}RVSYSTEMTHRDATA~~{M}E~~
{DOWN}{M}M{RIGHT}~{RIGHT}~SYSTEM No. 3~
{DOWN 40}{END}{UP}{DOWN}{M}E{RIGHT 5}~
{DOWN 2}    APPLICATION SYSTEM No. 3 OPEN CHANNEL REQUIREMENTS:~
{DOWN 2}+SYSTHRCANALANS~
{RIGHT}'-- OPEN CHANNELS ARE REQUIRED~{LEFT}
{IF SYSTHRCANALANS="YES"#OR#SYSTHRCANALANS="yes"}{DOWN 2}{M}RVSYSTHRCANALDATA~~{DOWN 14}
{DOWN 3}'     APPLICATION SYSTEM No. 3 STRUCTURE REQUIREMENTS:~
{DOWN 2}+SYSTHRSTRUCTANS~
{RIGHT}'-- STRUCTURES ARE REQUIRED~{LEFT}
{IF SYSTHRSTRUCTANS="YES"#OR#SYSTHRSTRUCTANS="yes"}{DOWN 2}{M}RVSYSTHRSTRUCTDAT~~{DOWN 10}
{DOWN 3}'     APPLICATION SYSTEM No. 3 PUMP REQUIREMENTS:~
{DOWN 2}+SYSTHRPUMPANS~
{RIGHT}'-- PUMPS ARE REQUIRED~{LEFT}
{IF SYSTHRPUMPANS="YES"#OR#SYSTHRPUMPANS="yes"}{DOWN 2}{M}RVSYSTHRPUMPDATA~~{DOWN 16}
{DOWN 3}'     APPLICATION SYSTEM No. 3 PIPELINE REQUIREMENTS:~
{DOWN 2}+SYSTHRPIPEANS~
```

Figure B-83 OUTPUT macro (cont).

```
{RIGHT}'-- PIPELINES ARE REQUIRED~{LEFT}
{IF SYSTHRPIPEANS="YES"#OR#SYSTHRPIPEANS="yes"}{DOWN 2}{M}RVSYSTHRPIPEDATA~~{DOWN 13}
{DOWN 3}'     APPLICATION SYSTEM No. 3 EXTRA EXPENSE REQUIREMENTS:~
{DOWN 2}+SYSTHREXTRAANS~
{RIGHT}'-- EXTRA EXPENSES ARE REQUIRED~{LEFT}
{IF SYSTHREXTRAANS="YES"#OR#SYSTHREXTRAANS="yes"}{DOWN 2}{M}RVSYSTHREXTRADATA~~{DOWN 12}
{IF NO.SYSTEMS<4}{BRANCH ENDSYSTEMOUTPUT}
{DOWN 2}{M}RVSYSTEMFORDATA~~{M}E~~
{DOWN}{M}M{RIGHT}~{RIGHT}~SYSTEM No. 4~
{DOWN 40}{END}{UP}{DOWN}{M}E{RIGHT 5}~
{DOWN 2}     APPLICATION SYSTEM No. 4 OPEN CHANNEL REQUIREMENTS:~
{DOWN 2}+SYSFORCANALANS~
{RIGHT}'-- OPEN CHANNELS ARE REQUIRED~{LEFT}
{IF SYSFORCANALANS="YES"#OR#SYSFORCANALANS="yes"}{DOWN 2}{M}RVSYSFORCANALDATA~~{DOWN 14}
{DOWN 3}'     APPLICATION SYSTEM No. 4 STRUCTURE REQUIREMENTS:~
{DOWN 2}+SYSFORSTRUCTANS~
{RIGHT}'-- STRUCTURES ARE REQUIRED~{LEFT}
{IF SYSFORSTRUCTANS="YES"#OR#SYSFORSTRUCTANS="yes"}{DOWN 2}{M}RVSYSFORSTRUCTDAT~~{DOWN 10}
{DOWN 3}'     APPLICATION SYSTEM No. 4 PUMP REQUIREMENTS:~
{DOWN 2}+SYSFORPUMPANS~
{RIGHT}'-- PUMPS ARE REQUIRED~{LEFT}
{IF SYSFORPUMPANS="YES"#OR#SYSFORPUMPANS="yes"}{DOWN 2}{M}RVSYSFORPUMPDATA~~{DOWN 16}
{DOWN 3}'     APPLICATION SYSTEM No. 4 PIPELINE REQUIREMENTS:~
{DOWN 2}+SYSFORPIPEANS~
{RIGHT}'-- PIPELINES ARE REQUIRED~{LEFT}
{IF SYSFORPIPEANS="YES"#OR#SYSFORPIPEANS="yes"}{DOWN 2}{M}RVSYSFORPIPEDATA~~{DOWN 13}
{DOWN 3}'     APPLICATION SYSTEM No. 4 EXTRA EXPENSE REQUIREMENTS:~
{DOWN 2}+SYSFOREXTRAANS~
{RIGHT}'-- EXTRA EXPENSES ARE REQUIRED~{LEFT}
{IF SYSFOREXTRAANS="YES"#OR#SYSFOREXTRAANS="yes"}{DOWN 2}{M}RVSYSFOREXTRADATA~~{DOWN 12}
{IF NO.SYSTEMS<5}{BRANCH ENDSYSTEMOUTPUT}
{DOWN 2}{M}RVSYSTEMFIVDATA~~{M}E~~
{DOWN}{M}M{RIGHT}~{RIGHT}~SYSTEM No. 5~
{DOWN 40}{END}{UP}{DOWN}{M}E{RIGHT 5}~
{DOWN 2}     APPLICATION SYSTEM No. 5 OPEN CHANNEL REQUIREMENTS:~
{DOWN 2}+SYSFIVCANALANS~
{RIGHT}'-- OPEN CHANNELS ARE REQUIRED~{LEFT}
{IF SYSFIVCANALANS="YES"#OR#SYSFIVCANALANS="yes"}{DOWN 2}{M}RVSYSFIVCANALDATA~~{DOWN 14}
{DOWN 3}'     APPLICATION SYSTEM No. 5 STRUCTURE REQUIREMENTS:~
{DOWN 2}+SYSFIVSTRUCTANS~
{RIGHT}'-- STRUCTURES ARE REQUIRED~{LEFT}
{IF SYSFIVSTRUCTANS="YES"#OR#SYSFIVSTRUCTANS="yes"}{DOWN 2}{M}RVSYSFIVSTRUCTDAT~~{DOWN 10}
{DOWN 3}'     APPLICATION SYSTEM No. 5 PUMP REQUIREMENTS:~
{DOWN 2}+SYSFIVPUMPANS~
{RIGHT}'-- PUMPS ARE REQUIRED~{LEFT}
{IF SYSFIVPUMPANS="YES"#OR#SYSFIVPUMPANS="yes"}{DOWN 2}{M}RVSYSFIVPUMPDATA~~{DOWN 16}
{DOWN 3}'     APPLICATION SYSTEM No. 5 PIPELINE REQUIREMENTS:~
{DOWN 2}+SYSFIVPIPEANS~
{RIGHT}'-- PIPELINES ARE REQUIRED~{LEFT}
{IF SYSFIVPIPEANS="YES"#OR#SYSFIVPIPEANS="yes"}{DOWN 2}{M}RVSYSFIVPIPEDATA~~{DOWN 13}
```

Figure B-83 OUTPUT macro (cont).

```
{DOWN 3}'    APPLICATION SYSTEM No. 5 EXTRA EXPENSE REQUIREMENTS:~
{DOWN 2}+SYSFIVEXTRAANS~
{RIGHT}'-- EXTRA EXPENSES ARE REQUIRED~{LEFT}
{IF SYSFIVEXTRAANS="YES"#OR#SYSFIVEXTRAANS="yes"}{DOWN 2}{M}RVSYSFIVEXTRADATA~~{DOWN 12}
{IF NO.SYSTEMS<6}{BRANCH ENDSYSTEMOUTPUT}
{DOWN 2}{M}RVSYSTEMSIXDATA~~{M}E~~
{DOWN}{M}M{RIGHT}~{RIGHT}~SYSTEM No. 6~
{DOWN 40}{END}{UP}{DOWN}{M}E{RIGHT 5}~
{DOWN 2}    APPLICATION SYSTEM No. 6 OPEN CHANNEL REQUIREMENTS:~
{DOWN 2}+SYSSIXCANALANS~
{RIGHT}'-- OPEN CHANNELS ARE REQUIRED~{LEFT}
{IF SYSSIXCANALANS="YES"#OR#SYSSIXCANALANS="yes"}{DOWN 2}{M}RVSYSSIXCANALDATA~~{DOWN 14}
{DOWN 3}'    APPLICATION SYSTEM No. 6 STRUCTURE REQUIREMENTS:~
{DOWN 2}+SYSSIXSTRUCTANS~
{RIGHT}'-- STRUCTURES ARE REQUIRED~{LEFT}
{IF SYSSIXSTRUCTANS="YES"#OR#SYSSIXSTRUCTANS="yes"}{DOWN 2}{M}RVSYSSIXSTRUCTDAT~~{DOWN 10}
{DOWN 3}'    APPLICATION SYSTEM No. 6 PUMP REQUIREMENTS:~
{DOWN 2}+SYSSIXPUMPANS~
{RIGHT}'-- PUMPS ARE REQUIRED~{LEFT}
{IF SYSSIXPUMPANS="YES"#OR#SYSSIXPUMPANS="yes"}{DOWN 2}{M}RVSYSSIXPUMPDATA~~{DOWN 16}
{DOWN 3}'    APPLICATION SYSTEM No. 6 PIPELINE REQUIREMENTS:~
{DOWN 2}+SYSSIXPIPEANS~
{RIGHT}'-- PIPELINES ARE REQUIRED~{LEFT}
{IF SYSSIXPIPEANS="YES"#OR#SYSSIXPIPEANS="yes"}{DOWN 2}{M}RVSYSSIXPIPEDATA~~{DOWN 13}
{DOWN 3}'    APPLICATION SYSTEM No. 6 EXTRA EXPENSE REQUIREMENTS:~
{DOWN 2}+SYSSIXEXTRAANS~
{RIGHT}'-- EXTRA EXPENSES ARE REQUIRED~{LEFT}
{IF SYSSIXEXTRAANS="YES"#OR#SYSSIXEXTRAANS="yes"}{DOWN 2}{M}RVSYSSIXEXTRADATA~~{DOWN 12}
{BRANCH ENDSYSTEMOUTPUT}
```

Figure B-83 OUTPUT macro (cont).

The ENDSYSTEMOUTPUT macro referenced in the OUTPUT macro is located in cell Y477 and listed in Figure B-84. The **** in Figure B-84 mean that line is part of the line above it in the actual spreadsheet. The purpose of this macro is to copy the drainage system and simulation information to the output area of the spreadsheet, unprotect the cells in the output area, name the output area DATAFILE and return to the macro SIMULATE.

The very last macro to execute is named EDITDATA. The EDITDATA macro is located in cell J808 and listed in Figure B-85. This macro simply displays the EDITDATA window and deletes the range name \S.

There are a four other macros in the part two spreadsheet which are used. They are named \P, \M, \L and \E. The \P macro is located in cell J819 and listed in Figure B-86. The purpose of the \P macro is to print the constructed data file to the disk with a file name entered by the user and return to the DATA window.

```
END OF SYSTEM OUTPUT ROUTINE
{DOWN 3}      FARM DRAINAGE REQUIREMENTS:~
{DOWN 2}+DRAINAGEANS~
{RIGHT}'-- DRAINAGE IS REQUIRED ON THE FARM~{LEFT}
{IF DRAINAGEANS="YES"#OR#DRAINAGEANS="yes"}{DOWN 2}{M}RVDRAINAGEDATA~~{DOWN 3}
 **** {RIGHT NO.DRAINFIELDS+4}{M}E{RIGHT 8-NO.DRAINFIELDS}{END}{DOWN}~{LEFT}{END}{LEFT}{END}{DOWN}
{DOWN 3}      SIMULATE INFORMATION:
{DOWN 2}{M}RVSIMULATEDATA~~
{M}RNDOUTPUTCONT~
{GOTO}AM1~
{M}RNCDATAFILE~{BS}{TAB}{LEFT}{END}{DOWN}{RIGHT}{END}{UP}{RIGHT 14}~
{M}RPADATAFILE~{RETURN}
```

Figure B-84 ENDSYSTEMOUTPUT macro.

```
{WINDOWSOFF}{PANELOFF}
{S}WUEDITDATA~{M}RND\S~
{PANELON}{WINDOWSON}
```

Figure B-85 EDITDATA macro.

```
PRINT DATA FILE MACRO \P
{WINDOWSOFF}{PANELOFF}
{S}WUPRINTDATAFILE~
{PANELON}{WINDOWSON}{WINDOWSOFF}
{S}PSSCSRDATAFILE~MNDF{?}~QGQ
{PANELOFF}{WINDOWSOFF}
{S}WUDATA~
{PANELON}{WINDOWSON}
```

Figure B-86 \P macro.

The \E macro is located in cell J813 and listed in Figure B-87. This macro brings up the DATA window and adjusts it restrict range to the range of the spreadsheet containing the completed data file.

```
EDITDATA FILE MACRO \E
{WINDOWSOFF}{PANELOFF}
{S}WUDATA~{S}WSRRDATAFILE~QQ
{HOME}{PANELON}{WINDOWSON}
```

Figure B-87 \E macro.

The \M menu is located in cell AH 238 and listed in Figure B-88. The macro simply displays the SEEPMENU window which contains suggested canal seepage rates.

The \L macro is located in cell AH233 and listed in Figure B-89. This macro simply returns the user to the SYSXXXCANALS screen after viewing the SEEPMENU screen.

```
SEEPAGE MENU MACRO
{PANELOFF}
{S}WUSEEPMENU~
```

Figure B-88 \M macro.

```
LEAVE MACRO
{PANELOFF}
{S}WU{RIGHT}~
```

Figure B-89 \L macro.

RANGES

There are numerous range names used in both FISA spreadsheets. Some of the range names may be the same and thus must be kept separate. This is why all ranges names are erased before the part two spreadsheet is combined with the part one spreadsheet. The range names appearing in the part one spreadsheet are listed in Figure B-90 along with the cell addresses of the ranges.

BEGIRRMONTH	H243	CAPCOST	H366	CLOOP	J66
CMLEAVE	N49	CMMACRO	J99	COUNTER1	J72
COUNTER2	J73	CREATEOUTPUTI	BH2	CROP	J103
CROP1COL	E74..E173	CROP2COL	G74..G173	CROPCOL	H71..H173
CROPDEFICIT	D211..D241	CROPGROWN	A211..A239	CROPLOOKUPCOL	N13..N23
CROPMENU	N10..Q23	DAYSAVAIL	G390	DEFANS1	H183
DEFANS2	H188	DEFICIT	J174	DEFICIT2	J218
ELECTRICANS	H405	ELECTRICDATA	A408..H421	ELECTRICRATES	J404
ENDIRRMONTH	H250	EQUALAD	J195	EXPNETRETURN	G211..G241
FARMDATA	M260	FIELD	J44	FIELDCOL	A74..A173
FIELDDATA	A49..H59	FIELDDATATABLE	A264..K363	FIELDS	A49..A59
FILEINFO	J21	FLOOP	J62	FLOWRATE	G388
FLOWVOLUME	G389	HEAD4	N10..O12	INCREMENT	J71
INFLRATE	H368	INPUTAD	J215	IRRAREA	C49..C59
LEAVEMENU	J79	LOANTERMS	A374..H379	MAD1COL	F264
MAD2COL	J264..J339	MESSAGE	A192..H199	NO.CROPS	A205
NO.FIELDS	H41	NO.SUPCANALS	H447	NO.SUPEXTRAS	H531
NO.SUPPIPES	H511	NO.SUPPUMPS	H488	NO.SUPSTRUCTS	H469
NORMYIELD	F211..F241	NO\M	J29	NO\S	J5
OBEGIRRMONTH	AM5	OENDIRRMONTH	AM7	OMONTHSIRR	AM3
ONO.FIELDS	AM9	ORUNNAME	AP1	PARTONEOUTPUT	BA2..BA82
PCM	R2	PRINTCM	J36	PRINTOUTANS	H24
PRINTSM	L36	PSM	AC2	ROTATIONCOL	C74..C173
ROTATIONS	E49..E59	RUNNAME	D31	SAVEWORKSHEET	J535
SEASON	J240	SEEPAGELEAVE	N49	SEEPMMACRO	AF233
SMLEAVE	N49	SMMACRO	J41	SOILLOOKUPCOL	X13..X36
SOILMENU	X10..Z36	SOILTYPENO.	G49..G59	SORTCOL	H70..H76
START	J11	SUPCANANS	H444	SUPCANDATA	A447..H461
SUPEXTRASANS	H528	SUPEXTRASDATA	A531..H543	SUPPIPEANS	H508
SUPPIPEDATA	A511..H524	SUPPLY	J364	SUPPLYCANAL	J444
SUPPLYEXTRAS	J527	SUPPLYMESSAGE	J394	SUPPLYPIPEINFO	D516..H523
SUPPLYPIPES	J507	SUPPLYPUMPANS	H485	SUPPLYPUMPS	J484
SUPPLYSTRUCTS	J464	SUPPUMPANS	H485	SUPPUMPDATA	A488..H504
SUPSTRUCTANS	H465	SUPSTRUCTDATA	A469..H479	TABLE	A264..K339
TABLEAD1COL	G264	TABLEAD2COL	K264	TABLECROP1COL	D264
TABLECROP2COL	H264	TABLEFIELDCOL	A264	TABLEHEADING	A260..K263
TABLEROTCOL	C264	TABLESOILCOL	B264	TAM1COL	E264
TAM2COL	I264	WATER	J384	WATERCOST	G396..G399
YEARSROT	E49..E59	YIELDDATA	E207..H241	ZEROAD	J183
\L	J79	\R	J1		

Figure B-90 Range names appearing in part one spreadsheet.

The range names appearing in the part two spreadsheet are listed in Figure B-91 along with the cell addresses of the ranges.

BORDER	Q48	BORDER1	S48	BORDERP	Q75
BORDERSCREEN	V1..AJ27	CANALP	Q115	CENPIVOTSCREEN	V149..AJ183
CENTERPIVOT	Q60	CENTERPIVOT1	S60	CENTERPIVOTP	Q101
CURRENTSYSTEM	M38	DATAFILE	AM1..BA971	DELETE\S	N7
DRAINAGE	O771	DRAINAGEANS	H776	DRAINAGEDATA	A779..M796
EDIT	J829	EDITDATA	J808	ENDSYSTEMINPUT	J1042
ENDSYSTEMOUTPUT	Y477	EXTRAP	Q143	FURROW	Q51
FURROW1	S51	FURROWP	Q80	FURROWSCREEN	V31..AJ58
HANDMOVESCREEN	V266..AJ304	LINEARMOVE	Q63	LINEARMOVE1	S63
LINEARMOVEP	Q108	LINMOVESCREEN	V190..AJ224	NO.DRAINFIELDS	H779
NO.FIELDS	AM9	NO.FIELDSINSYS	N38	NO.SYSFIVCANALS	H675
NO.SYSFIVEPUMPS	H716	NO.SYSFIVEXTRAS	H759	NO.SYSFIVPIPES	H739
NO.SYSFIVPUMPS	H716	NO.SYSFIVSTRUCT	H697	NO.SYSFORCANALS	H528
NO.SYSFOREXTRAS	H612	NO.SYSFORPIPES	H592	NO.SYSFORPUMPS	H569
NO.SYSFORSTRUCT	H550	NO.SYSONECANALS	H87	NO.SYSONEEXTRAS	H171
NO.SYSONEPIPES	H151	NO.SYSONEPUMPS	H128	NO.SYSONESTRUCT	H109
NO.SYSSIXCANALS	H954	NO.SYSSIXEXTRAS	H1038	NO.SYSSIXPIPES	H1018
NO.SYSSIXPUMPS	H995	NO.SYSSIXSTRUCT	H976	NO.SYSTEMS	H13
NO.SYSTHRCANALS	H381	NO.SYSTHREXTRAS	H465	NO.SYSTHRPIPES	H445
NO.SYSTHRPUMPS	H422	NO.SYSTHRSTRUCT	H403	NO.SYSTWOCANALS	H234
NO.SYSTWOEXTRAS	H318	NO.SYSTWOPIPES	H298	NO.SYSTWOPUMPS	H275
NO.SYSTWOSTRUCT	H256	NO\S	N9	OUTPUT	Y314
PIPEP	Q136	PUMPP	Q129	SETMOVE	Q57
SETMOVE1	S57	SETMOVEP	Q93	SIDEROLLSCREEN	V105..AJ143
SIMULATE	J799	SIMULATEDATA	A803..H813	SOLIDSET	Q54
SOLIDSET1	S54	SOLIDSETP	Q86	SOLIDSETSCREEN	V61..AJ100
STARTPARTII	N1	STRUCTP	Q122	SYSFIVCANAL	J671
SYSFIVCANALANS	H672	SYSFIVCANALDATA	A675..H689	SYSFIVEXTRAANS	H756
SYSFIVEXTRADATA	A759..H771	SYSFIVEXTRAS	J755	SYSFIVPARTII	Q633
SYSFIVPIPEANS	H736	SYSFIVPIPEDATA	A739..H752	SYSFIVPIPES	J735
SYSFIVPUMPANS	H713	SYSFIVPUMPDATA	A716..H732	SYSFIVPUMPS	J712
SYSFIVSTRUCTANS	H693	SYSFIVSTRUCTDAT	A697..H707	SYSFIVSTRUCTS	J692
SYSFORCANAL	J524	SYSFORCANALANS	H525	SYSFORCANALDATA	A528..H542
SYSFOREXTRAANS	H609	SYSFOREXTRADATA	A612..H624	SYSFOREXTRAS	J608
SYSFORPARTII	Q491	SYSFORPIPEANS	H589	SYSFORPIPEDATA	A592..H605
SYSFORPIPES	J588	SYSFORPUMPANS	H566	SYSFORPUMPDATA	A569..H585
SYSFORPUMPS	J565	SYSFORSTRUCTANS	H546	SYSFORSTRUCTDAT	A550..H560
SYSFORSTRUCTS	J545	SYSONECANAL	J83	SYSONECANALANS	H84
SYSONECANALDATA	A87..H101	SYSONEEXTRAANS	H168	SYSONEEXTRADATA	A171..H183
SYSONEEXTRAS	J167	SYSONEPARTII	Q67	SYSONEPIPEANS	H148
SYSONEPIPEDATA	A151..H164	SYSONEPIPES	J147	SYSONEPUMPANS	H125
SYSONEPUMPDAT	A128..H144	SYSONEPUMPDATA	A128..H144	SYSONEPUMPS	J124
SYSONESTRUCTANS	H105	SYSONESTRUCTDAT	A109..H119	SYSONESTRUCTS	J104
SYSSIXCANAL	J950	SYSSIXCANALANS	H951	SYSSIXCANALDATA	A954..H968
SYSSIXEXTRAANS	H1035	SYSSIXEXTRADATA	A1038..H1050	SYSSIXEXTRAS	J1034

Figure B-91 Range names appearing in the part two spreadsheet.

SYSSIXPARTII	Q908	SYSSIXPIPEANS	H1015	SYSSIXPIPEDATA	A1018..H1031
SYSSIXPIPES	J1014	SYSSIXPUMPANS	H992	SYSSIXPUMPDATA	A995..H1011
SYSSIXPUMPS	J991	SYSSIXSTRUCTANS	H972	SYSSIXSTRUCTDAT	A976..H986
SYSSIXSTRUCTS	J971	SYSTEM	J1	SYSTEM2	M21
SYSTEMDATA	A25..K38	SYSTEMFIELDS	C28..H28	SYSTEMFIV	Q625
SYSTEMFIVDATA	A628..O670	SYSTEMFOR	Q483	SYSTEMFORDATA	A481..O523
SYSTEMNO.	C25..H25	SYSTEMNO.1	C30..C38	SYSTEMNO.2	D30..D38
SYSTEMNO.3	E30..E38	SYSTEMNO.4	F30..F38	SYSTEMNO.5	G30..G38
SYSTEMNO.6	H30..H38	SYSTEMONE	P41	SYSTEMONEDATA	A41..O82
SYSTEMSIX	Q900	SYSTEMSIXDATA	A901..O941	SYSTEMTHR	Q341
SYSTEMTHRDATA	A334..O376	SYSTEMTWO	Q187	SYSTEMTWODATA	A187..O228
SYSTEMTYPE	C27..H27	SYSTHRCANAL	J377	SYSTHRCANALANS	H378
SYSTHRCANALDATA	A381..H395	SYSTHREXTRAANS	H462	SYSTHREXTRADATA	A465..H477
SYSTHREXTRAS	J461	SYSTHRPARTII	Q349	SYSTHRPIPEANS	H442
SYSTHRPIPEDATA	A445..H458	SYSTHRPIPES	J441	SYSTHRPUMPANS	H419
SYSTHRPUMPDATA	A422..H438	SYSTHRPUMPS	J418	SYSTHRSTRUCTANS	H399
SYSTHRSTRUCTDAT	A403..H413	SYSTHRSTRUCTS	J398	SYSTWOCANAL	J230
SYSTWOCANALANS	H231	SYSTWOCANALDATA	A234..H248	SYSTWOEXTRAANS	H315
SYSTWOEXTRADATA	A318..H330	SYSTWOEXTRAS	J314	SYSTWOPARTII	Q195
SYSTWOPIPEANS	H295	SYSTWOPIPEDATA	A298..H311	SYSTWOPIPES	J294
SYSTWOPUMPANS	H272	SYSTWOPUMPDATA	A275..H291	SYSTWOPUMPS	J271
SYSTWOSTRUCTANS	H252	SYSTWOSTRUCTDAT	A256..H266	SYSTWOSTRUCTS	J251
WORKSHEET2	A1..AK1053	\E	J813	\L	AH233
\M	AH238	\P	J819	\R	J15

Figure B-91 Range names appearing in the part two spreadsheet (cont).

Six of the range names appearing in the part two spreadsheet are of special interest as they contain the format and default values of the application system input screens. These range names are: BORDERSCREEN, FURROWSCREEN, SOLIDSETSCREEN, HANDMOVESCREEN, SIDEROLLSCREEN, CENPIVOTSCREEN, AND LINMOVESCREEN. The range names are indicative of the application system to which they pertain. The labels and values appearing in these ranges are copied into the application system input screens.

WINDOWS

Numerous windows are used throughout the FISA data file building process to prompt the user for the appropriate inputs and guide the user through the process. All the windows appear in both spreadsheets. The part two windows must appear in the part one spreadsheet because SYMPHONY'S File Combine feature does not load the windows of the file being combined. Thus, for the part one spreadsheet to operate the windows of the part two spreadsheet, they must also be defined in the part one spreadsheet. The part one windows appear in the part two spreadsheet because they are not erased before the part two spreadsheet is combined with the part one spreadsheet. The part one spreadsheet windows are not erased be cause SYMPHONY does not provide a command for erasing several window settings at once. The windows appearing in the FISA data file building spreadsheets are listed in Figure B-92 along with their cell addresses.

CHECKMEM	J839..P858	CROPMENU	N1..Q23	CROP	A62..J173
DATAFILE2	A839..H858	DATAFILE	A567..H586	DATA	AM1..BA890
DEFICIT2	A200..J239	DEFICIT	A171..J193	DRAINAGE	A775..O797
EDITDATA	A859..H878	EDIT	AM1..BA891	ELECTRICRATES	A404..J423
FARMDATA	A260..M363	FIELDWARNING	Y512..AE530	FIELD	A41..J60
FILEINFO	A21..J40	INTRO	A1..J20	LOADWORKSHEETII	BH23..BO42
MAIN	A1..IV8192	MESSAGE	A191..J199	PRINTDATAFILE	A879..H898
RECOVERMEM	BH43..BO62	SAVEWORKSHEET2	A819..H838	SAVEWORKSHEETI	A547..H566
SEASON	A240..J259	SEEPMENU	Y231..AC248	SIMULATE	A799..J818
SOILMENU	X1..Z36	SUPPLYCANAL	A443..J462	SUPPLYEXTRAS	A527..J546
SUPPLYMESSAGE	Y279..AE298	SUPPLYPIPES	A507..J526	SUPPLYPUMPS	A484..J505
SUPPLYSTRUCTS	A464..J483	SUPPLY	A364..J383	SYSFIVCANAL	A671..J690
SYSFIVEXTRAS	A755..J774	SYSFIVPIPES	A735..J754	SYSFIVPUMPS	A712..J733
SYSFIVSTRUCTS	A692..J711	SYSFORCANAL	A524..J543	SYSFOREXTRAS	A608..J627
SYSFORPIPES	A588..J607	SYSFORPUMPS	A565..J586	SYSFORSTRUCTS	A545..J564
SYSONECANAL	A83..J102	SYSONEEXTRAS	A167..J186	SYSONEPIPES	A147..J166
SYSONEPUMPS	A124..J145	SYSONESTRUCTS	A104..J123	SYSSIXCANAL	A950..J969
SYSSIXEXTRAS	A1034..J1053	SYSSIXPIPES	A1014..J1033	SYSSIXPUMPS	A991..J1012
SYSSIXSTRUCTS	A971..J990	SYSTEM2	A21..M40	SYSTEMFIV	A628..O670
SYSTEMFOR	A481..O523	SYSTEMONE	A41..O82	SYSTEMSIX	A901..O941
SYSTEMTHR	A334..O376	SYSTEMTWO	A187..O229	SYSTEM	A1..J20
SYSTHRCANAL	A377..J396	SYSTHREXTRAS	A461..J480	SYSTHRPIPES	A441..J460
SYSTHRPUMPS	A418..J439	SYSTHRSTRUCTS	A398..J417	SYSTWOCANAL	A230..J249
SYSTWOEXTRAS	A314..J333	SYSTWOPIPES	A294..J312	SYSTWOPUMPS	A271..J292
SYSTWOSTRUCTS	A251..J270	WAIT	Y251..AE254	WARNING	Y500..AE519
WATER	A384..J403				

Figure B-92 Window names appearing in the FISA spreadsheets.

APPENDIX C

SYSTEM ROUTINE PROGRAM LISTING

CONTENTS Page

```
$DEBUG
$NOFLOATCALLS
$LARGE
C
      PROGRAM SYSTEM
C  >>>> PROGRAM FOR COMPUTING COSTS AND EFFICIENCIES OF <<<<
C  >>>>      ON-FARM IRRIGATION APPLICATION SYSTEMS      <<<<
C
C  PROGRAMS AND SUBROUTINES WRITTEN BY J.R. BUSCH, WINCHMORE, 1982
C  MODIFIED BY B.W. SAUER, UNIVERSITY OF IDAHO, MOSCOW, 1986
C  EXCEPT WHERE NOTED ON FURROW AND BORDER EFFICIENCY ROUTINES
C  LAST UPDATE 5/21/87  BWS
C
C  PROVISION IS MADE TO ENTER DATA FOR ONE OR MORE SYSTEMS
C  SUPPLIED BY THE SAME WATER SOURCE ON A FARM
C
C  DATA FOR CROP ROTATION AND PLANT-SOIL-WATER RELATIONSHIPS
C  ARE READ FROM THE APPROPRIATE DATA FILES
C
C  INPUT DATA ALONG WITH DESCRIPTIONS ARE WRITTEN ON LU 12
C  IN ADDITION TO A SUMMARY OF ALL COMPUTATIONS
C
C  PERTINENT RESULTS ARE WRITTEN ON LU 12 IN THE SAME DATA FILE
C  THAT IS SUBSEQUENTLY READ BY THE SIMULATION MODULE
C
C
C
C  LOGICAL UNIT ASSIGNMENTS ARE AS FOLLOWS:
C     * -- READ FROM PROMPT
C     * -- WRITE PROMPT
C    12 -- READ/WRITE FILE WITH REQUIRED FIELD AND SYSTEM DATA AS
C          WELL AS PERTINENT OUTPUT, FOR USE IN SIMULATION PROGRAM
C
C
C  >> MAJOR ARRAYS AND VARIABLES ARE --------
C    NSYS -- NO. OF SYSTEMS
C    NPKSYS(I) -- NO. OF PADDOCKS IRRIGATED BY SYSTEM I
C    IPSYS(J,I) -- ARRAY OF PADDOCK ID NOS. IRRIGATED BY SYSTEM I
C    TLAB(J,2) -- LABOR REQT FOR PADDOCK J (1=HR/IRRIG,2=HR/SEASON)
C    EAPP(CROP,PADDOCK) -- ARRAY OF OVERALL APPLICATION EFFICIENCIES (%)
C    SYSVAL(J,I) -- ARRAY OF VALUES FOR SYSTEM I AS FOLLOWS
C          J = 1 -- FLOW ENTERING SYSTEM (CFS)
C              2 -- PERCENT OF TIME SYSTEM OPERATES
C              3 -- SYSTEM LIFE (YR)
C              4 -- TOTAL CAPITAL COST ($)--- (LOAN NO. 1)
C              5 -- CAPITAL NOT FINANCED OR SUBSIDIZED ($)
C              6 -- SUBSIDIZED CAPITAL ($)
C              7 -- FINANCED CAPITAL ($)
C              8 -- INTEREST RATE FOR LOAN NO. 1 (%) -- ATTACHED ITEMS
C              9 -- TIME OF LOAN NO. 1 (YR)
C             10 -- SALVAGE VALUE OF COMPONENTS ($)
C             11 -- ANNUAL MAINTENANCE EXPENSE ($)
C             12 -- ANNUAL MISCELLANEOUS EXPENSE ($)
C          PARAMETERS 13 -21 ARE THE SAME PARAMETERS AS 4 - 12 EXCEPT
C          UNATTACHED ITEMS (LOAN NO. 2)
C             22 -- ANNUAL CAPITAL RECOVERY COST ($)
C
C    SYST(J) -- A WORKING ARRAY WITH J EQUAL TO J OF SYSVAL ARRAY
C
C    NAPMP(I) -- NO. OF PUMPS IN SYSTEM I
C    IDXPMA(J,I) -- ID NOS. OF PUMPS IN SYSTEM I
C    PWRPMP(K) -- ARRAY OF PUMP POWER REQTS (KW)
C    QPMP(K) -- ARRAY OF PUMP FLOW RATES (GPM)
C
C    IDCP -- CROP ID NOS. READ FROM CROPADDOCK FILE
C    AREA -- PADDOCK AREAS READ FROM CROPADDOCK FILE
C    NCRP -- NO. OF CROPS IN EACH PADDOCK READ FROM CROPADDOCK FILE
C    CRPDK -- CROP-PADDOCK DATA READ FROM CROPADDOCK FILE
C    KSEL -- ARRAY OF PADDOCKS FOR WHICH APPLICATION SYSTEMS
C            HAVE BEEN SPECIFIED
```

```
C     IDS -- MENU OF SYSTEM ID NOS.
C     NCP -- NO. OF CROPS IN CROPADDOCK FILE MENU
C     DRAN -- DATA REQUIRED FOR DRAINAGE COMPUTATIONS
C     SOIL -- SOIL DATA FOR EACH FIELD
C     WCOST -- COST DATA FOR IRRIGATION WATER
C               1 - BASIC ALLOTMENT COST ($/AC)
C               2 - BASIC ALLOTMENT (AC-FT/AC)
C               3 - DEMAND VOLUME CHARGE ($/AC-FT/AC)
C               4 - DEMAND VOLUME CHARGE ABOVE ALLOTMENT ($/AC-FT/AC)
C     LIFE -- EXPECTED LIFE OF VARIOUS SYSTEM COMPONENTS (YR)
C               1-7 - LIFE OF APPLICATION SYSTEM TYPES 1-7
C                11 - UNLINED CANAL LIFE
C                12 - LINED CANAL LIFE
C                13 - PUMP LIFE
C                14 - LAND LEVELING LIFE
C     IACCST(N,I,J) -- ANNUAL CAPITAL CASH FLOW, SYSTEM I, YEAR J
C            N = 1 - PRINCIPLE REPAYMENT
C                2 - INTEREST PAYMENT
C                3 - TOTAL PAYMENT
C
C     ===>>  CHARACTER VARIABLES
C     TITLST -- NAME OF INPUT/ OUTPUT FILE
C     CNAME -- CROP NAMES READ FROM CROPADDOCK FILE
C     FORM -- FORMAT STATEMENTS FOR READING DATA FILE
C     SYSNAM -- ARRAY OF SYSTEM NAMES ENTERED
C     SID -- MENU OF SYSTEM NAMES
C
C ===>>  OTHER VARIABLES
C     LIN -- UNIT NUMBER OF INPUT/OUTPUT FILE
C     LEPD -- LENGTH OF ECONOMIC ANALYSIS PERIOD
C     DINF -- RATE OF INFLATION
C     LLIF(I) -- LENGTH OF LOAN I
C     DAIR(I) -- ANNUAL INTEREST RATE, LOAN I
C
C ==>> SEE DOCUMENTATION IN VARIOUS SUBROUTINES
C
C
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      COMMON/SOILS/SOIL(9,3)
      COMMON/SYSM/SYSFLD(9,30),VLOG(9,4)
C
      DIMENSION NT(30,20),NN(20),J1(20),ARRAY(9),CRPDAT(30,2)
C
      CHARACTER*24 CPKTIT,CNAME(30)*16, SYSNAM(20), SID(8),YN(30,3)*1,
     & TITLST,TITLCROP,TITLCOST,Y1*3,Y2*3,FORM*20,FLAG*3,M(51)*72,
     & COMP*26
      LOGICAL VLOG
C
      DATA SID/'GRADED BORDER','FURROW OR CORRUGATE',
     1'SOLID-SET SPRINKLER','HAND-MOVE SPRINKLER',
     2'SIDE-ROLL SPRINKLER','CENTER PIVOT','LINEAR MOVE','TRICKLE'/
C
C
C  ENTER A NAME FOR THE DATA FILE
7     WRITE(*,*)' ENTER THE NAME OF THE CROP ROTATION/SYSTEM DATA ',
     &'FILE TO BE USED'
      READ(*,'(A)')TITLST
C      OPEN (12,FILE=TITLST,IOSTAT=IOCHECK,BLANK='ZERO',STATUS='OLD')
      OPEN (12,FILE=TITLST,IOSTAT=IOCHECK,STATUS='OLD')
      IF(IOCHECK.NE.0) GO TO 992
      LIN = 12
701   WRITE(*,*)' ENTER THE NAME OF THE CROP DATA FILE TO BE USED'
```

```
      READ(*,'(A)')TITLCROP
      OPEN (13,FILE=TITLCROP,IOSTAT=IOCHECK,ACCESS='DIRECT',
     &FORM='FORMATTED',RECL=208,STATUS='OLD')
      IF(IOCHECK.NE.0) GO TO 993
702   WRITE(*,*)' ENTER THE NAME OF THE COST DATA FILE TO BE USED'
      READ(*,'(A)')TITLCOST
      OPEN (14,FILE=TITLCOST,IOSTAT=IOCHECK,ACCESS='DIRECT',
     &FORM='FORMATTED',RECL=208,STATUS='OLD')
      IF(IOCHECK.NE.0) GO TO 994
C
C
C  CLEAR ARRAYS
C
      DO 5 I=1,11
      DO 4 K = 1,2
4     TLAB(I,K) = 0.
      DO 5 J = 1,30
5     EAPP(J,I) = 0.
      DO 6 I = 1,30
6     PWRPMP(I) = 0.
      DO 601 I=1,4
      DO 601 J=1,11
      DO 601 K=1,30
601   IACCST(I,J,K)=0
      Y1 = 'YES'
      Y2 = 'yes'
C
C  SET UP READ FORMAT ARRAY
C
      FORM(1) = '(63X,F8.0)'
      FORM(2) = '(63X,I8)'
      FORM(3) = '(36X,F8.0,8F9.0)'
      FORM(4) = '(36X,5X,(A),8(6X,A))'
      FORM(5) = '(/36X,I8,8I9)'
      FORM(6) = '(A)'
      FORM(7) = '(27X,F8.0,8F9.0)'
      FORM(8) = '(/63X,I8)'
      FORM(9) = '(27X,9(A9))'
      FORM(10) = '(36X,5X,(A))'
      FORM(11) = '(/F8.0)'
      FORM(12) = '(/I8)'
      FORM(13) = '(2(/))'
      FORM(14) = '(3(/))'
      FORM(15) = '(4(/))'
      FORM(16) = '(5(/))'
      FORM(19) = '(18X,I8,8I9)'
      FORM(20) = '(F8.0)'
C
C  READ COMPONENT LIVES
C
      READ(14,801,REC=15)(LIFE(J),J=3,7)
      DO 8 I = 11,12
         READ(14,802,REC=I)LIFE(I)
8        READ(14,803,REC=I+2)LIFE(I+2)
801   FORMAT(22X,10I3)
802   FORMAT(29X,I3)
803   FORMAT(22X,I8)
C
C  READ CROP ROTATION/FIELD DATA
C  -- MOS. IN SEASON
      READ(LIN,FORM(6))M(1)
C      WRITE(*,'(1X,(A))')M(1)
      READ(LIN,FORM(12))MPS
C  -- NO FIELDS
      READ(LIN,FORM(14))
      READ(LIN,FORM(12))NFT
C  -- FIELD SPECIFIC DATA
      READ(LIN,FORM(16))
      DO 9 I = 1,NFT
9           READ(LIN,1101)N,AREA(N),NCRP(N),L,(SOIL(N,J),J = 1,3)
```

```
1101  FORMAT(I5,F21.0,2I18,9X,3F9.0)
C  --CROP ROTATION DATA
      READ(LIN,FORM(13))
      READ(LIN,FORM(12))NCR
      READ(LIN,FORM(15))
      DO 10 I = 1,NCR
            READ(LIN,1102)N,K,L,(ARRAY(J),J = 1,8)
            DO 10 II = 1,5,4
               CRPDK(N,L,II) = ARRAY(II)
               CRPDK(N,L,II+1) = ARRAY(II+1)
               CRPDK(N,L,II+3) = ARRAY(II+1)*ARRAY(II+2)/100.
               CRPDK(N,L,II+2) = CRPDK(N,L,II+3)*ARRAY(II+3)/100.
10    CONTINUE
1102  FORMAT(I8,2I9,8F9.0)
C
C
C  READ GENERAL SYSTEM DATA
C  -- CROPS GROWN IN ROTATIONS
      READ(LIN,'(//I8)')NCP
      READ(LIN,FORM(15))
      DO 11 I = 1,NCP
11     READ(LIN,1105)IDCP(I),CNAME(IDCP(I))
C11      WRITE(*,*)I,IDCP(I),CNAME(IDCP(I))
1105  FORMAT(I17,A)
C      WRITE(*,*)(IDCP(J),J=1,NCP)
      READ(LIN,FORM(13))
      READ(LIN,FORM(12))I
      ROC = I/100.
      READ(LIN,FORM(11))DINF
      DINF = DINF/100.
C      READ(LIN,FORM(20))SUBMAX
C      WRITE(*,*)' ROC,DINF,SUBMAX',ROC,DINF,SUBMAX
      READ(LIN,FORM(15))
      SUBTOT = 0.
C -- INTEREST RATES
      READ(LIN,1106)DAIR(1),DAIR(2),LLIF(1),LLIF(2)
1106  FORMAT(/36X,F8.0,F18.0//36X,I8,I18)
C
C!!!!!! SET LENGTH OF ECONOMIC ANALYSIS PERIOD !!!!!!!
      LEPD = 20
C  TOTAL NUMBER OF SYSTEMS - LIMITED BY ARRAY DIMENSIONS
      NSYMAX = 11
C
C      DINF = .05
C
      DAIR(1) = DAIR(1)/100.
      DAIR(2) = DAIR(2)/100.
C  CLEAR SYSTEM SUMMARY ARRAY
      DO 12 I=1,30
12    SYST(I) = 0.
C  READ GENERAL SUPPLY DATA
C -- FLOW DATA
      READ(LIN,FORM(14))
      READ(LIN,FORM(20))QINN,AVMAX,DPW
      SYST(1) = QINN
      SYST(2) = DPW/7.*100.
C -- WATER COST
      READ(LIN,FORM(14))
      READ(LIN,FORM(20))(WCOST(J),J = 1,4)
      DPAF = WCOST(1)/WCOST(2)
C  READ ELECTRIC RATE DATA
      READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
      DPKWH = 0.
      IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)THEN
            READ(LIN,'(12(/))')
            READ(LIN,1103)DPKWH,DPKWH2
            IF(DPKWH .LE. 0.0)DPKWH = DPKWH2
1103  FORMAT(45X,F8.0,F9.0)
      END IF
```

```
C  GO TO SUPPLY SUBROUTINE TO DETERMINE COSTS AND EFFICIENCIES
C
      WRITE(*,'(//(A))')' WORKING ON SUPPLY SYSTEM'
C  SUPPLY SYSTEM = SYSTEM #(SYSTEM MAX) FOR BOOKKEEPING
      NSYSS = NSYMAX
      CALL SUPPLY(NSYSS,DPAF,DPKWH,DEIR,TDHM)
C
C  SAVE SUPPLY SYSTEM DATA
      DO 15 I = 1,22
            SYSVAL(I,NSYSS) = SYST(I)
15    CONTINUE
      EAPP(1,NSYSS) = 100.-SSEEP(NSYSS)
C
C  READ GENERAL SYSTEM DATA
C -- SYSTEM/FIELD DISTRIBUTION
      READ(LIN,FORM(13))
      READ(LIN,FORM(12))NSYST
      READ(LIN,FORM(13))
      READ(LIN,FORM(19))(IDS(J),J = 1,NSYST)
      READ(LIN,FORM(19))(NPKSYS(J),J = 1,NSYST)
      READ(LIN,*)
      NFMAX = 0
      DO 16 I = 1,NSYST
16          NFMAX = MAX0(NFMAX,NPKSYS(I))
      DO 17 I = 1,NFMAX
17          READ(LIN,FORM(19))(IPSYS(I,J),J = 1,NSYST)
C - CHECK FOR FIELDS W/ MULTIPLE SYSTEM ASSIGNMENTS
      K = 1
      DO 18 I = 1,NSYST
            DO 18 J = 1,NFMAX
              IF(IPSYS(J,I) .EQ. 0)GOTO 18
              NN(K) = IPSYS(J,I)
              K = K+1
18    CONTINUE
      N = NFT-1
      DO 19 I = 1,N
            K = I+1
            DO 19 J = K,NFT
              IF(NN(I) .NE. NN(J))GOTO 19
              WRITE(*,1019)
              STOP
19    CONTINUE
1019  FORMAT(' DATA ERROR! TWO SYSTEMS SPECIFIED FOR A SINGLE FIELD.')
      READ(LIN,*)
C
C  CHECK FOR SYSTEM/CROP COMPATIBILITY
C
C  READ CROP/SYSTEM FLAGS
      DO 21 I = 1,NCP
C      WRITE(*,*)'REC',IDCP(I)
21         READ(13,1021,REC=IDCP(I))(CRPDAT(IDCP(I),J),J=1,2),
     &       (YN(IDCP(I),J),J=1,3)
1021  FORMAT(163X,F4.2,F4.0,1X,3(A,2X))
      DO 22 I = 1,NSYST
        JJ = IDS(I)
        DO 22 J = 1,NPKSYS(I)
          JJJ = IPSYS(J,I)
          DO 22 K = 1,NCRP(JJJ)
            DO 22 L = 1,5,4
              N = CRPDK(IPSYS(J,I),K,L)
              IF(N .EQ. 1)GOTO 22
              GO TO(211,211,212,212,212,212,212),JJ
211           IF(CRPDAT(N,JJ) .LE. 0.001)GOTO 991
              GOTO 22
212           JK = INT(FLOAT(JJ)/2.)
              IF(YN(N,JK) .EQ. 'N')GOTO 991
22    CONTINUE
C
C ***** LOOP BY IRRIGATION SYSTEM *****
C
```

```
      DO 100 NSYS = 1,NSYST
            WRITE(*,'(//(A),I3)')' WORKING ON SYSTEM',NSYS
C
C  CLEAR SYSTEM SUMMARY ARRAY
      DO 25 I=1,30
25        SYST(I) = 0.
      SYSNAM(NSYS) = SID(IDS(NSYS))
      READ(LIN,FORM(14))
C
C
C  CALL PROPER SUBROUTINE FOR SYSTEM TYPE
C
      GO TO (32,32,34,34,34,34,34,35),IDS(NSYS)
C
32    CALL SURFCE (NSYS,IDS(NSYS),J1,NT,DPAF,DPKWH,DEIR,TDHM,NSYSS)
      GO TO 40
C
34    CALL SPNKLR (NSYS,IDS(NSYS),J1,NT,DPAF,DPKWH,DEIR,TDHM,NSYSS)
      GO TO 40
C
C35    CALL TRIKLE (NSYS,IDS(NSYS),J1,NT,DPAF,DPKWH,DEIR,TDHM)
35    CONTINUE
C
C  SAVE SYSTEM COST DATA
C
40    DO 45 I=1,22
45       SYSVAL(I,NSYS) = SYST(I)
C
C ***** END OF MAIN SYSTEM LOOP *****
C
100   CONTINUE
C
C *** CHECK FOR DRAINAGE REQUIREMENTS ***
      READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' DRAIN FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 150
        CALL SDRAIN(NSYST)
C
150   READ(LIN,'(14(/))')
      DO 160 I = 1,NSYMAX
            SYSVAL(8,I) = DAIR(1)*100.
            SYSVAL(9,I) = FLOAT(LLIF(1))
            SYSVAL(17,I) = DAIR(2)*100.
160         SYSVAL(18,I) = FLOAT(LLIF(2))
C
C  ADD RESULTS TO LU 12 FOR USE IN SIMULATION PROGRAM
C
C *** SAVE SUPPLY SYSTEM DATA ***
C
      M(1)='(72(1H-))'
      M(2)='(///'' SUMMARY OF SUPPLY SYSTEM INFORMATION'')'
      M(3) ='(/''ESTIMATED SEEPAGE LOSSES   '',F9.3,'' %'')'
      WRITE(LIN,M(1))
      WRITE(LIN,M(2))
      WRITE(LIN,M(3))SSEEP(NSYSS)
C
      M(4)='(///'' SUMMARY OF INITIAL SYSTEM COSTS AND FINANCING ---'')'
      M(5)='(34X,''ATTACHED COMPONENTS   UNATTACHED COMPONENTS'')'
      M(6)='(37X,''(LOAN NO. 1)'',15X,''(LOAN NO.2)'')'
      M(7)='(''  TOTAL CAPITAL COST ($) . . . . . . .'',F9.2,F27.2)'
      M(9)='(''     CAPITAL NOT FINANCED ($) . . . . .'',F9.2,F27.2)'
C       M(10)='(''  SUBSIDIZED CAPITAL ($) . . . . . . .'',F9.2,F27.2)'
      M(11)='(''     FINANCED CAPITAL ($) . . . . . . .'',F9.2,F27.2)'
      M(12)='(''  INTEREST RATE (%)  . . . . . . . . .'',F9.2,F27.2)'
      M(13)='(''  TIME OF LOAN (YEARS) . . . . . . . .'',F9.0,F27.0)'
      M(14)='(''  SALVAGE VALUE ($)  . . . . . . . . .'',F9.2,F27.2)'
      M(15)='(''  ANNUAL MAINTENANCE EXPENSE ($) . .'',F9.2,F27.2)'
      M(16)='(''  ANNUAL MISCELLANEOUS EXPENSE ($) .'',F9.2,F27.2)'
      M(39)='(//6X,''ANNUAL CAPITAL CASH FLOW'')'
```

```
      M(40)='(5X,''YEAR  PRINCPLE INTREST     CASH    TOTAL''/45(1H-))'
      M(2)='(/''  ANNUAL CAPITAL RECOVERY ($)  . . .'',F9.2)'
      WRITE(LIN,M(4))
      WRITE(LIN,M(5))
      WRITE(LIN,M(6))
      WRITE(LIN,M(7))SYSVAL(4,NSYSS),SYSVAL(13,NSYSS)
C      WRITE(LIN,M(8))
      WRITE(LIN,M(9))SYSVAL(5,NSYSS),SYSVAL(14,NSYSS)
C      WRITE(LIN,M(10))SYSVAL(6,NSYSS),SYSVAL(15,NSYSS)
      WRITE(LIN,M(11))SYSVAL(7,NSYSS),SYSVAL(16,NSYSS)
      WRITE(LIN,M(12))SYSVAL(8,NSYSS),SYSVAL(17,NSYSS)
      WRITE(LIN,M(13))SYSVAL(9,NSYSS),SYSVAL(18,NSYSS)
      WRITE(LIN,M(14))SYSVAL(10,NSYSS),SYSVAL(19,NSYSS)
      WRITE(LIN,M(15))SYSVAL(11,NSYSS),SYSVAL(20,NSYSS)
      WRITE(LIN,M(16))SYSVAL(12,NSYSS),SYSVAL(21,NSYSS)
      WRITE(LIN,M(39))
      WRITE(LIN,M(40))
      MM = NINT(SYSVAL(5,NSYSS)+SYSVAL(14,NSYSS))
      K = 0
      WRITE(LIN,1109)K,K,K,MM,MM
      DO 46 K = 1,LEPD
46       WRITE(LIN,1109)K,(IACCST(KK,NSYSS,K),KK=1,4)
1109  FORMAT(I8,4I9)
      WRITE(LIN,M(2))SYSVAL(22,NSYSS)
C
      M(32)='(//18X,''ECONOMIC INFORMATION FOR SYSTEM COMPONENTS''/
     &18X,42(1H-))'
      M(50)='(/I8,'' COMPONENTS PURCHASED  (R = REPLACEMENT ITEM)''/)'
      M(33)='(38X,''TOTAL  SALVAGE   ANNUAL     LOAN'',2(''    ANNUAL''
     &))'
11091 FORMAT (10X,'ITEM',T26,    ' YR LIFE     COST   VALUE     COST
     &RATE(%) MAINT($)  MISC($)'/90(1H-))
1110  FORMAT(A,T28,I2,I5,6(I9))
      DO 461 K = 32,33
         IF(K .EQ. 33)WRITE(LIN,M(50))ITEMS(NSYSS)
461      WRITE(LIN,M(K))
      WRITE(LIN,11091)
      DO 462 I = 1,ITEMS(NSYSS)
462      WRITE(LIN,1110)COMP(NSYSS,I),(ICOMP(NSYSS,I,J),J=1,8)
C
      M(41)='(///1X,I7,'' CHANNEL(S) INCLUDED IN THIS SYSTEM''/)'
      WRITE(LIN,M(41))NCHAN(NSYSS)
      M(42)='('' SUMMARY INFORMATION FOR INCLUDED CHANNEL(S)'')'
      M(43)='(10X,''CHANNEL NO.      BOTTOM WIDTH*           DEPTH*'')'
      M(44)='(31X,''(FT)'',14X,''(FT)''/56(1H-)/30(I17,F18.1,F18.1/))'
      M(49)='('' * ESTIMATES ONLY.  DO NOT USE IN DESIGNING SYSTEM'')'
      IF(NCHAN(NSYSS).EQ.0 )GO TO 47
      WRITE(LIN,M(42))
      WRITE(LIN,M(43))
      WRITE(LIN,M(44))(J,CHAN(NSYSS,J,1),CHAN(NSYSS,J,2),
     &                 J=1,NCHAN(NSYSS))
      WRITE(LIN,M(49))
C
47    M(38)='(///1X,I7,'' PUMP(S) INCLUDED IN THIS SYSTEM''/)'
      WRITE(LIN,M(38))NAPMP(NSYSS)
      M(17)='('' SUMMARY INFORMATION FOR INCLUDED PUMP(S)'')'
      M(18)='(10X,''PUMP ID NO.       FLOW RATE        INPUT POWER'')'
      M(19)='(30X,''(GPM)'',14X,''(KW)''/56(1H-)/30(I17,F18.1,F18.1/))'
      IF(NAPMP(NSYSS).EQ.0 )GO TO 48
      WRITE(LIN,M(17))
      WRITE(LIN,M(18))
      WRITE(LIN,M(19))  (IDXPMA(J,NSYSS),QPMP(IDXPMA(J,NSYSS)),
     &                 PWRPMP(IDXPMA(J,NSYSS)),J=1,NAPMP(NSYSS))
C
48    M(45)='(///1X,I7,'' PIPE(S) INCLUDED IN THIS SYSTEM''/)'
      WRITE(LIN,M(45))NPIPE(NSYSS)
      M(46)='('' SUMMARY INFORMATION FOR INCLUDED PIPE(S)'')'
      M(47)='(10X,''PIPE NUMBER      NOMINAL DIA.*'')'
      M(48)='(31X,''(IN)''/45(1H-)/30(I17,F18.0/))'
      IF(NPIPE(NSYSS).EQ.0 )GO TO 50
```

