

# PHAUCET 2012

## version 8.2.20



Punching holes in Layflat Pipe

Various size Plastic Hole Punches

### PHAUCET

Pipe Hole and Universal Crown Evaluation Tool

Programmed by Doyle Burch  
Version 8.2.20 Jan 2012

WIN NT, 2000, XP, Vista

This program was developed to improve Distribution Uniformity in Layflat pipe. Distribution Uniformity can be improved using PHAUCET two ways.

1. Selecting correct hole diameters for head pressure.
2. Designing correct slope where layflat pipe is installed to offset head pressure.

## User Manual



[www.uaex.edu](http://www.uaex.edu)

## DISCLAIMER

Although the PHAUCET program has been tested by its developers, NO warranty, expressed or implied, is made as to the accuracy and functionality of the program and related program material nor shall the fact of distribution constitute any such warranty, and NO responsibility is assumed by the developers in connection therewith.

## SYSTEM REQUIREMENTS

Minimum requirements to run this program on a computer:

- Pentium 233-megahertz (MHz) processor or faster (300 MHz is recommended)
  - •At least 64 megabytes (MB) of RAM (128 MB is recommended)
  - •At least 20 megabytes (MG) of available space on the hard disk
- Windows XP or higher
- Printer

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## INSTALLATION

The self-extracting installation file is available for download from [www.uaex.edu](http://www.uaex.edu) and will automatically install PHAUCET onto the hard drive of your computer. Answer prompts as needed to complete the installation.

## REMOVING PHAUCET

**If you try to remove PHAUCET by deleting its folder in Windows Explorer you will not be able to remove all PHAUCET components!**

To uninstall PHAUCET, click on the Windows [Start] menu, select [Control Panel] then [Uninstall a Program]. Click on PHAUCET 2012 (fig. 1) then click [Uninstall/Change].

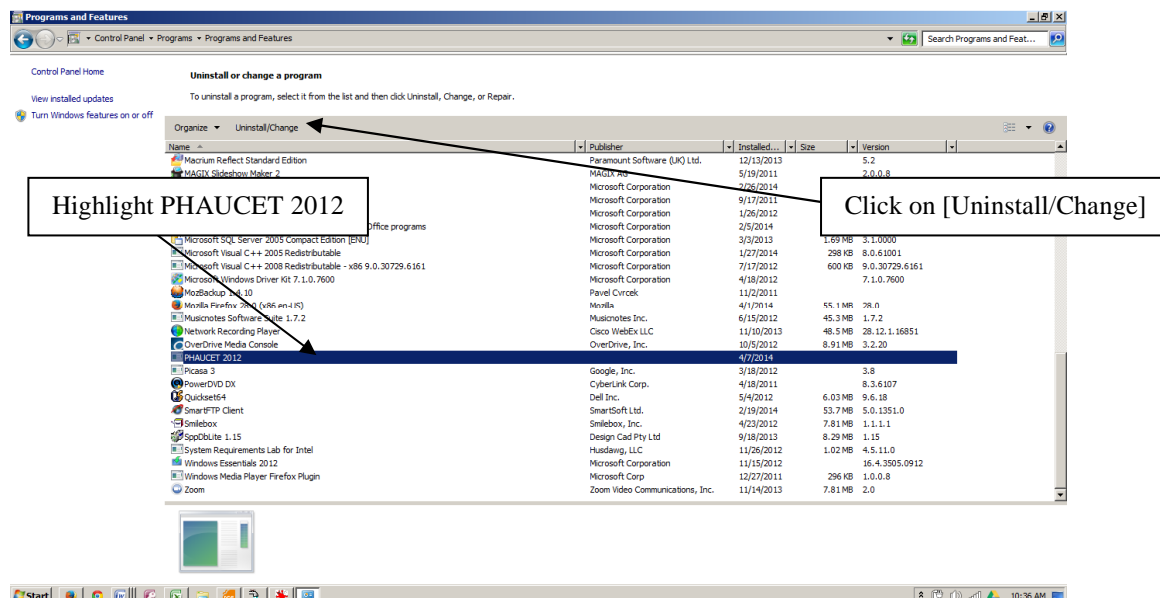


Figure 1 – Uninstall a Program window

The Application Removal window appears (fig. 2). Click the [Yes] button and this should remove all PHAUCET programs and libraries.

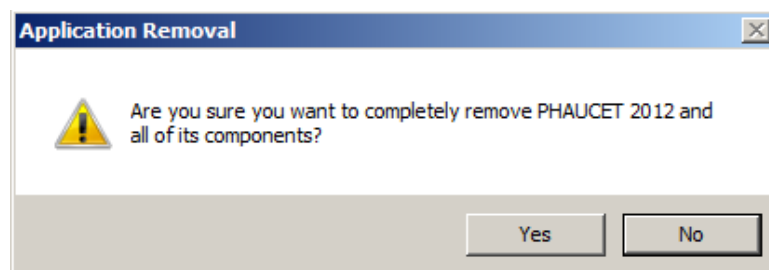


Figure 2 - Application Removal popup

## INTRODUCTION TO PHAUCET

### **What is PHAUCET?**

PHAUCET is a design and evaluation tool for furrow irrigation systems. Field and technical information is used to calculate existing system performance and define alternatives for improving irrigation efficiency.

### **What Does PHAUCET Do?**

PHAUCET uses pipe friction loss, crown profile elevations and selected hole sizes to calculate pressure throughout the system and a flow rate for each watered furrow. Furrow flow rates are compared and expressed as a percent of Distribution Uniformity. This provides an indication of system performance and the effects of system adjustments.

### **Why Use PHAUCET?**

PHAUCET was developed to provide producers, land grading contractors and planners a tool for designing efficient furrow irrigation systems. The design printouts define pipe and hole size combinations that deliver high distribution uniformity at calculated operating pressures. Uniform furrow flow rates normally advance water evenly to the low end of the field. This gives a more consistent water infiltration and reduces pump times. Chemical and nutrient losses due to leaching and surface runoff may be reduced.

Pipeline pressure is calculated and displayed for the entire system. This allows planners to make design adjustments that manage pressure and prevent pipe failure.

Optimum crown profile grades can be designed for most systems. This gives planners another tool for pipe pressure management. A designed grade often allows less expensive pipe to be used and reduces the number of different hole sizes required for high distribution uniformity. The crown elevation difference calculation helps prevent installation of systems that are erosive and difficult to maintain.

### **PHAUCET Design Parameters**

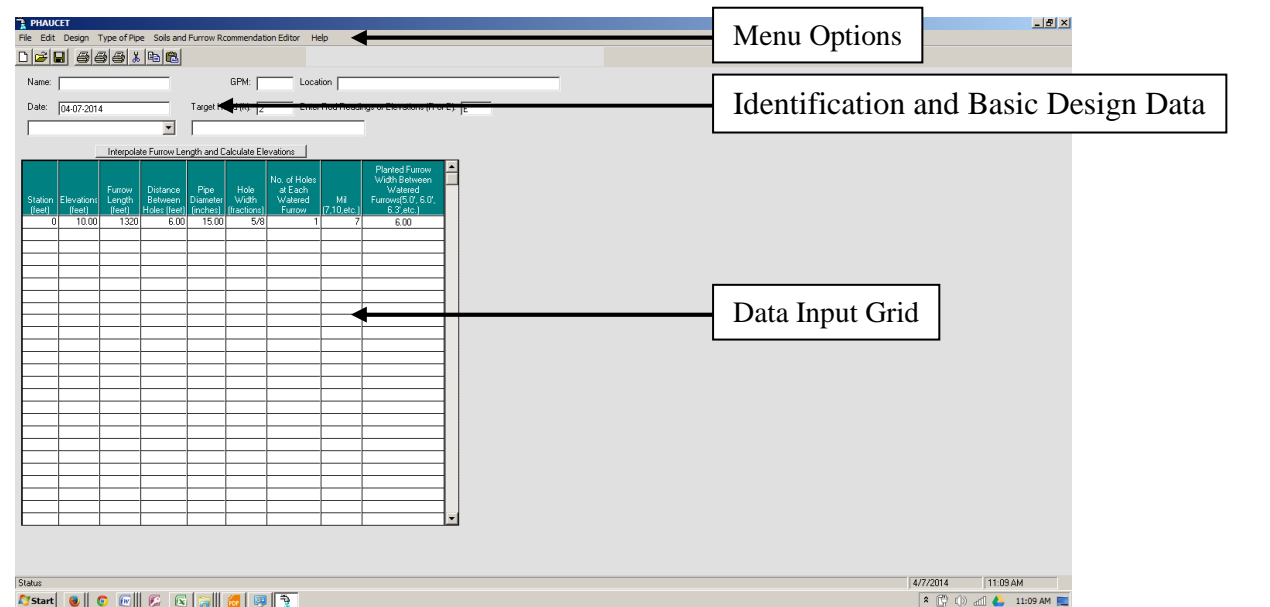
PHAUCET can design a system having up to 5280 watered furrows. The Input Screen will accept up to 320 line entries describing the crown profile, furrow length, furrow width, pipe diameter(s) and selected hole sizes. These limits should allow the flexibility to design or evaluate most furrow irrigation systems using surface pipelines.

Designs can be saved to a file and later recalled. PHAUCET uses Microsoft Windows conventions such as drop-down menus, the <Tab> key and a mouse to select program options and complete data entries. The calculated design can be viewed and printed in a Summary format or a Complete Design (each watered furrow) format.

## GETTING STARTED

PHAUCET uses measurements and information describing your field conditions to calculate the most efficient design of your furrow irrigation system. Before launching PHAUCET, you will need to gather the following information:

1. Accurate survey (normally 100 ft. stations) of the crown profile where layflat irrigation pipe is or will be installed
2. Accurate system flow (gallons per minute)
3. Watered furrow spacing (ft.)
4. Length(s) of irrigated furrows (ft.)
5. Diameter of layflat hole punchers available
6. Diameter (inches) of layflat irrigation pipe
7. Furrow flow rate (gpm) required for soil to be effectively irrigated
8. Wall thickness (mil) and allowable pressure (ft. of head) of selected layflat irrigation pipe



## INPUT SCREEN: Menu Options

### File Menu Option

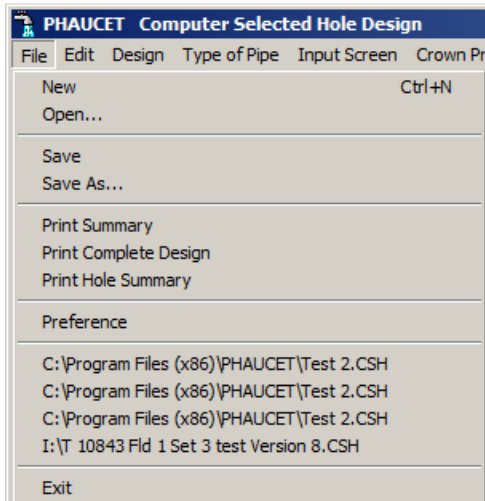


Figure 5 - File Menu Option

**File -> New:** This option clears all entered and calculated data from the program and inserts the stored default values. If the default values displayed are not accurate, type in corrections.

**File -> Open:** Click on Open to view design files in the selected drive. There are six types of files that can be retrieved (fig. 6). All design file types (\*.\*) are shown by default.

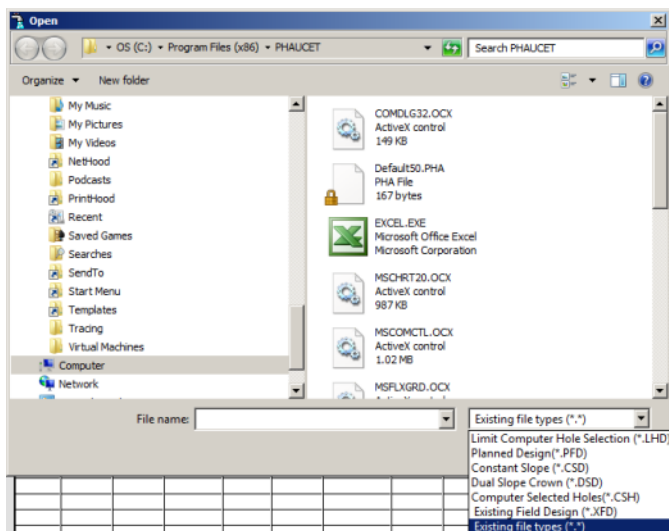


Figure 6 - Open dialog

- Limited Computer Hole Selection (LHD):** The LHD extension stands for “Limited Hole Design.”



- **Planned Design (PFD):** The PFD extension stands for “Planned Field Design” and typically describes a new system or an Existing Field Design (XFD) that has been adjusted for improved performance. The PFD and XFD files use different titles on printouts and design screens but all calculations are identical.
- **Constant Slope (CSD):** The CSD extension stands for “Constant Slope Design” and indicates a design prepared using a computer selected slope for the entire length of the crown profile.
- **Dual Slope Crown (DSD):** The DSD extension stands for “Dual Slope Design” and is a design prepared using a computer selected grade for the first one-half of the crown profile length and a flat slope for the remainder of the system.
- **Computer Selected Holes (CSH):** The CSH extension stands for “Computer Selected Hole” and is used to develop a Planned Design. It includes all hole sizes described when the Computer Hole Selection option is selected from the Design menu.
- **Existing Field Design (XFD):** The XFD extension stands for “Existing Field Design” and describes system performance prior to modification. This provides data for comparison with calculated design alternatives.

**File -> Save:** This option saves the design using the existing name and file extension of the most recent design selection.

**File -> Save As:** Select this option to enter detailed file names (fig. 7). This dialog box allows you to enter an extended name to clearly identify the file.

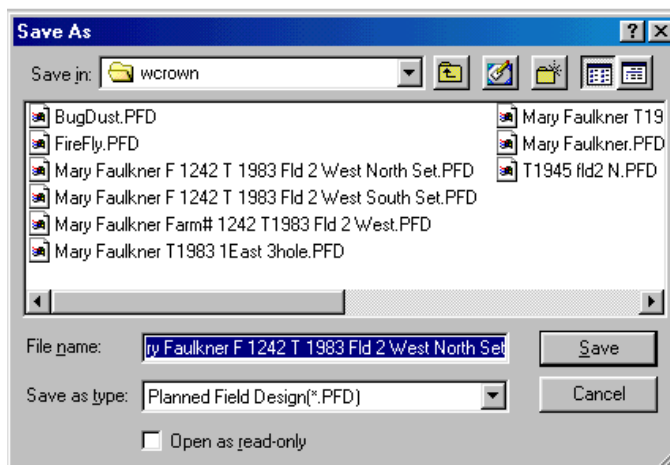


Figure 7 - Save As dialog

**File -> Print Summary:** Select this option to print the Summary Design view of a calculated design. This is usually a single page and displays all information needed to install most systems.

**File -> Print Complete Design:** This option prints the Complete Design view of all watered furrows in the calculated design. This is useful for complex systems and can be used to locate areas of excessive pipe pressure during the design process.

**File -> Print Hole Summary:** This printout describes the size, number and location of hole sizes selected for a calculated design. This report is handy for producers during installation of a system or planners when entering Computer Hole Selection (CSH) design information on the Input Screen. Select other print options for additional system details.

**File -> Preference:** This option displays the Preference Defaults (fig. 8) which are loaded each time PHAUCET is started. It is not necessary to return to Preference Defaults to edit values displayed on the Input Screen's Data Input Grid.

