Chapter 15 Resource Planning and Evaluation Tools and Worksheets

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FL652.1501Water quality, water management, and irrigation evaluation tools

FARM IRRIGATION RATING INDEX (FIRI) The Farm Irrigation Rating Index (FIRI) was developed to provide conservation planners with a tool to assist irrigators in:

1. planning on-farm irrigation improvements to achieve a specific level of water management and conservation;
2. determining the amount of water conserved when a practice or group of measures are installed; and
3. follow-up to document changes in irrigation water management.

The potential for improving irrigation systems for more efficient water use can be determined by field evaluations. The challenge is to provide a simple method for comparing the present irrigation system and management to irrigation systems that implement improvements to the system and/or changes to the management of the system. A simple and reliable method is needed due to the time and funds required to perform complete field evaluations.

FIRI was developed as a result of a western United States water conservation emphasis program during the 1980s. The development of FIRI is documented in the publication entitled "Farm Irrigation Rating Index (FIRI), *A Method for Planning, Evaluating, and Improving Irrigation Management*" (USDA, Soil Conservation Service, West National Technical Service Center, Portland Oregon, June 1991). FIRI provides a reliable and consistent rating method to document system and/or changes to the management of the system.

FIRI provides a uniform and objective rating method for evaluating irrigation systems and management alternatives during the planning phase and follow-up. During follow-up FIRI can be used to provide documentation of the effects of changes in irrigation management practices and/or system changes.

The FIRI rating method is the product of three (3) elements:

1. The on-farm water management. – The human element involves decisions which can be scientifically based on measuring water, monitoring soil moisture, and knowing how to operate the irrigation system efficiently. It also involves irrigator decisions on a maintenance program, tillage operation, and conservation cropping systems. How the water delivery system is operated also affects decisions on when and how much water to apply. Once a system is in operation, a management plan is needed.
2. The on-farm irrigation system. – For a sprinkler the key system components affecting water conservation are climatic effects, spray type, average wind speed, variation in nozzle pressure, and nozzle selection.

   Key system components for subirrigation are conveyance, uniformity of water table, capacity to maintain the desirable water table, surface slope, and prevention of tailwater loss.

   Key components for surface system are conveyance, distribution control, length of run, surface slope and prevention of tailwater reuse.
3. The potential efficiency of the system. – The system "potential efficiency" for an optimally performing unit for the site-specific physical layout can be obtained from the National Irrigation Guide, Part 652, Florida Supplement, Chapter 15, Table FL15-1. For future conditions, a properly designed and installed system utilizing the latest technology is desired.

FIRI provides a relative rating. It is the product of up to twelve (12) management and irrigation system factors to consistently rate from one location or system to another on the relative effectiveness of irrigation practices.

The FIRI rating is the product of the potential efficiency times the system and management factors, expressed as

FIRI = PE x SYS x MGT

where:

PE = potential efficiency

SYS = (Wc)(Ce)(L)(R) for surface systems and subsurface

= (Wc)(Ce)(C)(W(R) for sprinkler systems

= (Wc)(Ce)(C)(W)(E)(T) for drip/microirrigation systems

MGT = (Md)(S)(I)(M)(D)(Sc)

FIRI greatest value is in evaluating change—not in estimating the absolute value of on-farm irrigation water savings. It is preferable to refer to the end product as a rating of water use, present and/or changed/proposed. FIRI compares the present and future on-farm irrigation by using a standard set of system and management factors defined as follows.

System Factors

Wc - Improved distribution system. This category recognizes the ability of the irrigator to manage, direct, and control the water flow stream onto the farm, across the farm to one or more fields, and to multiple irrigation sets across the farm or field. The better the control, the higher the irrigation rating factor. For example, using a center pivot sprinkler (which is 1 set per field) and water from a local well via pipeline will have the highest factor. See Figure FL15-7.

Ce - Improved conveyance system. Conveyance efficiency is a function of seepage rates by soil groups and materials. The EFF (see Table 15-3) can be used to compute the conveyance efficiency of the delivery system. Fewer losses during the conveyance of irrigation water provide for higher system efficiency. This category recognizes the condition of the conveyance system which conveys the water from the source— whether off-farm or on-farm—to the field. Lined ditches will have less seepage than ditches constructed in sandy soils with no lining. See Figure FL15-8.

To compute the conveyance efficiency, first select a value for EFF, then raise EFF to the power of length in 1,000's.

$$Ce = EFF^{(length/1,000)}$$

For example, a 1,500 linear foot ditch in a gravelly sand soil will have a conveyance efficiency factor of 0.83.

$$Ce = 0.88^{(1,500/1,000)} = 0.83$$

In situations where the ditch has one or more soil types or part of the ditch is lined, the EFF factor is determined by computing a weighted average based on each length.

L - Land leveling. Most surface/subsurface irrigated fields in Florida have been leveled to a uniform slope. Uniform slope provides for more efficient application of water—mostly due to consistent advance and recede times between furrows or borders. Proper length of runs for slope and soil type also can increase efficiencies. Precision-leveled fields have higher efficiency potential and are easier to manage then less controlled grades and slopes. Laser or global positioning system (GPS) controlled leveling equipment is used to construct precision leveled fields.

Some tillage operations, when carried out year-after-year, can move enough soil to decrease the uniformity of slope in a field. The run length may not be optimum for soils, slope, or method of irrigation because of field layout, or cultural practices being implemented. Evaluate the impact of operation and maintenance on precision land leveling while conducting interviews with the irrigator and by visual inspection or survey of the field. In some instances, reconstruction of the precision leveling may be warranted. Proper run length requires an irrigation water management (IWM) plan that identifies proper design inflows and time of set. See Figure FL15-9 and Table FL15-4.

R - Adding tailwater recovery with and without irrigation storage reservoirs. Runoff from irrigated fields may be captured and reused, and its impact is evaluated under this factor. If tailwater is not captured, select zero (0). If tailwater is collected, estimate the percentage of the gross irrigation

volume captured as tailwater following an irrigation event. Use professional judgment and irrigator interviews to estimate the percentage of tailwater captured. This factor does not include capture of rainfall runoff; only irrigation amounts. The factors on the list are for water that is reused at 50% application efficiency. Higher application efficiencies will have higher factors. Sprinkler and microirrigation systems should have zero runoff if properly designed. However, if they have runoff that is reused, recalculate the reuse at the appropriate application efficiency percentage. See Figure FL15-10.

C - Climatic factor. This factor accounts for climate impacts on overall irrigation efficiency, particularly evaporation. ET from the crop is an input variable to this factor. Potential evaporation rates are contained in Table FL15-2. Alternately, ET can be calculated using an NRCS-approved program that estimates the peak average ET for a particular crop and location. The climate affects the evaporation from the ground and the plants being grown. See Figure FL15-11.

