

SURFACE SYSTEM SIZING CHAPTER

This chapter of the Irrigation Guide serves as a basis for making planning decisions regarding the sizing of a surface irrigation system, as shown on page 4 of Form NM-CONS-213.

It is not intended to be a technical prediction method to predict exact length of run, exact efficiencies, exact border or furrow widths, or exact times or irrigation set.

Experience has shown us that the use of technical prediction methods leaves a great deal to be desired, not only because of the tremendous number of assumptions involved, but also because it is not the objective of the irrigation program in New Mexico to predict exact times of set, exact efficiencies, etc. The objective of the SCS irrigation program in New Mexico is to increase the understanding of on-farm irrigation water management by presenting irrigation data to the landowner and planners which the landowner can use to understand the principles of irrigation and adjust his/her irrigation system to the varying conditions of each irrigation.

The major input of SCS assistance on irrigation system sizing should be to help the landowner evaluate his/her existing system and increase his/her knowledge of irrigation water management.

For the above-mentioned reasons, the basic guidelines presented in this chapter are just that--basic guidelines. If special cases arise which necessitate the use of more accurate prediction methods for times of set and/or efficiencies for a given surface system, consult the following information sources for additional guidance:

1. National Engineering Handbook, Section 15, Chapter 4, Border Irrigation
2. National Engineering Handbook, Section 15, Chapter 5, Furrow Irrigation
3. The SCS Area Engineer
4. The SCS Engineering Specialist

PRINCIPLES OF SURFACE IRRIGATION

The purpose of any irrigation system is to provide even distribution throughout the entire irrigation run. Even distribution depends not only on the system design but also on the skill and understanding of the irrigator. Providing the irrigator with incentive and guidance not only improves yields but also saves water, fuel, and fertilizer.

To get an even distribution on a surface irrigation system, the planner and the irrigator must have an understanding of the basic principles of surface irrigation.

BORDER IRRIGATION

In border irrigation, a combination of stream size and border width must be chosen so that the upper end of the border is irrigated by the time the advancing stream reaches the lower end of the border. At that time, move the water to the next border. Water in the first border should continue to move down the slope and complete the irrigation as shown in Figure 1.

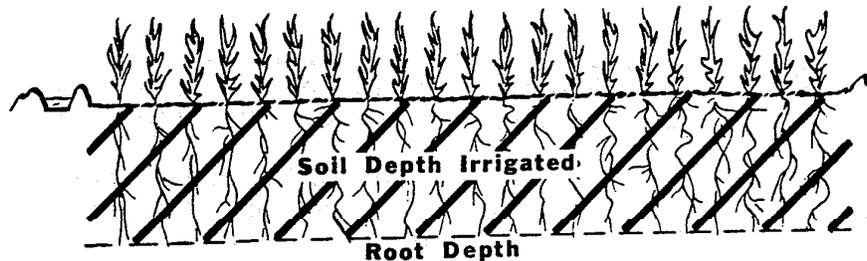


Figure 1

On soils which take water slowly, moisture may not have penetrated very deeply at the upper end when the stream reaches the lower end. If the water is shut off at that time, none of the field will be irrigated adequately as shown in Figure 2, and plant growth will be limited.

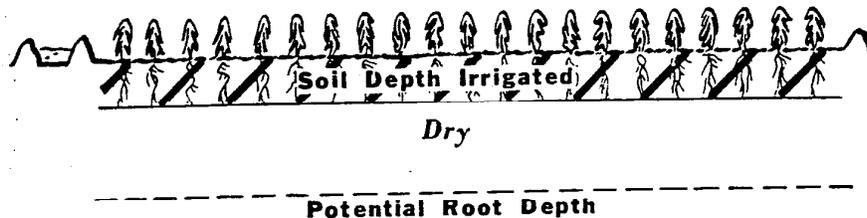


Figure 2

To obtain penetration, you may let the stream continue, but excessive ponding, deep percolation, or runoff may occur. See Figure 3.

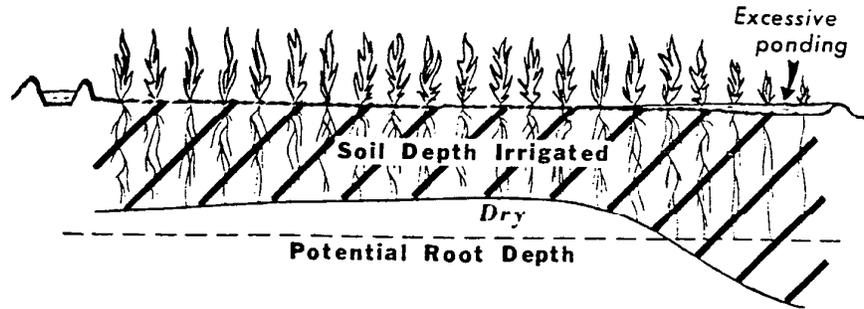


Figure 3

If practical, reduce the stream size when water approaches the end of the run and let it continue as long as necessary. In this way you can reduce ponding or runoff. See Figure 4. A smaller stream size or wider border may also help.

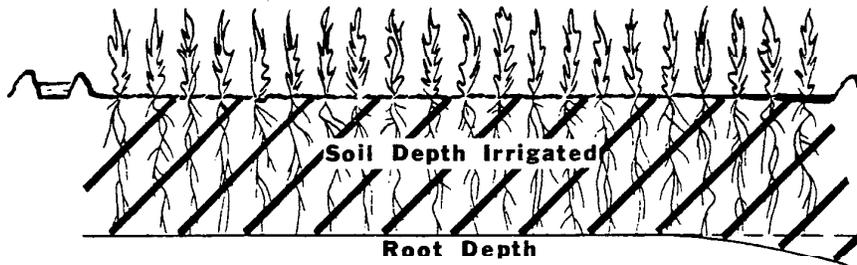


Figure 4

If you still have trouble getting adequate penetration at the upper end without excessive ponding, deep percolation, or runoff at the lower end, the field can be graded to a flatter slope. For the most efficient irrigation on soils which take water slowly, the slope can be eliminated completely.

On soils which take water rapidly, you are likely to have deep seepage losses at the upper end or too shallow an irrigation at the lower end. See Figure 5.

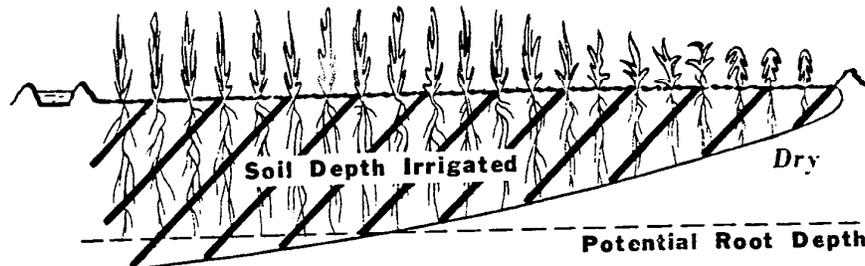


Figure 5

You can partially correct this problem by letting the stream continue after it has reached the end of the border. Water ponds and moves downward into the root zone at the lower end of the border. Notice from Figure 6 that a "4/5 Zone" is likely to persist. If this dry zone still persists, try a larger stream size, narrower border, or shorten the length of run.