Defaults	
Distance Between Stations (feet):	100
Change Hole Size (Press + or -):	5/8
Orifice Coefficient:	0.65
Hazen William C:	140.00
Warning for Max. Elevation Difference between Crown and Field (feet):	1.20
Pipe Diameter (inches):	15.00
Distance between watered furrows (feet):	3.17
Number of Holes Per Furrow:	1
Mil (Pipe Wall Thickness):	10
Elevations or Rod Readings (R or E):	E
Target Head (feet):	2
Hole Type Rectangle or Circular (R or C):	C
Diameter or Height of gated hole (inches):	1.2
Highest Target head for calculating Limited Holes Selection (ft.):	3.5
Increments in head change for Limited Hole Selection:	.5
Set OPEN FILE default extension (LHD, PFD, CSD, DSD, CSH, *)	*.*
Exit	

Figure 8 - Preference Defaults

- **Distance Between Stations (feet):** The Station column on the Input Screen's Data Input Grid uses this value to assist you when entering crown profile Stations.
- **Change Hole Size (Press + or -):** This entry will be displayed in the first cell of the Hole Diameter column on the Input Screen's Data Input Grid. Adjust the default value using the <+> or <-> keys. It is not necessary to edit the Preference Defaults when changing hole sizes on the Data Input Grid.
- **Orifice Coefficient:** This coefficient is used in calculating flow from a hole punched in layflat irrigation pipe.

- **Hazen Williams C:** This is a roughness coefficient used to calculate friction loss in the pipeline.
- **Crown Elevation Difference (feet):** Crown Elevation Difference indicates the difference between the planned and existing crown profile elevations. If a Constant Slope Design (CSD) or Dual Slope Design (DSD) calls for a constructed elevation 1.5 ft. above the existing condition, at any station on the system, the Crown Elevation Difference would be 1.5 ft. For most soils, if this difference is greater than 1.5 ft., excessive erosion will occur on the crown. This makes it difficult for the producer to maintain the designed crown grade. If the elevation difference exceeds the default number, the planned value will be highlighted **yellow** at the lower right corner of the design screen. If the difference is less than the default value it will not be highlighted.
- **Pipe Diameter (in.):** This is the diameter of the layflat irrigation pipe to be used in a design. The number is automatically entered in the first cell of the Pipe Diameter column on the Input Screen's Data Input Grid. It is not necessary to change the Preference Defaults if another (or multiple) size will be used. Type in size(s) on the Data Input Grid as needed.
- **Distance Between Watered Furrows (ft.):** This is the distance between the holes in the layflat irrigation pipe. This number is automatically entered in the first cell of the Distance Between Holes column on the Input Screen's Data Input Grid. It is not necessary to change the Preference Defaults if another spacing occurs on the field. Type in actual spacing (feet) on the Data Input Grid.
- **Number of Holes Per Furrow:** This is the number of holes punched at each watered furrow. This number is automatically entered in the first cell of the Number of Holes at Each Watered Furrow column on the Input Screen's Data Input Grid.
- **Mil:** This is the thickness of the wall of layflat irrigation pipe. This number is automatically entered in the first cell of the Mil column on the Input Screen's Data Input Grid. This number is for information only and does not affect program calculations.
- **Elevations or Rod Readings (R or E):** Crown profile survey information may be entered on the Input Screen's Data Input Grid using Rod Readings or Elevations. The default value is one character long and is displayed on the Input Screen for each new design. You may edit the value on the Input Screen if needed. Each design can have only one selection.
- **Exit:** Save the changes you have made and exit the Preference Defaults window.

**File -> Exit:** This option terminates the PHAUCET program.

## Edit Menu Option

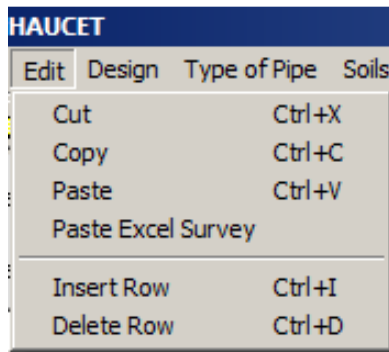


Figure 9 - Edit Menu Option

**Edit -> Cut:** This option can be used to delete displayed data. Highlight the items you want to erase, select Cut, or press the <Delete> key and the data will be removed.

**Edit -> Copy:** This option copies information from the Input Screen into computer memory. It does not place information in the Windows clipboard. Highlight the items you want to copy, select Copy, or Press <Ctrl + C>.

**Edit -> Paste:** Use this option to paste data to the Input Screen. Highlight the area for the inserted data and select Paste. The highlighted area must be large enough to hold the information, or some of the data will be lost.

**Edit -> Paste Excel Survey:** This option allows you to paste survey data saved in an Excel file to the Input Screen. Before selecting this option be sure to first select and copy both columns of survey data from the Excel file.

**Edit -> Insert Row:** Use this option to insert a blank line above the cursor. Select this item or press <Ctrl + I>. All lines below the existing line will be moved down one row. This allows accurate entry of recommendations (e.g. Computer Selected Hole) or field information (e.g. furrow length) at specific crown locations.

**Edit -> Delete Row:** Place the cursor on the row you wish to delete and select Delete Row or press <Ctrl + D>. All lines below the deleted line will be moved up one row.

## Design Menu Option

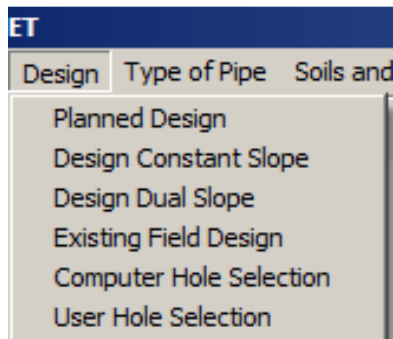


Figure 10 - Design Menu Option

**Design -> Planned Design (PFD):** This option is typically used for designing a new system or evaluating adjustments to an existing system. The Planned Design and Existing Field Design options have different titles on printouts and the design screen, but all calculations are identical. Review the maximum and minimum pipe pressure for every system alternative. Generally, pipe pressure should be less than about 2.0 ft. for 7 mil and less than 3.5 ft. for 10 mil systems.

**Design -> Design Constant Slope:** This option uses the Hole Size entered on the Input Screen and calculates the optimum crown slope to offset friction loss created in the pipe. This option is less accurate for designs with long supply lines (more than 300 ft.) or systems with intermittent watered furrows. An example of an intermittent watered furrow is a system with a delivery pipe (watered furrows) leading to an un-watered section (more than 300 ft.) then resuming water furrows beyond the dry area. This often occurs when part of an irrigated field is used as a building site. Review the crown elevation difference and pipe pressure when considering a grade adjustment.

**Design -> Design Dual Slope:** This option calculates a sloping crown for the first half (from the pump) of the total pipe length. The second half of the crown is designed level. Limitations are similar to the Design Constant Slope option.

**Design -> Existing Field Design (XFD):** This evaluation is calculated like a Planned Design but the printout and screen are labeled Existing Field Design. This option is useful when determining the efficiency of an existing system.

**Design -> Computer Hole Selection (CSH):** This option reduces design time by locating crown Stations where a hole size adjustment is needed. The Hole Size displayed on the output screen may or may not provide maximum Distribution Uniformity. Adjust the Target Head and click on [Re-Calculate] to determine the most practical design. If pressure is excessive, it may be necessary to use a larger size or thicker wall layflat pipe. The CSH design should be printed out and entered on the Input Screen. Recalculate as a Planned Design and review pipe pressure. Generally, 7 mil layflat pipe will withstand about 2.0 ft. of pressure with slight chance of failure. 10 mil pipe can withstand about 3.5 ft. of head pressure.

## Type of Pipe Menu Option

Click on the type of pipe that will be used in the system (fig. 11). If both types will be used, select “Layflat Tubing” and convert the designed hole size (for the rigid pipe) to a gate opening using the Hole Size Equivalents Chart in Appendix B.

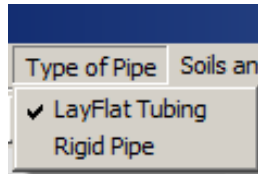


Figure 11 - Type of Pipe Menu Option

## Soils and Recommended Furrow Editor Menu Option

This option will open the Soils and Recommended Furrow Flow Editor in a separate window (fig. 12).

Soil Name and Texture (i.e. C. Sil)	Rec Furrow Flow
Acadia Sil	10
Beulah Fsl	25
Clana Lfs Fs	30

Figure 12 - Soils and Recommended Furrow Flow Editor

## Help Menu Option

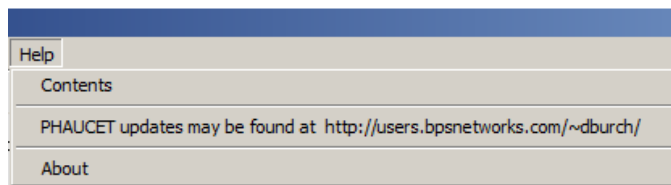


Figure 13 - Help Menu Option

**Help -> Contents:** Hints and instructions.

**Help -> PHAUCET updates:** Please note that this is no longer a working URL and will be fixed in a future revision.

**Help -> About:** PHAUCET version number and last revision date.

## INPUT SCREEN: Identification and Basic Design Data

Figure 14 - Identification and Basic Design Data

1. **Name:** The name cell can be 256 characters long. It should clearly identify the system and may also be used as a file name when saving a design.
2. **Date:** This cell defaults to the current date. If this is not correct, you may type over it.
3. **GPM:** The GPM is the system flow rate in Gallons Per Minute. An accurate flow rate is essential for a quality design. An in-line flow meter gives the most reliable measurement. Pumps should be run at their design RPM for several minutes to determine working flow rate.
4. **Target Head:** The Target Head is the maximum working pressure for the pipe being designed. Use manufacturer's recommendations for allowable pressure in layflat pipe. If the Maximum Head in a calculated design is less than the Target Head it is displayed in green. If the Maximum Head is greater than or equal to the Target Head it will be displayed in yellow. The Target Head is also considered in the Computer Hole Selection design (CSH) calculations. When the Target Head is adjusted in a CSH design, the program will attempt to calculate a design using the new value. This may increase or decrease the number of different hole sizes used in the design. Generally, increasing pipe pressure reduces the number of different hole sizes needed for high distribution uniformity.
5. **Location:** Enter a location description that clearly identifies the system.
6. **Enter Rod Reading or Elevations (R or E):** This cell is one character long. Crown profile surveys may be entered as either **R**od Readings or **E**levations.
7. **Soil Type:** The available values for this cell are based on the entries in the Soils and Recommended Furrow Flow Editor. Click the down-facing triangle ▼ to select a new soil type from the scrollable list. You may also highlight the cell and repeatedly type the first letter of the desired soil until it is selected.

8. **Recommended Furrow Flow:** This is a lookup based on the value in Soil Type. Values may be changed in the Soils and Recommended Furrow Flow Editor.
9. **Interpolate Furrow Length and Calculate Elevations:** Click this button and all blank data cells will be filled, except lines where the Hole Size is left blank (un-watered furrows). This can be used to calculate furrow and elevation information where no actual data is entered. It is not necessary to interpolate before selecting a design option. The program will automatically fill the input screen before completing flow calculations. **Do not click this button before entering hole sizes or all cells will be blanked out.**

### Input Screen: Data Input Grid

The next section of the Input Screen is the Data Input Grid (fig. 15). The Data Input Grid is directly below the Identification and Basic Design Data section.

1	2	3	4	5	6	7	8	9
Station (feet)	Elevations (feet)	Furrow Length (feet)	Distance Between Holes (feet)	Pipe Diameter (inches)	Hole Width (fractions)	No. of Holes at Each Watered Furrow	Mil (7,10,etc.)	Planted Furrow Width Between Watered Furrows(5.0', 6.0', 6.3',etc.)
0	10.00	1320	6.00	15.00	5/8	1	7	6.00

Figure 15 - Data Input Grid

Entries in the Data Input Grid must accurately describe field conditions in relation to the irrigation pipeline (i.e. furrow length begins at the delivery pipe and stops at the end of the irrigated row). When entering data in the Data Input Grid columns you may press the <Enter> key to copy data from the cell above to the current blank cell.

1. **Station (feet):** This column is used to locate field inventory data along the irrigation pipeline. The last entry in this column must equal the total length of pipe. To automatically calculate the distance of the next Station using the Distance Between Stations default value, click on next blank Station cell and press <Enter>. This can be repeated as many times as needed. Odd-distanced Stations should be entered by hand as needed to accurately describe the field.

Example: If the second Station entered is 100 and the third Station is blank, 200 will be entered in the third Station when the <Enter> key is pressed.

If the system will include a supply line or intermittent water furrows, you must enter Stations where these changes occur. An example of an intermittent watered furrow is a system with a delivery pipe (watered furrows) leading to an un-watered section then resuming watered furrows beyond the dry area. This frequently occurs when part of an irrigated field is used as a building site. Enter the actual Station of the first or last



watered furrow then add one foot to the previous Station and describe the altered condition (i.e. a watered row will have a furrow length and an un-watered furrow will not).

Example: Station (2+45) is where the crown turns and goes around a house site. You would need to enter Station (2+45) with a furrow length and hole size then enter Station (2+46) and leave the furrow length and hole size entries blank.

**Make certain there are no blank cells in the Station column before a design option is selected or an error in the program will occur.**

2. **Elevations (feet) OR Rod Readings (feet):** This column is determined by the value of Enter Rod Reading or Elevations (R or E) in the Identification and Basic Design Data section of the Input Screen. The column is used to enter elevations (or rod readings) along the crown profile. Blank cells between entered values will be interpolated according to their Station value. The program calculates all blank values when you click the [Interpolate Furrow Length and Calculate Elevations] button or select a Design menu item. For example, if an elevation of 10.0 is entered for Station (0+00) and an elevation of 9.8 is entered for crown Station (1+00), the program will interpolate the value for Station (0+50) as 9.9. If the crown profile survey includes a turn, convert all rod readings to elevations or adjust the rod readings relative to the first height of instrument.
3. **Furrow Length (feet):** The Furrow Length column is used to describe changes in irrigated furrow lengths. **If this entry is left blank the program will interpolate a length unless the hole size entry is also blank.** This interpolation is very useful for triangle or irregular shape fields. On a triangle field where the crown is straight and the row lengths taper, enter the Furrow Length at the first and last Stations. Click on the [Interpolate Furrow Length and Calculate Elevations] button or select a Design menu item and the program will calculate the rest of the Furrow Length values for you.
4. **Distance Between Holes (feet):** This entry describes the spacing between watered furrows. The Distance Between Holes may vary on fields with a curved crown or when different crops are irrigated as one system. Always enter the first and last Station for a particular hole spacing. All blank cells will be filled when the [Interpolate Furrow Length and Calculate Elevations] button is clicked or a Design menu item is selected.
5. **Pipe Diameter (inches):** Enter the desired pipe diameter you wish to use. If you need to change the pipe diameter at some point along the crown be sure to enter the Station where the first diameter ends and the Station where the next diameter starts.

Example: Assume you use 15 inch diameter pipe for the first 660 feet and drop down to 12 inch pipe for the remainder of the system. You would need to insert a line for Station (6+60) to enter the last occurrence of the 15 inch pipe and insert another line

for Station (6+61) to begin entering 12 inch pipe. If you enter 15 inch at Station (6+00) and 12 inch at Station (7+00) the program will start the 12 inch pipe at the crown Station (6+01).

6. **Hole Width (fraction):** You may select hole sizes from 0 to 3 inches in diameter. To select a hole size, place the cursor in the Hole Width column on the cell you want to change. Press the plus key <+> to increase the hole width or the minus key <-> to decrease hole width. Press <Enter> to copy the entry above to the current blank cell.
7. **Number of Holes at Each Watered Furrow:** Enter the number of holes that will be punched at each watered furrow. Occasionally, it is necessary to substitute two smaller holes for one large hole because the designed hole puncher is not available. The Hole Size Equivalents Chart in Appendix B provides multiple areas for all hole sizes. It is not unusual to design two holes per watered furrow for part of a pipeline and one hole per furrow for the remainder of the system. You must insert the Stations for the first and last occurrence of the altered value. The number at the first cell of the Data Input Grid will automatically continue unless an edit change is made.

Example: The area of one  $1 \frac{1}{16}$  inch hole is 0.887 square inches. Find a similar area in the Times 2 column of the Hole Size Equivalents Chart. The area of two  $\frac{3}{4}$  inch holes is 0.884 square inches. This means that two  $\frac{3}{4}$  inch holes could be substituted for one  $1 \frac{1}{16}$  inch hole.