```
      WRITE(LIN,M(46))
      WRITE(LIN,M(47))
      WRITE(LIN,M(48))(J,PIPE(NSYSS,J),J=1,NPIPE(NSYSS))
      WRITE(LIN,M(49))
50    WRITE(LIN,M(1))
C
C *** LOOP TO SAVE INDIVIDUAL APPLICATION SYSTEM DATA ***
C
      M(20)='(///'' SUMMARY OF APPLICATION SYSTEMS INFORMATION'')'
      WRITE(LIN,M(20))
      M(36)='(/''MAX. TIME SYSTEM OPERATES  '',F9.2,'' %'')'
      M(37)='(/''PROJECTED APPLICATION SYSTEM LIFE (YRS)'',F9.1)'
      M(21)='(///''SYSTEM NO'',I8,'' -- '',A/)'
      M(22)='(//'' FIELDS SERVED AND LABOR REQUIREMENTS'')'
      M(23)='(5X,''FIELD'',10X,''LABOR REQT.'',6X,''ADDITIONAL'')'
      M(24)='(6X,''NO.'',11X,''(HR/IRRIG)     (HR/SEASON)''/60(1H-))'
      M(51)='(20(I8,2F18.1/))'
      M(25)='(//'' OVERALL SYSTEM EFFICIENCIES FOR CROPS IN EACH'',
     &'' FIELD'')'
      M(26)='(5X,''FIELD      - CROP -'',14X,''APPLIC  DEEP     RUN-
     & HRS/SET OR'')'
11092 FORMAT(6X,'NO.        NO.    NAME',12X,'EFF(%)  PERC(%)',
     & 3X,'OFF(%)   HRS/PASS'/75(1H-))
      M(31)='(//''FLOW ENTERING SYSTEM  (CFS)'',F9.2)'
C
C
      DO 200 NSYS = 1,NSYST
C
      WRITE(LIN,M(21))NSYS,SYSNAM(NSYS)
      WRITE(LIN,M(31))SYSVAL(1,NSYS)
      WRITE(LIN,M(3))SSEEP(NSYS)
      WRITE(LIN,M(36))SYSVAL(2,NSYS)
      WRITE(LIN,M(37))SYSVAL(3,NSYS)
C
      DO 52 N = 22,24
52        WRITE(LIN,M(N))
      WRITE(LIN,M(51))(IPSYS(J,NSYS),TLAB(IPSYS(J,NSYS),1),
     &                 TLAB(IPSYS(J,NSYS),2),J=1,NPKSYS(NSYS))
C
      DO 53 N = 25,26
53        WRITE(LIN,M(N))
      WRITE(LIN,11092)
C
      DO 60 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
1124  FORMAT(I8/(I17,2X,A,4F9.1))
      WRITE(LIN,1124) IPK,(NT(J,IPK),CNAME(NT(J,IPK)),
     & EAPP(NT(J,IPK),IPK),SYSOBS(NT(J,IPK),IPK,1),
     & SYSOBS(NT(J,IPK),IPK,2),SYSOBS(NT(J,IPK),IPK,3),J=1,J1(IPK))
      WRITE(LIN,*)
60    CONTINUE
C
      WRITE(LIN,M(4))
      WRITE(LIN,M(5))
      WRITE(LIN,M(6))
      WRITE(LIN,M(7))SYSVAL(4,NSYS),SYSVAL(13,NSYS)
C      WRITE(LIN,M(8))
      WRITE(LIN,M(9))SYSVAL(5,NSYS),SYSVAL(14,NSYS)
C      WRITE(LIN,M(10))SYSVAL(6,NSYS),SYSVAL(15,NSYS)
      WRITE(LIN,M(11))SYSVAL(7,NSYS),SYSVAL(16,NSYS)
      WRITE(LIN,M(12))SYSVAL(8,NSYS),SYSVAL(17,NSYS)
      WRITE(LIN,M(13))SYSVAL(9,NSYS),SYSVAL(18,NSYS)
      WRITE(LIN,M(14))SYSVAL(10,NSYS),SYSVAL(19,NSYS)
      WRITE(LIN,M(15))SYSVAL(11,NSYS),SYSVAL(20,NSYS)
      WRITE(LIN,M(16))SYSVAL(12,NSYS),SYSVAL(21,NSYS)
      WRITE(LIN,M(39))
      WRITE(LIN,M(40))
      MM = NINT(SYSVAL(5,NSYS)+SYSVAL(14,NSYS))
      K = 0
      WRITE(LIN,1109)K,K,K,MM,MM
```

```
      DO 61 K = 1,LEPD
61       WRITE(LIN,1109)K,(IACCST(KK,NSYS,K),KK=1,4)
      WRITE(LIN,M(2))SYSVAL(22,NSYS)
C
      DO 611 K = 32,33
         IF(K .EQ. 33)WRITE(LIN,M(50))ITEMS(NSYS)
611     WRITE(LIN,M(K))
      WRITE(LIN,11091)
      DO 612 I = 1,ITEMS(NSYS)
612      WRITE(LIN,1110)COMP(NSYS,I),(ICOMP(NSYS,I,J),J=1,8)
C
      WRITE(LIN,M(41))NCHAN(NSYS)
      IF(NCHAN(NSYS).EQ.0 )GO TO 62
      WRITE(LIN,M(42))
      WRITE(LIN,M(43))
      WRITE(LIN,M(44))(J,CHAN(NSYS,J,1),CHAN(NSYS,J,2),J=1,NCHAN(NSYS))
      WRITE(LIN,M(49))
C
62    WRITE(LIN,M(38))NAPMP(NSYS)
      IF(NAPMP(NSYS).EQ.0 )GO TO 63
      WRITE(LIN,M(17))
      WRITE(LIN,M(18))
      WRITE(LIN,M(19))  (IDXPMA(J,NSYS),QPMP(IDXPMA(J,NSYS)),
     &                   PWRPMP(IDXPMA(J,NSYS)),J=1,NAPMP(NSYS))
C
63    WRITE(LIN,M(45))NPIPE(NSYS)
      IF(NPIPE(NSYS).EQ.0 )GO TO 199
      WRITE(LIN,M(46))
      WRITE(LIN,M(47))
      WRITE(LIN,M(48))(J,PIPE(NSYS,J),J=1,NPIPE(NSYS))
      WRITE(LIN,M(49))
 199  WRITE(LIN,M(1))
C
 200  CONTINUE
C
C  SAVE USLE DATA
      M(29)='(//'' THE FOLLOWING DATA ARE USED TO CALCULATE SOIL LOSSES
     &'')'
      M(30)='(/'' THE VALUES HAVE NO PHYSICAL MEANING''/)'
      WRITE(LIN,M(29))
      WRITE(LIN,M(30))
1130  FORMAT(I8,5F9.3)
      DO 300 I = 1,NSYST
        GOTO(300,300,299,299,299,299,299,299,300),IDS(I)
 299    DO 298 II = 1,NPKSYS(I)
         IPK = IPSYS(II,I)
         WRITE(LIN,1130)IPK,(SYSFLD(IPK,J),J = 27,29)
 298    CONTINUE
 300  CONTINUE
      WRITE(LIN,M(1))
C
      M(32)='(//''>>>THE PROGRAM HAS SUCCESSFULLY EXECUTED!! <<<''//)'
      M(33)='('' -- A LISTING OF INPUT DATA AND SUMMARY OUTPUT IS''\)'
      M(34)='('' IN FILE '',A/)'
      M(35)='('' -- DATA FOR THE SIMULATION PROGRAM IS INCLUDED'')'
      WRITE(*,M(32))
      WRITE(*,M(33))
      WRITE(*,M(34))TITLST
      WRITE(*,M(35))
      CLOSE (12)
      CLOSE (13)
      CLOSE (14)
      STOP
888   WRITE(*,*)' CANNOT OPEN FILE  IOCHECK =',IOCHECK
      STOP
990   FORMAT(' THE DATA FILE SPECIFIED DOES NOT EXIST!!'/' TRY AGAIN')
991   WRITE(*,9911)N,SID(JJ)
9911  FORMAT(' CROP',I3,' IS NOT SUITED FOR ',A,' SYSTEM')
      STOP
992   WRITE(*,990)
```

```
      GOTO 7
993   WRITE(*,990)
      GOTO 701
994   WRITE(*,990)
      GOTO 702
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE SUPPLY (NSYS,DPAF,DPKWH,DEIR,TDHM)
C
C  SUBROUTINE SUPPLY FOR COMPUTING COSTS AND EFFICIENCIES OF
C  IRRIGATION SUPPLY SYSTEMS
C
C  VARIABLES PASSED
C     DPAF -- COST OF IRRIGATION WATER ($/ac-ft)
C     DPKWH -- AVERAGE COST OF ELECTRIC POWER ($/KWH)
C     DEIR -- EXPECTED ANNUAL ENERGY COST INCREASE (decimal)
C     ECONV -- SUPPLY SYSTEM CONVEYANCE EFFICIENCY
C     TDHM -- MAXIMUM PUMPING HEAD
C
C     ===>>> OTHER VARIABLES
C     VF -- ARRAY OF VARIABLES PASSED FROM SUBROUTINES -- RACES,PIPES
C     MAD -- NET IRRIGATION APPLICATION
C            = MGT ALLOWED DEFICIT - APP DEFICIT
C         -- A "REAL" VARIABLE
C     J1 -- INDEXING VARIABLE
C     SYST(1) -- FLOW RATE ENTERING THE SUPPLY SYSTEM
C     SYST(2) -- % OF TIME SUPPLY SYSTEM OPERATES
C
C
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      DIMENSION VF(7,2),ARRAY(9,26)
C
      CHARACTER*3 FLAG,Y1,Y2,YN(9),FORM*20,SNM*30,COMP*26
C
      Y1 = 'YES'
      Y2 = 'yes'
      TDHS = 0.
C
C ***** READ CANAL FLAG *******
      READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SUP. CANAL FLAG',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 47
C  ASSUME CANAL USED 50% OF IRRIGATION SEASON
      DPY = MPS*30.*0.75*SYST(2)/100.
       CALL CANAL (NSYS,SYST(1),DPY,DPAF,VF)
C  N = LOAN #
      DO 45 N=1,2
            J=4
            IF(N.GT.1) J=13
            SYST(J) = SYST(J) + VF(1,N)
            SYST(J+1) = SYST(J+1) + VF(2,N)
            SYST(J+2) = SYST(J+2) + VF(3,N)
            SYST(J+3) = SYST(J+3) + VF(4,N)
            SYST(J+6) = SYST(J+6) + VF(5,N)
            SYST(J+7) = SYST(J+7) + VF(6,N)
            SYST(J+8) = SYST(J+8) + VF(7,N)
45    CONTINUE
C
C ***** READ STRUCTURE FLAG *******
47    READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SUP. STRUCT FLAG',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 55
C ***** READ STRUCTURE DATA *******
      CALL STRUCT(NSYS)
```

```
C
C ***** READ PUMP FLAG *******
55     READ(LIN,FORM(14))
       READ(LIN,FORM(6))FLAG
C       WRITE(*,*)' SUP. PUMP FLAG',FLAG
       IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 65
C ***** READ PUMP DATA *******
       CALL PUMP(NSYS,TDHS)
       TDHM = TDHS
C
C ***** READ PIPE FLAG *******
65     READ(LIN,FORM(14))
       READ(LIN,FORM(6))FLAG
C       WRITE(*,*)' SUP. PIPE FLAG ',FLAG
       IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 75
C ***** READ PIPE DATA *******
C - ASSUME PIPES USED 75% OF IRRIGATION SEASON
       HPS = MPS*30.*24.*0.75*SYST(2)/100.
       PMAX = TDHS/2.31
       IF(TDHS .EQ. 0.)PMAX = TDHM/2.31
       CALL PIPES (NSYS,SYST(1),DEIR,HPS,DPKWH,VF,PMAX)
C  N = LOAN #
       DO 60 N=1,2
             J=4
             IF(N.GT.1) J=13
             SYST(J) = SYST(J) + VF(1,N)
             SYST(J+1) = SYST(J+1) + VF(2,N)
             SYST(J+2) = SYST(J+2) + VF(3,N)
             SYST(J+3) = SYST(J+3) + VF(4,N)
             SYST(J+6) = SYST(J+6) + VF(5,N)
             SYST(J+7) = SYST(J+7) + VF(6,N)
             SYST(J+8) = SYST(J+8) + VF(7,N)
60     CONTINUE
C
C ***** READ OTHER EXPENSE FLAG *******
75     READ(LIN,FORM(14))
       READ(LIN,FORM(6))FLAG
C       WRITE(*,*)' SUP. OTHER FLAG ',FLAG
       IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 85
C ***** READ OTHER EXPENSE DATA *******
       CALL OTHER(NSYS)
C
85     RETURN
       END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE SURFCE (NSYS,ID,J1,NT,DPAF,DPKWH,DEIR,TDHM,NSYSS)
C
C  SUBROUTINE SURFCE  FOR COMPUTING COSTS AND EFFICIENCIES OF
C  BORDER AND FURROW IRRIGATION SYSTEMS
C
C  SELECTED VARIABLES
C    NSYS -- SYSTEM ID NO.
C    ID -- SYSTEM TYPE ID NO.
C    J1 -- ARRAY OF NO. OF CROPS IN EACH PADDOCK
C    NT -- ARRAY OF CROP ID NOS. FOR EACH PADDOCK
C    DPAF -- COST OF IRRIGATION WATER ($/ac-ft)
C    DPKWH -- AVERAGE POWER COST ($/KWH)
C    DEIR -- EXPECTED RATE OF ENERGY COST INCREASE (decimal)
C    TDHM -- MAXIMUM PUMPING HEAD
C
C    ===>>> OTHER VARIABLES
C    RN -- MANNING'S ROUGHNESS COEFFICIENT ENTERED AND USED IN
C          SUBROUTINE BORDER
C    VF -- ARRAY OF VARIABLES PASSED FROM SUBROUTINES -- RACES,PIPES
C    MAD -- NET IRRIGATION APPLICATION
C           = MGT ALLOWED DEFICIT - APP DEFICIT
C        -- A "REAL" VARIABLE
C    J1 -- INDEXING VARIABLE
C    QINN -- FLOW RATE ENTERING THE SYSTEM
C    HRD -- HRS PER DAY SYSTEM OPERATES
C
C
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      COMMON/SOILS/SOIL(9,3)
      COMMON/SYSM/SYSFLD(9,30),VLOG(9,4)
C
      DIMENSION NT(30,20),VF(7,2),MAD(30),J1(20),
     & FIFN(19),AA(19),BB(19),QTF(9),RNTF(9),ARRAY(9,26)
C
      CHARACTER*3 FLAG,Y1,Y2,YN(9),FORM*20,COMP*26
      LOGICAL VLOG
      REAL MAD
C
      DATA FIFN/.05,.10,.15,.20,.25,.30,.35,.40,.45,.50,
     &.60,.70,.80,.90,1.00,1.50,2.00,3.00,4.00/
      DATA AA/.0210,.0244,.0276,.0306,.0336,.0364,.0392,.0419,.0445,
     &.0471,.052,.0568,.0614,.0659,.0703,.0899,.1084,.1437,.1750/
      DATA BB/.6180,.6610,.6834,.6988,.7107,.7204,.7285,.7356,.7419,
     &.7475,.7572,.7656,.7728,.7792,.785,.799,.808,.816,.823/
C
      Y1 = 'YES'
      Y2 = 'yes'
      TDHS = 0.
C
      READ(LIN,FORM(1))QINN
      READ(LIN,FORM(1))HRD
      READ(LIN,FORM(15))
C
      SYST(1) = AMIN1(QINN,SYSVAL(1,NSYSS))
      IF(QINN.GT.SYSVAL(1,NSYSS))WRITE(*,4001)NSYS
4001  FORMAT(/' APPLICATION SYSTEM',I3,' CAPACITY EXCEEDS SUPPLY'
     &' SYSTEM CAPACITY.'/' SUPPLY SYSTEM VALUE IS USED IN PROGRAM.'//
     &' MAKE APPROPRIATE CHANGES TO DATA FILE.')
      SYST(2) = 100. * HRD/24.
```

```
      SYST(3) = LIFE(14)
C -- READ SYSTEM/FIELD DATA...
      NF = NPKSYS(NSYS)
      GOTO (401,451),ID
C
C  ... FOR BORDER
401   DO 402 I = 1,5
402         READ(LIN,FORM(3))(ARRAY(J,I),J = 1,NF)
      READ(LIN,FORM(4))(YN(J),J = 1,NF)
C      WRITE(*,FORM(4))(YN(J),J = 1,NF)
      DO 403 I = 1,NF
            ARRAY(I,6) = 2
            IF(YN(I) .EQ. 'YES' .OR. YN(I) .EQ. 'yes')
     &           ARRAY(I,6) = 1
403   CONTINUE
      DO 404 I = 8,17
         IF(I .EQ. 11)GOTO 404
         READ(LIN,FORM(3))(ARRAY(J,I),J = 1,NF)
C         WRITE(*,FORM(3))(ARRAY(J,I),J = 1,NF)
404   CONTINUE
      GOTO 500
C
C   ... FOR FURROW
451   DO 452 I = 1,17
         IF(I .EQ. 11)GOTO 452
         READ(LIN,FORM(3))(ARRAY(J,I),J = 1,NF)
C         WRITE(*,FORM(3))(ARRAY(J,I),J = 1,NF)
452   CONTINUE
C
C - TRANSFER DATA FROM READ ARRAY TO COMMON ARRAY
500   DO 501 I = 1,NF
            IPK = IPSYS(I,NSYS)
            DO 501 J = 1,17
                  SYSFLD(IPK,J) = ARRAY(I,J)
501   CONTINUE
C  LOOP FOR EACH PADDOCK
      DO 40 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
C
C
C  OBTAIN COEFFICIENTS FOR INTAKE RATE EQN
C
      FIF = SOIL(IPK,1)
      DO 10 J = 2,19
10       IF(FIF.LE.FIFN(J) .AND. FIF.GT.FIFN(J-1))GOTO 11
C  FOR FAMILY < FIRST CURVE NUMBER BUT > 0.
      IF(FIF.GT.0. .AND. FIF.LE.FIFN(1))THEN
         J=1
         GOTO 15
      END IF
C  FOR FAMILY > LAST CURVE NUMBER
      WRITE(*,151)IPK
      J = 8
151   FORMAT(/' BAD VALUE FOR SURFACE INTAKE FAMILY NUMBER ON FIELD',
     & I3/' FAMILY 0.40 IS USED IN CALCULATIONS')
      GOTO 15
C  FIND CLOSEST CURVE NUMBER
11    JJ2 = NINT(FIFN(J)*100.)
      JJ1 = NINT(FIFN(J-1)*100.)
      JJ0 = NINT(FIF*100.)
      IF((JJ0-JJ1).LT.(JJ2-JJ0))J=J-1
15    A = AA(J)
      B = BB(J)
C
C  SORT OUT WHICH CROPS ARE IRRIGATED IN THE PADDOCK
C
C  -- TMAD = AVERAGE MAD FOR DRAINAGE COMPUTATIONS
      TMAD = 0.
      J1(IPK) = 0
      DO 20 J = 1,NCP
```

```
          DO 16 JJ = 1,NCRP(IPK)
             DO 16 JJJ = 1,5,4
                NOCR = NINT(CRPDK(IPK,JJ,JJJ))
                IF(NOCR .EQ. 1)GOTO 16
                IF(NOCR .NE. IDCP(J))GOTO 16
                DO 152 L = 1,J1(IPK)
152                IF(NT(L,IPK) .EQ. NOCR)GOTO 16
                J1(IPK) = J1(IPK) + 1
                NT(J1(IPK),IPK) = NOCR
C                MAD(J1(IPK)) = CRPDK(IPK,JJ,JJJ+3)-CRPDK(IPK,JJ,JJJ+2)
                MAD(J1(IPK)) = CRPDK(IPK,JJ,JJJ+3)
                MAD(J1(IPK)) = AMAX1(MAD(J1(IPK)),0.)
                TMAD = TMAD + MAD(J1(IPK))
16        CONTINUE
20     CONTINUE
       DRAN(IPK,1) = SYSFLD(IPK,1)
       DRAN(IPK,4) = TMAD/J1(IPK)
       QT = 0.
       RNT = 0.
C  LOOP BY CROP
       DO 30 K = 1,J1(IPK)
       READ(13,201,REC=NT(K,IPK))RN,SPFUR
201    FORMAT(163X,F4.2,F4.0,1X,3(A,2X))
C
C  CHECK FOR SPECIFIED EFFICIENCIES
       IF(SYSFLD(IPK,15) .GT. 0.1)THEN
             EFFA = SYSFLD(IPK,15)
             DVOL = SYSFLD(IPK,16)
             RVOL = 100-EFFA-DVOL
             TIME = 0.0
             QU = SYSFLD(IPK,17)
             IF(ID .EQ. 2)QU=QU/448.8
             GOTO 25
       END IF
C  CALL PROPER SUBROUTINE -- 'BORDER' OR 'FURROW'
C
       GO TO (12,14),ID
C
C **** CHECK FOR BORDER IRRIG FEASIBILITY
12        CALL BORDER  (IPK,MAD(K),RN,A,B,QU,EFFA,DVOL,RVOL,TIME)
       GO TO 25
C
14     VLOG(IPK,1) = .FALSE.
C ***** CHECK FOR FURROW IRRIG FEASIBILITY
       IF(SPFUR .LE. 24.)VLOG(IPK,1) = .TRUE.
       CALL FURROW(IPK,MAD(K),A,B,SPFUR,QU,EFFA,DVOL,RVOL,TIME)
       GOTO 25
C
C - APPLICATION EFFICIENCIES -
25     EAPP(NT(K,IPK),IPK) = EFFA
       SYSOBS(NT(K,IPK),IPK,1) = DVOL
       SYSOBS(NT(K,IPK),IPK,2) = RVOL
       SYSOBS(NT(K,IPK),IPK,3) = TIME
C       WRITE(*,*)' DEPTH =',MAD(K)
C       WRITE(*,*)' EFF =',EFFA,' CROP = ',NT(K,IPK),' FLD = ',IPK
C       WRITE(*,*)'DEEP PERC = ',DVOL
       EFFAVE = EFFAVE+EFFA
       DPAVE = DPAVE+DVOL
       QT = QT+QU
       RNT = RNT+SPFUR
30     CONTINUE
C
       QTF(IPK) = QT/J1(IPK)
       RNTF(IPK) = RNT/J1(IPK)
       DRAN(IPK,2) = DPAVE/J1(IPK)
       DRAN(IPK,3) = EFFAVE/J1(IPK)
C
C  SUMMARIZE LAND PREP. DATA FOR SYSTEM SUMMARY
       J=4
       LOAN = NINT(SYSFLD(IPK,13))
```

```
      IF(LOAN .GT. 1) J=13
      T = SYSFLD(IPK,10)
C      SUB = SYSFLD(IPK,11)/100.
      FIN = SYSFLD(IPK,12)/100.
C      SUBADD = SUB*T
C      IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C        DIFF = (SUBTOT+SUBADD)-SUBMAX
C        SUBADD = SUBADD-DIFF
C        SUB2 = SUBADD/T
C        FIN = FIN + (SUB-SUB2)
C        SUB = SUB2
C      END IF
C      SUBTOT = SUBTOT+SUBADD
      SYST(J) = SYST(J) + T
C      SYST(J+1) = SYST(J+1) + T * (1.-(SUB+FIN))
      SYST(J+1) = SYST(J+1) + T * (1.-FIN)
      SYST(J+2) = SYST(J+2) + SUBADD
      SYST(J+3) = SYST(J+3) + T * FIN
      SYST(J+7) = SYST(J+7) + SYSFLD(IPK,14)
      LIF = LIFE(14)
      COMP(NSYS,ITEMS(NSYS)+1) = 'LAND LEVELING'
      CALL ECON(NSYS,T,LIF,LOAN,0.0,FIN,SUB,SYSFLD(IPK,14),0.0)
C
40    CONTINUE
C
C ***** READ CANAL FLAG *******
      READ(LIN,FORM(15))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SURF CANAL FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 47
C  ASSUME CANAL USED 50% OF IRRIGATION SEASON
      DPY = MPS*30.*0.5*HRD/24.
       CALL CANAL (NSYS,SYST(1),DPY,DPAF,VF)
C  N = LOAN #
      DO 45 N=1,2
            J=4
            IF(N.GT.1) J=13
            SYST(J) = SYST(J) + VF(1,N)
            SYST(J+1) = SYST(J+1) + VF(2,N)
            SYST(J+2) = SYST(J+2) + VF(3,N)
            SYST(J+3) = SYST(J+3) + VF(4,N)
            SYST(J+6) = SYST(J+6) + VF(5,N)
            SYST(J+7) = SYST(J+7) + VF(6,N)
            SYST(J+8) = SYST(J+8) + VF(7,N)
45    CONTINUE
C
47    QIN = QINN - QINN*SSEEP(NSYS)/100.
C      WRITE(*,*)'SURF QIN,QINNET',QINN,QIN
      DO 48 J = 1,NPKSYS(NSYS)
         I = IPSYS(J,NSYS)
C - FIND NUMBER OF SETS
         IF(ID .EQ. 1)THEN
          NSET = NINT(AREA(I)*43560./(QIN/QTF(I)*SYSFLD(I,4))+.35)
         ELSE
          NSET =  NINT(AREA(I)*43560./SYSFLD(I,4)/
     &                 (QIN/QTF(I)*RNTF(I))+.35)
         END IF
C - COMPUTE LABOR REQUIREMENTS
         TLAB(I,1) = SYSFLD(I,8)*AREA(I)
         TLAB(I,2) = SYSFLD(I,9)
48    CONTINUE
C
C ***** READ STRUCTURE FLAG *******
      READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SURF STRUCT FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 55
C ***** READ STRUCTURE DATA *******
      CALL STRUCT(NSYS)
C
```

```
C ***** READ PUMP FLAG *******
55    READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SURF PUMP FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 65
C ***** READ PUMP DATA *******
      CALL PUMP(NSYS,TDHS)
C
C ***** READ PIPE FLAG *******
65    READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SURF PIPE FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 75
C ***** READ PIPE DATA *******
C - ASSUME PIPES USED 50% OF IRRIGATION SEASON
      HPS = MPS*30.*0.5*HRD
      PMAX = TDHS/2.31
      IF(TDHS .EQ. 0.)PMAX = TDHM/2.31
      CALL PIPES (NSYS,SYST(1),DEIR,HPS,DPKWH,VF,PMAX)
C  N = LOAN #
      DO 60 N=1,2
            J=4
            IF(N.GT.1) J=13
            SYST(J) = SYST(J) + VF(1,N)
            SYST(J+1) = SYST(J+1) + VF(2,N)
            SYST(J+2) = SYST(J+2) + VF(3,N)
            SYST(J+3) = SYST(J+3) + VF(4,N)
            SYST(J+6) = SYST(J+6) + VF(5,N)
            SYST(J+7) = SYST(J+7) + VF(6,N)
            SYST(J+8) = SYST(J+8) + VF(7,N)
60    CONTINUE
C
C ***** READ OTHER EXPENSE FLAG *******
75    READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SURF OTHER FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 85
C ***** READ OTHER EXPENSE DATA *******
      CALL OTHER(NSYS)
C
85    RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE SPNKLR(NSYS,ID,J1,NT,DPAF,DPKWH,DEIR,TDHM,NSYSS)
C
C  SUBROUTINE SPNKLR FOR COMPUTING COSTS AND EFFICIENCIES OF
C  SPRINKLER IRRIGATION SYSTEMS
C
C  VARIABLES PASSED
C    NSYS -- SYSTEM ID NO.
C    ID -- SYSTEM TYPE ID NO.
C    J1 -- ARRAY OF NO. OF CROPS IN EACH PADDOCK
C    NT -- ARRAY OF CROP ID NOS. FOR EACH PADDOCK
C    DPAF -- COST OF IRRIGATION WATER ($/ac-ft)
C    DPKWH -- AVERAGE COST POWER ($/KWH)
C    DEIR -- RATE OF ENERGY COST INCREASE (decimal)
C    TDHM -- MAXIMUM PUMPING HEAD
C
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      COMMON/SYSM/SYSFLD(9,30),VLOG(9,4)
      COMMON/SOILS/SOIL(9,3)
C
      DIMENSION NT(30,20),RN(30),VF(7,2),MAD(30),J1(20),ARRAY(9,26)
C
      REAL MAD
      LOGICAL VLOG
      CHARACTER*3 FLAG,Y1,Y2,YN(9,4),LBL(5)*9,FORM*20,COMP*26
C
      Y1 = 'YES'
      Y2 = 'yes'
      TDHS = 0.
C  LOOP FOR EACH FIELD
      DO 20 I=1,NPKSYS(NSYS)
      IPK = IPSYS(I,NSYS)
C      WRITE(*,*)' FIELD NUMBER ',IPK
C
C
C  SORT OUT WHICH CROPS ARE IRRIGATED IN THE PADDOCK
C
C  -- DRAN(IPK,4) = AVE. IRRIG. APPLICATION FOR DRAINAGE COMPUTATIONS
      TMAD = 0.
      J1(IPK) = 0
      DO 10 J = 1,NCP
         DO 6 JJ = 1,NCRP(IPK)
            DO 6 JJJ = 1,5,4
               NOCR = NINT(CRPDK(IPK,JJ,JJJ))
               IF(NOCR .EQ. 1) GOTO 6
               IF(NOCR .NE. IDCP(J))GOTO 6
               DO 52 L = 1,J1(IPK)
52                IF(NOCR .EQ. NT(L,IPK))GOTO 6
               J1(IPK) = J1(IPK) + 1
               NT(J1(IPK),IPK) = NOCR
               MAD(J1(IPK)) = CRPDK(IPK,JJ,JJJ+3)-CRPDK(IPK,JJ,JJJ+2)
               MAD(J1(IPK)) = AMAX1(MAD(J1(IPK)),0.)
               TMAD = TMAD + MAD(J1(IPK))
6           CONTINUE
10    CONTINUE
      DRAN(IPK,4) = TMAD/J1(IPK)
      DRAN(IPK,4) = AMAX1(DRAN(IPK,4),0.)
C      WRITE(*,*)' FIELD, DEPTH',IPK,DRAN(IPK,4)
20    CONTINUE
C
```

```
      DO 22 J = 1,9
        DO 22 I = 1,26
        ARRAY(J,I) = 0.
22      IF( J .EQ. 2)ARRAY(J,I) = 1.E10
C
C  CALL PROPER SUBROUTINE TO INPUT SYSTEM SPECIFIC DATA
C
      IDT = ID-2
C
C -- READ SYSTEM/FIELD DATA
C
      NF = NPKSYS(NSYS)
      READ(LIN,FORM(1))HPD
      SYST(2) = HPD/24.*100.
      DTPW = 0.
      NL = 1
      IF(IDT .EQ. 1)NL = 2
      IF(IDT .LT. 4 )THEN
            IF(IDT .GT. 1) READ(LIN,FORM(1))DTPW
            READ(LIN,FORM(8))IWIND
            NL = 4
      END IF
      GO TO (210,220,220,230,230),IDT
C
C   READ SOLID SET DATA
C
210   READ(LIN,FORM(15))
      READ(LIN,FORM(4))(YN(J,1),J = 1,NF)
      DO 211 I = 1,24
         IF(I .EQ. 14 .OR. I .EQ. 19)GOTO 211
         IF(I .EQ. 5)READ(LIN,FORM(14))
         READ(LIN,FORM(3))(ARRAY(J,I),J = 1,NF)
211   CONTINUE
      DO 212 I = 1,NF
212      YN(I,2) = Y1
      GOTO 250
C
C   READ HAND MOVE & SIDE-ROLL DATA
C
220   DO 221 I = 1,9
         IF(I .EQ. 5) READ(LIN,'(/)')
         IF(I .EQ. 6 .OR. I .EQ. 8)GOTO 221
         READ(LIN,FORM(1))ARRAY(1,I)
221   CONTINUE
      DO 222 I = 13,17
         IF(I .EQ. 14)GOTO 222
         READ(LIN,FORM(1))ARRAY(1,I)
222   CONTINUE
      READ(LIN,FORM(1))ARRAY(1,23)
      READ(LIN,FORM(1))ARRAY(1,24)
      READ(LIN,FORM(15))
      READ(LIN,FORM(3))(ARRAY(J,10),J = 1,NF)
      READ(LIN,FORM(3))(ARRAY(J,6),J = 1,NF)
      READ(LIN,FORM(3))(ARRAY(J,8),J = 1,NF)
      READ(LIN,FORM(4))(YN(J,1),J = 1,NF)
      DO 223 I = 11,12
223      READ(LIN,FORM(3))(ARRAY(J,I),J = 1,NF)
      DO 224 I = 18,22
         IF(I .EQ. 19)GOTO 224
         READ(LIN,FORM(3))(ARRAY(J,I),J = 1,NF)
224   CONTINUE
      GOTO 250
C
C   READ CENTER PIVOT OR LINEAR MOVE DATA
C
230   DO 231 I = 1,4
         IF(I .EQ. 4) READ(LIN,FORM(13))
231      READ(LIN,FORM(1))ARRAY(1,I)
      DO 232 I = 2,4
         READ(LIN,'(63X,5X,(A))')YN(1,I)
```

```
C          WRITE(*,*)'YN(1,I),I',YN(1,I),I
232    CONTINUE
       READ(LIN,FORM(1))ARRAY(1,7)
       DO 233 I = 13,17
          IF(I .EQ. 14)GOTO 233
          READ(LIN,FORM(1))ARRAY(1,I)
233    CONTINUE
       READ(LIN,FORM(1))ARRAY(1,23)
       READ(LIN,FORM(1))ARRAY(1,24)
       READ(LIN,FORM(15))
       DO 234 I = 5,6
234       READ(LIN,FORM(3))(ARRAY(J,I),J = 1,NF)
       READ(LIN,FORM(4))(YN(J,1),J = 1,NF)
C      WRITE(*,*)'YN(J,1)',(J,YN(J,1),J=1,NF)
       DO 235 I = 18,22
          IF(I .EQ. 19)GOTO 235
          READ(LIN,FORM(3))(ARRAY(J,I),J = 1,NF)
235    CONTINUE
       NL = 4
       GOTO 250
C
C -- TRANSFER DATA FROM READ ARRAY TO COMMON ARRAY
C
250    DO 255 I = 1,NF
            IPK = IPSYS(I,NSYS)
            II = I
            DO 252 J = 1,NL
                IF(J .GT. 1)II = 1
                IF(YN(II,J) .EQ. Y1 .OR. YN(II,J) .EQ. Y2)THEN
                    VLOG(IPK,J) = .TRUE.
C                   WRITE(*,*)'IPK,J,VLOG(IPK,J)',IPK,J,VLOG(IPK,J)
                ELSE
                    VLOG(IPK,J) = .FALSE.
C                   WRITE(*,*)'IPK,J,VLOG(IPK,J)',IPK,J,VLOG(IPK,J)
                END IF
252         CONTINUE
            DO 255 J = 1,26
                SYSFLD(IPK,J) = ARRAY(I,J)
C       WRITE(*,*)SYSFLD(IPK,J)
C              PUT SYSTEM-SPECIFIC VALUES INTO FIELD ARRAY
                IF(ARRAY(2,J) .EQ. 1.E10 .AND. I .GT. 1)
     &           SYSFLD(IPK,J) = ARRAY(1,J)
255    CONTINUE
C - LOOP BY FIELD -
       T = 0.
       DO 50 I = 1,NPKSYS(NSYS)
            IPK = IPSYS(I,NSYS)
            GO TO(30,30,30,32,34),IDT
C
30        CALL SSSM(IPK,DRAN(IPK,4),IWIND,EFFAVE,DPPCT,WLPCT,ROPCT,TIME)
              DRAN(IPK,1) = SYSFLD(IPK,1)
              SYST(1) = SYST(1)+SYSFLD(IPK,9)*AREA(IPK)/23.8
              TLAB(IPK,1) = SYSFLD(IPK,11)*AREA(IPK)
              TLAB(IPK,2) = SYSFLD(IPK,12)
              IF(IDT .EQ. 1)THEN
               NLAT = NINT(SYSFLD(IPK,6)/SYSFLD(IPK,2)*SYSFLD(IPK,7))
                T = NLAT*SYSFLD(IPK,13)
              ELSE
               NSET = NINT(SYSFLD(IPK,6)/SYSFLD(IPK,2))
                T = NINT(SYSFLD(IPK,7))*SYSFLD(IPK,13)
              END IF
              GO TO 40
C
32        CALL CP (IPK,EFFAVE,DPPCT,WLPCT,ROPCT,TIME)
              DRAN(IPK,1) = SYSFLD(IPK,6)*2.
              GO TO 3234
C
34        CALL LM (IPK,EFFAVE,DPPCT,WLPCT,ROPCT,TIME)
              DRAN(IPK,1) = SYSFLD(IPK,6)
C
```

```
3234        SYST(1) = SYST(1)+SYSFLD(IPK,3)*AREA(IPK)/23.8
            TLAB(IPK,1) = SYSFLD(IPK,7)*AREA(IPK)
            TLAB(IPK,2) = 0.0
            T = SYSFLD(IPK,13)
            GO TO 40
C
40        DO 42 J = 1,J1(IPK)
              SYSOBS(NT(J,IPK),IPK,1) = DPPCT
              SYSOBS(NT(J,IPK),IPK,2) = ROPCT
              SYSOBS(NT(J,IPK),IPK,3) = TIME
42            EAPP(NT(J,IPK),IPK) = EFFAVE
          DRAN(IPK,2) = DPPCT
          DRAN(IPK,3) = EFFAVE
          IF(SYST(1) .GT. SYSVAL(1,NSYSS))WRITE(*,4200)NSYS
4200  FORMAT(/'APPLICATION SYSTEM',I3,' CAPACITY EXCEEDS SUPPLY '
     &'SYSTEM CAPACITY.'/'SUPPLY SYSTEM VALUE USED IN THIS PROGRAM.'//
     &' MAKE APPROPRIATE CHANGES TO DATA FILE.')
          SYST(1) = AMIN1(SYST(1),SYSVAL(1,NSYSS))
C      WRITE(*,*)' EFF = ',EFFAVE,' SYST =',NSYS,' FLD = ',IPK
C
C  SUMMARIZE SYSTEM COST DATA AND PUT IN SYSTEM SUMMARY FILE
C
          SYST(3) = LIFE(ID)
          COMP(NSYS,ITEMS(NSYS)+1) = 'APPLICATION SYSTEM'
          J = 4
          LOAN = NINT(SYSFLD(IPK,16))
          IF(LOAN .GT. 1)J = 13
          NDIV = 1.
          IF(IDT .NE. 1)NDIV = NPKSYS(NSYS)
          T = T/NDIV
C          SUB = SYSFLD(IPK,14)/100.
          FIN = SYSFLD(IPK,15)/100.
          SAL = SYSFLD(IPK,17)/100.
C          SUBADD = SUB*T
C          IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C            DIFF = (SUBTOT+SUBADD)-SUBMAX
C            SUBADD = SUBADD - DIFF
C            SUB2 = SUBADD/T
C            FIN = FIN+(SUB-SUB2)
C            SUB = SUB2
C          END IF
C          SUBTOT = SUBTOT+SUBADD
          SYST(J) = SYST(J) + T
C          SYST(J+1) = SYST(J+1) + T * (1.-(SUB+FIN))
          SYST(J+1) = SYST(J+1) + T * (1.-FIN)
          SYST(J+2) = SYST(J+2) + SUBADD
          SYST(J+3) = SYST(J+3) + T*FIN
          SYST(J+6) = SYST(J+6) + T*SAL
          AMAINT = SYSFLD(IPK,23)/(NDIV*100.)*T
          SYST(J+7) = SYST(J+7) + AMAINT
          AMISC = SYSFLD(IPK,24)/NDIV+SYSFLD(IPK,12)
          SYST(J+8) = SYST(J+8) + AMISC
          LIF = LIFE(ID)
          CALL ECON(NSYS,T,LIF,LOAN,SAL,FIN,SUB,AMAINT,AMISC)
C
C  SUMMARIZE LAND PREP. DATA FOR SYSTEM SUMMARY FILE
          J = 4
          LOAN = NINT(SYSFLD(IPK,21))
          IF(LOAN .GT. 1)J = 13
          T = SYSFLD(IPK,18)
          COMP(NSYS,ITEMS(NSYS)+1) = 'LAND GRADING'
C          SUB = SYSFLD(IPK,19)/100.
          FIN = SYSFLD(IPK,20)/100.
C          SUBADD = SUB*T
C          IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C            DIFF = (SUBTOT+SUBADD)-SUBMAX
C            SUBADD = SUBADD - DIFF
C            SUB2 = SUBADD/T
C            FIN = FIN+(SUB-SUB2)
C            SUB = SUB2
```

```
C           END IF
C           SUBTOT = SUBTOT+SUBADD
           SYST(J) = SYST(J) + T
C           SYST(J+1) = SYST(J+1) + T * (1.-(SUB+FIN))
           SYST(J+1) = SYST(J+1) + T * (1.-FIN)
           SYST(J+2) = SYST(J+2) + SUBADD
           SYST(J+3) = SYST(J+3) + T*FIN
           SYST(J+7) = SYST(J+7) + SYSFLD(IPK,22)
           LIF = LIFE(14)
           CALL ECON(NSYS,T,LIF,LOAN,0.0,FIN,SUB,SYSFLD(IPK,22),0.0)
50    CONTINUE
C
C
C ******* READ CANAL FLAG ****
C
      READ(LIN,FORM(15))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SP CANAL FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 65
C  ASSUME CANAL USED 50% OF SEASON
      DPY = MPS*30.*0.5*HPD/24.
C
      CALL CANAL(NSYS,SYST(1),DPY,DPAF,VF)
C
C  N = LOAN #
      DO 60 N = 1,2
           J = 4
           IF(N .GT. 1)J = 13
           SYST(J) = SYST(J) + VF(1,N)
           SYST(J+1) = SYST(J+1) + VF(2,N)
           SYST(J+2) = SYST(J+2) + VF(3,N)
           SYST(J+3) = SYST(J+3) + VF(4,N)
           SYST(J+6) = SYST(J+6) + VF(5,N)
           SYST(J+7) = SYST(J+7) + VF(6,N)
           SYST(J+8) = SYST(J+8) + VF(7,N)
60    CONTINUE
C
C
C  ******* READ STRUCTURE FLAG ****
C
65    READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SP STRUCT FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 75
C ****** READ STRUCTURE DATA ******
      CALL STRUCT(NSYS)
C
C
C  ******* READ PUMP FLAG ****
C
75    READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SP PUMP FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 85
C
C  ***** READ PUMP DATA *****
      CALL PUMP(NSYS,TDHS)
C
C
C  ******* READ PIPE FLAG ****
C
85    READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SP PIPE FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 95
C  ASSUME PIPES USED 50% OF SEASON
      HPS = MPS*30.*0.5*HPD
      PMAX = TDHS/2.31
      IF(TDHS .EQ. 0.)PMAX = TDHM/2.31
C
```

```
      CALL PIPES(NSYS,SYST(1),DEIR,HPS,DPKWH,VF,PMAX)
C
C  N = LOAN #
      DO 90 N = 1,2
            J = 4
            IF(N .GT. 1)J = 13
            SYST(J) = SYST(J) + VF(1,N)
            SYST(J+1) = SYST(J+1) + VF(2,N)
            SYST(J+2) = SYST(J+2) + VF(3,N)
            SYST(J+3) = SYST(J+3) + VF(4,N)
            SYST(J+6) = SYST(J+6) + VF(5,N)
            SYST(J+7) = SYST(J+7) + VF(6,N)
            SYST(J+8) = SYST(J+8) + VF(7,N)
90    CONTINUE
C
C
C  ******** READ OTHER FLAG ****
C
95    READ(LIN,FORM(14))
      READ(LIN,FORM(6))FLAG
C      WRITE(*,*)' SP OTHER FLAG ',FLAG
      IF(FLAG .NE. Y1 .AND. FLAG .NE. Y2)GOTO 105
C  ****** READ OTHER DATA ******
      CALL OTHER(NSYS)
C
105   RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE SDRAIN(NSYST)
C
C  SUBROUTINE SDRAIN FOR ESTIMATING COSTS OF SUBSURFACE DRAINAGE
C  WRITTEN BY G.D. GALINATO, UNIV OF IDAHO, MOSCOW, IDAHO  USA
C  MODIFIED BY J.R. BUSCH, WINCHMORE  JUNE,1982
C  MODIFIED BY B.W. SAUER, MOSCOW  JUNE,1986
C
C  ALL COMPUTATIONS ARE IN ENGLISH UNITS
C
C  COMMON ARRAY DRAN(I,J) - DRAINAGE DATA FOR FIELD I
C          J = 1 -- FIELD LENGTH (FT)
C              2 -- % DEEP PERCOLATION LOSSES
C              3 -- % IRRIGATION EFFICIENCY
C              4 -- NET IRRIGATION APPLICATION
C
C
C  VARIABLES PASSED-----------
C    SLIFE -- SYSTEM LIFE IN YEARS
C   DRAIN -- ARRAY CONTAINING DRAINAGE DATA AS FOLLOWS:
C     1 - DAYS BETWEEN IRRIGATIONS
C     2 - ROOTZONE DEPTH (FT)
C     3 - DRAIN DEPTH (FT)
C     4 - DEPTH TO LOWER BARRIER (FT)
C     5 - PERMEABILITY BETWEEN ROOT ZONE & LOWER BARRIER (FT/DAY)
C     6 - MIN. W.T. DEPTH BELOW SURFACE (FT)
C     7 - LATERAL DRAIN SLOPE (%)
C     8 - CONTINGENCY COST (%)
C     9 - PERCENT OF COST SUBSIDIZED
C     10 - PERCENT OF COST FINANCED
C     11 - LOAN NUMBER
C     12 - MAINTENANCE COST (% OF INVESTMENT)
C     13 - SALVAGE COST AT END OF LIFE (% OF INITIAL COST)
C     14 - ANNUAL MISC. COSTS ($)
C
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      DIMENSION QP(10),DRAIN(9,20),ID(9)
      REAL MAD
      CHARACTER*20 FORM,COMP*26
C
C  ***** READ DRAINAGE DATA *****
      READ(LIN,FORM(8))NF
      READ(LIN,FORM(5))(ID(J),J =1,NF)
      READ(LIN,*)
      DO 5 I = 1,14
           IF(I .EQ. 9)GOTO 5
           READ(LIN,FORM(3))(DRAIN(J,I),J = 1,NF)
C          WRITE(*,*)(DRAIN(J,I),J = 1,NF)
5     CONTINUE
      READ(LIN,*)
C
C ***** GET COST DATA *****
      READ(14,501,REC=10)N,LIF,CEX,CBF,CGE,X,C4,X,C6,X,C8
501   FORMAT(22X,2I3,29F7.2)
C
      C4 = C4/100.
      C6 = C6/100.
      C8 = C8/100.
      CRF = ROC*(1.+ROC)**LIF/((1.+ROC)**LIF-1.)
C
```

```
C  ********* LOOP BY FIELD *********
C
      DO 100 I = 1,NF
C
      IPK = ID(I)
      CROPA = AREA(ID(I))
      CONTG = DRAIN(I,8)/100.
      SLOP = DRAIN(I,7)/100.
      LNO = NINT(DRAIN(I,11))
      FL = DRAN(IPK,1)
      DVOL = DRAN(IPK,2)
      EFFA = DRAN(IPK,3)
      MAD = DRAN(IPK,4)
      IF(MAD .LE. 0)GOTO 100
C
C
      DRAIN(I,4) = DRAIN(I,4)-DRAIN(I,3)
      DRAIN(I,6) = DRAIN(I,3)-DRAIN(I,6)
C---CONVERT D.P. TO CU FT PER SQ FT PER IRRIGATION
      QD = ((MAD/EFFA)*DVOL/3.048)/DRAIN(I,1)
      DBF1 = DRAIN(I,4) + DRAIN(I,3) - DRAIN(I,2)
C---COMPUTE SPACING USING DONNAN*S EQUATION--FT
      DSPAC = (4.*DRAIN(I,5)*(DBF1**2.-DRAIN(I,4)**2.)/QD)**(1./2.)
C---FIND DRAIN DISCHARGE USING  USBR EQUATION
      DDB1 = DRAIN(I,4) + DRAIN(I,6)/2.
      QLF = (2.*3.1416*DRAIN(I,5)*DRAIN(I,6)*DDB1)/DSPAC
      QLF = QLF/ 86400.
C
C---ASSUMPTION: LENGTH OF LATERAL DRAIN = FIELD WIDTH
C                         MANNINGS N=.015
C
      NN = 0
      DO 20 LZ=4,8,2
      NN=NN+1
      XLD=LZ/12.
      AREP=(3.1416*XLD**2.)/4.
      HR=XLD/4.
      VL=(1.49*HR**(2./3.)*SLOP**(1./2.))/.015
      QP(NN) = AREP*VL
   20 CONTINUE
C
C---COMPUTE COST OF PIPES
      FWIDT = CROPA*43560./FL
      XL1=QP(1)/QLF
      IF(XL1.GE.FWIDT)GO TO 68
      XL2=FWIDT-XL1
      XL3=QP(2)/QLF
      IF(XL3.GE.FWIDT)GO TO 82
      XL4=FWIDT-XL3
      XL3 = FWIDT - XL4 - XL1
      CPP=XL1*C4 + XL3*C6 + XL4*C8
      VOLP=(3.1416/(144.*4.*27.))*(4.**2.*XL1+6.**2.*XL3+8.**2.
     _*XL4)
      GO TO 80
   68 CPP = FWIDT*C4
      VOLP = 3.1416*4.**2.*FWIDT/(144.*4.*27.)
      GO TO 80
   82 CPP = XL1*C4 + XL2*C6
      VOLP = (3.1416/(144.*4.*27.))*(4.**2.*XL1+6.**2.*XL2)
   80 CONTINUE
C---COMPUTE COST OF EXCVA. AND BACKFILL
C   ASSUME 8-FT DEPTH, 12 INCHES MIN WIDTH
C   USE FACTOR .889 CU YD/LF--USBR
      VODEX = FWIDT * .889
      VODBF = VODEX - VOLP
      ERCD = VODEX * CEX + VODBF * CBF
      DNCST = CPP + ERCD + FWIDT* CGE/27.
      DNCST = (DNCST + DNCST*CONTG) * REAL(NINT((FL/DSPAC)+.3))
C
C  ADD PROPER VALUES TO ELEMENTS IN THE V-ARRAY FOR PASSING TO
```

```
C  THE CALLING PROGRAM
C
C        SUB = DRAIN(I,9)/100.
       FIN = DRAIN(I,10)/100.
       SAL = DRAIN(I,13)/100.
       J = 4
       LOAN = NINT(DRAIN(I,11))
       IF(LOAN .EQ. 2)J = 13
C        SUBADD = SUB*DNCST
C        IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C          DIFF = (SUBTOT+SUBADD)-SUBMAX
C          SUBADD = SUBADD-DIFF
C          SUB2 = SUBADD/DNCST
C          FIN = FIN+(SUB-SUB2)
C          SUB = SUB2
C        END IF
       SUBTOT = SUBTOT+SUBADD
       SYSVAL(J,IPK) = SYSVAL(4,IPK) + DNCST
C        SYSVAL(J+1,IPK) = SYSVAL(J+1,IPK) + DNCST*(1.-(SUB+FIN))
       SYSVAL(J+1,IPK) = SYSVAL(J+1,IPK) + DNCST*(1.-FIN)
       SYSVAL(J+2,IPK) = SYSVAL(J+2,IPK) + SUBADD
       SYSVAL(J+3,IPK) = SYSVAL(J+3,IPK) + DNCST*FIN
       SYSVAL(J+6,IPK) = SYSVAL(J+6,IPK) + DNCST*SAL
       AMAINT = DNCST*DRAIN(I,12)/100.
       SYSVAL(J+7,IPK) = SYSVAL(J+7,IPK) + AMAINT
       SYSVAL(J+8,IPK) = SYSVAL(J+8,IPK) + DRAIN(I,14)
       SYST(22) = 0.
       DO 95 II = 1,NSYST
          DO 95 J = 1,NPKSYS(II)
             IF(IPK .EQ. IPSYS(J,II))GOTO 96
95     CONTINUE
96     CALL ECON(II,DNCST,LIF,LOAN,SAL,FIN,SUB,AMAINT,DRAIN(I,14))
       SYSVAL(22,IPK) = SYSVAL(22,IPK) + SYST(22)
C
100    CONTINUE
C
       RETURN
       END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE CANAL(NSYS,QSYS,DPY,DPAF,VF)
C***********************************************************************
C*                                                                     *
C* ECONOMIC OPEN CHANNEL SIZING PROGRAM FOR IRRIGATION DITCHES/CANALS *
C*                                                                     *
C*                  DEVELOPED AT UNIVERSITY OF IDAHO DEPARTMENT        *
C*                                                                     *
C*    OF AGRICULTURAL ENGINEERING FOR SCS IRRIGATION PLANNING MODEL    *
C*                                                                     *
C***********************************************************************
C
C     CDAT(I,J) - DATA SPECIFIC TO CANAL I
C           J = 1 - LENGTH (FT)                  6 - % COST FINANCED
C               2 - SLOPE (%)                    7 - LOAN #
C               3 - DESIGN FLOWRATE (CFS)        8 - ANN. MAINTENANCE
C               4 - SEEPAGE RATE (FT3/FT2/DAY)    (% OF ORIGINAL COST)
C               5 - SALVAGE VALUE(% OF COST)     9 - ANN. MISC. COST ($)
C     LINE(I) - SPECIFIES LINED OR UNLINED CANAL I
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      COMMON /MANING/A, B, QDF, SLP, VEL, WPER, XN, Z
C
      DIMENSION VF(7,2),BW(7),DEPN(7),DEPX(7),SSLP(7),CDAT(5,10)
C
      CHARACTER*3 YN(9),FORM*20,COMP*26,LABL(2)*22
C
C *** DATA FOR STANDARD CONCRETE-LINED FARM DITCH DIMENSIONS
      DATA BW/   1.,  2.,  2.,  3.,  4.,  5.,  6./
      DATA DEPN/15., 15., 24., 27., 33., 36., 42./
      DATA DEPX/30., 30., 48., 54., 66., 72., 84./
      DATA SSLP/1.0, 1.0, 1.5, 1.5, 1.5, 1.5, 1.5/
C *** ROUTINE TO READ FROM SYSTEM FILE
C
      READ(LIN,FORM(8))NCHANS
C      WRITE(*,*)'NCHANS ',NCHANS
      READ(LIN,1002)(YN(J),J = 1,NCHANS)
 1002 FORMAT(///27X,5X,(A),8(6X,(A)))
C      WRITE(*,1002)(YN(J),J = 1,NCHANS)
      DO 111 I = 1,9
  111    READ(LIN,FORM(7))(CDAT(J,I),J = 1,NCHANS)
C  111        WRITE(*,FORM(7))(CDAT(J,I),J = 1,NCHANS)
      READ(LIN,*)
C *** READ DATA FROM COST FILE ***
C
      READ(14,1003,REC=11)LABL(2),DPLFU
      READ(14,1003,REC=12)LABL(1),DPLFL
 1003 FORMAT(A22,F7.2)
C
      DO 100 I = 1,7
      DO 100 J = 1,2
  100 VF(I,J) = 0.
C ***** MAIN COMPUTATIONS *****
C
      NCHAN(NSYS) = NCHANS
      DO 1000 N = 1,NCHANS
C --- SET UP CONSTANTS ---
C
      DIST = 100.
      VMIN = .5
      FB = 4./12.
```

```
      SLP = CDAT(N,2)/100.
      QDF = CDAT(N,3)
      IF(QDF .LE. 0.)QDF = QSYS
      RSEEP = CDAT(N,4)
      LINE = 2
C      WRITE(*,*)'LINE FLAG',YN(N)
      IF(YN(N) .EQ. 'YES' .OR. YN(N) .EQ. 'yes')LINE = 1
      LIF = LIFE(13-LINE)
C      WRITE(*,*)'CANAL LINE,LIFE',LINE,LIF
      NL = NINT(CDAT(N,7))
C --- SIZING SEGMENT ---
      IF(LINE .EQ. 1) THEN
            XN = 0.015
            VMAX = 5.
            IB2 = 7
      ELSE
            XN = 0.022
            Z = 1.
            IB2 = 20
            IF(RSEEP .GT. 0.25)GOTO 210
C - HARDPAN
              VMAX = 5.0
            GOTO 300
  210       IF(RSEEP .GT. 0.50)GOTO 220
C - COMPACT SOIL
              VMAX = 3.5
            GOTO 300
  220       IF(RSEEP .GT. 0.90)GOTO 230
C - SILT LOAM
              VMAX = 2.0
            GOTO 300
  230       IF(RSEEP .GT. 1.20)GOTO 240
C - SANDY LOAM
              VMAX = 1.75
              Z = 1.25
            GOTO 300
  240       IF(RSEEP .GT. 1.50)GOTO 250
C - LOAM
              VMAX = 2.0
            GOTO 300
  250       IF(RSEEP .GT. 2.0)GOTO 260
C - SAND
              VMAX = 1.5
              Z = 1.5
            GOTO 300
C - GRAVEL
  260         VMAX = 4.
              XN = 0.025
  300 END IF
      CRF = (ROC*(1.+ROC)**LIF)/((1.+ROC)**LIF-1.)
      CMIN = 1.E10
C         --- LOOP BY BOTTOM WIDTH INCREMENTS ---
      DO 900 IB = 1, IB2
            GOTO(410, 420) LINE
  410             B = BW(IB)
                  Z = SSLP(IB)
                  BOUNR = DEPX(IB)/12.-FB
                  BOUNL = 0.
                  DINC = 2./12.
            GOTO 450
  420             B = 0.5*IB
                  Z = 1.
                  BOUNR = 6.
                  BOUNL = 0.
                  DINC = 4./12.
            GOTO 450
C
C   *** GOLDEN SECTION SEARCH ALGORITHM ***
C
C    FINDS DEPTH FOR DESIRED BOTTOM WIDTH
```

```
C
  450       ACC = 0.01
            K = 1
            BRMAX = BOUNR
            YLEN = BOUNR-BOUNL
            IF(YLEN .LE.  ACC)GOTO 750
            YL = BOUNR-YLEN*0.618
            YR = BOUNL+YLEN*0.618
            CALL QCALC(YR, DIFFR)
            CALL QCALC(YL, DIFFL)
  700       IF(DIFFR .LE. DIFFL)THEN
                  BOUNL = YL
                  YLEN = BOUNR-BOUNL
                  IF(YLEN .LE. ACC)GOTO 750
                  DIFFL = DIFFR
                  YL = YR
                  YR = BOUNL+YLEN*0.618
                  CALL QCALC(YR, DIFFR)
            ELSE
                  BOUNR = YR
                  YLEN = BOUNR-BOUNL
                  IF(YLEN .LE. ACC)GOTO 750
                  DIFFR = DIFFL
                  YR = YL
                  YL = BOUNR-YLEN*0.618
                  CALL QCALC(YL, DIFFL)
            END IF
            K = K+1
C       *** TOO MANY ITERATIONS ***
            IF(K .GT. 40)THEN
 1500             WRITE(*,1501)NSYS,N
                  GOTO 1000
            END IF
            GOTO 700
C       --- CHECK FOR SUFFICIENT CAPACITY ---
  750       IF(BOUNR .EQ. BRMAX)GOTO 900
            Y = (YR+YL)*.5
            CALL QCALC(Y,DIFFR)
            YTOT = (INT(Y/DINC)+1)*DINC+FB
            IF(LINE .EQ. 1)YTOT = AMAX1(YTOT,DEPN(IB)/12.)
            YTOT = AMAX1(YTOT, 1.0)
            ATOT = (B+Z*YTOT)*YTOT
C --- CHECK FOR VELOCITIES TOO HIGH OR TOO LOW ---
            IF(VEL .GT.  VMAX)GOTO 900
C           IF(VEL .LT.  VMIN)GOTO 900
C       --- COMMENCE ECONOMIC ANALYSIS ---
            VSEEP = DPY*RSEEP*WPER/43560.*DIST
            CSEEP = DPAF*VSEEP
            CMAINT = SYSVAL(N,9)*CINST/100.
            GOTO(810, 820) LINE
C - CANAL COSTS ASSUME STD. LINED CANAL HAS 5-FT PERIMETER AND
C       STD. UNLINED CANAL HAS 3.75-SQ.FT. CROSS-SECTIONAL AREA.
C             ESTIMATED COSTS FIGURED PROPORTIONATELY.
  810             P = B+2*YTOT*SQRT(1.+Z**2)
                  CINST = DPLFL*P/5.*DIST
            GOTO 850
  820             CINST = DPLFU*ATOT/3.75*DIST
C
  850       CANNL = CRF*CINST + CMAINT + CSEEP
            IF(CANNL .LT.  CMIN)THEN
                  BMIN = B
                  YMIN = YTOT
                  WPMIN = WPER
                  CMIN = CANNL
                  T = CINST
            END IF
  900 CONTINUE
      IF(CMIN .NE. 1.E10)GOTO 950
            IF(LINE .EQ. 1)WRITE(*,63)
            IF(LINE .EQ. 2)WRITE(*,64)
```