W - Wind factor. The wind speed and sprinkler water droplet size have an effect on the amount of evaporation and the movement of water off the target area. The higher the average wind speed and the smaller the droplet size, the lower the factor is. Evaluate this factor using the average wind speed for the growing season. Because the stage of crop growth impacts evaporation rates, consider the dominant vegetative condition for the year when evaluating this factor. See Figure FL15-12.

Sd - Sprinkler factor. This factor evaluates the impact on uniformity caused by pressure variation across the sprinkler system, the impact this pressure variation has on uniformity of the flow from the sprinklers, and the sprinkler application rate versus the intake rate of the soil. The more uniform the sprinkler output, the better is the chance of not under-irrigating or over-irrigating the crop. Keeping the application rate less than the intake rate minimizes surface runoff. See Figure FL15-13.

E - Emitter clogging factor. This factor evaluates the susceptibility of the microirrigation outlets to clogging. Since measuring clogged emitters is difficult, outlet size and filtration effort are used as a substitute. The larger the outlet and the greater the amount of filtering, the lesser the chances are of clogging. Other items to keep in mind are the temperature of the water and the flushing frequency. The different scenarios describing various factors in emitter clogging have subtle differences. Use careful judgment to select the scenario that fits best the microirrigation system under investigation. See Figure FL15-14.

T - Drip/Micro design factor. This factor evaluates the impact of the relationship between pressure, flow, type of emitter, and the variability in emitter manufacturing (coefficient of variability [CV]). The CV depends on the manufacturing process and should be provided by the manufacturer. Sloping fields can cause differences in pressure and thus differences in flow unless the emitters are made to compensate for those pressure differences. Point source emitters usually have less variation than lateral line emitters. See Figure FL15-15.

Management Factors

Md - Water Measurement. Water must be measured to each field for optimum irrigation water management. The measurement at the farm delivery point can be translated to each field if the water is not split. There are a variety of methods to measure water. Weirs, orifices, flumes, and propeller meters are just a few of these methods. Check to see where and how the water is measured. Water measured at the delivery point to the farm scores lower as it could make it difficult to track the amount of water delivered to an individual field. See Figure FL15-1.

S - Soil Moisture/Scheduling. The soil moisture deficit in the root zone must be measured (monitored) and irrigations scheduled to obtain good water management. The selections available

under this category range from no scheduling of any kind to continuous monitoring of soil moisture, water applied, and evapotranspiration (ET) amounts via electronic sensors. Select the method that best describes the irrigator's moisture monitoring and irrigation scheduling. See Figure FL15-2.

I - Irrigation Skill. Good management requires an operator trained in how to apply the water. An automated system can be properly managed to substitute for a trained irrigator. More mechanical skill will be required to manage a sprinkler or microirrigation system. Having the necessary information does not mean the irrigator follows the recommendations for the irrigation timing and amount. The factor selected in this category is the planner's best professional judgment after talking with the irrigator and reviewing management records. See Figure FL15-3.

M - Maintenance. A system must be maintained in order to be managed at its potential. Nozzles on sprinklers have to be replaced; fields need to be re-leveled; structures for water control have to be replaced when they deteriorate; spray emitters must be unplugged and maintained in proper position to obtain desired wetted area; and system leaks must be repaired. Good maintenance of irrigation facilities is fulfilled by planned periodic actions by the irrigator. The factor assigned to maintenance should be an indication of the irrigator's general maintenance program, not an indication of system condition before and after installation. Maintenance factor should be selected using the planner's best professional judgment after talking with the irrigator and reviewing management records. See Figure FL15-4.

D - Water Delivery. To properly irrigate the crop, water must be available when needed at the rate for optimum application. Uncontrolled water is not normally available all season, every year. In short supply areas there is probably lower efficiency than in full supply areas. If you are on a rotation and receive water on a preset interval, whether you need it or not, there is a tendency to over irrigate during part of the season and not have sufficient water during peak use periods. An arranged system is one where you can request water from an irrigation company. Usually there is some storage. There can be restrictions, fixed operation, or limited rates during the season which reduces efficiency. A demand system with full control of when and how much is ideal for good water management. If water is delivered by an irrigation district using canals and pipelines, the water may be available on a rotational basis, and the crop may get water on a fixed interval which limits management practices. Other irrigation entities may provide water available at any time, but the amount may be restricted. The irrigator may have an on-site supply—whether it is a well or a reservoir—and these other supplies could be available on demand with a limited or unrestricted amount of water. See Figure FL15-5.

Sc - Soil Condition Index. Conservation tillage, no till, crop residue use, and a conservation cropping system are management tools to improve soil conditioning and facilitate better irrigation on cropland. Crop residues on the soil surface increase intake, reduce runoff, and reduce water lost by evaporation from the soil surface.

Sc is a conservation planning assessment tool to predict the effect of cropland management systems on soil organic matter. Soil condition is defined as the degree to which a soil maintains its ability to: (1) accept, store and release water, nutrients, and energy, (2) promote and sustain root growth, (3) sustain soil biological and chemical processes, and (4) resist erosion, compaction, and other management impacts. Sc evaluates the effect of farming practices on soil organic matter.

A combination of effects causes degradation of soil condition. Wind and water erosion remove fine soil particles, organic matter, and plant nutrients, thus reducing productivity and the ability of the soil to hold water. Excessive tillage

accelerates erosion and organic matter oxidation, and causes compaction. Crop rotations which produce low amounts of residue, and/or which involve extensive residue removal, result in inadequate amounts of organic material returned to the soil. See Figure FL15-6.

A Microsoft (MS) Excel® worksheet titled FL-FIRI" was developed by Florida NRCS to perform the FIRI calculations necessary to determine changes in water use from proposed system or management changes by the irrigator. See Exhibit FL15-1. The FL-FIRI worksheet and detailed instructions on its use can be downloaded from the Florida FOTG, Section I., C. References, 1. Engineering References, b. Part 650, NEFH – Florida Supplement - Chapter 20 – Engineering Software, at the following web address:
http://efotg.sc.egov.usda.gov/treemenuFS.aspx

Example

The following example is intended to provide a basic understanding of the functionality of the FIRI rating system.

1. For this example, a cooperator is located in climatic zone 4 and has requested assistance to evaluate a decision to convert a 20 acre citrus grove currently irrigated by microirrigation system (micro spray) to strawberries that would be irrigated by microirrigation system (drip) under plastic.
2. In discussion with the cooperator and visual observation of current management situation on the farm, the planner begin documenting observations on the FL-FIRI worksheet. See Exhibit FL15-1, to view the potential outcome of water savings based on the present situation versus the planned scenario.
3. The net irrigation requirement for the crops are obtained from Table FL4-6 Part 652, Chapter 4. The net irrigation requirement in climatic zone 4 for citrus is 15.80 and for strawberries is 9.60.
4. Based on the observations made and interviewing the cooperator, the various system and management factors were entered into the spreadsheet. Results from - FIRI documents that based on the proposed changes in the irrigation system, management, and systems management, the FIRI rating increased from 69.2 to 81.4, a difference of 14.9.
5. The 14.9 change in the FIRI rating represents approximately 6.2 million gallons of water that could be conserved. In this example, the large potential water savings can be attributed to converting from citrus with a net irrigation requirement of 15.80 inches to strawberries with a net irrigation requirement of 9.60 inches.