8. **Mil (7,10 etc.):** You may need to change mil size at some point along the pipeline. This column can be used to describe the Station where the adjustment is planned. You must insert the Stations for the first and last occurrence of the altered value. The number at the first cell in the column will continue automatically unless an edit change is made. All blank cells will be filled when the [Interpolate Furrow Length and Calculate Elevations] button is clicked or a Design menu item is selected.
9. **Planted Furrow Width between Watered Furrows (5.0, 6.0, 6.3, etc.):** This column should match the distance between the planted furrow and watered furrow.

Example 1: If you are planting on 38 inch centers (3.17) and your tubing is crossing the irrigated rows at an angle measuring (4.25), the Planted Furrow Width column is (3.17).

Example 2: If you are planting on 38 inch centers and irrigating every other middle (6.33) and your tubing is crossing the irrigated rows at an angle measuring (14.00), the Planted Furrow Width column is (6.33).

## DESIGN SCREEN

Design Screen displays the results of design calculations. The Design Screen may be seen in either a Complete Design view or a Summary Design view.

The Design Screen displays the calculated results when a selection is made from the Design menu. The results are shown by default in the Complete Design Screen view (fig. 16) but may also be formatted in the Summary Design Screen view. The Design Screen looks similar to the Input Screen but only the Identification and Basic Design Data at the top may be edited.

**PHAUCET Planned Design**

File Edit Design Type of Pipe Input Screen Crown Profile **1** s and Furrow Recommendation Editor Help

Total Acres = 29.3

Name: \_\_\_\_\_ GPM: 2000 Location: \_\_\_\_\_

Date: 05-31-2009 Target Head (ft): 2 Enter Rod Readings or Elevations (R or E): R

Acadia Sil Recommended Furrow Flow = 10 GPM Average Furrow Flow = 9.7

Distribution Uniformity = 92.6 **2**

Station (Feet)	Hole Dia. (Inches)	Hole Number	Furrow Flow (GPM)	Head (feet)	Flow Ratio <b>3</b>	Furrow Length (feet)	Rod Reading (feet)	Number of Holes per Furrow	Mil	Pipe Diameter	Planted Width Between Watered Furrows
0	7/8	1	12.29	1.58	96	1300	10.00	1	6	15	6.33
6	7/8	2	12.25	1.57	96	1297	10.01	1	6	15	6.33
13	7/8	3	12.21	1.56	95	1294	10.01	1	6	15	6.33
19	7/8	4	12.17	1.55	95	1291	10.02	1	6	15	6.33
25	7/8	5	12.13	1.54	95	1288	10.03	1	6	15	6.33
32	7/8	6	12.09	1.53	95	1284	10.03	1	6	15	6.33
38	7/8	7	12.05	1.52	95	1281	10.04	1	6	15	6.33
44	7/8	8	12.01	1.51	95	1278	10.04	1	6	15	6.33
51	7/8	9	11.98	1.50	95	1275	10.05	1	6	15	6.33
57	7/8	10	11.94	1.49	95	1272	10.06	1	6	15	6.33
63	7/8	11	11.90	1.48	95	1269	10.06	1	6	15	6.33
70	7/8	12	11.87	1.47	95	1266	10.07	1	6	15	6.33
76	7/8	13	11.83	1.47	95	1263	10.08	1	6	15	6.33
82	7/8	14	11.79	1.46	95	1260	10.08	1	6	15	6.33
89	7/8	15	11.76	1.45	95	1256	10.09	1	6	15	6.33
95	7/8	16	11.73	1.44	95	1253	10.10	1	6	15	6.33
101	7/8	17	11.69	1.43	95	1251	10.10	1	6	15	6.33
108	7/8	18	11.66	1.42	95	1247	10.11	1	6	15	6.33
114	7/8	19	11.63	1.42	95	1244	10.11	1	6	15	6.33
120	7/8	20	11.60	1.41	95	1241	10.12	1	6	15	6.33
127	7/8	21	11.57	1.40	95	1238	10.13	1	6	15	6.33
133	7/8	22	11.54	1.39	94	1235	10.13	1	6	15	6.33
139	7/8	23	11.51	1.39	94	1232	10.14	1	6	15	6.33
146	7/8	24	11.48	1.38	95	1228	10.15	1	6	15	6.33
152	7/8	25	11.45	1.37	94	1226	10.15	1	6	15	6.33

Re-Calculate **5**  
Complete Design **6**

Gross Applied (in.)	Hours	Days
0.5	3.3	.1
1.0	6.6	.3
1.5	9.9	.4
2.0	13.3	.6
3.0	19.9	.8

**Active Design**

Stations	Hole Diameter	Number of Holes
0 - 570	7/8	91
576 - 899	13/16	52
905 - 1298	11/16	63

Highest Head: 1.79  
Max Head Station: 1298  
Lowest Head: 1.22  
Low Head Station: 468  
Max. Furrow Flow: 12.29  
Min. Furrow Flow: 7.18  
Calculated GPM: 2000

Figure 16 – Complete Design Screen view

- 1. Crown Profile:** This menu option displays the Profile of Crown Elevations as a graphical report (fig. 17) and is only available from the Design Screen.

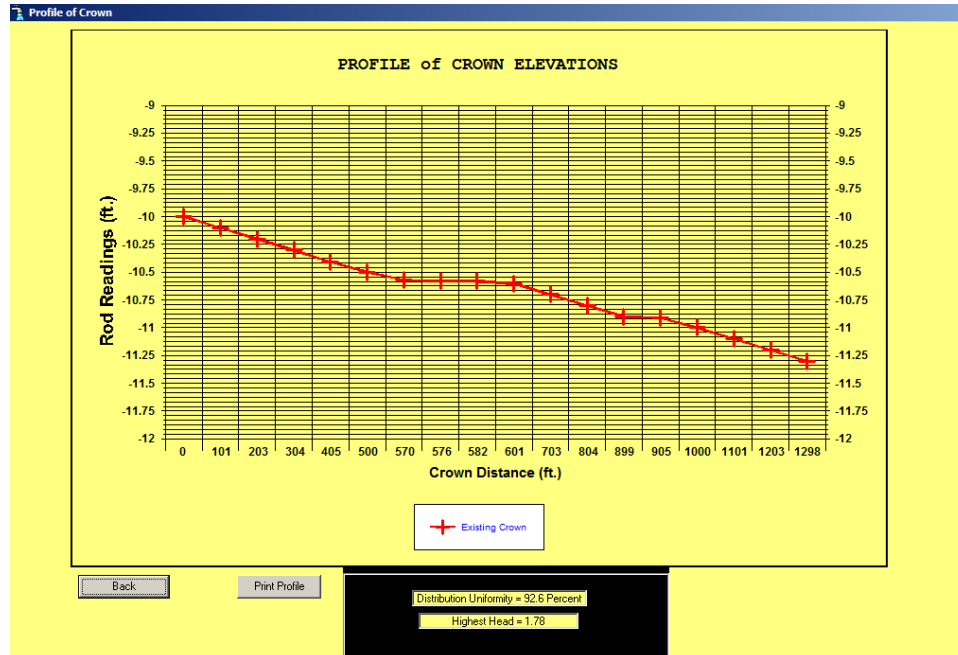


Figure 17 – Profile of Crown Elevations report

2. **Distribution Uniformity:** Distribution Uniformity is explained in the Technical conventions in Appendix A. The higher the Distribution Uniformity the more even the flow from the pipeline. A quality design will provide Distribution Uniformity above 90 percent for most systems.
3. **Head (feet):** This column displays the head pressure in the pipeline. This is helpful in locating excessive pressure that may cause the pipe to burst. You may need to increase the Hole Diameter(s) and/or Pipe Diameter if the pressure is above recommended limits. Generally, 7 mil pipe will withstand about 2.0 ft. of head pressure and 10 mil pipe about 3.5 ft.
4. **Flow Ratio:** This column is useful in locating Stations where Hole Diameter adjustments are needed to improve Distribution Uniformity. The optimum Flow Ratio is 1.00. Note it is not always practical to bring an entire system within these limits.

Flow Ratio Value	Rating
< .90	poor
.90 - .94	fair
.95 - 1.05	good
1.06 - 1.10	fair
> 1.10	poor

5. **Re-Calculate:** This button recalculates using the selected Design menu option. This is handy when a designer wants to compare Computer Selected Holes with varying Target Heads.

6. **Complete Design:** Click this button to toggle from the Complete Design Screen view to the Summary Design Screen view (fig. 18)

PHAUCET Planned Design

File Edit Design Type of Pipe Input Screen Crown Profile Soils and Furrow Recommendation Editor Help

Total Acres = 29.3

Name: \_\_\_\_\_ GPM: 2000 Location: \_\_\_\_\_

Date: 05-31-2009 Target Head (ft): 2 Enter Rod Readings or Elevations (R or E): [R] \_\_\_\_\_

Acadia Sil Recommended Furrow Flow = 10 GPM Average Furrow Flow = 9.7

Distribution Uniformity = 92.6

Station (feet)	Hole Dia (inches)	Hole Number	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Rod Reading (feet)	Number of Holes per Furrow	Pipe Diameter	Planted Width Between Watered Furrows
0	7/8	1	12.29	1.58	.96	1300	10.00	1	6	15
101	7/8	17	11.69	1.43	.95	1251	10.10	1	6	15
203	7/8	33	11.25	1.33	.95	1201	10.20	1	6	15
304	7/8	49	10.96	1.26	.96	1151	10.30	1	6	15
405	7/8	65	10.91	1.22	.99	1102	10.41	1	6	15
500	7/8	80	10.79	1.22	1.03	1055	10.50	1	6	15
570	7/8	91	10.84	1.23	1.07	1021	10.57	1	6	15
576	13/16	92	9.36	1.24	.93	1018	10.58	1	6	15
582	13/16	93	9.37	1.24	.93	1015	10.58	1	6	15
601	13/16	96	9.38	1.24	.94	1006	10.60	1	6	15
703	13/16	112	9.54	1.28	1.01	956	10.70	1	6	15
804	13/16	128	9.76	1.34	1.09	906	10.80	1	6	15
899	13/16	143	10.02	1.41	1.18	859	10.90	1	6	15
995	11/16	144	7.18	1.42	.85	857	10.91	1	6	15
1000	11/16	159	7.39	1.50	.92	810	11.00	1	6	15
1101	11/16	175	7.61	1.59	1.01	761	11.10	1	6	15
1203	11/16	191	7.84	1.69	1.12	710	11.20	1	6	15
1298	11/16	206	8.06	1.78	1.23	661	11.30	1	6	15

Re-Calculate Summary

Gross Applied (in.) Hours Days

0.5	3.3	1
1.0	6.6	3
1.5	9.9	4
2.0	13.3	6
3.0	19.9	8

Active Design

Stations	Hole Diameter	Number of Holes
0 - 570	7/8	91
576 - 899	13/16	52
905 - 1298	11/16	63

Figure 18 - Summary Design Screen view

7. **Field Area Calculator:** This feature calculates the area irrigated by any part of the pipeline and is only available while in the Complete Design Screen view. This is useful when an irregular shaped field will be divided for a multiple set system. To measure an area, drag and hold the mouse over two or more irrigated furrows in the Station column to highlight your selection. The calculated values for Acres Selected and Percent will appear in **blue** beside Total Acres until you release the mouse button.

PHAUCET Planned Design

File Edit Design Type of Pipe Input Screen Crown Profile Soils and Furrow Recommendation Editor Help

Total Acres = 29.3 Acres Selected = 2.8 Percent = 9.5

Name: \_\_\_\_\_ GPM: 2000 Location: \_\_\_\_\_

Date: 05-31-2009 Target Head (ft): 2 Enter Rod Readings or Elevations (R or E): [R] \_\_\_\_\_

Acadia Sil Recommended Furrow Flow = 10 GPM Average Furrow Flow = 9.7

Distribution Uniformity = 92.6

Station (feet)	Hole Dia (inches)	Hole Number	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Rod Reading (feet)	Number of Holes per Furrow	Pipe Diameter	Planted Width Between Watered Furrows
0	7/8	1	12.29	1.58	.96	1300	10.00	1	6	15
6	7/8	2	12.25	1.57	.96	1297	10.01	1	6	15
13	7/8	3	12.21	1.56	.96	1294	10.01	1	6	15
19	7/8	4	12.13	1.55	.96	1291	10.02	1	6	15
25	7/8	5	12.13	1.54	.95	1288	10.03	1	6	15
32	7/8	6	12.09	1.53	.95	1284	10.03	1	6	15
38	7/8	7	12.05	1.52	.95	1281	10.04	1	6	15
44	7/8	8	12.01	1.51	.95	1278	10.04	1	6	15
51	7/8	9	11.98	1.50	.95	1275	10.05	1	6	15
57	7/8	10	11.94	1.49	.95	1272	10.06	1	6	15
63	7/8	11	11.90	1.48	.95	1269	10.06	1	6	15
70	7/8	12	11.87	1.47	.96	1266	10.07	1	6	15
76	7/8	13	11.83	1.47	.96	1263	10.08	1	6	15
82	7/8	14	11.79	1.46	.95	1260	10.08	1	6	15
89	7/8	15	11.76	1.45	.95	1256	10.09	1	6	15
95	7/8	16	11.73	1.44	.95	1253	10.10	1	6	15
101	7/8	17	11.69	1.43	.95	1251	10.10	1	6	15
107	7/8	18	11.66	1.42	.95	1247	10.11	1	6	15
114	7/8	19	11.63	1.42	.95	1244	10.11	1	6	15
120	7/8	20	11.60	1.41	.96	1241	10.12	1	6	15
127	7/8	21	11.57	1.40	.96	1238	10.13	1	6	15
133	7/8	22	11.54	1.39	.94	1235	10.13	1	6	15
139	7/8	23	11.51	1.39	.94	1232	10.14	1	6	15
146	7/8	24	11.48	1.38	.95	1228	10.15	1	6	15
152	7/8	25	11.45	1.37	.94	1226	10.15	1	6	15

Re-Calculate Complete Design

Gross Applied (in.) Hours Days

0.5	3.3	1
1.0	6.6	3
1.5	9.9	4
2.0	13.3	6
3.0	19.9	8

Active Design

Stations	Hole Diameter	Number of Holes
0 - 570	7/8	91
576 - 899	13/16	52
905 - 1298	11/16	63

Figure 19 - Field Area Calculator

## APPENDIX A: REFERENCE MATERIALS

### GLOSSARY

<b>Crown</b>	High end of the irrigated field where the furrow irrigation pipe is installed
<b>Delivery Pipe</b>	Pipe used to discharge water into the irrigated furrow; this part of the pipeline will have holes and distributes water across the upper end of the field
<b>Distribution Uniformity</b>	<p>Used in this program as an indicator of how even the furrow flow rates are in relation to each other. This is computed as follows:</p> <div style="border: 1px solid black; padding: 10px; margin: 10px auto; width: fit-content;"> <math display="block">\frac{\text{Avg. low } \frac{1}{4} \text{ furrow flow rate}}{\text{Avg. furrow flow rate}}</math> </div> <p>“Avg. low <math>\frac{1}{4}</math> furrow flow rate” is the average of the lowest 25% of furrow flow rates.</p> <p>“Avg. furrow flow rate” is the average flow rate of the entire irrigated set.</p> <p>The higher the Distribution Uniformity, the more evenly distributed the furrow flow rates.</p> <p>The “low <math>\frac{1}{4}</math> furrow flow rate” considers furrow length. For instance, a triangular shaped field will need more water applied to the long rows than to the short rows. The “low <math>\frac{1}{4}</math> furrow flow rate” is not necessarily the smallest 25% of the flow rate streams within the system (see Assumptions in Appendix A).</p>
<b>GPM</b>	Gallons Per Minute
<b>Grade</b>	Crown elevation changes (Crown Profile)
<b>Hazen Williams Coefficient</b>	Hazen Williams “C” coefficient used for calculating friction loss in pipeline
<b>Head</b>	Pressure units in this program are expressed as feet of head
<b>Hole Diameter</b>	Diameter of opening cut in layflat pipe for outlet of water into the irrigated furrows

<b>Layflat Pipe</b>	Thin walled collapsible tubing made of polyethylene plastic; sometimes referred to as rollout pipe or garbage bag pipe
<b>Mil</b>	The wall thickness of layflat irrigation tubing
<b>Orifice Coefficient</b>	“C” coefficient in the orifice flow equation used to calculate flow through a sharp edged orifice
<b>Supply Pipe</b>	Pipe used to supply water to the irrigated set; in fields with multiple sets, this would be the section of pipe with no holes that conveys water from the pump to the first watered furrow

## APPENDIX A: REFERENCE MATERIALS

### TECHNICAL EQUATIONS

“**Friction Loss**” values for water flowing through pipe are computed using the Hazen-Williams empirical equation:

$$h_f = 0.2083 \left[ \left( \frac{100}{C} \right)^{1.852} * \frac{Q^{1.852}}{d^{4.8655}} \right]$$

Where:

$h_f$  = friction head loss in feet of water per 100 ft. for the specified pipe

$C$  = Hazen-Williams friction loss factor (a constant for internal pipe roughness; recommended value for layflat pipe = 140)

$Q$  = flow rate in U.S. gallons per minute

$d$  = inside diameter of pipe in inches (layflat pipe diameters: 12”, 15”, 18”; use same diameter for O.D. and I.D.)