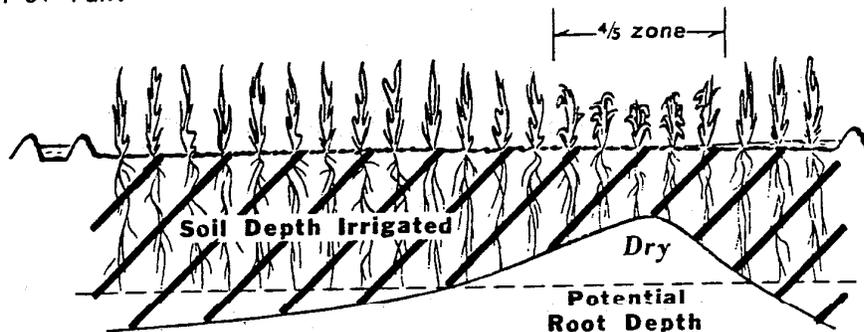


Figure 6

LEVEL BASIN IRRIGATION

To irrigate a level basin with no fall in any direction, use as large a stream as possible without causing erosion. Water should cover the entire area in no longer than one-fourth the time it stands in the basin. If it doesn't, consider making the basin smaller.

Basin irrigation provides excellent water control with high irrigation uniformity for a low labor requirement. Simply deliver the amount of water you want and go on to the next set. Remember that too much water will cause scalding of plants during hot weather unless you have some means for draining off excess water.

FURROW IRRIGATION

In furrow irrigation the objective is to keep water on all parts of the field for equal periods of time. Estimate the time water must be on the soil to provide the desired penetration from the intake family curves. Choose a nonerosive stream which reaches the end of the furrow in one-fourth the estimated penetration time or less and change the set when the water has been on the lower end of the run for the required time.

The purpose of the one-fourth rule is to get even distribution down the entire furrow. There is a tendency for water to be on the upper end longer than the lower end so by using a large stream at first, you can make the intake opportunity time more nearly equal throughout the entire irrigation run. By reducing the stream size when it reaches the end of the run, you can avoid excess ponding or runoff. If this is not practical, you may prefer to flatten the lower end of the run or use a tailwater pump back system to use the excess water. See Figure 7.

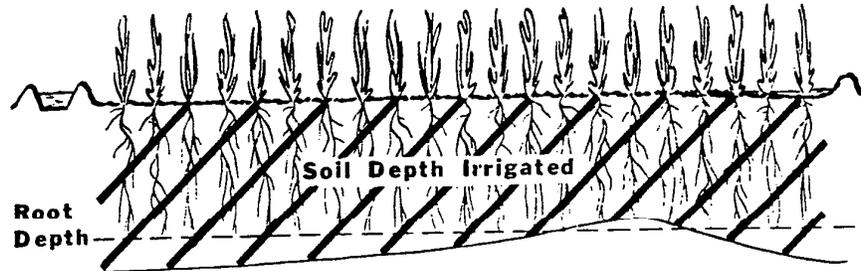


Figure 7

On soils which take water slowly you will need a small stream size or a long period of time. Figure 8 shows what can happen if the intake opportunity is too short and the stream is too large. The only adequate penetration may be where water was ponded. Too much water will cause excessive ponding or runoff.

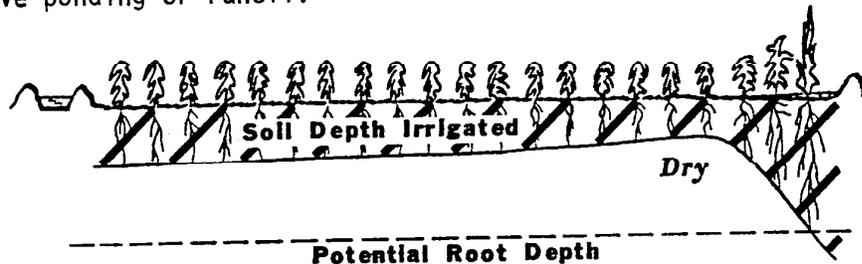


Figure 8

Consideration should also be given to grading the field to a flatter slope with near level furrows. The stream size can be adjusted to get the desired subbing into the beds with no runoff.

On soils that take water rapidly, the largest possible nonerosive stream is needed at first. This stream size will be limited by slope and furrow capacity.

If the run is too long, the upper end will be over-irrigated and the lower end will be under-irrigated. If you pond water at lower end, you are still likely to have a "4/5 zone" develop where there is not adequate soil moisture for plant growth. See Figure 9.

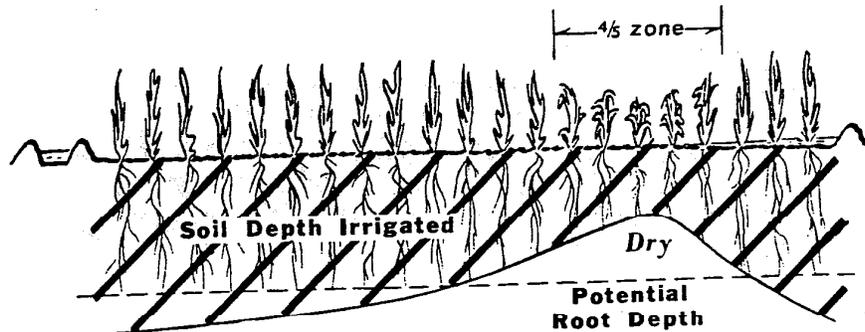


Figure 9

The above basic principles of surface irrigation should be understood by not only the irrigator but also the planner of the irrigation system. The following explanations of the variables in surface irrigation systems are given in an attempt to give the planner a better idea of how each one of the variables affects the uniformity or the end product of any surface irrigation system, and it also gives him an idea of approximate uniformities and sizes that will work on the particular irrigated farm that he is planning.

VARIABLES

In sizing a surface irrigation system, we first need to agree on what items we are trying to size. Usually, the following items are considered as those that can be controlled by the landowner:

1. Slope of irrigation.
2. Border or furrow width.
3. Height of border or furrow ridge.
4. Number of borders or furrows irrigated per set.
5. Length of run.
6. Time of irrigation set.

Items over which the landowner usually has little or no control of are:

1. Existing soils in the field to be irrigated.
2. Irrigation characteristics of the soil.

INTAKE FAMILY

The first item of information that must be obtained before any sizing can take place is an inventory of the soils in the field to be irrigated. This information is usually obtained from the field office soil survey.

Once the planner knows the major or critical soil in the field to be irrigated, he then must make some estimate of the intake characteristics of the soil under surface irrigation methods. These estimates have been made in the "Soil Interpretations for Irrigation" chapter of the Irrigation Guide for New Mexico.