Potential Efficiency, E

The potential efficiency is obtained from Table FL15-1. Eighty-five percent (85%) for a microirrigation system (spray) was used for the present irrigation. Ninety percent (90%) for a continuous tape drip system was used for the planned system.

Management Factors

The cooperator does not currently measure flow of water to the irrigation system but does to plan to install an automated flow measuring device that provides the ability to record flow to the entire farm and each individual field (Md increases from 0.9 to 1.00). The current method of soil moisture monitoring and irrigation scheduling is the NRCS feel and appearance method. The cooperator plans to schedule irrigations using regional weather networks (S increases from 0.95 to 0.97). The irrigation skill is a subjective analysis made by the planner when discussing the cooperator's irrigation management of the irrigation system (i.e., in the micro spray system, the cooperator is not measuring water flow to the system, using the NRCS feel and appearance method for scheduling irrigation and monitoring soil moisture, etc.). The cooperator is planning to convert the citrus grove to strawberries and will convert the micro spray to a continuous tape drip system. With this crop and system conversion, the cooperator plans to implement an irrigation water management (IWM) plan (I increases from 0.92 to 1.00). The planner determines the cooperator has a steady routine of maintaining the channels used to convey water. With the proposed irrigation system conversion, the new system will be easier to maintain and the cooperator plans to develop

and maintenance program (M increases from 0.98 to 1.00). The current source of water for the cooperator is an on farm well that provides the required volume water for irrigation. This well will be used for the new system as well (D, no change). The crop conversion from citrus to strawberries will decrease the cover maintained by the citrus trees and the vegetation between rows. Converting to a crop such as strawberries creates a more high intensity land use, heavy equipment used to create beds and lay for the strawberries, planting, fertilizing, etc. compacts the soil. The bare soil between the strawberry beds is more susceptible to erosion and the amount of organic matter returned to the soil decreases. This crop conversion will cause Sc to decrease from 1.00 to 0.95.

System Factors

The distribution system for the micro spray system allows the cooperator to control flow rates to each set. With the proposed system conversion, all flow rates to each set can controlled (Wc, no change). The cooperator currently has a conveyance system comprised of closed conduit pipeline. In the planned system, the conveyance system will also be closed conduit pipelines (Ce, no change). Land leveling is not a factor in microirrigation systems (I, will be 1.00). There is no tailwater recovery in the current system or the planned system (R, no change). Evaporation has some effect on the micro spray system and minimal effect the proposed microirrigation system. An estimate of ET is determined to be 0.30 in/day from Figure FL15-11. (C, will be 1.00). The wind effects the micro spray system but has no effect on the planned system (W increase from 0.94 to 1.00). The sprinkler factor has no effect on the current or planned system (Sd, 1.00 for both systems). Approximately 20% of the micro spray emitters are estimated to be clogged and the existing system has no method of treatment or flushing. The proposed microirrigation will be drip covered under plastic treated with a screen media filter and chemicals, the system will have the ability for continuous flushing with less than 5% of emitters being clogged (E increases from 0.96 to 0.97). The coefficient of variability (CV) of the exiting micro spray system is estimated to be marginal and flow variation of +/- 30%. For the proposed microirrigation system, the (CV) will be +/- 5% (T increases from 0.9 to 1.00).

Additional evaluations are needed for special water use to determine how efficient the system will apply water for situations such as frost protection, waste utilization, fertigation, or chemigation as examples. FIRI represents typical conditions and will only provide a rating of change. It is not a substitute for detailed irrigation trials and evaluations.

Summary

FIRI is a valuable tool for identifying the increments of change in on-farm irrigation water use that can result from improvements in system or management elements. FIRI can be translated into water conservation terms, such as reduced demands for water, reduced losses and waste, and amount of water conserved.

FIRI is not intended to replace irrigation system evaluations, but is intended to be used as a tool in determining the effects on water use from changes in the irrigation system, management techniques, and crops planted. As field evaluation data is collected, factors used in FIRI will be refined to improve its use.

Exhibit FL15-1 – **Florida Farm Irrigation Rating Index Worksheet**

USDA

FL-FIRI
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Sheet 1 of 2

Florida Farm Irrigation Rating Index (FL - FIRI) Version 1.0

Cooperator:	John Doe	Farm Name:	Dried Up, Inc.
Location:	Plant City	Field ID:	
Conservation District:	Hillsborough	Field Office:	Plant City
Water Management District:	Southwest Florida Water Management District	County:	Hillsborough
Irrigated Area, acres:	20.0		

Irrigation System

Category	Present		Planned	
Irrigated Crop, Net Irrigation Requirement (NIR), inches	Citrus	NIR (in) 15.80	Strawberries	NIR (in) 9.60
Irrigation System Type	Microirrigation–sprays	0.85	Microirrigation–continuous tape	0.9

Management Factors

Category	Action	Rating	Action	Rating
Improved Water Measurement	No flow measuring devices	0.80	Flow measurement–whole farm plus individual field automatically recorded	1.00
Improved Soil Moisture Monitoring and Irrigation Scheduling	Soil moisture by Natural Resources Conservation Service (NRCS) feel method	0.95	Irrigation scheduling via regional weather network	0.97
Irrigation Skill and Action	Good–lack of full attention	0.92	Following irrigation water management (WM) plan	1.00
Maintenance Factor	Good	0.98	Future	1.00
Water Delivery	Demand–unrestricted rate	1.00	Demand–unrestricted rate	1.00
Improved Soil Condition Index	Soil Condition Index = 1.0 or more	1.00	Soil Condition Index = 0.4	0.95

System Factors

Category	Action	Rating	Action	Rating
Improved Distribution System	All flow rates to each set are adequately controlled	1.00	All flow rates to each set are adequately controlled	1.00
Improved Conveyance System	Material / Length (ft)		Material / Length (ft)	
	Closed conduit pipeline	1.00	Closed conduit pipeline	1.00
Improved Land Leveling	A sprinkler or microirrigation system is used	1.00	A sprinkler or microirrigation system is used	1.00
Adding Tailwater Recovery With and Without Irrigation Storage Reservoirs	0%	1.00	0%	1.00
Climatic Factor	Warm–peak average evapotranspiration (ET) of 0.30	1.00	Non-spray Low Energy Precision Application (LEPA) or point source microirrigation	1.00
Wind Factor	Fine spray–wind speed 1-4 mph	0.94	Non-spray Low Energy Precision Application (LEPA) or point source microirrigation	1.00
Sprinkler Factor	Microirrigation system	1.00	Microirrigation system	1.00
Emitter Clogging Factor	Spray–Treatment: none; Flushing: none; Temperature: 149F; Sum of clogging: > 20%	0.96	Dripper-covered–Treatment: screen+media filter+chemical; Flushing: continuous; Temperature: 68F; Sum of clogging: < 5%	0.97
Drip-Micro Design Factor	Marginal coefficient of variability (CV)–flow variability +/- 30%	0.90	Excellent coefficient of variability (CV)–flow variability +/ 5%	1.00
FIRI Rating:	**Present Condition =**	69.2	**Planned Condition =**	84.1

Change in FIRI Rating	14.9
Water Conserved per acre (acre-feet/acre)	0.95
Water Conserved (acre-feet)	19.0
Water Conserved (acre-inch)	228.3
Water Conserved (gallons)	6,198,354
Water Conserved (in percent)	50%

Exhibit FL15-1 – **Florida Farm Irrigation Rating Index Worksheet**

USDA

FL-FIRI
03/15
Sheet 2 of 2

Comments:
Proposed system conversion from microirrigation system (spray) to a microirrigation system (drip). Cooperater is also requesting assistance to doument any potential water savings by converting the 20 acre citrus grove into strawberries.