---

“**Flow Through Hole**” values are calculated using the orifice flow rate equation:

$$Q = (C_d A_o \sqrt{2gH}) * 448.83$$

Where:

$Q$  = pipe flow rate, in U.S. gallons per minute (1 cubic foot per second = 448.83 gallons per minute)

$C_d$  = coefficient of discharge (dimensionless ratio of the velocity of the fluid through an orifice over the frictionless velocity)

$A_o$  = orifice area, in square feet

$g$  = acceleration due to gravity (32.2 feet per second squared)

$H$  = center line head / pressure, in feet



## APPENDIX A: REFERENCE MATERIALS ASSUMPTIONS

- It is assumed for calculating friction loss and flow area that layflat pipe behaves as a circular rigid pipe of the same diameter as the nominal diameter.
- It is assumed that holes punched in layflat pipe for furrow flow are circular.
- The required flow rate into furrows is assumed to change in direct ratio to the relative length of the furrow. For example, a 1300 ft. furrow is assumed to require two times the water of a 650 ft. foot furrow.
- Crown elevations and furrow lengths are assumed to vary uniformly between data entry points. For example:

Crown Distance	Elevation	Furrow Length
(0+00)	100.00	1320
(10+00)	99.00	660

The elevation at each 100 ft. of crown distance would be decreased by 0.1 ft. Each furrow length would be decreased by 66 ft.

## APPENDIX B: HOLE SIZE EQUIVALENTS CHART

Diameter	Area Sq. In.	Times 2	Times 3	Gate Opening In.
1/4	0.049	0.098	0.147	1/16
5/16	0.077	0.153	0.230	1/16
3/8	0.110	0.221	0.331	1/16
7/16	0.150	0.301	0.451	1/8
1/2	0.196	0.393	0.589	3/16
9/16	0.249	0.497	0.746	3/16
5/8	0.307	0.614	0.920	1/4
11/16	0.371	0.742	1.114	5/16
3/4	0.442	0.884	1.325	3/8
13/16	0.518	1.037	1.555	7/16
7/8	0.601	1.203	1.804	1/2
15/16	0.690	1.381	2.071	9/16
1	0.785	1.571	2.356	5/8
1 1/16	0.887	1.773	2.660	11/16
1 1/8	0.994	1.988	2.982	13/16
1 3/16	1.108	2.215	3.323	7/8
1 1/4	1.227	2.454	3.682	1
1 5/16	1.353	2.706	4.059	1 1/16
1 3/8	1.485	2.970	4.455	1 3/16
1 7/16	1.623	3.246	4.869	1 5/16
1 1/2	1.767	3.534	5.301	1 7/16
1 9/16	1.917	3.835	5.752	1 9/16
1 5/8	2.074	4.148	6.222	1 11/16
1 11/16	2.237	4.473	6.710	1 13/16
1 3/4	2.405	4.811	7.216	1 15/16
1 13/16	2.580	5.160	7.740	2 1/16
1 7/8	2.761	5.522	8.283	2 3/16
1 15/16	2.948	5.897	8.845	2 3/8
2	3.142	6.283	9.425	2 1/2
2 1/16	3.341	6.682	10.023	
2 1/8	3.547	7.093	10.640	
2 3/16	3.758	7.517	11.275	
2 1/4	3.976	7.952	11.928	
2 5/16	4.200	8.400	12.600	
2 3/8	4.430	8.860	13.290	
2 7/16	4.666	9.333	13.999	
2 1/2	4.909	9.817	14.726	
2 9/16	5.157	10.314	15.472	
2 5/8	5.412	10.824	16.236	
2 11/16	5.673	11.345	17.018	
2 3/4	5.940	11.879	17.819	
2 13/16	6.213	12.425	18.638	
2 7/8	6.492	12.984	19.475	
2 15/16	6.777	13.554	20.331	
3	7.069	14.137	21.206	

## **APPENDIX C: EXAMPLE DESIGNS**

The following systems describe typical fields that can be designed using this program. All field information must be entered with a corresponding crown profile station. The quality of a design will vary with the accuracy of field data. If you are unsure of how to enter data for a particular field or complete a practical design, contact Chris Henry, Extension Assistant Professor with the University of Arkansas System's Division of Agriculture at [cghenry@uark.edu](mailto:cghenry@uark.edu) or 870-673-2661.

The optimum furrow flow rate for a particular system varies with soil texture, furrow length and field grade. Fields with 1300 ft. long rows and very sandy or cracking clay soils generally require 20 to 30 gpm per furrow to be effective. Loamy soils need 8 to 20 gpm and silty soils from 5 to 15 gpm. Furrow flow rates of 3 gpm are generally not recommended unless row length is less than 200 ft or field slope is greater than 1 percent.

The Computer Hole Selection (CSH) design option reduces design time by locating Stations where a hole size adjustment is needed. The actual sizes used for a quality design may be different than the CSH recommendation, but the Stations where the changes occur are often the same. It is sometimes useful to adjust the Target Head and recalculate the CSH design. This changes pipe pressure and may reduce the number of different hole sizes needed for the system.

Check the maximum and minimum pipe pressure after every design calculation. Generally, do not exceed 2.0 ft. of head in 7 mil pipe and 3.5 ft. in 10 mil pipe. Pressure less than 0.5 ft. should be avoided if possible.

## General Rules of Thumb

1. Pipe Diameter Guide:
  - 12" pipe < 1400 gpm
  - 15" pipe > 1400 gpm and < 2500 gpm
  - 18" pipe > 2500 gpm and < 3500 gpm
2. Mil Thickness Guide:
  - 7 mil < 2 ft head
  - 10 mil < 3.5 ft head

**NOTE: Rules 1 and 2 are guides, it is always best to follow pipe manufacturer's recommendations.**

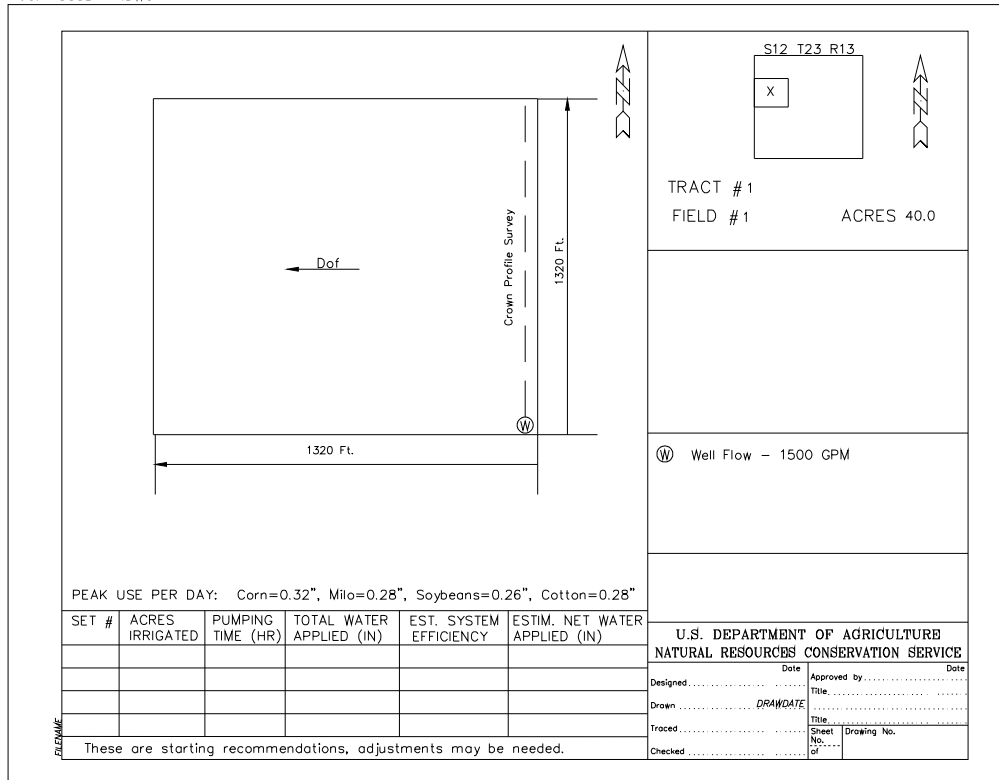
3. If High and Low Head vary by 1.5 ft or less, use 7 mil pipe.  
If High and Low Head vary 3.0 ft or less use 10 mil pipe.
4. If High and Low Head vary less than 0.5, you might be able to use a smaller diameter pipe.
5. If the Highest Head is in the last half of the pipe, you might be able to use a smaller diameter pipe.
6. Flow Ratios should generally fall between 0.9 and 1.1. The closer they are to 1.0, the higher the distribution uniformity.
7. Furrow Flow Rates for soils:
  - Very Sandy or Cracking Clays require 20 to 30 gpm
  - Loamy Soils require 8 to 20 gpm
  - Silty Soils require 5 to 15 gpm
8. Distribution Uniformity should be greater than 90%.
9. Higher Head designs in general require fewer hole sizes.

## Example 1: Design with Consistent Furrow Lengths

Square forty acre field with a silt loam soil and a flat crown (fig. 1.1 & 1.2)

Figure 1.1 - Example 1 Field Dimensions

Title: SCSBA-F.DWG



NOTE: To edit entered title block text, use DDATTE and select the text.

Station	Rod	Elevation	Comments
0+00	5.60	10.00	First Watered Furrow
1+00	5.60	10.00	Row spacing is 38 inches for the entire field.
2+00	5.60	10.00	Plan to irrigate every other row. Use 6.3 ft. for design.
3+00	5.60	10.00	
4+00	5.60	10.00	
5+00	5.60	10.00	
6+00	5.60	10.00	
7+00	5.60	10.00	
8+00	5.60	10.00	
9+00	5.60	10.00	
10+00	5.60	10.00	
11+00	5.60	10.00	
12+00	5.60	10.00	
13+00	5.60	10.00	
13+20	5.60	10.00	Last Watered Furrow

Figure 1.2 - Example 1 Crown Profile Survey

**STEP 1:** To begin this design, open the PHAUCET program. From the Input Screen enter the field identification and system flow rate data at the top of the screen. Use the default Target Head of 1.0 to get started. It will be explained in a later example why this value may need to be changed. The elevation data has already been calculated for this design so enter E in the **Enter Rod Readings or Elevations (R or E)** box.

Complete the Station column by placing the cursor in the first cell and then using the enter key to fill in the remaining cells. The program automatically increments each station by the distance set in the default value. This will work for all stations except (13+20) since it is not an even increment.

After completing the Station column, fill the first cell in the Elevation, Furrow Length, Distance Between Holes (watering every other furrow) and Pipe Diameter columns. All of these values are known except the Pipe Diameter. Until experience is gained in designing systems, the user may have difficulty determining a pipe size, refer to Rule 1 in the **General Rules of Thumb** for assistance. The crown profile grade and length can cause exceptions to this general rule. For this example, use 15" 7 mil pipe as a starting pipe size with the well flow being 1500 gpm. Since all of these values are constant throughout the field, only the first cell in each column needs to be filled out and the computer will interpolate the rest.

Next, fill in the hole diameter for each station. For right now, we will use 5/8 for the Hole Diameter. The easiest method to accomplish this is to place the cursor on the first cell in the Hole Diameter column, and continue to press Enter to repeat the size for each station displayed in the crown profile Station column. This information must be filled out for all stations. **NOTE:** The initial hole size entered in this column is not important because the Computer Hole Selection design feature will be used to determine the hole sizes.

To fill the rest of the columns on the Data Input Grid, click on the Interpolate Furrow Length and Calculate Elevations button or select a design option. All blank cells (except Hole Size) are automatically filled when a design option is selected. The Input Screen should appear similar to (fig. 1.3).

**PHAUCET**

File Edit Design Type of Pipe Soils and Furrow Recommendation Editor Help

Name:  GPM:  Location:

Date:  Target Head (ft):  Enter Rod Readings or Elevations (R or E):

Station (feet)	Elevation (feet)	Furrow Length (feet)	Distance Between Holes (feet)	Pipe Diameter (inches)	Hole Diameter (fractions)	No. of Holes at Each Watered Furrow	Mil (7, 10, etc.)	Planted Furrow Width Between Watered Furrows (5.0', 6.0', 6.3', etc.)
0	10.00	1320	6.33	15.00	5/8	1	10	6.33
100	10.00	1320	6.33	15.00	5/8	1	10	6.33
200	10.00	1320	6.33	15.00	5/8	1	10	6.33
300	10.00	1320	6.33	15.00	5/8	1	10	6.33
400	10.00	1320	6.33	15.00	5/8	1	10	6.33
500	10.00	1320	6.33	15.00	5/8	1	10	6.33
600	10.00	1320	6.33	15.00	5/8	1	10	6.33
700	10.00	1320	6.33	15.00	5/8	1	10	6.33
800	10.00	1320	6.33	15.00	5/8	1	10	6.33
900	10.00	1320	6.33	15.00	5/8	1	10	6.33
1000	10.00	1320	6.33	15.00	5/8	1	10	6.33
1100	10.00	1320	6.33	15.00	5/8	1	10	6.33
1200	10.00	1320	6.33	15.00	5/8	1	10	6.33
1300	10.00	1320	6.33	15.00	5/8	1	10	6.33
1320	10.00	1320	6.33	15.00	5/8	1	10	6.33

Figure 1.3 – Example 1 Input Screen

**STEP 2:** Click on the Computer Hole Selection option from the Design menu. The screen should be similar to (fig. 1.4).