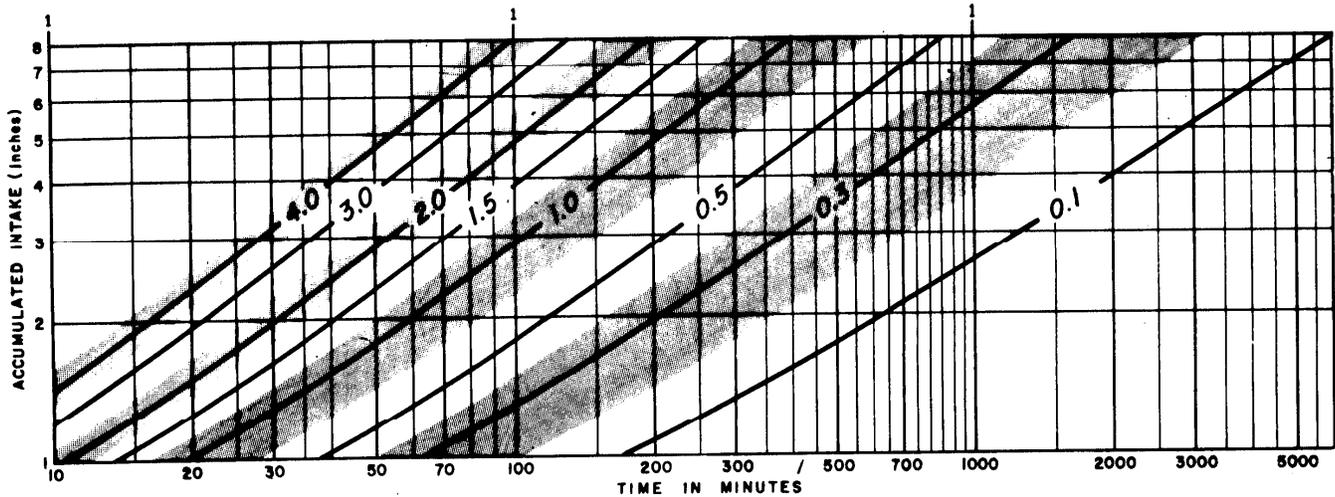
The most important of these interpretations, from the surface sizing standpoint, is the family intake rate curve, shown in column 10 of "Soil Interpretations for Irrigation" for each field office.

The intake rate curve number shown is not the average intake rate nor is it the initial intake rate, as soil intake rate varies greatly with time of application.

The attached example shows how the intake rate varies for a soil in the .5 intake family.

Table 1 - Suggested Planning Efficiency (Uniformity) for Graded Border Irrigation by Slope and Intake Family

Irrigation slope s_0	Intake Family																															
	0.3				0.5				1.0				1.5				2.0				3.0				4.0							
	Net depth of application in inches																															
Feet per Foot	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4				
0.0005	65	65	70	70	65	65	70	70	75	75	80	80	75	75	80	80	75	75	80	80	65	70	70	70	65	70	70	70	65	70	70	70
.0010	60	60	65	65	65	65	70	70	70	70	75	75	75	75	80	80	75	75	80	80	65	70	70	70	65	70	70	70	65	70	70	70
.0020	60	60	55	50	65	65	70	70	65	65	70	70	70	70	75	75	70	70	75	75	65	70	70	70	65	70	70	70	65	70	70	70
.0030	55	55	50		60	60	65	65	65	65	70	70	65	65	70	70	65	65	70	70	65	70	70	70	65	70	70	70	65	70	70	70
.0040	55	50			60	60	65	60	60	60	65	65	65	65	70	70	65	65	70	70	65	70	70	70	60	65	65	65	60	65	65	65
.0050	50				60	60	60	55	60	60	65	65	65	65	70	70	65	65	70	70	65	70	70	70	60	65	65	65	60	65	65	65
.0075					55	55	50		60	60	65	65	60	60	65	65	65	65	70	70	65	70	70	70	60	65	65	65	60	65	65	65
.0100					55	55			60	60	65	65	60	60	65	65	60	60	65	65	60	65	65	65	60	65	65	65	60	65	65	65
.0150					55				55	55	60	60	60	60	65	65	60	60	65	65	60	65	65	65	60	65	65	65	60	65	65	65
.0200					50				55	55	60	55	60	60	65	65	60	60	65	65	60	65	65	65	60	65	65	65	60	65	65	65
.0250									55	55	55	50	60	60	65	65	60	60	65	65	60	65	65	65					60	60	60	
.0300									55	55	50		55	55	60	60	55	55	60	60	55	60	60	60					60	60	60	
.0400									50	50			55	55	60	60		55	60	60		60	60	60								
.0500													55	55	60	55		55	60	60												
.0600													50	50	55	50			55	55												



INTAKE GROUPING for SURFACE IRRIGATION DESIGN

Intake Family	Net Depth of Application in Inches							
	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
0.1	169	374	628	923	1255	2014	2886	3858
0.3	62	129	208	296	392	604	841	1100
0.5	38	75	119	166	217	328	450	580
1.0	20	38	59	82	106	158	214	273
1.5	14	26	40	56	72	106	143	181
2.0	11	20	31	42	54	80	107	136
3.0	7	14	21	29	37	54	72	91
4.0	6	11	16	22	28	41	55	69

5L-17903-NM (Rev. 1977)

TOTAL NET WATER APPLIED	TIME TO INFILTRATE NET WATER	AVERAGE INTAKE RATE-INCHES PER HOUR
1 inch	38 minutes	1.6
2 inches	119 minutes	1.0
3 inches	217 minutes	.83
4 inches	328 minutes	.73
5 inches	450 minutes	.67
6 inches	580 minutes	.62

As can be seen from the attached example, the final intake rate of the .5 family approaches .5 inches per hour, but in the range of normal irrigation (2-4 inches net) the intake rate is much greater than .5 inches per hour.

SLOPE

The slope of the land in the direction of irrigation has a very dominant effect on the uniformity (efficiency) of an irrigation system. Table 1 and Table 1A show the maximum probable efficiencies to be obtained for various slopes and net depths of application. The one major drawback of these tables is that they assume a constant slope in the direction of irrigation. Decreasing slopes in the direction of irrigation and/or level ends make predictions of efficiency very difficult.

As a rule of thumb, a decreasing slope in the direction of irrigation will give a higher uniformity (efficiency) than that shown for a given slope and intake family combination, but this uniformity (efficiency) will usually not exceed the maximum shown for the intake family.

Success in planning an irrigation system depends on the ability of the planner to make a reasonable estimate of the uniformity (efficiency) that can be achieved on a particular site under a given set of management conditions. In most cases, the principal hazard is overestimating uniformity (efficiency), which leads to planning irrigation systems with too long a run. Usually, it is possible for the irrigator to adjust stream sizes enough for the planned layout to operate satisfactorily. In all irrigation methods, uniformity is affected more by management practices of the irrigator, than by any other factor.

Since the objective of any surface sizing is to help the cooperater choose a slope that will do an adequate job of irrigation and not to predict exact efficiencies, these tables should be used to show the landowner the effect the slope has on uniformity, rather than attempting to show the exact uniformity (efficiency) that can be expected for a given slope.

TABLE 1-A
RECOMMENDED PLANNING EFFICIENCIES FOR FURROW IRRIGATION

Slope Group In %	Planned Slope In %	Field Efficiency In %
.05 - .15	0.1	70
.15 - .30	0.2	70
.30 - .50	0.4	70
.50 - 1.0	0.75	65
1.0 - 2.0	1.5	60

BORDER WIDTH

Border strip widths suitable for any particular field depend on (1) size of the available irrigating stream, (2) amount of cross slope, (3) kind of equipment used, and (4) accuracy of land leveling as related to the normal depth of flow expected. The border strips must be wide enough to permit efficient operation of farm equipment. Mowers and rakes, for example, can be operated where there is a small amount of overlap on passes. Other equipment such as plows, seeders, and cultivators requires a definite width for each pass. The border strip must be wide enough to accommodate at least one pass of a plow, seeder, cultivator, etc., but it is desirable for the strip to be wide enough for an even number of passes.

A width of about 15 feet is the practical minimum for each strip on hay and grain fields. Narrower strips are satisfactory for pastures. For row crops grown on level border strips, the strips usually must be wide enough to allow for at least two passes with four-row equipment.