Prepared by:	T.O. Dry	Date:	3/12/2015
Checked by:	Erie Gator	Date:	3/12/2015

Local Criteria

Conditions typical to your area should be identified. In addition, identify conditions unique to the area or outside normal operations. For example, open channels used for conveyance in organic/muck soils will normally not have excessive seepage loss although the permeability of muck may be rapid. The area normally has a high water table and the seepage loss contributes to maintaining the water table, so an F factor of 0.85 may be appropriate. Wind and evaporation would not affect below canopy sprinklers as greatly as above tree canopy sprinklers.

Table FL15-1 - System Potential Efficiencies (E)

Sprinkle Irrigation	**Percent**
Hand line or wheel line	70
Solid Set (above canopy)	75
Solid Set (below canopy)	80
Traveling Gun (gun type or boom)	65
Periodic Move gun type or boom sprinklers	60
Center Pivot, Standard	80
Center Pivot, Low pressure improved	85
Center Pivot, Low Energy Precision Application (LEPA)	92
Center Pivot, Low Elevation Spray Application (LESA)	89
Center Pivot, Low Pressure In Canopy (LPIC)	87
Center Pivot, Mid Elevation Spray Application (MESA)	85
Center Pivot, Variable Rate Irrigation (VRI)	87
Linear (lateral) Move	82
Linear (lateral) Move, Low Energy Precision Application (LEPA), Low Elevation Spray Application (LESA), Low Pressure In Canopy (LPIC), Mid Elevation Spray Application (MESA)	87
Linear (lateral) Move, Variable Rate Irrigation	87
Periodic Move Lateral	75
LEPA – center pivot and linear move	95

Subirrigation	**Percent**
Underground Conduit	85
Open Ditch (Irrigating Laterals or Furrows)	
Flow Through	80
Backup	75
Crown Flood	80

Microirrigation	**Percent**
Spray Emitters	85
Point Source Emitters	90
Line Source Emitters	90
Subsurface Drip Irrigation (SDI)	92

Surface Irrigation	**Percent**
Graded Furrow	80
Level Furrow	85

Table FL15-2 Potential Evaporation Rate (inches per day)

Month	Climatic Zone						
	1	2	3	4	5	6	7
January	0.06	0.07	0.09	0.09	0.10	0.10	0.11
February	0.09	0.11	0.12	0.12	0.13	0.13	0.14
March	0.12	0.14	0.14	0.14	0.16	0.16	0.17
April	0.16	0.17	0.19	0.19	0.19	0.19	0.19
May	0.19	0.19	0.20	0.20	0.19	0.19	0.19
June	0.19	0.20	0.20	0.20	0.18	0.18	0.18
July	0.18	0.19	0.19	0.18	0.18	0.18	0.18
August	0.17	0.17	0.17	0.17	0.18	0.17	0.17
September	0.15	0.15	0.15	0.16	0.15	0.15	0.15
October	0.11	0.11	0.13	0.14	0.14	0.14	0.14
November	0.08	0.09	0.10	0.11	0.12	0.11	0.12
December	0.06	0.07	0.08	0.08	0.10	0.10	0.11

Table FL15-3 -Tabulation of Evaluating Factors - Management

Improved Water Measurement	**Md Factor**
No Flow Measuring Devices	0.90
Flow Measurement-Whole Farm Manually Recorded	0.93
Flow Measurement-Whole Farm Automatically Recorded	0.95
Flow Measurement-Whole Farm Plus Individual Field Manually Recorded	0.97
Flow Measurement-Whole Farm Plus Individual Field Manually Recorded	1.00

Improved Soil Moisture Monitoring and Irrigation Scheduling	**S Factor**
None	0.90
Visual Crop Stress	0.94
Soil Moisture by NRCS Feel and Appearance Method	0.95
Checkbook scheduling, irrigation scheduler, etc.	0.95
Irrigation scheduling via pan evaporation or atmometer for field	0.96
Irrigation scheduling via regional weather network	0.97
Soil moisture using gypsum blocks, moisture probe, etc.	0.98
Continuous measurement of soil moisture, water applied, and evapotranspiration (ET)	1.00

Irrigation Skill and Action	**I Factor**
Significant over irrigation	0.80
Good-Lack of full attention	0.92
Following irrigation water management (IWM) plan	1.00

Maintenance	**M Factor**
Poor	0.90
Fair	0.94
Good	0.98
Excellent	1.00
Future	1.00

Table FL15-3 -Tabulation of Evaluating Factors – Management (Continued)

Water Delivery	**W Factor**
Rotation-limited rate	0.80
Rotation-fixed rate	0.83
Rotation-moderate frequency	0.85
Rotation-moderate amount	0.88
Arranged-fixed duration	0.90
Arranged-restricted duration	0.93
Arranged-limited rate	0.96
Arranged-arranged rate	0.97
Demand-limited rate	0.98
Demand-unrestricted	1.00

Improved Soil Condition Index	**Sc Factor**
Soil Condition Index = 0	0.90
Soil Condition Index = 0.1	0.91
Soil Condition Index = 0.2	0.92
Soil Condition Index = 0.3	0.93
Soil Condition Index = 0.4	0.94
Soil Condition Index = 0.5	0.95
Soil Condition Index = 0.6	0.96
Soil Condition Index = 0.7	0.97
Soil Condition Index = 0.8	0.98
Soil Condition Index = 0.9	0.99
Soil Condition Index = 1.0 or more	1.00

Table FL15-3 -Tabulation of Evaluating Factors – System

Improved Distribution System	**Wc Factor**
Very poor diversion facilities with little control of flow rate to farm	0.90
Can flow rates to farm, but the on-farm delivery system is such that it is very hard to deliver the desired flow to any given field	0.94
Flow rates to each field are adequately controlled but flow rates to each set are difficult to control	0.98
All flow rates to each set are adequately controlled	1.00