PHAUCET Computer Selected Hole Design

File Edit Design Type of Pipe Input Screen Crown Profile Soils and Furrow Recommendation Editor Help

Total Acres = 39.9

Name: \_\_\_\_\_ GPM: 1500 Location: \_\_\_\_\_

Date: 03-30-2014 Target Head (ft): 1.0 Enter Rod Readings or Elevations (R or E): E

Average Furrow Flow = 7.2

Distribution Uniformity = 94.9

Station (feet)	Hole Dia (Inches)	Hole Number	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Elevation (feet)	Number of Holes per Furrow	MI	Pipe Diameter	Planted Width Between Watered Furrows
0	11/16	1	7.67	1.62	1.07	1320	10.00	1	10	15	6.33
6	11/16	2	7.65	1.61	1.07	1320	10.00	1	10	15	6.33
13	11/16	3	7.62	1.60	1.06	1320	10.00	1	10	15	6.33
19	11/16	4	7.60	1.59	1.06	1320	10.00	1	10	15	6.33
25	11/16	5	7.57	1.58	1.06	1320	10.00	1	10	15	6.33
32	11/16	6	7.55	1.57	1.05	1320	10.00	1	10	15	6.33
38	11/16	7	7.53	1.56	1.05	1320	10.00	1	10	15	6.33
44	11/16	8	7.51	1.55	1.05	1320	10.00	1	10	15	6.33
51	11/16	9	7.48	1.54	1.04	1320	10.00	1	10	15	6.33
57	11/16	10	7.46	1.53	1.04	1320	10.00	1	10	15	6.33
63	11/16	11	7.44	1.52	1.04	1320	10.00	1	10	15	6.33
70	11/16	12	7.41	1.51	1.03	1320	10.00	1	10	15	6.33
76	11/16	13	7.39	1.50	1.03	1320	10.00	1	10	15	6.33
82	11/16	14	7.37	1.49	1.03	1320	10.00	1	10	15	6.33
89	11/16	15	7.35	1.48	1.02	1320	10.00	1	10	15	6.33
95	11/16	16	7.33	1.48	1.02	1320	10.00	1	10	15	6.33
101	11/16	17	7.30	1.47	1.02	1320	10.00	1	10	15	6.33
108	11/16	18	7.28	1.46	1.01	1320	10.00	1	10	15	6.33
114	11/16	19	7.26	1.45	1.01	1320	10.00	1	10	15	6.33
120	11/16	20	7.24	1.44	1.01	1320	10.00	1	10	15	6.33
127	11/16	21	7.22	1.43	1.01	1320	10.00	1	10	15	6.33
133	11/16	22	7.20	1.42	1.01	1320	10.00	1	10	15	6.33
139	11/16	23	7.18	1.42	1.01	1320	10.00	1	10	15	6.33
146	11/16	24	7.16	1.41	1.01	1320	10.00	1	10	15	6.33
152	11/16	25	7.14	1.40	1.01	1320	10.00	1	10	15	6.33

Re-Calculate Complete Design

Active Design

Stations 0 - 241 247 - 1317

Hole Diameter 11/16 3/4

Number of Holes 39 170

Highest Head 1.62

Max Head Station 0

Lowest Head 30

Low Head Station 1317

Max. Furrow Flow 8.15

Min. Furrow Flow 6.80

Calculated GPM 1500

Figure 1.4 – Example 1 CSH Design Screen

Print out the Hole Summary from the File drop-down menu and then click on Window in the menu bar and select Information and Survey.

Once you are back to the Data Input Grid, use the Insert Line edit feature to enter design data from the CSH printout. One helpful hint when inserting a row; if you are going to insert station (5+35), click on station (6+00) then choose Edit and Insert Row. Notice that the row you inserted is above station (6+00). Stations (5+35) and (5+36) mark the location where a change in hole size occurs.

To change the hole sizes based on the CSH printout use the + and - keys. Position the cursor anywhere on the line to be adjusted and press (+) to increase or (-) to decrease the size as needed. The 5/8 inch hole size on the CSH printout can be ignored since it is used for only a few furrows. The designer should adjust CSH recommendation as needed to develop “practical” systems. This often increases producer acceptance of “new” technology.

Click on Interpolate to complete the revised Input Screen (fig. 1.5) and compare with the CSH printout.



**PHAUCET**

File Edit Design Type of Pipe Soils and Furrow Recommendation Editor Help

Name:  GPM: 1500 Location:

Date: 03-30-2014 Target Head (ft): 1.0 Enter Rod Readings or Elevations (R or E): E

Station (feet)	Elevations (feet)	Furrow Length (feet)	Distance Between Holes (feet)	Pipe Diameter (inches)	Hole Diameter (fractions)	No. of Holes at Each Watered Furrow	Mil (7,10, etc.)	Planted Furrow Width Between Watered Furrows (5.0', 6.0', 6.3', etc.)
0	10.00	1320	6.33	15.00	5/8	1	10	6.33
100	10.00	1320	6.33	15.00	5/8	1	10	6.33
200	10.00	1320	6.33	15.00	5/8	1	10	6.33
300	10.00	1320	6.33	15.00	5/8	1	10	6.33
400	10.00	1320	6.33	15.00	5/8	1	10	6.33
500	10.00	1320	6.33	15.00	5/8	1	10	6.33
535	10.00	1320	6.33	15.00	5/8	1	10	6.33
536	10.00	1320	6.33	15.00	5/8	1	10	6.33
600	10.00	1320	6.33	15.00	5/8	1	10	6.33
700	10.00	1320	6.33	15.00	5/8	1	10	6.33
800	10.00	1320	6.33	15.00	5/8	1	10	6.33
900	10.00	1320	6.33	15.00	5/8	1	10	6.33
1000	10.00	1320	6.33	15.00	5/8	1	10	6.33
1100	10.00	1320	6.33	15.00	5/8	1	10	6.33
1200	10.00	1320	6.33	15.00	5/8	1	10	6.33
1300	10.00	1320	6.33	15.00	5/8	1	10	6.33
1320	10.00	1320	6.33	15.00	5/8	1	10	6.33

Figure 1.5 – Example 1 Revised Input Screen

Click on the Planned Field Design option in the Design menu to recalculate the design (fig. 1.6).

**PHAUCET Computer Selected Hole Design**

File Edit Design Type of Pipe Input Screen Crown Profile Soils and Furrow Recommendation Editor Help

Total Acres = 39.9

Name:  GPM: 1500 Location:

Date: 03-30-2014 Target Head (ft): 1.0 Enter Rod Readings or Elevations (R or E): E

**Distribution Uniformity = 94.9**

Station (feet)	Hole Dia (Inches)	Hole Number	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Elevation (feet)	Number of Holes per Furrow	Mil	Pipe Diameter	Planted Width Between Watered Furrows
0	11/16	1	7.67	1.62	1.07	1320	10.00	1	10	15	6.33
6	11/16	2	7.65	1.61	1.07	1320	10.00	1	10	15	6.33
13	11/16	3	7.62	1.60	1.06	1320	10.00	1	10	15	6.33
19	11/16	4	7.60	1.59	1.06	1320	10.00	1	10	15	6.33
25	11/16	5	7.57	1.58	1.06	1320	10.00	1	10	15	6.33
32	11/16	6	7.55	1.57	1.06	1320	10.00	1	10	15	6.33
38	11/16	7	7.53	1.56	1.06	1320	10.00	1	10	15	6.33
44	11/16	8	7.51	1.55	1.06	1320	10.00	1	10	15	6.33
51	11/16	9	7.48	1.54	1.06	1320	10.00	1	10	15	6.33
57	11/16	10	7.46	1.53	1.06	1320	10.00	1	10	15	6.33
63	11/16	11	7.44	1.52	1.06	1320	10.00	1	10	15	6.33
70	11/16	12	7.41	1.51	1.06	1320	10.00	1	10	15	6.33
76	11/16	13	7.39	1.50	1.06	1320	10.00	1	10	15	6.33
82	11/16	14	7.37	1.49	1.06	1320	10.00	1	10	15	6.33
89	11/16	15	7.35	1.48	1.06	1320	10.00	1	10	15	6.33
95	11/16	16	7.33	1.48	1.06	1320	10.00	1	10	15	6.33
101	11/16	17	7.30	1.47	1.06	1320	10.00	1	10	15	6.33
108	11/16	18	7.28	1.46	1.06	1320	10.00	1	10	15	6.33
114	11/16	19	7.26	1.45	1.06	1320	10.00	1	10	15	6.33
120	11/16	20	7.24	1.44	1.06	1320	10.00	1	10	15	6.33
127	11/16	21	7.22	1.43	1.06	1320	10.00	1	10	15	6.33
133	11/16	22	7.20	1.42	1.06	1320	10.00	1	10	15	6.33
139	11/16	23	7.18	1.42	1.06	1320	10.00	1	10	15	6.33
146	11/16	24	7.16	1.41	1.06	1320	10.00	1	10	15	6.33
152	11/16	25	7.14	1.40	1.06	1320	10.00	1	10	15	6.33

**Re-Calculate Complete Design**

**Active Design**

Stations 0 - 241  
247 - 1317

Hole Diameter 11/16  
3/4

Number of Holes 39  
170

Highest Head 1.62

Max Head Station 0

Lowest Head .90

Low Head Station 1317

Max Furrow Flow 8.15

Min Furrow Flow 6.80

Calculated GPM 1500

Figure 1.6 – Example 1 Planned Field Design

Distribution Uniformity is 94.7% (see General Rules of Thumb #8) and the highest head pressure in the system is 1.7 ft. This system alternative provides high distribution uniformity at pressure considered safe for 7 mil pipe (see General Rules of Thumb #2).

This system delivers about 7 gpm per watered furrow which is adequate for most silt loam soils (see General Rules of Thumb #7). The producer can locate the change to a 3/4 inch hole by counting furrows or measurement.

**STEP 3:** To save the design with a specific name, choose the Save As option in the File menu before printing the Summary Report and the Hole Size Summary. Use a file name that clearly identifies the system. The file name is displayed at the upper left corner of the print out.

**STEP 4:** The PHAUCET design is more clearly understood when presented as a plan view of the field that describes all system details (fig. 1.7). This plan view can be created in AutoCAD or other drawing software. The number and location of each hole size can be calculated from the Summary or Complete Reports or simply print out the Hole Size Summary.

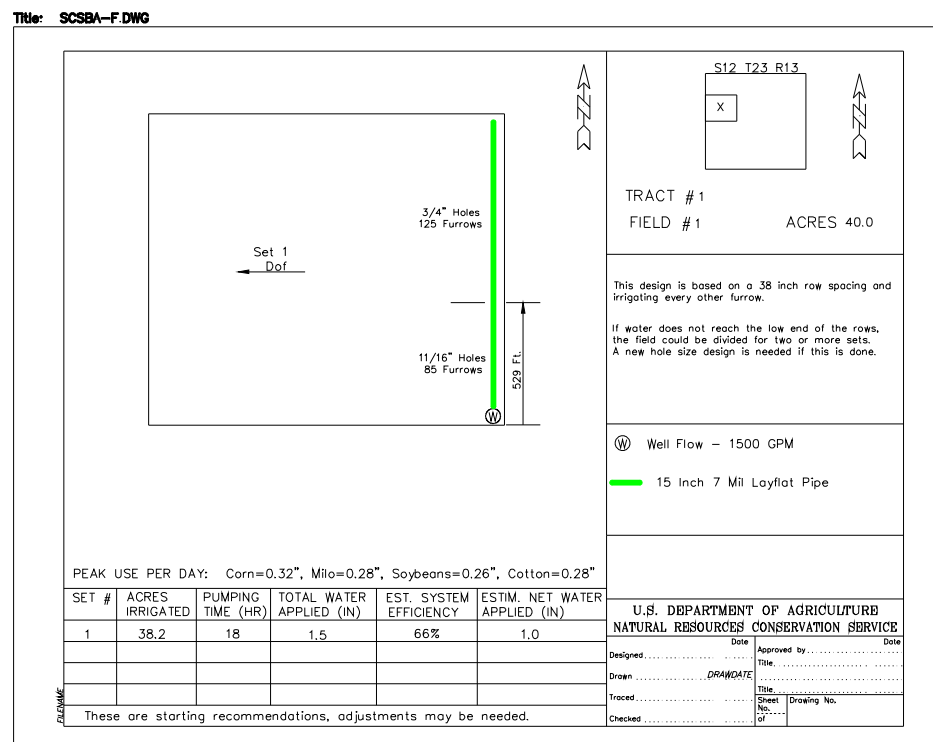


Figure 1.7 – Example 1 Plan View

## Example 2: Design with Diagonal Crown

The crown on this field is straight but runs diagonally across the crop rows. The irrigated furrow spacing is increased due to this angle. The spacing should be recorded at the time the crown survey is completed (fig. 2.1).

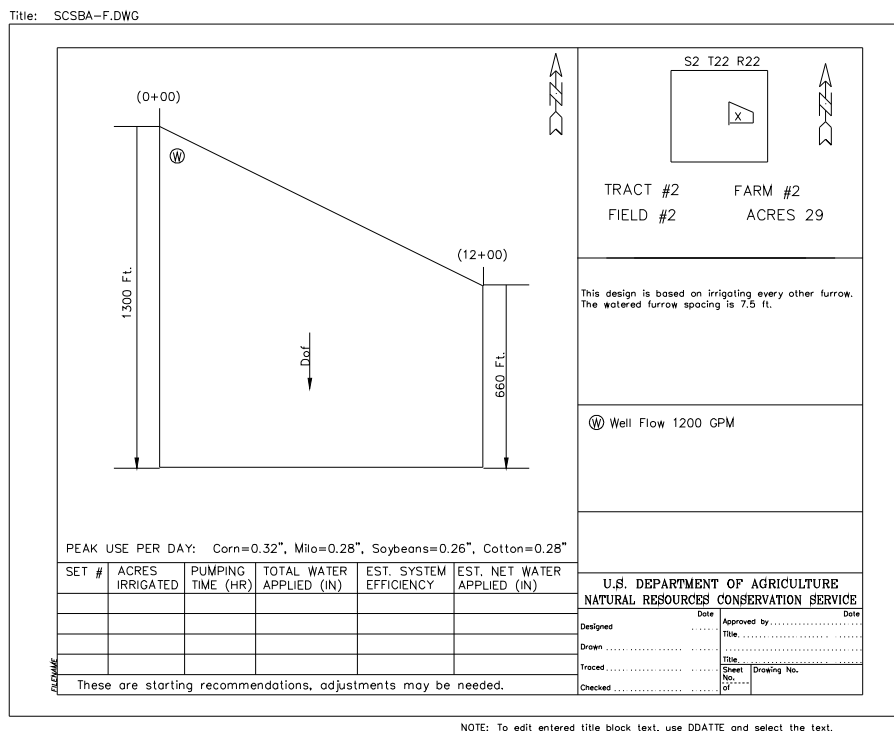


Figure 2.1 – Example 2 Field Dimensions

Station	Rod	Elevation	Comments
0+00	6.00	10.00	First Watered Furrow
1+00	6.00	10.00	Pipe is diagonal to the rows.
2+00	6.00	10.00	Watered Furrow spacing is 7.5 ft.
3+00	6.00	10.00	
4+00	6.05	9.95	
5+00	6.10	9.90	
6+00	6.15	9.85	
7+00	6.20	9.80	
8+00	6.35	9.65	
9+00	6.50	9.50	
10+00	6.33	9.67	
11+00	6.16	9.84	
12+00	6.00	10.00	Last Watered Furrow

Figure 2.2 - Example 2 Crown Profile Survey

**STEP 1:** The survey rod readings were converted to elevations. Enter the Information and Design data then the Station and Elevation data on the Data Input Grid. You know that at the well the furrow length is 1300 ft. and at the last irrigated row the length is 660 ft. Therefore, you only need to enter 1300 in the Furrow Length column at station (0+00) and 660 at station (12+00). (**NOTE:** Once you have finished entering the data in the other columns, the program will automatically fill in the rest of the furrow lengths). Fill in the data for Distance Between Holes, Pipe Diameter (see Rule of Thumb 1) and Hole Diameter. Remember that the value in each column can be repeated by using the Enter key. When finished, click on Interpolate Furrow Length and Calculate Elevations (fig. 2.3).