Maximum width is influenced largely by the difficulties in keeping water spread over the entire width of a strip. Under normal construction, wide border strips are expected to have greater differences in cross slope elevation than narrower strips. As flow depth decreases because of increased slope, minor surface irregularities in the border strip may cause incomplete water coverage. For this reason, the border strip width must be reduced as irrigation grade increases (see table 2).

Table 2 -- Recommended maximum border strip width

<u>Irrigation grade</u>	<u>Maximum strip width</u>
<u>Feet per foot</u>	<u>Feet</u>
Level	200
0.0 -0.001	120
0.001-0.005	60
0.005-0.010	50
0.010-0.020	40
0.020-0.040	30
0.040-0.060	20

FURROW SPACING

Furrow spacing will be determined by the row spacing customarily used in the field office for each kind of cultivated row crop. Factors other than irrigation usually determine the spacing between rows. However, if

furrow spacing is too wide, irrigations will need to be continued for an extra length of time to wet the root zone area between furrows, and excessive amounts of deep percolation losses will usually occur.

MAXIMUM RECOMMENDED STREAM SIZES - FURROWS The maximum stream size for furrows is limited to a non-erosive stream, and by the furrow capacity. The maximum non-erosive stream size is usually computed by the following formulas:

COURSE TEXTURED SOIL

$$Q_{\text{gpm}} = \frac{10}{\text{Furrow slope in Percent}}$$

FINE TEXTURED SOIL

$$Q_{\text{gpm}} = \frac{15}{\text{Furrow slope in Percent}}$$

The usual maximum furrow capacity for a 36-inch spaced furrow is between 40 and 50 gallons per minute per furrow. Furrow stream sizes should be adequate to get the water to the driest part of the irrigation run in one quarter of the necessary intake time.

EXAMPLE

INTAKE FAMILY - .5

Desired net application - 4 inches

From intake family curve - time needed to infiltrate 4 inches into the soil is 328 minutes (5.5 hours).

The furrow stream size should be adequate to get the water to the driest part of the field (or end of the run) in one quarter of the irrigation time or (5.5 divided by 4) 1.4 hours.

By talking to the farmer about his current irrigation system of operation during the planning process, the planner can quickly see if the current irrigation system falls within the suggested limit for furrow irrigation.

COMPUTER ASSISTED PLANNING
FOR
SURFACE IRRIGATION SYSTEM SIZING

With advancements in computer technology, various agricultural agencies have devoted a great deal of time and effort into the development of computer programs that assist in the sizing and prediction of surface irrigation system parameters.

Many of these programs have been developed by universities and research institutions that have different agendas and target groups than those of the Soil Conservation Service. Typical of these programs are the SIRMOD program produced by Utah State University and the SRFR program developed by the ARS Water Conservation Laboratory at Phoenix, Arizona. Both of these programs use very complicated yet precise processes for the prediction of surface irrigation parameters. The current drawback of these two programs is the difficulty of these programs to be user friendly for SCS FO staffs and irrigation farmers.

In an effort to fill this gap in technology, the SCS in two western states, Arizona and Montana, has made a concerted effort to streamline and computerize the planning and sizing for surface irrigation systems. These states have produced two separate computer programs, SIMENU and SURFACE, which produce essentially the same answers but in different output formats.

Both programs, SURFACE and SIMENU, have been used successfully by the SCS in numerous states to adequately provide planning alternatives in the sizing of surface irrigation systems. As with any simplified synthetic prediction programs, the answers produced by SIMENU and SURFACE may not accurately reflect what is happening in a particular field, but the range of answers for a particular set of field variables will give an accurate picture to the SCS technician and the farmer as to what trends can be expected when a particular field variable is changed.

With these experiences and goals in mind, both SURFACE and SIMENU are approved programs for use by the SCS in New Mexico and the printout of these programs may be used to substitute for the information asked for on the form NM-ENG-125.

Operating instructions for both programs are included on the program disks, with detailed instructions provided in Appendix A for the use of SURFACE. At the present time, no detailed instructions are available for the use of the menu-driven SIMENU program, but assistance is available from SCS

area engineers and the SCS engineering specialist in the use and operation of both programs.

If more precise answers are needed in the prediction of surface irrigation parameters, the SIRMOD program is available through all area engineers to assist in the prediction and analysis process.

APPENDIX A

COMPUTER PROGRAMS

SURFACE IRRIGATION SYSTEM DESIGN

SURFACE

MSDOS version

Users Guide

by John Dalton
Bozeman, Montana

Version 2.3
5/1/91

TABLE OF CONTENTS

OVERVIEW	1
LIMITATIONS	2
PROGRAM INSTALLATION	3
SYSTEM REQUIREMENTS	3
FILES	3
USER SUPPORT	4
INSTALLATION	4
PROGRAM OPERATION	5
CONVENTIONS	5
GRADED BORDER SYSTEM, DEMO NO 1	6
PROCEDURE	6
Main menu bar	6
Border menu selection	7
Graded border type job selection	7
Job data input	8
Output table type selection	9
Output table variables	10
Border width, length	11
Intake family number	11
Field slope	11
Flow rate	11
Net irrigation	11
OUTPUT SCREEN	12
GRAPH OUTPUT	12
SEND GRAPH TO PRINTER	12
PRINTED TABLE	13
TO REVISE JOB	13
EXIT TO MAIN MENU	13
LEVEL BORDER, DEMO NO 2	14
Input screen	14
Output table	15
CONTOUR DITCH, DEMO NO 3	16
Input screen	16
output table	17
GRADED FURROW ANALYSIS, DEMO NO 4	18
Input screen	18
Output table	19
GRADED FURROW CHART PLOTTING DATA, DEMO NO 5	20
Input screen	20
Output table	21
MANIPULATING OLD FILES	22
Get Old Job	23
See Job Directory	24
Delete Old Jobs	25

OVERVIEW

This program is used for design of new surface irrigation systems. It may also be used for limited analysis of existing systems.

WARNING Read the Limitations section on page 2.

The following types of systems are covered:

- o Graded furrow
- o Corrugations
- o Cutback furrow
- o Level furrow
- o Graded border
- o Level border (basin)
- o Contour ditch or wild flooding.

Furrow computations are strictly in accordance with procedures in the corrected version of SCS National Engineering Handbook (NEH) Section 15, Irrigation, Chapter 5 Furrow Irrigation.

The furrow options may be used to develop data for plotting furrow design charts as shown in Figures 5-17 and 5-18 of NEH, chapter 5.

Border computations are based on material in SCS National Engineering Handbook, Section 15, Chapter 4, Border Irrigation. Some algorithms are the same as used in TI-59 programmable calculator programs SCS-WTSC-IRR-No. 8 (Border Evaluation Present) and SCS-WTSC-IRR-No. 5 (Level Border Analysis). These programs were originally written by H.G. Collins and P. Koluvek at the SCS West National Technical Center.

Jobs are saved to a file and can be easily revised.

LIMITATIONS

Computations made with this program are only a tool to help understand what could happen in the field if everything were perfectly as listed in program input. In reality, field conditions are rarely the same. For this reason it is recommended that the printout not be given directly to the irrigator. All factors connected with the actual system and management should be considered and a summary based on all the factors should then be discussed with the irrigator and given to him or her.

Application efficiencies computed using these methods can be unrealistically high. Extremely good management, good land leveling, and accurately measured and timed flows would be required to obtain efficiencies 70 percent for graded borders and graded furrows and 40 percent for contour ditches. Variations in soil intake rate, timing and flow rate are usually such that actual field efficiencies are significantly lower than these figures. Also, distribution uniformities are not considered in the application efficiencies computed, and particularly for wild flood and contour ditches, will additionally lower actual efficiencies.