```
            WRITE(*,60)N,NSYS
            GOTO 1000
  950 T = T*CDAT(N,1)/100.
      SAL = CDAT(N,5)/100.
C       WRITE(*,*)' BEST CANAL B,Y,COST ',BMIN,YMIN,T
        CHAN(NSYS,N,1) = BMIN
        CHAN(NSYS,N,2) = YMIN
        COMP(NSYS,ITEMS(NSYS)+1) = LABL(LINE)
C       SUB = CDAT(N,6)/100.
      FIN = CDAT(N,6)/100.
      PMAINT = CDAT(N,8)/100.
C       SUBADD = SUB*T
C       IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C         DIFF = (SUBTOT+SUBADD)-SUBMAX
C         SUBADD = SUBADD -DIFF
C         SUB2 = SUBADD/T
C        FIN = FIN+(SUB-SUB2)
C         SUB = SUB2
C     END IF
C       SUBTOT = SUBTOT + SUBADD
      VF(1,NL) = VF(1,NL)+T
C       VF(2,NL) = VF(2,NL)+T*(1.-(SUB+FIN))
      VF(2,NL) = VF(2,NL)+T*(1.-FIN)
      VF(3,NL) = VF(3,NL)+SUBADD
      VF(4,NL) = VF(4,NL)+T*FIN
      VF(5,NL) = VF(5,NL)+T*SAL
      AMAINT = T*PMAINT
      VF(6,NL) = VF(6,NL)+AMAINT
      VF(7,NL) = VF(7,NL)+CDAT(N,9)
      CALL ECON(NSYS,T,LIF,NL,SAL,FIN,SUB,AMAINT,CDAT(N,9))
C  SUM SEEPAGE RATE AND WETTED PERIMETER FOR WEIGHTED AVG.
      SYST(28) = SYST(28) + RSEEP*CDAT(N,1)
      SYST(29) = SYST(29) + WPMIN*CDAT(N,1)
      SYST(30) = SYST(30) + CDAT(N,1)
C  DETERMINE % OF LINED LENGTH
      IF(LINE .NE. 1)SLINE = SLINE + CDAT(N,1)
 1000 CONTINUE
      SYST(28) = SYST(28)/SYST(30)
      SYST(29) = SYST(29)/SYST(30)
C  USE WEIGHTED AVERAGES TO COMPUTE CONVEYANCE EFFICIENCY
C  ASSUME 1% LOSS TO VEGETATION IN UNLINED SECTIONS
C  QLOSS(CFS) = LENGTH(FT) * WP(FT) * SEEPRATE(FT**3/FT**2/DAY)
      QLOSS = SYST(30)*SYST(29)*SYST(28)/86400.
      QIN = SYST(1)
      SSEEP(NSYS) = QLOSS/QIN*100. + (SLINE/SYST(30))*1.
C       WRITE(*,*)'SYSTEM, % SEEPAGE',NSYS,SSEEP(NSYS)
      RETURN
C
C  *** OUTPUT FORMAT STATEMENTS ***
C
   60 FORMAT(/' COST ESTIMATES FOR CANAL',I3,' ON SYSTEM',I3,
     & ' NOT MADE')
   63 FORMAT(/' TOO MUCH CAPACITY FOR STANDARD SIZED, CONCRETE-LINED'
     &' DITCH')
   64 FORMAT(/' UNLINED CANAL REQUIRED IS LARGER THAN THIS PROGRAM CAN
     &HANDLE')
 1501 FORMAT(' PROBLEM IN CANAL SIZING ROUTINE FOR SYSTEM',I3/
     &' CHECK DATA INPUTS FOR CHANNEL',I3/)
      END
```

```
C
C
C   ***** SUBROUTINE TO CALCULATE OPEN CHANNEL FLOW RATE *****
C
C
      SUBROUTINE QCALC(Y, QDIFF)
C
      COMMON /MANING/A, B, QDF, SLP, VEL, WPER, XN, Z
C
C
      A = (B+Z*Y)*Y
      WPER = B+2*Y*SQRT(1+Z**2)
      R = A/WPER
      VEL = 1.49/XN*R**(2./3.)*SQRT(SLP)
      Q = VEL*A
      QDIFF = ABS(QDF - Q)
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE PIPES(NSYS,QSYS,DEIR,HPS,DPKWH,V,PMAX)
C*************************************************************************
C*                                                                       *
C*  ECONOMIC PIPE SIZING PROGRAM (ANNUAL COST BASIS) FOR IRRIGATION      *
C*                                                                       *
C*          PIPES, DEVELOPED AT UNIVERSITY OF IDAHO DEPARTMENT           *
C*                                                                       *
C*    OF AGRICULTURAL ENGINEERING FOR SCS IRRIGATION PLANNING MODEL      *
C*                                                                       *
C*************************************************************************
C
C     CDAT(I,J) - DATA SPECIFIC TO PIPE I          5 - % FINANCED
C           J = 1 - LENGTH (FT)                    6 - LOAN #
C               2 - SLOPE (%)                      7 - ANN. MAINT. COST
C               3 - DESIGN FLOWRATE (CFS)              (% TOTAL COST)
C               4 - SALVAGE VALUE (%)              8 - ANN. MISC. COST ($)
C     MATL(I) - MATERIAL SPECIFIED FOR PIPE I (S=STEEL, P=PVC, A=ALUM)
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      DIMENSION V(7,2),CDAT(5,9),DAT(20,2)
      CHARACTER MATL(5),FORM*20,COMP*26,LABL*22
C
C --- SET PROGRAM CONSTANTS ---
      NPR = 3
      IF(PMAX .LE. 100)NPR = 2
      IF(PMAX .LE. 50)NPR = 1
      EPUMP = 0.70
      PI = 3.141593
      DO 100 I = 1,7
      DO 100 J = 1,2
  100 V(I,J) = 0.
C --- READ NECESSARY DATA FROM SYSTEM FILE
      READ(LIN,FORM(8))NPIPES
C      WRITE(*,*)'NPIPES ',NPIPES
      READ(LIN,1002)(MATL(J),J = 1,NPIPES)
 1002 FORMAT(///27X,7X,A,4(8X,A))
      DO 105 I = 1,8
  105 READ(LIN,FORM(7))(CDAT(J,I),J = 1,NPIPES)
C 105        WRITE(*,FORM(7))(CDAT(J,I),J = 1,NPIPES)
      READ(LIN,*)
C
C --- SELECT MOST ECONOMIC PIPE SIZE ---
      NPIPE(NSYS) = NPIPES
      DO 2000 N = 1,NPIPES
C
      IF(N .GT. 1 .AND. MATL(N) .EQ. MATL(N-1))GOTO 1010
      IF(MATL(N) .EQ. 'S'.OR. MATL(N) .EQ. 's')NN = 0
      IF(MATL(N) .EQ. 'P'.OR. MATL(N) .EQ. 'p')NN = 3
      IF(MATL(N) .EQ. 'A'.OR. MATL(N) .EQ. 'a')NN = 6
C
C --- READ NECESSARY DATA FROM COST FILE (NPR = PRESSURE RANGE)
C      WRITE(*,*)'NN,NPR,REC,PMAX',NN,NPR,NN+NPR,PMAX
      READ(14,1005,REC=NN+NPR)LABL,NSIZE,HWC,LIF,
     &                          (DAT(J,1),DAT(J,2),J=1,NSIZE)
C      WRITE(*,*)NSIZE,HWC,LIF,(DAT(J,1),DAT(J,2),J=1,NSIZE)
1005  FORMAT(A22,I3,F3.0,I3,29F7.2)
1010  Q = CDAT(N,3)
      IF(Q .LE. 0.)Q=QSYS
      SAL = CDAT(N,4)/100.
C      SUB = CDAT(N,5)/100.
```

```
      FIN = CDAT(N,5)/100.
      NL = NINT(CDAT(N,6))
      PMAINT = CDAT(N,7)/100.
C      WRITE(*,*)'ROC,LIF',ROC,LIF
      CRF = (ROC*(1.+ROC)**LIF)/((1.+ROC)**LIF-1.)
      AGF = 1./ROC - LIF/((1.+ROC)**LIF-1.)
      ACMIN = 1.E10
C --- LOOP BY PIPE DIAMETER ---
      DO 1100 NEL = 1, NSIZE
            DIA = DAT(NEL, 1)
            AR = PI*(0.5*DIA/12.)**2
            VEL = Q/AR
C         --- CHECK FOR VELOCITIES > 5 FT/S ---
            IF(VEL .GT.  5.)GOTO 1100
            HL = 10.46*(Q/HWC)**1.852/DIA**4.8655 + CDAT(N,2)
            EKW = HL*Q/(EPUMP*5308.)
            EKWS = EKW*QSYS/Q
            ACEC = EKWS*HPS*DPKWH
            AEINC = ACEC*DEIR
            ACEC = ACEC+AEINC*AGF
            ACIC = DAT(NEL, 2)*CRF
            ACMNT = .02*DAT(NEL,2)
            ACTC = ACEC+ACIC+ACMNT
            ACMIN = AMIN1(ACTC,ACMIN)
C         --- CHECK FOR MINIMUM VALUE ---
            IF(ACTC .GT.  ACMIN .OR.  NEL .EQ.  NSIZE)THEN
                  NN = NEL
                  IF(ACTC .GT. ACMIN)NN = NEL-1
                  GOTO 1150
            END IF
 1100 CONTINUE
      IF(ACMIN .GE. 1.E10)THEN
            WRITE(*,1111)NSYS
            GOTO 2000
      END IF
 1111 FORMAT(/' UNABLE TO SPECIFY PIPE WITH SUFFICIENT CAPACITY FOR '
     &'SYSTEM #',I3/' CHECK INPUT DATA')
C --- COMPUTE COSTS ---
 1150 T = DAT(NN,2)*CDAT(N,1)/100.
C NOTE:V(1) INCLUDES 10% ADDITIONAL COST FOR FITTINGS
      T = T*1.1
C      WRITE(*,*)' BEST $',T,DAT(NN,1),' IN DIA'
      PIPE(NSYS,N) = DAT(NN,1)
      COMP(NSYS,ITEMS(NSYS)+1) = LABL
C      SUBADD = SUB*T
C      IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C        DIFF = (SUBTOT+SUBADD)-SUBMAX
C        SUBADD = SUBADD - DIFF
C        SUB2 = SUBADD/T
C        FIN = FIN+(SUB-SUB2)
C        SUB = SUB2
C      END IF
C      SUBTOT = SUBTOT+SUBADD
      V(1,NL) = V(1,NL)+T
C      V(2,NL) = V(2,NL)+T*(1.-(SUB+FIN))
      V(2,NL) = V(2,NL)+T*(1.-FIN)
      V(3,NL) = V(3,NL)+SUBADD
      V(4,NL) = V(4,NL)+T*FIN
      V(5,NL) = V(5,NL)+T*SAL
      AMAINT = T*PMAINT
      V(6,NL) = V(6,NL)+AMAINT
      V(7,NL) = V(7,NL)+CDAT(N,8)
      CALL ECON(NSYS,T,LIF,NL,SAL,FIN,SUB,AMAINT,CDAT(N,8))
 2000 CONTINUE
      RETURN
      END
```

```
C
C
C
      SUBROUTINE PUMP(NSYS,TDHS)
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      CHARACTER*20 FORM,COMP*26
C
      DIMENSION ARRAY(9,13)
C
C  ***** READ PUMP DATA *****
      READ(LIN,FORM(8))N
C      WRITE(*,*)'NPUMPS ',N
      READ(LIN,FORM(13))
      DO 10 I = 1,12
10        READ(LIN,FORM(7))(ARRAY(J,I),J = 1,N)
C10          WRITE(*,FORM(7))(ARRAY(J,I),J = 1,N)
      READ(LIN,*)
C - CHECK FOR DEFAULTS
      DO 15 J = 1,N
        IF(ARRAY(J,1) .LE. 0.)ARRAY(J,1) = SYST(1)*448.8/N
        IF(ARRAY(J,5) .LE. 0.)ARRAY(J,5) = 75.
15      IF(ARRAY(J,6) .LE. 0.)ARRAY(J,6) = 95.
C - INDEX PUMPS
      NAPMP(NSYS) = N
      DO 20 IDNO = 1,30
            IF(PWRPMP(IDNO) .LE. 0.)GOTO 25
20    CONTINUE
25    DO 30 I = 1,N
           IDXPMA(I,NSYS) = IDNO
           TDH = (ARRAY(I,2)-ARRAY(I,3))*2.31 + ARRAY(I,4)
           TDHS = AMAX1(ARRAY(I,2)*2.31,TDHS)
           EFF = ARRAY(I,5)*ARRAY(I,6)/10000.
           PWRPMP(IDNO) = TDH*ARRAY(I,1)/(5310.*EFF)
           QPMP(IDNO) = ARRAY(I,1)
           IDNO = IDNO +1
30    CONTINUE
C
C SUMMARIZE PUMP DATA FOR SYSTEM SUMMARY
      DO 40 I = 1,N
            J = 4
            LOAN = NINT(ARRAY(I,10))
            IF(LOAN .GT. 1)J = 13
            T = ARRAY(I,7)
C ESTIMATE UNKNOWN PUMP COSTS USING LINEAR REGRESSION EQN.
C REF: T. L. SPOFFORD, USDA-SCS, EPHRATA, WA
            IF(T .LT. .01)T = PWRPMP(IDXPMA(I,NSYS))/.746*76.31+907.19
            SAL = ARRAY(I,8)/100.
C            SUB = ARRAY(I,9)/100.
            FIN = ARRAY(I,9)/100.
C            SUBADD = SUB*T
C            IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C              DIFF = (SUBTOT+SUBADD)-SUBMAX
C              SUBADD = SUBADD-DIFF
C              SUB2 = SUBADD/T
C              FIN = FIN+(SUB-SUB2)
C              SUB = SUB2
C            END IF
C            SUBTOT = SUBTOT+SUBADD
            SYST(J) = SYST(J) + T
C            SYST(J+1) = SYST(J+1) + T * (1.-(SUB+FIN))
            SYST(J+1) = SYST(J+1) + T * (1.-FIN)
            SYST(J+2) = SYST(J+2) + SUBADD
```

```
         SYST(J+3) = SYST(J+3) + T*FIN
         SYST(J+6) = SYST(J+6) + T*SAL
         AMAINT = ARRAY(I,11)/100.*T
         SYST(J+7) = SYST(J+7) + AMAINT
         SYST(J+8) = SYST(J+8) + ARRAY(I,12)
         COMP(NSYS,ITEMS(NSYS)+1) = 'PUMP'
      CALL ECON(NSYS,T,LIFE(13),LOAN,SAL,FIN,SUB,AMAINT,ARRAY(I,12))
40   CONTINUE
     RETURN
     END
```

```
C
C
C
C
      SUBROUTINE OTHER(NSYS)
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      CHARACTER*20 FORM,LBL*9,COMP*26
C
      DIMENSION ARRAY(9,8),LBL(9)
C
C  ****** READ OTHER DATA ******
      READ(LIN,FORM(8))N
C      WRITE(*,*)'NOTHER ',N
      READ(LIN,FORM(13))
      READ(LIN,FORM(9))(LBL(J),J = 1,N)
      DO 10 I = 1,7
10        READ(LIN,FORM(7))(ARRAY(J,I),J = 1,N)
C10         WRITE(*,*)(ARRAY(J,I),J = 1,N)
      READ(LIN,*)
C
C  SAVE DATA FOR SYSTEM SUMMARY
      DO 20 I = 1,N
            LIF = NINT(ARRAY(I,2))
            J = 4
            LOAN = NINT(ARRAY(I,5))
            IF(LOAN .GT. 1)J = 13
            T = ARRAY(I,1)
            SAL = ARRAY(I,3)/100.
C            SUB = ARRAY(I,4)/100.
            FIN = ARRAY(I,4)/100.
C            SUBADD = SUB*T
C            IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C              DIFF = (SUBTOT+SUBADD)-SUBMAX
C              SUBADD = SUBADD-DIFF
C              SUB2 = SUBADD/T
C              FIN = FIN+(SUB-SUB2)
C              SUB = SUB2
C            END IF
C            SUBTOT = SUBTOT+SUBADD
            SYST(J) = SYST(J) + T
C            SYST(J+1) = SYST(J+1) + T * (1.-(SUB+FIN))
            SYST(J+1) = SYST(J+1) + T * (1.-FIN)
            SYST(J+2) = SYST(J+2) + SUBADD
            SYST(J+3) = SYST(J+3) + T*FIN
            SYST(J+6) = SYST(J+6) + T*SAL
            AMAINT = ARRAY(I,6)/100.*T
            SYST(J+7) = SYST(J+7) + AMAINT
            SYST(J+8) = SYST(J+8) + ARRAY(I,7)
            COMP(NSYS,ITEMS(NSYS)+1) = LBL(I)(1:9)
            CALL ECON(NSYS,T,LIF,LOAN,SAL,FIN,SUB,AMAINT,ARRAY(I,7))
20    CONTINUE
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE STRUCT(NSYS)
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
      CHARACTER*20 FORM,COMP*26
C
      DIMENSION ARRAY(9,7)
C
C ****** READ STRUCTURE DATA ******
      READ(LIN,FORM(8))N
C      WRITE(*,*)'NSTRUCT ',N
      READ(LIN,FORM(13))
      DO 10 I = 1,6
10        READ(LIN,FORM(7))(ARRAY(J,I),J = 1,N)
C10          WRITE(*,FORM(7))(ARRAY(J,I),J = 1,N)
      READ(LIN,*)
C
C  SUMMARIZE STRUCTURE DATA FOR SYSTEM SUMMARY
      DO 20 I = 1,N
            J = 4
            LOAN = NINT(ARRAY(I,4))
            IF(LOAN .GT. 1)J = 13
            T = ARRAY(I,1)
            SAL = ARRAY(I,2)/100.
C            SUB = ARRAY(I,3)/100.
            FIN = ARRAY(I,3)/100.
C            SUBADD = SUB*T
C            IF((SUBTOT+SUBADD) .GT. SUBMAX)THEN
C              DIFF = (SUBTOT+SUBADD)-SUBMAX
C              SUBADD = SUBADD-DIFF
C              SUB2 = SUBADD/T
C              FIN = FIN+(SUB-SUB2)
C              SUB = SUB2
C            END IF
            SUBTOT = SUBTOT+SUBADD
            SYST(J) = SYST(J) + T
C            SYST(J+1) = SYST(J+1) + T * (1.-(SUB+FIN))
            SYST(J+1) = SYST(J+1) + T * (1.-FIN)
            SYST(J+2) = SYST(J+2) + SUBADD
            SYST(J+3) = SYST(J+3) + T*FIN
            SYST(J+6) = SYST(J+6) + T*SAL
            AMAINT = ARRAY(I,5)/100.*T
            SYST(J+7) = SYST(J+7) + AMAINT
            SYST(J+8) = SYST(J+8) + ARRAY(I,6)
            COMP(NSYS,ITEMS(NSYS)+1) = 'STRUCTURE'
        CALL ECON(NSYS,T,LIFE(12),LOAN,SAL,FIN,SUB,AMAINT,ARRAY(I,6))
 20   CONTINUE
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE ECON(NSYS,TCI,LIF,LOAN,SVF,FINF,SUBF,AMAINT,AMISC)
C
C
      COMMON  IDCP(30),AREA(11),NCRP(11),CRPDK(11,30,8),KSEL(11),
     1NPKSYS(11),IDS(11),IPSYS(11,11),NCP,TLAB(11,2),DRAN(9,4),
     2SYST(30),SYSVAL(22,11),NAPMP(30),IDXPMA(30,11),PWRPMP(30),
     3EAPP(30,11),QPMP(30),FORM(20),WCOST(4),LIFE(15),IACCST(4,11,30),
     4ROC,LLIF(2),DAIR(2),MPS,LIN,DINF,LEPD,SUBMAX,SUBTOT,COMP(11,150),
     5ICOMP(11,150,8),ITEMS(11),PIPE(11,5),CHAN(11,5,2),SYSOBS(30,11,3),
     6NPIPE(11),NCHAN(11),SSEEP(11)
C
C SUBROUTINE TO DETERMINE CAPITAL RECOVERY AND ANNUAL CAPITAL CASH
C FLOW FOR IRRIGATION SYSTEM COMPONENTS
C
      CHARACTER*20 FORM,COMP*26
C
      NOC = INT(LEPD/LIF)+1
      NREP = 0
      DO 100 I = 1,NOC
            IY1 = NREP*LIF+1
            IY2 = IY1+LLIF(LOAN)-1
            IY2 = MIN0(IY2,LEPD)
            CAF = (1.+DINF)**(IY1-1)
            TC = TCI*CAF
C      WRITE(*,*)'OCCURANCE, COST',I,TC
            SAL = SVF*TC
            IF((IY1+LIF-1).GT.LEPD)
     &             SAL =SAL+((IY1+LIF-1)-LEPD)*(TC-SAL)/LIF
            IF(SAL .EQ. TC)GOTO 100
            PWF = 1./(1.+DINF)**IY1
            CRF = ROC*(1.+ROC)**LEPD/((1.+ROC)**LEPD-1.)
            ADDLCR = ((TC-SAL)*CRF+SAL*ROC)*PWF
            IF(IY1 .GE. LEPD)ADDLCR = 0.
C      WRITE(*,*)' YEAR,TC,SAL,SVF',IY1,TC,SAL,SVF
            SYST(22) = SYST(22)+ADDLCR
C      WRITE(*,*)'NSYS, ADDED CR, TOT CR',NSYS,ADDLCR,SYST(22)
            X1 = DAIR(LOAN)
            X2 = LLIF(LOAN)
            IF(LOAN .LE. 0 .OR. LOAN .GT. 2)X1=0
            IF(LOAN .LE. 0 .OR. LOAN .GT. 2)X2=1
            TCF = TC*FINF
C  SAVE DATA FOR INDIVIDUAL COMPONENT COST ANALYSIS
           ITEMS(NSYS) = ITEMS(NSYS)+1
           ITEMS(NSYS) = MIN0(ITEMS(NSYS),149)
           ICOMP(NSYS,ITEMS(NSYS),1) = IY1-1
           ICOMP(NSYS,ITEMS(NSYS),2) = LIF
           ICOMP(NSYS,ITEMS(NSYS),3) = NINT(TC)
           ICOMP(NSYS,ITEMS(NSYS),4) = NINT(SAL)
           IF(NREP .EQ. 0)ICOMP(NSYS,ITEMS(NSYS),4) = NINT(TC*SVF)
           ICOMP(NSYS,ITEMS(NSYS),5) = NINT(ADDLCR/PWF)
           ICOMP(NSYS,ITEMS(NSYS),6) = NINT(100.*X1)
           ICOMP(NSYS,ITEMS(NSYS),7) = NINT(AMAINT)*CAF
           ICOMP(NSYS,ITEMS(NSYS),8) = NINT(AMISC)*CAF
           IF(NREP.GT.0)THEN
            COMP(NSYS,ITEMS(NSYS))=COMP(NSYS,ITEMS(NSYS)-1)
            COMP(NSYS,ITEMS(NSYS))(24:24)='R'
           END IF
C  ASSUME NO SUBSIDIES ON REPLACEMENTS
C             IF(NREP .GT. 0)TCF = TC*(FINF+SUBF)
            CRFT = ((X1*((1.+X1)**X2))/(((1.+X1)**X2)-1.))*TCF
            DO 50 IYR = IY1,IY2
              ICRFT = NINT(CRFT)
              ITCF = NINT(X1*TCF)
              IACCST(4,NSYS,IYR) = IACCST(4,NSYS,IYR)+ICRFT
              IACCST(2,NSYS,IYR) = IACCST(2,NSYS,IYR)+ITCF
              IACCST(1,NSYS,IYR) = IACCST(1,NSYS,IYR)+(ICRFT-ITCF)
              IF(IYR .EQ. IY1 .AND. IY1 .GT. 1)THEN
```

```
C                    CASH = TC*(1.-(FINF+SUBF))
                    CASH = TC*(1.-FINF)
                    CASH = AMAX1(0.,CASH)
                    IACCST(3,NSYS,IYR-1) = IACCST(3,NSYS,IYR-1)+CASH
                    IACCST(4,NSYS,IYR-1) = IACCST(4,NSYS,IYR-1)+CASH
                 END IF
                 TCF = TCF-(ICRFT-ITCF)
                 TCF = AMAX1(TCF,0.)
   50          CONTINUE
               NREP = NREP+1
  100 CONTINUE
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE BORDER(NFLD,DMAD,XN,A,B,QU,EFFA,DPPCT,ROPCT,Y0)
C---THIS SUBROUTINE COMPUTES APPLICATION EFFICIENCIES OF
C   BORDER IRRIGATION SYSTEMS....R.G.ALLEN...G.D.GALINATO....
C   UNIVERSITY OF IDAHO, MOSCOW, IDAHO USA
C    MODIFIED BY J.R. BUSCH WINCHMORE  10 JUNE 1982
C    MODIFIED BY B. A. KING  UNIVERSITY OF IDAHO 25 OCT 1985
C
C  SYSTEM/FIELD PARAMETERS PASSED:
C   SYSFLD(I,J)  SYSTEM PARAMETERS FOR FIELD I
C    J = 1 - FIELD LENGTH (FT)        10 - TOT. LAND GRADING COST ($)
C        2 - FIELD WIDTH (FT)         11 - % L.G. COST SUBSIDIZED
C        3 - FIELD SLOPE (%)          12 - % L.G. COST FINANCED
C        4 - BORDER LENGTH (FT)       13 - LOAN NUMBER
C        5 - BORDER WIDTH (FT)        14 - ANN. MAINT. COST ($)
C        6 - TYPE OF BORDER (1=OPEN END, 2=CLOSED END)
C        7 -                          15 - APPLICATION EFF. (%)
C        8 - LABOR (HR/IRRIG/AC)      16 - DEEP PERC.  (% OF APPLIED)
C        9 - ADD'L LABOR (HR/IRRIG)   17 - UNIT FLOW RATE (CFS/FT)
C
      COMMON/BORD/TIN(10),TRS(10),MAD,XLNT,SL,RN,TYPE,
     & C,AC,BC,CU,TINH,RVOL,DVOL,TM
      COMMON/SYSM/SYSFLD(9,30),VLOG(9,4)
      DIMENSION EF(5)
      REAL MAD
      LOGICAL BEFORE,VLOG
      DATA BEFORE/.FALSE./
C
      RN = XN
      MAD = DMAD
      AC = A
      BC = B
      C=0.275
C
C---COMPUTE ADVANCE USING GENERALIZED DIMENSIONLESS SOLUTION
C    DEVELOPED BY N.D. KATOPODES AND THEODOR STRELKOFF, UCD.
C
C----COMPUTE NORMAL DEPTH USING MANNINGS EQUATION FOR OPEN CHANNEL FLOW
C
      XLNT = SYSFLD(NFLD,4)
      SL = SYSFLD(NFLD,3)/100.
      TYPE = SYSFLD(NFLD,6)
      CU = 1.486
      IF(SL.LE.0.0001) SL=0.0001
      TM =((MAD-C)/AC)**(1/BC)
      QU = MAD*XLNT/7.2/TM/60.
      ND = (QU*RN/(CU*SL**.5))**.600
      TLAG=ND**2/QU/SL/120/2
      IF(TLAG.GT.30.) TLAG=30.
      TM=TM-TLAG
      QU = MAD*XLNT/7.2/TM/60.
      TTA = TM
C
C -- HOOKE AND JEEVES SEARCH ALGORITHM TO FIND THE OPTIMUM UNIT FLOW
C -- RATE AND CUT-OFF TIME GIVEN FIELD SPECIFIC PARAMETERS.
C
      SETF = -5000.0
      SETX = QU
      SETY = TTA
      BASEX=SETX
      BASEY=SETY
      X0 = SETX
      Y0= SETY
      DELTA = 0.1
 10   CALL BORDR(X0,Y0,EF(1),NFLD)
      XP = X0 * (1.0 + DELTA)
      YP = Y0 * (1.0 + DELTA)
      XN = X0 * (1.0 - DELTA)
```

```
      YN = Y0 * (1.0 - DELTA)
      CALL BORDR(XP,Y0,EF(2),NFLD)
      CALL BORDR(X0,YP,EF(3),NFLD)
      CALL BORDR(XN,Y0,EF(4),NFLD)
      CALL BORDR(X0,YN,EF(5),NFLD)
      IF(YP.GT.1500.) GOTO 9999
C
C -- FIND MAXIMUM VALUE OF EFFICIENCY
C
      FQ = EF(1)
      I = 1
      DO 702 J = 2,5
      IF(EF(J).GT.FQ) THEN
        FQ = EF(J)
        I = J
      ENDIF
  702 CONTINUE
      IF(SETF.GT.FQ) GO TO 800
      GOTO (800,100,200,300,400) I
      WRITE(*,*) ' PROBLEMS IN BORDER FLOW MODEL. CHECK INPUTS FOR ',
     &'FIELD ',NFLD
      EFFA = -1.
      DPPCT = 0.
      ROPCT = 0.
      RETURN
C --- FP0 GIVES MAXIMUM VALUE OF EFFICIENCY
 100  BASEX = XP
      BASEY = Y0
      BASEF = EF(2)
      GO TO 500
C --  F0P GIVES MAXIMUM VALUE OF EFFICIENCY
 200  BASEX = X0
      BASEY = YP
      BASEF = EF(3)
      GO TO 500
C --  FN0 GIVES MAXIMUM VALUE OF EFFICIENCY
 300  BASEX = XN
      BASEY = Y0
      BASEF = EF(4)
      GO TO 500
C --  F0N GIVES MAXIMUM VALUE OF EFFICIENCY
 400  BASEX = X0
      BASEY = YN
      BASEF = EF(5)
C --  DETERMINE NEW BASE
 500  X0 = 2*BASEX - SETX
      Y0 = 2*BASEY - SETY
      SETX = BASEX
      SETY = BASEY
      SETF = BASEF
C -- TRY TO FIND NEXT BASE
      GO TO 10
C -- EXPLORATORY SEARCH WAS A FAILURE
 800  IF (BEFORE .AND. DELTA .GT. 0.05) GOTO 900
      IF (BEFORE .AND. DELTA .LT. 0.1) GOTO 1000
      BEFORE = .TRUE.
      SETX = BASEX
      SETY = BASEY
      X0 = SETX
      Y0 = SETY
      GO TO 10
 900  DELTA = DELTA/2.0
      BEFORE = .FALSE.
      SETX = BASEX
      SETY = BASEY
      X0 = SETX
      Y0 = SETY
      GO TO 10
 1000 CONTINUE
      CALL BORDR(X0,Y0,EFFA,NFLD)
```

```
      DPPCT = DVOL
      ROPCT = RVOL
      QU = X0
      Y0 = Y0/60.
      IF(EFFA .LE. 0.)GOTO 9999
      RETURN
C
 9999 WRITE(*,3021)NFLD
 3021 FORMAT(' THE EFFICIENCY VALUES FOR FIELD ',I3,' ARE INVALID.'/
     & ' CHECK INPUT VALUES.')
      RETURN
      END
```

```
C
C
      SUBROUTINE BORDR(QU,TTA,EFFA,NFLD)
      COMMON/BORD/TIN(10),TRS(10),MAD,XLNT,SL,RN,TYPE,
     & C,AC,BC,CU,TINH,RVOL,DVOL,TM
C
      DIMENSION TA(10),LAL(2),LG(2),XI(10),XDS(10),TDS(4,10),
     *CF(4,5),COEF(5,9,4),COEF1(90),COEF2(90)
      EQUIVALENCE (COEF1(1),COEF(1,1,1)),(COEF2(1),COEF(1,1,3))
      REAL MAD
      DATA COEF1/
     & -0.4150, 2.3160, 0.0924,-0.0455,-0.0079,
     & -0.2994, 2.1981, 0.1181,-0.0494,-0.0148,
     & -0.1468, 2.0824, 0.1333,-0.0090,-0.0006,
     &  0.0407, 1.9526, 0.1403,-0.0103,-0.0041,
     &  0.2987, 1.7926, 0.1221, 0.0004,-0.0019,
     &  0.5293, 1.6122, 0.1013, 0.0084,-0.0002,
     &  0.5849, 1.4689, 0.1509, 0.0419, 0.0043,
     &  0.5818, 1.4445, 0.1806, 0.0430, 0.0037,
     &  0.5825, 1.4489, 0.1794, 0.0388, 0.0033,
     & -0.4824, 2.9732, 0.3149,-0.1295,-0.0414,
     & -0.3600, 2.7319, 0.3469,-0.0548,-0.0225,
     & -0.2239, 2.5006, 0.4359, 0.0363,-0.0062,
     & -0.0068, 2.2471, 0.4526, 0.1211, 0.0153,
     &  0.2474, 2.1225, 0.4042, 0.0571,-0.0012,
     &  0.5693, 1.9495, 0.2585, 0.0054,-0.0058,
     &  0.5726, 1.7614, 0.4251, 0.1288, 0.0135,
     &  0.5847, 1.7385, 0.4384, 0.1193, 0.0111,
     &  0.5823, 1.7349, 0.4484, 0.1193, 0.0110/
      DATA COEF2/
     & -0.6769, 3.9867, 1.1193,-0.1685,-0.1404,
     & -0.5245, 3.4924, 1.2310, 0.2436, 0.0035,
     & -0.2962, 3.1432, 1.2328, 0.4197, 0.0608,
     & -0.0400, 2.9050, 1.2328, 0.4439, 0.0608,
     &  0.2539, 2.6001, 1.0028, 0.3401, 0.0424,
     &  0.4791, 2.3461, 0.9260, 0.3266, 0.0400,
     &  0.5835, 2.3119, 0.9534, 0.3031, 0.0325,
     &  0.6093, 2.2950, 0.9449, 0.2758, 0.0271,
     &  0.6482, 2.2491, 0.8792, 0.2468, 0.0236,
     & -0.6234, 6.7411, 5.6423, 2.1934, 0.2117,
     & -0.5195, 6.0496, 6.2052, 3.5753, 0.7379,
     & -0.2863, 5.5300, 5.4534, 2.8355, 0.5053,
     &  0.0297, 4.8251, 4.2143, 1.9799, 0.3144,
     &  0.4247, 4.0387, 3.0400, 1.3074, 0.1874,
     &  0.6862, 3.5188, 2.1300, 0.7616, 0.0916,
     &  0.8811, 3.4234, 1.9788, 0.6451, 0.0701,
     &  0.9393, 3.2551, 1.7330, 0.5178, 0.0517,
     &  0.9496, 3.2288, 1.6451, 0.4667, 0.0446/
C
C *** INTERNAL FUNCTIONS
C
C INFILTRATION DEPTH FUNCTION
      FZ(X)=AC*X**BC+C
C INFLITRATION RATE FUNCTION
      FR(X)=AC*BC*X**(BC-1.0)
C
C *** ZERO OUT VARIABLES
      DO 1011 I = 1,10
      TA(I)=0.0
      TIN(I)=0.0
 1011 TRS(I)=0.0
      OVRFLW=0.0
      Q0 = QU
      YN = (Q0*RN/(CU*SL**.5))**.600
      TLAG=YN**2/Q0/SL/120/2
C      WRITE(*,*) 'YN =',YN
      IF(YN*12.0.GT.8.0) GOTO 435
      IF(TLAG.GT.30.) TLAG=30.
C
C----CALCULATE DIMENSIONAL PARAMETERS USED IN COMPUTATION OF ADVANCE
```

```
      TS = (YN/(AC/(60.**BC*12.)))**(1./BC)
      XS = Q0/YN*TS
      P = SL*Q0*TS/YN**2
C
C----CALCULATE THE SQUARE OF THE FROUDE NUMBER AND TEST FOR ZERO INERTIA
      FN2 = Q0**2/(32.17*YN**3)
      IF(FN2.LT..05) GO TO 17
      WRITE(*,2003) FN2
 2003 FORMAT(5X,'THE VALUE OF THE FROUDE NUMBER DESCRIBING THE'/
     *5X,'FLOW OF WATER ALONG THE FIELD IS HIGHER THAN'/
     *5X,'ALLOWED FOR ACCURATE ADVANCE PREDICTIONS USING'/
     *5X,'THE ASSUMPTION OF ZERO INERTIA.  THE VALUE OF'/
     *5X,'THE FROUDE NO.**2 IS',F6.2,' ,WHICH IS '/
     *5X,'GREATER THAN THE SUGGESTED VALUE OF .05'/)
 17   CONTINUE
C----DETERMINE COEFFICIENTS OF THE 4TH DEGREE POLYNOMIAL REGRESSION
C    EQUATIONS DESCRIBING T* VS X* FOR THE FOUR CURVES
C    OF ALPHA AND NPL WHICH ENVELOPE BC AND P.
C
      LAL(1) = INT(BC*10.)
      LAL(2) = LAL(1)+1
      PLG = ALOG10(P*10.**6)
      LG(1) = INT(PLG)
      LG(2) = LG(1)+1
      JC = 0
      DO 210 I=1,2
      LALPHA = LAL(I)-5
      DO 210 J=1,2
      NPL = LG(J)
      IF(NPL.GT.9) NPL=9
      IF(NPL.LT.1) NPL=1
      JC = JC+1
      DO 205 JP=1,5
  205 CF(JC,JP) = COEF(JP,NPL,LALPHA)
  210 CONTINUE
C
C----DIVIDE FIELD INTO 10 STATIONS AND CALCULATE DIMINSIONLESS DISTANCES
      XL = XLNT/10.
      XJ = 0.
      DO 220 I=1,10
      XJ = XJ+XL
      XI(I) = XJ
  220 XDS(I) = XJ/XS
C
C----COMPUTE DIMENSIONLESS ADVANCE TIMES OF EACH STATION FOR
C    EACH OF 4 SETS OF REGRESSED CURVES
      DO 250 JC=1,4
      DO 250 I=1,10
      TJ = CF(JC,1)
      DO 240 JP=2,5
  240 TJ = TJ+CF(JC,JP)*(ALOG(XDS(I)))**(JP-1)
  250 TDS(JC,I) = EXP(TJ)
C
C----DETERMINE INTERPOLATED VALUE OF TDS BETWEEN THE FOUR CURVES
      P1 = 10.**(LG(1)-6)
      P2 = 10.**(LG(2)-6)
      IF(LG(1).LT.1.OR.LG(2).GT.9) GO TO 260
      DP = (P-P1)/(P2-P1)
      GO TO 264
  260 DP = 0.
  264 DO 270 J=1,3,2
      DO 270 I=1,10
  270 TDS(J,I) = TDS(J,I)+DP*(TDS(J+1,I)-TDS(J,I))
      DP = (BC*10.-LAL(1))/(LAL(2)-LAL(1))
      DO 280 I=1,10
  280 TDS(1,I) = TDS(1,I)+DP*(TDS(3,I)-TDS(1,I))
C
C----TRANSFORM DIMENSIONLESS TIME INTO ACTUAL TIME IN MINUTES
C
C----FACTOR OF 1.14 IS A FACTOR OF INGNORANCE TO GET OUTPUT TO MATCH
```

```
C----THAT OF THE ZERO INERTIAL MODEL BRDRFLW BY STRELKOFF
      DO 290 I=10,1,-1
      TA(I) = TDS(1,I)*TS/60.*1.14
      IF(TTA+TLAG-TA(I).LT.0.0) J9=I-1
  290 CONTINUE
C----DETERMINE THE TOTAL VOLUME OF WATER TO FLOW ONTO THE FIELD
      VON = TTA*Q0*60./XLNT*12.
C
C------COMPUTATION OF VOLUMES OF INFILTRATION FOR THE STATIONS,
C       AND RUNOFF FROM THE FIELD USING A KINEMATIC WAVE MODEL DERIVED
C       BY SHERMAN AND SINGH IN WATER RESOURCE RESEARCH VOL 14 NO.2 4/'78
C
C----COMPUTE THE RECESSION CURVE
C----FIND THE AVERAGE INFILTRATION RATE IN THE FIELD AT BEGINNING OF
C     RECESSION
      TR = TTA+TLAG
C      WRITE(*,*) 'TR =',TR,' TA(1) =',TA(1)
      IF((TR-TA(1)).LE.0.0) GOTO 435
      IF((TR-TA(10)).LE.0.0) THEN
        AIN=FR(TR)/2.0
        DO 8 K=1,J9-1
    8   AIN=AIN+FR(TR-TA(K))
        AIN=(AIN+(FR(TR-TA(J9)))/2.0)/J9
      ELSE
        AIN = FR(TR)/20.
        DO 300 I=1,9
  300   AIN = AIN+(FR(TR-TA(I)))/10.
        AIN=AIN+FR(TR-TA(10))/20.
      ENDIF
      K9=J9
      AIN = AIN/(60.*12.)
      ALPHA=SL**.5/RN
      FIL=(AIN/3.281)**(2./3.)
C -- CALCULATE THE RECESSION USING KINEMATIC MODEL EQUATION USING A
C -- FACTOR OF INGNORANCE TO GET THE RESULTS TO MATCH THE ZERO
C -- INERTIAL MODEL BY STRELKOFF
      DO 99 I=1,10
      TRS(I)=TR+((XI(I)/3.281/ALPHA/FIL)**(3./5.))/60.*.77
   99 CONTINUE
C      WRITE(*,*) 'TRS(10)=',TRS(10),'TA(10) =',TA(10)
      IF(TRS(10).LT.TA(10)) GO TO 435
      IF(NINT(TYPE).EQ.2) GO TO 960
C----CALCULATE TOTAL INFILTRATION OF THE STATIONS AND FIND AVERAGE
  340 TINH = FZ(TR)
      TAIN = TINH/20.
      DO 350 I=1,9
      TIN(I) = FZ(TRS(I)-TA(I))
      IF(TIN(I).LT.0.5) TIN(I)=0.0
      TAIN = TAIN+TIN(I)/10.
C      WRITE(*,*) 'I= ',I,'TIN= ',TIN(I)
  350 CONTINUE
      TIN(10) = FZ(TRS(10)-TA(10))
      IF(TIN(10).LT.0.5) TIN(10)=0.0
      VIN = TAIN + TIN(10)/20.
C      WRITE(*,*) 'I= 10 ','TIN= ',TIN(I)
C---DETERMINE TOTAL RUNOFF
      IF(TIN(10).EQ.0.0) VIN=VON
      VINN = VIN
      VSR = VON-VINN
      IF(VSR.LT.0.) VSR=0.0
      IF(NINT(TYPE).EQ.2.AND.OVRFLW.GT.0.0) VSR=OVRFLW
C----CALCULATE DEEP PERCOLATION
      IF(TINH.LE.MAD.AND.TIN(10).LE.MAD) GO TO 380
      TN = MAD
      VDP = AMAX1((TINH-TN),0.)/20.
      DO 360 I=1,9
      VDP = VDP+AMAX1((TIN(I)-TN),0.)/10.
  360 CONTINUE
      VDP = VDP+AMAX1((TIN(10)-TN),0.)/20.
      GO TO 385
```

```
  380 VDP = 0.
C
C----CALCULATE APPLICATION EFFICIENCY
  385 EFFA = (VON-VDP-VSR)/VON*100.
C----CALCULATE SEASON LOSSES
      RVOL = VSR/VON * 100.
      DVOL = VDP/VON * 100.
C      WRITE(*,*) 'VON =',VON,'VDP =',VDP,'VSR =',VSR,'EFFA =',EFFA
C
      GO TO 200
 435  CONTINUE
      EFFA =0.0
      GO TO 200
C
C     COMPUTATIONS FOR CASE OF BLOCK ENDED BORDER
  960 TINH=FZ(TR)
      TAIN=TAINH/20.
      IF(TR.GT.TA(10)) GOTO 351
      DO 3 I =1,10
    3 IF(TRS(I).LT.TA(10)) J9=I
      IF(J9.GT.8) GOTO 352
      DO 4 I =1,J9-1
    4 TAIN=TAIN+FZ(TRS(I)-TA(I))/10.
      DO 2 I = J9, 9
2     TAIN=TAIN+FZ(MAX(TRS(J9)-TA(I),0.0))/10.
      GOTO 352
 351  DO 353 I = 1,9
 353  TAIN=TAIN+FZ(TR-TA(I))/10.
      TAIN=TAIN+FZ(TR-TA(10))/20.
 352  SVOL=VON-TAIN
C      WRITE(*,*) 'SVOL =',SVOL,' VON =',VON,' TAIN =',TAIN
      SVOL=MAX(SVOL,0.0)
      TRIVOL=SL*XLNT**2/2
      IF(SVOL/12*XLNT.GT.TRIVOL) GO TO 238
      YEND=12.0*(MAX(SVOL,0.0)/12*XLNT*2*SL)**.5
      GOTO 237
 238  YEND=12.0*(SL*XLNT+(SVOL/12*XLNT-TRIVOL)/XLNT)
 237  CONTINUE
      IF(YEND.GT.8.0) THEN
         PVOL=64/SL/288/XLNT*12.0
         OVRFLW=SVOL-PVOL
         YEND=8.0
      ELSE
         OVRFLW=0.0
      ENDIF
C      WRITE(*,*) 'SVOL=',SVOL/12*XLNT,'TRIVOL=',TRIVOL,'MAD=',MAD
      IF(YEND.GE.XLNT*SL*12.) GO TO 990
C     SLNTH IS THE SUBMERGED LENGTH OF THE BORDER
C     ULNTH IS THE UNSUBMERGED LENGTH OF THE BORDER
      SLNTH=YEND/12./SL
 970  ULNTH=XLNT-SLNTH
      K9=INT(ULNTH/XL)
      IF(K9.LT.1) THEN
      K9=1
      DLNTH=0.0
      SLNTH=XLNTH-XL
      ULNTH=XL
      ELSE
      DLNTH=XI(K9+1)-ULNTH
      ENDIF
      IF(TRS(K9).LE.TA(K9)) GOTO 435
      AIN =FR(TRS(K9)-TA(K9))/2.
      IF(K9+1.GT.9) GOTO 721
      DO 971 I = K9+1,9
      IF(TRS(K9).LE.TA(I)) THEN
      AIN = AIN+FR(5.0)
      ELSE
      AIN = AIN+FR(TRS(K9)-TA(I))
      ENDIF
  971 CONTINUE
```

```
      IF(TRS(K9).LE.TA(10)) THEN
      AIN =(AIN+FR(1.0)/2.)/(10-K9)
      ELSE
      AIN =(AIN+(FR(TRS(K9)-TA(10)))/2.)/(10-K9)
      ENDIF
      GO TO 722
  721 IF(TRS(K9).LE.TA(10)) THEN
        AIN = AIN+FR(1.0)
      ELSE
        AIN = AIN+(FR(TRS(K9)-TA(10)))/2.0
      ENDIF
 722  DYINC=DLNTH*SL*12.0
      TINC=DYINC/AIN
      TRS(K9+1)=(TRS(K9+1)-TRS(K9))*(1-(DLNTH/XL))+TINC+TRS(K9)
      IF(K9+1.GE.10) GOTO 21
      YINC=XL*SL*12.0
      DO 221 I=K9+1,9
      AIN = (FR(TRS(I)-TA(I)))/2.0
      IF(I.GT.8) GOTO 321
      DO 219 J=I+1,9
      IF(TRS(I).LE.TA(J)) THEN
      AIN = AIN+FR(1.0)
      ELSE
      AIN = AIN+FR(TRS(I)-TA(J))
      ENDIF
 219  CONTINUE
      IF(TRS(I).LE.TA(10)) THEN
      AIN = (AIN+FR(1.0)/2.0)/(10-I)
      ELSE
      AIN =(AIN+(FR(TRS(I)-TA(10)))/2.0)/(10-I)
      ENDIF
 221  TRS(I+1)=TRS(I)+YINC/AIN
      GOTO 21
 321  IF(TRS(9)-TA(10).LE.0.) THEN
      AIN=AIN+FR(1.0)
      ELSE
      AIN =AIN+(FR(TRS(9)-TA(10)))/2.0
      ENDIF
      TRS(10)=TRS(9)+YINC/AIN
   21 DO 1991 I=1,10
C      WRITE(*,*) 'I =',I,'TRS(I)=',TRS(I),'TA(I) =',TA(I)
 1991 CONTINUE
C      WRITE(*,*) 'MAD =',MAD
      GOTO 340
      EFFA=-50.0
      GO TO 200
  990 YHEAD=YEND-XLNT*SL*12
      DO 5 I=1,10
5     IF(TRS(I).GT.TA(I)) J9=I
C      WRITE(*,*) 'J9 = ',J9
C      WRITE(*,*) 'MAD =',MAD
      AIN = FR(TR)/.20
      DO 991 I = 1,J9-1
  991 AIN = AIN + FR(TRS(I)-TA(I))/10.
      DO 992 I = J9,9
  992 AIN = AIN +FR(TA(10)-TA(I))/10.
      AIN = AIN +FR(5.0)/20.
      TDEPLE=YHEAD/AIN
      TR=TR+TDEPLE
      AIN = FR(TR)/20.
      DO 3002 I=1,J9-1
3002  AIN = AIN+FR(TRS(I)-TA(I)+TDEPLE)/10.
      DO 3003 I=J9,9
3003  AIN = AIN +FR(TA(10)-TA(I)+TDEPLE)/10.
      AIN = AIN +FR(TDEPLE)/20.
      YINC=XL*SL*12.0
      TREMP=TR
      DO 121 I= 1,10
      TRS(I)=TREMP+YINC/AIN
C      WRITE(*,*) 'I =',I,'TRS(I) =',TRS(I),'TA(I) =',TA(I)
```

```
      AIN = FR(TRS(I)-TA(I))/2.0
      IF(I.GT.8) GO TO 821
      DO 119 J=I+1,9
      IF(TRS(I)-TA(J).LT.0.) THEN
      AIN = AIN+0.0
      ELSE
      AIN = AIN+FR(TRS(I)-TA(J))
      ENDIF
  119 CONTINUE
      IF(TRS(I)-TA(10).GT.0.) THEN
      AIN =(AIN+(FR(TRS(I)-TA(10)))/2.0)/(10-I)
      ELSE
      AIN=(AIN+0)/(10-I)
      ENDIF
  121 TREMP=TRS(I)
      GOTO 822
  821 AIN = AIN+(FR(TRS(I)-TA(I)))/2.0
      TRS(10)=TRS(9)+YINC/AIN
  822 GO TO 340
C
C
  200 CONTINUE
      IF(TINH.LT.MAD) EFFA = (TINH-MAD)*10+(TTA-TM)/10.
      IF(TIN(10).LT.MAD) EFFA = (TIN(10)-MAD)*10+(TTA-TM)/10.
      IF(TRS(10).LT.TA(10)) EFFA=-2000+TTA
      IF(YN*12.0.GT.8.0) EFFA=-2000-YN*12.0+8.0
      RETURN
      END
```

```
$DEBUG
$LARGE
$NOFLOATCALLS
      SUBROUTINE FURROW(NFLD,AIRRIG,AA,BB,SPFUR,SETX,EFF,DPPCT,
     & ROPCT,HPR)
C
C ********************************************************************
C **                                                                **
C **  University of Idaho Kinematic Wave Furrow Model for           **
C **  Soil Conservation Service System Planning Program             **
C **  Written by B. W. Sauer, Moscow, 1986                          **
C **                                                                **
C ********************************************************************
C
C  SYSTEM/FIELD DATA USED:
C   SYSFLD(I,J)  VARIABLES FOR FIELD I
C     J = 1 - FIELD LENGTH (FT)           10 - LAND GRADING COST ($)
C         2 - FIELD WIDTH (FT)            11 - % L.G. COSTS SUBSIDIZED
C         3 - FURROW SLOPE (%)            12 - % L.G. COSTS FINANCED
C         4 - FURROW LENGTH (FT)          13 - LOAN #
C         5 - MAX. FURROW FLOW (GPM)      14 - ANN. MAINT. COST ($)
C         6 - SET TIME INCREMENT (HRS)    15 - APPL. EFF. (%)
C         7 - MAX.  TOTAL SET TIME (HRS)  16 - DEEP PERC. (% OF APPL.)
C         8 - LABOR (HR/IRRIG/AC)         17 - FURROW FLOW (GPM)
C         9 - ADD'L. LABOR (HR/IRRIG)
C     VLOG(I,J)  LOGICAL VARIABLES FOR FIELD I
C           J = 1 - CORRUGATE?
C
C >>>>>>>>>>>>>>>  STORAGE AND VARIABLE DECLARATIONS  <<<<<<<<<<<<<<<
C
      COMMON/FUROW/XM,SLP,RL
      COMMON/GEOMF/RHO1,RHO2,XSIG1,XSIG2,ZA,ZB,ZC,ZD,QMAX
      COMMON/IRRIG/TOC,ADTM,Z,TM
      COMMON/SYSM/SYSFLD(9,30),VLOG(9,4)
C
      DIMENSION FLOWD(500,2), FCHAR(2,7)
C
      LOGICAL VLOG
C *** INITIALIZE VARIABLES
C
      DATA FCHAR/0.822,5.277, 0.574,0.940,  0.269,0.031,  2.778,2.330,
     & 2.32,0.96,  0.432,0.255,  0.04,0.10/
C
      VAPP = 0.0
      DP = 0.0
C
C *** FURROW GEOMETRY FOR CROP AND SOIL
C  K - 1=FURROW, 2 = CORRUGATES
      K = 1
      IF(VLOG(NFLD,1))K = 2
      XSIG1=FCHAR(K,1)
      XSIG2=FCHAR(K,2)
      RHO1=FCHAR(K,3)
      RHO2=FCHAR(K,4)
      B1=FCHAR(K,5)
      B2=FCHAR(K,6)
      XM=FCHAR(K,7)/1.49
      ZA=AA
      ZB=BB
      ZC=0.275
      ZD=1.0E-8
C
C **** MODEL THE IRRIGATION AND DETERMINE MOST EFFICIENT FLOW RATE ****
C *** SET PROGRAM CONSTANTS ***
C
      SLP = SYSFLD(NFLD,3)/100.
      SLP = AMAX1(SLP,0.0001)
      RL = SYSFLD(NFLD,4)
      TSH = SYSFLD(NFLD,6)
      TM = SYSFLD(NFLD,7)
```

```
      TWRAT=0.4
      TW=TWRAT*SPFUR/12.
      AFUR=(TW/B1)**(1./B2)
 11   IF(SYSFLD(NFLD,5) .LT. 0.1)THEN
            QMAX = SQRT(RHO1*SLP)/XM*AFUR**(RHO2/2)
      ELSE
            QMAX=SYSFLD(NFLD,5)/448.8
      END IF
      TSH=AMAX1(1.,TSH)
      TS=TSH*3600.
      FAREA=RL*SPFUR/12.
      Z=AIRRIG/12.0*FAREA
      TM = TM*3600.
C
C ****** ONE PARAMETER OPTIMIZATION ******
C
C   GOLDEN SECTION SEARCH ALGORITHM TO FIND THE
C   FURROW FLOW RATE WHICH MAXIMIZES IRRIGATION EFFICIENCY
C
C
 3000 K = 0
      BOUNL=0.0
      BOUNR=QMAX
      ACC=0.5/448.8
      XLEN=BOUNR-BOUNL
      IF(XLEN .LE. ACC)GOTO 3100
      XLEFT=BOUNR-XLEN*0.618
      XRGHT=BOUNL+XLEN*0.618
      CALL WAVE(XRGHT,T,TS,0,2,Z,SLP,XM,FLOWD,ROFR,DPR,EFFR,VAPPR)
      CALL WAVE(XLEFT,T,TS,0,2,Z,SLP,XM,FLOWD,ROFL,DPL,EFFL,VAPPL)
C      WRITE(*,*)' EFFR, EFFL ',EFFR,EFFL
 3010 K = K+1
      IF(K .GT. 40)GOTO 1300
      EDIFF = EFFR-EFFL
      NODE = NINT(SIGN(0.5,EDIFF) - SIGN(0.5,-EDIFF))+2
      GOTO (3030, 3015, 3020) NODE
 3015 GOTO (3030, 3020, 3030) NINT(ABS(EFFR))+1
 3020   BOUNL=XLEFT
        XLEN=BOUNR-BOUNL
        IF(XLEN .LE. ACC)GOTO 3100
        EFFL=EFFR
        DPL=DPR
        ROFL=ROFR
        VAPPL=VAPPR
        XLEFT=XRGHT
        XRGHT=BOUNL+XLEN*0.618
        CALL WAVE(XRGHT,T,TS,0,2,Z,SLP,XM,FLOWD,ROFR,DPR,EFFR,VAPPR)
C      WRITE(*,*)' EFFR',EFFR
        GOTO 3010
 3030 BOUNR=XRGHT
        XLEN=BOUNR-BOUNL
        IF(XLEN .LE. ACC)GOTO 3100
        EFFR=EFFL
        DPR=DPL
        ROFR=ROFL
        VAPPR=VAPPL
        XRGHT=XLEFT
        XLEFT=BOUNR-XLEN*0.618
        CALL WAVE(XLEFT,T,TS,0,2,Z,SLP,XM,FLOWD,ROFL,DPL,EFFL,VAPPL)
C      WRITE(*,*)' EFFL ',EFFL
      GOTO 3010
 3100 SETX=(XLEFT+XRGHT)/2.
      IF(EFFR .LT. 0.)SETX = XLEFT
      IF(EFFL .LT. 0.)SETX = XRGHT
      CALL WAVE (SETX,T,TS,0,0,Z,SLP,XM,FLOWD,ROF,DP,EFF,VAPP)
      IF(EFF .LT. EFFR)THEN
         EFF = EFFR
         DP = DPR
         ROF = ROFR
         VAPP = VAPPR
```