**PHAUCET Computer Selected Hole Design**

File Edit Design Type of Pipe Crown Profile Soils and Furrow Recommendation Editor Help

Total Acres = 39.9

Name:  GPM: 1200 Location:

Date: 03-30-2014 Target Head (ft): 2 Enter Rod Readings or Elevations (R or E): E

Average Furrow Flow = 7.2

Interpolate Furrow Length and Calculate Elevations

Station (feet)	Elevation (feet)	Furrow Length (feet)	Distance Between Holes (feet)	Pipe Diameter (inches)	Hole Diameter (fractions)	No. of Holes at Each Watered Furrow	Mil (7,10,etc.)	Planted Furrow Width Between Watered Furrows(5.0', 6.0', 6.3', etc.)
0	10.00	1300	7.50	12.00	5/8	1	10	3.17
100	10.00	1247	7.50	12.00	5/8	1	10	3.17
200	10.00	1194	7.50	12.00	5/8	1	10	3.17
300	10.00	1141	7.50	12.00	5/8	1	10	3.17
400	9.95	1088	7.50	12.00	5/8	1	10	3.17
500	9.90	1035	7.50	12.00	5/8	1	10	3.17
600	9.85	982	7.50	12.00	5/8	1	10	3.17
700	9.80	929	7.50	12.00	5/8	1	10	3.17
800	9.65	876	7.50	12.00	5/8	1	10	3.17
900	9.50	823	7.50	12.00	5/8	1	10	3.17
1000	9.67	770	7.50	12.00	5/8	1	10	3.17
1100	9.84	717	7.50	12.00	5/8	1	10	3.17
1200	10.00	660	7.50	12.00	5/8	1	10	3.17

Figure 2.3 – Example 2 Data Input Grid

**STEP 2:** Select Computer Hole Selection design from the Design menu (fig. 2.4).

**PHAU CET Computer Selected Hole Design**

File Edit Design Type of Pipe Input Screen Crown Profile Soils and Furrow Recommendation Editor Help

Total Acres = 27.1

Name: \_\_\_\_\_ GPM: 1200 Location: \_\_\_\_\_

Date: 03-31-2014 Target Head (ft): 1 Enter Rod Readings or Elevations (R or E): E

Kobel C Recommended Furrow Flow = 20 GPM Average Furrow Flow = 7.5

Distribution Uniformity = 93.3

Station (Feet)	Hole Dia. (Inches)	Hole Number	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Elevation (feet)	Number of Holes per Furrow	ML	Pipe Diameter	Planted Width Between Watered Furrows
0	3/4	1	9.34	1.32	1.01	1300	10.00	1	10	12	7.50
105	3/4	15	9.14	1.62	.97	1244	10.00	1	10	12	7.50
203	3/4	28	8.50	1.40	.94	1193	10.00	1	10	12	7.50
255	13/16	35	9.60	1.30	1.09	1165	10.00	1	10	12	7.50
300	13/16	41	9.32	1.22	1.08	1141	10.00	1	10	12	7.50
308	13/16	42	9.29	1.22	1.08	1137	10.00	1	10	12	7.50
345	3/4	47	7.79	1.18	.92	1117	9.98	1	10	12	7.50
405	3/4	55	7.63	1.13	.93	1085	9.95	1	10	12	7.50
503	3/4	68	7.44	1.07	.95	1034	9.90	1	10	12	7.50
600	3/4	81	7.31	1.04	.98	982	9.86	1	10	12	7.50
608	3/4	82	7.31	1.04	.98	978	9.86	1	10	12	7.50
705	3/4	95	7.34	1.04	1.04	926	9.79	1	10	12	7.50
743	11/16	100	6.28	1.08	.91	907	9.74	1	10	12	7.50
803	11/16	108	6.48	1.15	.98	875	9.65	1	10	12	7.50
900	11/16	121	6.82	1.28	1.09	823	9.50	1	10	12	7.50
908	11/16	122	6.78	1.26	1.09	819	9.51	1	10	12	7.50
1005	11/16	135	6.30	1.09	1.08	767	9.68	1	10	12	7.50
1103	11/16	148	5.79	.92	1.06	716	9.84	1	10	12	7.50
1200	11/16	161	5.27	.76	1.05	660	10.00	1	10	12	7.50

Re-Calculate Complete Design

Gross Applied (in.)	Hours	Days
0.5	5.1	.2
1.0	10.2	.4
1.5	15.3	.6
2.0	20.4	.9
3.0	30.7	1.3

Active Design

Stations	Hole Diameter	Number of Holes
0 - 248	3/4	34
255 - 338	13/16	12
345 - 735	3/4	53
743 - 1200	11/16	62

Highest Head 1.92

Max Head Station 0

Lowest Head .76

Low Head Station 1200

Max. Furrow Flow 9.94

Min. Furrow Flow 5.27

Calculated GPM 1200

Figure 2.4 – Example 2 CSH Design

Print out the Summary design or the Hole Size Summary. Toggle back to the Data Input Grid by using the Window option on the menu bar. Enter this data on the Data Input Grid. The twelve 13/16" holes at station (2+55) through (3+08) could be changed to 3/4" without seriously reducing system performance (fig. 2.5). To change the Hole Diameter, press the + or – key. Notice that the first and last occurrence of each hole size is listed on the Data Input Grid. All crown profile stations must display a hole size or the program can not calculate a design. For example, on the CSH printout, the hole diameter changes between station (7+35) and (7+36).

**NOTE:** the actual change in hole diameter will occur at the next watered furrow (in this case 7.5 ft. past the (7+35) station). Insert the (7+36) station and enter 11/16" in the hole diameter column.

**PHAUCET**

File Edit Design Type of Pipe Soils and Furrow Recommendation Editor Help

Name:  GPM:  Location:

Date:  Target Head (ft):  Enter Rod Readings or Elevations (R or E):

Acadia Sil  Recommended Furrow Flow = 10 GPM

Interpolate Furrow Length and Calculate Elevations

Station (feet)	Elevations (feet)	Furrow Length (feet)	Distance Between Holes (feet)	Pipe Diameter (inches)	Hole Diameter (fractions)	No. of Holes at Each Watered Furrow	Mil (7,10,etc.)	Planted Furrow Width Between Watered Furrows(5.0', 6.0', 6.3', etc.)
0	10.00	1300	7.50	12.00	3/4	1	10	7.50
100	10.00	1247	7.50	12.00	3/4	1	10	7.50
200	10.00	1194	7.50	12.00	3/4	1	10	7.50
300	10.00	1141	7.50	12.00	3/4	1	10	7.50
400	9.95	1088	7.50	12.00	3/4	1	10	7.50
500	9.90	1035	7.50	12.00	3/4	1	10	7.50
600	9.86	982	7.50	12.00	3/4	1	10	7.50
700	9.80	929	7.50	12.00	3/4	1	10	7.50
735	9.75	910	7.50	12.00	3/4	1	10	7.50
736	9.75	909	7.50	12.00	11/16	1	10	7.50
800	9.65	876	7.50	12.00	11/16	1	10	7.50
900	9.50	823	7.50	12.00	11/16	1	10	7.50
1000	9.67	770	7.50	12.00	11/16	1	10	7.50
1100	9.84	717	7.50	12.00	11/16	1	10	7.50
1200	10.00	660	7.50	12.00	11/16	1	10	7.50

Figure 2.5 – Example 2 Revised Data Input Grid

Recalculate as a Planned Field Design (fig. 2.6). Notice that the first 11/16" hole occurs at the (7+43) rather than (7+36) as entered on the Input Grid. The reason for this is the 7.5 ft. watered furrow spacing.

**PHAUCET Planned Design**

File Edit Design Type of Pipe Input Screen Crown Profile Soils and Furrow Recommendation Editor Help

Total Acres = 27.1

Name: \_\_\_\_\_ GPM: 1200 Location: \_\_\_\_\_

Date: 03-31-2014 Target Head (R): 1 Enter Rod Readings or Elevations (R or E): E

Acadia Sil Recommended Furrow Flow = 10 GPM Average Furrow Flow = 7.5

Distribution Uniformity = 94

Station (Feet)	Hole Dia (Inches)	Hole Number	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Elevation (feet)	Number of Holes per Furrow	Mil	Pipe Diameter	Planted Width Between Watered Furrows
0	3/4	1	10.04	1.95	1.02	1300	10.00	1	10	12	7.50
8	3/4	2	9.98	1.93	1.01	1296	10.00	1	10	12	7.50
15	3/4	3	9.92	1.91	1.01	1292	10.00	1	10	12	7.50
23	3/4	4	9.86	1.89	1.01	1288	10.00	1	10	12	7.50
30	3/4	5	9.80	1.86	1.01	1284	10.00	1	10	12	7.50
38	3/4	6	9.74	1.84	1.00	1280	10.00	1	10	12	7.50
45	3/4	7	9.68	1.82	1.00	1276	10.00	1	10	12	7.50
53	3/4	8	9.63	1.80	1.00	1272	10.00	1	10	12	7.50
60	3/4	9	9.57	1.78	.99	1268	10.00	1	10	12	7.50
68	3/4	10	9.52	1.76	.99	1264	10.00	1	10	12	7.50
75	3/4	11	9.46	1.74	.99	1260	10.00	1	10	12	7.50
83	3/4	12	9.41	1.72	.99	1257	10.00	1	10	12	7.50
90	3/4	13	9.35	1.70	.99	1252	10.00	1	10	12	7.50
98	3/4	14	9.30	1.68	.99	1248	10.00	1	10	12	7.50
105	3/4	15	9.25	1.66	.99	1244	10.00	1	10	12	7.50
113	3/4	16	9.20	1.64	.99	1241	10.00	1	10	12	7.50
120	3/4	17	9.14	1.62	.97	1236	10.00	1	10	12	7.50
128	3/4	18	9.09	1.60	.97	1232	10.00	1	10	12	7.50
135	3/4	19	9.04	1.59	.97	1228	10.00	1	10	12	7.50
143	3/4	20	8.99	1.57	.97	1225	10.00	1	10	12	7.50
150	3/4	21	8.94	1.55	.96	1221	10.00	1	10	12	7.50
158	3/4	22	8.89	1.54	.96	1216	10.00	1	10	12	7.50
165	3/4	23	8.85	1.52	.96	1213	10.00	1	10	12	7.50
173	3/4	24	8.80	1.50	.96	1209	10.00	1	10	12	7.50
180	3/4	25	8.75	1.49	.96	1205	10.00	1	10	12	7.50

ReCalculate Complete Design

Active Design

Stations 0 - 735 743 - 1200

Hole Diameter 3/4 11/16

Number of Holes 99 62

Highest Head 1.95

Max Head Station 0

Lowest Head .79

Low Head Station 1200

Max Furrow Flow 10.04

Min Furrow Flow 5.36

Calculated GPM 1200

Figure 2.6 – Example 2 Planned Field Design

This design provides good distribution uniformity and head is considered safe for 7 mil 12 inch layflat pipe (see Rule of Thumb 2 and 8). The furrow flow rate is adequate for a silt loam or loam soil (see Rule of Thumb 7).

**STEP 3:** Save the design, then print out the Summary page and the hole size summary. If you would like to evaluate other design options, return to the Input Data Grid and adjust as needed. Check pipe pressure after each design calculation.

To determine if a Constant Slope Design (CSD) or Dual Slope Design (DSD) is practical for this field, use one hole size for the entire delivery pipe and select CSD or DSD from the design menu. If distribution uniformity or head pressure is not acceptable, try a different hole size. If the Crown Elevation Difference is greater than 1.5 ft. it may be difficult for the producer to maintain the design grade. If the program is unable to calculate a CSD, an error message will be displayed. Click on OK and adjust the hole and/or pipe size in the Data Input Grid. Recalculate as a CSD.

The recommended slope value is expressed as an amount per 100 ft. For example: If the recommended slope is 0.1 per 100 ft. multiply this number by the number of 100 ft. stations in the crown (1200 ft. crown would be 12). Then subtract this amount from the (0+00) station elevation ( $10.0 - 1.2 = 8.8$ ). When the correct hole size is entered for all watered furrows, recalculate as a Planned Field Design and review head pressure. Save the design using a different name than the first design or the file will be over written.

**STEP 4:** See (fig. 2.7) for an example plan view of the field.

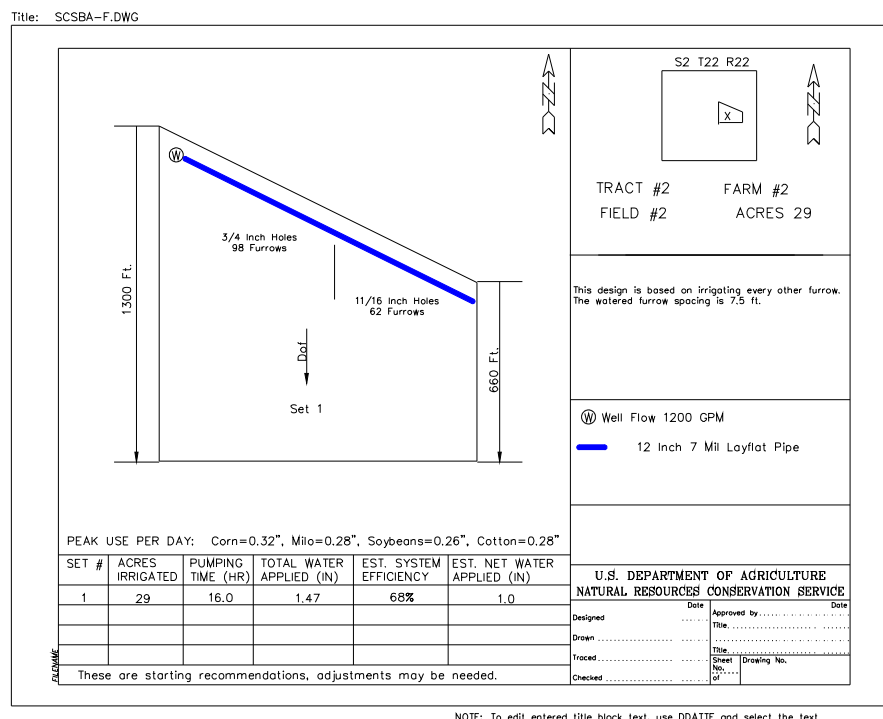


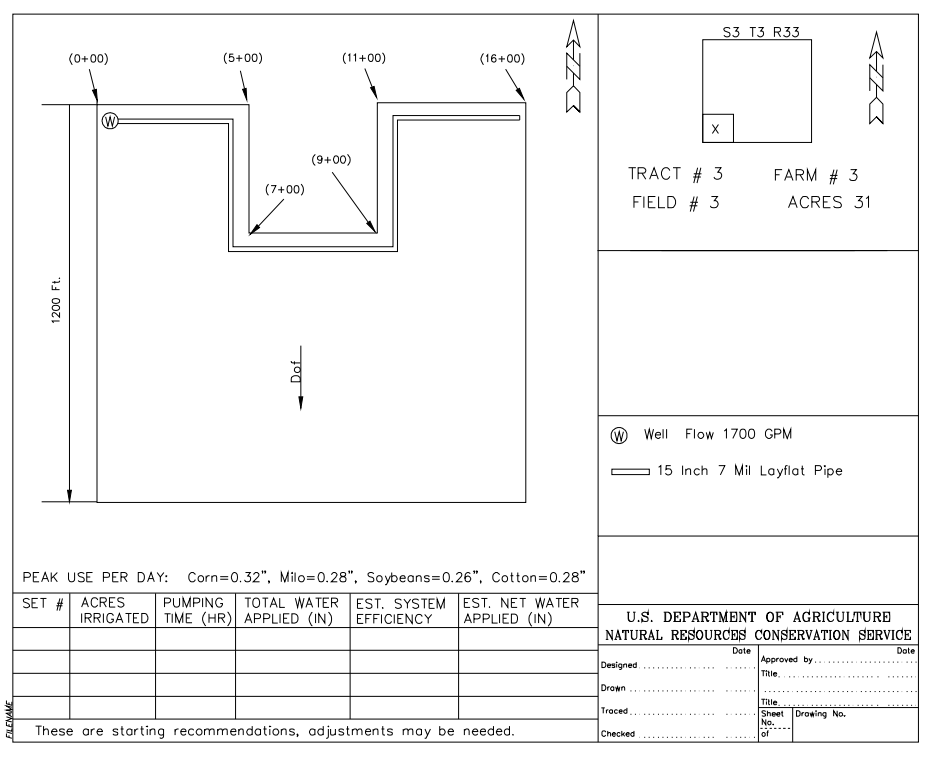
Figure 2.7 – Example 2 Plan View



### Example 3: Design with Intermittent Watered Furrows

This field has loam soils and intermittent watered furrows (fig. 32). The delivery pipe begins at the (0+00) station and runs east. The last watered furrow in the first reach occurs at station (5+00). The pipeline turns south (no irrigated furrows) for 200 feet then turns east for two hundred feet. The second reach of irrigated furrows begins at station (7+00) and ends at station (9+00). The pipe turns north (non-irrigated furrows) and then turns east again at station (11+00). The third reach of irrigated furrows begins at station (11+00) and ends at the north east corner of the field at station (16+00). The crown profile survey (fig. 3.1) must include a similar description or the design will not be accurate.