SCS irrigation guide data should be used as a guide to maximum practical design efficiencies. Lower design efficiencies should be used if management and system are less than ideal, which is usually the case.

All computational procedures for surface irrigation assume uniform slopes and known soil intake characteristics. Frequently field slopes are not uniform. The hydraulics used in the equations therefore do not accurately represent flow characteristics. This is particularly true of wild flooding and contour ditches.

The intake family curve number is usually not determined by actual field trials. Major differences in intake and flow characteristics are computed by using just one increment curve number each side of the initially estimated curve number. In reality it is quite possible that the actual field intake characteristics may vary by one or more increments from the estimate. It is our recommendation to use this program to always make a run with one intake curve number above and one below the estimated curve. This will give some idea of the variation that one may expect in the field. The irrigator must be coached on how to deal with these variations.

PROGRAM INSTALLATION

SYSTEM REQUIREMENTS

- o IBM compatible machine with graphic display capabilities, including all AT&T models.
- o DOS 2.0 or later
- o 640K memory
- o Hard Disk (The program will run off of a 1.2 MB floppy, but this slows it down)
- o AT&T 6300 monochrome, CGA, EGA, VGA, AT&T color, or Hercules monochrome graphic monitor. (Color enhances use of this program)

FILES

The program runs under MSDOS and is written in "C" language. A commercial package of functions called "Vitamin C" is used for windows manipulation. A licence is not required for distribution of executable files created using Vitamin C. Compilation was done with the Borland Turbo C compiler, version 2.0.

The program is distributed with the following files:

SURFACE.EXE	Executable surface irrigation program
SURFACE.HLP	Help file, called by SURFACE
SURFACE.NDX	Index to help file
ATT.BGI	Graphic drivers for various graphic boards. (These are automatically selected depending on which graphic board you have.)
CGA.BGI	
EGAVGA.BGI	
HERC.BGI	
TRIP.CHR	Font for graphic screen
DEFAULT.SRF	Default job file (Used if no file name entered)
DEMO1.SRF	Graded border demonstration
DEMO2.SRF	Level border demonstration
DEMO3.SRF	Contour ditch demonstration
DEMO4.SRF	Graded furrow demonstration
DEMO5.SRF	Graded furrow chart data demonstration
SURFACE.DOC	This user guide, formatted for MS WORD, word processor

Other files are created during operation of the program.

SURFACE documentation

USER SUPPORT

John Dalton, SCS State Office, Bozeman, Montana will be responsible for user support and program maintenance. If operational problems are encountered, contact him at:

Soil Conservation Service
Federal Building, Room 443
10 East Babcock Street
Bozeman, MT 59715
(406)587-6825

If problems are encountered, please have information ready including a listing of all data inputs attempted and where the problem was encountered.

INSTALLATION

Print this document by printing from the DOS version of Microsoft WORD using the file SURFACE.DOC.

Running from floppy disk

Make a copy of the master disk and run from the copy.

Hard disk installation

The distribution files are on one floppy disk. Transfer all distribution files to a sub-directory on drive C:, using the copy command: copy *.*

PROGRAM OPERATION

CONVENTIONS

KEY

ACTION

F1 Help key - A window will pop up and display information about the entry that you are currently being asked to make. Press F1 again to get out of the help window.

ESC If you are in a menu, pressing <ESC> will get you back out.

f10 Re-do last entry screen. effective only when noted on screen.

Up and Down arrow

If you are in a vertical menu, use these keys to move up and down in the menu.

If you are entering data in fields, use these to move backwards and forwards through fields.

Right and Left arrows

If you are in a horizontal menu, use these to move right and left in the menu. You may also press the first capital letter of the menu item to move to that item.

Ent (Enter)

Use the <Ent> key to accept an entry once you have typed in the required entry. Also used to proceed to the next activity.

Editing and entry

Use the **arrow keys**, **delete**, and **backspace** keys to edit entries as you are making them.

SURFACE documentation

GRADED BORDER SYSTEM, DEMO NO. 1

This option is for use on uniform width borders on a uniform slope. Sometimes it is used to estimate flow conditions on a variable slope by using an average slope. This will not give very accurate results.

In this example we will design a new graded border system. We could also have found the intake family number and studied deep percolation, runoff and efficiency of an existing system by entering actual data in the program and varying the intake family in different runs until we found an intake family number that best fit actual conditions.

PROCEDURE

Start the program by entering "surface" at the DOS prompt.

The following screen will come up:

```
-----SURFACE IRRIGATION SYSTEM MENU-----  
| Furrow      -Border      Get-file      Quit      |  
-----
```

```
SURFACE IRRIGATION SYSTEM DESIGN  
Version 2.3 5/1/91  
by John Dalton  
Bozeman Montana
```

F1-Help and exit from help ESC-Exit from menus

```
-----  
Select type of border irrigation  
-----
```

At the top of the screen is a horizontal menu bar. At the bottom of the screen is a window with explanations of what the currently highlighted selection is. Further explanation can be obtained from a context sensitive help window by pressing the <F1> key.

SURFACE documentation

Move through the menu bar by pressing the right and left arrow keys. You may also move in the menu by pressing the letter key which is capitalized in each selection.

In this case we will select the menu item named "Border" by pressing the <Ent> key.

Now the following menu will come up:

```
-----SURFACE IRRIGATION SYSTEM MENU-----
| Furrow      -Border      Get-file      Quit      |
-----
| Graded border system
| Level border (basin) system
| Contour ditch or wild flood system
|-----
SURFACE IRRIGATION SYSTEM DESIGN
Version 2.3  5/1/91
by John Dalton
Bozeman Montana
```

```
F1-Help and exit from help      ESC-Exit from menus
```

```
-----
Select type of border irrigation
-----
```

We select the first item, "Graded border system". Try the help key <F1>. Use <F1> to get back out of the help screen.

SURFACE documentation

Now a window will come up which will allow you to enter general job data.

```
=====SURFACE IRRIGATION SYSTEM ANALYSIS=====
                                     GRADED BORDER ANALYSIS
                                     Date: 06/01/90
Name of job: Graded Border Example
Your name:   Joe Tech
Location:    Home place
Office:      Bozeman, MT
Job data file name: DEMO1

                                     F1-Help and exit from help screen
=====
Enter the name of this job
-----
```

The date is automatically entered by the system.

The first item will be to enter a descriptive name for the job. Use the arrow keys, backspace and delete keys to edit the entry if an error is made. Use the up arrow to come back to this entry if you see a mistake after leaving the field.

The next three items will have information from the last job run. To accept the data in these fields, press <Ent>. Otherwise type in a new entry.

The last item is the job data file name. If the job is saved, this file name will be used. The name "DEFAULT" will come up automatically. Press <Ent> to accept this name. Otherwise type any name up to eight characters long. Use any DOS file name allowable characters. Do not include an extension as the program will add the extension ".SRF" to the file name.