```
      END IF
      IF(EFF .LT. EFFL)THEN
         EFF = EFFL
         DP = DPL
         ROF = ROFL
         VAPP = VAPPL
      END IF
      IF(EFF .LT. 0.)GOTO 1313
 3101 TOT=VAPP
C      WRITE(*,*)' VAPP,DP,ROF ',TOT,DP,ROF
      DPPCT = DP/TOT*100.
      ROPCT = ROF/TOT*100.
      HPR = TOC
C *** THAT IS ALL!
C
      RETURN
C
C *** TOO MANY ITERATIONS ***
 1300 WRITE(*,41)NFLD
C      WRITE(*,*)' TOT,DP,RO ',TOT,DP,RO
      GOTO 3101
C
C *** STREAM LIMITS TOO SMALL ***
 1313 WRITE(*,40)NFLD
      IF(SYSFLD(NFLD,5) .LT. 0.1)GOTO 1300
      SYSFLD(NFLD,5) = 0.
      GOTO 11
C
   39 FORMAT(' BAD VALUE FOR FURROW INTAKE FAMILY NUMBER ON FIELD',I3/
     &' FAMILY 0.40 IS USED')
   40 FORMAT(' STREAMSIZE LIMIT TOO SMALL FOR FIELD',I3/' EFFICIENCY '
     &'VALUES DETERMINED WITHOUT LIMITS')
   41 FORMAT(' CALCULATIONS FOR DETERMINING EFFICIENCY IN FIELD',I3,
     &' DO NOT CONVERGE.'/'USE RESULTS WITH CAUTION')
      END
```

```
C
C*****************************************************************************
C****                                                                    *****
C**** WAVE is a irrigation model for furrow irrigated lands.  It          *****
C**** was devired from the kinematic wave model set forth by W.          *****
C**** Walker at Utah State University.                                   *****
C****                                                                    *****
C*****************************************************************************
C
      SUBROUTINE WAVE(QIN,TADV,TSP,IO,IQ,ZRQ,SO,RN,QOF,
     & ROF,DP,EFFA,VAPP)
C           KINEMATIC WAVE MODEL <840530.1428>
C
C *** DATA STORAGE REQUIREMENTS
C
      DIMENSION AR(500,2),DZ(500,2),Q(500,2),DX(500),QOF(500,2)
C
C *** CONSTANTS USED IN THE SUBROUTINE
C
      COMMON/GEOMF/RHO1,RHO2,XSIG1,XSIG2,ZA,ZB,ZC,ZD,QMAX
      COMMON/FUROW/XM,SLP,RL
      COMMON/IRRIG/TOC,ADTM,Z,TM
      DATA THETA/0.60/,PHI/0.60/,E6/60.0/
C
C *** INTERNAL FUNCTIONS
C INFILTRATION FUNCTION
      FZ(X)=(ZA*(X**ZB)+ZC*(X**ZD))/12.
C FLOW AS A FUNCTION OF AREA
      FQ(X)=ALPHA*(X**AMP1)
C AREA AS A FUNCTION OF FLOW
      FA(X)=(X/ALPHA)**(1.0/AMP1)
C
C *** MAIN ENTRY POINT, INITIALIZATION OF INTERNAL PARAMETERS
C
C      WRITE(*,*)' WAVE QIN =',QIN*448.8
      IF(IQ .EQ. 2 .AND. QIN .GT. QMAX)GOTO 120
      IF(QIN .LE. 0.0 .OR. TSP .LE. 0.0)GOTO 120
      IF(TSP .GT. TM)GOTO 120
      ALPHA=SQRT(S0*RHO1)/RN
      AMP1=RHO2/2.0
      ADV0=TM
      Q2=QMAX
      T2=0.
      AMP=AMP1-1.0
      RQDPTH=ZRQ/RL
      TS=TSP
      DELTS=TS
C MAKE TIME STEP SIZE FUNCTION OF Q
      ITK = 0
      DT = 10.*60.
      IF(QIN .LE. .05)DT=(20.-10.*(.05-QIN)/.05)*60.
      IF(QIN .LE. .025)DT=(30.-10.*(.025-QIN)/.025)*60.
      IF(QIN .LE. .01)DT=30.*60.
      DT=AMAX1(DT,600.)
C  FOR VERY LOW INFILTRATION RATES
C     DT=60.
C
C *** INTERNAL RETURN POINT, INITIALIZATION OF PARAMETERS
C
   10 CONTINUE
      DO 20 I=1,500
      DX(I)=0.0
      DO 20 J=1,2
           AR(I,J)=0.0
           DZ(I,J)=0.0
           Q(I,J)=0.0
   20      QOF(I,J)=0.0
      IS=1
      NC=0
      IR=0
```

```
      ZEND=0.0
      TIM=DT
C
C *** CALCULATE THE INITIAL ADVANCE
C
      DZ(1,1)=FZ((DT/E6))
      AR(1,1)=FA(QIN)
      Q(1,1)=QIN
      DX(2)=(QIN*TIM*THETA)/(PHI*(AR(1,1)+DZ(1,1)))
      ADV=DX(2)
      I=1
C
C *** NEXT TIME STEP
C
   30 IS=IS+1
      TIM=IS*DT
      IF(IQ .EQ. 2)THEN
            IF(ADV .EQ.  ADV0 .AND.  ADV .LT.  RL)GOTO 130
      END IF
      ADV0=ADV
      IF(IS.GT.449) GO TO 120
      IF(TIM.GT.TM.AND. ZEND.LT.RQDPTH.AND. AR(N,1).LE.(0.05*AR(N,2)))
     & GO TO 120
      IF(ADV.LT.RL) THEN
            NC=NC+1
            IF(IQ .NE. 1 .AND. TIM .GE. TS) TS=TS+DELTS
      END IF
      IF(TIM.LE.TS) J=1
C
C *** LOOP THRU CELLS
C
   39 DO 40 N=1,NC+1
            Q(N,2)=Q(N,1)
            DZ(N,2)=DZ(N,1)
            IF(AR(N,1).LE.(0.05*AR(N,2)).AND.TIM.GT.TS) J=N
   40       AR(N,2)=AR(N,1)
C
C *** CALCULATE INFILTRATION COMPONENT
C
      DO 50 N=J,NC+1
            TL=FLOAT(IS-(N-1))*DT/E6
   50       DZ(N,1)=FZ(TL)
C
C *** COMPUTE FLOW PROFILE
C
      AR(1,1)=FA(QIN)
      Q(1,1)=QIN
      IF(TIM.LE.TS) GO TO 60
      Q(1,1)=0.0
      AR(1,1)=0.0
C
C *** FLOW PROFILE FOR CELLS 2 THRU NC
C
   60 DO 85 N=J,NC
            N1=N+1
            QJ=Q(N,2)
            QL=Q(N,1)
            QM=Q(N1,2)
C
C *** CALCULATE C2
C
            DENOM=THETA*DT*ALPHA
            C2=-(THETA*QL+(1.0-THETA)*QJ)/THETA/ALPHA
            C2=C2+QM*(1.0-THETA)/THETA/ALPHA
            C2=C2+DX(N1)*(PHI*DZ(N,1)+(1.0-PHI)*DZ(N1,1))/DENOM
            C2=C2-DX(N1)*(PHI*DZ(N,2)+(1.0-PHI)*DZ(N1,2))/DENOM
            C2=C2+PHI*DX(N1)*AR(N,1)/DENOM
            C2=C2-DX(N1)*(PHI*AR(N,2)+(1.0-PHI)*AR(N1,2))/DENOM
C
C *** CALCULATE C1
```

```
C
            C1=DX(N+1)*(1.0-PHI)/DENOM
C
C *** SOLVE EQUATION
C
            I=0
            DAN=50.0
            AR(N1,1)=AR(N,1)*0.95
   70       I=I+1
            IF(I.GT.500) THEN
               IF(ITK.GT.3) WRITE(*,1001)
               IF(ITK.GT.3) GOTO 130
               DT = DT*2.
               ITK = ITK+1
               GOTO 10
            END IF
            IF(AR(N1,1) .LE. 0.) THEN
                  DAK=0.0
                  GOTO 71
            END IF
            DAK=(AR(N1,1)**AMP1+C1*AR(N1,1)+C2)/(AMP1*AR(N1,1)**AMP+C1)
   71       AR(N1,1)=AR(N1,1)-DAK
            IF(AR(N1,1).LE.0.0) AR(N1,1)=AR(N,1)*0.05
            IF(ABS(AR(N1,1)-DAN).LE.0.00001) GO TO 80
            DAN=AR(N1,1)
            GOTO 70
C
C *** ROOT HAS BEEN FOUND
C
   80       CONTINUE
            IF(AR(N1,1) .LE. 0.)THEN
                  Q(N1,1)=0.
                  GOTO 85
            END IF
            Q(N1,1)=FQ(AR(N1,1))
   85 CONTINUE
C
C *** WETTING FRONT AT END-OF-FIELD?
C
      IF(ADV.GE.RL) GOTO 90
C
C *** ADVANCE CELLS
C
      N=NC+1
      DX(N+1)=THETA*FQ(AR(N,1))/(PHI*(AR(N,1)+DZ(N,1)))*DT
      ADV=ADV+DX(N+1)
C      WRITE(*,*)ADV,TIM,N
      IF(ADV.GE.RL) ADTM=TIM/E6
C
C *** NEXT TIME STEP
C
      GOTO 30
C
C *** RUNOFF FROM END OF FIELD
C
   90 IR=IR+1
      QOF(IR,1)=TIM/E6
      QOF(IR,2)=THETA*Q(N,1)+(1.0-THETA)*Q(N,2)
C
C *** CHECK ON THE SET TIME IF AT SCHEDULED END-OF-IRRIGATION
C *** CALCULATE INFILTRATION VOLUME.
C
      IF(TS.GT.TIM) GOTO 30
C
C *** IF INFILTRIATION VOLUME IS NOT SUFFICIENT EXTEND SET TIME
C
      ZEND=(DZ(NC,1)+DZ(NC+1,1))/2.0
      IF(ZEND.LT.RQDPTH .AND.(TS+DELTS).LE.TM) TS=TS+DELTS
      IF(ZEND.LT.RQDPTH) GOTO 30
      IF(J.LT.NC) GOTO 30
```

```
C
C *** NORMAL IRRIGATION FINISH
C
      DP=0.0
      Z=0.0
      DO 100 I=1,NC
      DP=DP+DX(I+1)*(MAX(DZ(I,1)-RQDPTH,0.0)+MAX(DZ(I+1,1)-RQDPTH,0.0))
     &/2.0
  100 Z=Z+DX(I+1)*(DZ(I,1)+DZ(I+1,1))/2.0
      QOF(IR,1)=-1.0
      QOF(IR,2)=-1.0
      VAPP=QIN*TS
      ROF=QIN*TS-Z
      TOC=TS/E6/E6
      EFFA=(VAPP-DP-ROF)/VAPP*100
      RETURN
C
C *** ABNORMAL END OF SUBROUTINE
C
  120 IF(IQ .NE. 1)GOTO 130
      WRITE(*,1001)
      GOTO 130
      STOP 7777
C
C *** ABNORMAL END FOR OPTIMIZING ROUTINE
C
  130 VAPP=0.0
      ROF=0.0
      TOC=TS/E6**2
      EFFA=-1.0
      IF(NC .LT. 1)EFFA = -2.0
      RETURN
C
C *** MORE THAN 100 TRIES TO FIND THE INFLOW
C
  990 WRITE(*,1001)
      GOTO 130
C *** FORMAT STATEMENTS
C
 1001 FORMAT(' ERROR IN FURROW MODEL.  CHECK INPUT DATA')
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE CP(NFLD,EFF,DPPCT,WLPCT,ROPCT,HPR)
C***********************************************************************
C*                                                                     *
C*   CENTER PIVOT MODEL DEVELOPED AT UNIVERSITY OF IDAHO DEPARTMENT    *
C*                                                                     *
C*   OF AGRICULTURAL ENGINEERING FOR SCS IRRIGATION PLANNING MODEL     *
C*                                                                     *
C***********************************************************************
C
C      SYSTEM/FIELD INPUT DATA PASSED:
C       SYSFLD(I,J)  PARAMETERS FOR FIELD I
C       J = 1 - LATERAL LENGTH (FT)         17 - SALVAGE VALUE ($)
C           2 - LATERAL I. DIA. (IN)        18 - LAND GRADING COST ($)
C           3 - DESIGN FLOW RATE (IN/DAY)   19 - % L.G. COST SUBS.
C           4 - SPRINKLER TYPE #            20 - % L.G. COST FIN.
C           5 - AVE. FIELD SLOPE (%)        21 - L.G. COST LOAN #
C           6 - FIELD RADIUS (FT)           22 - ANN. L.G. COSTS ($)
C           7 - LABOR/IRRIG (HR)            23 - ANN. MAINT COSTS ($)
C          13 - TOTAL COST ($)              24 - ANN. MISC. COSTS ($)
C          14 - % COST SUBSIDIZED           25 - APPLICATION EFF. (%)
C          15 - % COST FINANCED             26 - 5 DEEP PERC. LOSSES
C          16 - LOAN #
C       VLOG(I,J)  LOGICAL PARAMETERS FOR FIELD I
C            J = 1 - RESERVOIR TILLAGE?
C                2 - PRESSURE REGULATORS?
C                3 - ENDGUN?
C                4 - AVE. WIND > 5 MPH?
C
C
      COMMON/DROPS/DSPLH, AC, BC, CC, DC, EC
      COMMON/ROFF/APMAX, GRAPP, PR, SIF, TC, TF, TS
      COMMON/SOILS/SOIL(9,3)
      COMMON/SYSM/SYSFLD(9,30),VLOG(9,4)
C
      DIMENSION QD(300), PD(300), SLP(3), Q(3,300), P(3,300), SPRAD(300)
     & ,QTOT(3), ROR(3,5), REY(3,3,5), DAP(3,300)
C
      LOGICAL LOPBAK,ENDGUN,WINDY,PITS,VLOG
C
C
C --- INTERNAL FUNCTIONS
C
C     SPRINKLER DESIGN Q
      FDQ(X) = GPA*SSP*X/6922.
C
C     SPRINKLER WETTED RADIUS
      FWR(X,Y) = A*(X*SQRT(Y))**B
C
C     HAZEN-WILLIAMS HEAD LOSS
      FHW(X) = FF*SSP*X**1.852/DL2
C
C     AREA IN SECTOR COVERED BY SPRINKLER
      FAREA(X,N) = X*2*PI*SPRAD(N)*SSP
C
C ******  CENTER PIVOT SIMULATION ROUTINE  ******
C
C
      RL = SYSFLD(NFLD,1)
      RF = SYSFLD(NFLD,6)
      NST = NINT(SYSFLD(NFLD,4))
      GPA = 18.857*SYSFLD(NFLD,3)
      IREG = 0
      IF(VLOG(NFLD,2))IREG = 1
      ENDGUN = VLOG(NFLD,3)
      WINDY = VLOG(NFLD,4)
      PITS = VLOG(NFLD,1)
      SIF = SOIL(NFLD,2)
```

```
      SK = SOIL(NFLD,3)
C
      CALL SPCHR(NST,A,B,PSPM,SSP)
      PTOS = RL
      DL2 = SYSFLD(NFLD,2)**4.8655
      FF = (.285*145)**(-1.852)
      PI = 3.141593
      ACRES = PI*RF**2/43560.
      QSUM = 0.
      NSP = INT(RL/SSP)
      HZ = RL*SYSFLD(NFLD,5)/100.
      SLP(1) = HZ/RL
      SLP(2) = (-1)*SLP(1)
      SLP(3) = 0.
C *** FIND DESIGN P & Q VALUES ***
      IF(ENDGUN) THEN
            NGUN = NSP+1
            PD(NGUN) = PSPM
            EGR = ((RL+.5*SSP)+RF)/2.
            SPRAD(NGUN) = EGR
            EGSP = RF-(RL+.5*SSP)
            EGSP = AMAX1(EGSP,0.)
            QD(NGUN) = GPA*EGSP*EGR/6922/.64
            QSUM = QSUM+QD(NGUN)
      END IF
      PD(NSP) = PSPM
      QD(NSP) = FDQ(PTOS)
      SPRAD(NSP) = PTOS
      DO 500 I = NSP-1, 1, -1
            PTOS = PTOS-SSP
            QSUM = QSUM+QD(I+1)
            QD(I) = FDQ(PTOS)
            PD(I) = PD(I+1)+FHW(QSUM)
            SPRAD(I) = PTOS
  500 CONTINUE
      QSUM = QSUM+QD(1)
      PPIV = PD(1)+FHW(QSUM)+HZ
C *** CHECK FOR PRESSURE REGULATION
      GOTO (600,700) IREG
C
C <<< REGULATED SPRINKLERS >>>
C
  600 DO 690 J = 1,3
            Q0 = QSUM
            P0 = PPIV
            DZ = SLP(J)*SSP
            DO 610 I = 1, NSP
                  P0 = P0-FHW(Q0)
                  Q0 = Q0-QD(I)
                  Q(J,I) = QD(I)
                  P(J,I) = PSPM
  610       CONTINUE
            IF(ENDGUN) THEN
                  P(J,NGUN) = P(J,NSP)
                  Q(J,NGUN) = QD(NGUN)
            END IF
            QTOT(J) = QSUM
  690 CONTINUE
      GOTO 799
C
C <<< NON-REGULATED SPRINKLERS >>>
C
  700 DO 790 J = 1,3
            LK = 1
            LOPBAK = .TRUE.
            RATIO = 0.
            RATLL = 0.99
            RATUL = 1.01
            Q1 = 0.
            Q2 = 0.
```

```
            Q3 = 0.
            P0 = PPIV
            QSUM = 0.
            DZ = SLP(J)*SSP
C     NO FRICTION LOSSES
            P(J,1) = P0-DZ
            Q(J,1) = QD(1)*SQRT(P(J,1)/PD(1))
            QSUM = Q(J,1)
            DO 720 I = 2, NSP
                  P(J,I) = P(J,I-1)-DZ
                  Q(J,I) = QD(I)*SQRT(P(J,I)/PD(I))
C     FC NOZZLES
                  IF(NST .EQ. 4 .AND. P(J,I) .GT. PSPM)Q(J,I) = QD(I)
                  QSUM = QSUM + Q(J,I)
  720 CONTINUE
            IF(ENDGUN) THEN
                  P(J,NGUN) = P(J,NSP)
                  Q(J,NGUN) = QD(NGUN)*SQRT(P(J,NGUN)/PD(NGUN))
                  QSUM = QSUM+Q(J,NGUN)
            END IF
C INCLUDE FRICTION LOSSES
            QPIV = QSUM
            Q3 = QSUM
  725       LK = LK+1
            Q6 = QPIV
            IF(LK .GE. 20)GOTO 2000
            P(J,1) = PPIV - DZ - FHW(QPIV)
            Q(J,1) = QD(1)*SQRT(P(J,1)/PD(1))
            QSUM = Q(J,1)
            DO 730 I = 2, NSP
                  Q6 = Q6-Q(J,I-1)
                  P(J,I) = P(J,I-1)-DZ
                  IF(Q6 .GT.  0.) P(J,I) = P(J,I)-FHW(Q6)
                  IF(P(J,I) .GE.  0.) THEN
                        Q(J,I) = QD(I)*SQRT(P(J,I)/PD(I))
                        IF(NST.EQ. 4 .AND. P(J,I).GT. PSPM)Q(J,I)=QD(I)
                  ELSE
                        Q(J,I)= 0.
                  END IF
                  QSUM = QSUM + Q(J,I)
  730 CONTINUE
            IF(ENDGUN) THEN
                  P(J,NGUN) = P(J,NSP)
                  IF(P(J,NSP) .GE. 0.)THEN
                        Q(J,NGUN) = QD(NGUN)*SQRT(P(J,NGUN)/PD(NGUN))
                  ELSE
                        Q(J,NGUN) = 0.
                  END IF
                  QSUM = QSUM+Q(J,NGUN)
            END IF
C --- AITKEN ACCELERATION PARAMERTERS
            Q1 = Q2
            Q2 = Q3
            Q3 = QSUM
C --- CHECK IF ANOTHER LOOP IS REQ'D.
            RATIO = Q2/Q3
            IF(RATLL .LT.  RATIO .AND.  RATIO .LT.  RATUL)
     &            LOPBAK = .FALSE.
            IF(LOPBAK .AND. LK .EQ. 2) QPIV = QSUM
            IF(LOPBAK .AND. LK .GE. 3) QPIV = Q3-(Q3-Q2)**2/
     &                                        ((Q1-Q2)-(Q2-Q3))
            IF(LOPBAK) GOTO 725
            QTOT(J) = QSUM
  790 CONTINUE
C
C
C *** PROCEDURE TO CHECK POTENTIAL RUNOFF AND ADJUST ROTATION SPEED ***
C
C
C DETERMINE AVE. FIELD APP. RATE & MIN. AND MAX. ROTATION TIMES
```

```
  799 AIPH = GPA/453.
      HPRMIN = ANINT(PI*2.*RL/720.)
      HPR = HPRMIN*10.
C   LOOK FOR R.O. AT 75% OF DISTANCE FROM PIVOT
      PL = .75
      NPT = INT(PL*RL/SSP)+1
      QPT = PL*RL*2.*SSP*QTOT(2)/RF**2
      QPT1 = Q(2,NPT)
      PPT = P(2,NPT)/2.31
      WD = 2.*A*(QPT1*SQRT(PPT))**B
      IF(NST .EQ.  7)WD = 2*(A*(QPT1/5.*SQRT(PPT))**B+
     &                      SQRT(24.**2-(2*SSP/5.)**2))
C
C --- LOOP TO ADJUST CP SPEED TO MINIMIZE R.O.  ON DOWNSLOPE RAY ---
C
      HPRU = HPR+1.
      HPRL = HPRMIN
 1000 TC = WD*HPR/(2.*PL*RL*PI)
      SIT = SIF*2.176*(.5*TC)**(-.4314)
      APMAX = 245.*PL*RL*QTOT(2)/(RF**2*WD)
      CALL RUNOFF
      IF(PR .GT.  0.) THEN
            IF(HPR .EQ.  HPRMIN)GOTO 1200
            IF(HPR .EQ.  HPRU)GOTO 1200
            HPRU = HPR
            HPR = HPR-AINT((HPRU-HPRL)/2.+.5)
            HPR = AMAX1(HPR,HPRMIN)
      ELSE
            IF(HPR .EQ.  HPRL)GOTO 1200
            HPRL = HPR
            HPR = HPR+AINT((HPRU-HPRL)/2.+.5)
      END IF
      GOTO 1000
 1200 DPR = HPR/24.
C
C
C ***** DETERMINE IRRIGATION PERFORMANCE *****
C
C --- ESTABLISH R.O. CHECK POINTS ---
      NROPT1 = NINT(.3*RL/SSP)
      NROPT2 = NINT(.62*RL/SSP)
      NROPT3 = NINT(.82*RL/SSP)
      NROPT4 = NINT(.94*RL/SSP)
      SECTR = .25
      SUMA = 0.
      SUMB = 0.
      SUMC = 0.
      DO 1500 J = 1,3
            IF (J .EQ. 3) SECTR = .5
            TSEC = HPR*SECTR
            K = 0
            DO 1400 I = 1, NSP
                  QPT = 2.*SPRAD(I)*SSP*QTOT(J)/RF**2
C --- ESTIMATE APPLICATION DEPTH, NO LOSSES ---
                  DAP(J,I) = 96.25*TSEC*QPT/FAREA(SECTR,I)
                  IF(I .EQ. NROPT1) GOTO 1300
                  IF(I .EQ. NROPT2) GOTO 1300
                  IF(I .EQ. NROPT3) GOTO 1300
                  IF(I .EQ. NROPT4) GOTO 1300
                  GOTO 1400
C
C --- COMPUTE RUNOFF AT APPROPRIATE POINTS ---
C
 1300             K =K+1
C --- COMPUTE WETTED DIAMETER ---
                  WD = 2*A*(Q(J,I)*SQRT(P(J,I)/2.31))**B
C    5-SPRAY (48 ft) BOOMS ON OUTER 25%, 3-SPRAY (24 ft) ON NEXT 25%
                  IF(NST .EQ.  7) THEN
                     IF(I .EQ.  NROPT3 .OR.  I .EQ.  NROPT4)
     &                  WD = 2*(A*(Q(J,I)/5.*SQRT(P(J,I)/2.31))**B+
```

```
     &                          SQRT(24.**2-(2*SSP/5.)**2))
                       IF(I .EQ. NROPT2)
     &                     WD = 2*(A*(Q(J,I)/3.*SQRT(P(J,I)/2.31))**B+
     &                          SQRT(12.**2-(SSP/3.)**2))
                  END IF
                  TC = WD*HPR/(2*PI*SPRAD(I))
                  SIT = SIF*2.176*(.5*TC)**(-.4314)
                  APMAX = 245.*SPRAD(I)*QTOT(J)/(RF**2*WD)
                  PROR = 0.
                  RO = 0.
C --- FIND POTENTIAL R.O.  ---
                  CALL RUNOFF
C
                  PR = AMAX1(PR,0.)
                  IF(PR .LE.  0.)GOTO 1350
                  PROR = APMAX-SIT
C --- FIND SURFACE STORAGE ---
                  IF(ABS(SLP(J)) .GE.  .05) THEN
                        SSTOR = 0.
                  ELSE
                        SSTOR = .4423+(-9.34*ABS(SLP(J)))
                        SSTOR = AMAX1(SSTOR, 0.)
                  END IF
                  PR = PR-SSTOR
                  PR = AMAX1(PR,0.)
C                  IF(ABS(SLP(J)) .LE. .0045)THEN
C                        BBOX = 250.
C                  ELSE
C                        BBOX = 119.124*(ABS(SLP(J))*100)**(-.9035)
C                  END IF
C                  BBOX = AMAX1(BBOX,250.)
                  BBOX = 30.
                  REY(1,J,K) = .9*BBOX*PR*PROR**(1./3.)
 1350             ROR(J,K) = PR
                  IF(PITS)ROR(J,K) = ROR(J,K)*.15
                  RATL = SPRAD(J)/RL
C
C --- CALL USLE SUBROUTINE TO FIND EROSION LOSSES ---
C
              CALL USLECP(RL,RATL,P(J,1),WD,SLP(J),REY,J,K,PITS,SK)
C
 1400       CONTINUE
            IF(ENDGUN) DAP(J,NGUN) = 96.25*TSEC*Q(J,NGUN)*.45/
     &                                (2.*PI*SECTR*EGR*EGSP)
C --- FIND AVERAGE R.O.  FOR RAY ---
            ROR(J,5) = (ROR(J,1)+ROR(J,2)+ROR(J,3)+ROR(J,4))*.25
          DO 1500 I = 1,3
            REY(I,J,5)=(REY(I,J,1)+REY(I,J,2)+REY(I,J,3)+REY(I,J,4))*.25
 1500 CONTINUE
C
C --- COMPUTE WIND LOSSES ---
      WLTOT = 0.
      SECTR = .25
      WLF = .005
      IF (WINDY) WLF = .01
      DROP = 0.
      IF(NST .GE.  6) DROP = 6.
      DO 1600 J = 1,3
            IF(J .EQ. 3)SECTR = .5
            DO 1550 I = 1,NSP
                  WL = DAP(J,I)*(12.-DROP)*WLF
                  DAP(J,I) = DAP(J,I)-WL
                  A1 = FAREA(SECTR,I)
                  WLTOT = WLTOT+WL*A1
 1550       CONTINUE
            IF (ENDGUN)THEN
                  WL = DAP(J,NGUN)*12.*WLF
                  DAP(J,NGUN) = DAP(J,NGUN)-WL
                  A1 = SECTR*2*PI*EGR*EGSP
                  WLTOT = WLTOT+WL*A1
```

```
            END IF
 1600 CONTINUE
C
C --- LOOPS TO COMPUTE APPLICATION UNIFORMITY SUMS ---
      DO 1620 J = 1,3
            DO 1610 I = 1, NSP
                  SUMA = SUMA+SPRAD(I)
                  SUMB = SUMB+SPRAD(I)*DAP(J,I)
 1610       CONTINUE
            IF(ENDGUN)THEN
                  SUMA = SUMA+EGR
                  SUMB = SUMB+EGR*DAP(J,NGUN)
            END IF
 1620 CONTINUE
      DBAR = SUMB/SUMA
      DO 1650 J = 1, 3
            DO 1640 I = 1, NSP
                  SUMC = SUMC+SPRAD(I)*ABS(DAP(J,I)-DBAR)
 1640       CONTINUE
            IF(ENDGUN) SUMC = SUMC+EGR*ABS(DAP(J,NGUN)-DBAR)
 1650 CONTINUE
C --- COMPUTE CHRISTIANSEN'S UNIFORMITY COEFFICIENT
      CUADJ = 7.
      IF(NST .GT. 4)CUADJ = 9.
      CUFLD = 100.*(1.-SUMC/SUMB)-CUADJ
C
C --- COMPUTE IRRIGATION AND IRRIGATION LOSS TOTALS (ac-in) ---
      QSUM = ((QTOT(1)+QTOT(2))*.25 + QTOT(3)*.5)*HPR/453.
      WLTOT = WLTOT/43560.
      ROTOT = ((ROR(1,5)+ROR(2,5))*.25 + ROR(3,5)*.5)*PI*RF**2/43560.
      APTOT = QSUM-WLTOT-ROTOT
      DPTOT = APTOT*(1-CUFLD/100.)
      APTOT = APTOT-DPTOT
      EFF = APTOT/QSUM*100.
      ENERGY = PPIV/2.31*QTOT(3)*HPR/(2296.*APTOT/ACRES)
C  SAVE WEIGHTED AVERAGE SOIL LOSS COEFFS.
      DO 1700 I = 1,3
 1700 SYSFLD(NFLD,I+26) = ((REY(I,1,5)+REY(I,2,5))*.25+REY(I,3,5)*.5)
      WLPCT = WLTOT/QSUM*100
      ROPCT = ROTOT/QSUM*100
      DPPCT = DPTOT/QSUM*100
      RETURN
 2000 WRITE(*,2001)NFLD
 2001 FORMAT(/' PROBLEM WITH SYSTEM DATA FOR FIELD',I3/' CHECK INPUTS')
      WLPCT = 0.
      ROPCT = 0.
      DPPCT = 0.
      EFF = -1.
      RETURN
      END
```

```
C
C ***** SUBROUTINE TO DETERMINE SPRINKLER CHARACTERISTICS *****
C
      SUBROUTINE SPCHR(N,A,B,P,S)
C
C
C SUBSCRIPTS ARE: 1=HP IMPACTS, 2=LP IMPACTS-STD. NOZZLES
C    3=LP IMPACTS-CD NOZZLES, 4=LP IMPACTS-FC NOZZLES,
C    5=SPRAYS-TOP MOUNT, 6=SPRAYS-DROP TUBES, 7=SPRAYS-BOOMS
C
      COMMON/DROPS/DSPLH, AC, BC, CC, DC, EC
C
      DIMENSION CA(7), CB(7), PMIN(7), SPACE(7), AA(7), BB(7), CCC(7),
     &          DD(7), EE(7), DS(7)
      DATA CA/31.13, 26.53, 29.71, 30.51, 7.15, 5.43, 12.35/
      DATA CB/0.135, 0.130, 0.119, 0.154, 0.28, 0.29, 0.274/
      DATA PMIN/50.,  30.,   25.,   35.,   20.,  20.,   20./
      DATA SPACE/30., 30.,   30.,   30.,   10.,  10.,   20./
      DATA AA/-.879, -.68, -.7595, -.68, -.09804, -.1, -.5025/
      DATA BB/2.5627, 1.88, 2.2841, 1.88, .3404, .34, -.8453/
      DATA CCC/1.2617, .82,  .4152,  .82, .6867, .69, 1.1388/
      DATA DD/ 2.57,    1.9,  1.22,   1.9,  1.4,  1.4,  1.73/
      DATA DS /1.33,    .87,  .47,    .87,  1.4,  1.4,  1.73/
      DATA EE/4*.017242, 3*.017931/
      A = CA(N)
      B = CB(N)
      P = PMIN(N)*2.31
      S = SPACE(N)
      DSPLH = DS(N)
      AC = AA(N)
      BC = BB(N)
      CC = CCC(N)
      DC = DD(N)
      EC = EE(N)
      RETURN
      END
```

```
C
C
C ***** SUBROUTINE TO ESTIMATE RUN OFF VOLUME *****
C
C
      SUBROUTINE RUNOFF
C
      COMMON/ROFF/APMAX, GRAPP, PR, SIF, TC, TF, TS
C
C *** FUNCTION TO FIND SOIL INTAKE RATE ***
C
      FIF(X) = SIF*2.176*X**(-.4314)
C
      PI = 3.141593
      TS1 = 0.
      TS2 = 0.
      TI = .5*TC
      SIT = FIF(TI)
      IF(APMAX .GT. SIT) GOTO 200
      PR = 0.
      RETURN
C --- SEARCH FOR PTS. WHERE APPLICATION AND INTAKE CURVES MEET ---
  200 T = TC/10.
      NV = 1
      GOTO 500
  300 TS = T
      T = .5*TC+T*.75
      NV = 2
      GOTO 500
  400 TF = T
C --- COMPUTE POTENTIAL R.O. VOLUME ---
      ASNF = (TF-.5*TC)/(.5*TC)
      ASNS = (TS-.5*TC)/(.5*TC)
      ARTF = APMAX/TC*((TF-.5*TC)*SQRT(TC*TF-TF**2)+
     &      .25*TC**2*ATAN(ASNF/SQRT(1-ASNF**2))+.125*PI*TC**2)
      ARTS = APMAX/TC*((TS-.5*TC)*SQRT(TC*TS-TS**2)+
     &      .25*TC**2*ATAN(ASNS/SQRT(1-ASNS**2))+.125*PI*TC**2)
      SITF = SIF*3.827*TF**.5686
      SITS = SIF*3.827*TS**.5686
      GRAPP = ARTF-ARTS
      PR = GRAPP-(SITF-SITS)
      RETURN
C
C --- ITERATION ROUTINE ---
C
  500 IF(TS2 .EQ. 0.)XY=0.
  510 T = T+(TC/100.)
  520 IF(T .GE. TC) GOTO 600
      TS1 = FIF(T)
      TS2 = APMAX*SQRT(T*TC-T**2)/(.5*TC)
      IF(INT(SQRT((TS1**2 +TS2**2)/2)*100.)/100 .NE. INT(TS1*100.)/100)
     & GOTO 550
      GOTO(300,400)NV
  550 IF(NV .EQ. 1) THEN
            IF(TS1 .GT. TS2) GOTO 510
            XY = TS1/TS2
      ELSE
            IF(TS1 .LT. TS2) GOTO 510
            XY = TS2/TS1
      END IF
  600 T = T-(1-XY)*(TC/100)
      GOTO 520
      END
```

```
C
C
C
C***********************************************************************
C*                                                                    *
C*       USLE SUBROUTINE TO ESTIMATE EROSION YIELD FROM SPRINKLE     *
C*                                                                    *
C*    IRRIGATED LAND.  ORIGINAL ROUTINE WRITTEN BY P. KOLUVEK AND     *
C*                                                                    *
C*    T. SPOFFORD, USDA-SCS. ADAPTED FOR UNIVERSITY OF IDAHO DEPT.    *
C*                                                                    *
C*       OF AGRICULTURAL ENGINEERING IRRIGATION PLANNING MODEL        *
C*                                                                    *
C*      NOTE: THIS SUBROUTINE IS SPECIFICALLY FOR CENTER PIVOTS       *
C*                                                                    *
C***********************************************************************
C
C
      SUBROUTINE USLECP(RL,RATL, PPIV, WD, SLP, REY,J,K,PITS,SK)
C
C
      COMMON/DROPS/DSPLH, AC, BC, CC, DC, EC
      COMMON/ROFF/APMAX, GRAPP, PR, SIF, TC, TF, TS
C
      LOGICAL PITS
C
      DIMENSION REY(3,3,5)
C
C --- FIND DROPLET ENERGY VALUES ---
C
      PI = 3.141593
      DSSPH = DC-(EC*PPIV)
      DSPL = (AC*RATL**2)+BC*RATL+CC
      RATDS = DSPLH/DSSPH
      DSSPP = DSPL/RATDS
      DS = DSSPP
      APAVE = APMAX*PI/4.
      REY(2,J,K) = ((-8.59*DS**3)-(3.83*DS**2)+581.87*DS - 294.27)
     &           *APAVE*TC
      EL = ((1.-RATL)*RL+WD*.5)*(TF-TS)/TC
      SV = .7
      S = ABS(SLP*100)
      THETA = ATAN(S)
      IF(S .GT.  9.)THEN
           SLS1 = SQRT((EL/72.6) * COS(THETA))
           SLS2 = (SIN(THETA)/SIN(5.143*PI/180.))**SV
      ELSE
           IF(PR .LE. 0.)EL = WD
           CM = .5
           IF(S .LE. 4.5)CM = .4
           IF(S .LE. 3.5)CM = .3
           IF(S .LE. 1.) CM = .2
           SLS1 = (EL/72.6*COS(THETA))**CM
           SLS2 = 65.41*SIN(THETA)**2+4.56*SIN(THETA)+.65
      END IF
      SLS = SLS1+SLS2
      PAS = 1.
      IF(PITS) PAS = (SK**0.85)-.1
      PT = AMAX1(PAS, .25)
      REY(3,J,K) = SK*SLS*PT
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE LM(NFLD,EFF,DPPCT,WLPCT,ROPCT,HPR)
C************************************************************************
C*                                                                      *
C*   LINEAR MOVE MODEL DEVELOPED AT UNIVERSITY OF IDAHO DEPARTMENT      *
C*                                                                      *
C*   OF AGRICULTURAL ENGINEERING FOR SCS IRRIGATION PLANNING MODEL      *
C*                                                                      *
C************************************************************************
C
C     SYSTEM/FIELD INPUT DATA PASSED:
C      SYSFLD(I,J)  PARAMETERS FOR FIELD I
C      J = 1 - LATERAL LENGTH (FT)           17 - SALVAGE VALUE ($)
C          2 - LATERAL I. DIA. (IN)          18 - LAND GRADING COSTS ($)
C          3 - DESIGN FLOWRATE (IN/DAY)      19 - % L.G. COSTS SUBSIDIZED
C          4 - SPRINKLER TYPE #              20 - % L.G. COSTS FINANCED
C          5 - AVE. FIELD SLOPE (%)          21 - LAND GRADING LOAN #
C          6 - FIELD LENGTH, PERP. TO TRAVEL (FT)
C          7 - LABOR/IRRIG (HR)              22 - ANN. SMOOTHING COSTS($)
C         13 - TOTAL COST ($)                23 - ANN. MAINT. COSTS ($)
C         14 - % COST SUBSIDIZED             24 - ANN. MISC. COSTS ($)
C         15 - % COST FINANCED               25 - APPLICATION EFF. (%)
C         16 - LOAN #                        26 - % DEEP PERC. LOSSES
C      VLOG(I,J)  LOGICAL PARAMETERS FOR FIELD I
C           J = 1 - RESERVOIR TILLAGE?
C               2 - PRESSURE REGULATORS?
C               3 - CENTRAL LATERAL FEED?
C               4 - AVE. WIND > 5 MPH?
C
C
      COMMON/ROFF/APMAX, GRAPP, PR, SIF, TC, TF, TS
      COMMON/SOILS/SOIL(9,3)
      COMMON/SYSM/SYSFLD(9,30),VLOG(9,4)
C
      DIMENSION QD(300), PD(300), SLP(3), Q(3,300), P(3,300), QTOT(3),
     & ROR(3,3), REY(3,3,3), DAP(3,300)
C
      LOGICAL LOPBAK,WINDY,PITS,VLOG
C
C --- INTERNAL FUNCTIONS
C
C     SPRINKLER WETTED RADIUS
      FWR(X,Y) = A*(X*SQRT(Y))**B
C
C     HAZEN-WILLIAMS HEAD LOSS
      FHW(X) = FF*SSP*X**1.852/DL2
C
C
C ******  LINEAR MOVE SIMULATION ROUTINE  ******
C
C
      RL = SYSFLD(NFLD,1)
      RF = SYSFLD(NFLD,6)
      NST = NINT(SYSFLD(NFLD,4))
      GPA = 18.857*SYSFLD(NFLD,3)
      IREG = 0
      IF(VLOG(NFLD,2))IREG = 1
      FEED = 1.
      IF(VLOG(NFLD,3))FEED = 2.
      WINDY = VLOG(NFLD,4)
      PITS = VLOG(NFLD,1)
      SIF = SOIL(NFLD,2)
      SK = SOIL(NFLD,3)
C
      CALL SPCHR(NST,A,B,PSPM,SSP)
      DL2 = SYSFLD(NFLD,2)**4.8655
      FF = (.285*145)**(-1.852)
      PI = 3.141593
```

```
      ACRES = RF*RL/43560.
      QSUM = 0.
      NSP = INT(RL/SSP/FEED)
      SLP(1) = SYSFLD(NFLD,5)/100.
      SLP(2) = SLP(1)*(-1.)
      SLP(3) = 0.
      HZ = RL*SLP(1)/FEED
C *** FIND DESIGN P & Q VALUES ***
      PD(NSP) = PSPM
      QD(NSP) = RF*SSP*GPA/43560.
      DO 500 I = NSP-1, 1, -1
            QSUM = QSUM+QD(I+1)
            QD(I) = QD(NSP)
            PD(I) = PD(I+1)+FHW(QSUM)
  500 CONTINUE
      QSUM = QSUM+QD(1)
      PSUP = PD(1)+FHW(QSUM)+HZ
C *** CHECK FOR PRESSURE REGULATION
      GOTO (600,700) IREG
C
C <<< REGULATED SPRINKLERS >>>
C
  600 DO 690 J = 1,3
            Q0 = QSUM
            P0 = PSUP
            DZ = SLP(J)*SSP
            DO 610 I = 1, NSP
                  P0 = P0-FHW(Q0)
                  Q0 = Q0-QD(I)
                  Q(J,I) = QD(I)
                  P(J,I) = PSPM
  610       CONTINUE
            QTOT(J) = QSUM
  690 CONTINUE
      GOTO 799
C
C <<< NON-REGULATED SPRINKLERS >>>
C
  700 DO 790 J = 1,3
            LK = 1
            LOPBAK = .TRUE.
            RATIO = 0.
            RATLL = 0.99
            RATUL = 1.01
            Q1 = 0.
            Q2 = 0.
            Q3 = 0.
            P0 = PSUP
            QSUM = 0.
            DZ = SLP(J)*SSP
C    NO FRICTION LOSSES
            P(J,1) = P0-DZ
            Q(J,1) = QD(1)*SQRT(P(J,1)/PD(1))
            QSUM = Q(J,1)
            DO 720 I = 2, NSP
                  P(J,I) = P(J,I-1)-DZ
                  Q(J,I) = QD(I)*SQRT(P(J,I)/PD(I))
                  QSUM = QSUM + Q(J,I)
  720 CONTINUE
C INCLUDE FRICTION LOSSES
            QPIV = QSUM
            Q3 = QSUM
  725       LK = LK+1
            Q6 = QPIV
            IF(LK .GE. 20)GOTO 2000
            P(J,1) = PSUP - DZ - FHW(QPIV)
            Q(J,1) = QD(1)*SQRT(P(J,1)/PD(1))
            QSUM = Q(J,1)
            DO 730 I = 2, NSP
                  Q6 = Q6-Q(J,I-1)
```

```
                 P(J,I) = P(J,I-1)-DZ
                 IF(Q6 .GT.  0.) P(J,I) = P(J,I)-FHW(Q6)
                 IF(P(J,I) .GE.  0.) THEN
                       Q(J,I) = QD(I)*SQRT(P(J,I)/PD(I))
                       IF(NST.EQ. 4 .AND. P(J,I).GE. PSPM)Q(J,I)=QD(I)
                 ELSE
                       Q(J,I)= 0.
                 END IF
                 QSUM = QSUM + Q(J,I)
  730 CONTINUE
C --- AITKEN ACCELERATION PARAMERTERS
           Q1 = Q2
           Q2 = Q3
           Q3 = QSUM
C --- CHECK IF ANOTHER LOOP IS REQ'D.
           RATIO = Q2/Q3
           IF(RATLL .LT.  RATIO .AND.  RATIO .LT.  RATUL)
     &          LOPBAK = .FALSE.
           IF(LOPBAK .AND. LK .EQ. 2) QPIV = QSUM
           IF(LOPBAK .AND. LK .GE. 3) QPIV = Q3-(Q3-Q2)**2/
     &                                  ((Q1-Q2)-(Q2-Q3))
           IF(LOPBAK) GOTO 725
           QTOT(J) = QSUM
  790 CONTINUE
C
C
C *** PROCEDURE TO CHECK POTENTIAL RUNOFF AND ADJUST TRAVEL SPEED ***
C
C
C DETERMINE INITIAL TIME OF IRRIG.  & AVE.  FIELD APP.  RATE
  799 AIPH = GPA/453.
      HPRMIN = ANINT(RF/720.)
      HPR = HPRMIN*10.
C LOOK FOR R.O.  AT 50% OF DISTANCE FROM SUPPLY
      PL = .5
      NPT = NINT(PL*RL/SSP/FEED)
      QPT = Q(2,NPT)
      PPT = P(2,NPT)/2.31
      WD = 2.*A*(QPT*SQRT(PPT))**B
      IF(NST .EQ.  7)WD = 2.*(A*(QPT/5.*SQRT(PPT))**B+
     &                       SQRT(24.**2-(2*SSP/5.)**2))
C
C --- LOOP TO ADJUST SPEED TO MINIMIZE R.O. ON DOWNSLOPE POSITION ---
C
      HPRU = HPR+1.
      HPRL = HPRMIN
 1000 TC = WD*HPR/RF
      SIT = SIF*2.176*(.5*TC)**(-.4314)
      APAVE = QPT/(SSP*WD)*96.3
      APMAX = APAVE*4./PI
      CALL RUNOFF
      IF(PR .GT.  0.) THEN
           IF(HPR .EQ.  HPRMIN)GOTO 1200
           IF(HPR .EQ.  HPRU)GOTO 1200
           HPRU = HPR
           HPR = HPR-AINT((HPRU-HPRL)/2.+.5)
           HPR = AMAX1(HPR,HPRMIN)
      ELSE
           IF(HPR .EQ.  HPRL)GOTO 1200
           HPRL = HPR
           HPR = HPR+AINT((HPRU-HPRL)/2.+.5)
      END IF
      GOTO 1000
 1200 DPR = HPR/24.
C
C
C ***** DETERMINE IRRIGATION PERFORMANCE *****
C
C --- ESTABLISH R.O. CHECK POINTS ---
      NROPT1 = NSP
```

```
      NROPT2 = 1
      SECTR = .25
      ASP = RF*SSP
      SUMB = 0.
      SUMC = 0.
      DO 1500 J = 1,3
            IF (J .EQ. 3) SECTR = .5
            TSEC = HPR*SECTR
            K = 0
            DO 1400 I = 1, NSP
                  QPT = Q(J,I)
C --- ESTIMATE APPLICATION DEPTH, NO LOSSES ---
                  DAP(J,I) = 96.25*TSEC*QPT/(ASP*SECTR)
                  IF(I .EQ. NROPT1) GOTO 1300
                  IF(I .EQ. NROPT2) GOTO 1300
                  GOTO 1400
C
C --- COMPUTE RUNOFF AT APPROPRIATE POINTS ---
C
 1300             K =K+1
C --- COMPUTE WETTED DIAMETER ---
                  IF(NST .EQ.  7) THEN
                        WD = 2.*(A*(Q(J,I)/5.*SQRT(P(J,I)/2.31))**B+
     &                          SQRT(24.**2-(2*SSP/5.)**2))
                  ELSE
                        WD = 2*A*(Q(J,I)*SQRT(P(J,I)/2.31))**B
                  END IF
                  APAVE = Q(J,I)/(SSP*WD)*96.3
                  APMAX = APAVE*4./PI
                  PROR = 0.
                  RO = 0.
C --- FIND POTENTIAL R.O.  ---
                  CALL RUNOFF
C
                  PR = AMAX1(PR,0.)
                  IF(PR .LE.  0.)GOTO 1350
                  PROR = APMAX-SIT
C --- FIND SURFACE STORAGE ---
                  IF(ABS(SLP(J)) .GE.  .05) THEN
                        SSTOR = 0.
                  ELSE
                        SSTOR = .4423+(-9.34*ABS(SLP(J)))
                        SSTOR = AMAX1(SSTOR, 0.)
                  END IF
                  PR = PR-SSTOR
                  PR = AMAX1(PR,0.)
C                  IF(ABS(SLP(J)) .LE. .0045)THEN
C                        BBOX = 250.
C                  ELSE
C                        BBOX = 119.124*(ABS(SLP(J))*100)**(-.9035)
C                  END IF
C                  BBOX = AMAX1(BBOX,250.)
                  BBOX = 30.
                  REY(1,J,K) = .9*BBOX*PR*PROR**(1./3.)
 1350             ROR(J,K) = PR
C  REDUCE POTENTIAL R.O. BY 85% IF CONSERVATION TILLAGE IS USED
                  IF(PITS)ROR(J,K) = ROR(J,K)*.15
C
C --- CALL USLE SUBROUTINE TO FIND EROSION LOSSES ---
C
                CALL USLE(RL,Q(J,I),P(J,I),WD,SLP(J),REY,J,K,PITS,SK)
C
 1400       CONTINUE
C --- FIND AVERAGE R.O.  FOR RAY ---
            ROR(J,3) = (ROR(J,1)+ROR(J,2))*.5
            DO 1500 I = 1,3
                  REY(I,J,3)=(REY(I,J,1)+REY(I,J,2))*.5
 1500 CONTINUE
C
C --- COMPUTE WIND LOSSES ---
```

```
      WLTOT = 0.
      SECTR = .25
      WLF = .005
      IF (WINDY) WLF = .01
      DROP = 0.
      IF(NST .GE.  6) DROP = 6.
      DO 1600 J = 1,3
            IF(J .EQ. 3)SECTR = .5
            DO 1600 I = 1,NSP
                  WL = DAP(J,I)*(12.-DROP)*WLF
                  DAP(J,I) = DAP(J,I)-WL
                  WLTOT = WLTOT+WL*ASP*SECTR
 1600 CONTINUE
C
C --- LOOPS TO COMPUTE APPLICATION UNIFORMITY SUMS ---
      DO 1620 J = 1,3
            DO 1620 I = 1, NSP
                  SUMB = SUMB+DAP(J,I)
 1620 CONTINUE
      DBAR = SUMB/NSP/3
      DO 1650 J = 1, 3
            DO 1650 I = 1, NSP
                  SUMC = SUMC+ABS(DAP(J,I)-DBAR)
 1650 CONTINUE
C --- COMPUTE CHRISTIANSEN'S UNIFORMITY COEFFICIENT
      CUADJ = 7.
      IF(NST .GT. 4)CUADJ = 9.
      CUFLD = 100.*(1.-SUMC/(DBAR*NSP*3))-CUADJ
C
C --- COMPUTE IRRIGATION AND IRRIGATION LOSS TOTALS (ac-in) ---
      QSUM = ((QTOT(1)+QTOT(2))*.25 + QTOT(3)*.5)*HPR/453.*FEED
      WLTOT = WLTOT/43560.*FEED
      ROTOT = ((ROR(1,3)+ROR(2,3))*.25 + ROR(3,3)*.5)*RF*RL/43560.*FEED
      APTOT = QSUM-WLTOT-ROTOT
      DPTOT = APTOT*(1.-CUFLD/100.)
      APTOT = APTOT-DPTOT
      EFF = APTOT/QSUM*100.
      ENERGY = PSUP/2.31*QTOT(3)*FEED*HPR/(2296.*APTOT/ACRES)
C  SAVE WEIGHTED AVERAGE SOIL LOSS COEFFICIENTS
      DO 1700 I = 1,3
 1700 SYSFLD(NFLD,I+26) = ((REY(I,1,3)+REY(I,2,3))*.25+REY(I,3,3)*.5)
      WLPCT = WLTOT/QSUM*100.
      ROPCT = ROTOT/QSUM*100.
      DPPCT = DPTOT/QSUM*100.
      RETURN
 2000 WRITE(*,2001)NFLD
 2001 FORMAT(/' PROBLEMS IN INPUT DATA FOR FIELD ',I3/' CHECK DATA')
      WLPCT = 0.
      ROPCT = 0.
      WLPCT = 0.
      EFF = -1.
      RETURN
      END
```

```
C
C
C
C*********************************************************************
C*                                                                   *
C* GENERAL USLE SUBROUTINE TO ESTIMATE EROSION YIELD FROM SPRINKLE   *
C*                                                                   *
C*    IRRIGATED LAND.  ORIGINAL ROUTINE WRITTEN BY P. KOLUVEK AND    *
C*                                                                   *
C*    T. SPOFFORD, USDA-SCS. ADAPTED FOR UNIVERSITY OF IDAHO DEPT.   *
C*                                                                   *
C*       OF AGRICULTURAL ENGINEERING IRRIGATION PLANNING MODEL       *
C*                                                                   *
C*********************************************************************
C
C
      SUBROUTINE USLE(RL,QPT,PPT,WD,SLP,REY,J,K,PITS,SK)
C
C
      COMMON/ROFF/APMAX, GRAPP, PR, SIF, TC, TF, TS
C
      LOGICAL PITS
C
      DIMENSION REY(3,3,3)
C
C --- FIND DROPLET ENERGY VALUES ---
C
      PI = 3.141593
      NS = SQRT(.347*QPT/SQRT(PPT/2.31))
      DS = .73+(2.51*NS)-(.01576*PPT/2.31)
      APAVE = APMAX*PI/4.
      REY(2,J,K) = ((-8.59*DS**3)-(3.83*DS**2)+581.87*DS - 294.27)
     C            *APAVE*TC
      EL = ((1.-RATL)*RL+WD*.5)*(TF-TS)/TC
      SV = .7
      S = ABS(SLP*100.)
      THETA = ATAN(S)
      IF(S .GT.  9.)THEN
            SLS1 = SQRT((EL/72.6) * COS(THETA))
            SLS2 = (SIN(THETA)/SIN(5.143*PI/180.))**SV
      ELSE
            IF(PR .LE. 0.)EL = WD
            CM = .5
            IF(S .LE. 4.5)CM = .4
            IF(S .LE. 3.5)CM = .3
            IF(S .LE. 1.) CM = .2
            SLS1 = (EL/72.6*COS(THETA))**CM
            SLS2 = 65.41*SIN(THETA)**2+4.56*SIN(THETA)+.65
      END IF
      SLS = SLS1+SLS2
      PAS = 1.
      IF(PITS) PAS = (SK**0.85)-.1
      PT = AMAX1(PAS, .25)
      REY(3,J,K) = SK*SLS*PT
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE SSSM(NFLD,DID,IWIND,EFF,DPPCT,WLPCT,ROPCT,TCMAXT)
C***********************************************************************
C*                                                                     *
C*  SOLID SET/SET-MOVE MODEL DEVELOPED AT UNIVERSITY OF IDAHO DEPT.    *
C*                                                                     *
C*   OF AGRICULTURAL ENGINEERING FOR SCS IRRIGATION PLANNING MODEL     *
C*                                                                     *
C***********************************************************************
C
C SYSTEM/FIELD INPUT DATA PASSED:
C  SYSFLD(I,J) SYSTEM PARAMETERS FOR FIELD I
C   J = 1 - LATERAL LENGTH (FT)             14 - % COST SUBSIDIZED
C       2 - LATERAL SPACING (FT)            15 - % COST FINANCED
C       3 - LATERAL I.DIA. (IN)             16 - LOAN #
C       4 - SPRINKLER SPACING (FT)          17 - SALVAGE VALUE (%)
C       5 - SPRINKLER TYPE #                18 - LAND GRADING COST ($)
C       6 - TRAVEL DIST/BLOCK WIDTH (FT)    19 - % L.G. COSTS SUBS.
C       7 - # LATS/# BLOCKS                 20 - % L.G. COSTS FIN.
C       8 - SET TIME INCREMENT (HRS)        21 - L.G. LOAN #
C       9 - DESIGN FLOWRATE (IN/DAY)        22 - ANN. SMOOTHING COST ($)
C      10 - AVE. FIELD SLOPE (%)            23 - ANN. MAINT. COST ($)
C      11 - LABOR PER IRRIG/SET (HR)        24 - ANN. MISC. COST ($)
C      12 - ADD'L LABOR (HR/SEASON)         25 - APPLICATION EFF. (%)
C      13 - COST/LATERAL ($)                26 - % DEEP PERC. LOSS
C  VLOG(I,J) LOGICAL VARIABLES FOR FIELD I
C   J = 1 - RESERVOIR TILLAGE USED?
C       2 - SOLID SET?
C
C
      COMMON/ROFF/APMAX, GRAPP, PR, SIF, TC, TF, TS
      COMMON/SOILS/SOIL(9,3)
      COMMON/SYSM/SYSFLD(9,30),VLOG(9,4)
C
      DIMENSION  SLP(3), Q(3,100), P(3,100), QTOT(3), ROR(3,3),
     & REY(3,3,3), DAP(3,100), CUP(5,5), QD(100), PD(100)
C
      INTEGER PATRN(18,7,3)
C
      LOGICAL LOPBAK,SSET,PITS,VLOG
C
      DATA PATRN/6*0,10,3*13,10,7*0,
     2 4*0,10,26,39,70,73,76,69,49,21,5*0,
     3 3*0,10,31,75,107,120,122,124,122,100,65,28,2,3*0,
     4 3*0,26,73,115,146,166,168,169,157,138,107,62,15,3*0,
     5 2*0,9,39,97,140,171,205,204,202,177,155,129,86,34,4,2*0,
     6 2*0,19,56,109,151,201,293,296,299,212,166,133,95,43,4,2*0,
     7 2*0,19,56,109,151,201,293,296,299,212,166,133,95,43,4,2*0,
     2 18*0,      7*0,38,48,57,55,46,23,5,4*0,
     3 5*0,30,62,93,104,114,120,111,86,51,13,3*0,
     4 4*0,20,62,111,158,172,185,181,162,136,96,57,8,2*0,
     5 4*0,28,86,148,228,231,233,178,185,153,120,79,31,2*0,
     6 2*0,6,12,51,103,188,308,337,366,288,202,160,129,90,45,3,0,
     7 2*0,6,12,51,103,188,308,337,366,288,202,160,129,90,45,3,0,
     2 18*0,      7*0,5,9,13,21,35,35,13,4*0,
     3 5*0,3,8,30,48,66,107,117,102,76,41,3*0,
     4 5*0,8,22,89,133,177,211,204,168,127,98,44,2*0,
     5 5*0,11,32,176,230,284,289,255,195,158,129,84,34,0,
     6 4*0,4,15,54,264,343,421,375,281,204,167,138,109,50,7,
     7 4*0,4,15,54,264,343,421,375,281,204,167,138,109,50,7/
C
C --- INTERNAL FUNCTIONS
C
C     SPRINKLER WETTED DIAMETER
      FWD(X,Y) = 2.*A*(X*SQRT(Y/2.31))**B
C
C     HAZEN-WILLIAMS HEAD LOSS
      FHW(X) = FF*SSP*X**1.852/DL2
```