Improved Conveyance System	**EFF**
Open ditch or canal-very gravelly bed and bank	0.80
Open ditch or canal-sand/gravelly bed and bank	0.88
Open ditch or canal-sand bed and bank	0.95
Open ditch or canal-sandy/loam bed and bank	0.97
Open ditch or canal-clay/silt loam bed and bank	0.99
Open ditch or canal-clay soil bed and bank	1.00
Open ditch or canal-concrete lined	1.00
Closed conduit pipeline	1.00

Improved Land Leveling	**L Factor**
A sprinkler or microirrigation system is used	1.00
Unleveled-not proper run length	0.75
Unleveled-proper run length	0.80
Land smoothed	0.90
Land leveled	0.94
Land precision leveled	0.98
Land precision leveled-slope <= 0.005	1.00

Table FL15-3 -Tabulation of Evaluating Factors – Systems Continued

Adding Tailwater Recovery with and without Irrigation Storage Reservoirs	**R Factor**
0%	1.00
10%	1.05
20%	1.10
30%	1.15
40%	1.20
50%	1.25
60%	1.30
70%	1.35
80%	1.40
90%	1.45
100%	1.50

Climatic	**C Factor**
Cool-peak average evapotranspiration (ET) of 0.15	1.01
Warm-peak average evapotranspiration (ET) of 0.30	1.00
Hot-peak average evapotranspiration (ET) of 0.45	0.98
Hot-peak average evapotranspiration (ET) of 0.60	0.95

Wind	**W Factor**
Surface system	1.00
Non-spray LEPA or point source microirrigation	1.00
Fine spray-wind speed 1-4 mph	0.94
Fine spray-wind speed 4-10 mph	0.90
Fine spray-wind speed >10 mph	0.87
Medium spray-wind speed 1-4 mph	0.96
Medium spray-wind speed 4-10 mph	0.93
Medium spray-wind speed >10 mph	0.91
Coarse spray-wind speed 1-4 mph	0.98
Coarse spray-wind speed 4-10 mph	0.96
Coarse spray-wind speed >10 mph	0.96

Sprinkler	**Sd Factor**
Surface system	1.00
Microirrigation system	1.00
Pressure variation >40%; Uniformity < 70%; Application rate > Soil intake	0.86
Pressure variation >30%; Uniformity 70-80%; Application rate <= Soil intake	0.93
Pressure variation <=20%; Uniformity >80%; Application rate <= Soil intake	1.00

Table FL15-3 – Tabulation of Evaluating Factors – Systems Continued

Emitter Clogging	**E Factor**
Surface system	1.00
Sprinkler system	1.00
Bubbler-Treatment: none; Flushing: none; Temperature:149F; Sum of clogging: >20%	0.98
Bubbler-Treatment: screen; Flushing: manual; Temperature:122F; Sum of clogging: 15%	0.99
Bubbler-Treatment: screen + media filter; Flushing: periodic; Temperature:95F; Sum of clogging: 10%	0.99
Bubbler-Treatment: screen + media filter + chemical; Flushing: continuous; Temperature:68F; Sum of clogging: < 5%	1.00
Spray- Treatment: none; Flushing: none; Temperature:149F; Sum of clogging: >20%	0.96
Spray-Treatment: screen; Flushing: manual; Temperature:122F; Sum of clogging: 15%	0.97
Spray- Treatment: screen + media filter; Flushing: periodic; Temperature:95F; Sum of clogging: 10%	0.98
Spray- Treatment: screen + media filter + chemical; Flushing: continuous; Temperature:68F; Sum of clogging: < 5%	0.99
Dripper-no cover-Treatment: none; Flushing: none; Temperature: 149F; Sum of clogging: >20%	0.94
Dripper-no cover- Treatment: screen; Flushing: manual; Temperature:122F; Sum of clogging: 15%	0.95
Dripper-no cover- Treatment: screen + media filter; Flushing: periodic; Temperature:95F; Sum of clogging: 10%	0.97
Dripper-no cover- screen + media filter + chemical; Flushing: continuous; Temperature:68F; Sum of clogging: < 5%	0.98
Dripper-covered-Treatment: none; Flushing: none; Temperature: 149F; Sum of clogging: >20%	0.92
Dripper-covered - Treatment: screen; Flushing: manual; Temperature:122F; Sum of clogging: 15%	0.94
Dripper-covered - Treatment: screen + media filter; Flushing: periodic; Temperature:95F; Sum of clogging: 10%	0.95
Dripper-covered - screen + media filter + chemical; Flushing: continuous; Temperature:68F; Sum of clogging: < 5%	0.97
Dripper-underground-Treatment: none; Flushing: none; Temperature: 149F; Sum of clogging: >20%	0.90
Dripper-underground - Treatment: screen; Flushing: manual; Temperature:122F; Sum of clogging: 15%	0.92
Dripper-underground - Treatment: screen + media filter; Flushing: periodic; Temperature:95F; Sum of clogging: 10%	0.94
Dripper-underground - screen + media filter + chemical; Flushing: continuous; Temperature:68F; Sum of clogging: < 5%	0.96

Table FL15-3 – Tabulation of Evaluating Factors – System Continued

Drip/Micro	**Sd Factor**
Surface system	1.00
Sprinkler system	1.00
Excellent coefficient of variability (CV)-flow variability +/- 30%	0.94
Excellent coefficient of variability (CV)-flow variability +/- 15%	0.97
Excellent coefficient of variability (CV)-flow variability +/- 5%	1.00
Average coefficient of variability (CV)-flow variability +/- 30%	0.92
Average coefficient of variability (CV)-flow variability +/- 15%	0.95
Average coefficient of variability (CV)-flow variability +/- 5%	0.98
Marginal coefficient of variability (CV)-flow variability +/- 30%	0.90
Marginal coefficient of variability (CV)-flow variability +/- 15%	0.93
Marginal coefficient of variability (CV)-flow variability +/- 5%	0.96