SURFACE documentation

You will now specify how the output table will be configured. Tables which vary by time of set, flow rate, width of border or length of border can be made. A pop up window will come up allowing your selection. Usually we will select time of set as first trial.

```
=====SURFACE IRRIGATION SYSTEM ANALYSIS=====
                                                    Date: 06/01/90
                GRADED BORDER ANALYSIS
Name of job: Graded Border Example
Your name:   Joe Tech
Location:    Home Place
Office:      Bozeman, MT
Job data file name: DEMO1
Build an output table using the following variable:
                                                    =====Variable=====
                                                    | Time of set
                                                    | Flow rate
                                                    | Width of border
                                                    | Length of border
                                                    |=====
                F1 Help and exit from help screen
=====
up and down arrow keys to move in list, <Ent> to select variable
-----
```

SURFACE documentation

Now a box will pop up which will allow entry of the start time and end time to be used in the table and the time increment used to calculate each line in table. We will start the table at one hour and go to 8 hours in 1/2 hour increments.

```
=====SURFACE IRRIGATION SYSTEM ANALYSIS=====
                                     GRADED BORDER ANALYSIS
                                     Date: 06/01/90
Name of job: Graded Border Example
Your name:   Joe Tech
Location:    Home place
Office:      Bozeman, MT
Job data file name: DEMO1
Build an output table using the following variable: time
=====
| Start | Stop | Increment |
| (hrs) | (hrs) | (hrs) |
|-----|-----|-----|
| 1.0   | 8.0   | 0.5   |
|-----|-----|-----|
                                     F1-Help and exit from help screen
=====
```

SURFACE documentation

Now enter data as described in each field. Use the <F1> key to get help for any field.

A selection list pops up to give roughness (Manning's "n" values) for several conditions. Select the one most nearly describing your condition.

```
=====SURFACE IRRIGATION SYSTEM ANALYSIS=====
                                                    Date: 06/01/90
                GRADED BORDER ANALYSIS
Name of job:  Graded Border Example
Your name:   Joe Tech
Location:    Home place
Office:      Bozeman, MT
Job data file name:  DEMO1
Build an output table using the following variable: time
=====
|      Start      |      Stop      |      Increment      |
|      (hrs)      |      (hrs)      |      (hrs)          |
|-----|-----|-----|
|      1.0        |      8.0        |      0.5            |
|-----|-----|-----|
=====
Border width:  80 ft                Border Length: 1300 ft
Intake family number:  1.00          =====n value=====
Roughness coefficient (Manning's n):| Alfalfa 0.15 |
Flow to border:          cfs         | Drilled 0.10 |
Design net irrigation application dep| Sod      0.25 |
                                       | Smooth  0.04 |
                                       =====
                                     F1-Help and exit from help screen
=====
up and down arrow keys to move in list, <ent> to select n value
=====
```

When all data has been entered, press <Ent> to continue and perform computations. If you have entered a field slope of less than 0.004 the computations will take a long time. How long depends on the computer being used. If the computer has a math chip computations will take a few seconds. If you are using a machine without a math chip, computations will take a minute or more.

To speed up initial trials if the slope is less than 0.004, enter a slope of 0.004 and make only the final run with the actual slope. Differences are small using the steeper slope.

SURFACE documentation

OUTPUT SCREEN

Now the final screen will come up:

<up>, <dn> arrow, <pg up>, <pg dn> keys to move in window

GRADED BORDER ANALYSIS

Date: 06/01/90

Job name: Graded Border Example
Location: Home place
By: Joe Tech
Office: Bozeman, MT

Roughness coefficient (n)= 0.150
Slope (S)= 0.0020 ft/ft
Net application (Fn)= 5.30 inches
Flow per border (Q)= 5.00 cfs

Intake family (If)= 1.00
Border width (W)= 80 ft
Border length (L)= 1300 ft

Inflow Time	Unit Flow (cfs/ft)	Gross Application (in)	Deep Percolation (in)	Runoff (in)	Application Efficiency (percent)	Notes
1 hr, 0 min		Gross application depth does not meet net requirements				
1 hr, 30 min		Application depth is less than 80% of net requirements				
2 hr, 0 min		Application depth is less than 80% of net requirements				
2 hr, 30 min		Application depth is less than 80% of net requirements				
3 hr, 0 min	0.062	6.23	0.00	1.71	72.5	
3 hr, 30 min	0.062	7.27	0.00	2.22	69.5	

F10-Revise job P-Print job G-Graph display Q or <ESC>-Exit to main menu

You will not be able to see the whole output all at once. Use the up and down keys and <Pg Up> and <Pg Dn> keys to move in the output document. Press <P> to send a copy to the printer. Press <Q> to get a graph of the output results. <F0> allows you to go back and revise the job, <ESC> or <Q> gets back to the main menu.

GRAPH OUTPUT

A bar graph showing net irrigation, deep percolation and runoff will be produced.

SEND GRAPH TO PRINTER

Graphs can be printed in two different ways. A small quick graph can be printed to some EPSON or IBM graphics compatible printers by simply pressing the <P> key while the graph is on the screen. This does not work on all printer setups.

A larger graph may be printed using the <Print Screen> key. To print graphics in this way, the command "graphics" must have been entered on some machines from the DOS prompt before starting the

SURFACE documentation

SURFACE program. The graphic board used by the computer determines whether or not "graphics" must be entered.

PRINTED TABLE

Press <P> to send the final table to the printer. The final output document is shown below:

=====
GRADED BORDER ANALYSIS

Date: 06/01/90

Job name: Graded Border Example
Location: Home place
By: Joe Tech
Office: Bozeman, MT

Roughness coefficient (n)= 0.150 Intake family (If)= 1.00
Slope (S)= 0.0020 ft/ft Border width (W)= 80 ft
Net application (Fn)= 5.30 inches Border length (L)= 1300 ft
Flow per border (Q)= 5.00 cfs

Table with 7 columns: Inflow Time, Unit Flow (cfs/ft), Gross Application (in), Deep Percolation (in), Runoff (in), Application Efficiency (percent), Notes. Rows show data for 1 to 8 hours.

TO REVISE JOB

To revise this job, press <F10>.

EXIT TO MAIN MENU

To return to main menu, press either <Q> or <Esc>.

The remaining examples are run in much the same way as example No. 1. We will only show special features of the following types of operations.

SURFACE documentation

LEVEL BORDER, DEMO NO 2

This option performs computations on rectangular level borders of basins. It will not work on contour basins.

The level border option requires that an application efficiency be assumed during design. Application efficiencies of between 80 and 90 percent should be obtainable under good management. The most important management factor will be to accurately control inflow rates and time.

The following is an example of the input screen:

```
=====SURFACE IRRIGATION SYSTEM ANALYSIS=====
                                                    Date: 06/01/90
                          LEVEL BORDER (BASIN) ANALYSIS
Name of job: Level Border Example
Your name: Joe Tech
Location: Home place
Office: Bozeman, MT
Job data file name: DEMO2
Build an output table using the following variable: Flow
=====
| Start | Stop | Increment |
| (cfs) | (cfs) | (cfs) |
|-----|-----|-----|
| 1.0 | 6.0 | 0.5 |
|-----|-----|-----|
=====
Border width: 100 ft
Intake family number: 1.00
Roughness coefficient (Manning's n): Alfalfa 0.15
Design net irrigation application depth: 4.00 inches
Design application efficiency: 85 percent

Press <Ent> to continue ...
=====
-----
```

SURFACE documentation

Output from the run will be as follows:

LEVEL BORDER ANALYSIS

Date: 06/01/90

Job name: Level Border Example
 Location: Home place
 By: Joe tech
 Office: Bozeman, MT

Border width: (W)= 100 ft Intake family curve number (If)=1.00
 Roughness coefficient (n)=0.150 Design application depth (Fn)= 4.00
 inches
 Design efficiency (E)= 85.0 percent Gross application (Fg)= 4.71 inches