```
C
C
C ******  SET-MOVE SIMULATION ROUTINE  ******
C
      RL = SYSFLD(NFLD,1)
      RF = SYSFLD(NFLD,6)
      NST = NINT(SYSFLD(NFLD,5))
      GPA = 18.875*SYSFLD(NFLD,9)
      SSP = SYSFLD(NFLD,4)
      SPLAT = SYSFLD(NFLD,2)
      TINC = SYSFLD(NFLD,8)
      SSET = VLOG(NFLD,2)
      PITS = VLOG(NFLD,1)
      SIF = SOIL(NFLD,2)
      SK = SOIL(NFLD,3)
C      WRITE(*,*)'REQ''D DEPTH',DID
C
      CALL SPCHR(NST,A,B,PSPM,SPSP)
      DL2 = SYSFLD(NFLD,3)**4.8655
      FF = (.285*145)**(-1.852)
      PI = 3.141593
      QSUM = 0.
      NSP = INT(RL/SSP)
      SLP(1) = SYSFLD(NFLD,10)/100.
      SLP(2)=SLP(1)*(-1.)
      SLP(3) = 0.
C *** FIND DESIGN P & Q VALUES ***
      PD(NSP) = PSPM
      QD(NSP) = RF*SSP*GPA/43560.
      DO 500 I = NSP-1,1,-1
            QSUM = QSUM+QD(I+1)
            PD(I) = PD(I+1)+FHW(QSUM)
            QD(I) = QD(NSP)*SQRT(PD(I)/PSPM)
            IF(NST .EQ. 4 .AND. PD(I) .GE. PSPM)QD(I) = QD(NSP)
  500 CONTINUE
      QSUM = QSUM+QD(1)
      PMAIN = PD(1)+FHW(QSUM)
  600 ACRES = SPLAT*RL/43560.
C
C <<< ITERATIVE PROCEDURE FOR NON-REGULATED SPRINKLERS >>>
C
  700 DO 790 J = 1,3
            LK = 1
            LOPBAK = .TRUE.
            RATIO = 0.
            RATLL = 0.99
            RATUL = 1.01
            Q1 = 0.
            Q2 = 0.
            Q3 = 0.
            PO = PMAIN
            QSUM = 0.
            DZ = SLP(J)*SSP
C    NO FRICTION LOSSES
            P(J,1) = PO-DZ
            Q(J,1) = QD(1)*SQRT(P(J,1)/PD(1))
            QSUM = Q(J,1)
            DO 720 I = 2, NSP
                  P(J,I) = P(J,I-1)-DZ
                  Q(J,I) = QD(I)*SQRT(P(J,I)/PD(I))
                  IF(NST .EQ. 4 .AND. P(J,I) .GE. PSPM)Q(J,I) = QD(I)
                  QSUM = QSUM + Q(J,I)
  720 CONTINUE
C INCLUDE FRICTION LOSSES
            QPIV = QSUM
            Q3 = QSUM
  725       LK = LK+1
            Q6 = QPIV
            IF(LK .GE. 20)GOTO 2000
            P(J,1) = PMAIN - DZ - FHW(QPIV)
```

```
      Q(J,1) = QD(1)*SQRT(P(J,1)/PD(1))
      QSUM = Q(J,1)
      DO 730 I = 2, NSP
            Q6 = Q6-Q(J,I-1)
            P(J,I) = P(J,I-1)-DZ
            IF(Q6 .GT.  0.) P(J,I) = P(J,I)-FHW(Q6)
            IF(P(J,I) .GE.  0.) THEN
                  Q(J,I) = QD(I)*SQRT(P(J,I)/PD(I))
                  IF(NST.EQ. 4 .AND. P(J,I).GE. PSPM)Q(J,I)=QD(I)
            ELSE
                  Q(J,I)= 0.
            END IF
            QSUM = QSUM + Q(J,I)
  730 CONTINUE
C --- AITKEN ACCELERATION PARAMERTERS
      Q1 = Q2
      Q2 = Q3
      Q3 = QSUM
C --- CHECK IF ANOTHER LOOP IS REQ'D.
      RATIO = Q2/Q3
      IF(RATLL .LT.  RATIO .AND.  RATIO .LT.  RATUL)
     &      LOPBAK = .FALSE.
      IF(LOPBAK .AND. LK .EQ. 2) QPIV = QSUM
      IF(LOPBAK .AND. LK .GE. 3) QPIV = Q3-(Q3-Q2)**2/
     &                                  ((Q1-Q2)-(Q2-Q3))
      IF(LOPBAK) GOTO 725
      QTOT(J) = QSUM
  790 CONTINUE
C
C
C *** PROCEDURE TO CHECK POTENTIAL RUNOFF AND ADJUST SET TIME ***
C
C
C DETERMINE INITIAL TIME OF IRRIG.  & AVE.  FIELD APP.  RATE
  799 EIE = .90
      AIPH = QD(NSP)/(SSP*SPLAT)*96.3
      EIT = DID/EIE/AIPH
      IEIT = INT(EIT/TINC)*TINC+TINC
      ITINC = INT(TINC)
      TMOVE = .5
      IF(SSET)TMOVE = 0.
C LOOK FOR R.O.  AT 50% OF DISTANCE FROM MAIN
      PL = .5
      NPT = NINT(PL*RL/SSP)
      QPT = Q(2,NPT)
      PPT = P(2,NPT)
      WD = FWD(QPT,PPT)
      APAVE = QPT/(SSP*SPLAT)*96.3
      APMAX = APAVE
C
C --- LOOP TO ADJUST SET TIME TO MINIMIZE R.O. ON DOWNSLOPE RUN ---
C
      DO 1000 I = ITINC, IEIT,ITINC
            TCMAXT = FLOAT(I)
            TC = TCMAXT-TMOVE
            TCMAX = TC
            SIT = SIF*2.176*TC**(-.4314)
            CALL SSSMRO
            IF(PR .GT. 0.)THEN
                  IF(TC .GT. TINC)THEN
                        TCMAX = TC-TINC
                        TCMAXT = TCMAX+TMOVE
                        GOTO 1100
                  END IF
            END IF
 1000 CONTINUE
 1100 CUFLD = 0.
 1120 TSET = TINC
 1150 NSETS = INT((TSET-TINC)/TCMAXT)+1
      AIT = TSET-NSETS*TMOVE
```

```
      DPR = AIT/24.
      TC = AMIN1(TCMAX,AIT)
C
C
C ***** DETERMINE IRRIGATION PERFORMANCE *****
C
      WLF = 0.05
      IF(IWIND .EQ.  2)WLF = 0.1
      IF(IWIND .EQ.  3)WLF = 0.12
C --- ESTABLISH R.O.  CHECK POINTS ---
      NROPT1 = NSP
      NROPT2 = 1
      SECTR = .25
      ASP = SPLAT*SSP
      DO 1500 J = 1,3
            IF (J .EQ.  3) SECTR = .5
            K = 0
            DO 1400 I = 1, NSP
C --- ESTIMATE APPLICATION DEPTH, NO LOSSES ---
                  DAP(J,I) = 96.25*AIT*Q(J,I)/ASP
                  IF(I .EQ. NROPT1) GOTO 1300
                  IF(I .EQ. NROPT2) GOTO 1300
                  GOTO 1400
C
C --- COMPUTE RUNOFF AT APPROPRIATE POINTS ---
C
 1300             K =K+1
                  APAVE = Q(J,I)/(SSP*SPLAT)*96.3
                  APMAX = APAVE
                  PROR = 0.
                  RO = 0.
C --- FIND POTENTIAL R.O. ---
                  CALL SSSMRO
C
                  PR = AMAX1(PR,0.)
                  IF(PR .LE.  0.)GOTO 1350
                  PROR = APMAX-SIT
C --- FIND SURFACE STORAGE ---
                  IF(ABS(SLP(J)) .GE.  .05) THEN
                        SSTOR = 0.
                  ELSE
                        SSTOR = .4423+(-9.34*ABS(SLP(J)))
                        SSTOR = AMAX1(SSTOR, 0.)
                  END IF
                  PR = PR-SSTOR
                  PR = AMAX1(PR,0.)
C                  IF(ABS(SLP(J)) .LE. .0045)THEN
C                        BBOX = 250.
C                  ELSE
C                        BBOX = 119.124*(ABS(SLP(J))*100)**(-.9035)
C                  END IF
C                  BBOX = AMAX1(BBOX,250.)
                  BBOX = 30.
                  REY(1,J,K) = .9*BBOX*PR*PROR**(1./3.)
 1350             ROR(J,K) = PR
                  IF(PITS)ROR(J,K) = ROR(J,K)*.15
C
C --- CALL USLE SUBROUTINE TO FIND EROSION LOSSES ---
C
                CALL USLE(RL,Q(J,I),P(J,I),WD,SLP(J),REY,J,K,PITS,SK)
C
 1400       CONTINUE
C --- FIND AVERAGE R.O.  FOR RAY ---
            ROR(J,3) = (ROR(J,1)+ROR(J,2))*.5
            DO 1500 I = 1,3
                  REY(I,J,3)=(REY(I,J,1)+REY(I,J,2))*.5
 1500 CONTINUE
      IF(CUFLD .NE. 0.) GOTO 1800
C
C *** PROCEDURE TO ESTIMATE APPLICATION UNIFORMITY ***
```

```
C
      NPT = NINT(0.37*RL/SSP)
      WD = FWD(Q(3,NPT),P(3,NPT))
      WR = WD*.5
      RMAX = WR+IWIND*1./6.*WR
      NCUPS = 25
      NEFSP = 20
      DO 1600 I = 1,5
C --- FIND COORDINATES OF CATCH CAN ---
          CX1 = (I)/5.*SPLAT-SPLAT/10.
          DO 1600 J = 1,5
              CUP(I,J) = 0.
              CY1 = (J)/10.*SSP-SSP/20.
              DO 1600 K = 1,NEFSP
                  IF(K .LE. 8) THEN
                        L1 = 2
                        L2 = 10
                  ELSE
                        L1 = 8
                        L2 = 18
                  END IF
                  C10 = (INT((K-1)/4)-1)*SPLAT+.5*WR
C --- FIND COORDINATES OF PATTERN MATRIX ELEMENTS ---
                  DO 1630 L = L1,L2
                      CX2 = WR*(1.-1./6.*(L-1))+C10
                      CX3 = WR*(1.-1./6.*L)+C10
C --- DO X-COORDS. BRACKET CAN COORDS.???
                      IF(CX2 .GT. CX1 .AND. CX3 .LE. CX1)THEN
                          DO 1640 M = 2,7
                              CY2 = WR*(1.-1./6.*(M-2))
                              CY3 = WR*(1.-1./6.*(M-1))
                              KK = MOD(K,4)+1
                              GOTO (1650,1651,1655,1653)KK
 1650                          CY2 = 2.*SSP-CY2
                               CY3 = 2.*SSP-CY3
                              GOTO 1655
 1651                          CY2 = CY2-SSP
                               CY3 = CY3-SSP
                              GOTO 1655
 1653                          CY2 = SSP-CY2
                               CY3 = SSP-CY3
 1655                         CONTINUE
C --- DO Y-COORDS.  BRACKET CAN COORDS.???
                              IF((CY2.GT.CY1 .AND.  CY3.LE.CY1) .OR.
     &                            (CY2.LT.CY1 .AND.  CY3.GE.CY1))THEN
C --- INTERPOLATE FROM PATTERN MATRIX, Y-COORDS. ---
                                  CALL TRP(FLOAT(PATRN(L-1,M-1,IWIND)),
     &                         FLOAT(PATRN(L-1,M,IWIND)),CY2,CY3,CY1,V1)
                                  CALL TRP(FLOAT(PATRN(L,M-1,IWIND)),
     &                         FLOAT(PATRN(L,M,IWIND)),CY2,CY3,CY1,V2)
C --- INTERPOLATE BETWEEN X-COORDS. ---
                                  CALL TRP(V1,V2,CX2,CX3,CX1,V3)
C --- ADD INTERPOLATED VALUE TO CAN TOTAL ---
                                  CUP(I,J) = CUP(I,J)+APAVE*V3/100.
                              END IF
 1640                     CONTINUE
                      END IF
 1630             CONTINUE
 1600 CONTINUE
C
C --- LOOPS TO COMPUTE APPLICATION UNIFORMITY SUMS ---
      DO 1700 J = 1,5
            DO 1700 I = 1, 5
                  SUMB = SUMB+CUP(J,I)
 1700 CONTINUE
      DBAR = SUMB/NCUPS
      DO 1750 J = 1, 5
            DO 1750 I = 1, 5
                  SUMC = SUMC+ABS(CUP(J,I)-DBAR)
 1750 CONTINUE
```

```
C --- COMPUTE CHRISTIANSEN'S UNIFORMITY COEFFICIENT
      CUFLD = 100.*(1.-SUMC/(DBAR*NCUPS))
C
C --- COMPUTE IRRIGATION AND IRRIGATION LOSS TOTALS (ac-in) ---
 1800 QSUM = ((QTOT(1)+QTOT(2))*.25 + QTOT(3)*.5)*AIT/453.
      WLTOT = QSUM*WLF
      ROTOT = ((ROR(1,3)+ROR(2,3))*.25 + ROR(3,3)*.5)*SSP*RL/43560.
      APTOT = QSUM-WLTOT-ROTOT
      DPTOT = APTOT-(DID*ACRES)
      DPTOT = AMAX1(DPTOT,0.)
      APTOT = QSUM-WLTOT-ROTOT-DPTOT
      APDEP = APTOT/ACRES
      EFF = APTOT/QSUM*100.
      ENERGY = PMAIN/2.31*QTOT(3)*AIT/(2296.*APTOT/ACRES)
      IF(APDEP+DPTOT/ACRES .LT.  DID*(1.+(1.-CUFLD/100.)))THEN
            TSET = TSET+TINC
            GOTO 1150
      END IF
C  SAVE WEIGHTED AVERAGE SOIL LOSS COEFFICIENTS
      DO 1900 I = 1,3
 1900 SYSFLD(NFLD,I+26) = ((REY(I,1,3)+REY(I,2,3))*.25+REY(I,3,3)*.5)
      WLPCT = WLTOT/QSUM*100.
      ROPCT = ROTOT/QSUM*100.
      DPPCT = DPTOT/QSUM*100.
      RETURN
C - ERROR HANDLING ROUTINE -
 2000 WRITE(*,2001)NFLD
 2001 FORMAT(/' PROBLEMS IN DATA FOR SYSTEM IN FIELD ',I3/' CHECK',
     &'INPUTS.')
      EFF = -1.
      WLPCT = 0.
      ROPCT = 0.
      DPPCT = 0.
      RETURN
      END
```

```
C
C
      SUBROUTINE TRP(V1,V2,U1,U2,U,V)
C
C ***** SUBROUTINE FOR LINEAR INTERPOLATION *****
C
      V = (U-U1)/(U2-U1)*(V2-V1)+V1
      RETURN
      END
```

```
C
C
C
C   ***** SUBROUTINE TO ESTIMATE RUN OFF VOLUME *****
C ***** FOR SOILD SET & SET/MOVE SPRINKLER SYSTEMS *****
C
C
      SUBROUTINE SSSMRO
C
      COMMON/ROFF/APMAX, GRAPP, PR, SIF, TC, TF, TS
C
C *** FUNCTION TO FIND SOIL INTAKE RATE ***
C
      FIF(X) = SIF*2.176*X**(-.4314)
C
      PI = 3.141593
      TS1 = 0.
      TS2 = 0.
      TI = TC
      SIT = FIF(TI)
      IF(APMAX .GT. SIT) GOTO 200
      PR = 0.
      RETURN
C --- SEARCH FOR PTS. WHERE APPLICATION AND INTAKE CURVES MEET ---
  200 T = TC/10.
      GOTO 500
  300 TS = T
  400 TF = TC
C --- COMPUTE POTENTIAL R.O. VOLUME ---
      ARTF = APMAX*TF
      ARTS = APMAX*TS
      SITF = SIF*3.827*TF**.5686
      SITS = SIF*3.827*TS**.5686
      GRAPP = ARTF-ARTS
      PR = GRAPP-(SITF-SITS)
      RETURN
C
C --- ITERATION ROUTINE ---
C
  500 IF(TS2 .EQ. 0.)XY=0.
  510 T = T+(TC/100.)
  520 IF(T .GE. TC) GOTO 600
      TS1 = FIF(T)
      TS2 = APMAX
      IF(INT(SQRT((TS1**2 +TS2**2)/2)*100.)/100 .NE.  INT(TS1*100.)/100)
     & GOTO 550
      GOTO 300
  550 IF(TS1 .GT. TS2) GOTO 510
      XY = TS1/TS2
  600 T = T-(1-XY)*(TC/100)
      GOTO 520
      END
```

SYSTEM ROUTINE NOTES

The most recent edition of the SYSTEM program does not allow for any subsidation of capital costs but the majority of the program code remains in the program to handle subsidies. In the SYSTEM listing, this code has been removed through the use of comment lines. By removing the first character in these lines and removing certain duplicate lines from the executable code, most of the subsidy calculations can be restored and the program recompiled. Caution should be taken, however, that additional data is required in the FISA data file and data input and output routines involving subsidies will need to be altered.

If the subsidized cost portion of the program is restored, the following documentation is valid:

> Subsidized capital costs are subtracted from the total capital costs and not included in the capital cash flow figures. The total amount of subsidized capital costs is limited to the maximum subsidy limit specified in the input data file and these subsidies are assigned to the components as they appear in the irrigation system data file (i.e. they are are applied to any supply system components then to application system 1 components, system 2 components, etc.). Any specified subsidized costs greater than the subsidy limit are assumed to be financed. It should be noted that subsidies are applied only to the initial capital costs and are not assumed for any replacement costs.
>
> For all replacement costs, the same percentage of the cost is assumed to be financed as in the initial capital outlay. If any of the initial cost had been subsidized, this portion of the replacement cost is assumed to be financed by the specified loan as well.

A number of the program and subprogram listings in this appendix include the metacommands $DEBUG, $NOFLOATCALLS, and $LARGE for the Microsoft Version 3.3 FORTRAN compiler. This does not imply that these commands are required, desirable, or even allowable for other FORTRAN compilers. Before using these commands with another compiler, check the reference guide.

The program listings presented here contain a number of statements that were used in the program development to view intermediate program variables. These statements, primarily of the 'WRITE(*,*)' type, have been removed from the executable code by the use of comment lines but have been retained in the listings. Should further program development be done, any of these statements can easily be activated for debugging purposes.

Provisions have also been made for the inclusion of a subroutine to model the performance of trickle or drip irrigation systems. This subroutine, as yet unwritten, would be named TRIKLE. It would be called from the main SYSTEM routine and would have a system type number of 8.

The current array dimensions of SYSTEM limit the program to a maximum of: 11 fields, 30 crops, 30 pumps, 150 total irrigation system components, 11 systems (10 application systems plus the supply system) and a 30-year economic analysis period. A listing of selected array variables used in the SYSTEM and SIMULATE programs is provided in Appendix F.

APPENDIX D

SIMULATE ROUTINE PROGRAM LISTING

CONTENTS

```
$DEBUG
$NOFLOATCALLS
$LARGE
      PROGRAM SIMULATE
C >>> PROGRAM FOR SIMULATING THE OPERATION OF AN IRRIGATION SYSTEM <<<
C
C     THIS PROGRAM INCORPORATES AGRONOMIC, IRRIGATION SYSTEMS AND
C     WATER SUPPLY DATA IN ESTIMATING IRRIGATION SYSTEM PERFORMANCE
C     AND COSTS
C
C     WRITTEN BY J.R. BUSCH, WINCHMORE, 1982
C     MODIFIED BY B.W. SAUER, MOSCOW, 1986
C     LAST UPDATE - 5/5/87  BWS
C
C     PROGRAM LOGIC AND OPERATION ARE DESCRIBED IN A REPORT
C     AS YET UNNAMED
C
C
C     PROGRAM OUTPUT IS PRINTED IN FILE SPECIFIED AS LU 10 AND/OR 20
C
C     THIS PROGRAM ESTIMATES CROP WATER REQUIREMENTS TWICE MONTHLY
C
C==>>>>  DESCRIPTIONS OF VARIABLES  <<<<<<<
C    ICROPS --CROPDATE FILE READ IN VIA SUBROUTINE AGRON
C    CROPF -- CROPFPOLY FILE READ IN VIA SUBROUTINE AGRON
C    RAIN -- DAILY RAINFALL DATA READ FROM RAINFALL FILE VIA
C            SUBROUTINE LOAD
C    PET -- POTENTIAL ET (PENMAN) READ INTO WATEREQT
C           -- MONTHLY TOTAL PET
C    CRPDK -- CROP-PADDOCK ARRAY READ FROM CROPADDOCK FILE
C             ON LU 11
C    IDXCRP -- INDEX ARRAY OF CROP ROTATION IN EACH PADDOCK DURING
C              SIMULATION PERIOD
C    MONLEN -- NO. OF DAYS IN EACH MONTH
C    RQI(I,J) -- IRRIGATION WATER REQUIREMENT IN PADDOCK I DURING
C                A HALF-MONTHLY PERIOD.  J = 1 OR 2 WITH 1 REFERRING
C                TO PRESENT PERIOD AND 2 TO PREVIOUS PERIOD.
C    AREA -- PADDOCK AREA IN HA
C    MPRIOR -- IRRITATION PRIORITIES FOR EACH HALF-MONTHLY PERIOD
C              READ FROM CROPADDOCK FILE
C    IPDKPR -- INDEX OF IRRIGATION PRIORITIES FOR EACH PADDOCK DURING
C              A HALF-MONTHLY PERIOD
C              -- COMPUTED IN SUPROUTINE ALLOCATE
C    KCP -- INDEX DENOTING WHETHER CROP NO. 1 OR CROP NO. 2 IS
C           GROWING IN A PADDOCK DURING A HALF-MONTHLY PERIOD
C    IDXSYS -- IRRIGATION APPLICATION SYSTEM-PADDOCK INDEX ARRAY
C    JFLG -- INDEX FLAG USED TO FLAG WHETHER LABOR OR WATER IS
C            LIMITING IN ANY PERIOD.
C            -- SAME AS "LFLAG" IN SUBROUTINE ALLOCATE
C    ISFLAG -- INDEX FLAG USED TO FLAG WHETHER SYSTEM CAPACITY
C              IS LIMITING
C              -- SAME AS "ISFLAG" IN SUBROUTINE ALLOCATE
C    PDSUM -- ARRAY OF RESULTS FOR EACH PERIOD FROM SUBROUTINES
C             ALLOCATE AND ADJUST SUBROUTINES CONTAINING:
C       1-- PADDOCK ID NO.
C       2-- CROP ID NO.
C       3-- NET IRRIGATION REQUIREMENT
C       4-- IRRIGATION APPLICATION
C       5-- GROSS IRRIGATION REQUIREMENT
C       6-- NET APPLICATION > APPLICATION DEFICIT
C       7-- LABOR REQUIRED
C
C    SYSV -- VOLUME OF WATER APPLIED THROUGH A SYSTEM
C            IN A PERIOD.  DATA ARE STORED FOR ONLY
C            PRESENT AND PREVIOUS PERIODS
C    ISF -- INDEX FLAG TO DETERMINE IF SYSTEM CAPACITY
C           IS LIMITING.  DATA ARE STORED FOR ONLY
C           PRESENT AND PREVIOUS PERIODS
C    SMD -- SOIL MOISTURE DEFICIT FOR EACH PADDOCK.  DATA ARE
C           STORED FOR ONLY PRESENT AND PREVIOUS PERIODS.
```

```
C    ANNSUM -- ANNUAL SUMMARY ARRAY FOR EACH CROP.  DATA ARE
C              OBTAINED FROM PDSUM ARRAY IN SUBROUTINE YEARSUM.
C    SYSUM -- ANNUAL SUMMARY ARRAY FOR THE IRRIGATION SUPPLY AND
C             EACH APPLICATION SYSTEM.  DATA ARE OBTAINED FROM PDSUM
C             AND ISFLAG ARRAYS IN SUBROUTINE YEARSUM.
C    SYSVAL -- ARRAY OF APPLICATION SYSTEM PARAMETERS READ FROM
C              SYSTEMS FILE
C    NAPMP -- NO. OF PUMPS ASSOCIATED WITH EACH SYSTEM READ FROM
C             SYSTEMS AND SUPPLY FILES
C    IDXPMA -- ARRAY OF ID NOS. FOR PUMPS ASSOCIATED WITH EACH
C              SYSTEM READ FROM SYSTEMS AND SUPPLY FILES
C    PWRPMP -- ARRAY OF PUMP POWER REQUIREMENTS READ FROM SYSTEMS
C              AND SUPPLY FILES
C    QPMP -- ARRAY OF PUMP FLOW RATES READ FROM SYSTEMS & SUPPLY FILES
C    WCOST -- COST OF WATER ENTERING THE SYSTEM -- FROM SUPPLY FILE
C    SUPRAM -- ARRAY OF VALUES FOR SUPPLY SYSTEM -- FROM SUPPLY FILE
C    TPUMP -- ARRAY OF PUMP TARIFF DATA INPUT IN THE MAIN SIMULATE
C             PROGRAM
C    EAPP -- APPLICATION EFFICIENCY ARRAY READ FROM THE SYSTEMS FILE
C    IDCP -- ARRAY OF CROP ID NOS. READ FROM CROPADDOCK FILE
C      NPKSYS -- NO. OF PADDOCKS IRRIGATED BY AN APPLICATION SYSTEM.
C               READ FROM SYSTEMS FILE
C    TLAB -- LABOR REQUIREMENT FOR PADDOCKS FROM SYSTEMS FILE
C    TOTIRG -- NO. OF IRRIGATIONS IN EACH PADDOCK DURING SIMULATION
C              PERIOD COMPUTED IN SUBROUTINE YEARSUM
C
C
C ===>>>  OTHER VARIABLES
C    NCRP -- NO. OF CROPS IN EACH PADDOCK
C    NDAY -- NO. OF DAYS IN HALF-MONTHLY PERIOD
C    J1 -- HALF MONTHLY PD NO. THAT MARKS THE BEGINNING OF THE
C          IRRIGATION SEASON.  PD NO. 1 IS FIRST HALF OF JUNE &
C          PD NO. 24 IS LAST HALF OF MAY
C    J2 -- PD NO. OF LAST PERIOD IN THE IRRIGATION SEASON
C    FLATP -- ANNUAL INFLATION RATE FOR ENERGY AS A PERCENT
C
C    XLAB -- MAX LABOR AVAILABLE IN HR/WK
C    RLABC -- LABOR WAGE RATE IN $/HR
C    RLABI -- INFLATION RATE FOR LABOR AS A PERCENT
C    OMI -- INFLATION (PERCENT) FOR GENERAL O&M
C    RINV -- RETURN ON INVESTMENT
C    ISTART -- BEGINNING YEAR FOR SIMULATION
C    ISTOP -- ENDING YEAR FOR SIMULATION
C    NYEAR -- NO. OF YEARS OF SIMULATION
C    TLBR -- LABOR REQUIRED IN PD I.  THIS VALUE IS USED IF
C            ADJUST IS CALLED FOR PERIOD I.
C    LYEAR -- YEAR
C    TWTR -- SEE DOCUMENTATION FOR ADJUST
C    LD1 -- NO. OF DAYS IN PREVIOUS PD.
C    JDAY -- DAY WITHIN THE YEAR -- JAN 1 IS DAY NO. 1
C    LPDY -- NO. OF DAYS IN CURRENT PERIOD
C
C
      DIMENSION TRUMP(30,10),NCRP(20),NDAY(2),TEX(20),IACCST(4,20,31),
     1 TREQ(24),MO(12),ARRAY(9),IDS(20),K1(20),NT(20,30)
C
C
      COMMON/CROPP/ICROPS(6,30),CROPF(30,24),YIELD(8,30)
      COMMON/PREC/RAIN(24)
      COMMON/PUMPP/NAPMP(21),IDXPMA(10,21),PWRPMP(20),QPMP(20),
     & TPUMP(20)
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12),
     & RQI(20,2 ),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
      COMMON/SYSTUM/WCOST(10),NPKSYS(20),IPSYS(20,20)
```

```
C
      CHARACTER*24 DTITLE,TITLE,STITLE,RSTFIL,CRPFIL,SYSROT,RAINFL,
     & PETFIL
      CHARACTER*20 SYSNAM(20),F(20),CNAME(30)*16,SUPTIT
      CHARACTER*3 Y1,Y2,FLAG
      DATA Y1,Y2,LEPD/'YES','yes',20/
C
C -- ASSIGN LU NOS.  #8 WRITE        #7 READ
C
      IFLAG9 = 0
      WRITE(*,1111)
1111  FORMAT(//' INPUT DATA FOR THE OPERATION SIMULATION MODULE'//
     1' -THE MAXIMUM NUMBER OF CHARACTERS IN ANY TITLE IS 20'/
     2'  WITH NO EMBEDDED BLANKS AND ONLY ALPHANUMERIC CHARACTERS'//
     3' -ALL NUMERIC DATA ARE ENTERED IN FREE FORMAT (LIST DIRECTED)')
C
C  OUTPUT FILE HAS THE SAME NAME AS THE TITLE
C
C******* OPEN OUTPUT FILE(DTITLE), GET RUN TITLE(TITLE) ******
5     WRITE(*,*)' ENTER THE NAME OF THE CROP ROTATION/SYSTEM DATA',
     &' FILE TO BE USED'
      READ(*,'(A)')SYSROT
      OPEN(12,FILE=SYSROT,IOSTAT=IOCHECK,STATUS='OLD',BLANK='ZERO')
      IF(IOCHECK .NE. 0)GOTO 990
501   WRITE(*,*)' ENTER THE NAME OF THE CROP DATA FILE TO BE USED'
      READ(*,'(A)')CRPFIL
      OPEN(13,FILE=CRPFIL,IOSTAT=IOCHECK,ACCESS='DIRECT',
     &FORM='FORMATTED',RECL=208,STATUS='OLD')
      IF(IOCHECK .NE. 0)GOTO 991
502   WRITE(*,*)' ENTER THE NAME OF THE RAINFALL FILE'
      READ(*,'(A)')RAINFL
      OPEN(14,FILE=RAINFL,STATUS='OLD',IOSTAT=IOCHECK)
      IF(IOCHECK .NE. 0) GOTO 992
503   WRITE(*,*)' ENTER THE NAME OF THE PET FILE'
      READ(*,'(A)')PETFIL
      OPEN(15,FILE=PETFIL,STATUS='OLD',IOSTAT=IOCHECK)
      IF(IOCHECK .NE. 0) GOTO 993
      WRITE(*,'(//A/)')' ENTER THE NAME FOR THIS SIMULATION RUN.'
      WRITE(*,'(A//A)')' REMEMBER, NO BLANKS ARE ALLOWED IN THIS NAME!',
     &' (OUTPUT FILE(S) FOR THIS RUN WILL HAVE THE SAME NAME)'
      READ(*,'(A)')TITLE
C  SEARCH FOR TITLE END
      DO 5031 ILEN = 1,24
5031    IF(TITLE(ILEN:ILEN) .EQ. ' ')GOTO 504
504       WRITE(*,5004)
5004  FORMAT(//' SELECT THE FOLLOWING OUTPUT FORMAT:'/' 1 -- DETAILED'
     &,' OUTPUT ONLY'/' 2 -- CONDENSED OUTPUT ONLY'/' 3 -- BOTH',
     &' DETAILED AND CONDENSED OUTPUTS'/)
      READ(*,*)ISHRT
C
C  --- WRITE OUT NAMES OF INPUT DATA FILES
      WRITE(*,1100)TITLE,SYSROT,CRPFIL,RAINFL,PETFIL
1100  FORMAT(/////,5X,'RESULTS FROM THE SIMULATE ROUTINE IN FILE ',
     1A,//8X,'INPUT DATA ARE FROM THE FOLLOWING FILES:'//
     210X,'IRRIG. SYSTEMS/CROP ROTATION FILE --- ',A,//
     310X,'CROP DATA FILE ---------------------- ',A,//
     410X,'RAINFALL FILE ----------------------- ',A,//
     510X,'POTENTIAL ET (PET) FILE ------------- ',A,/)
C
      WRITE(*,1013)
1013  FORMAT(//' ENTER BEGINNING AND ENDING YEARS FOR SIMULATION RUN')
      READ(*,*)TEX1,TEX2
      ISTART = NINT(TEX1)
      ISTOP = NINT(TEX2)
      IF(ISTART.GT.100)ISTART=ISTART-1900
      IF(ISTOP.GT.100)ISTOP=ISTOP-1900
        NYEAR = ISTOP-ISTART+1
C  SET UP IO FORMAT ARRAY
C
      F(1) = '(63X,F8.0)'
```

```
      F(2) = '(8X,4I9)'
      F(3) = '(36X,9F9.0)'
      F(4) = '(36X,9(A))'
      F(5) = '(/36X,I8,8I9)'
      F(6) = '(A)'
      F(7) = '(27X,F8.0,8F9.0)'
      F(8) = '(/63X,I8)'
      F(9) = '(27X,9(A9))'
      F(10) = '(36X,(A))'
      F(11) = '(/F8.0)'
      F(12) = '(/I8)'
      F(13) = '(2(/))'
      F(14) = '(3(/))'
      F(15) = '(4(/))'
      F(16) = '(5(/))'
      F(17) = '(36X,F9.2,F27.2)'
      F(18) = '(////(A))'
      F(19) = '(18X,I8,8I9)'
      F(20) = '(F8.0)'
C
C
C  DETERMINE THE HISTORICAL MEAN PET VALUES
C  -- LOGICAL UNIT AND MEAN VALUE ARRAY ARE ARGUMENTS
C
      CALL PETAVE(15,APET)
C
C  LOCATE STARTING RECORDS IN RAINFALL AND PET FILES AND CHECK
C  FOR DATA AVAILABILITY
C  --LOGICAL UNITS AND FIRST & LAST SIMULATION YEARS ARE ARGUMENTS
C
      CALL LOCATE (14,15,ISTART,ISTOP)
C
C
C
C >>>>>>>>>> READ IRRIG. SYSTEM/CROP ROTATION FILE
C >>>>>>>> ARRAYS AND VARIABLES ARE -------------
C     NCP -- TOTAL NO OF CROPS IN MENU
C     IDCP -- CROP ID NO.
C     CNAME -- CROP NAME  (CHARACTER*16)
C     MBEG & MFIN -- NOS. OF MONTHS MARKING BEGINNING & ENDING OF SEASON
C     NPDK -- NO. OF PADDOCKS
C     AREA -- AREA OF PADDOCK
C     NCRP -- NO. OF CROPS IN PADDOCK
C     CRPDK(I,J,K) -- CROP-PADDOCK ARRAY
C           I -- PADDOCK NO.
C           J -- CROP ROTATION POSITION
C           K -- VARIABLE POSITION (1-8)
C     NTCP -- TOTAL NO OF CROPS IN CRPDK ARRAY
C     MPRIOR -- IRRIGATION PRIORITIES OF CROPS
C
C  BEGINNING AND ENDING MONTHS OF IRRIGATION SEASON
      READ(12,F(13))
      READ(12,F(12)) MBEG
      READ(12,F(12)) MFIN
      READ(12,F(12)) NPDK
C      WRITE(*,*)' MBEG,NFIN,NPDK',MBEG,MFIN,NPDK
C  FIELD DATA
      READ(12,F(16))
      DO 10 I=1,NPDK
10          READ(12,1001) AREA(I),NCRP(I)
C10    WRITE(*,*)AREA(I),NCRP(I)
1001  FORMAT(5X,F21.0,I18)
C  CROP ROTATION DATA
      READ(12,F(13))
      READ(12,F(12))NCR
      READ(12,F(15))
      DO 15 I=1,NCR
          READ(12,1501)N,K,L,(ARRAY(J),J=1,8)
C         WRITE(*,1501)N,K,L,(ARRAY(J),J=1,8)
          DO 15 II = 1,5,4
```

```
                CRPDK(N,L,II) = ARRAY(II)
                CRPDK(N,L,II+1) = ARRAY(II+1)
                CRPDK(N,L,II+3) = ARRAY(II+1)*ARRAY(II+2)/100.
                CRPDK(N,L,II+2) = CRPDK(N,L,II+3)*ARRAY(II+3)/100.
C      WRITE(*,*)'FIELD,CR#,CROP',N,L,CRPDK(N,L,II)
C      WRITE(*,*)'MAD,AD',CRPDK(N,L,II+3),CRPDK(N,L,II+2)
15    CONTINUE
1501  FORMAT(I8,2I9,8F9.0)
      MFX = MFIN
      J1 = (MBEG*2) - 1
      J2 = MFX*2
      READ(12,*)
      READ(12,F(12)) NTCP
      READ(12,F(15))
      DO 16 I = 1,NTCP
16       READ(12,1601) IDCP(I),CNAME(IDCP(I)),(YIELD(J,IDCP(I)),J=1,2)
C16     WRITE(*,1601) IDCP(I),CNAME(IDCP(I)),(YIELD(J,IDCP(I)),J=1,2)
1601  FORMAT(I17,1X,A16,1X,2F9.0)
C
      DO 165 IPK = 1,NPDK
      K1(IPK) = 0
      DO 165 J = 1,NTCP
         DO 165 JJ = 1,NCRP(IPK)
            DO 165 JJJ = 1,5,4
               NOCR = NINT(CRPDK(IPK,JJ,JJJ))
               IF(NOCR .EQ. 1)GOTO 165
               IF(NOCR .NE. IDCP(J))GOTO 165
               DO 162 L = 1,K1(IPK)
162               IF(NT(IPK,K1(IPK)) .EQ. NOCR) GOTO 165
               K1(IPK) = K1(IPK)+1
               NT(IPK,K1(IPK)) = NOCR
C      WRITE(*,*)'IPK,K1,NT',IPK,K1(IPK),NOCR
165   CONTINUE
C SUPPLY SYSTEM DATA
      SUPTIT = 'SUPPLY SYSTEM'
      READ(12,F(13))
      READ(12,F(11))RINV
C            WRITE(*,*)' RINV ',RINV
      READ(12,'(14(/))')
      READ(12,F(20))SUPRAM(2),AVMAX,DPW
C            WRITE(*,F(20))SUPRAM(2),AVMAX,DPW
      SUPRAM(1) =  SUPRAM(2)*23.8*DPW/7.
      READ(12,F(14))
      READ(12,F(20))(WCOST(J),J=1,4)
      CALL ZERO(TPUMP,16)
      READ(12,F(14))
      READ(12,F(6))FLAG
C      WRITE(*,*)' ELEC FLAG ',FLAG
      IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)THEN
            READ(12,'(/)')
            DO 17 I = 1,7
               READ(12,F(1))ARRAY(I)
            IF(I .LE. 3)TPUMP(I) = ARRAY(I)
C            WRITE(*,*)ARRAY(I)
17          CONTINUE
            TPUMP(16) = ARRAY(4)
            TPUMP(15) = ARRAY(6)
            TPUMP(14) = ARRAY(5)
            FLATP = ARRAY(7)
            READ(12,'(/)')
            CALL ZERO(ARRAY,9)
            DO 18 I = 4,6
               READ(12,1801)TPUMP(I),TPUMP(I+5)
               ARRAY(1) = ARRAY(1)+TPUMP(I)
18             ARRAY(2) = ARRAY(2)+TPUMP(I+5)
C18           WRITE(*,*)TPUMP(I),TPUMP(I+5)
C  IF ONLY 1 SEASON RATE ENTERED, ASSUME VALID FOR WHOLE YEAR
            DO 182 I = 1,2
            IF(ARRAY(I) .LE. 0.000)THEN
              DO 181 J = 4,6
```

```
                IF(I .EQ. 1)TPUMP(J) = TPUMP(J+5)
181             IF(I .EQ. 2)TPUMP(J+5) = TPUMP(J)
            END IF
182         CONTINUE
      END IF
1801  FORMAT(45X,F8.0,F9.0)
C - SKIP SPECIFIC SUPPLY SYSTEM DATA
      READ(12,F(18))FLAG
C             WRITE(*,*)' SUP CAN FLAG ',FLAG
      IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(15(/))')
      READ(12,F(18))FLAG
C             WRITE(*,*)' SUP STRUCT FLAG ',FLAG
      IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(11(/))')
      READ(12,F(18))FLAG
C             WRITE(*,*)' SUP PUMP FLAG ',FLAG
      IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(17(/))')
      READ(12,F(18))FLAG
C             WRITE(*,*)' SUP PIPE FLAG ',FLAG
      IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(14(/))')
      READ(12,F(18))FLAG
C             WRITE(*,*)' SUP OTHER FLAG ',FLAG
      IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(13(/))')
C - READ APPLICATION SYSTEM TYPE DATA
      READ(12,F(13))
      READ(12,F(12))NSYS
C             WRITE(*,*)' NSYS ',NSYS
      READ(12,F(13))
      READ(12,F(19))(IDS(J),J=1,NSYS)
C           WRITE(*,F(19))(IDS(J),J=1,NSYS)
      READ(12,F(19))(NPKSYS(J),J=1,NSYS)
C           WRITE(*,F(19))(NPKSYS(J),J=1,NSYS)
      READ(12,*)
      NFMAX = 0
      DO 19 I = 1,NSYS
19        NFMAX = MAX0(NFMAX,NPKSYS(I))
      DO 1901 I = 1,NFMAX
1901      READ(12,F(19))(IPSYS(I,J),J=1,NSYS)
C1901    WRITE(*,F(19))(IPSYS(I,J),J=1,NSYS)
      READ(12,*)
C - SET UP SYSTEM/FIELD INDEX ARRAY
      DO 1902 I = 1,NSYS
          DO 1902 J = 1,NPKSYS(I)
1902          IDXSYS(IPSYS(J,I)) = I
C - SKIP OVER INDIVIDUAL IRRIGATION SYSTEM DATA
      DO 20 N = 1,NSYS
          GOTO(191,192,193,194,194,195,195),IDS(N)
C BORDER SYSTEMS
191       READ(12,'(26(/))')
          GOTO 199
C FURROW SYSTEMS
192       READ(12,'(27(/))')
          GOTO 199
C SOLID SET SPRINKLER SYSTEMS
193       READ(12,'(39(/))')
          GOTO 199
C HAND-MOVE AND SIDE-ROLL SYSTEMS
194       READ(12,'(38(/))')
          GOTO 199
C CENTER PIVOT AND LATERAL MOVE SYSTEMS
195       READ(12,'(34(/))')
          GOTO 199
C
199       READ(12,F(18))FLAG
C             WRITE(*,*)'  CAN FLAG ',FLAG
          IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(15(/))')
          READ(12,F(18))FLAG
C             WRITE(*,*)'  STRUCT FLAG ',FLAG
          IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(11(/))')
          READ(12,F(18))FLAG
C             WRITE(*,*)'  PUMP FLAG ',FLAG
```

```
          IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(17(/))')
          READ(12,F(18))FLAG
C                 WRITE(*,*)'  PIPE FLAG ',FLAG
          IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(14(/))')
          READ(12,F(18))FLAG
C                 WRITE(*,*)'  OTHER FLAG ',FLAG
          IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(13(/))')
20    CONTINUE
C - SKIP DRAINAGE DATA
      READ(12,F(18))FLAG
C                 WRITE(*,*)' DRAIN FLAG ',FLAG
      IF(FLAG .EQ. Y1 .OR. FLAG .EQ. Y2)READ(12,'(18(/))')
      READ(12,'(/)')
      READ(12,201)XLAB
      READ(12,201)RLABC
      READ(12,201)RLABI
      READ(12,*)
      READ(12,201)OMI
201   FORMAT(//63X,F8.0)
C      WRITE(*,*)' XLAB,RLABC,RLABI,OMI',XLAB,RLABC,RLABI,OMI
C
C >>>> INPUT DATA FOR WATER SUPPLY SYSTEMS
C  >> MAJOR ARRAYS AND VARIABLES ARE --------
C    WCOST(I) -- COST OF WATER ENTERING THE SYSTEM
C    SUPRAM(J) -- ARRAY OF VALUES FOR SYSTEM AS FOLLOWS
C          J = 1 -- VOLUME ENTERING SYSTEM (AC-IN/DAY)
C              2 -- FLOW ENTERING SYSTEM (CFS)
C              3 -- CONVEYANCE EFFICIENCY (%)
C              4 -- SYSTEM LIFE (YR)
C              5 -- TOTAL CAPITAL COST ($)--- (LOAN NO. 1)
C              6 -- CAPITAL NOT FINANCED OR SUBSIDIZED ($)
C              7 -- SUBSIDIZED CAPITAL ($)
C              8 -- FINANCED CAPITAL ($)
C              9 -- INTEREST RATE FOR LOAN NO. 1 (%) -- ATTACHED ITEMS
C             10 -- TIME OF LOAN NO. 1 (YR)
C             11 -- SALVAGE VALUE OF COMPONENTS ($)
C             12 -- ANNUAL MAINTENANCE EXPENSE ($)
C             13 -- ANNUAL MISCELLANEOUS EXPENSE ($)
C         PARAMETERS 14 -22 ARE THE SAME PARAMETERS AS 5 - 13 EXCEPT
C         UNATTACHED ITEMS (LOAN NO. 2)
C             23 -- ANNUAL CAPITAL RECOVERY COST ($)
C
C     NAPMP -- NO. OF PUMPS IN SYSTEM
C    IDXPMA(J) -- ID NOS. OF PUMPS IN SYSTEM
C    PWRPMP(K) -- ARRAY OF PUMP POWER REQTS (KW)
C     QPMP(K) -- ARRAY OF PUMP FLOW RATES (GPM)
C
C
C   SET SUPPLY SYSTEM SYSTEM NUMBER
       NSUP = 20
C
       READ(12,F(15))
       READ(12,2402)SUPRAM(3)
       SUPRAM(3) = 100.-SUPRAM(3)
C              WRITE(*,*)' ECONV ',SUPRAM(3)
       READ(12,F(16))
       DO 22 I = 5,13
            IF(I .EQ. 7)GOTO 22
            READ(12,F(17))SUPRAM(I),SUPRAM(I+9)
C       WRITE(*,F(17))SUPRAM(I),SUPRAM(I+9)
22     CONTINUE
       READ(12,F(15))
       DO 221 I=1,LEPD+1
221       READ(12,F(2))(IACCST(K,NSUP,I),K=1,4)
C221   WRITE(*,*)I,(IACCST(K,NSUP,I),K=1,4)
       READ(12,*)
       READ(12,F(17))SUPRAM(23)
C              WRITE(*,F(17))SUPRAM(23)
C TRANSFER SUPRAM ECONOMIC VALUES INTO COL.= NSUP OF SYSVAL MATRIX
      DO 222 I = 4,22
```

```
222       SYSVAL(I,NSUP) = SUPRAM(I+1)
      READ(12,F(14))
C  SKIP COMPONENT COSTS
      READ(12,F(12))NN
      DO 223 I = 1,NN+6
223    READ(12,*)
C  SKIP CANAL DATA
      READ(12,F(12))NN
      IF(NN .GT. 0)THEN
        DO 224 I = 1,NN+6
224       READ(12,*)
      END IF
      READ(12,F(13))
C
      READ(12,F(12))NAPMP(NSUP)
C             WRITE(*,*)' NPUMP SUP',NAPMP(NSUP)
      IF(NAPMP(NSUP) .LE. 0)GOTO 24
         READ(12,F(15))
         DO 23 I = 1,NAPMP(NSUP)
23          READ(12,2301)IDXPMA(I,NSUP),QPMP(IDXPMA(I,NSUP)),
    &         PWRPMP(IDXPMA(I,NSUP))
C23             WRITE(*,2301)IDXPMA(I,NSUP),QPMP(IDXPMA(I,NSUP)),
C      &        PWRPMP(IDXPMA(I,NSUP))
2301  FORMAT(I17,2F18.1)
24    READ(12,F(13))
C  SKIP PIPE DATA
      READ(12,F(12))NN
      IF(NN .GT. 0)THEN
        DO 241 I = 1,NN+6
241       READ(12,*)
      END IF
      READ(12,F(16))
C
C  >>>INPUTS FOR IRRIGATION SYSTEMS
C   >>>>>>> GENERATED FROM "SYSTEMS" ROUTINE
C  >> MAJOR ARRAYS AND VARIABLES ARE --------
C    NSYS -- NO. OF SYSTEMS
C    NPKSYS(I) -- NO. OF PADDOCKS IRRIGATED BY SYSTEM I
C    IPSYS(J,I) -- ARRAY OF PADDOCK ID NOS. IRRIGATED BY SYSTEM I
C    TLAB(J,2) -- LABOR REQT FOR PADDOCK J (1=HR/IRRIG, 2=HR/SEASON)
C    EAPP(CROP,PADDOCK) -- ARRAY OF OVERALL APPLICATION EFFICIENCIES
C    SYSVAL(J,I) -- ARRAY OF VALUES FOR SYSTEM I AS FOLLOWS
C          J = 1 -- FLOW ENTERING SYSTEM (CFS)
C              2 -- PERCENT OF TIME SYSTEM OPERATES
C              3 -- SYSTEM LIFE (YR)
C              4 -- TOTAL CAPITAL COST ($)--- (LOAN NO. 1)
C              5 -- CAPITAL NOT FINANCED OR SUBSIDIZED ($)
C              6 -- SUBSIDIZED CAPITAL ($)
C              7 -- FINANCED CAPITAL ($)
C              8 -- INTEREST RATE FOR LOAN NO. 1 (%) -- ATTACHED ITEMS
C              9 -- TIME OF LOAN NO. 1 (YR)
C             10 -- SALVAGE VALUE OF COMPONENTS ($)
C             11 -- ANNUAL MAINTENANCE EXPENSE ($)
C             12 -- ANNUAL MISCELLANEOUS EXPENSE ($)
C          PARAMETERS 13 -21 ARE THE SAME PARAMETERS AS 4 - 12 EXCEPT
C          UNATTACHED ITEMS (LOAN NO. 2)
C
C    NAPMP(I) -- NO. OF PUMPS IN SYSTEM I
C    IDXPMA(J,I) -- ID NOS. OF PUMPS IN SYSTEM I
C    PWRPMP(K) -- ARRAY OF PUMP POWER REQTS (KW)
C    QPMP(K) -- ARRAY OF PUMP FLOW RATES (GPM)
C
           DO 30 N = 1,NSYS
        READ(12,F(13))
        READ(12,2401)SYSNAM(N)
C             WRITE(*,*)' NAME ',N,SYSNAM(N)
2401  FORMAT(20X,A)
        READ(12,'(/)')
        DO 242 I = 1,2
           IF(I .EQ. 2)READ(12,'(/)')
```

```
242         READ(12,2402)SYSVAL(I,N)
C242            WRITE(*,2402)SYSVAL(I,N)
2402  FORMAT(/27X,F9.0)
            READ(12,2412)SYSVAL(3,N)
C                WRITE(*,2412)SYSVAL(3,N)
2412  FORMAT(/40X,F8.0)
         READ(12,F(16))
         DO 25 I = 1,NPKSYS(N)
25          READ(12,2403)(TLAB(IPSYS(I,N),J),J=1,2)
C25            WRITE(*,*)' TLAB ',(TLAB(IPSYS(I,N),J),J=1,2)
2403  FORMAT(17X,F9.1,F18.1)
         READ(12,F(16))
         DO 26 I = 1,NPKSYS(N)
            READ(12,F(12))IPK
C      WRITE(*,*)' NPKSYS,IPK,K1',NPKSYS(N),IPK,K1(IPK)
            DO 26 J = 1,K1(IPK)
               READ(12,2404)NC,EAPP(NC,IPK),DP(NC,IPK)
C        WRITE(*,*)'IPK,NCROP,EFF ',IPK,NC,EAPP(NC,IPK),DP(NC,IPK)
               IF(EAPP(NC,IPK).LE. 0.0001)GOTO 994
               EAPP(NC,IPK) = EAPP(NC,IPK)/100.
26             DP(NC,IPK) = DP(NC,IPK)/100.
2404  FORMAT(I17,18X,4F9.1)
         READ(12,'(6(/))')
         DO 27 I = 4,12
            IF(I .EQ. 6)GOTO 27
            READ(12,F(17))SYSVAL(I,N),SYSVAL(I+9,N)
C      WRITE(*,F(17))SYSVAL(I,N),SYSVAL(I+9,N)
27       CONTINUE
      READ(12,F(15))
      DO 271 I=1,LEPD+1
271         READ(12,F(2))(IACCST(K,N,I),K=1,4)
C271   WRITE(*,*)I,(IACCST(K,N,I),K=1,4)
         READ(12,*)
         READ(12,F(17))SYSVAL(22,N)
C       WRITE(*,F(17))SYSVAL(22,N)
         READ(12,F(14))
C  SKIP COMPONENT COSTS
      READ(12,F(12))NN
      DO 272 I = 1,NN+6
272    READ(12,*)
C  SKIP CANAL DATA
      READ(12,F(12))NN
      IF(NN .GT. 0)THEN
        DO 273 I = 1,NN+6
273      READ(12,*)
      END IF
      READ(12,F(13))
C
         READ(12,F(12))NAPMP(N)
C             WRITE(*,*)' NAPMP ',N,NAPMP(N)
         IF(NAPMP(N) .LE. 0)GOTO 29
            READ(12,F(15))
         DO 28 I = 1,NAPMP(N)
28          READ(12,2301)IDXPMA(I,N),QPMP(IDXPMA(I,N)),
     &         PWRPMP(IDXPMA(I,N))
C28             WRITE(*,2301)IDXPMA(I,N),QPMP(IDXPMA(I,N)),
C     &          PWRPMP(IDXPMA(I,N))
29    READ(12,F(13))
C  SKIP PIPE DATA
      READ(12,F(12))NN
      IF(NN .GT. 0)THEN
        DO 291 I = 1,NN+6
291      READ(12,*)
      END IF
      READ(12,'(/)')
30    CONTINUE
C
C - READ SOIL LOSS DATA
C
      READ(12,F(16))
```

```
      DO 31 I = 1,NSYS
         GOTO(31,31,311,311,311,311,311),IDS(I)
311         DO 32 II = 1,NPKSYS(I)
            IPDK = IPSYS(II,I)
            READ(12,3101)(SLOSS(IPDK,J),J=1,3)
C       WRITE(*,3101)(SLOSS(I,J),J=1,3)
32       CONTINUE
31    CONTINUE
3101  FORMAT(8X,3F9.3)
C
C
C  READ AGRONOMIC FILES FOR CROP DATES AND ET COEFFICIENTS
C  VIA SUBROUTINE AGRON -- CROPS & CROPF FILES
C   --CROPS FILE IS CROP-DATE ARRAY WITH DATES FOR START OF VARIOUS
C      GROWTH STAGES(PLANTING, HARVEST, EFFECTIVE COVER, FLOWERING AND
C      YIELD FORMATION)
C   --CROPF ARRAY IS FILE OF COEFFICIENTS FOR RELATING AET/PET
C   --YIELD ARRAY INCLUDES YIELD SUCEPTABILITY FACTORS AND CROP COVER
C      AND RESIDUE YIELD INFORMATION
C
      CALL AGRON (NTCP,IDCP,13)
C
C
      WRITE(*,10131)
10131 FORMAT(//' I AM NOW THINKING, COMPUTING AND TRYING TO DIGEST ALL'/
     1' THE DATA YOU HAVE FED ME.  I WILL TELL YOU WHEN I HAVE'/
     2' SUCCESSFULLY COMPLETED ALL DETAILS ----- PROVIDED YOU '/
     3' HAVE NOT FED ME BAD DATA THAT WILL RESULT IN INDIGESTION!!'//)
C
C
C  SET UP INDEX ARRAY OF CROP ROTATION FOR SIMULATION PERIOD
C  --IDXCRP(PADDOCK,YEAR) DENOTES CROP IN PADDOCK FOR THAT YEAR
      DO 65 IPDK=1,NPDK
         I = 0
         II = MAX0(NYEAR,NCRP(IPDK))
         DO 65 IYR =1,II
            I = I + 1
            IDXCRP(IPDK,IYR) = I
C     WRITE(*,*)' IPDK,IYR,IDXCRP(IPDK,IYR)',IPDK,IYR,IDXCRP(IPDK,IYR)
            IF(I.GE.NCRP(IPDK)) I = 0
65    CONTINUE
C
C     INITIALIZE PRIORITIES
C  ENTER SIMULATION LOOP
C  -- INITIALIZE SOIL MOISTURE LEVELS (SMD) AT FIELD CAPACITY AND
C     IRRIGATION REQUIREMENTS (RQI) AT ZERO (DONE IN BLOCK DATA)
      TOTWTR=0
      TOTLBR=0
C
C  *********** ENTER YEARLY LOOP ***********
C
      DO 120 IYR=1,NYEAR
      WRITE(*,*)' WORKING ON SIMULATION FOR YEAR',IYR
      LYEAR = ISTART + IYR - 1
      JDAY = 0
      LPDY = 1
      KTPD = 0
      MONLEN(2)=28
      IF (MOD(LYEAR,4).EQ.0) MONLEN(2) = 29
C
C
C
C  ***** ENTER LOOP FOR 2-WEEK PERIODS *****
C
      DO 90 IMNTH = 1,12
      MONTH = IMNTH
      NDAY(1) = MONLEN(MONTH)/2
      NDAY(2) = MONLEN(MONTH) - NDAY(1)
C
      DO  90 KPD = 1,2
```