Title: SCSBA-F.DWG



NOTE: To edit entered title block text, use DDATE and select the text.

Figure 3.1 - Example 3 Field Dimensions

Station	Rod	Elevation	Comments
0+00	5.60	10.00	First irrigated furrow
1+00	5.80	9.80	Row spacing is 38 inches, alt. Furrows irrigated
2+00	5.80	9.80	irrigated
3+00	5.80	9.80	
4+00	5.70	9.90	
5+00	5.60	10.00	Last irrigated furrow turn south
6+00	5.80	9.80	
7+00	6.00	9.60	First irrigated row, turn east
8+00	6.00	9.60	
9+00	5.90	9.70	Last irrigated row, turn north
10+00	5.80	9.80	
11+00	5.80	9.80	First irrigated row, turn east
12+00	5.80	9.80	
13+00	5.80	9.80	
14+00	6.00	9.60	
15+00	6.00	9.60	
16+00	6.00	9.60	Last irrigated row

Figure 3.2 – Example 3 Crown Profile Survey

This field has four reaches in the delivery pipe. The first and last profile stations where any change in a field feature occurs must be described or the design will not be accurate.

If the layflat pipe is to be installed diagonal to the irrigated rows for more than 50 ft., the watered furrow spacing increases. This change in spacing should be measured and recorded on the survey. If the survey included more than one height of instrument, elevations should be used for the design or the rod readings must be adjusted relative to the first H.I.

**NOTE:** This system will require more than one roll of layflat pipe due to the crown length. If a different type of pipe (size or mil) will be used to finish the field, this must be entered on the Data Input Grid or the pressure calculations will not be accurate. It is not unusual for a producer to finish a field with a smaller, less expensive type of layflat pipe.

**STEP 1:** Type in the field data. To mark the change from irrigated to non-irrigated two stations must be entered. For example, the first reach of the delivery pipe ends at station (5+00), therefore station (5+01) is the start of the non-irrigating section of the pipe. Both of these stations must be put into the grid to show that change. When finished, the Data Input Grid should look like (fig. 3.3).

**PHAUCET**

File Edit Design Type of Pipe Soils and Furrow Recommendation Editor Help

Name:  GPM:  Location:

Date:  Target Head (ft):  Enter Rod Readings or Elevations (R or E):

Station (feet)	Elevation (feet)	Furrow Length (feet)	Distance Between Holes (feet)	Pipe Diameter (inches)	Hole Diameter (fractions)	No. of Holes at Each Watered Furrow	Mil (7,10,etc.)	Planted Furrow Width Between Furrows(5.0', 6.0', 6.3', etc.)
0	10.00	1200	6.30	15.00	5/8	1	10	3.176.30
100	9.80	1200	6.30	15.00	5/8	1	10	3.176.30
200	9.80	1200	6.30	15.00	5/8	1	10	3.176.30
300	9.80	1200	6.30	15.00	5/8	1	10	3.176.30
400	9.90	1200	6.30	15.00	5/8	1	10	3.176.30
500	10.00	1200	6.30	15.00	5/8	1	10	3.176.30
501	10.00			15.00			10	3.176.30
600	9.80			15.00			10	3.176.30
700	9.60			15.00			10	3.176.30
701	9.60	1000	6.30	15.00	5/8	1	10	3.176.30
800	9.60	1000	6.30	15.00	5/8	1	10	3.176.30
900	9.70	1000	6.30	15.00	5/8	1	10	3.176.30
901	9.70			15.00			10	3.176.30
1000	9.80			15.00			10	3.176.30
1100	9.80			15.00			10	3.176.30
1101	9.80	1200	6.30	15.00	5/8	1	10	3.176.30
1200	9.80	1200	6.30	15.00	5/8	1	10	3.176.30
1300	9.80	1200	6.30	15.00	5/8	1	10	3.176.30
1400	9.60	1200	6.30	15.00	5/8	1	10	3.176.30
1500	9.60	1200	6.30	15.00	5/8	1	10	3.176.30
1600	9.60	1200	6.30	15.00	5/8	1	10	6.30

Figure 3.3 – Example 3 Input Screen

**STEP 2:** Select Computer Hole Selection from the design menu. Increase the target head to 1.4 in order to reduce the number of recommended hole sizes then hit recalculate (fig. 3.4). When using CSH, the Target Head should be adjusted up or down to determine the most practical design. Check Highest Head after each design calculation to make sure it is within the acceptable range for the mil thickness being used (Rule of Thumb 2).

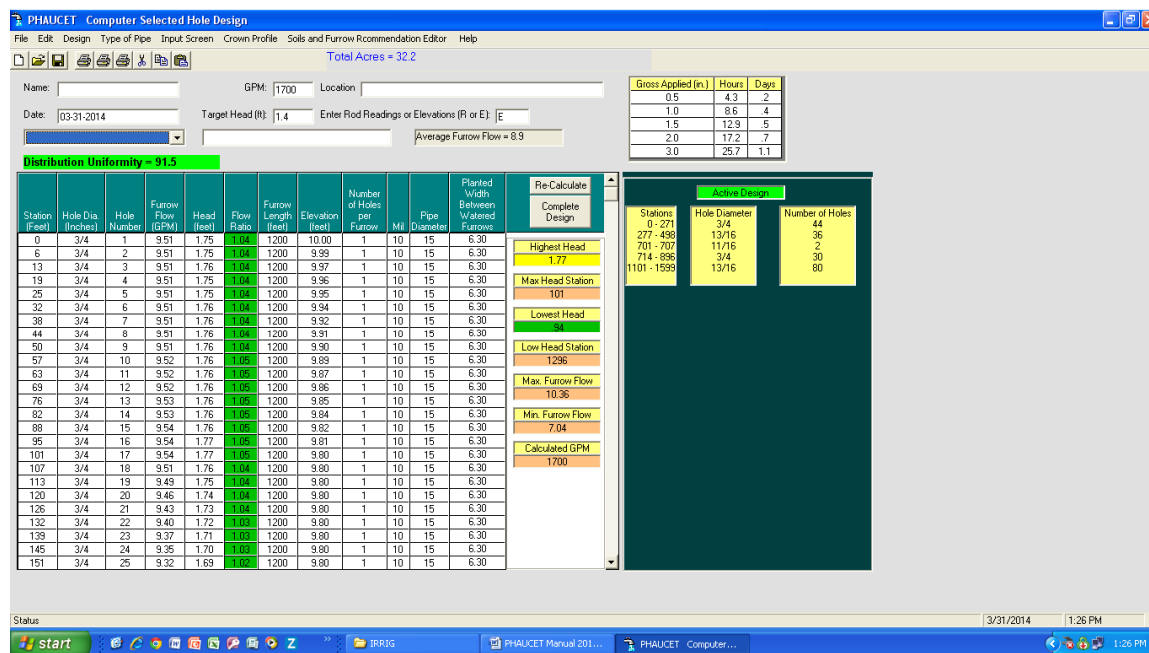


Figure 3.4 – Example 3 CSH Design

The 3/4 inch hole described at station (8+90) and (8+96) should be ignored since it is for a low number of furrows. The 13/16 inch hole at station (11+01) continued to the end of the pipeline (station 16+00). Print out the Summary Design and/or the Hole Size Summary. Toggle back to the Data Input Grid and enter the data. Recalculate as a Planned Field Design (fig. 3.5).

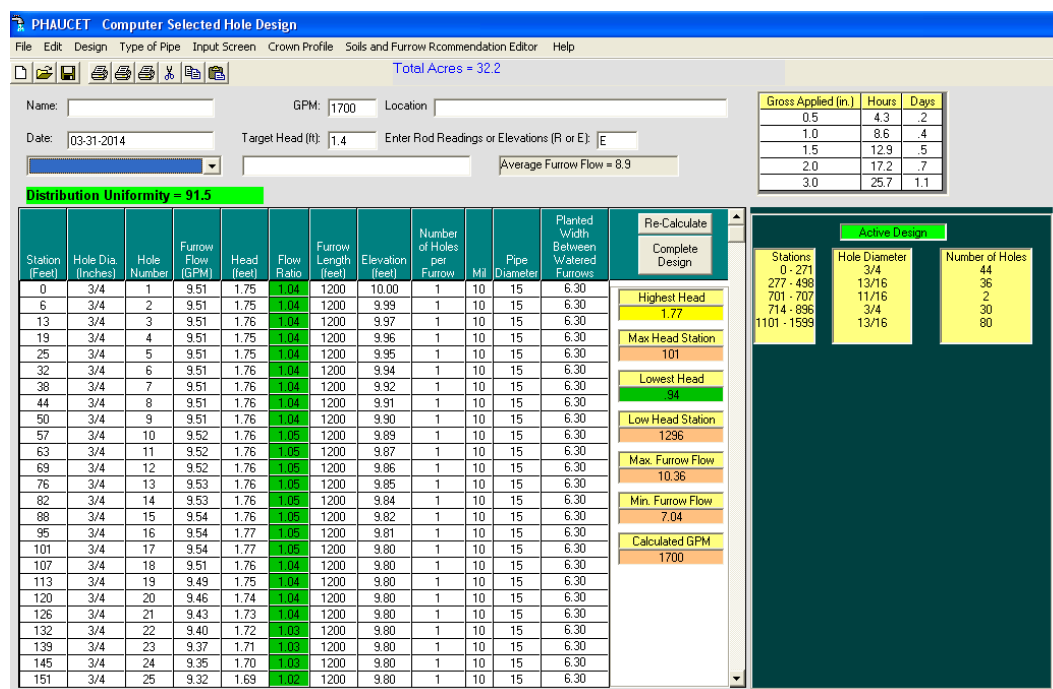


Figure 3.5 – Example 3 Planned Design

This is a portion of the Summary printout. The 3/4 inch holes began at station (0+00) and the 13/16 inch holes shown at station (11+01) continued to the end of the system. This plan provides high distribution uniformity and the head is considered safe for 7 mil layflat pipe (Rule of Thumb 8 and 2).

**STEP 3:** Save the file and print the Design Summary and the Hole Size Summary.

**STEP 4:** A design plan view will help avoid confusion when installing this type of system (fig. 3.6).

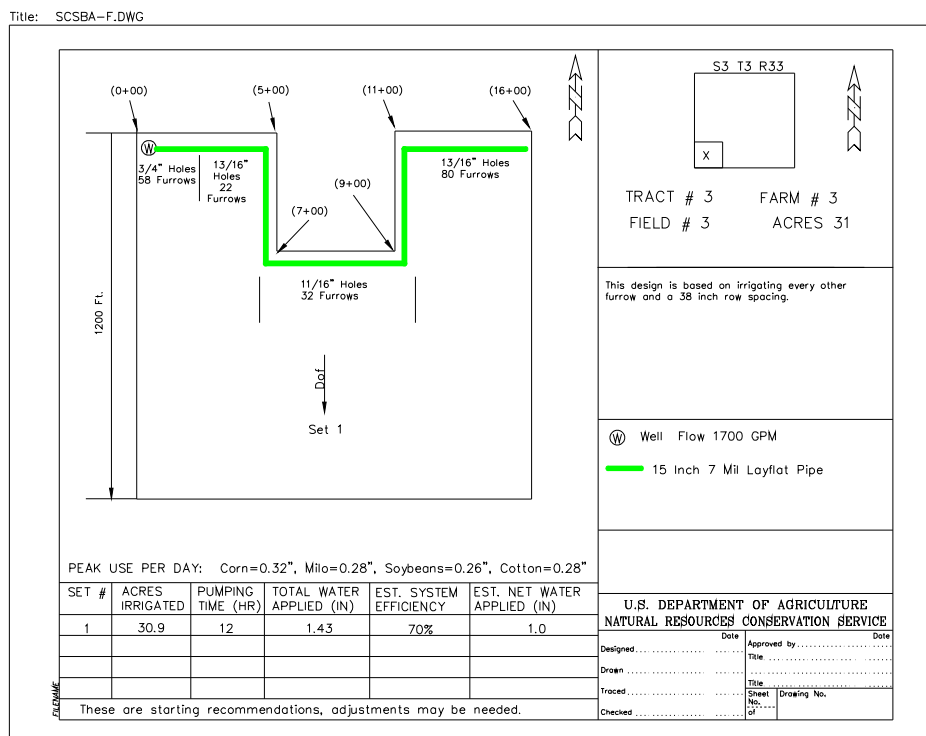


Figure 3.6 – Example 3 Plan View

## Example 4: Design with Multiple Irrigation Sets

This field has uneven row lengths and will be irrigated in two sets due to the loamy soil type and low pump flow (fig. 4.1 and 4.2). A quality design should divide a field to provide an adequate furrow flow rate according to furrow lengths and soil types (see Rule of Thumb 7). For this example, we will divide the area of the field into two equal sets. On a field with uneven row lengths, it is a little more difficult to find the center of the acreage. An automatic feature (Field Area Calculator) within the program will help divide the field into equal sets.

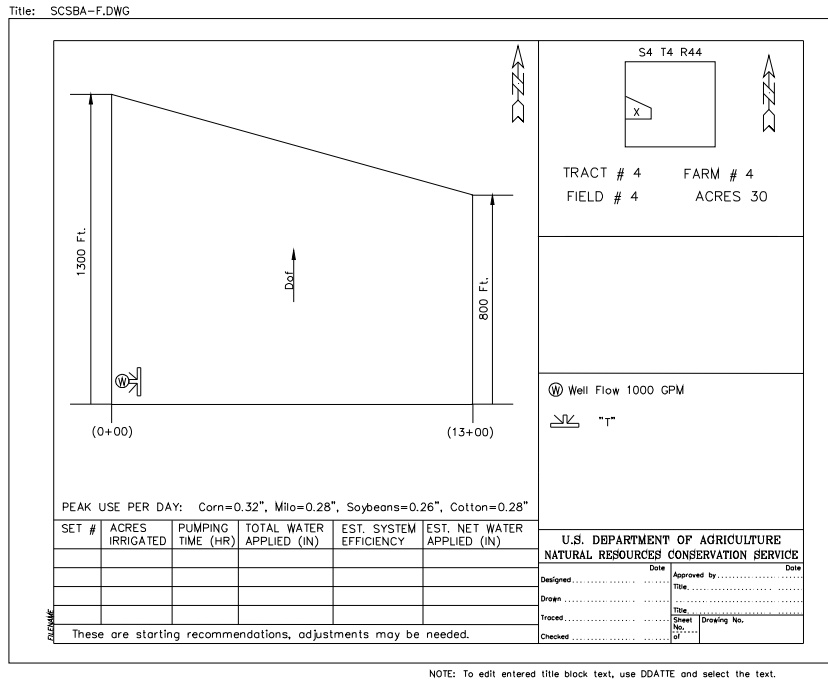


Figure 4.1 - Example 4 Field Dimensions

Station	Rod	Elevation	Comments
0+00	5.60	10.00	First irrigated furrow
1+00	5.80	9.80	Row spacing is 38 inches
2+00	6.00	9.60	Irrigate every other furrow
3+00	6.00	9.60	
4+00	5.80	9.80	
5+00	5.80	9.80	
6+00	5.40	10.20	
7+00	5.40	10.20	
8+00	5.40	10.20	
9+00	5.40	10.20	
10+00	5.35	10.25	
11+00	5.30	10.30	
12+00	5.25	10.35	
13+00	5.20	10.40	Last irrigated furrow

Figure 4.2 – Example 4 Crown Profile Survey

**STEP 1:** The first objective is to locate the crown profile station that will separate the field into two equal sets. **NOTE:** Head pressure and distribution uniformity are not important at this point. The actual design for both sets will begin when the first objective is completed. The Field Area Calculator can be used to find the area irrigated by any part of a system. To use the Calculator, type the crown profile survey (with furrow lengths) into the Data Input Grid (fig. 4.3).