Figure FL15-1 – Water Measurement Factor, Md

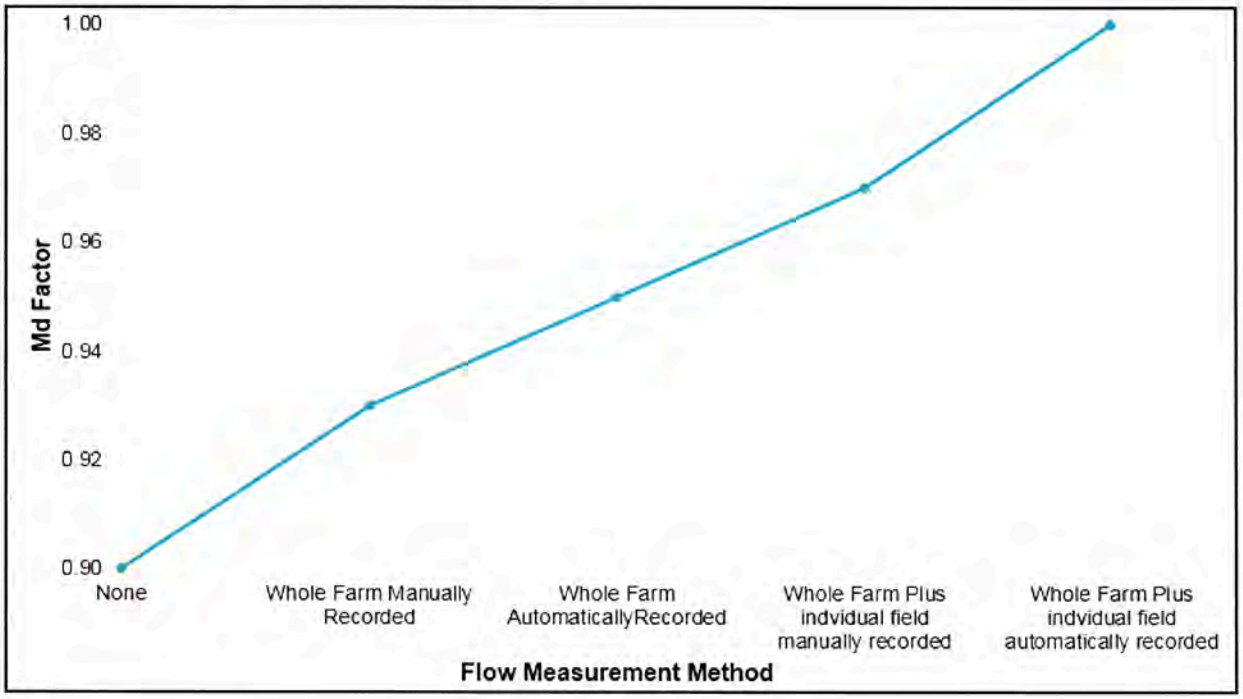


Figure FL15-2 – Soil Moisture/Scheduling Factor, S

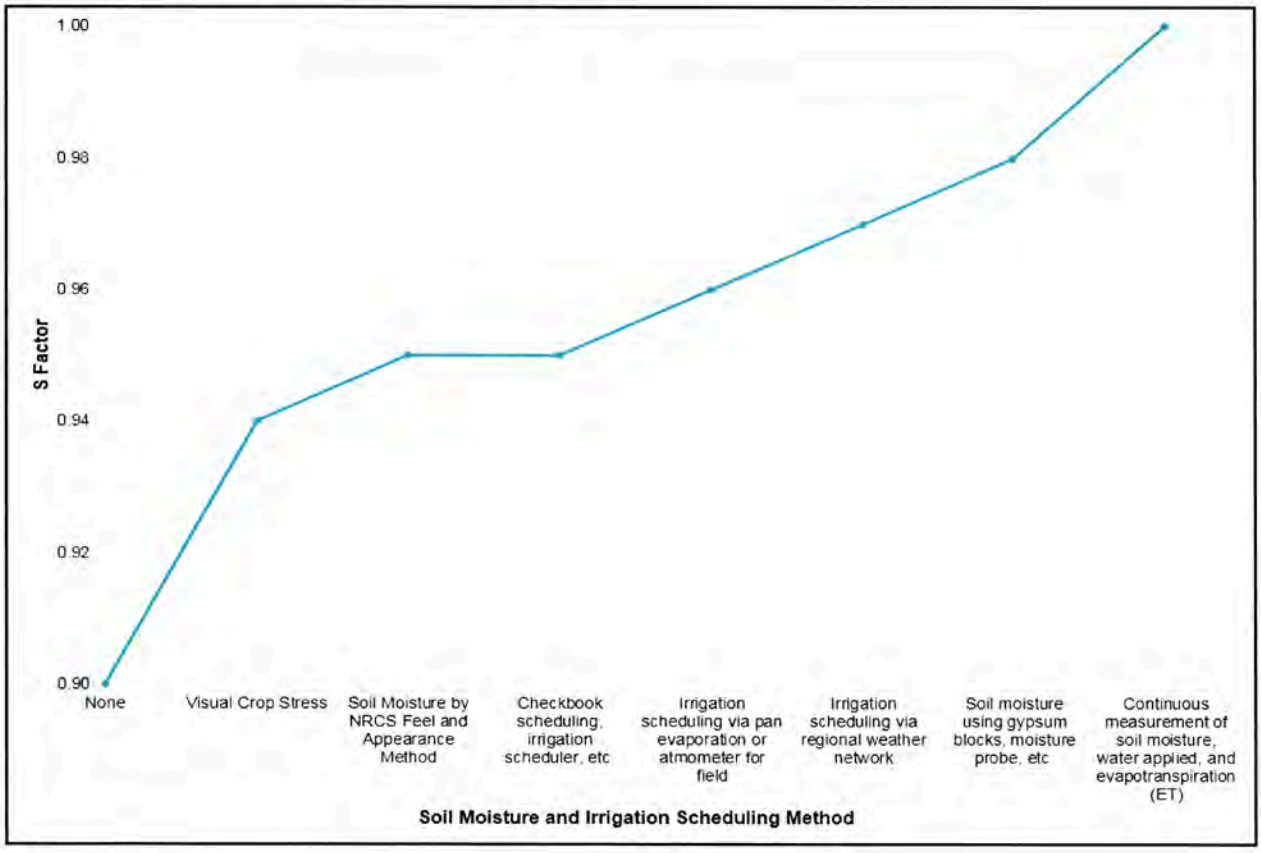


Figure FL15-3 – Irrigator Skill Factor, I