```
      KTPD = KTPD + 1
C             WRITE(*,*)' MONTH, PER.',IMNTH,KTPD
      TLBR = TOTLBR
      TWTR = TOTWTR
      LD1 = LPDY
      JDAY = JDAY + LPDY
      LPDY = NDAY(KPD)
C
C  CALL SUBROUTINE WTREQT   TO OBTAIN IRRIGATION REQUIREMENTS
C
76    CALL WTREQT  (KPD,JDAY,LPDY,IYR,MONTH,NPDK,SLOSS)
C
C  CHECK IF CURRENT PERIOD IS WITHIN IRRIGATION SEASON
       IF(MONTH.GE.MBEG.AND.MONTH.LE.MFIN)GO TO 79
       DO 78 I = 1,NPDK
       SMD(I,1) = SMD(I,1) + RQI(I,1)
       IF (SMD(I,1).GT.CRPDK(I,IDXCRP(I,IYR),KCP(I,1)+1))
     1       SMD(I,1)= CRPDK(I,IDXCRP(I,IYR),KCP(I,1)+1)
C       WRITE(*,*)'FIELD,PRESEASON DEF',I,SMD(I,1)
78     CONTINUE
       GO TO  90
C
C  CALL SUBROUTINE PRIOR TO ESTABLISH IRRIGATION PRIORITIES
C
79     CALL PRIOR(KTPD,JDAY,LPDY,IYR,NPDK)
C
C  ENTER ALLOCATION LOOP
C   CALL SUBROUTINE ALOCAT   TO COMPUTE THE IRRIGATION APPLICATIONS
C   IN THE PERIOD UNDER CONSIDERATION
C
80     CALL ALOCAT  (NDAY(KPD),KTPD,IYR,XLAB,NSYS,NPDK,NTCP,TOTLBR,
     1  TOTWTR,MONTH,MFIN,JDAY,IDS)
90     CONTINUE
C
C  SUMMARIZE PERTINENT DATA FOR EACH YEAR VIA SUBROUTINE YERSUM
C
         CALL YERSUM (IDS,IYR,NTCP,NCRP,NSYS,NPDK,J1,J2,TREQ)
120    CONTINUE
C
C  END OF SUMULATION LOOP
C
       CLOSE(12)
       CLOSE(14)
       CLOSE(15)
       IF(ISHRT .EQ. 2)GOTO 121
       DTITLE = TITLE
       DTITLE(ILEN: )='.LNG'
       OPEN(10,FILE=DTITLE)
       IF(ISHRT .LE. 1)GOTO 125
121    STITLE = TITLE
       STITLE(ILEN: )='.SHT'
       OPEN(20,FILE=STITLE)
C
C  CALL SUBROUTINE SUMOUT TO COMPUTE AND PRINT OUT FINAL SUMMARY
C
125    CALL SUMOUT (NYEAR,TITLE,NTCP,SYSNAM,NP,RINV,RLABC,
     1 RLABI,OMI,FLATP,NPDK,NSYS,CNAME,SUPTIT,IACCST,TREQ,LEPD,NSUP,
     2 ISHRT,K1,NT)
C
321    WRITE(*,1020) DTITLE,STITLE,SYSROT
1020   FORMAT(//' THE JOB IS FINISHED AND OUTPUT DATA ARE IN FILE(S) ',
     1A/52X,A//' INPUT DATA ARE IN FILE ',A//)
       STOP
9901   FORMAT(' THE DATA FILE DOES NOT EXIST!!'/' TRY AGAIN'//)
9902   FORMAT(//' BAD IRRIGATION EFFICIENCY VALUE.  EXECUTION HALTED')
990    WRITE(*,9901)
       GOTO 5
991    WRITE(*,9901)
       GOTO 501
992    WRITE(*,9901)
```

```
      GOTO 502
993   WRITE(*,9901)
      GOTO 503
994   WRITE(*,9902)
      STOP
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      BLOCK DATA
C *****************************************************
C     SUBROUTINE TO INITIALIZE COMMON VARIABLES
C *****************************************************
C
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12)
     & ,RQI(20,2 ),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
C
      DATA MONLEN/31,28,31,30,31,30,31,31,30,31,30,31/
C
      DATA IPDKPR,SMD,  ISF, RQI, JFLG,  ANLSUM, EROS,  YDAT/
     &      40*0,60*0.,40*0,40*0.,1250*0,3600*0.,120*0.,240*0./
C
      DATA MPRIOR/720*0/
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE LOCATE (LUA,LUB,ISTART,ISTOP)
C
C  SUBROUTINE TO LOCATE STARTING RECORDS IN RAINFALL AND PET FILES
C  --LUA = LU OF RAINFALL FILE
C  --LUB = LU OF PET FILE
C  -- ISTART = STARTING YEAR OF SIMULATION
C  -- ISTOP = LAST YEAR OF SIMULATION
C
C  LOOP TO CHECK FOR SUFFICIENT RECORD LENGTH
      DO 10 I = 1,101
         READ(LUA,*,END=80)LYEAR
C        WRITE(*,*)LYEAR
         IF(LYEAR .GT. 100)LYEAR =LYEAR-1900
         IF(LYEAR .EQ. ISTOP)GOTO 11
         READ(LUA,*)
10    CONTINUE
11    REWIND(LUA)
      KK=0
      GOTO 20
C
19    READ(LUA,*)
20    READ(LUA,*,END=80) LYEAR
      IF(LYEAR .GT. 100)LYEAR =LYEAR-1900
      KK=KK+1
      IDIF = ISTART - LYEAR
      IF(IDIF)30,40,19
30    WRITE(*,150) LYEAR
150   FORMAT(' RAINFALL FILE BEGINS WITH 19',I2,'.  >RUN TERMINATED'
     1'<'/1X,80('X'))
      STOP
40    BACKSPACE (LUA)
      IF(KK .EQ. 1)REWIND(LUA)
C
C  LOOP TO CHECK FOR SUFFICIENT RECORD LENGTH
      DO 45 I = 1,101
         READ(LUB,*,END=85)LYEAR
C        WRITE(*,*) LYEAR
         IF(LYEAR .GT. 100)LYEAR =LYEAR-1900
         IF(LYEAR .EQ. ISTOP)GOTO 46
         READ(LUB,*)
45    CONTINUE
46    REWIND(LUB)
      KK=0
      GOTO 50
C
49    READ(LUB,*)
50    READ(LUB,*,END=85) LYEAR
      IF(LYEAR .GT. 100)LYEAR =LYEAR-1900
      KK=KK+1
      IDIF = ISTART - LYEAR
      IF(IDIF) 70,60,49
60    BACKSPACE (LUB)
      IF(KK .EQ. 1)REWIND(LUB)
      GO TO 90
C
70    WRITE(*,160) LYEAR
160   FORMAT(' PET FILE BEGINS WITH 19',I2,'.  >RUN TERMINATED'
     1'<'/1X,80('X'))
      STOP
80    WRITE(*,151) LYEAR
151   FORMAT(' RAINFALL FILE ENDS WITH 19',I2,'. >RUN TERMINATED<'/
     11X,80('*'))
      STOP
85    WRITE(*,161) LYEAR
161   FORMAT(' PET FILE ENDS WITH 19',I2,'. >RUN TERMINATED<'/
     11X,80('*'))
      STOP
```

```
90    RETURN
      END
```

```
C
C
C
C
      SUBROUTINE PETAVE(LUA,APET)
C
C   SUBROUTINE TO DETERMINE HISTORICAL MEAN PET VALUES
C
C
      DIMENSION APET(24),ARRAY(24)
C
      KNT = 0
10    READ(LUA,1001,END=100) (ARRAY(J),J=1,24)
1001  FORMAT(8X,12F7.2/8X,12F7.2)
      DO 20 I = 1,24
20          APET(I) = APET(I) + ARRAY(I)
      KNT = KNT+1
      GOTO 10
C
100   CONTINUE
C      WRITE(*,*)' HISTORICAL MEAN PET'
C      WRITE(*,1001) (APET(J),J=1,24)
      REWIND(LUA)
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE AGRON(NTCP,IDCP,LUN)
C
C  SUBROUTINE AGRON FOR READING AGRONOMIC DATA FOR CROP DATES
C  AND POLYNOMIAL COEFFICIENTS FOR CROP ET CURVES
C  --COEFFICIENTS ARE FOR MODIFIED PENMAN EQUATION AS
C    USED BY THE USDA (1981)
C
C
C  NCP = NUMBER OF CROPS IN CROPS FILE
C  NCROPF = NUMBER OF CROPS IN CROPF FILE
      COMMON/CROPP/ICROPS(6,30),CROPF(30,24),YIELD(8,30)
C
C
C  READ CROPDATE FILE
C  TOTAL NO. OF CROPS -- NTCP
C
      DIMENSION IDCP(30)
C
      DO 10 I=1,NTCP
            II = IDCP(I)
            READ(LUN,1001,REC=II) (ICROPS(J,II),J=1,6),
     &        (CROPF(II,J),J=1,24),(YIELD(J,II),J=3,8)
10    CONTINUE
1001  FORMAT(15X,6I6,28F4.2,17X,2F5.0)
      CLOSE(LUN)
C
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE WTREQT  (KPD,JDAY,NDAY,IYR,MTH,NPDK,SLOSS)
C
C  SUBROUTINE WTREQT   COMPUTES THE NET IRRIGATION REQUIREMENT
C  FOR A GIVEN PERIOD
C    KPD -- NUMBER OF PERIOD WITHIN A MONTH
C    JDAY -- DAY NUMBER OF PERIOD START
C    MDAY -- JULIAN DAY, MIDDLE OF PERIOD
C    NDAY -- NUMBER OF DAYS IN PERIOD
C    IYR -- YEAR NUMBER
C    MTH -- NUMBER OF MONTH WITHIN A YEAR
C    NPDK -- NUMBER OF PADDOCKS
C
      COMMON/CROPP/ICROPS(6,30),CROPF(30,24),YIELD(8,30)
      COMMON/PREC/RAIN(24)
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12),
     & RQI(20,2 ),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
C
C  CRPDK -- CROP-PADDOCK ARRAY
C  IDXCRP -- CROP INDEX ARRAY
C  SMD -- SOIL MOISTURE DEFICIT ARRAY
C
      INTEGER X1(20),X2(20),X3(20),X4(20),X5(20),X6(20),X7(20),X8(20)
      DIMENSION W(20),SLOSS(20,4)
C
C  READ IN DATA FOR JAN - DEC PERIOD
C
      IF(MTH.NE.1.OR.KPD.NE.1) GO TO 20
C
C  READ RAIN AND PET DATA
      READ(14,1104) (RAIN(J),J=1,24)
C      WRITE(*,1104) (RAIN(J),J=1,24)
      READ(15,1104) (PET(J),J=1,24)
1104  FORMAT(8X,12F7.2/8X,12F7.2)
C
20    KTPD = (MTH-1)*2+KPD
      PPET = PET(KTPD)
      PPREC = RAIN(KTPD)
C
C  ASSIGN IRRIGATION STRATEGIES
C
      DO 24 I=1,NPDK
      IX1 = NINT(CRPDK(I,IDXCRP(I,IYR),1))
      IX2 = NINT(CRPDK(I,IDXCRP(I,IYR),5))
      X1(I)=ICROPS(1,IX1)
      X2(I)=ICROPS(2,IX1)
      X3(I)=ICROPS(3,IX1)
      X4(I)=IX1
      X5(I)=ICROPS(1,IX2)
      X6(I)=ICROPS(2,IX2)
      X7(I)=ICROPS(3,IX2)
      X8(I)=IX2
24    CONTINUE
C
C  INITIALIZE PARAMETERS FOR SOIL MOISTURE DEPLETION
C  -- SHAPE FACTOR FOR ET REDUCTION FACTOR (SMFRAC)
C     REF: MINHAS ET AL -- WTR RES RESEARCH 10(3):383-393
      A = 30.
C
      MDAY = JDAY+NINT(NDAY/2.)
C
      DO 60 II=1,2
       IF(II .EQ. 2)THEN
            KTPD = KTPD+1
            IF(KTPD .GT. 24)KTPD = 1
            KTPD2 = KTPD-1
            IF(KTPD2 .LE. 0)KTPD2 = 24
            MDAY = MDAY+NDAY
```

```
             PPREC = 0.
             PPET = PPET*APET(KTPD)/APET(KTPD2)
         END IF
C             WRITE(*,*)' MDAY(WTREQT) = ',MDAY
C
C   ENTER PADDOCK (FIELD) LOOP
C
        DO 60 I=1,NPDK
        DEF = SMD(I,1)
        SMD(I,3) = DEF
        RQX = 0.
        K = 1
        IF(MDAY.GE.X2(I) .AND. MDAY.GE.X5(I)) K = 5
        KCP(I,II) = K
C
C   ACCOUNT FOR EXPANDING ROOT ZONE DEPTH (RZD) IN
C    VEGETATIVE STATE
C     RZD VARIES BETWEEN 0.5 AND 1.0 OF THE ROOT ZONE
        RZD = 1.
        CAN = 0.
        IF (MDAY .LT. X1(I) .OR. MDAY .GT. X2(I))THEN
C       FALL-PLANTED CROP
           IF(X1(I) .GT. X2(I) .AND. MDAY .LT. X2(I))THEN
              RZD = 0.5 + 0.5*FLOAT(MDAY)/FLOAT(X3(I))
              CAN = 1.0 * FLOAT(MDAY)/FLOAT(X3(I))
              GOTO 29
           END IF
           IF(MDAY .LT. X5(I)  .OR.  MDAY .GT. X6(I)) GO TO 29
           IF(X8(I) .EQ. 1) GO TO 29
           IF(X5(I) .EQ. X7(I)) GO TO 29
           RZD = 0.5 + 0.5 * FLOAT(MDAY - X5(I))/ FLOAT(X7(I)-X5(I))
           CAN = 1.0 * FLOAT(MDAY - X5(I))/ FLOAT(X7(I)-X5(I))
        ELSE
C       FALL-PLANTED CROP
           IF(X4(I) .GT. X5(I) .AND. MDAY .GT. X4(I))THEN
              RZD = 0.5
              CAN = 0.0
              GOTO 29
           END IF
           IF(X3(I) .EQ. X1(I)) GO TO 29
           IF(X4(I) .EQ. 1) GO TO 29
           RZD = 0.5 + 0.5 * FLOAT(MDAY-X1(I))/FLOAT(X3(I)-X1(I))
           CAN = 1.0 * FLOAT(MDAY-X1(I))/FLOAT(X3(I)-X1(I))
        END IF
29      RZD = AMIN1(RZD,1.)
        CAN = AMIN1(CAN,1.)
        TAM = CRPDK(I,IDXCRP(I,IYR),K+1) * RZD
        XMAD = CRPDK(I,IDXCRP(I,IYR),K+3)
        BLIM1 = ((XMAD * RZD) + DEF)/2.
        BLIM = AMIN1(BLIM1,XMAD)
        W(I) = (TAM-BLIM)/TAM
        IF(SLOSS(I,4) .LE. 0.001)SLOSS(I,4) = CAN*100.
C        WRITE(*,*)'FLD,PER,RZD,CAN',I,KTPD,RZD,SLOSS(I,4)
C
C
C     SELECTION OF SMFRAC(I)=I(CROP TYPE) AND COMPUTING CROP COEFFICIENTS
C
        IF(MDAY .GE. X1(I) .OR. X1(I) .GT. X2(I))GOTO 30
310     FCROP = CROPF(1,KTPD)
        GO TO 38
C
30      IF(MDAY .GE. X2(I)) GO TO 32
        FCROP =  CROPF(X4(I),KTPD)
        GO TO 36
C
32      IF(X8(I) .EQ. 1) GO TO 310
        IF(MDAY .GE. X5(I)) GO TO 34
        GO TO 310
C
34      IF (MDAY .GT. X6(I) .AND. X5(I) .LT. X6(I)) GO TO 310
```

```
      FCROP = CROPF(X8(I),KTPD)
      GOTO 36
C
C36    SMFRAC=(1.0-EXP(-A*W(I)))/(1.0-2.0*EXP(-A)+EXP(-A*W(I)))
C  ADJUST ET FOR MOISTURE STRESS CONDITIONS
36    SMFRAC = 1.0
      IF(BLIM1 .GE. (XMAD*RZD))SMFRAC = (TAM-BLIM1)/(TAM-XMAD*RZD)
      SMFRAC = AMAX1(SMFRAC,0.0)
      GO TO 39
C  ADJUST ET FOR FALLOW
 38   SMFRAC=W(I)/(2.0-W(I))
 39   CONTINUE
C
C    DETERMINE AET
C
C      IF(X8(I) .EQ. 11)WRITE(*,*)'KC,FLD,PER',FCROP,I,KTPD
      AET = PPET * FCROP*SMFRAC
      ET(I,II) = AET
C
C  DETERMINE EFFECTIVE RAINFALL
C  REF: USDA-SCS TECH. RELEASE #21, 1967
      PMTH = PPREC*2.
      ETMTH = 2.*AET
      EIR = ETMTH-PMTH
      EIR = AMAX1(EIR,0.)
      FF = 0.531747 + 0.295164*EIR - 0.057697*EIR**2 + 0.003804*EIR**3
      PPRECE = (0.70917+PMTH**0.82416 -0.11556)*10**(0.02426*AET)
     &              * FF/2.
      PPRECE = AMIN1(PPRECE,AET,PPREC)
C      WRITE(*,*)'PERIOD,EFFECT RAIN',KTPD,PPRECE
C
C  WATER BALANCE
C
      DEF = DEF + AET - PPRECE
      IF(DEF.LT.0.0) DEF = 0.
      IF(DEF.LT.BLIM) GO TO 45
      IF(MDAY.LT.X1(I) .AND. X1(I).LT.X2(I))GO TO 45
      IF(MDAY.GT.X2(I).AND.MDAY.LT.X5(I))GO TO 45
      IF(MDAY.GT.X6(I) .AND. X5(I).LT.X6(I)) GO TO 45
      RQX = DEF - BLIM
      DEF = BLIM
45    IF(DEF.GT.TAM) DEF = TAM
      IF(RQX .LE. 0.0) THEN
            RQI(I,II) = 0.0
            SMD(I,II) = DEF
            GOTO 59
      END IF
      IF(DEF.LT.CRPDK(I,IDXCRP(I,IYR),K+2)) THEN
            RQI(I,II) = RQX
            SMD(I,II) = DEF
      ELSE
            RQI(I,II) = RQX + DEF - CRPDK(I,IDXCRP(I,IYR),K+2)
            SMD(I,II) = CRPDK(I,IDXCRP(I,IYR),K+2)
      END IF
C59    IF(II .EQ. 1 .AND. RQI(I,II) .GT. 0.000)
C     & WRITE(*,*)'PERIOD,FIELD,REQD WATER,KC',KTPD,I,RQI(I,II),FCROP
59    CONTINUE
60    CONTINUE
C
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE PRIOR(KTPD,JDAY,NDAY,IYR,NPDK)
C
C SUBROUTINE TO SET UP IRRIGATION PRIORITIES FOR FIELDS FOR THE
C SIMULATION PERIOD.
C
      COMMON/CROPP/ICROPS(6,30),CROPF(30,24),YIELD(8,30)
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12),
     & RQI(20,2 ),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
C
      DIMENSION X1(20)
      INTEGER X2(20)
      REAL MAD, MADD
C
      CALL ZERO(X1,20)
      KKTPD = KTPD
      MDAY = JDAY +NINT(NDAY/2.)
      NDAY0 = 15
      DO 100 II = 1,2
         NCPP = 0
         DO 50 I = 1,NPDK
            IX1 = NINT(CRPDK(I,IDXCRP(I,IYR),KCP(I,II)))
C   CHECK FOR FALL PLANTED CROPS
            IF(ICROPS(1,IX1) .GT. ICROPS(2,IX1))GOTO 5
            IF(MDAY.LT.ICROPS(1,IX1) .OR. MDAY.GT.ICROPS(2,IX1))IX1=1
    5       IF(MDAY .GT. ICROPS(4,IX1))GOTO 10
              NKY = 1
              GOTO 40
   10       IF(MDAY .GT. ICROPS(5,IX1))GOTO 20
              NKY = 2
              GOTO 40
   20       IF(MDAY .GT. ICROPS(6,IX1))GOTO 30
              NKY = 3
              GOTO 40
   30       NKY = 4
            IF(ICROPS(1,IX1) .LT. ICROPS(2,IX1))GOTO 40
            IF(MDAY .GT. ICROPS(1,IX1))NKY = 1
   40       DO 45 J = I-1,1,-1
               IF(IX1 .EQ. X2(J))GOTO 50
   45       CONTINUE
            NCPP = NCPP+1
            XX = YIELD(NKY+2,IX1)*YIELD(1,IX1)*YIELD(2,IX1)
            X2(NCPP) = IX1
            ETM = ET(I,II)
            ETMD = ETM/NDAY
            IF(ETM .LE. 0)GOTO 50
            MAD = CRPDK(I,IDXCRP(I,IYR),KCP(I,II)+3)
            AD = CRPDK(I,IDXCRP(I,IYR),KCP(I,II)+2)
            TAM = CRPDK(I,IDXCRP(I,IYR),KCP(I,II)+1)
            MADD = MAD/TAM
C        WRITE(*,*)'MAD,AD,TAM,ETM',MAD,AD,TAM,ETM
            TT = (TAM-SMD(I,3))/ETMD
            TT = AMAX1(TT,MAD/ETMD)
            T = FLOAT(NDAY)
            IF(II .GT. 1)GOTO 48
            IF(SMD(I,3) .GT. AD)THEN
               T = T+NDAY0*(MAD-AD/SMD(I,3))
               T = AMIN1(T,FLOAT(NDAY+NDAY0))
            END IF
   48       IF(TT .LE. T)THEN
               ETA = ETM
               GOTO 49
```

```
            END IF
            X = -1.*ETMD*T/((1.-MADD)*TAM) + MADD/(1.-MADD)
            ETA = TAM/T*(1.-(1.-MADD)*EXP(X))
   49       X1(NCPP) = XX*(1.-ETA/ETM)
C  PRIORITIZE NON-CRIT CROPS BY BUMPING UP PRIOR. FACTOR ON CRIT CROPS
            X1(NCPP) = X1(NCPP)*1.E10
            IF(X1(NCPP) .LE. 0.001)X1(NCPP) = XX
C       WRITE(*,*)'XX,X1(CROP)',XX,X1(NCPP)
   50     CONTINUE
C  SORT CROPS (X2(N)) BY ORDER OF YIELD PARAMETER X1(N)
          DO 70 I = 1,NCPP-1
            XM = X1(I)
            MM = X2(I)
            JM = I
            DO 60 J = I+1,NCPP
              IF(XM .GE. X1(J))GOTO 60
              XM = X1(J)
              MM = X2(J)
              JM = J
   60       CONTINUE
            T1 = X1(JM)
            T2 = X2(JM)
            X1(JM) = X1(I)
            X2(JM) = X2(I)
            X1(I) = T1
            X2(I) = T2
   70     CONTINUE
C  PUT RANKED VALUES INTO MPRIOR MATRIX
          DO 80 I = 1,NCPP
C       WRITE(*,*)' RANK,CRP,VALUE ',I,X2(I),X1(I)
            MPRIOR(I,KKTPD) = X2(I)
            X1(I) = 0.
            X2(I) = 0
   80   CONTINUE
C       WRITE(*,*)
          KKTPD = KKTPD+1
          IF(KKTPD .GT. 24)KKTPD = 1
          MDAY = MDAY+NDAY
  100   CONTINUE
        RETURN
        END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
       SUBROUTINE ALOCAT   (NDY,KTD,IYR,XLAB,NSYS,NPDK,NTCP,TOTLBR,
     1  TOTWTR,MONTH,MFIN,JDAY,IDS)
C      SUBROUTINE ALOCAT   FOR COMPUTING THE EFFECTIVE APPLICATION
C      OF WATER TO EACH PADDOCK IN A 2-WEEK TIME PERIOD
C        NDY -- NO. OF DAYS IN THE PERIOD
C        KTD -- 2-WEEK PERIOD WITHIN A YEAR
C        IYR -- YEAR NO.
C        XLAB -- LABOR CONSTRAINT (HRS/WEEK)
C        NSYS -- NO. OF DIFFERENT APPLICATION SYSTEMS
C        NPDK -- NO. OF PADDOCKS
C        NTCP -- TOTAL NO. OF CROPS (USED FOR ESTABLISHING IRRIGATION
C                PRIORITIES)
C        VRQD -- VOLUME OF WATER REQD BY A PADDOCK -- ACRE-INCHES
C        APPN -- NET VOLUME OF WATER APPLIED (IN)
C        GRQD -- GROSS WATER REQT (AC-IN)
C        SYSVOL -- VOLUME DELIVERED THROUGH A SYSTEM IN A PERIOD
C        ISFLG -- INDEX FLAG FOR SYSTEM CAPACITY
C        TCAP -- TOTAL CAPACITY OF A SYSTEM DURING A PERIOD (AC-IN)
C        K -- SAME AS KCP
C        KPR -- INDEX USED FOR COMPUTING IRRIGATION PRIORITIES
C
C
      COMMON/CROPP/ICROPS(6,30),CROPF(30,24),YIELD(8,30)
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12)
     & ,RQI(20,2 ),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
C
       DIMENSION VRQD(20),APPN(20), GRQD(20) ,SYSVOL(20),ISFLG(20),
     1TCAP(20),KPR(20),IDS(20),RQDLBR(20),RXL(20)
C
C     SET OP INDEX OF IRRIGATION PRIORITIES FOR EACH PADDOCK
C
      KKTD = KTD
      DO 97 II = 1,2
      DO 2 I = 1,NPDK
2     KPR(I) = 0
      LL = 1
      LU = NPDK
      LI = 1
      IF(MOD(KKTD,2).EQ.0) GO TO 4
      LL = NPDK
      LU = 1
      LI = -1
4      IPRR=1
       DO 8 I=1,NTCP
      IF(MPRIOR(I,KKTD).EQ.0) GO TO 9
       DO 6 J=LL,LU,LI
       IF ( NINT(CRPDK(J,IDXCRP(J,IYR),KCP(J,II))).NE.MPRIOR(I,KKTD))
     1             GO TO 6
       IPDKPR(IPRR,II) = J
      KPR(J) = 1
       IPRR = IPRR + 1
6      CONTINUE
8      CONTINUE
9     IF (IPRR.GT.NPDK) GO TO 96
      DO 95 J=LL,LU,LI
      IF(KPR(J).GT.0) GO TO 95
      IPDKPR(IPRR,II) = J
      IPRR = IPRR + 1
95    CONTINUE
96     KKTD = KKTD+1
C      WRITE(*,*)'FIELD PRIORITIES',(IPDKPR(J,II),J=1,NPDK)
```

```
C      WRITE(*,*)'CROPS           ',(MPRIOR(J,KKTD-1),J=1,NPDK)
97     CONTINUE
C
C  BEGIN IRRIGATION ALLOCATION PROCEDURE
C
       TOTWTR =0.
       TOTLBR =0.
       LFLAG  =0
      SP3 = SUPRAM(3)/100.
C    AV = AVAILABLE WATER(AC-IN)
       AV = SUPRAM(1) * REAL(NDY)
C    ALB = AVAILABLE LABOR(HRS)
       ALB = (XLAB/7.) * REAL(NDY)
C     INITIALIZE FOR SYSTEMS
       DO 5 I=1,NSYS
       SYSVOL(I) = 0.
5      ISFLG(I) = 0
C
C   CLEAR ARRAYS
      CALL ZERO(APPN,NPDK)
      CALL ZERO(GRQD,NPDK)
      CALL ZERO(RQDLBR,NPDK)
C
C     COMPUTE IRRIGATION VOLUME AND LABOR REQUIREMENTS
C     AND INITIALIZE APPLICATION ARRAY
C     -- VRQD = VOLUME REQUIRED IN ACRE-INCHES (NET APPLCATION)
C
      DO 10 I = 1,NPDK
       II = IPDKPR(I,1)
C      IDXT - - CROP NO.
       IDXT = IDXCRP(II,IYR)
       ICPXT = NINT(CRPDK(II,IDXT,KCP(II,1)))
       OAE = EAPP(ICPXT,II) * SP3
C     CHECK IF PADDOCK HAS NO CROP (FALLOW)
       IF(ICPXT.EQ.1) GO TO 10
C
C   COMPUTE NET REQUIREMENT(AC-IN)
      VRQD(II) = RQI(II,1) * AREA(II)/EAPP(ICPXT,II)
C
C     COMPUTE GROSS REQUIREMENT(AC-IN)
C
       GRQD(II) = VRQD(II) / SP3
       IF(GRQD(II).EQ.0.0) GO TO 10
       RXL(II)=TLAB(II,1)/(CRPDK(II,IDXT,KCP(II,1)+3)-
     & CRPDK(II,IDXT,KCP(II,1)+2))
C  FALL-PLANTED CROPS
      IF(IDS(IDXSYS(II)) .LE. 2)
     & RXL(II)=TLAB(II,1)/CRPDK(II,IDXT,KCP(II,1)+3)
       RQDLBR(II) = RXL(II) * GRQD(II)*OAE/AREA(II)
10    CONTINUE
C
C     ENTER ALLOCATION LOOP IN ORDER OF PRIORITY FOR ALL PADDOCKS
C
C
      DO 40 I=1,NPDK
       II = IPDKPR(I,1)
C      IDXT - - CROP NO.
       IDXT = IDXCRP(II,IYR)
C      IXS - - SYSTEM INDEX
       IXS = IDXSYS(II)
      ICPXT = NINT(CRPDK(II,IDXT,KCP(II,1)))
      OAE = EAPP(ICPXT,II) * SP3
      TCAP(IXS)=(SYSVAL(1,IXS)  * SYSVAL(2,IXS)/100.)*23.8
     1              * REAL(NDY)
C
C     CHECK IF PADDOCK HAS NO CROP (FALLOW)
      IF(ICPXT.EQ.1) GO TO 40
C
      IF(GRQD(II).EQ.0.0) GO TO 40
      GTEMP = GRQD(II)
```

```
C
C     CHECK SYSTEM, WATER AND LABOR CONSTRAINTS
       IF(ISFLG(IXS).GT.0) GO TO 40
       SYSVOL(IXS) = SYSVOL(IXS) + VRQD(II)
       IF(SYSVOL(IXS) .GT. TCAP(IXS)) THEN
            GRQD(II) = (TCAP(IXS) - (SYSVOL(IXS)-VRQD(II)))/SP3
            ISFLG(IXS) = 1
       END IF
C     CHECK WATER AVAILABILITY
       TOTWTR = TOTWTR + GRQD(II)
       IF(TOTWTR .GT. AV) THEN
C     ----SET SYSTEM CAPACITY FLAG = 0 IF WATER SUPPLY IS LIMITING
            ISFLG(IXS) = 0
            LFLAG = 1
            GTEMP = AV - (TOTWTR - GRQD(II))
            ATEMP = GTEMP * OAE/  AREA(II)
       END IF
C     CHECK LABOR AVAILABILITY
       TOTLBR = TOTLBR + RQDLBR(II)
C      WRITE(*,*)'FLD,RQDLBR,TOTAL,AVAIL',II,RQDLBR(II),TOTLBR,ALB
       IF(TOTLBR .GT. ALB) THEN
C  ----- SET SYSTEM CAPACITY FLAG = 0 IF LABOR IS LIMITING
            ISFLG(IXS) = 0
            APPN(II) = ((ALB-(TOTLBR - RQDLBR(II)))/RXL(II))
            GRQD(II) = APPN(II)*AREA(II) /OAE
            IF(GRQD(II) .LE. GTEMP) THEN
                 LFLAG  = 2
                 GO TO 60
            END IF
       END IF
       IF(LFLAG .LT. 1) THEN
            APPN(II) = GRQD(II) * OAE/ AREA(II)
       ELSE
            GRQD(II) = GTEMP
            APPN(II) = ATEMP
            GO TO 60
       END IF
40     CONTINUE
C
C     COMPUTE SOIL MOISTURE DEFICITS
C
60    DO 70 I=1,NPDK
       MDAY = JDAY + NINT(NDAY/2.)
       IX1 = NINT(CRPDK(I,IDXCRP(I,IYR),KCP(I,1)))
C  FALL-PLANTED CROPS
       IF(ICROPS(1,IX1) .GT. ICROPS(2,IX1))GOTO 601
C
       IF(MDAY.LT.ICROPS(1,IX1) .OR. MDAY.GT.ICROPS(2,IX1))IX1 = 1
C  FIND CROP GROWTH PERIOD (1-4)
601   IF(MDAY .GT. ICROPS(4,IX1))GOTO 61
         NKY = 1
         GOTO 64
61    IF(MDAY .GT. ICROPS(5,IX1))GOTO 62
         NKY = 2
         GOTO 64
62    IF(MDAY .GT. ICROPS(6,IX1))GOTO 63
         NKY = 3
         GOTO 64
63    NKY = 4
      IF(ICROPS(1,IX1) .LT. ICROPS(2,IX1)) GOTO 64
        IF(MDAY .GT. ICROPS(1,IX1))NKY = 1
64    YDAT(IX1,NKY) = YDAT(IX1,NKY)+ET(I,1)
      YDAT(IX1,NKY+4) = YDAT(IX1,NKY+4)+ET(I,1)
      IX2 = MIN0(KCP(I,1),2)
      YDAT2(IX1,I,NKY) = YDAT2(IX1,I,NKY)+ET(I,1)
      YDAT2(IX1,I,NKY+4) = YDAT2(IX1,I,NKY+4)+ET(I,1)
       SMD(I,1) = SMD(I,1) + RQI(I,1) - APPN(I)
       D = CRPDK(I,IDXCRP(I,IYR),KCP(I,1)+1)
       IF(SMD(I,1) .GT. D)SMD(I,1) = D
C
```

```
      IF(ET(I,1) .LE. 0.)GOTO 65
      IF(SMD(I,1) .GT. CRPDK(I,IDXCRP(I,IYR),KCP(I,1)+3))
     &      CALL STRESS(I,IDXCRP(I,IYR),KCP(I,1),IX1,NDY,NKY)
C
C65    CONTINUE
65     IF(I .NE. 6)GOTO 70
C       WRITE(*,*)'FIELD,PERIOD',I,KTD
C       WRITE(*,*)'REQUIRED,APPLIED,SMD',RQI(I,1),APPN(I),SMD(I,1)
C       WRITE(*,*)
70     CONTINUE
C
C      SET UP SUMMARY ARRAY
C
       DO 80 I = 1,NPDK
        PDSUM(1,I,KTD) = I
        PDSUM(2,I,KTD) = CRPDK(I,IDXCRP(I,IYR),KCP(I,1))
        PDSUM(3,I,KTD) = RQI(I,1)
        PDSUM(4,I,KTD) = APPN(I)
        PDSUM(5,I,KTD) = GRQD(I)
        PDSUM(6,I,KTD) = 0.
        PDSUM(7,I,KTD) = RQDLBR(I)
80     CONTINUE
C
C      FLAG CONSTRAINTS
        JFLG(KTD,IYR) = LFLAG
C
C      FLAG SYSTEM CHARACTERISTICS
C
        DO 90 I=1,NSYS
        SYSV(I,1) = SYSVOL(I)
        ISF(I,1) = ISFLG (I)
90      ISFLAG(I,KTD) = ISFLG(I)
C
C CHECK NEXT PERIOD FOR POTENTIAL PROBLEMS AND INCREASE IRRIGATION
C APPLICATION IN PRESENT PERIOD AS APPLICABLE
C
      IF(LFLAG .GT. 0)GOTO 99
      MMONTH = MONTH
      IF(MOD(KTD,2) .EQ. 0)MMONTH = MMONTH+1
      NDAY2 = MONLEN(MMONTH)/2
      IF(MMONTH .GT. MFIN)GOTO 99
      IF(MMONTH .EQ. MONTH)NDAY2 = MONLEN(MONTH)-NDY
C
      CALL FORCST(KTD,NPDK,NDAY2,IYR,XLAB,AV,ALB,TCAP,TOTWTR,TOTLBR,
     & SYSVOL,NSYS,IDS)
99     RETURN
       END
```

```
C
C
      SUBROUTINE STRESS(I,II,III,NCP,NDAY,NKY)
C
C  SUBROUTINE TO ADJUST ACTUAL ET TO ACCOUNT FOR REDUCTION DUE TO
C  MOISTURE STRESS.  ASSUMES NO STRESS OCCURS IF SOIL MOISTURE LEVELS
C  ARE MAINTAINED ABOVE MANAGEMENT ALLOWED DEFICIT (MAD) LEVELS.
C
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12)
     & ,RQI(20,2 ),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
C
      REAL MAD
C
      ETRATE = ET(I,1)/NDAY
      MAD = CRPDK(I,II,III+3)
      TAM = CRPDK(I,II,III+1)
      SDAY1 = ANINT(SMD(I,1)-MAD)/ETRATE
      SDAY0 = NDAY-SDAY1
      ETSTRS = (TAM-SMD(I,1))/(TAM-MAD)*ETRATE
      ET2 = SDAY0*ETRATE + SDAY1*ETSTRS
C       WRITE(*,*)' SMD1,SMD2',SMD(I,1),SMD(I,1)-ET(I,1)+ET2
C       WRITE(*,*)'CROP,ET,ET2,PERIOD',NCP,ET(I,1),ET2,NKY
C  READJUST SOIL WATER BALANCE FOR REDUCED ET
      SMD(I,1) = SMD(I,1)-ET(I,1)+ET2
      SMD(I,1) = AMAX1(0.,SMD(I,1))
C  READJUST ETACT TOTAL FOR PERIOD
      YDAT(NCP,NKY) = YDAT(NCP,NKY)+ET2-ET(I,1)
      IC = MIN0(III,2)
      YDAT2(NCP,I,NKY) = YDAT2(NCP,I,NKY)+ET2-ET(I,1)
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE FORCST(KTD,NPDK,NDY,IYR,XLAB,AV,ALB,TCAP,TWTR1,TLBR1,
     & SYSV1,NSYS,IDS)
C
C SUBROUTINE TO PREDICT POSSIBLE IRRIGATION LIMITATIONS IN SUBSEQUENT
C PERIOD AND RECTIFY BY WATERING AHEAD IN CURRENT PERIOD.
C
C     ICPXT - CROP INDEX NUMBER
C     IXS   - SYSTEM INDEX NUMBER
C     SYSVOL - CUMULATIVE SYSTEM VOLUME
C     TCAP - TOTAL SYSTEM CAPACITY(AC-IN)
C
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12),
     & RQI(20,2),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
C
      DIMENSION SYSVOL(20),TCAP(20),RXL(20),VRQD(20),GRQD(20),
     & APPN(20),SYSV1(20),ISFLG(20),IDS(20)
C
C  FORECAST TOTAL FARM DEFICIT, IRRIGATION TOTALS
C
      TOTVOL = 0.
      TOTLAB = 0.
      CALL ZERO(APPN,NPDK)
      CALL ZERO(GRQD,NPDK)
      DO 6 I=1,NSYS
         ISFLG(I) = 0
         IF(ISFLAG(I,KTD).EQ.1)ISFLG(I)=1
    6    SYSVOL(I) = 0.
      AVWAT = SUPRAM(1) * REAL(NDY)
      AVLAB = (XLAB/7.)*REAL(NDY)
      DO 10 I=1,NPDK
            II = IPDKPR(I,2)
            IXS = IDXSYS(II)
            IDXT = IDXCRP(II,IYR)
            ICPXT = NINT(CRPDK(II,IDXT,KCP(II,2)))
            IF(ICPXT .EQ. 1)GOTO 10
            PDKVOL = RQI(II,2)*AREA(II)/EAPP(ICPXT,II)
            TOTVOL = TOTVOL+PDKVOL
            SYSVOL(IXS) = SYSVOL(IXS)+PDKVOL
            RXL(II)=TLAB(II,1)/
     &       (CRPDK(II,IDXT,KCP(II,2)+3)-CRPDK(II,IDXT,KCP(II,2)+2))
C     SURFACE SYSTEMS
            IF(IDS(IDXSYS(II)) .LE. 2)
     &            RXL(II)=TLAB(II,1)/CRPDK(II,IDXT,KCP(II,2)+3)
            TOTLAB = TOTLAB + RXL(II)*RQI(II,2)
   10 CONTINUE
      TOTVOL = TOTVOL/(SUPRAM(3)/100.)
C
C    CHECK FOR TOTAL VOLUME, SYSTEM CAPACITY, AND LABOR PROBLEMS.
C    ADD TO IRRIGATION REQUIREMENTS AS NEEDED IN ORDER OF
C    SUBSEQUENT PERIOD PRIORITIES.
C
      DO 40 I = 1,NPDK
            II = IPDKPR(I,2)
            IXS = IDXSYS(II)
            IDXT = IDXCRP(II,IYR)
            ICPXT = NINT(CRPDK(II,IDXT,KCP(II,2)))
            ICPXT1 = NINT(CRPDK(II,IDXT,KCP(II,1)))
            IF(ICPXT1 .EQ. 1)GOTO 40
            AD = CRPDK(II,IDXCRP(II,IYR),KCP(II,1)+2)
C
            IF(AD .LE. 0.)GOTO 40
C  CHECK TOTAL VOLUME
            IF(TOTVOL .LE. AVWAT) GOTO 20
                  GOTO 35
```

```
C  CHECK SYSTEM CAPACITY
   20        IF(SYSVOL(IXS) .LE. TCAP(IXS)) GOTO 30
                   GOTO 35
C  CHECK LABOR AVAILABILITY
   30        IF(TOTLAB .LE. AVLAB) GOTO 40
                   GOTO 35
C
C  -- CHECK FEASIBILITY OF WATERING AHEAD IN PERIOD --
C
   35        SP3 = SUPRAM(3)/100.
             OAE = EAPP(ICPXT1,II)*SP3
C
C   COMPUTE ADD'L NET REQUIREMENT
             VRQD(II) = AD*AREA(II)/EAPP(ICPXT1,II)
C
C   COMPUTE ADD'L GROSS REQUIREMENT
C
             GRQD(II) = VRQD(II) / SP3
             GTEMP = GRQD(II)
C
C     CHECK SYSTEM, WATER AND LABOR CONSTRAINTS
             IF(ISFLG(IXS) .GT. 0)GOTO 40
             SYSV1(IXS) = SYSV1(IXS) + VRQD(II)
             IF(SYSV1(IXS) .GT. TCAP(IXS))THEN
                GRQD(II) = (TCAP(IXS) - (SYSV1(IXS)-VRQD(II)))/SP3
                ISFLG(IXS) = 1
C IF(GRQD(II).LT.  0.)WRITE(*,*)'!!!!TCAP,SYSV,VRQD,II,IXS',
C     &TCAP(IXS),SYSV1(IXS),VRQD(II),II,IXS
             END IF
C     CHECK WATER AVAILABILITY
             TWTR1 = TWTR1 + GRQD(II)
             IF(TWTR1 .GT. AV) THEN
                LFLAG = 1
                ISFLG(IXS) = 0
                GTEMP = AV - (TWTR1 - GRQD(II))
                ATEMP = GTEMP * OAE/  AREA(II)
C       IF(ATEMP.LT.0.)WRITE(*,*)'G,AV,TWT,GRQ',GTEMP,AV,TWTR1,GRQD(II)
             END IF
C     CHECK LABOR AVAILABILITY
             TLBB = RXL(II)*GRQD(II)*OAE/AREA(II)
             TLBR1 = TLBR1 + TLBB
             IF(TLBR1 .GT. ALB) THEN
                ISFLG(IXS) = 0
                APPN(II) = ((ALB-(TLBR1 - TLBB))/RXL(II))
                GRQD(II) = APPN(II)*AREA(II) /OAE
                IF(GRQD(II) .LE. GTEMP) THEN
                   LFLAG  = 2
                   GO TO 60
                END IF
             END IF
             IF(LFLAG .LT. 1) THEN
                APPN(II) = GRQD(II) * OAE/ AREA(II)
              ELSE
                GRQD(II) = GTEMP
                APPN(II) = ATEMP
                GO TO 60
             END IF
             TWTR1 = TWTR1 - AD*AREA(II)/OAE
             SYSV1(IXS) = SYSV1(IXS)-AD*AREA(II)/EAPP(ICPXT1,II)
             TLBR1 = TLBR1 - AD*RXL(II)
40      CONTINUE
C
C     UPDATE SOIL MOISTURE DEFICITS
C
60    DO 70 I=1,NPDK
C      WRITE(*,*)' FIELD, ADD. WATER',I,APPN(I)
      IF(APPN(I).LT.0.)THEN
             WRITE(*,*)'LFLAG,ISFLG(I),YEAR =',LFLAG,ISFLG(I),IYR
             STOP
      END IF
```

```
       SMD(I,1) = SMD(I,1) - APPN(I)
       SMD(I,1) =  AMAX1(SMD(I,1),0.)
70    CONTINUE
C     UPDATE SUMMARY ARRAY
C
      DO 80 I = 1,NPDK
       PDSUM(4,I,KTD) = PDSUM(4,I,KTD)+APPN(I)
       PDSUM(5,I,KTD) = PDSUM(5,I,KTD)+GRQD(I)
       PDSUM(6,I,KTD) = APPN(I)
80    CONTINUE
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE YERSUM (IDS,IYR,NCP,NCRP,NSYS,NPDK,J1,J2,TREQ)
C
C  SUBROUTINE YERSUM  IS USED TO SUMMARIZE PERTINENT DATA FOR
C  EACH 2-WEEK PERIOD FOR EACH YEAR
C
C    IYR -- COUNTER NUMBER OF CURRENT YEAR
C    NCP -- TOTAL NUMBER OF CROPS
C    NCRP -- NUMBER OF YEARS IN ROTATION
C    NSYS -- TOTAL NUMBER OF SYSTEMS
C    NPDK -- TOTAL NUMBER OF PADDOCKS
C    WCA -- WORKING ARRAY USED TO BUILD ANNSUM ARRAY
C    ISCNT -- INDEX INDICATING AN APPLICATION SYSTEM APPLIES
C             WATER IN A HALF-MONTHLY PERIOD
C
C
      DIMENSION WCA(8),ISCNT(20),TREQ(24),NCRP(20),IDS(20),ICFLG(20,30)
     &,APPSUM(20,30)
C
      COMMON/CROPP/ICROPS(6,30),CROPF(30,24),YIELD(8,30)
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12),
     & RQI(20,2 ),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
C
C  SUMMARY DATA ARE STORED IN ARRAY ANNSUM
C
C  --CLEAR ARRAY ON FIRST ACCESS
C
      IF(IYR.GT.1) GO TO 10
      CALL ZERO(TREQ,24)
      CALL ZERO(TOTIRG,20)
      DO 8 I=1,24
      DO 5 J=1,30
      DO 5 K=1,11
5     ANNSUM(K,J,I) = 0.
      DO 6 J=1,3
      DO 6 K=1,50
6     ANLSUM(J,I,K) = 0.
      DO 8 J=1,20
      DO 8 K=1,3
8     SYSUM(K,J,I) = 0.
C
C  SUMMARIZE DATA BY PERIOD
C
10    DO 9 I=1,20
       DO 9 J=1,30
         APPSUM(I,J)=0
9        ICFLG(I,J)=0
      DO 70 ID =1,24
      IF(ID.LT.J1.OR.ID.GT.J2) GO TO 70
      I = ID
      IC = 0
      IRRR = IYR
      DO 14 IK = 1,20
14    ISCNT(IK) = 0
      TWR1 = 0.
C
C  ENTER LOOP TO COLLATE DATA FROM EACH PADDOCK FOR EACH CROP
C
      DO 40 IX = 1,NCP
      IC = IDCP(IX)
      J = 0
C  CLEAR WORKING ARRAY
```

```
      CALL ZERO(WCA,8)
C  LOOP FOR EACH PADDOCK
      DO 30 IP=1,NPDK
      IF(NINT(PDSUM(2,IP,ID)).NE.IC) GO TO 30
C     SAVE DATA FOR FIELD/CROP SUMMARY
      ICFLG(IP,IC) = 1
      H2ODEF = PDSUM(3,IP,ID)-PDSUM(4,IP,ID)
      FLDCRP(IP,IC,1) = FLDCRP(IP,IC,1)+AMAX1(0.0,H2ODEF)
      IF(PDSUM(3,IP,ID) .LE. 0.01)GOTO 27
      DEFLAB = 0.
      IF(ISFLAG(IDXSYS(IP),ID).LE. 0 .AND. JFLG(ID,IYR) .EQ. 2)
     & DEFLAB = PDSUM(7,IP,ID)*(1.-PDSUM(4,IP,ID)/PDSUM(3,IP,ID))
      FLDCRP(IP,IC,3) = FLDCRP(IP,IC,3)+AMAX1(0.0,DEFLAB)
C
27     APPSUM(IP,IC) = APPSUM(IP,IC)+PDSUM(4,IP,ID)
      IXXX = IDXCRP(IP,IRRR)
      J = 2
      K = KCP(IP,1)
      IF(IDS(IDXSYS(IP)) .LE. 2)THEN
C       SURFACE SYSTEM
        TOTIRG(IP) = TOTIRG(IP) + PDSUM(4,IP,ID)/
     1            CRPDK(IP,IXXX,K+3)
      ELSE
C       SPRINKLER SYSTEM
        TOTIRG(IP) = TOTIRG(IP) + PDSUM(4,IP,ID)/(CRPDK(IP,IXXX,K+3)
     1            -CRPDK(IP,IXXX,K+2))
      END IF
      WCA(1) = WCA(1) + PDSUM(3,IP,ID) * AREA(IP)
      WCA(2) = WCA(2) + AREA(IP)
      WCA(3) = WCA(3) + PDSUM(4,IP,ID) * AREA(IP)
      IF(WCA(1).LE.0.1) GOTO 28
       WCA(4)=1.
       TWR1 = 1.
       ISCNT(IDXSYS(IP)) = 1
28    WCA(7) = 1.
      TMP = PDSUM(3,IP,ID) - (PDSUM(4,IP,ID) + 0.1)
      IF(TMP.LE.0.0) GO TO 29
      WCA(5) = 1.
29    WCA(6) = WCA(6) + PDSUM(6,IP,ID)* AREA(IP)
      IF(PDSUM(6,IP,ID).GT.0.)WCA(8) = 1.
30    CONTINUE
C
      IF (J.LT.1) GO TO 40
C  --NET REQUIREMENT (BY CROP)
      ANNSUM(1,IC,I) = ANNSUM(1,IC,I) + WCA(1)/WCA(2)
C          (BY PERIOD)
C      ANLSUM(1,I,IYR) = ANLSUM(1,I,IYR) + WCA(1)/WCA(2)
C  --NET APPLICATION (BY CROP)
      ANNSUM(2,IC,I) = ANNSUM(2,IC,I) + WCA(3)/WCA(2)
C          (BY PERIOD)
C      ANLSUM(2,I,IYR) = ANLSUM(2,I,IYR) + WCA(3)/WCA(2)
C  --NET SUPPLEMENTAL APPLICATION
      SUPP = WCA(6)/WCA(2)
C      IF(SUPP .GT. 0.)WRITE(*,*)'ADDED WATER =',SUPP
      ANNSUM(3,IC,I) = ANNSUM(3,IC,I) + SUPP
C  --MAXIMUM DEFICIT
      DEF =(WCA(1) - WCA(3))/ WCA(2)
      DEF = AMAX1(DEF,0.0)
      IF(ANNSUM(4,IC,I).LT.DEF) ANNSUM(4,IC,I) = DEF
C  --NET DEFICIT
      ANNSUM(10,IC,I) = ANNSUM(10,IC,I) + DEF
C  --SUM SQUARES TO OBTAIN STD. DEVIATION OF DEFICITS
      ANNSUM(11,IC,I) = ANNSUM(11,IC,I) + (DEF*DEF)
C  --MAX SUPPLEMENTAL APPLICATION
      IF(ANNSUM(5,IC,I).LT.SUPP) ANNSUM(5,IC,I) = SUPP
C  --NO. OF TIMES CROP APPEARS
      ANNSUM(6,IC,I) = ANNSUM(6,IC,I) + WCA(7)
C  --NO. OF TIMES CROP REQUIRES WATER
      ANNSUM(7,IC,I) = ANNSUM(7,IC,I) + WCA(4)
C  --NO. OF TIMES WATER DEMANDS ARE NOT MET
```

```
      ANNSUM(8,IC,I) = ANNSUM(8,IC,I) + WCA(5)
C  --NO. OF TIMES REALLOCATED WATER IS ADDED
      ANNSUM(9,IC,I) = ANNSUM(9,IC,I) + WCA(8)
C
40    CONTINUE
C
C  ---TOTAL NO. OF TIMES WATER IS REQUIRED IN PERIOD I
      TREQ(I) = TREQ(I) + TWR1
C
C  SUMMARIES FOR EACH SYSTEM IN SUMMARY ARRAY
C
      DO 60 IS = 1,NSYS
C
C  CLEAR WORKING ARRAY
      CALL ZERO(WCA,8)
C
C  SUM TOTAL SYSTEM FLOW
      DO 50 IP =1,NPDK
      IF(IDXSYS(IP).NE.IS) GO TO 50
      WCA(1) = WCA(1) + PDSUM(5,IP,ID) * SUPRAM(3)/100.
      IF(ISFLAG(IS,ID).GT.0) WCA(2)=1.
50    CONTINUE
C
C  SUMMARIZE DATA FOR EACH SYSTEM
C  --TOTAL VOLUME ENTERING SYSTEM
      SYSUM(1,IS,I) = SYSUM(1,IS,I) + WCA(1)
C  --NUMBER OF TIMES SYSTEM IS REQUIRED
      SYSUM(2,IS,I) = SYSUM(2,IS,I) + REAL(ISCNT(IS))
C  --NUMBER OF TIMES SYSTEM SIZE IS LIMITING
      SYSUM(3,IS,I) = SYSUM(3,IS,I) + WCA(2)
60    CONTINUE
C
      DO 65 IP = 1,NPDK
C ==>TOTAL NET IRRIG. REQT. FOR PERIOD
      ANLSUM(1,I,IYR) = ANLSUM(1,I,IYR) + PDSUM(3,IP,I)*AREA(IP)
C ==>TOTAL IRRIG. APPLICATION FOR PERIOD
      ANLSUM(2,I,IYR) = ANLSUM(2,I,IYR) + PDSUM(4,IP,I)*AREA(IP)
C ==>TOTAL GROSS WATER REQT. FOR PERIOD
      ANLSUM(3,I,IYR) = ANLSUM(3,I,IYR) + PDSUM(5,IP,I)
C -->AVERAGE IRRIGATION PRIORITY
      IC = MPRIOR(IP,I)
      IF(IC .LT. 1)GOTO 65
      ANNSUM(12,IC,I) = ANNSUM(12,IC,I)+IP
      MPRIOR(IP,I) = 0
C
65    CONTINUE
70    CONTINUE
      DO 80 IP=1,NPDK
C     CALL USLE SUBROUTINE FOR SPRINKLER IRRIGATED FIELDS
         ITYPE =IDS(IDXSYS(IP))
         CALL USLE(IP,IYR,NCRP,ITYPE,APPSUM)
C  ESTIMATE YIELD REDUCTIONS FOR FIELD/CROP SUMMARY
         DO 75 J = 1,NCP
            IC = IDCP(J)
            IX1 = NINT(CRPDK(IP,IDXCRP(IP,IYR),1))
            IX2 = NINT(CRPDK(IP,IDXCRP(IP,IYR),5))
            IF(IC .EQ. 1 .OR. ICFLG(IP,IC) .NE. 1)GOTO 75
            K = 1
C  FALL-PLANTED CROPS - ASSUME NO YIELD REDUCTION DURING FIRST FALL
         IF(IC .EQ. IX2 .AND. ICROPS(1,IX2) .GT. ICROPS(2,IX2))GOTO 75
C  COUNT FALL PLANTED CROPS IN HARVEST YEAR ONLY
            FLDCRP(IP,IC,2) = FLDCRP(IP,IC,2)+1.
            FLDCRP(IP,IC,4) = FLDCRP(IP,IC,4)+1.
            CALL ZERO(WCA,6)
            DO 72 II = 1,4
             WCA(II)=(YDAT2(IC,IP,II+4)-YDAT2(IC,IP,II))*YIELD(II+2,IC)
             WCA(5) = WCA(5)+WCA(II)
             WCA(6) = WCA(6)+YDAT2(IC,IP,II+4)
72          CONTINUE
         FLDCRP(IP,IC,7) = FLDCRP(IP,IC,7)+WCA(5)/WCA(6)*100.
```