Station (feet)	Elevation (feet)	Furrow Length (feet)	Distance Between Holes (feet)	Pipe Diameter (inches)	Hole Diameter (fractions)	No. of Holes at Each Watered Furrow	Mil (7,10,etc.)	Planted Furrow Width Between Watered Furrows (5.0', 6.0', 6.3', etc.)
0	10.00	1300	6.30	12.00	5/8	1	10	6.30
100	9.80	1262	6.30	12.00	5/8	1	10	6.30
200	9.60	1224	6.30	12.00	5/8	1	10	6.30
300	9.60	1186	6.30	12.00	5/8	1	10	6.30
400	9.80	1148	6.30	12.00	5/8	1	10	6.30
500	9.80	1110	6.30	12.00	5/8	1	10	6.30
600	10.20	1072	6.30	12.00	5/8	1	10	6.30
700	10.20	1034	6.30	12.00	5/8	1	10	6.30
800	10.20	996	6.30	12.00	5/8	1	10	6.30
900	10.20	958	6.30	12.00	5/8	1	10	6.30
1000	10.25	920	6.30	12.00	5/8	1	10	6.30
1100	10.30	882	6.30	12.00	5/8	1	10	6.30
1200	10.35	844	6.30	12.00	5/8	1	10	6.30
1300	10.40	800	6.30	12.00	5/8	1	10	6.30

Figure 4.3 – Example 4 Data Input Grid



Select any design option and toggle to the complete design screen. Position the cursor at (0+00) in the Station column. Click, hold and drag the mouse down the column to find the station that displays fifty percent of the total field acreage. The Selected (measured) acres are displayed in blue on the upper right part of the design screen (fig. 4.4).

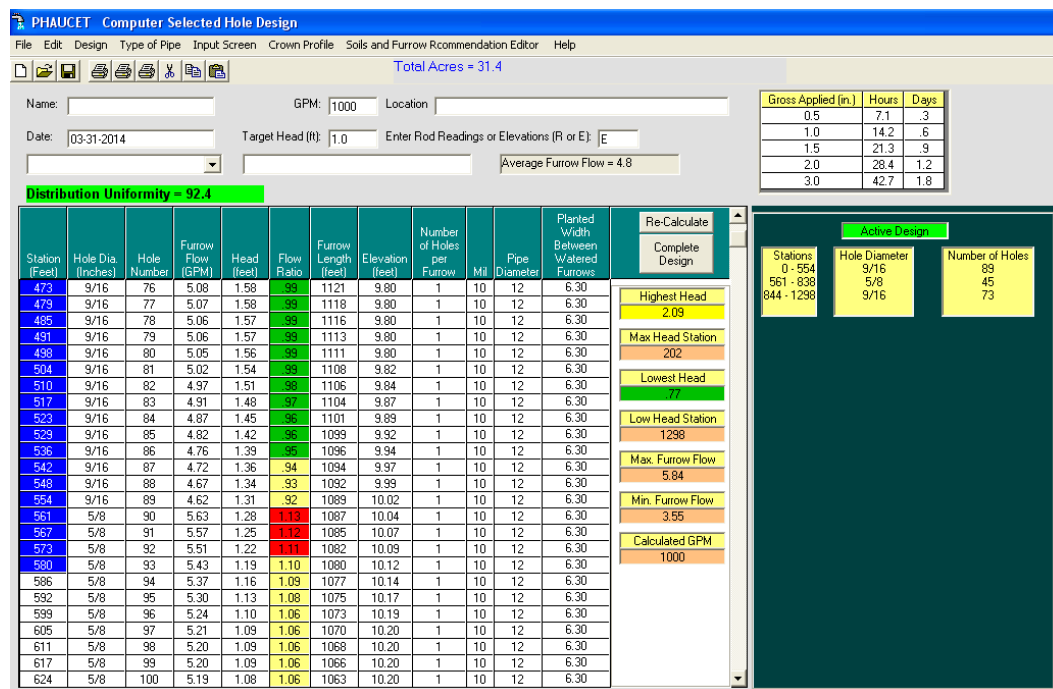


Figure 4.4 - Field Area Calculator

The field will be evenly divided if the west set begins at the well and ends at station (5+73). Print out the complete report. This will provide furrow lengths and elevations needed for the actual designs. This file is of no further use and does not need to be saved.



Figure 4.6 – Example 4 West Planned Field Design

**STEP 4:** Save the west (set 1) design and print out the design summary.

**STEP 5:** To begin the east (set 2) design, select File New and fill in the identification and pump flow information. Use the furrow length and elevation data from the Complete printout of the Field Area Calculator file to enter data for the entire length of the crown profile. **NOTE:** Only the station, elevation and pipe information is needed until you reach station (5+73). Enter the first hole size at station (5+73). **DO NOT** enter a hole size for any station before (5+73) or the design will not be accurate (fig. 4.7).

PHAUCET NRCS-USA Input Screen

File Edit Defaults Design Type of Pipe Window Help

Name:  GPM:  Location:

Date:  Target Head:  Enter Rod Readings or Elevations (R or E):

Interpolate Furrow Length and Calculate Elevations

Station (feet)	Elevations (feet)	Furrow Length (feet)	Distance Between Holes (feet)	Pipe Diameter (inches)	Hole Diameter (fractions)	No. of Holes at Each Watered Furrow	Mil (7.10, etc.)
0	10.00			12.00			7
101	9.80			12.00			7
202	9.60			12.00			7
302	9.60			12.00			7
403	9.80			12.00			7
504	9.82			12.00			7
573	10.09	1082	6.30	12.00	5/8	1	7
605	10.20	1070	6.3	12.00	5/8	1	7
706	10.20	1032	6.3	12.00	5/8	1	7
800	10.20	996	6.3	12.00	5/8	1	7
901	10.20	958	6.3	12.00	5/8	1	7
1002	10.25	919	6.3	12.00	5/8	1	7
1103	10.30	881	6.3	12.00	5/8	1	7
1203	10.35	843	6.3	12.00	5/8	1	7
1298	10.40	801	6.3	12.00	5/8	1	7

Figure 4.7 – Example 4 East Data Input Grid

**STEP 6:** Select Computer Hole Selection from the design menu. The calculated design provides good distribution uniformity but the Highest Head is 2.99 ft. (fig. 4.8).

NRCS-USA Computer Selected Hole Design

File Edit Defaults Design Type of Pipe Window Help

Total Acres = 15.1

Name: **Example 4 East** GPM: **1000** Location: **Farm #4 Tract 4 Fld. 4 East Set**

Date: **03-06-2001** Target Head: **1.0** Enter Rod Readings or Elevations (R or E): **E**

**Distribution Uniformity = 98.6**

Station (Feet)	Hole Dia. (Inches)	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Elevation (feet)	Number of Holes per Furrow	Mil	Pipe Diameter
0			2.99			10.00		7	12
101			2.97			9.80		7	12
202			2.94			9.60		7	12
302			2.71			9.60		7	12
403			2.29			9.80		7	12
504			2.04			9.82		7	12
573	13/16	10.70	1.61	1.08	1082	10.09	1	7	12
579	13/16	10.58	1.58	1.07	1080	10.11	1	7	12
611	13/16	10.05	1.42	1.03	1068	10.20	1	7	12
712	13/16	9.43	1.25	1.00	1030	10.20	1	7	12
806	13/16	8.99	1.14	.99	994	10.20	1	7	12
907	13/16	8.66	1.06	.99	956	10.20	1	7	12
1008	13/16	8.25	.96	.99	917	10.25	1	7	12
1109	13/16	7.92	.88	.99	879	10.30	1	7	12
1203	13/16	7.67	.83	1.00	843	10.35	1	7	12
1209	13/16	7.65	.83	1.00	840	10.35	1	7	12
1298	13/16	7.52	.78	1.02	801	10.40	1	7	12

Re-Calculate

Summary

Highest Head  
**2.99**

Max Head Station  
0

Lowest Head  
.78

Low Head Station  
1298

Max. Furrow Flow  
10.70

Min. Furrow Flow  
7.43

Calculated GPM  
1000

Figure 4.8 CSH Design

This is excessive for 12 inch 7 mil pipe (Rule of Thumb 2). The producer could use this design with 12 inch 10 mil pipe or the system could be redesigned using 15 inch layflat pipe. Increasing the pipe size will usually lower head pressure. For this example, toggle back to the Input screen and change the pipe size to 15 inch 7 mil pipe for the entire crown. (**NOTE:** Excessive pressure on this particular system is due to the increase in elevation at the end of the crown).

Select Computer Hole Selection from the design menu. The Highest Head is still excessive, so the Target Head should be reduced to 0.8 and again select the CSH design option (fig. 4.9).

**NRCS-USA Computer Selected Hole Design**

File Edit Defaults Design Type of Pipe Window Help

Total Acres = 15.1

Name:  GPM:  Location:

Date:  Target Head:  Enter Rod Readings or Elevations (R or E):

**Distribution Uniformity = 91.9**

Station (Feet)	Hole Dia. (Inches)	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Elevation (feet)	Number of Holes per Furrow	Mil	Pipe Diameter
0			1.65			10.00		7	15
101			1.77			9.80		7	15
202			1.90			9.60		7	15
302			1.82			9.60		7	15
403			1.54			9.80		7	15
504			1.45			9.82		7	15
573	7/8	10.36	1.12	1.05	1082	10.09	1	7	15
579	7/8	10.24	1.10	1.04	1080	10.11	1	7	15
611	7/8	9.71	.99	1.00	1068	10.20	1	7	15
712	7/8	9.42	.93	1.00	1030	10.20	1	7	15
806	7/8	9.22	.89	1.02	994	10.20	1	7	15
907	7/8	9.07	.86	1.04	956	10.20	1	7	15
1008	7/8	8.71	.80	1.04	917	10.25	1	7	15
1109	7/8	8.39	.74	1.05	879	10.30	1	7	15
1134	13/16	7.17	.72	.90	869	10.32	1	7	15
1203	13/16	6.99	.69	.91	843	10.35	1	7	15
1209	13/16	6.97	.68	.91	840	10.35	1	7	15
1298	13/16	6.83	.64	.92	801	10.40	1	7	15

Re-Calculate

Summary

Highest Head  
**1.90**

Max Head Station  
202

Lowest Head  
.64

Low Head Station  
1298

Max. Furrow Flow  
10.36

Min. Furrow Flow  
6.73

Calculated GPM  
1000

Figure 4.9 – Example 4 East Planned Field Design

The CSH indicates a 7/8" and 13/16" hole gives high Distribution Uniformity and pressure is safe for 7 mil 15 inch layflat pipe (fig. 4.9).

Notice that the flow ratio for the lower part of the 7/8" hole sizes is slightly high. To see if an adjustment will improve the design, toggle to the Input Grid and reduce the hole size for stations (9+07) through (11+09) to 13/16". Recalculate as a Planned Design (fig. 4.10)

**NRCS-USA Planned Design**

File Edit Defaults Design Type of Pipe Window Help

Total Acres = 15.1

Name: **Example 4 East** GPM: **1000** Location: **Farm #4 Tract 4 Fld. 4 East Set**

Date: **03-06-2001** Target Head: **0.8** Enter Rod Readings or Elevations (R or E): **E**

**Distribution Uniformity = 94**

Station (Feet)	Hole Dia. (Inches)	Furrow Flow (GPM)	Head (feet)	Flow Ratio	Furrow Length (feet)	Elevation (feet)	Number of Holes per Furrow	Mil	Pipe Diameter
0			1.72			10.00		7	15
101			1.85			9.80		7	15
202			1.97			9.60		7	15
302			1.89			9.60		7	15
403			1.62			9.80		7	15
504			1.52			9.82		7	15
573	7/8	10.70	1.20	1.08	1082	10.09	1	7	15
579	7/8	10.58	1.17	1.07	1080	10.11	1	7	15
611	7/8	10.07	1.06	1.03	1068	10.20	1	7	15
712	7/8	9.79	1.00	1.04	1030	10.20	1	7	15
806	7/8	9.61	.97	1.06	994	10.20	1	7	15
901	7/8	9.49	.94	1.08	958	10.20	1	7	15
907	13/16	8.16	.94	.94	956	10.20	1	7	15
1008	13/16	7.87	.87	.94	917	10.25	1	7	15
1109	13/16	7.61	.82	.95	879	10.30	1	7	15
1140	13/16	7.51	.79	.95	867	10.32	1	7	15
1203	13/16	7.37	.77	.96	843	10.35	1	7	15
1209	13/16	7.36	.76	.96	840	10.35	1	7	15
1298	13/16	7.23	.72	.97	801	10.40	1	7	15

Re-Calculate

Summary

Highest Head  
**1.97**

Max Head Station  
202

Lowest Head  
.72

Low Head Station  
1298

Max. Furrow Flow  
10.70

Min. Furrow Flow  
7.13

Calculated GPM  
1000

Figure 4.10 - Example 4 East Planned Design

This increases distribution uniformity and pressure is below 2.0 ft. This adjustment improved the design.

**STEP 7:** Save the east (set 2) design and print out the design Summary and hole summary.

**STEP 8:** A plan view of any system must clearly describe the size and mil thickness of layflat pipe used in the design (fig. 4.11). Color has proven to be an effective label for layflat pipe. To avoid confusion between systems, the designer should use consistent labels for all plan views.

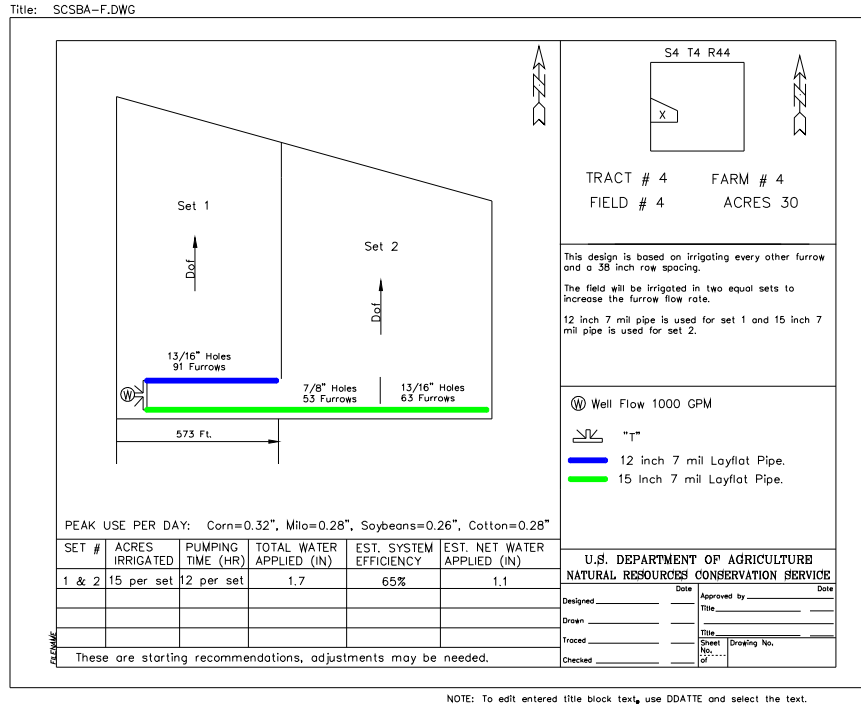


Figure 4.11 – Example 4 Plan View

This plan view will allow the producer to locate the break between sets by counting furrows or by direct measurement. It is critical that the producer understand that the number of furrows described is the number of IRRIGATED furrows. If the system is designed to irrigate EVERY OTHER furrow, he would double this amount to find the total number of rows from the well to the start of the east set.