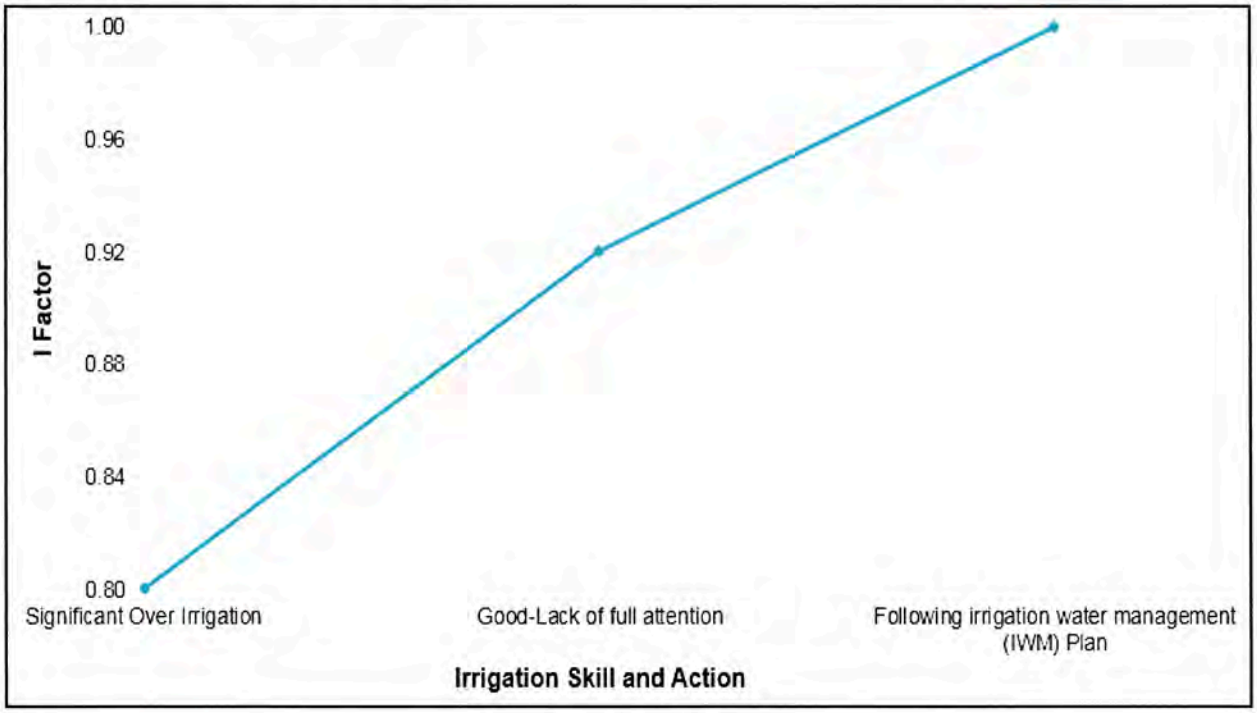


Figure FL15-4 – Maintenance Factor, M

Figure FL15-5 – Water Delivery Factor, D

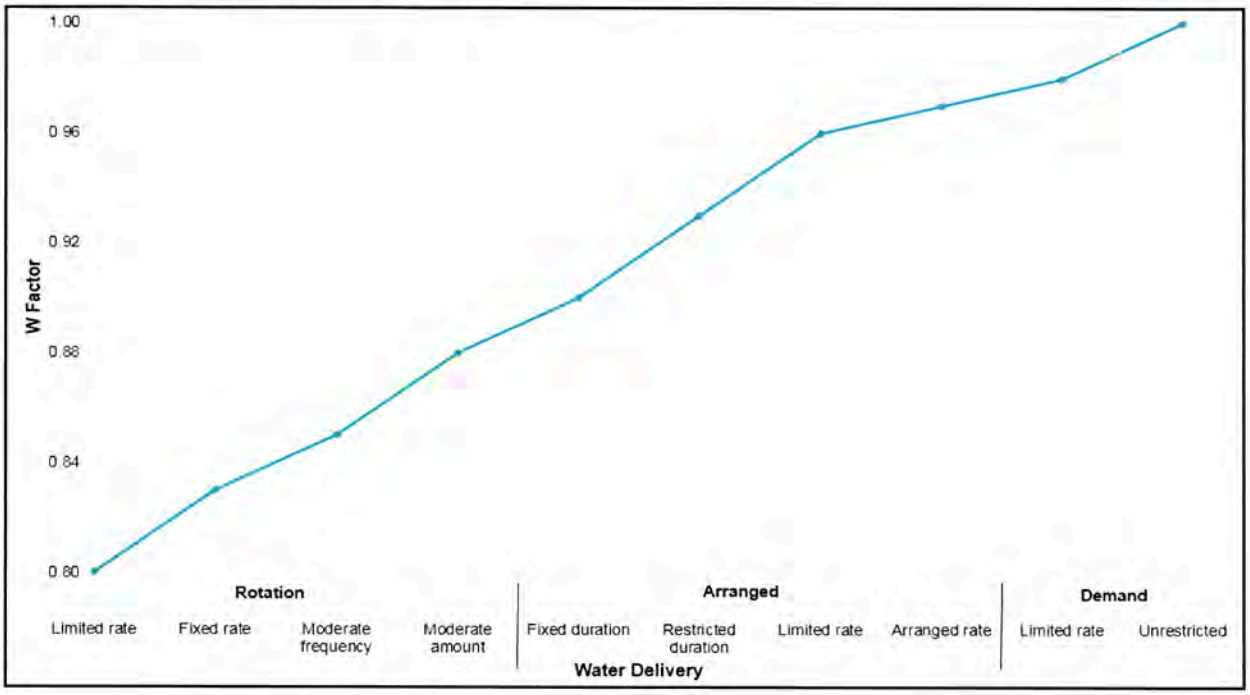


Figure FL15-6 – Soil Condition Index Factor, Sc

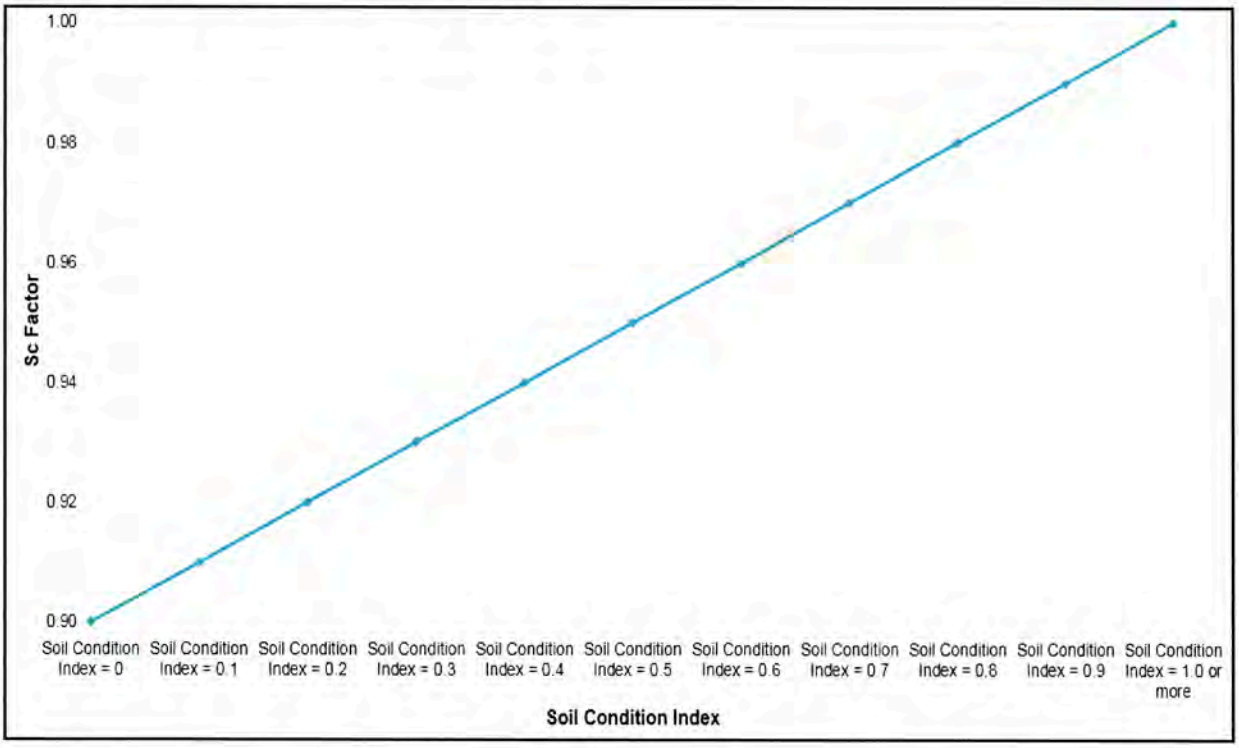