```
           FLDCRP(IP,IC,8) = FLDCRP(IP,IC,8)+1.
75         CONTINUE
80      CONTINUE
C   CLEAR SOIL MOISTURE DEFICIT FOR NEXT YEAR
        DO 90 I = 1,NPDK
          DO 90 J = 1,3
90          SMD(I,J) = 0.
95      RETURN
        END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE USLE(IP,IYR,NCRP,ITYPE,APSUM)
C
C
C SUBROUTINE USLE DETERMINES CROP DEPENDENT PARAMETERS AND COMPLETES
C CALCULATIONS FOR ESTIMATED ANNUAL SOIL LOSS UNDER SPRINKLER
C IRRIGATION.  ORIGINAL USLE PROGRAM FOR SPRINKLER IRRIGATION SOIL
C EROSION WRITTEN BY P. KOLUVEK AND T. SPOFFORD, USDA-SCS.
C
      COMMON/CROPP/ICROPS(6,30),CROPF(30,24),YIELD(8,30)
      COMMON/H2OREQ/PET(24),CRPDK(20,30,8),IDXCRP(20,50),MONLEN(12),
     & RQI(20,2 ),KCP(20,2),SMD(20,3),APET(24),ET(20,2)
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
C
      DIMENSION NCRP(20),APSUM(20,30)
C
      DO 50 K=1,5,4
C FIND CURRENT CROP
      IC = NINT(CRPDK(IP,IDXCRP(IP,IYR),K))
      IF(IC .EQ. 1 .AND. K .EQ. 5)GOTO 50
      IF(K .GT. 1 .AND. ICROPS(1,IC) .GT. ICROPS(2,IC))GOTO 50
      IF(ITYPE .LE. 2)GOTO 10
C FIND PREVIOUS CROP
      K2 = 5
      IF(K .EQ. 5)K2 = 1
      IY2 = MOD(IYR-1,NCRP(IP))
      IF(IY2 .LT. 1)IY2 = NCRP(IP)
      IC2 = NINT(CRPDK(IP,IDXCRP(IP,IY2),K2))
      IF(K2.EQ.5)THEN
         IF(IC2.EQ.1 .OR. ICROPS(1,IC2) .GT. ICROPS(2,IC2))
     &     IC2 =NINT(CRPDK(IP,IDXCRP(IP,IY2),1))
      END IF
C COLLECT NECESSARY DATA FOR CALCULATIONS
C       WRITE(*,*)' USLE CROP #, LAST CROP #',IC,IC2
      RES = YIELD(8,IC2)
      CANULT = YIELD(7,IC)
      CAN = SLOSS(IP,4)
C       WRITE(*,*)'RES, CANULT, CAN',RES, CANULT, CAN
C ANNUAL SOIL LOSS CALCULATIONS
      CULT = CANULT*(.5+.5*SIN((3.03*CAN/CANULT-1.47)*3.14159/180.))
      CMIN = 35.
      CMAX = 50.
      CUSLE = CULT/CMAX*100.
      CRS = CMIN/CULT
      RE = SLOSS(IP,2)*CRS
      RE = AMAX1(RE,0.0)
      IF(RE .GT. 0.0)RE1 = 0.1*RE/100.
      RS = RE1+SLOSS(IP,1)
      C1 = 0.1374*RES**0.8439
      C2 = (C1+CUSLE)-(CUSLE*C1)/100.
      C = EXP(-0.025*C2)
C       WRITE(*,*)'FIELD,TONS/ACRE',IP,C*RS*SLOSS(IP,3)
      EROS(IC,1) = EROS(IC,1) + C*RS*SLOSS(IP,3)
      EROS(IC,2) = EROS(IC,2) + 1.
C
C  ANNUAL NITROGEN PERCOLATION CALCULATIONS
C N-PERCOLATION FUNCTION: ADAPTED FROM 'TECHNICAL NOTES, USDA-SCS,
C WTSC, PORTLAND, OR, MARCH, 1981.
10    PERC = (0.029*1.3*(APSUM(IP,IC)*DP(IC,IP))**0.7)*100.
      EROS(IC,3) = EROS(IC,3) + PERC
      EROS(IC,4) = EROS(IC,4) + 1.
C             WRITE(*,*)' FIELD, %N LOSS,TOTL',IP,PERC,EROS(IC,3)
C             WRITE(*,*)' APPSUM,DP',APSUM(IP,IC),DP(IC,IP)
```

```
      FLDCRP(IP,IC,5) = FLDCRP(IP,IC,5) + PERC
      FLDCRP(IP,IC,6) = FLDCRP(IP,IC,6) + 1.
50    CONTINUE
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE SUMOUT(NYEAR,TITLE,NCP,SYSNAM,NP,RINV,RLABC,
     1RLABI,OMI,FLATP,NPK,NSYS,CNAME,SUPTIT,IACCST,TREQ,LEPD,NSUP,
     2ISHRT,K1,NT)
C
C
C  SUBROUTINE SUMOUT IS USED TO GENERATE AND PRINT OUTPUT SUMMARIES
C  FOR EACH SYSTEM AND EACH CROP
C
C    NYEAR -- NUMBER OF YEARS IN THE SIMULATION
C    NPK -- NUMBER OF PADDOCKS
C    ITOT -- WORKING ARRAY FOR COMPUTING SEASONAL TOTALS (INTEGER)
C    IOUT -- WORKING ARRAY FOR OUTPUT OF VALUES AS INTEGERS
C    TREQ -- TOTAL NO. OF TIMES AN APPLICATION SYSTEM IS REQUIRED
C            IN A PERIOD THROUGHOUT THE ENTIRE SIMULATION
C    TTL -- TOTAL NO. OF TIMES LABOR CONSTRAINTS APPLY FOR ANY PERIOD
C    TTW -- TOTAL NO. OF TIMES WATER CONSTRAINTS APPLY FOR ANY PERIOD
C    PCP -- PERCENT OF TOTAL WATER PUMPED THAT IS PUMPED BY ANY PUMP
C    EL -- ARRAY FOR ENRGY USED IN DIFFERENT BLOCKS USED FOR
C          COMPUTING TOTAL PUMPING COST.  INCLUDES CONSTANTS.
C
C
C
      COMMON/CROPP/ICROPS(6,30),CROPF(30,24),YIELD(8,30)
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
      COMMON/PUMPP/NAPMP(21),IDXPMA(10,21),PWRPMP(20),QPMP(20),
     & TPUMP(20)
      COMMON/SYSTUM/WCOST(10),NPKSYS(20),IPSYS(20,20)
C
      DIMENSION ITOT(10),IOUT(40,30),TREQ(24),TTW(24),TTL(24),PCP(40),
     1HRTOT(24),EL(12),ROUT(15,24),RTOT(15),IACCST(4,20,31),YSUM(3,30)
     2,ISUM(20,10),K1(20),NT(20,30),SYSHRS(20),SYSKWH(20),IC(5)
      CHARACTER*3 MNAME(12)
      CHARACTER*20 SYSNAM(20),SUPTIT,CNAME(30)*16
C
      CHARACTER*24  TITLE

      DATA MNAME/'JAN','FEB','MAR','APR','MAY','JUN','JUL','AUG','SEP',
     1'OCT','NOV','DEC'/
      DATA HRTOT/15,16,14,14.25,15,16,15,15,15,16,15,15,
     2 15,16,15,16,15,15,16,15,15,15,15,16/
C
C     WRITE A DESCRIPTIVE TITLE IN THE OUTPUT FILE
C
      IF(ISHRT .EQ. 2)GOTO 4
      WRITE(10,1000) TITLE,NYEAR
1000  FORMAT(//' IRRIGATION SIMULATION OUTPUT FOR'/1X,A//
     1' SUMMARIES ARE GIVEN FOR: '/
     2'    1. ADEQUACY OF IRRIGATION FOR ALL CROPS'/
     3'    2. IRRIGATION WATER USE'/
     4'    3. IRRIGATION SYSTEM PERFORMANCE AND COST'/
     5'    4. RESULTS ARE BASED ON ',I2,' YEARS RECORDS FOR'/
     6'       RAINFALL AND PET DATA')
C
4     RRINV = RINV
      RINV = RINV/100.
C
C  CLEAR NECESSARY ARRAYS
      CALL ZERO(TTW,24)
      CALL ZERO(TTL,24)
      DO 5 I=1,3
      DO 5 J=1,30
5       YSUM(I,J) = 0.
```

```
C
C  OUTPUT SUMMARIES FOR EACH CROP IRRIGATED
C
      DO 40 IX = 1,NCP
      I = IDCP(IX)
      IF(I .EQ. 1)GOTO 40
      DO 12 IPX=1,24
      IF(ANNSUM(6,I,IPX).GT.0.01) GO TO 18
12    CONTINUE
      GO TO 40
C
18    IF(ISHRT .EQ. 2)GOTO 20
      WRITE (10,1001) CNAME(I)
1001  FORMAT (///' CROP SUMMARY RESULTS FOR ',A,/
     1 1X,38('=')/)
      WRITE (10,1002)(MNAME(J),J=1,6)
1002  FORMAT(' ---- MONTH ----->', 6(7X,A)/
     1' ---- HALF ------>  ', 6('  1ST  2ND')/
     2 1X, 79('-'))
C
C  COMPUTE AND SET UP SUMMARY ARRAY
C  --OUTPUT IS IN REAL FORM
C
C  ---CLEAR ARRAY FOR SEASONAL TOTALS
C
20    CALL ZERO(RTOT,8)
C
      DO 30 J = 1,24
C  --AVE WATER REQT
      ROUT(1,J) = 0.
      ROUT(9,J) = 0.
      IF(ANNSUM(6,I,J).LT.0.1) GO TO 21
      ROUT(1,J) = ANNSUM(1,I,J)/ANNSUM(6,I,J)
      ROUT(9,J) = 100.*(ANNSUM(7,I,J)/ANNSUM(6,I,J))
C  --AVE WATER REQT WHEN IRRIGATION IS REQUIRED
21    DO 22 JJ = 2,5
22      ROUT(JJ,J) = 0.
      ROUT(10,J) = 0.
      ROUT(11,J) = 0.
C          IF(I .EQ. 1 .AND. ANNSUM(1,I,J).GT. 0.)THEN
C           WRITE(*,*)'PROBLEM!!!!!!!!!(SO)'
C             WRITE(*,*)'PERIOD,AMT',J,ANNSUM(1,I,J)
C          END IF
      IF(ANNSUM(7,I,J).LT.0.1) GO TO 23
      ROUT(2,J) = ANNSUM(1,I,J)/ANNSUM(7,I,J)
C  --AVE IRRIG APPLICATION WHEN IRRIG IS REQD
      ROUT(3,J) = ANNSUM(2,I,J)/ANNSUM(7,I,J)
C  --% OF TIME REQT > APPLIED
      ROUT(4,J) = 100.*(ANNSUM(8,I,J)/ANNSUM(7,I,J))
C  --AVE SHORTFALL WHEN SHORTFALL OCCURS
      IF(ANNSUM(8,I,J).LT.0.1) GO TO 23
      TEX = (ANNSUM(10,I,J)/ANNSUM(8,I,J))
      ROUT(5,J) = TEX
C  --MAX SHORTFALL
23    ROUT(6,J) = ANNSUM(4,I,J)
C  --STD. DEVIATION OF SHORTFALL
      IF(ANNSUM(8,I,J).LT.1.1) GO TO 24
      TEX3 = ANNSUM(8,I,J) - 1.0
      TEX2 = (ANNSUM(11,I,J)/TEX3)
     &-(ANNSUM(10,I,J)*ANNSUM(10,I,J))/(TEX3*ANNSUM(8,I,J))
      IF (TEX2.LE.0.0001) GO TO 24
      TEX2 = SQRT(TEX2)
      ROUT(10,J) = TEX2
C  --% OF TIME READJUSTMENT IS NEEDED
24    IF(ANNSUM(6,I,J).LT.0.1) GO TO 241
      ROUT(11,J) = 100*ANNSUM(9,I,J)/ANNSUM(6,I,J)
C  --AVE READJUSTMENT
241   ROUT(7,J) = 0.
      IF(ANNSUM(9,I,J).LT.0.1) GO TO 25
      ROUT(7,J) = ANNSUM(3,I,J)/ANNSUM(9,I,J)
```

```
C  --MAX READJUSTMENT
25     ROUT(8,J) = ANNSUM(5,I,J)
C  --SUM SEASONAL TOTALS
       RTOT(1) = RTOT(1) + ROUT(1,J)
       RTOT(2) = RTOT(2) + ROUT(2,J)
       RTOT(3) = RTOT(3) + ROUT(3,J)
       RTOT(5) = RTOT(5) + ROUT(5,J)
       RTOT(7) = RTOT(7) + ROUT(7,J)
30     CONTINUE
       IF(ISHRT .EQ. 2)GOTO 40
C
C  PRINT OUT RESULTS
C
       DO 35 JJ = 0,1
             J1 = JJ*12+1
             J2 = J1+11
C
       WRITE(10,1004) (ROUT(1,J),J=J1,J2)
1004   FORMAT(' AVERAGE IRRIG'/'  REQUIREMENT - (IN)',12F5.1)
C
       WRITE(10,10041) (NINT(ROUT(9,J)),J=J1,J2)
10041 FORMAT(' PERCENT OF TIME'/'  IRRIG IS REQD  (%)',12I5)
C
       WRITE(10,1005) (ROUT(2,J),J=J1,J2)
1005   FORMAT(' AVE REQUIREMENT'/'  WHEN REQUIRED (IN)',12F5.1)
C
       WRITE(10,1006) (ROUT(3,J),J=J1,J2)
1006   FORMAT(' AVE APPLIED'/'  WHEN REQUIRED (IN)',12F5.1)
       WRITE(10,1007) (NINT(ROUT(4,J)),J=J1,J2)
1007   FORMAT(' PERCENT OF TIME'/'  REQT > APPLIED (%)',12I5)
C
       WRITE(10,1008) (ROUT(5,J),J=J1,J2)
1008   FORMAT(' AVERAGE SHORTFALL'/' WHEN OCCURRING (IN)',12F5.1)
C
       WRITE(10,1009) (ROUT(6,J),J=J1,J2)
1009   FORMAT(' MAXIMUM'/'  SHORTFALL - - (IN)',12F5.1)
C
       WRITE(10,10091)(ROUT(10,J),J=J1,J2)
10091 FORMAT(' STD. DEVIATION'/'  OF SHORTFALLS (IN)',12F5.1)
C
       WRITE(10,10082) (NINT(ROUT(11,J)),J=J1,J2)
10082 FORMAT(' PERCENT OF TIME'/' READJSTMNT REQD (%)',12I5)
C
       WRITE(10,1010) (ROUT(7,J),J=J1,J2)
1010   FORMAT(' AVERAGE'/'  READJUSTMENT  (IN)',12F5.1)
C
       WRITE(10,1011) (ROUT(8,J),J=J1,J2)
1011   FORMAT(' MAXIMUM'/'  READJUSTMENT  (IN)',12F5.1)
C
       IF(JJ .GT. 0)GOTO 35
       WRITE (10,2001) CNAME(I)
2001   FORMAT ( //' CROP SUMMARY RESULTS FOR ',A,' --- CONTINUED'/
     1 1X,38('=')/)
       WRITE (10,1002)(MNAME(J),J=7,12)
C
35     CONTINUE
C
C  PRINT OUT SEASONAL TOTALS
       WRITE(10,2005)CNAME(I)
2005   FORMAT(//' SEASONAL TOTALS FOR ',A/1X,36('=')/
     &/' AVERAGE IRRIG ',' AVERAGE REQT  ','  AVE APPLIED  ',
     &'  AVE SHORTFALLS ',' AVERAGE'/
     &' REQUIREMENT(IN)',2('  WHEN REQD(IN) '),' OCCURRING(IN) ',
     &'READJUSTMENT(IN)'/1X,79('-'))
       WRITE(10,2006)RTOT(1),RTOT(2),RTOT(3),RTOT(5),RTOT(7)
2006   FORMAT(6X,5(F5.1,11X))
       SLAVE = 0.
       DPPCT = 0.
       IF(EROS(I,4).LT.0.1 .AND. EROS(I,2).LT.0.1)GOTO 371
       DPPCT = EROS(I,3)/EROS(I,4)
```

```
      IF(EROS(I,2) .LT. 0.1)GOTO 37
      SLAVE = EROS(I,1)/EROS(I,2)
      WRITE(10,2007)SLAVE,DPPCT
      GOTO 371
37    WRITE(10,20071)DPPCT
2007  FORMAT(//' ESTIMATED ANNUAL SOIL LOSS',F9.2,' T/ACRE (Sprinkle',
     &' irrig. only)'//' ESTIMATED ANNUAL NITROGEN PERCOLATION LOSS  ',
     &F9.2,' % OF APPLIED')
20071 FORMAT(////' ESTIMATED ANNUAL NITROGEN PERCOLATION LOSS  ',
     &F9.2,' % OF APPLIED')
C
371   RTOT(5) = 0.
      RTOT(6) = 0.
      DO 38 J = 1,4
C WRITE(*,*)'CROP,ETA,ETM,KY',I,YDAT(I,J),YDAT(I,J+4),YIELD(J+2,I)
         RTOT(J) = (YDAT(I,J+4)-YDAT(I,J))*YIELD(J+2,I)
         RTOT(5) = RTOT(5)+RTOT(J)
         RTOT(6) = RTOT(6)+YDAT(I,J+4)
38    CONTINUE
      DO 39 J = 1,5
39       RTOT(J) = RTOT(J)/RTOT(6)*100.
      WRITE(10,2008)(RTOT(J),J=1,5)
2008  FORMAT(//' ESTIMATED AVERAGE YIELD REDUCTION BY GROWTH STAGE'/
     &' GROWTH STAGE       1       2       3       4',11X,'TOTAL'/15X,4(1X
     &,6('-')),8X,6('-')/' REDUCTION  (%)',4(F7.1),F14.1/1X,79('-'))
C
40    CONTINUE
      IF(ISHRT .EQ. 2)GOTO 61
C
C  WRITE OUT SUMMARY OF CAUSES OF DECIFITS
C                        (NOTE: 10 DECIFITS = 1 FIT)
C
45    WRITE(10,1012)
1012  FORMAT(/1X,78('=')//' PERCENT OF TIME SHORTFALLS OCCUR WHEN'
     1/' WATER IS REQUIRED DUE TO VARIOUS CONSTRAINTS'/1X,43('=')//)
C
      WRITE(10,1013)(MNAME(I),I=1,6)
1013  FORMAT(' ---- MONTH ------>', 6(5X,A)/
     1' ---- HALF ------->   ', 6(' 1ST 2ND')/1X, 68('-'))
C
C  --WATER AND LABOR CONSTRAINTS
      DO 48 I=1,NYEAR
      DO 48 J=1,24
      IF(JFLG(J,I).EQ.2) TTL(J)=TTL(J)+1
      IF(JFLG(J,I).EQ.1) TTW(J)=TTW(J)+1
48    CONTINUE
C
      DO 50 I = 1,24
      IOUT(1,I) = 0
      IOUT(2,I) = 0
      IF(TREQ(I).LT.0.1) GO TO 50
      IOUT(1,I) = NINT(100.*TTW(I)/TREQ(I))
      IOUT(2,I) = NINT(100.*TTL(I)/TREQ(I))
50    CONTINUE
      DO 52 II = 0,1
            I1 = II*12+1
            I2 = I1+11
            WRITE(10,1014) (IOUT(1,I),I=I1,I2)
1014  FORMAT(' WATER AS'/'   LIMITING - - - (%)',12I4)
            WRITE(10,1015) (IOUT(2,I),I=I1,I2)
1015  FORMAT(' LABOR AS'/'   LIMITING - - - (%)',12I4)
            IF(II .GT. 0)GOTO 52
            WRITE(10,2012)
2012  FORMAT(//' PERCENT OF TIME SHORTFALLS OCCUR WHEN WATER'/
     1' IS REQUIRED DUE TO VARIOUS CONSTRAINTS -- CONTINUED'/)
C
            WRITE(10,1013)(MNAME(I),I=7,12)
52    CONTINUE
C
C  --SYSTEM CONSTRAINTS
```

```
      DO 55 I=1,NSYS
      DO 55 J=1,24
      IOUT(I,J) = 0
      IOUT(I+NSYS,J) = 0
      IF(SYSUM(2,I,J).LT.0.1) GO TO 55
      IOUT(I,J) = NINT(100. * SYSUM(2,I,J)/TREQ(J))
      IOUT(I+NSYS,J) = NINT(100.*SYSUM(3,I,J)/TREQ(J))
55    CONTINUE
      WRITE(10,1016)
1016  FORMAT(//1X,78('=')//' PERCENT OF TIME EACH SYSTEM IS REQUIRED'/
     1' AND PERCENT OF TIME ITS CAPACITY IS LIMITING'/1X,44('='))
      DO 60 I=1,NSYS
      WRITE(10,1017) SYSNAM(I)
1017  FORMAT(//' ===',A,'===')
      WRITE(10,1013)(MNAME(J),J=1,6)
      DO 60 JJ = 0,1
            J1 = JJ*12+1
            J2 = J1+11
            WRITE(10,1018) (IOUT(I,J),J=J1,J2)
            WRITE(10,1019) (IOUT(I+NSYS,J),J=J1,J2)
      IF(JJ .EQ. 1)WRITE(10,2016)
1018  FORMAT('  --TIME REQUIRED (%)',12I4)
1019  FORMAT('  --CAP. LIMITING (%)',12I4)
C
      IF (JJ .GT. 0)GOTO 60
2016  FORMAT(/1X,78('-')/)
      WRITE(10,2017)
2017  FORMAT(//)
      WRITE(10,1013)(MNAME(J),J=7,12)
60    CONTINUE
C
61    TAT = 0.
      DO 132 I=1,NPK
132   TAT = TAT + AREA(I)
C
C  COMPUTE AND PRINT OUT SUMMARY OF WATER USE
C
      IF(ISHRT .EQ. 2)GOTO 119
      CALL ZERO(RTOT,13)
      DO 600 I=1,NYEAR
        DO 600 J = 1,24
        ANLSUM(1,J,I) = ANLSUM(1,J,I)/TAT
        ANLSUM(2,J,I) = ANLSUM(2,J,I)/TAT
        ANLSUM(3,J,I) = ANLSUM(3,J,I)/12.
        DO 600 K = 1,3
          YSUM(K,I) = YSUM(K,I)+ANLSUM(K,J,I)
600   CONTINUE
      WRITE(10,3000)
3000  FORMAT(1X,79('=')//' IRRIGATION WATER USE SUMMARY'/1X,28('='))
C
      DO 700 N = 1,3
      IF(N .EQ. 1)WRITE(10,3001)
      IF(N .EQ. 2)WRITE(10,3011)
      IF(N .EQ. 3)WRITE(10,3021)
3001  FORMAT(///' TOTAL NET IRRIGATION REQUIREMENT (IN)'/1X,38('-')/)
3002  FORMAT(///' TOTAL NET IRRIGATION REQUIREMENT (IN) --- CONTINUED'
     &/1X,38('-')/)
      WRITE(10,3004)(MNAME(J),J=1,6)
3004  FORMAT(10X,6(7X,A)/4X,'YEAR',4X,6('  1ST  2ND')/1X,79('-'))
      DO 601 I = 1,NYEAR
         IF(N .LT. 3)WRITE(10,3005)I,(ANLSUM(N,J,I),J=1,12)
         IF(N .EQ. 3)WRITE(10,3025)I,(NINT(ANLSUM(N,J,I)),J=1,12)
         DO 601 J = 1,12
            RTOT(J) = RTOT(J)+ANLSUM(N,J,I)
601   CONTINUE
3005  FORMAT(1X,I7,4X,12F5.1,F7.1)
3006  FORMAT(/4X,'MEAN'4X,12F5.1,F7.1)
      DO 602 I = 1,12
602     RTOT(I) = RTOT(I)/NYEAR
      IF(N .LT. 3)WRITE(10,3006)(RTOT(J),J=1,12)
```

```
      IF(N .EQ. 3)WRITE(10,3026)(NINT(RTOT(J)),J=1,12)
      CALL ZERO(RTOT,12)
      IF(N .EQ. 1)WRITE(10,3002)
      IF(N .EQ. 2)WRITE(10,3012)
      IF(N .EQ. 3)WRITE(10,3022)
      WRITE(10,3007)(MNAME(J),J=7,12)
3007  FORMAT(10X,6(7X,A),4X,'ANNUAL'/4X,'YEAR',4X,6('  1ST  2ND'),
     &2X,'TOTAL'/1X,79('-'))
      DO 603 I = 1,NYEAR
         IF(N .LT. 3)WRITE(10,3005)I,(ANLSUM(N,J,I),J=13,24),YSUM(N,I)
         IF(N .EQ. 3)WRITE(10,3025)I,(NINT(ANLSUM(N,J,I)),J=13,24),
     & NINT(YSUM(N,I))
         RTOT(13) = RTOT(13)+YSUM(N,I)
         DO 603 J=1,12
            RTOT(J) = RTOT(J)+ANLSUM(N,J+12,I)
603   CONTINUE
      DO 604 I = 1,13
604      RTOT(I) = RTOT(I)/NYEAR
      IF(N .LT. 3)WRITE(10,3006)(RTOT(J),J=1,13)
      IF(N .EQ. 3)WRITE(10,3026)(NINT(RTOT(J)),J=1,13)
      CALL ZERO(RTOT,13)
C
700   CONTINUE
C
3011  FORMAT(1X,79('-')///' TOTAL NET IRRIGATION APPLICATION (IN)'
     &/1X,38('-'))
3012  FORMAT(///' TOTAL NET IRRIGATION APPLICATION (IN) --- CONTINUED'
     &/1X,38('-'))
3021  FORMAT(///' TOTAL GROSS WATER REQUIREMENT (AC-FT)'/1X,37('-'))
3022  FORMAT(///' TOTAL GROSS WATER REQUIREMENT (AC-FT) --- CONTINUED'
     &/1X,37('-'))
3025  FORMAT(1X,I7,4X,12I5,I7)
3026  FORMAT(/4X,'MEAN',4X,12I5,I7)
C
C
C  COMPUTE AND WRITE OUT AVERAGE IRRIGATION PRIORITIES
C
      WRITE(10,3100)
3100  FORMAT(1X,79('=')//' AVERAGE IRRIGATION PRIORITY'/1X,27('=')/)
      DO 800 K = 0,6,6
      WRITE(10,1002)(MNAME(J),J=K+1,K+6)
      J1 = K*2+1
      J2 = J1+11
      DO 750 IX = 1,NCP
        I = IDCP(IX)
        IF(I .EQ. 1)GOTO 750
        DO 730 IPD = 1,24
730     IF(ANNSUM(6,I,IPD) .GT. 0.01)GOTO 740
        GOTO 750
740     DO 745 J = J1,J2
            IOUT(12,J) = 0
            IF(ANNSUM(6,I,J).LT.0.1)GOTO 745
            IOUT(12,J) = NINT(ANNSUM(12,I,J)/ANNSUM(6,I,J))
745     CONTINUE
        WRITE(10,3101)CNAME(I),(IOUT(12,J),J=J1,J2)
750   CONTINUE
      IF(K .EQ. 0)WRITE(10,'(/)')
3101  FORMAT(1X,A,T21,12I5)
800   CONTINUE
C
C
C  COMPUTE AND PRINT OUT SUMMARY AND COST INFORMATION FOR SYSTEMS
C   -SUMMARY INFORMATION
C
      WRITE(10,3033)
3033  FORMAT(1X,79('=')//' IRRIGATION SYSTEM ECONOMIC SUMMARY'/
     &1X,35('=')/)
119   I=0
120   I=I+1
      TA = 0.
```

```
      DO 64 J=1,NPKSYS(I)
64    TA = TA + AREA(IPSYS(J,I))
      IF(ISHRT .EQ. 2)GOTO 75
      WRITE(10,1020) SYSNAM(I)
1020  FORMAT(//' IRRIGATION SYSTEM SUMMARY FOR ',A/)
C
      ITOT(2) = NINT(SYSVAL(2,I))
      ITOT(3)  = NINT(SYSVAL(3,I))
      WRITE(10,1021) TA,SYSVAL(1,I),ITOT(2),ITOT(3)
C
C  --CHECK IF ATTACHED COMPONENTS ARE PRESENT
      IF(SYSVAL(4,I).LT.0.1.AND.SYSVAL(12,I).LT.0.01) GO TO 68
      WRITE(10,1022)
C
      DO 66 J=1,9
         IF(I .EQ. 3)GOTO 66
         ITOT(J) = NINT(SYSVAL(J+3,I))
66    CONTINUE
      WRITE(10,1023)(ITOT(J),J=1,2),ITOT(4),SYSVAL(8,I),(ITOT(J),J=6,9)
C
C  --CHECK IF UNATTACHED COMPONENTS ARE PRESENT
68    IF(SYSVAL(13,I).LT.0.1.AND.SYSVAL(21,I).LT.0.01) GO TO 72
      WRITE(10,1024)
      DO 70 J=1,9
         IF(I .EQ. 3)GOTO 70
         ITOT(J) = NINT(SYSVAL(J+12,I))
70    CONTINUE
      WRITE(10,1023)(ITOT(J),J=1,2),ITOT(4),SYSVAL(17,I),(ITOT(J),J=6,9)
C
C  --INFLATION RATES, RATE OF RETURN, ETC.
72    WRITE(10,1025) RRINV,RLABC,RLABI,OMI,FLATP
C
C   COMPUTE ANNUAL COSTS FOR THE LIFE OF THE SYSTEM
C    --COMPUTE ENERGY COST FOR AVERAGE CONDITIONS
C    ----VOLUME IN EACH BILLING PERIOD FOR EACH PUMP
75    XT = 0.
      DO 76 J=1,NAPMP(I)
76    XT = XT +   QPMP(IDXPMA(J,I))
C   ----% OF WATER PUMPED BY ANY ONE PUMP
      DO 78 J = 1,NAPMP(I)
78    PCP(J) =   QPMP(IDXPMA(J,I))/XT
      PLUMP = 0.
      ANNRG = 0.
C
C  CALCULATE ENERGY COST FOR EACH PUMP
      DO 99 J=1,NAPMP(I)
      ID = IDXPMA(J,I)
C   --INDEXES OF 2-WK PDS IN BILLING PDS
      IDT = ID
      IF(NP.EQ.1) IDT = 1
      NBPD =NINT(12/(TPUMP(16)))
      IXPD = 0
      IXSPR = NINT(TPUMP(14))*2
      IXWPR = NINT(TPUMP(15))*2
      LBPD = NINT(TPUMP(16))*2
C
C  COMPUTE POWER CHARGES FOR EACH BILLING PD.
      PWRCHG = 0.
      DO 98 II=1,NBPD
      WVOL = 0.
      HRS = 0.
C
C  COMPUTE WATER PUMPED IN EACH BILLING PD. (ACRE-INCHES)
      DO 80 IJ=1,LBPD
      IXPD = IXPD +1
      IF(IXPD.GT.24) IXPD=IXPD-24
C
      IF(I.NE.NSUP) GO TO 792
      DO 79 JJ=1,NSYS
79    WVOL = WVOL +(SYSUM(1,JJ,IXPD)/FLOAT(NYEAR))
```

```
      GO TO 794
792    WVOL = WVOL +(SYSUM(1,I,IXPD)/FLOAT(NYEAR))
794   HRS =HRS + HRTOT(IXPD)
80    CONTINUE
C
C  --HOURS OF OPERATION AND KWH
      HROP =(WVOL *PCP(J)/QPMP(ID))*453.
      WH  = HROP * PWRPMP(ID)
      SYSHRS(I) = SYSHRS(I)+HROP
      SYSKWH(I) = SYSKWH(I)+WH
      CALL ZERO(EL,6)
C
      IF(IXBP .LT. IXSPR .OR. TPUMP(14) .LT. 0.1  .OR.
     &      IXBP .GE. IXWPR .OR. TPUMP(15) .LT. 0.1) GOTO 90
C -- SUMMER RATES --
      IF(WH .LT. TPUMP(8) .OR. TPUMP(8) .LT. 0.1)THEN
            EL(1) = WH
      ELSE
            EL(1) = TPUMP(8)
            EL(2) = WH-EL(1)
      END IF
      EL(3) = 1.
      GOTO 98
C -- WINTER RATES --
90    IF(WH .LT. TPUMP(13) .OR. TPUMP(13) .LT. 0.1)THEN
            EL(4) = WH
      ELSE
            EL(4) = TPUMP(13)
            EL(5) = WH-EL(4)
      END IF
      EL(6) = 1.
C  --EQUATION FOR POWER COST FOR A BILLING PERIOD
98    PWRCHG = PWRCHG + TPUMP(4) + PWRPMP(ID)*TPUMP(5)*EL(3) +
     1       EL(1)*TPUMP(6) + EL(2)*TPUMP(7) +
     2       PWRPMP(ID)*TPUMP(10)*EL(6) +
     3        EL(4)*TPUMP(11) + EL(5)*TPUMP(12)
C
C   TOTAL ANNUAL ENERGY COST
      ANNRG = ANNRG + PWRCHG + TPUMP(2) + TPUMP(3)*PWRPMP(ID)
      PLUMP = PLUMP + TPUMP(1)
99    CONTINUE
       IF(I.EQ.NSUP) GO TO 150
C  --TOTAL ANNUAL LABOR COST
      TRLB = 0.
      DO 102 J=1,NPKSYS(I)
      TRLB = TRLB + TLAB(IPSYS(J,I),1)*TOTIRG(IPSYS(J,I)) +
     & TLAB(IPSYS(J,I),2)
102   CONTINUE
      CTLAB = (TRLB/FLOAT(NYEAR)) * RLABC
C
C  --SET UP ARRAY OF ITEMIZED ANNUAL COSTS FOR THE LIFE OF THE SYSTEM
      DO 104 J=1,30
      DO 104 J1=1,20
104   IOUT(J1,J) = 0
C
      CRF=(RINV*((1.+RINV)**LEPD))/(((1.+RINV)**LEPD)-1.)
      PWC = 0.
      PWO = 0.
      DO 110 J=1,LEPD+1
      JJ = J-1
      IOUT(1,J) = JJ
      IOUT(2,J) = IACCST(1,I,J)
      IOUT(3,J) = IACCST(2,I,J)
      IOUT(4,J) = IACCST(3,I,J)
      IOUT(5,J) = IACCST(4,I,J)
      IF(J .EQ. 1)GOTO 105
C
C  --OPERATING COSTS AS FF --> LABOR, ENERGY,MAINT,MISC,TOTAL
C  --LABOR
      IOUT(6,J) = NINT(CTLAB *((1.+RLABI/100.)**FLOAT(JJ-1)))
```

```
C  --ENERGY
      IOUT(7,J) = NINT(ANNRG *((1.+FLATP/100.)**FLOAT(JJ-1)))
C  --MAINTENANCE
      IOUT(8,J) = NINT((SYSVAL(11,I)+SYSVAL(20,I))*
     1                ((1.+OMI/100.)**FLOAT(JJ-1)))
C  --MISCELLANEOUS
      IOUT(9,J) = NINT((SYSVAL(12,I)+SYSVAL(21,I))*
     1                ((1.+OMI/100.)**FLOAT(JJ-1)))
C
105   IOUT(10,J) = IOUT(6,J)+IOUT(7,J) + IOUT(8,J) + IOUT(9,J)
      IOUT(11,J) = IOUT(10,J) + IOUT(5,J)
C  COMPUTE PRESENT WORTH OF CAPITAL AND OPERATING EXPENSES
      IF(JJ .LE. 0) GOTO 110
      PWC = PWC+((FLOAT(IOUT(5,J)))/((1.+RINV)**FLOAT(JJ)))
      PWO = PWO+((FLOAT(IOUT(10,J)))/((1.+RINV)**FLOAT(JJ)))
C
      DO 1051  K = 2,5
1051     ISUM(I,K) = ISUM(I,K)+
     & (FLOAT(IOUT(K+4,J))/(1.+RINV)**FLOAT(JJ))
C
110   CONTINUE
C
      DO 111 K = 2,5
111      ISUM(I,K) = NINT(ISUM(I,K)*CRF)
      ISUM(I,1) = NINT(PWC*CRF)
C
C  COMPUTE ANNUAL COST
C  --WITH SUBSIDY
      IC(1) = NINT((PWC+PWO)*CRF)
      IC(2) = NINT(SYSVAL(22,I))
      IC(3) = NINT(SYSHRS(I))
      IC(4) = NINT(SYSKWH(I))
      IC(5) = NINT(SYSVAL(5,I)+SYSVAL(14,I))
      IF(ISHRT .EQ. 2)GOTO 115
      WRITE(10,1027) SYSNAM(I),TA
      WRITE(10,1028) (IC(J),J=1,5)
      WRITE(10,1029)
      WRITE(10,1030)((IOUT(J,J1),J=1,11),J1=1,LEPD+1)
      WRITE(10,2016)
115   IF(I.LT.NSYS) GO TO 120
C
C  COSTS FOR WATER SUPPLY SYSTEM
C
      IF(ISHRT .EQ. 2)GOTO 145
      WRITE(10,1031)
1031  FORMAT(// ' SUMMARY FOR WATER SUPPLY SYSTEM -- '/)
      ITOT(1) = NINT(SUPRAM(1))
      ITOT(3) = NINT(SUPRAM(3))
      WRITE(10,1032) TAT, ITOT(1),SUPRAM(2),ITOT(3)
C
C --CHECK IF ATTACHED COMPONENTS ARE PRESENT
      IF(SUPRAM(5).LT.0.1.AND.SUPRAM(13).LT.0.1) GO TO 140
      DO 136 I=1,9
        IF(I .EQ. 3)GOTO 136
        ITOT(I) = NINT(SUPRAM(I+4))
136   CONTINUE
      WRITE(10,1022)
      WRITE(10,1023)(ITOT(I),I=1,2),ITOT(4),SUPRAM(9),(ITOT(I),I=6,9)
C
C  --CHECK IF UNATTACHED COMPONENTS ARE PRESENT
140   IF(SUPRAM(14).LT.0.1.AND.SUPRAM(22).LT.0.1) GO TO 144
      DO 142 I=1,9
        IF(I .EQ. 3)GOTO 142
        ITOT(I) = NINT(SUPRAM(I+13))
142   CONTINUE
      WRITE(10,1024)
      WRITE(10,1023)(ITOT(I),I=1,2),ITOT(4),SUPRAM(18),(ITOT(I),I=6,9)
144   WRITE(10,1033) RRINV,OMI,FLATP
C
C  COMPUTE ANNUAL COSTS FOR THE LIFE OF THE SYSTEM
```

```
C  --ENERGY FOR PUMPING
 145    I = NSUP
        GO TO 75
 150    CONTINUE
 C   WATER COST
        WCST = 0.
        WCST = WCST+WCOST(1)*TAT
        WTOT = 0.
        DO 155 I = 1,24
        DO 155 J = 1,NSYS
 155    WTOT = WTOT + SYSUM(1,J,I)/12.
        WTOT = WTOT/FLOAT(NYEAR)/TAT
        IF(WCOST(2).EQ.0.0) GO TO 160
        IF(WTOT .LT. WCOST(2))GOTO 160
        WCST = WCST + (WTOT-WCOST(2))*WCOST(4) + WCOST(2)*WCOST(3)
        GO TO 165
 C
 160    WCST = WCST + WTOT*WCOST(3)
 C
 165    DO 167 J =1,30
        DO 167 J1=1,20
 167    IOUT(J1,J) = 0
        X3 = SUPRAM(18)/100.
        X4 = SUPRAM(19)
        CRFNA = ((X3*((1.+X3)**X4))/(((1.+X3)**X4)-1.)) * PLUMP
        PLUMP0 = PLUMP
        PWC = 0.
        PWO = 0.
C
        DO 180 J=1,LEPD+1
        JJ = J-1
        IOUT(1,J) = JJ
        IF(J .GT. NINT(X4) .OR. J .EQ. 1)THEN
           X0 = 0.
           X1 = 0.
           X2 = 0.
           GOTO 176
        END IF
        X2 = CRFNA
        X1 = X3 * PLUMP
        X0 = X2-X1
        PLUMP = PLUMP - X0
C
176     IOUT(2,J) = NINT(X0)+IACCST(1,NSUP,J)
        IOUT(3,J) = NINT(X1)+IACCST(2,NSUP,J)
        IOUT(4,J) = IACCST(3,NSUP,J)
        IOUT(5,J) = NINT(X2)+IACCST(4,NSUP,J)
        IF(J .EQ. 1)GOTO 178
C
C  --OPERATING COSTS AS FF --> WATER, ENERGY, MAINT, MISC, TOTAL
C  --WATER
177     IOUT(6,J) = NINT(WCST *((1.+OMI/100.)**FLOAT(JJ-1)))
C  --ENERGY
        IOUT(7,J) = NINT(ANNRG *((1.+FLATP/100.)**FLOAT(JJ-1)))
C  --MAINTENANCE
        IOUT(8,J) = NINT((SUPRAM(12)+SUPRAM(21)) *
      1                  ((1.+OMI/100.)**FLOAT(JJ-1)))
C  --MISCELLANEOUS
        IOUT(9,J) = NINT((SUPRAM(13) + SUPRAM(22)) *
      1                 ((1.+OMI/100.)**FLOAT(JJ-1)))
C
178     IOUT(10,J) = IOUT(6,J)+IOUT(7,J)+IOUT(8,J)+IOUT(9,J)
        IOUT(11,J) = IOUT(10,J)+IOUT(5,J)
C  PRESENT WORTH OF OPERATING EXPENSES
        IF(JJ .LE. 0)GOTO 180
        PWC = PWC +((FLOAT(IOUT(5,J)))/((1.+RINV)**FLOAT(JJ)))
        PWO = PWO +((FLOAT(IOUT(10,J)))/((1.+RINV)**FLOAT(JJ)))
C
        DO 1781 K = 3,5
1781       ISUM(NSUP,K)=ISUM(NSUP,K)+
```

```
     &   FLOAT(IOUT(K+4,J))/(1.+RINV)**FLOAT(JJ)
      ISUM(NSUP,6)=ISUM(NSUP,6)+FLOAT(IOUT(6,J))/(1.+RINV)**FLOAT(JJ)
C
180   CONTINUE
C
      DO 1801 K = 3,6
1801     ISUM(NSUP,K) = NINT(ISUM(NSUP,K)*CRF)
      ISUM(NSUP,1) = NINT(PWC*CRF)
      IF(ISHRT .EQ. 2)GOTO 181
      IC(1) = NINT((PWC+PWO+PLUMPO)*CRF)
      IC(2) = NINT(SUPRAM(23))
      IC(3) = NINT(SYSHRS(NSUP))
      IC(4) = NINT(SYSKWH(NSUP))
      IC(5) = NINT(SUPRAM(6)+SUPRAM(15))
      WRITE(10,1027) SUPTIT,TAT
      WRITE(10,1028) (IC(J),J=1,5)
      WRITE(10,1034)
      WRITE(10,1030)((IOUT(J,J1),J=1,11),J1=1,LEPD+1)
      WRITE(10,2016)
C
181   IF(ISHRT .NE. 1)CALL SHOUT(NYEAR,TITLE,SYSNAM,NPK,NSYS,CNAME,
     & SUPTIT,NSUP,K1,NT,ISUM)
1021  FORMAT(' TOTAL AREA SERVED (ACRES)  - - - - - - -      ',F6.1/
     1    ' FLOW ENTERING SYSTEM (CFS) - - - - - - -     ',F7.2/
     2    ' PERCENT OF TIME SYSTEM OPERATES (%)  - -     ',I4/
     3    ' SYSTEM LIFE (YEARS)  - - - - - - - - - -     ',I4/)
C
1022  FORMAT(' INPUT DATA FOR ATTACHED COMPONENTS'/
     1'    -- (LOAN NO. 1)')
C
1023  FORMAT('    TOTAL CAPITAL COST ($) - - - - - - - - -',I8/
     1    '    CAPITAL NOT FINANCED ($) - - - - - - - -',I8/
     3    '    FINANCED CAPITAL ($) - - - - - - - - - -',I8/
     4    '    FINANCE INTEREST RATE (%)  - - - - - - -',F10.1/
     5    '    TIME OF LOAN (YEARS) - - - - - - - - - -',I8/
     6    '    SALVAGE VALUE ($)  - - - - - - - - - - -',I8/
     7    '    ANNUAL MAINTENANCE EXPENSE ($) - - - - -',I8/
     8    '    ANNUAL MISCELLANEOUS EXPENSE ($) - - - -',I8/)
C     2    '    SUBSIDIZED CAPITAL ($) - - - - - - - - -',I8/
C
1024  FORMAT(' INPUT DATA FOR NON-ATTACHED COMPONENTS'/
     1'    -- (LOAN NO. 2)')
C
1025  FORMAT(' RETURN ON INVESTMENT (%) - - - - - - - - -',F10.1/
     1    ' LABOR WAGE RATE ($/HR)    - - - - - - - - -',F11.2/
     2    ' INFLATION FOR LABOR (%)   - - - - - - - - -',F10.1/
     3    ' INFLATION FOR OPERATION AND MAINT. (%) -',F10.1/
     4    ' INFLATION FOR ENERGY (%) - - - - - - - - -',F10.1/)
C
1027  FORMAT(//' EXPECTED COSTS FOR IRRIGATION FOR ',A/
     1' OVER THE LIFE OF THE SYSTEM'
     2//' THE SYSTEM SUPPLIES ',F6.1,' ACRES')
C
1028  FORMAT(/' TOTAL OVERALL ANNUAL COST ($) - - - - - - - - -',I8/
     1 ' OVERALL ANNUAL CAPITAL COST ($) - - - - - - - -',I8/
     2 '    (NOTE: USE THESE COSTS ONLY FOR COMPARING SYSTEMS)'//
     3 ' SYSTEM POWER ESTIMATES FOR AVERAGE SEASON'/
     4 '    HOURS OF OPERATION PER SEASON - - - - - - -',I10/
     5 '    SEASONAL KILOWATT-HOURS - - - - - - - - - -',I10//
     6 ' TOTAL CAPITAL COST NOT FINANCED ($) - - - - - -',I8)
C     6 ' TOTAL CAPITAL COST NOT SUBSIDIZED OR FINANCED ($) -',I8)
C
1029  FORMAT(//6X,' - - - CAPITAL COSTS - - -     OPERATING ',
     1'COSTS FOR AVERAGE CONDITIONS   ',' OVERALL'/' YR ',
     2' REPYMNT  INTRST   CASH    TOTAL  LABOR  ENERGY  MAINT ',
     3' MISC  TOTAL',6X,'TOTAL'/2X,84('-'))
C
1030  FORMAT(1X,I2,1X,I7,1X,I7,1X,I7,2X,I7,I7,I7,I7,I7,I7,I11)
C
1032  FORMAT(' TOTAL AREA SERVED (ACRES)  - - - - - - -      ',F5.1/
```

```
     1    ' SYSTEM CAPACITY'/
     2    '     MAX VOLUME DELIVERED (ACRE-IN/24 HR) ',I8/
     3    '     MAX FLOW RATE (CFS) - - - - - - - - - -',F11.2/
     4    ' CONVEYANCE EFFICIENCY (%)  - - - - - - - -',I8/)
C
1033  FORMAT(' RETURN ON INVESTMENT (%) - - - - - - - - -',F10.1/
     1    ' INFLATION FOR OPERATION AND MAINT. (%) -',F10.1/
     2    ' INFLATION FOR ENERGY (%) - - - - - - - - -',F10.1/)
C
C
1034  FORMAT(//6X,' - - - CAPITAL COSTS - - -    OPERATING ',
     1'COSTS FOR AVERAGE CONDITIONS  ',' OVERALL'/' YR ',
     2' REPYMNT  INTRST   CASH    TOTAL  WATER  ENERGY  MAINT ',
     3' MISC  TOTAL',6X,'TOTAL'/2X,84('-'))
C
      RETURN
      END
```

```
C
C
      SUBROUTINE ZERO(X,N)
      DIMENSION X(N)
      DO 10 I=1,N
10       X(I) = 0.0
      RETURN
      END
```

```
$DEBUG
$NOFLOATCALLS
$LARGE
      SUBROUTINE SHOUT(NYEAR,TITLE,SYSNAM,NPDK,NSYS,CNAME,SUPTIT,
     & NSUP,K1,NT,ISUM)
C
C
C  SUBROUTINE SHOUT IS USED TO GENERATE AND PRINT CONDENSED OUTPUT
C  SUMMARIES FOR SYSTEMS AND CROPS
C
C
C
      COMMON/SYSPAD/AREA(20),MPRIOR(30,24),IPDKPR(20,2),IDXSYS(20),
     & JFLG(25,50),ISFLAG(20,25),PDSUM(10,20,25),SYSV(20,2),ISF(20,2),
     & SYSVAL(22,20),SUPRAM(23),EAPP(30,20),TLAB(20,2),SLOSS(20,4)
      COMMON/SUMMAR/ANNSUM(15,30,24),SYSUM(3,20,24),IDCP(30),TOTIRG(20)
     &,ANLSUM(3,24,50),EROS(30,4),DP(30,20),YDAT(30,8),FLDCRP(20,30,10)
     &,YDAT2(30,20,8)
C
      DIMENSION ITOT(10),ROUT(20,15),ISUM(20,10),K1(20),NT(20,30),
     & RTOT(10),RTOT2(20,10)
C
      CHARACTER*20 SYSNAM(20),SUPTIT,TITLE,CNAME(30)*16
C
      WRITE(20,1000)TITLE,NYEAR
1000  FORMAT(//' SUMMARIZED IRRIGATION SIMULATION OUTPUT FOR'/1X,A//
     &' RESULTS ARE BASED ON ',I2,' YEARS OF RAINFALL AND PET DATA')
      WRITE(20,1010)
1010  FORMAT(//' SIMULATED SEASONAL PERFORMANCE BY CROP')
1001  FORMAT(//' FIELD #',I2,' (',A,' IRRIGATION SYSTEM)'//
     118X,'AVG IRRIGATION',5X,'AVG LABOR',4X,'AVG NUTRIENT',6X,
     2'AVG YIELD'/' CROP',12X,2X,'DEFICIT(AC-IN)',2X,'DEFICIT(HRS)',
     33X,'LOSS(% APPLD)',3X,'REDUCTION(%)'/1X,76(1H-))
      DO 50 IPK = 1,NPDK
         WRITE(20,1001)IPK,SYSNAM(IDXSYS(IPK))
         DO 40 J = 1,K1(IPK)
            NOCR = NT(IPK,J)
            IC = IDCP(NOCR)
C      WRITE(*,*)'IPK,NOCR',IPK,NOCR,CNAME(NOCR)
            DO 10 K = 2,8,2
C        WRITE(*,*) IPK,NOCR,FLDCRP(IPK,NOCR,K-1),FLDCRP(IPK,NOCR,K)
             ROUT(IPK,K/2) = 0.
       IF(FLDCRP(IPK,NOCR,K) .GT. 0.0)
     &       ROUT(IPK,K/2) = FLDCRP(IPK,NOCR,K-1)/FLDCRP(IPK,NOCR,K)
10          CONTINUE
            ROUT(IPK,1) = ROUT(IPK,1)*AREA(IPK)
C  SUM FOR ALL CROPS IN FIELD
            DO 20 K = 1,4
               RTOT2(IPK,K) = RTOT2(IPK,K)+ROUT(IPK,K)
20             RTOT2(IPK,K+4) = RTOT2(IPK,K+4)+1.
C
C  PRINT OUT DATA FOR EACH FIELD AND CROP
            WRITE(20,1002)CNAME(NOCR),(ROUT(IPK,J1),J1=1,4)
40       CONTINUE
1002  FORMAT(1X,A,4F15.2)
C
C  COMPUTE FIELD AVERAGES
         DO 42 K = 1,4
            RTOT2(IPK,K) = RTOT2(IPK,K)/RTOT2(IPK,K+4)
42          RTOT(K) = RTOT(K)+RTOT2(IPK,K)
C
50    CONTINUE
C
C   PRINT CROP DATA SUMMARY FOR ALL FIELDS FOR ALL CROPS
      WRITE(20,1005)
      DO 60 IPK = 1,NPDK
60       WRITE(20,1006)IPK,SYSNAM(IDXSYS(IPK)),(RTOT2(IPK,I),I=1,3)
      RTOT(3) = RTOT(3)/NPDK
      WRITE(20,1007)(RTOT(I),I=1,3)
C
```

```
1005  FORMAT(1X,77(1H-)//
     & ' SIMULATED SEASONAL PERFORMANCE FOR ALL CROPS')
1006  FORMAT(//' FIELD #',I2,' (',A,' IRRIGATION SYSTEM)'//
     12X,'AVG IRRIGATION',5X,'AVG LABOR',6X,'AVG NUTRIENT'/
     23X,'DEFICIT(AC-IN)',3X,'DEFICIT(HRS)',4X,'LOSS(% APPLD)',
     3/1X,48(1H-)/1X,3F15.2)
1007  FORMAT(1X,45(1H-)//' SEASONAL PERFORMANCE SUMMARY FOR ALL ',
     1'SYSTEMS'//2X,'AVG IRRIGATION',5X,'AVG LABOR',6X,'AVG NUTRIENT'/
     23X,'DEFICIT(AC-IN)',3X,'DEFICIT(HRS)',4X,'LOSS(% APPLD)',
     3/1X,48(1H-)/1X,3F15.2)
C
C  PRINT DATA FOR IRRIGATION SYSTEM COSTS
C
      WRITE(20,2000)
2000  FORMAT(///' ESTIMATED ANNUAL COSTS FOR IRRIGATION SYSTEMS')
2001  FORMAT(//1X,A//'  CAPITAL   LABOR  ENERGY   MAINT    MISC',8X,
     1 'TOTAL'/1X,53(1H-)/1X,5I8,I13)
      DO 100 IS = 1,NSYS
         DO 70 I = 1,5
            ITOT(I) = ITOT(I)+ISUM(IS,I)
70          ISUM(IS,7) = ISUM(IS,7)+ISUM(IS,I)
         WRITE(20,2001)SYSNAM(IS),(ISUM(IS,J),J=1,5),ISUM(IS,7)
100   CONTINUE
C
C  PRINT DATA FOR SUPPLY SYSTEM COSTS
C
      WRITE(20,2100)
2100  FORMAT(///' ESTIMATED ANNUAL COSTS FOR SUPPLY SYSTEM')
2101  FORMAT(//1X,A//'  CAPITAL  ENERGY   MAINT     MISC    WATER',8X,
     1 'TOTAL'/1X,53(1H-)/1X,5I8,I13)
      ITOT(1) = ITOT(1)+ISUM(NSUP,1)
      ISUM(NSUP,7) = ISUM(NSUP,7)+ISUM(NSUP,1)
      DO 110 I = 3,6
         ITOT(I) = ITOT(I)+ISUM(NSUP,I)
110      ISUM(NSUP,7) = ISUM(NSUP,7)+ISUM(NSUP,I)
      WRITE(20,2101)SUPTIT,ISUM(NSUP,1),(ISUM(NSUP,J),J=3,7)
C
C  PRINT DATA FOR SUPPLY AND IRRIGATION SYSTEM COST TOTALS
C
      WRITE(20,2200)
2200  FORMAT(///' ESTIMATED ANNUAL COST TOTALS')
2201  FORMAT(//'  CAPITAL   LABOR  ENERGY   MAINT    MISC    WATER'
     1 ,8X,'TOTAL'/1X,61(1H-)/1X,6I8,I13)
      DO 120 I = 1,7
120      ITOT(8) = ITOT(8)+ITOT(I)
      WRITE(20,2201)(ITOT(J),J=1,6),ITOT(8)
      RETURN
      END
```

APPENDIX E

SELECTED MATRIX DEFINTIONS FOR SYSTEM AND SIMULATE ROUTINES

CONTENTS

PURPOSE

The purpose of this section is to provide a brief explanation of some of the array variables used in the SYSTEM and SIMULATE programs. This will enable the program user who is familiar with the FORTRAN language to utilize the program listings and examine the methods of calculation of some of the various parameters.

Because of the complexity of both programs, a listing of some of the major variables is provided. Many of the arrays shown in this list are used in both SYSTEM and SIMULATE while others are found in just one of the programs. Many of these arrays are found in several of the subroutines and are passed through the use of COMMON statements.

The listing provided here does not include all of the major variables. Further definitions of these and many other variables are provided in comment lines in the actual program listings. The arrays listed in this section are in alphabetical order. The definitions presented are brief but should provide a hint as to the type of data stored in the multitude of array elements used in this program.

ARRAY DEFINITIONS

```
ANLSUM(1,N,M)  GROSS IRRIG. REQUIRED
      (2,N,M)  NET IRRIG. REQUIRED
      (3,N,M)  NET IRRIG. APPLIED
          N = PERIOD (1-24)
          M = YEAR

ANNSUM(1,N,M)  NET IRRIG. REQD.
      (2,N,M)  NET IRRIG. APPLIED
      (3,N,M)  NET SUPPLEMENTAL IRRIG.
      (4,N,M)  MAX. DEFICIT
      (5,N,M)  NET DEFICIT
      (6,N,M)  # TIMES CROP APPEARS
      (7,N,M)  # TIMES CROP REQUIRES WATER
      (8,N,M)  # TIMES IRRIG. DEMANDS NOT MET
      (9,N,M)  # TIMES SUPPLEMENTAL IRRIG. USED
      (10,N,M) NET DEFICIT
      (11,N,M) SUM OF SQUARES, NET DEFICIT
          N = CROP #
          M = PERIOD (1-24)

APET(N)   AVERAGE POTENTIAL ET FOR PERIOD
          N = PERIOD # (1-24)

AREA(N)   AREA OF FIELD (AC)
          N = FIELD #

CHAN(N,M,1)    ESTIMATED CHANNEL BOTTOM WIDTH
    (N,M,2)    ESTIMATED CHANNEL DEPTH
               N = SYSTEM #
               M = # OF CHANNEL W/IN SYSTEM

COMP(N,M) NAME OF PURCHASED COMPONENT
          N = SYSTEM #
          M = COMPONENT #

CROPF(N,1)-(N,24)   Kc FOR PERIOD 1-24
          N = CROP #

CRPDK(N,M,1)   CROP #, FIRST CROP
     (N,M,2)   TOTAL AVAILABLE MOISTURE, FIRST CROP
     (N,M,3)   APPLICATION DEFICIT, FIRST CROP
     (N,M,4)   MGMT. ALLOWED DEFICIT, FIRST CROP
     (N,M,5)   CROP #, SECOND CROP
     (N,M,6)   TOTAL AVAILABLE MOISTURE, SECOND CROP
     (N,M,7)   APPLICATION DEFICIT, SECOND CROP
     (N,M,8)   MGMT. ALLOWED DEFICIT, SECOND CROP
          N = FIELD #
          M = POSITION OF CROP IN ROTATION

DRAIN(N,1)     DAYS BETWEEN IRRIGATIONS
     (N,2)     ROOT ZONE DEPTH (FT)
     (N,3)     DRAIN DEPTH (FT)
     (N,4)     DEPTH TO LOWER BARRIER (FT)
     (N,5)     PERMEABILITY BETWEEN ROOT ZONE AND BARRIER (FT/DAY)
     (N,6)     MAX WATER TABLE BELOW SURFACE (FT)
     (N,7)     LATERAL DRAIN SLOPE (%)
     (N,8)     CONTINGENCY COST (% OF INVESTMENT)
     (N,9)     % COST SUBSIDIZED
     (N,10)    % COST FINANCED
     (N,11)    LOAN #
     (N,12)    MAINTENANCE COST (% OF INVESTMENT)
     (N,13)    SALVAGE VALUE AT END OF LIFE (% OF ORIGINAL)
     (N,14)    ANNUAL MISC. COSTS ($)
          N = FIELD #
```

```
DRAN(N,1) FIELD LENGTH (FT)
    (N,2) AVERAGE DEEP PERCOLATION (% OF APPLIED)
    (N,3) APPLICATION EFFICIENCY (%)
    (N,4) NET AVERAGE IRRIGATION (IN)
          N = FIELD #

EAPP(N,M) IRRIGATION APPLICATION EFFICIENCY FOR CROP AND SYSTEM
          N = CROP #
          M = SYSTEM #

EROS(N,1) TOTAL OF ANNUAL SOIL LOSS (t/AC)
    (N,2) # TIMES SOIL LOSS CALCULATED
    (N,3) TOTAL ANNUAL NITROGEN LOSS (%)
    (N,4) # TIMES NITROGEN LOSS CALCULATED
          N = CROP #

ET(N,M)   MAXIMUM ET
          N = FIELD #
          M = PERIOD (1=CURRENT, 2= FORECAST)

FLDCRP(N,M,1)  SUM OF ANNUAL IRRIGATION DEFICITS (IN)
      (N,M,2)  NUMBER OF SEASONS TO COMPUTE IRRIG. DEFICIT TOTAL
      (N,M,3)  SUM OF ANNUAL LABOR DEFICITS (HRS)
      (N,M,4)  NUMBER OF SEASONS TO COMPUTE LABOR DEFICIT TOTAL
      (N,M,5)  SUM OF ANNUAL NUTRITENT LOSS (%)
      (N,M,6)  NUMBER OF SEASONS TO COMPUTE NUTRIENT LOSS
      (N,M,7)  SUM OF ANNUAL CROP REDUCTION (%)
      (N,M,8)  NUMBER OF SEASONS TO COMPUTE CROP REDUCTION
               N = FIELD #
               M = CROP #

IACCST(1,N,M)  ANNUAL CAPITAL CASH FLOW, PRINCIPLE
      (2,N,M)  ANNUAL CAPITAL CASH FLOW, INTEREST
      (3,N,M)  ANNUAL CAPITAL CASH FLOW, CASH PAYMENT
      (4,N,M)  ANNUAL CAPITAL CASH FLOW, TOTAL
               N = SYSTEM #
               M = YEAR

ICOMP(N,M,1)   YEAR OF CAPITAL COMPONENT PURCHASE
     (N,M,2)   LIFE OF CAPITAL COMPONENT PURCHASE
     (N,M,3)   TOTAL COST OF CAPITAL COMPONENT PURCHASE
     (N,M,4)   SALVAGE VALUE OF CAPITAL COMPONENT PURCHASE
     (N,M,5)   ANNUAL COST OF CAPITAL COMPONENT PURCHASE
     (N,M,6)   LOAN RATE OF CAPITAL COMPONENT PURCHASE
               N = SYSTEM #
               M = COMPONENT #

ICROPS(1,N)    PLANTING DATE
      (2,N)    HARVEST DATE
      (3,N)    EFFECTIVE COVER DATE
      (4,N)    FLOWERING DATE
      (5,N)    YIELD FORMATION DATE
      (6,N)    RIPENING DATE
          N = CROP #

IDCP(N)   INDEX NUMBER FOR CROPS IN ROTATION
          N = CROP # (1-TOTAL NUMBER OF CROPS IN ROTATIONS)

IDS(N)    APPLICATION SYSTEM TYPE INDEX NUMBER
          N = FIELD #  (IDS(N) = 1  ===>> BORDER SYSTEM, ETC.)