Border Length (ft)	Border Flow (cfs)	Unit Flow (cfs/ft)	Inflow Time	Travel Time To End	Deep Percolation (in)	Flow Depth (in)
164	1.0	0.010	1 hr, 47 min	1 hr, 4 min	0.71	2.06
217	1.5	0.015	1 hr, 34 min	1 hr, 4 min	0.71	2.53
262	2.0	0.020	1 hr, 26 min	1 hr, 4 min	0.71	2.92
302	2.5	0.025	1 hr, 19 min	1 hr, 4 min	0.71	3.26
338	3.0	0.030	1 hr, 14 min	1 hr, 4 min	0.71	3.56
372	3.5	0.035	1 hr, 9 min	1 hr, 4 min	0.71	3.84
403	4.0	0.040	1 hr, 6 min	1 hr, 4 min	0.71	4.10
432	4.5	0.045	1 hr, 3 min	1 hr, 4 min	0.71	4.35
460	5.0	0.050	1 hr, 0 min	1 hr, 4 min	0.71	4.62
486	5.5	0.055	0 hr, 58 min	1 hr, 4 min	0.71	4.87
511	6.0	0.060	0 hr, 56 min	1 hr, 4 min	0.71	5.12

Notice that both border length and inflow time vary with inflow.

CONTOUR DITCH, DEMO NO 3

Any computation involving contour ditch or wild flooding can only be a very rough approximation of what may actually take place in the field. Overlapping flows and very poor distribution uniformity lower efficiencies drastically. Variable slopes and lengths of run make computations very difficult. The answers obtained by this program should only be used as a tool to get a very rough indication of what may happen.

The same procedures as used on a graded border system are used here. The only difference is that a unit width of one foot is used instead of border width. Since there is nothing to confine the lateral spread of the flow, we only can look at a portion of the flow from a turnout and assume the rest of the flow is the same. Unfortunately this is not the truth. The flow is concentrated at one location and then spreads out as it moves down the slope. When the next turnout is turned on, flow from it overlaps some of the area covered by the first. Keep all this in mind when you look at the results of computations.

The following is an example of the input screen:

```

=====SURFACE IRRIGATION SYSTEM ANALYSIS=====
                                     Date: 06/01/90
                CONTOUR DITCH OR WILD FLOOD ANALYSIS
Name of job: Contour Ditch Example
Your name:   Joe Tech
Location:    Home place
Office:      Bozeman, MT
Job data file name: DEMO3
Build an output table using the following variable: Time
=====
| Start | Stop | Increment |
| (hrs) | (hrs) | (hrs) |
|-----|-----|-----|
| 1.0   | 5.0   | 0.2   |
|-----|-----|-----|
=====
Run length:      250 ft (NOTE: Unit stream width is setto one foot)
Intake family number: 1.00      Field slope: 0.0150 ft/ft
Roughness coefficient (Manning's n): Alfalfa 0.15
Unit flow to field: 0.01 cfs/ft
Design net irrigation application depth: 3.00 inches

Press <Ent> to continue ...
=====

```

SURFACE documentation

Output from the run will be as follows:

 CONTOUR DITCH OR WILD FLOOD ANALYSIS

Date: 06/01/90

Job name: Contour Ditch Example
 Location: Home place
 By: Joe Tech
 Office: Bozeman, MT

Roughness coefficient (n)= 0.150 Intake family (If)= 1.00
 Slope (S)= 0.0150 ft/ft Unit flow width (W)= 1 ft
 Net application (Fn)= 3.00 inches
 Inflow time (Ti)= 3 hours, 24 minutes

Flow Length (ft)	Unit Flow (cfs/ft)	Gross Application (in)	Deep Percolation (in)	Runoff (in)	Application Efficiency (percent)	Notes
100	0.010	14.69	1.85	9.84	20.4	
150	0.010	9.79	1.85	4.94	30.6	
200	0.010	7.34	1.85	2.50	40.8	(4)
250	0.010	5.88	1.85	1.03	51.1	(4)
300	0.010	4.90	1.85	0.05	61.3	(4)
350	Gross application depth does not meet net requirements					
400	Gross application depth does not meet net requirements					
450	Gross application depth does not meet net requirements					
500	Gross application depth does not meet net requirements					
550	Gross application depth does not meet net requirements					
600	Gross application depth does not meet net requirements					

(4) Less than minimum recommended depth of flow.

You will frequently see the less than minimum recommended depth of flow warning in this type of computation. This means that the depth is so shallow that there will be poor distribution if there are any high and low spots in the ground surface. We will frequently need to make compromises which ignore this in selecting contour ditch spacing.

GRADED FURROW ANALYSIS, DEMO NO 4

Graded furrow means there is a uniform slope in the direction of irrigation. If the slope not uniform, and the average slope is used in these calculations, the hydraulics used will not be accurate and you will only get a rough approximation of what will happen. This approximation is often made, but keep in mind that the accuracy will not be good.

Furrow condition has a lot to do with furrow intake rates. The first irrigation in a non-wheel row will usually have the highest intake rates. Wheel rows will have lower rates and subsequent irrigations with no intervening cultivations will have even lower intake rates. It is a good idea to try several intake family numbers in various runs to see what kind of variation one might expect.

While entering data we are asked the question:

```

-----
| Output time in |
| hours or minutes |
| (H/M) H |
-----
    
```

In this case we accept "H" (hours). this will give the table in terms of hours and minutes application time. DEMO5 will show how to use the "M" (minutes) option.

The following is an example of the input screen:

```

=====SURFACE IRRIGATION SYSTEM ANALYSIS=====
                                     Date: 06/01/90
                                     GRADED FURROW ANALYSIS
Name of job: Graded Furrow Example
Your name:   Joe Tech
Location:    Home place
Office:      Bozeman, MT
Job data file name: DEMO4
Build an output table using the following variable: flow
-----
| Start | Stop | Increment | Output time in |
| (gpm) | (gpm) | (gpm) | hours or minutes? |
|-----|-----|-----| (H/M) H |
| 6.0   | 50.0 | 2.0   | |
|-----|-----|-----|
Design at 100 percent of furrow length
Furrow spacing: 30 inches           Furrow length: 1000 feet
Intake family number: 0.60
Field slope: 0.0020 ft/ft (Minimum slope = 0.0005 ft/ft)
Design net irrigation application depth: 5.30 inches

                                     Press <Ent> to continue ...
=====
    
```

SURFACE documentation

Output from the run will be as follows:

GRADED FURROW

Date: 06/01/90

Job name: Graded Furrow Example

Location: Home Place

By: Joe Tech

Office: Bozeman, MT

Length (L)= 1000 ft

Intake family (If) = 0.60

Net application (Fn)= 5.3 inches

Furrow spacing (w) = 30 inches

Slope (S)= 0.0020 ft/ft

Roughness coefficient (n) = 0.040

Design at: 100 percent of furrow length

Flow (gpm)	Gross Applic. (in)	Application Time	Runoff (in)	Deep Percolation (in)	Application Efficiency (percent)
6.0	Too little flow - application time exceeds 48 hours				
8.0	14.3	46 hr, 35 min	3.76	5.29	36.9
10.0	11.2	29 hr, 7 min	3.28	2.62	47.3
12.0	10.5	22 hr, 41 min	3.55	1.63	50.6
14.0	10.5	19 hr, 27 min	4.03	1.16	50.5
16.0	10.8	17 hr, 31 min	4.60	0.89	49.1
18.0	11.2	16 hr, 12 min	5.19	0.73	47.2
20.0	11.7	15 hr, 13 min	5.79	0.63	45.2
22.0	12.2	14 hr, 28 min	6.40	0.55	43.3
24.0	12.8	13 hr, 50 min	6.99	0.50	41.4
26.0	13.3	13 hr, 19 min	7.58	0.46	39.8
28.0	13.9	12 hr, 52 min	8.15	0.42	38.2
30.0	14.4	12 hr, 29 min	8.71	0.40	36.8
32.0	14.9	12 hr, 8 min	9.26	0.38	35.5
34.0	15.5	11 hr, 49 min	9.81	0.36	34.3
36.0	16.0	11 hr, 32 min	10.34	0.35	33.2
38.0	16.5	11 hr, 16 min	10.86	0.34	32.1
40.0	17.0	11 hr, 2 min	11.37	0.33	31.2
42.0	17.5	10 hr, 49 min	11.87	0.32	30.3
44.0	18.0	10 hr, 37 min	12.36	0.31	29.5
46.0	18.5	10 hr, 25 min	12.85	0.30	28.7
48.0	18.9	10 hr, 14 min	13.33	0.30	28.0
50.0	19.4	10 hr, 4 min	13.79	0.29	27.3

.... Flow should not exceed 50 gpm in furrows

GRADED FURROW CHART PLOTTING DATA, DEMO NO 5

The option to do graded furrow using minutes onl application time is intended only for use in plotting furrow curves.

The following is an example of the input screen:

```

=====SURFACE IRRIGATION SYSTEM ANALYSIS=====
                                     Date: 06/01/90
                                     GRADED FURROW ANALYSIS
Name of job: Graded Furrow Chart Example
Your name:   Joe Tech
Location:    Home place
Office:      Bozeman, MT
Job data file name: DEMO5
Build an output table using the following variable: flow
=====
| Start | Stop | Increment | Output time in |
| (ft)  | (ft) | (ft)      | hours or minutes? |
|-----|-----|-----|-----|
| 100.0 | 2000.0 | 100.0    | (H/M) m          |
|-----|-----|-----|-----|
Design at 100 percent of furrow length
Furrow spacing: 30 inches
Intake family number: 0.60
Field slope: 0.0020 ft/ft (Minimum slope = 0.0005 ft/ft)
Design net irrigation application depth: 5.00 inches
Flow into furrow: 15 gpm

                                     Press <Ent> to continue ...
=====
    
```

SURFACE documentation

Output from the run will be as follows:

GRADED FURROW

Date: 06/01/90

Job name: Graded Furrow Chart Example
 Location: Home place
 By: Joe Tech
 Office: Bozeman, MT
 Flow (Q) = 15.0 gpm
 Net application (Fn) = 5.0 inches
 Slope (S) = 0.0020 ft/ft
 Design at: 100 percent of furrow length

Intake family (If) = 0.60
 Furrow spacing (w) = 30 inches
 Roughness coefficient (n) = 0.040

Length (ft)	Gross Applic. (in)	Application Time	Runoff (in)	Deep Percolation (in)	Application Efficiency (percent)
100	72.0	748 min	66.95	0.01	6.9
200	36.3	754 min	31.28	0.03	13.8
300	24.5	764 min	19.45	0.06	20.4
400	18.7	777 min	13.60	0.10	26.7
500	15.3	796 min	10.16	0.16	32.6
600	13.2	821 min	7.92	0.25	38.0
700	11.8	855 min	6.39	0.37	42.5
800	10.8	901 min	5.31	0.53	46.1
900	10.3	961 min	4.54	0.74	48.6
1000	10.0	1041 min	4.00	1.03	49.9
1100	10.0	1147 min	3.64	1.40	49.8
1200	10.3	1285 min	3.43	1.88	48.5
1300	10.9	1466 min	3.35	2.51	46.1
1400	11.7	1701 min	3.39	3.30	42.8
1500	12.9	2007 min	3.57	4.31	38.8
1600	14.4	2402 min	3.87	5.57	34.6
1700	16.5	2912 min	4.34	7.15	30.3
1800	19.1	3569 min	4.99	9.10	26.2
1900	22.4	4415 min	5.86	11.51	22.4
2000	26.5	5500 min	7.01	14.45	18.9

There are no warning messages or restrictions in this mode. Not that times are in minutes to make it easier to plot this data on furrow curves. Examples of furrow curve plots are shown in Section 5, Figures 5-17 and 5-18 of SCS National Engineering Handbook, Chapter 5.

Notice that the flows build to a peak efficiency at 1000 foot length and then start going down again.

SURFACE documentation

MANIPULATING OLD FILES

Previously run job files can be retrieved and revised.

To retrieve an old job file select "Get-file" from the main menu bar and then select "Get old job" from the pull down menu.

```
-----SURFACE IRRIGATION SYSTEM MENU-----  
| Furrow          Border          -Get-file          Quit          |  
-----  
| -Get old job    |  
| Job directory   |  
| Delete job files|  
-----
```

SURFACE IRRIGATION SYSTEM DESIGN
Version 2.3 5/1/91
by John Dalton
Bozeman Montana

F1-Help and exit from help ESC-Exit from menus

Get an old job from files

SURFACE documentation

The following job file list will then pop up.

```
-----SURFACE IRRIGATION SYSTEM MENU-----
| Furrow          Border          -Get-file          Quit          |
-----

-----Get Old Job File-----
|
|          Select file =FILE SELECTION LIST =
|          ...EXIT...
|          DEMO4.SRF
|          DEMO3.SRF
|          DEMO2.SRF
|          DEMO1.SRF
|          =====
|
-----

          F1-Help and exit from help          ESC-Exit from menus
-----
Use up and down arrow keys to move in list, <Ent> to select file
-----
```

The first file name in the list is the last job run. All files are listed in reverse chronological order. By selecting ...EXIT... you will return to the main menu without selecting an old job.

The first screen to come up will contain general job data. Use the <Ent> key to move through the fields. Make changes in fields as necessary.

Finally the rest of the job input screen will come up with fields containing data. Change the input data as necessary.

After changes are made, save the job by selecting "Quit/save".

SURFACE documentation

To determine which job files are in the current directory, select "Get-file" from the main menu bar and then "Job directory" from the pull down menu.

The following screen will come up:

```
-----SURFACE IRRIGATION SYSTEM MENU-----  
| Furrow          Border          -Get-file          Quit          |  
-----
```

```
=====Current Directory: *.SRF=====
```

```
DEMO1.SRF      DEMO2.SRF      DEMO3.SRF      DEMO4.SRF
```

```
Press <Ent> to continue ....
```

```
=====
```

```
F1-Help and exit from help      ESC-Exit from menus
```

```
-----
```

SURFACE documentation

To delete old job files, select "Get-file" from the main menu bar and then "Delete job files" from the pull down menu. The following window will then pop up:

```
-----SURFACE IRRIGATION SYSTEM MENU-----
| Furrow      Border      -Get-file      Quit      |
-----
      -Delete Existing Job Files-
      Deleted file name =SELECT A FILE TO DELETE=
      ...EXIT...
      DEMO4.SRF
      DEMO3.SRF
      DEMO2.SRF
      DEMO1.SRF
      =====
```

F1-Help and exit from help ESC-Exit from menus

Use up and down arrow keys to move in list, <Ent> to select file

After selecting a file to delete, you will be asked if you really want to delete the file. If you answer "Y", the file will be deleted and the file list will again come up. You can then delete other files or exit.