IDXCRP(N,M)    POSITION OF CROP IN ROTATION (1-NCRP(N))
          N = FIELD #
          M = YEAR

IDXPMA(N,M)    OVERALL PUMP ID NUMBER
          N = # OF PUMP WITHIN SYSTEM (1-NAPMP(M))
          M = SYSTEM # (20 = SUPPLY SYSTEM)
```

```
IDXSYS(N) SYSTEM #
          N = FIELD #

IPDKPR(N,M)     IRRIGATION PRIORITY RANKING FOR FIELD (1-NPDK)
          N = FIELD #
          M = PERIOD (1=CURRENT, 2=FORECAST)

IPSYS(N,M)      LIST OF FIELD #'S IRRIGATED BY SYSTEM
          N = NUMBER OF FIELD ASSOC. WITH SYSTEM (1-NPKSYS(M))
          M = SYSTEM #

ISFLAG(N,M)     SYSTEM CAPACITY FLAG (=1 IF CAPACITY LIMITING)
          N = SYSTEM
          M = PERIOD (1-24)

ITEMS(N)  NUMBER OF COMPONENTS PURCHASED FOR SYSTEM N

JFLG(N,M) CONSTRAINT FLAG (=1 IF AVAIL. WATER LIMITS, =2 IF LABOR)
          N = PERIOD (1-24)
          M = YEAR

KCP(N,M)  CROP FLAG "1" OR "5"
          N = FIELD #
          M = PERIOD (1-24)

MPRIOR(N,M)     CROP # IN POSITION N, PERIOD M
          N = RANKING
          M = PERIOD (1-24)

NAPMP(N)  NUMBER TO PUMPS IN IRRIGATION SYSTEM N
          N = SYSTEM #, INCLUDES SUPPLY SYSTEM(N = NSUP)

NCRP(N)   NUMBER OF CROPS IN ROTATION
          N = FIELD #

NPKSYS(N) NUMBER OF FIELDS IRRIGATED BY SYSTEM
          N = SYSTEM #

PDSUM(1,N,M)    FIELD #
     (2,N,M)    CROP #
     (3,N,M)    IRRIG. REQUIRED (IN)
     (4,N,M)    NET IRRIG. APPLIED (IN)
     (5,N,M)    GROSS IRRIG. VOLUME REQD. (AC-IN)
     (6,N,M)    NET APPLICATION > A.D. AMOUNT (IN)
     (7,N,M)    LABOR REQUIRED (HRS)
          N = FIELD #
          M = PERIOD (1-24)

PET(N)    POTENTIAL ET FOR PERIOD
          N = PERIOD # (1-24)

PIPE(N,M) ESTIMATED PIPE DIAMETER (IN)
          N = SYSTEM #
          M = # OF PIPE W/IN SYSTEM

PWRPMP(N) POWER REQUIREMENT FOR PUMP (KW)
          N = PUMP #

QPMP(N)   DESIGN FLOW RATE FOR PUMP
          N = PUMP #

RAIN(N)   PRECIPITATION AMOUNT FOR HALF-MONTH PERIOD OR DAY (IN)
          N = PERIOD OR DAY NUMBER

RQI(N,1)  IRRIGATION REQT. (IN)
   (N,2)  FORECAST IRRIG. REQT. (IN)
          N = FIELD #
```

```
SLOSS(N,M)      VALUES USED IN USLE TO CALCULATE SOIL LOSS
                N = FIELD #
                M = VALUE INDEX (1-4)  (4 = % CANOPY AT IRRIG. START)

SMD(N,M)  SOIL MOISTURE DEFICIT (IN)
          N = FIELD #
          M = PERIOD (1=CURRENT, 2=FORECAST)

SOIL(N,1) FURROW INTAKE FAMILY
    (N,2) SPRINKLER INTAKE RATE (IN/HR)
    (N,3) EROSIVITY (K) FACTOR
          N = FIELD #

SSEEP(N)  CONVEYANCE LOSSES DUE TO OPEN CHANNEL SEEPAGE (%)

SUPRAM(N) SUPPLY SYSTEM PARAMETERS
      (1) VOLUME ENTERING SYSTEM (AC-IN/DAY)
      (2) FLOW ENTERING SYSTEM (CFS)
      (3) CONVEYANCE EFFICIENCY (%)
      (4) SYSTEM LIFE (YR)
      (5) TOTAL CAPITAL COST - ATTACHED ITEMS, LOAN 1 ($)
      (6) CAPITAL NOT FINANCED OR SUBSIDIZED - LOAN 1 ($)
      (7) SUBSIDIZED CAPITAL - LOAN 1 ($)
      (8) FINANCED CAPITAL - LOAN 1 ($)
      (9) INTEREST RATE - LOAN 1 ($)
     (10) LENGTH OF LOAN 1 (YR)
     (11) SALVAGE VALUE OF COMPONENTS - LOAN 1 ($)
     (12) ANNUAL MAINTENANCE COSTS - LOAN 1 ($)
     (13) ANNUAL MISCELLANEOUS EXPENSE - LOAN 1 ($)
     (14-22) SAME PARAMETERS AS (5-13) EXCEPT FOR LOAN 2 (UNATTACHED
             ITEMS)
     (23) ANNUAL CAPITAL RECOVERY COST ($)

 SYSFLD(N,#)     NUMERIC VALUES USED IN SYSTEM MODELS
  VLOG(N,#)     LOGICAL VARIABLES USED IN SYSTEM MODELS
          N = FIELD #

FOR BORDERS:

SYSFLD(N,1)     FIELD LENGTH (FT)
      (N,2)     FIELD WIDTH (FT)
      (N,3)     FIELD SLOPE (%)
      (N,4)     BORDER LENGTH (FT)
      (N,5)     BORDER WIDTH (FT)
      (N,6)     OPEN END (1=OPEN END, 2=CLOSED END)
      (N,7)
      (N,8)     LABOR REQ'D (HR/IRRIG/AC)
      (N,9)     ADD'L. LABOR (HRS/SEASON)
      (N,10)    TOTAL LAND GRADING COSTS ($)
      (N,11)    % LAND GRADING COSTS SUBSIDIZED
      (N,12)    % LAND GRADING COSTS FINANCED
      (N,13)    LOAN #
      (N,14)    ANNUAL MAINTENANCE COSTS ($)
      (N,15)    AVERAGE IRRIGATION APPLICATION EFFICIENCY (%)
      (N,16)    AVERAGE % DEEP PERCOLATION
      (N,17)    UNIT IRRIGATION FLOW (CFS/FT WIDTH)
```

FOR FURROW:

SYSFLD(N,1)	FIELD LENGTH (FT)
(N,2)	FIELD WIDTH (FT)
(N,3)	FIELD SLOPE (%)
(N,4)	FURROW LENGTH (FT)
(N,5)	MAX FURROW FLOW
(N,6)	IRRIG. SET TIME INCREMENT
(N,7)	MAX IRRIG. SET TIME
(N,8)	LABOR REQ'T (HR/IRRIG/AC)
(N,9)	ADD'L LABOR (HRS/SEASON)
(N,10)	TOTAL INITIAL LAND GRADING COST ($)
(N,11)	% LAND GRADING COST SUBSIDIZED
(N,12)	% LAND GRADING COST FINANCED
(N,13)	LOAN #
(N,14)	ANNUAL MAINTENANCE COSTS ($)
(N,15)	IRRIGATION APPLICATION EFFICIENCY (%)
(N,16)	AVERAGE % DEEP PERCOLATION
(N,17)	FURROW FLOW RATE (GPM)

FOR SOLID SET:

SYSFLD(N,1)	LATERAL LENGTH (FT)
(N,2)	LATERAL SPACING (FT)
(N,3)	LATERAL DIAMETER (IN)
(N,4)	SPRINKLER SPACING (FT)
(N,5)	SPRINKLER TYPE #
(N,6)	BLOCK WIDTH (FT)
(N,7)	TOTAL # OF BLOCKS
(N,8)	SET TIME INCREMENT (HR)
(N,9)	DESIGN FLOW (IN/DAY)
(N,10)	AVERAGE FIELD SLOPE (%)
(N,11)	LABOR REQ'D (HR/IRRIG/AC)
(N,12)	ADD'L LABOR (HRS/SEASON)
(N,13)	COST PER LATERAL LINE ($)
(N,14)	% COST SUBSIDIZED
(N,15)	% COST FINANCED
(N,16)	LOAN #
(N,17)	SALVAGE VALUE (%)
(N,18)	LAND GRADING COST ($)
(N,19)	% LAND GRADING COST SUBSIDIZED
(N,20)	% LAND GRADING COST FINANCED
(N,21)	LOAN # FOR LAND GRADING
(N,22)	ANNUAL LAND SMOOTHING COST ($)
(N,23)	ANNUAL MAINTENANCE COST (% OF ORIGINAL)
(N,24)	ANNUAL MISCELLANEOUS COSTS ($)
(N,25)	IRRIGATION APPLICATION EFFICIENCY (%)
(N,26)	DEEP PERCOLATION LOSSES (%)

VLOG(N,1)	RESERVOIR TILLAGE USED?
(N,2)	SOLID SET SYSTEM?

FOR SET MOVE:

SYSFLD(N,1)	LATERAL LENGTH (FT)
(N,2)	LATERAL SPACING (FT)
(N,3)	LATERAL DIAMETER (IN)
(N,4)	SPRINKLER SPACING (FT)
(N,5)	SPRINKLER TYPE #
(N,6)	LATERAL TRAVEL (FT)
(N,7)	TOTAL # OF LATERALS
(N,8)	SET TIME INCREMENT (HR)
(N,9)	DESIGN FLOW (IN/DAY)
(N,10)	AVERAGE FIELD SLOPE (%)
(N,11)	LABOR REQ'D (HR/IRRIG/AC)
(N,12)	ADD'L LABOR (HRS/SEASON)
(N,13)	COST PER LATERAL LINE ($)
(N,14)	% COST SUBSIDIZED
(N,15)	% COST FINANCED
(N,16)	LOAN #
(N,17)	SALVAGE VALUE (% OF ORIGINAL)
(N,18)	LAND GRADING COST ($)
(N,19)	% LAND GRADING COST SUBSIDIZED
(N,20)	% LAND GRADING COST FINANCED
(N,21)	LOAN # FOR LAND GRADING
(N,22)	ANNUAL LAND SMOOTHING COST ($)
(N,23)	ANNUAL MAINTENANCE COST (% OF ORIGINAL)
(N,24)	ANNUAL MISCELLANEOUS COSTS ($)
(N,25)	IRRIGATION APPLICATION EFFICIENCY (%)
(N,26)	DEEP PERCOLATION LOSSES (%)

VLOG(N,1)	RESERVOIR TILLAGE USED?
(N,2)	SOLID SET SYSTEM?

FOR CENTER PIVOT:

SYSFLD(N,1)	LATERAL LENGTH (FT)
(N,2)	LATERAL DIAMETER (IN)
(N,3)	DESIGN FLOW (IN/DAY)
(N,4)	SPRINKLER TYPE #
(N,5)	AVERAGE FIELD SLOPE (%)
(N,6)	FIELD RADIUS (FT)
(N,7)	LABOR REQ'T. (HR/IRRIG/AC)
(N,8)	
(N,9)	
(N,10)	
(N,11)	
(N,12)	
(N,13)	TOTAL COST ($)
(N,14)	% TOTAL COST SUBSIDIZED
(N,15)	% TOTAL COST FINANCED
(N,16)	LOAN #
(N,17)	SALVAGE VALUE (% OF TOTAL)
(N,18)	LAND GRADING COST ($)
(N,19)	% LAND GRADING COST SUBSIDIZED
(N,20)	% LAND GRADING COST FINANCED
(N,21)	LOAN # FOR LAND GRADING COSTS
(N,22)	ANNUAL LAND SMOOTHING COST ($)
(N,23)	ANNUAL MAINTENANCE COST (% OF ORIGINAL)
(N,24)	ANNUAL MISCELLANEOUS COST ($)
(N,25)	AVERAGE APPLICATION EFFICIENCY (%)
(N,26)	AVERAGE DEEP PERCOLATION LOSSES (%)

VLOG(N,1)	RESERVOIR TILLAGE?
(N,2)	PRESSURE REGULATORS ON SPRINKLERS?
(N,3)	ENDGUN USED?
(N,4)	AVERAGE WIND > 5 MPH?

```
FOR LINEAR MOVE:

SYSFLD(N,1)     LATERAL LENGTH (FT)
      (N,2)     LATERAL DIAMETER (IN)
      (N,3)     DESIGN FLOW (IN/DAY)
      (N,4)     SPRINKLER TYPE #
      (N,5)     AVERAGE FIELD SLOPE (%)
      (N,6)     FIELD LENGTH IN DIRECTION OF TRAVEL (FT)
      (N,7)     LABOR REQ'T. (HR/IRRIG/AC)
      (N,8)
      (N,9)
      (N,10)
      (N,11)
      (N,12)
      (N,13)    TOTAL COST ($)
      (N,14)    % TOTAL COST SUBSIDIZED
      (N,15)    % TOTAL COST FINANCED
      (N,16)    LOAN #
      (N,17)    SALVAGE VALUE (% OF TOTAL)
      (N,18)    LAND GRADING COST ($)
      (N,19)    % LAND GRADING COST SUBSIDIZED
      (N,20)    % LAND GRADING COST FINANCED
      (N,21)    LOAN # FOR LAND GRADING COSTS
      (N,22)    ANNUAL LAND SMOOTHING COST ($)
      (N,23)    ANNUAL MAINTENANCE COST (% OF ORIGINAL)
      (N,24)    ANNUAL MISCELLANEOUS COST ($)
      (N,25)    AVERAGE APPLICATION EFFICIENCY (%)
      (N,26)    AVERAGE DEEP PERCOLATION LOSSES (%)

  VLOG(N,1)     RESERVOIR TILLAGE?
      (N,2)     PRESSURE REGULATORS ON SPRINKLERS?
      (N,3)     LATERAL SUPPLIED IN CENTER?
      (N,4)     AVERAGE WIND > 5 MPH?

SYSOBS(N,M,1)   DEEP PERCOLATION LOSS (%)
      (N,M,2)   RUNOFF LOSS (%)
      (N,M,3)   HRS/SET OR HRS/PASS FOR MOST EFFICIENT IRRIGATION
                N = CROP #
                M = FIELD #

SYSUM(1,N,M)    TOTAL VOLUME ENTERING SYSTEM
     (2,N,M)    # TIMES SYSTEM IS REQUIRED
     (3,N,M)    # TIMES SYSTEM SIZE LIMITS
           N = SYSTEM #
           M = PERIOD (1-24)

SYSV(N,M) VOLUME OF WATER APPLIED BY A SYSTEM
           N = APPLICATION SYSTEM #
           M = PERIOD (1=CURRENT, 2=FORCAST)

SYSVAL(N,M)     APPLICATION SYSTEM PARAMETERS
      (1,M)     FLOW ENTERING SYSTEM (CFS)
      (2,M)     PERCENT OF TIME SYSTEM OPERATES
      (3,M)     MAIN SYSTEM LIFE (YRS)
      (4,M)     TOTAL CAPITAL COST - ATTACHED ITEMS, LOAN 1 ($)
      (5,M)     CAPITAL NOT FINANCED OR SUBSIDIZED - LOAN 1 ($)
      (6,M)     SUBSIDIZED CAPITAL - LOAN 1 ($)
      (7,M)     FINANCED CAPITAL - LOAN 1 ($)
      (8,M)     INTEREST RATE - LOAN 1 (%)
      (9,M)     LENGTH OF LOAN 1 (YR)
     (10,M)     SALVAGE VALUE OF COMPONENTS - LOAN 1 ($)
     (11,M)     ANNUAL MAINTENANCE COST - LOAN 1 ($)
     (12,M)     ANNUAL MISCELLANEOUS COSTS - LOAN 1 ($)
     (13,M)-(21,M)  SAME AS PARAMETERS (4,M)-(12,M) EXCEPT FOR LOAN 2
                (UNATTACHED) ITEMS
     (22,M)     ANNUAL CAPITAL RECOVERY COST ($)
          M = SYSTEM #
```

```
TLAB(N,1) TOTAL LABOR USED TO OPERATE SYSTEM (HRS/IRRIG)
    (N,2) ADDITIONAL LABOR (HRS/SEASON)
          N = FIELD #

TOTIRG(N) TOTAL NUMBER OF IRRIGATIONS FOR A FIELD
          N = FIELD #

TPUMP(1)  INSTALLATION CHARGE ($)
     (2)  ANNUAL LUMP CHARGE ($)
     (3)  ANNUAL DEMAND CHARGE ($/KW)
     (4)  BILLING PERIOD LUMP CHARGE-SUMMER ($)
     (5)  BILLING PERIOD DEMAND CHARGE-SUMMER ($/KW)
     (6)  BILLING PERIOD POWER CHARGE-SUMMER ($/KWH)
     (7)
     (8)
     (9)  BILLING PERIOD LUMP CHARGE-WINTER ($)
     (10) BILLING PERIOD DEMAND CHARGE-WINTER ($/KW)
     (11) BILLING PERIOD POWER CHARGE-WINTER ($/KWH)
     (12)
     (13)
     (14) START OF SUMMER RATES (MONTH)
     (15) START OF WINTER RATES (MONTH)
     (16) BILLING PERIOD LENGTH (MONTH)

WCOST(1)  COST OF BASIC ALLOTMENT ($/AC)
     (2)  VOLUME OF BASIC ALLOTMENT (AC-FT/AC)
     (3)  CAPACITY COST ($/(AC-FT/AC))
     (4)  COST OF ADD'L. WATER ($/(AC-FT/AC))

YDAT(N,1) TOTAL ACTUAL ET FOR CROP GROWTH PERIOD 1
    (N,2) TOTAL ACTUAL ET FOR CROP GROWTH PERIOD 2
    (N,3) TOTAL ACTUAL ET FOR CROP GROWTH PERIOD 3
    (N,4) TOTAL ACTUAL ET FOR CROP GROWTH PERIOD 4
    (N,5) TOTAL MAXIMUM ET FOR CROP GROWTH PERIOD 1
    (N,6) TOTAL MAXIMUM ET FOR CROP GROWTH PERIOD 2
    (N,7) TOTAL MAXIMUM ET FOR CROP GROWTH PERIOD 3
    (N,8) TOTAL MAXIMUM ET FOR CROP GROWTH PERIOD 4
          N = CROP #

YDAT2(N,M,1-8) SAME AS YDAT(N,I-8) ABOVE, INCLUDES CLASSIFICATION
               BY FIELD.  FOR SINGLE SEASON ONLY.
               N = CROP #
               M = FIELD #

YIELD(1,N)     NORMAL YIELD
     (2,N)     EXPECTED RETURN ($/UNIT)
     (3,N)     1ST PERIOD Ky FACTOR
     (4,N)     2ND PERIOD Ky FACTOR
     (5,N)     3RD PERIOD Ky FACTOR
     (6,N)     4TH PERIOD Ky FACTOR
     (7,N)     MAX. CROP COVER
     (8,N)     AVE. RESIDUE YIELD
          N = CROP #
```

APPENDIX F

CRFILGEN PROGRAM LISTING

CONTENTS

PROGRAM PURPOSE

The sole purpose of the program CRFILGEN is to create a direct access file containing the cropdata required by the SYSTEM and SIMULATE routines. A direct access cropdata file is used to minimize the static data requirements of the SYSTEM and SIMULATE routines but yet have quick access to the required information. The CRFILGEN program uses the print file created by the LOTUS SYMPHONY CROPDATA spreadsheet. The user is requested to enter the name of the sequential access cropdata file created using the spreadsheet and the desired name of the direct access cropdata file to be created. The Crop Identification No. in the sequential access file is used as the record number in the direct access file. Thus, the crops in the sequential access file **must** be listed according to the Crop Identification No. and in increments of one (ie. 1, 2, 3, 4, 5, 6, etc).

```
      PROGRAM CRFILGEN
C -- PROGRAM TO CONVERT SEQUENTIAL CROP INFORMATION FILE TO DIRECT
C    ACCESS CROP INFORMATION FILE.  CROP No. BECOMES RECORD No.
      CHARACTER CROPNAME*15,SFILENAME*12,DFILENAME*12,SS*3,SM*3,CM*3
      INTEGER DATE(6),OTHER(3),CROPNO
      REAL KVALUES(29)
      DATA DATE/6*0/
      WRITE(*,*) ' ENTER THE FILENAME OF THE SEQUENTIAL CROP INFORMATION
     * FILE.'
      WRITE(*,*)
      READ(*,'(A)') SFILENAME
      WRITE(*,'(//)')
      WRITE(*,*) ' ENTER THE FILENAME OF THE DIRECT CROP INFORMATION FIL
     *E.'
      WRITE(*,*)
      READ(*,'(A)') DFILENAME
      WRITE(*,'(/)')
      OPEN(10,FILE=SFILENAME,STATUS='OLD',IOSTAT=IOCHECK)
      IF(IOCHECK.NE.0) GOTO 1000
      OPEN(15,FILE=DFILENAME,STATUS='NEW',ACCESS='DIRECT',
     *FORM='FORMATTED',IOSTAT=IOCHECK,RECL=208)
      IF(IOCHECK.GT.0) GOTO 2000
      WRITE(*,50) SFILENAME,DFILENAME
   50 FORMAT(' THE DATA LISTED BELOW IS BEING READ FROM FILE ',A12/,
     *' AND STORED IN FILE ',A12/)
   10  READ(10,100,END=5000) CROPNO,CROPNAME,(DATE(K),K=1,6)
     * ,(KVALUES(J),J=1,29),OTHER(1),SS,SM,CM,(OTHER(N),N=2,3)
  100 FORMAT(I3,1X,A15,6(I6,1X),28(F4.0,1X),F4.0,1X,I4,1X,3A3,2(I5,1X))
  110 FORMAT(I3,1X,A15,6(I6,1X),28(F4.2,1X),F4.2,1X,I4,1X,3A3,2(I5,1X)/)
  101 WRITE(*,110) CROPNO,CROPNAME,(DATE(K),K=1,6)
     * ,(KVALUES(J),J=1,29),OTHER(1),SS,SM,CM, (OTHER(N),N=2,3)
      WRITE(15,200,REC=CROPNO)CROPNAME,(DATE(K),K=1,6)
     * ,(KVALUES(J),J=1,29),OTHER(1),SS,SM,CM, (OTHER(N),N=2,3)
  200 FORMAT(A15,6I6,29F4.2,I4,3A3,2I5)
      GOTO 10
 5000 WRITE(*,'(/)')
      WRITE(*,*) ' DIRECT ACCESS CROP INFORMATION FILE ',DFILENAME,
     *' HAS BEEN CREATED'
      WRITE(*,'(//)')
      CLOSE(10)
      CLOSE(15)
      STOP
 1000 WRITE(*,*) ' CANNOT OPEN SEQUENTIAL CROP FILE ',SFILENAME
      STOP
 2000 WRITE(*,*) ' CANNOT OPEN DIRECT CROP FILE ',DFILENAME
      STOP
      END
```

APPENDIX G

COFILGEN PROGRAM LISTING

CONTENTS

PROGRAM PURPOSE

The sole purpose of the program COFILGEN is to create a direct access file containing the component costdata required by the SYSTEM and SIMULATE routines. A direct access costdata file is used to minimize the static data requirements in SYSTEM and SIMULATE routines but yet have quick access to the desired information. The COFILGEN program uses the print file created by the LOTUS SYMPHONY COSTDATA spreadsheet. The user is requested to enter the name of the sequential access costdata file created using the spreadsheet and the desired name of the direct access costdata file to be created. The cost information must appear in the sequential access costdata file as explained in the COSTDATA spreadsheet.

```
C -- PROGRAM TO CONVERT SEQUENTIAL COST INFORMATION FILE TO DIRECT
C     ACCESS COST INFORMATION FILE.
      PROGRAM COFILGEN
      CHARACTER ITEMNAME*22,SFILENAME*20,DFILENAME*20
      INTEGER DATE(6)
      REAL KVALUES(29)
      WRITE(*,*) ' ENTER THE FILENAME OF THE SEQUENTIAL COST INFORMATION
     * FILE.'
      WRITE(*,*)
      READ(*,'(A)') SFILENAME
      WRITE(*,'(//)')
      WRITE(*,*) ' ENTER THE FILENAME OF THE DIRECT COST INFORMATION FIL
     *E.'
      WRITE(*,*)
      READ(*,'(A)') DFILENAME
      WRITE(*,'(/)')
      OPEN(10,FILE=SFILENAME,STATUS='OLD',IOSTAT=IOCHECK)
      IF(IOCHECK.NE.0) GOTO 1000
      OPEN(15,FILE=DFILENAME,STATUS='NEW',ACCESS='DIRECT',
     *FORM='FORMATTED',IOSTAT=IOCHECK,RECL=208)
      IF(IOCHECK.GT.0) GOTO 2000
      WRITE(*,50) SFILENAME,DFILENAME
   50 FORMAT(' THE DATA LISTED BELOW IS BEING READ FROM FILE ',A12/,
     *' AND STORED IN FILE ',A12/)
       DO 32 M = 1,9
   10  READ(10,100) ITEMNAME,(DATE(K),K=1,3)
     * ,(KVALUES(J),J=1,DATE(1)*2)
  100 FORMAT(A22,3(I8,1X),29(F8.0,1X))
  110 FORMAT(A22,3(I3,1X),29(F7.2,1X)/)
  101 WRITE(*,110) ITEMNAME,(DATE(K),K=1,3)
     * ,(KVALUES(J),J=1,DATE(1)*2)
      WRITE(15,200,REC=M) ITEMNAME,(DATE(K),K=1,3)
     * ,(KVALUES(J),J=1,DATE(1)*2)
  200 FORMAT(A22,3I3,29F7.2)
   32 CONTINUE
      READ(10,150) ITEMNAME,DATE(1),DATE(2),(KVALUES(J),J=1,DATE(1)*2+3)
  150 FORMAT(A22,2(I8,1X),29(F8.0,1X))
      WRITE(*,149)ITEMNAME,DATE(1),DATE(2),(KVALUES(J),J=1,DATE(1)*2+3)
  149 FORMAT(A22,2(I8,1X),29(F7.2,1X))
      WRITE(15,151,REC=10) ITEMNAME,DATE(1),DATE(2),(KVALUES(J),J=1,
     *DATE(1)*2+3)
  151 FORMAT(A22,2(I3),29F7.2)
      DO 33 M=1,2
      READ(10,250) ITEMNAME,COST,LIFE
  250 FORMAT(A22,F8.0,1X,I8)
      WRITE(*,249) ITEMNAME,COST,LIFE
  249 FORMAT(A22,F7.2,1X,I3)
      WRITE(15,251,REC=10+M) ITEMNAME,COST,LIFE
  251 FORMAT(A22,F7.2,I3)
   33 CONTINUE
      DO 34 M=1,2
      READ(10,350) ITEMNAME,LIFE
  350 FORMAT(A22,I8)
      WRITE(*,350) ITEMNAME,LIFE
      WRITE(15,350,REC=12+M) ITEMNAME,LIFE
   34 CONTINUE
      READ(10,400) ITEMNAME,(DATE(J),J=1,5)
  400 FORMAT(A22,5(I8,1X))
      WRITE(*,400) ITEMNAME,(DATE(J),J=1,5)
      WRITE(15,450,REC=15) ITEMNAME,(DATE(J),J=1,5)
  450 FORMAT(A22,5I3)
      WRITE(*,'(/)')
      WRITE(*,*) ' DIRECT ACCESS COST INFORMATION FILE ',DFILENAME,
     *' HAS BEEN CREATED'
      WRITE(*,'(//)')
      CLOSE(10)
      CLOSE(15)
      STOP
 1000 WRITE(*,*) ' CANNOT OPEN SEQUENTIAL COST FILE ',SFILENAME
      STOP
```

```
2000  WRITE(*,*) ' CANNOT OPEN DIRECT COST FILE ',DFILENAME
      STOP
      END
```

APPENDIX H

STAND-ALONE APPLICATION SYSTEM MODELS

Contents

STAND-ALONE PROGRAM PURPOSE

Stand-alone models of each of the irrigation applications systems considered by the SYSTEM routine are provided to give the user the opportunity to adjust the parameters of the proposed application system(s) and evaluate the effects on the operational characteristics. This allows the user to develop a "feel" for how sensitive a system's operating characteristics are to various site-specific parameters and thus aid in selection of the most suitable system configuration for the particular conditions. This is an important step in selecting the optimum irrigation system as changes in system parameters can have a profound influence on system performance and thus system selection. These stand-alone models do not compute capital or operational costs. The SYSTEM and SIMULATE routines must be used to compute costs.

Following is a brief description of how to use each of the application system stand-alone models and their associated input and output.

GRADED BORDER MODEL

Introduction

A computer routine to model the irrigation of sloping borders which determines the optimum unit flow rate and time to cut off has been developed. The advance portion of the program is based on the zero-inertia model developed and reported by Katopodes and Strelkoff (1977) and a computer routine written by Allen, et al (1978). The recession portion of the program is based on a simplified solution of the kinematic wave model reported by Sherman and Singh (1978). The volume of runoff and deep percolation is computed algebraically using the advance and recession model mentioned above. The model will handle both closed and open ended borders. For closed end borders, the height of the end dike is assumed to be 8 inches. Flow rates and application times which result in downstream depths of flow greater than 8 inches lead to runoff. The limit on maximum unit stream size is set by assuming a maximum depth of flow of 8 inches at the head end of the border.

The optimization portion of the program utilizes a two-dimensional search called the Hooke and Jeeves Search Algorithm (Phillips, et al, 1976). Given initial values of time to cut off and unit stream size (generated within the program) and field characteristics, the optimization algorithm finds the most efficient combination of time to cut off and unit stream size. The model runs quite fast on an IBM-PC computer which has a 8087 math coprocessor installed.

Required Input

The program is written to be interactive and thus prompts for the necessary user input. The user must input the border characteristics; slope, length, desired depth of application, Manning's roughness coefficient, border end condition (open or close ended) and soil intake parameters. The user is prompted for each input which must be typed into the computer. In some cases, prompts are accompanied by a list of values to aid in the selection of the necessary input. For example, the user is given a list of suggested values of Manning's roughness coefficient for various crops and conditions. The zero-inertia portion of the model requires that the soil intake parameters be entered in the form to the SCS intake family (F=aT^b+c). To facilitate entering the intake parameters, the user is prompted with a list of intake families from which to choose.

Output

Once the optimal solution is found, a summary report of the findings are printed. This summary includes the input values entered and used in finding the optimal solution. Computed information shown in the summary includes the depths of application at the head and downstream ends of the border, time to cut off, time for all water to disappear from the surface, unit flow rate, application efficiency, percent of applied water going to deep percolation and percent going to runoff.

References

Allen, R. G., C. E. Brockway, and J. R. Busch. 1978. Planning optimal irrigation distribution and application systems: Teton flood damaged lands. Idaho Water and Energy Resources Research Institute, University of Idaho, Moscow, Idaho.

Katopodes, A. M. and Theodor Strelkoff. 1977. Dimensionless Solutions of Border-Irrigation Advance. ASCE J. Irrig. and Drain. Div. 103(IR4): pp.401-417.

Phillips, D. T., A. Favindran, J. J. Solberg. 1976. Operations Research - Principles and Practice. Wiley and Sons. New York.

Sherman, B. and V. P. Singh. 1978. A Kinematic Model for Surface Irrigation. Water Resources Res. 14(2): pp.357-364.

FURROW MODEL

Introduction

A computer program to model furrow irrigation and utilize the model to maximize irrigation efficiencies was adapted from the kinematic wave model developed at Utah State University (Elliot, et al., 1982) and later adapted to model sediment yield and runoff from irrigation furrows. The model consists of a main program which contains an interactive data entry routine, the optimization algorithms used, and a segment which outputs the irrigation performance, as well as the kinematic wave subroutine which contains the actual irrigation model.

Description

Much of the input data for the model is entered from the keyboard with the appropriate operator prompts. Required information about the field includes the furrow length and field slope. Data pertaining to the furrow spacing, geometry, and infiltration characteristics are also required. Furrow geometry is determined from the furrow spacing and the crop to be irrigated. Using empirical formulas developed at the Kimberly Irrigation Research Center, coefficients relating furrow area, topwidth, depth, and hydraulic radius are determined from the particular crop to be irrigated. Furrow infiltration characteristics can be determined by entering the SCS furrow infiltration family curve number (USDA-SCS, 1980) or by entering four coefficients (A,B,C & D) for the modified Kostiakov equation:

Z = A*IOT**B + C*IOT**D

where:

Z = depth of water infiltrated
IOT = infiltration opportunity time

Limits are also entered, including the maximum furrow flow rate and irrigation time increment. The maximum flow rate can be an input or it can be computed from the furrow geometry. The maximum total irrigation time is an input parameter as well, and the irrigation time increment can be entered as any value less than the maximum irrigation time.

Input data are entered in English units, with flow rates in gpm, time units in hours, furrow dimensions in feet, and desired infiltration depth and infiltration coefficients in inches. The basic furrow irrigation model is contained in the subroutine WAVE. This routine is adapted from a sediment yield model developed by Clarence Robison at the Kimberly Research Center. This routine contains numeric models of the advance, infiltration, and recession phases for an irrigation furrow. Through use of this routine, furrow advance time, total irrigation amount, deep percolation volume, runoff volume, and irrigation application efficiency are computed. The routine also has optional provisions for determining the furrow flow necessary to achieve a particular advance time as well as the irrigation set time required to apply a desired depth at the lower end of the furrow. These two options are selected through the use of an input flag.

Program Use

The main portion of the furrow irrigation modeling package has provisions for selection of furrow flow rates to maximize irrigation efficiency. This single parameter search (Phillips, et al., 1976) will find the furrow flow rate resulting in the highest irrigation efficiency for a particular irrigation requirement.

The user may specify an irrigation set time increment, such as 1, 2, 6, or 8 hours, and the most efficient flow rate and total irrigation time will be determined based on these time increments. For example, if a 6-hour time increment is specified, the most efficient furrow flow will be determined for a total irrigation period of some multiple of six hours (6, 12,18, 24, etc.). Currently, the most efficient flow rate will be found within 0.5 gallons per minute. This range, however, can be adjusted through simple program changes. A smaller range will result in more computer run time as more iterations will be required.

Output

Once an optimal furrow flow rate is found, a irrigation performance report is printed. Provided in the report is runoff, deep percolation, and total application volumes, irrigation application efficiency, and an estimated application efficiency with tailwater reuse provisions which assume a 90% reuse of the runoff volume. Also on the performance report are the optimal furrow flow rate, the irrigation set time increment, the total irrigation set time, the end-of-furrow advance time, and both the desired and actual irrigation depths.

Adaptability

Currently the model has no provisions for cut-back irrigation, but the programs could be easily adapted to model this as well. This cutback could be based on either irrigation time or stream advance. It should be noted that for the purpose of speeding program execution, the original kinematic wave subroutine was modified to make infiltration and advance calculations utilizing twenty-minute time steps rather than the ten minute steps of the original model. This makes a considerable reduction in execution time with little effect on the accuracy of the results.

The current version of the model does not include a limit on furrow flow rate based on the maximum nonerosive stream size. The only limit placed on the stream size is based on the furrow geometry and capacity. The current recommendations used by the SCS for maximum nonerosive streamsizes based on soil erosivity and furrow slope could easily be incorporated into this model if desired. The model in its current form is a stand-alone program but can easily be adapted for use as part of a larger modeling package.

References

Elliot, E. L., W. R. Walker, G. V. Skogerboe. 1982. Zero-inertia modeling of furrow irrigation advance. ASCE J. Irrig. and Drain. Div. 108(IR3): 179-195.

Phillips, D. T., A. Ravindran, J. J. Solberg. 1976. Operations Research - Principles and Practice. John Wiley and Sons. New York.

USDA-SCS. 1980. Furrow irrigation. In: SCS national engineering handbook - chapter 5.

SOLID SET/SET-MOVE MODEL

Introduction

A computer model was developed to evaluate the irrigation performance of solid set and set-move irrigation systems. The model was designed to provide estimates of irrigation efficiency and uniformity for these types of systems operating under a variety of conditions. The model estimates losses due to wind, evaporation, deep percolation, and surface runoff, and includes provisions for estimating soil erosion losses and irrigation energy requirements. The model works with limited amounts of data and utilizes many generalized parameters.

Data Requirements

This model requires data pertaining to the particular field, the irrigation system and the field environment. Field data which must be supplied include the field size, the maximum slope, the sprinkler infiltration rate, and whether reservoir or basin tillage is used to reduce surface runoff. Necessary irrigation system data include lateral lengths, the area watered by a single lateral or block, the lateral pipe size, the sprinkler spacing along the lateral, the system capacity, and the type of sprinkler and nozzle,which are selected from a menu of four types.

Other data required by the model are the desired irrigation depth, the expected average wind conditions, and several parameters used to estimate soil erosion losses including the erosivity (K) index, the amount of crop residue, and the amount of canopy cover.

Computations

The model simulates the performance of a single lateral. Based on the specified sprinkler spacing along the lateral and area covered by the lateral, the flow rate and operating pressure of each sprinkler the lateral are determined. Using the design pressure and flow values for a sprinkler, the diameter of the sprinkler pattern is determined (Kincaid, 1982). The spacing between laterals may be selected by the programm user or computed, based on the estimated sprinkler pattern diameter and average wind conditions (Addink, et. al., 1980; Pair, et.al., 1982). When the lateral spacing is not specified, the spacing for each of the three wind ranges (0-4, 4-10, and 10-14 mph) is 0.6, 0.5, and 0.4 times the wetted pattern diameter, respectively. Spacings are rounded downward to the nearest 10-ft increment and are constrained to a 30-ft minimum and a 60-ft maximum.
An iterative procedure is used to estimate the flow from each sprinkler on the lateral with the lateral having each of three degrees of slope. The slope conditions include a constant downhill slope, a constant uphill slope, and a level condition. The uphill and downhill slopes are assumed to be of the maximum slope found in the field. The uphill slope condition is used to determine the minimum required mainline pressure for the system. Data computed assuming a downhill lateral run are used to find the maximum set time which minimize surface runoff.

Wind and evaporation losses are assumed to be a percentage of the total irrigation amount, with the percentage determined by the range of the expected wind conditions (SCS, 1983). Runoff amounts are estimated at sprinklers at each end of a lateral having each of the three slope conditions. From this runoff data, a modified version of the Universal Soil Loss Equation (USLE) can be used to estimate soil losses due to the irrigation. These runoff estimates, as well as the total lateral flow in each of the three slope conditions, are weighted to represent conditions throughout the field.

Application uniformity for the system is estimated using a method similar to that of James and Blair (1984). Distribution pattern matrices of Seginer and Kostrinsky (1975), developed from catch can tests made with several different wind speeds, were normalized by dividing each value by the average depth. By interpolation, three normalized sprinkler pattern matrices were developed for wind velocities at the midpoint of the three wind ranges (2.5, 7, and 12.5 mph).

A grid of 25 catch cans is assumed to be located in the area between four sprinklers on two different lateral settings. The wind is assumed to be perpendicular to the laterals. The depth applied at each can position is computed by superimposing over the catch can grid, the distribution pattern matrices for each of the 20 sprinklers which could contribute to the application within the grid. The contribution to each can from each sprinkler operating under the particular wind condition is totaled and Christiansen's uniformity coefficient (CU) computed from the data.

The application uniformity is used to determine the irrigation amount necessary to assure adequate irrigation throughout the entire irrigated area. This assumes that the required amount is equal to the desired irrigation depth plus an additional amount equal to:

$$(1 - CU) \times (\text{Desired irrigation depth})$$

The model determines the irrigation time required to apply this amount of water. Once the total irrigation time is determined, and assuming that the entire root zone is filled to field capacity, the deep percolation losses are estimated using a water balance technique. The irrigation efficiency is then calculated as well as the estimated energy requirement for a unit of applied water.

Output

Input data entered by the user and a summary of the irrigation performance are output for the user. Irrigation performance data include the total irrigation amount required for one lateral position, itemized losses to wind and evaporation, runoff, and deep percolation, Christiansen's uniformity coefficient, irrigation efficiency, soil erosion loss estimates, and application energy estimates.

References

Addink, J. W., J. Keller, C. H. Pair, R. E. Sneed, and J. W. Wolfe. 1980. Chapter 15--Design and operation of sprinkler systems. In: Design and operation of farm irrigation systems, M. E. Jensen (ed.). ASAE, St. Joseph, MI. p. 621-660.

James, L. G. and S. K. Blair. 1984. Effect of wind on center pivot application uniformity. ASAE paper 84-2582. 10 p. Kincaid, D. C. 1982. Sprinkler pattern radius. Trans. ASAE 25(6):1668-1672.

Pair, C. H., W. W. Hinz, C. R. Reid, and K. R. Frost. 1975. Sprinkler irrigation. Irrigation Assn., Silver Spring, MD. 615 p.

Seginer, I. and M. Kostrinsky. 1975. Wind, sprinkler patterns and system design. Jour. Irrig. and Drain. Div. ASCE 101(IR4):251-264.

USDA-SCS. 1983. National engineering handbook, Sec. 15--Irrigation, Chapter 11--Sprinkle irrigation. 121 p.

CENTER PIVOT MODEL

Introduction

A computer model of a center pivot irrigation system was developed for the purpose of evaluating the system's performance. The model was designed to provide estimates of application depth and uniformity, losses due to wind, evaporation, deep percolation, and runoff, as well as estimated irrigation energy requirements. In addition, the model includes provisions for estimating soil erosion losses from irrigation.

The model requires a limited amount of data and utilizes many generalized parameters to model "typical" center pivot systems.

Data Requirements

While attempts were made to minimize data requirements, certain data pertaining to the irrigation system, the field, and other parameters are required. System data required include lateral length, the irrigated field radius, and the design flow rate. The particular sprinkler type is selected from a 7-item menu that includes both impact and spray sprinklers. Pressure-regulated sprinklers and an endgun may be specified as well.

Data which must be supplied about the field include the soil intake rate and the average field slope conditions, as well as whether any type of reservoir or basin tillage is used to reduce runoff. In addition, average winds of more than 5 mph are noted. The calculations used to estimate erosion amounts require the soil's erosivity (K) index, the amount of crop residue, and the extent of the canopy cover.

Computations

Based on the type of sprinkler specified, a uniform sprinkler spacing is determined, as well as the total number of sprinklers. The model evaluates the system at three positions in the field (i.e. along 3 rays). The slope of the lateral along each ray is determined from the average field slope data. Two of the rays, simulating the two "worst case" lateral positions, assume constant uphill and downhill slopes of the same pitch as that of the field average. The third evaluation is made for a ray which assumes a level lateral position.

Assuming a level lateral, the design flow and lateral pressure for each sprinkler are determined. The design flows of each sprinkler are determined by the sprinkler's distance from the pivot and the design flow rate. Design sprinkler pressures for regulated sprinklers are assumed to be constant but design pressures for non-regulated sprinklers are determined from the lateral pressures at that point. Pivot pressures are then determined. For laterals with regulated sprinklers, the elevation head difference between the pivot and the end of the lateral when in the constant uphill slope position is added to the design pivot pressure. The pivot pressure is assumed to be the design pivot pressure for non-regulated laterals.

The model then simulates the operation of the center pivot along the three rays, finding the pressure and flow values for each sprinkler along the lateral. All sprinklers having pressure regulators are assumed to operate at the minimum required sprinkler pressure for that particular sprinkler type, with each sprinkler supplying its design flow rate. An iterative procedure, similar to that used by James (1982), is used to determine the sprinkler (lateral) pressure and flow for nonregulated sprinklers. Non-regulated sprinkler flows are determined utilizing the ratio between the estimated lateral pressure and the sprinkler's design pressure. Once each sprinkler's flow is determined, the total system flow along each ray is computed.

The rotational speed of the center pivot system is determined so that surface runoff is minimized at a point 3/4 of the lateral radius outward from the pivot. The lateral is assumed to be along the ray having the constant downhill slope, the position having the greatest application rate in the unregulated condition. The time for the system to make a complete lap around the field is then adjusted until runoff at this point is eliminated or a predetermined minimum rotational time for the system is reached, limiting further runoff reductions. The minimum rotational time is set by assuming that the end of the lateral travels at a maximum speed of 12 ft/min. This adjusted time is then used to evaluate the system's one-revolution performance.

The performance of the system is determined by evaluating the performance at several points along the three rays and weighting the results by the area of the field that these points represent. Runoff amounts are estimated at four points along each ray. These points are at distances 0.3, 0.62, 0.82, and 0.94 of the lateral length from the pivot point. These distances represent the midpoints of four concentric rings, each containing 1/4 of the total area covered by the lateral.

Runoff amounts are estimated using a procedure developed by Gilley (1984). This procedure requires the determination of sprinkler pattern diameter and peak application rate. The pattern diameter is determined by estimating the diameter of throw for the sprinkler nearest the evaluation point. This diameter is determined by the sprinkler's operating pressure and flow and sprinkler type (Kincaid, 1982; James and Blair, 1983). Since a particular point under a center pivot system is wetted by several sprinklers, the mean application rate at a point is assumed to be a function of the total system flow along the particular ray and the distance from the pivot. Surface storage volumes at each point are also estimated (Dillon, et al., 1972) and subtracted from the potential runoff volumes. The addition of artificial surface storage (pits) is assumed to reduce the runoff by 85% (Kincaid and Busch, 1986). Runoff values for the points along each ray are averaged.

In addition to runoff, the total application depth is calculated at each sprinkler along the lateral for each ray. This is estimated from the total system flow, the distance from the pivot, and the rotation speed of the system. This application depth is then modified to account for wind and evaporation losses. Wind and evaporation losses are assumed to be a function of two wind regimes used and the height of the sprinkler. For average winds less than 5 mph, these losses are estimated to be 0.5% of the gross application depth per foot of sprinkler elevation, and 1.0 % per foot elevation for average winds greater than 5 mph.

Utilizing the adjusted application depths calculated for each sprinkler point, Christiansen's Uniformity Coefficient (CU) is calculated

(Heermann and Hein, 1968). The application depths of each individual sprinkler are evaluated in this process, as well as typical uniformity variations, dependent upon the sprinkler type, that exist in all center pivot systems, even under ideal conditions. By assuming that the only deep percolation losses are due to nonuniform application, the deep percolation losses are estimated using the formula:

$$\text{Deep percolation losses} = (1 - CU) \times (\text{net application})$$

At each point where irrigation runoff is evaluated, the amount of soil lost to erosion can be estimated. These calculations involve the use of the Universal Soil Loss Equation (USLE), and several parameters empirically developed by the Soil Conservation service for the Pacific Northwest region. Some of these parameters include droplet size and energy (von Bernuth and Gilley, 1983) and conservation tillage practices. These soil loss amounts are also averaged for each ray.

Performance data from each ray are weighted to estimate values for the whole field. It is estimated that the system's performance on each of the maximum positive and negative sloping rays is representative of the performance expected on 25% of the field area. The remainder of the field is assumed to be represented by the performance of the system on the ray having the level slope and the performance data from all three rays are weighted accordingly.

Output

The input data and the system performance data are output for the user. All system, field and other pertinent data entered by the user are displayed. Performance data output include the total irrigation amount, total losses to wind, runoff and deep percolation, Christiansen's Uniformity, irrigation efficiency, actual average irrigation depth, soil erosion losses, and estimated application energy requirements.

References

Dillon, R. C., E. A. Hiler, G. Vittetoe. 1972. Center-pivot sprinkler design based on intake characteristics. Trans. ASAE 15(5):996-1001

Gilley, J. R. 1984. Suitability of reduced pressure center pivots. J. of Irrig. and Drain. Div. ASCE. v110, IR(1):22-34.

Heermann, D. F. and P. R. Hein. 1968. Performance characteristics of self propelled center pivot sprinkler irrigation system. Trans. ASAE 11(1):11-15.

James, L. G. 1982. Modeling the performance of center pivot irrigation systems operating on variable topography. Trans. ASAE 25(1):143-149.

James, L. G. and S. K. Blair. 1983. Performance of low pressure center pivot systems. ASAE Paper 83-2021.

Kincaid, D. C. 1982. Sprinkler pattern radius. Trans ASAE 25(6):1668-1672.

Kincaid D. C. and J. R. Busch. 1986. Draft final report: Very low pressure application methods for center pivot irrigation on sloping lands. Report submitted to Bonneville Power Administration.

Kincaid, D. C. and D. F. Heermann. 1970. Pressure distribution on a center pivot irrigation system. Trans. ASAE 13(5):556-558.

von Bernuth, R. D. and J. R. Gilley. 1983. Evaluation of center pivot application packages considering droplet induced infiltration reduction. ASAE paper 83-2156.

LINEAR MOVE MODEL

Introduction

A computer model designed to simulate the performance of a continuously moving lateral or linear move irrigation system was developed for the purpose of evaluating the system's performance. The model provides estimates of application depth and uniformity, application losses due to wind, evaporation, deep percolation, and surface runoff, as well as estimates for irrigation energy requirements.

The model was developed from a similar center pivot system performance model and is much the same in structure and format.

Data Requirements

This model requires data pertaining to the irrigation system, the irrigated field, and several other parameters. System data required include the lateral length and diameter, the design application rate, and whether or not the lateral is supplied at its midpoint. The type of sprinkler used on the lateral is selected from a 7-item menu and pressure regulators may be specified for the sprinklers.

Data for the irrigated field include the soil's sprinkler infiltration rate, the field's maximum slope conditions, and whether any type of reservoir or basin tillage is used to reduce surface runoff. The expected average wind range is also required. The optional calculations to estimate soil erosion amounts require additional data, including the soil's erosivity (K) index, the amount of surface crop residue, and the extent of the crop canopy cover.

Computations

A uniform sprinkler spacing and total number of sprinklers along the lateral is determined based on the type of sprinkler selected. The performance of the system is then evaluated for three lateral slope conditions. Two "worst case" lateral positions assume the lateral to have a constant uphill and downhill slopes of the same pitch as the field's maximum slope. The third position assumes a level lateral.

The design flow and pressure for each sprinkler are determined assuming a level lateral. Regulated sprinklers are assumed to operate at a constant pressure while non-regulated sprinklers operate at pressures which vary due to friction losses in the lateral. The required supply point pressure is assumed to be the design supply pressure if non-regulated sprinklers are selected, but for regulated sprinklers, the elevation head difference between the supply point and the end of the lateral when in the uphill position is added to the design supply pressure.

For each of the three lateral slope positions, the system operation is simulated, with the pressure and flow values for each sprinkler being found. By assuming the two halves are symmetrical, only one half of a system with a central supply point is simulated, reducing the number of calculations. All regulated sprinklers are assumed to operate at their design pressures and supply their design flow rates. An iterative procedure, similar to that used by James (1982) in a center pivot model, is used to determine the individual non-regulated sprinkler pressures and flows. By summing the individual sprinkler flows, the total system flow is computed.

The speed of the system is determined so that surface runoff is minimized at the lateral midpoint when the lateral has a constant downhill slope, the position having the greatest flowrate in the unregulated condition. The time for the system to cover the entire field length is adjusted until runoff at this point is eliminated or minimized when a predetermined minimum time limit is reached. This limit is set assuming that the lateral travels at a maximum speed of 12 ft/min. This adjusted time for one pass over the field is then used to evaluate the system performance.

The system performance is evaluated by evaluating the performance at two points, the first and last sprinkler along the lateral, for each of the three lateral slope conditions, a total of 6 points. Runoff amounts at these points are estimated using a procedure developed by Gilley (1984) for runoff under center pivots. The wetted pattern at the point is assumed to be that of the wetted diameter of the nearest sprinkler. This diameter is determined from the sprinkler's operating pressure and flow and sprinkler type (Kincaid, 1982; James and Blair, 1983). The mean application rate at this point is determined from the wetted diameter and the sprinkler flow rate. Surface storage amounts at the point are estimated (Dillon, et al., 1972) and subtracted from the potential runoff amounts. The use of tillage methods to create additional surface storage is assumed to reduce runoff by 85%, based on preliminary results of Kincaid and Busch (1986). Runoff amounts are then averaged for each lateral slope condition.

In addition, the total application depth is calculated at each sprinkler along the lateral for each simulated lateral position. This depth is then adjusted to allow for wind and evaporation losses. These losses are assumed to be a function of the two wind regimes used and the height of the sprinkler. For average winds less than 5 mph, these losses are estimated to be 0.5% of the gross application depth per foot of sprinkler elevation, and 1.0% per foot elevation for average winds greater than 5 mph.

Using the adjusted application depths calculated at each sprinkler, Christiansen's Uniformity Coefficient (CU) is calculated. The uniformity coefficient calculated utilizing the application depths at each sprinkler are also adjusted to account for uniformity variations that exist in all systems of this type, even under ideal conditions. These variations are somewhat dependant upon the type of sprinkler that is used. The adjusted CU value is used to estimate the losses to deep percolation using the formula:

$$\text{Deep percolation losses} = (1\text{-CU}) \times (\text{net application})$$

At each point where runoff is evaluated, the soil loss to erosion can be estimated utilizing the Universal Soil Loss Equation (USLE) and several parameters developed by the Soil Conservation Service for the Pacific Northwest region. These parameters include droplet size (von Bernuth and Gilley, 1983) and effects of conservation tillage practices. Like the surface runoff amounts, soil loss amounts are averaged for each simulated lateral position.

The performance data obtained from each of the three simulated lateral positions are weighted to estimate values for the entire field. The data from the two sloping simulations are weighted 25% each and the level simulation data are weighted 50%.

Output

Input data and system performance data are displayed for the user. All data entered by the user from the keyboard as well as several computed parameters are output. The performance data include the total irrigation amount, total losses to wind, runoff, and deep percolation, Christiansen's Uniformity Coefficient, irrigation efficiency, actual average irrigation depth, soil erosion losses, and estimated application energy requirements.

References

Dillon, R. C., E. A. Hiler, and G. Vittitoe. 1972. Center-pivot sprinkler design based on intake characteristics. Trans. ASAE 15(5):996-1001.

Gilley, J. R. 1984. Suitability of reduced pressure center pivots. J. of Irrig. and Drain. Div., ASCE. v110, IR(1):22-34.

James, L. G. 1982. Modeling the performance of center picot irrigation systems operating on variable topography. Trans. of ASAE 25(1):143-149.

James, L. G. and S. K. Blair. 1983. Performance of low pressure center pivot systems. ASAE Paper 83-2021.

Kincaid, D. C. 1982. Sprinkler pattern radius. Trans. of ASAE 25(6)1668-1672.

Kincaid, D. C. and J. R. Busch. 1986. Draft final report: Very low pressure application methods for center pivot irrigation on sloping lands. Report submitted to Bonneville Power Administration.

von Bernuth, R. D. and J. R. Gilley. 1983. Evaluation of center pivot application packages considering droplet induced infiltration reduction. ASAE Paper 83-2156.