Figure FL15-7 – Distribution System Factor, Wc

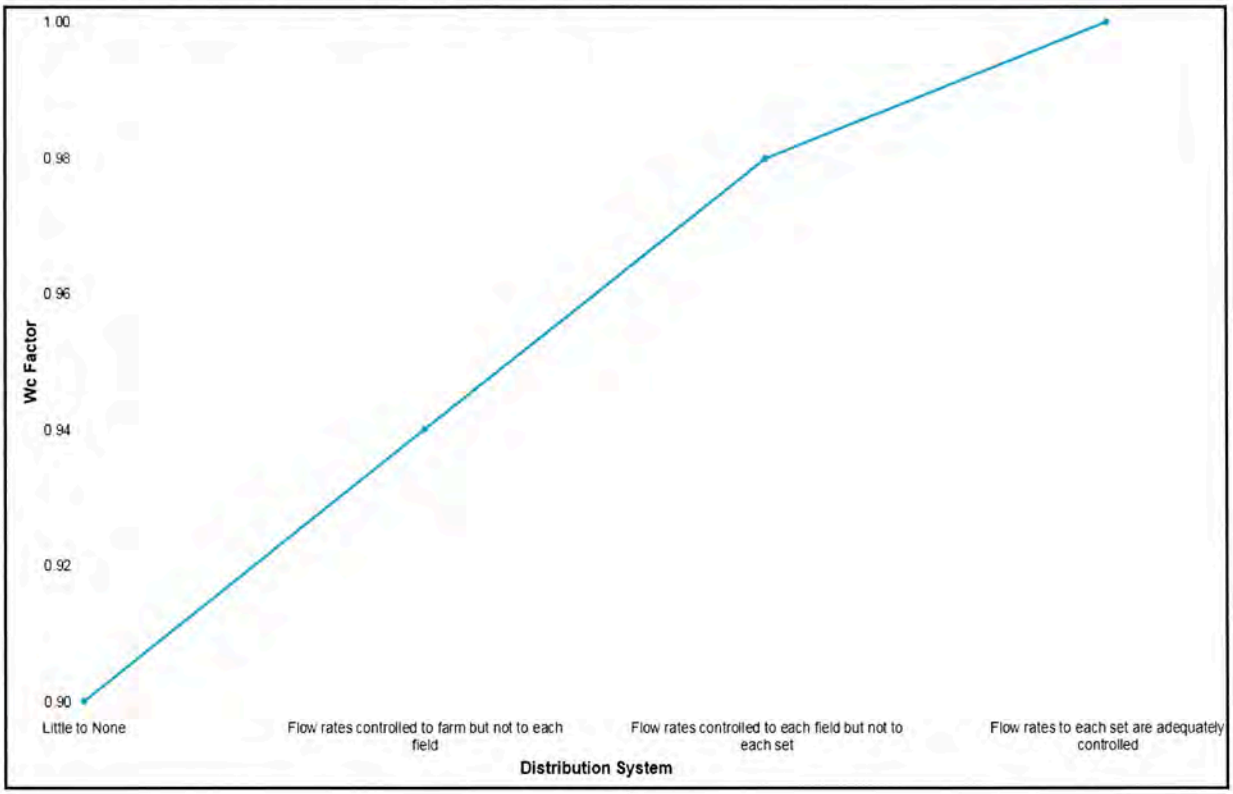


Figure FL15-8 –Conveyance Efficiency Factor, Ce

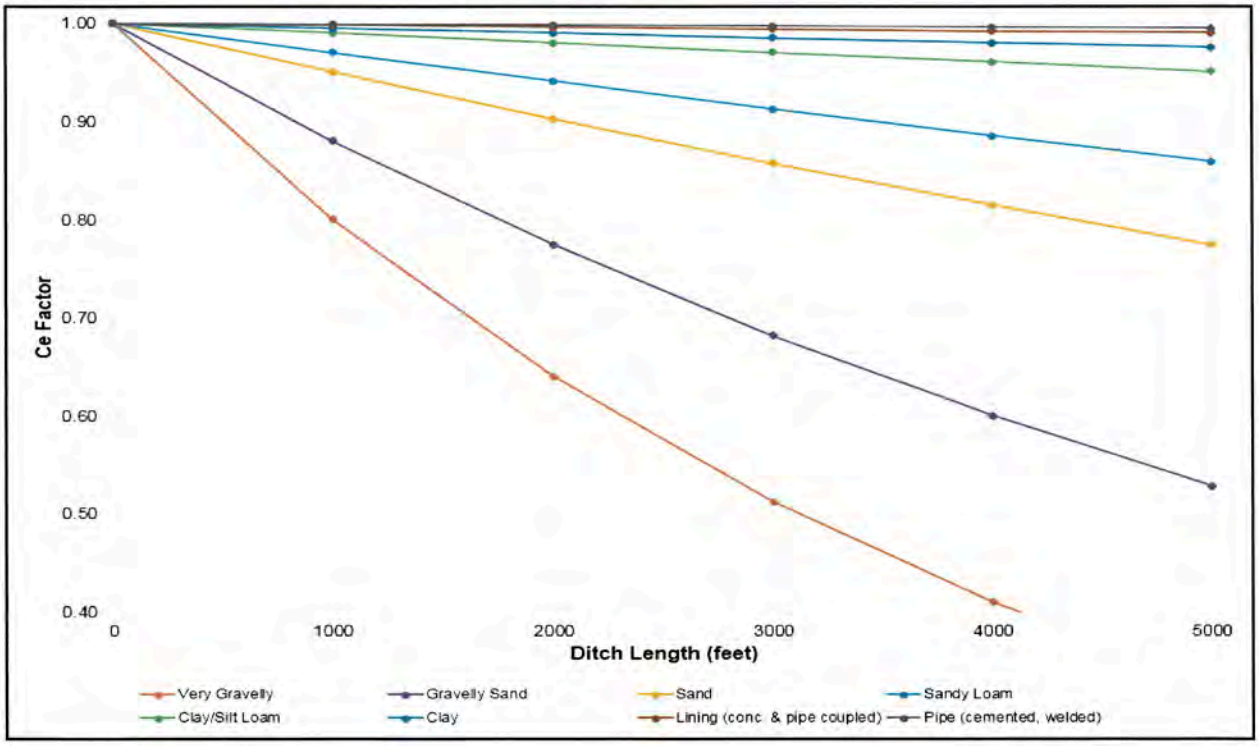


Figure FL15-9 – Land Leveling Factor, L (Refer to Table FL15-4)

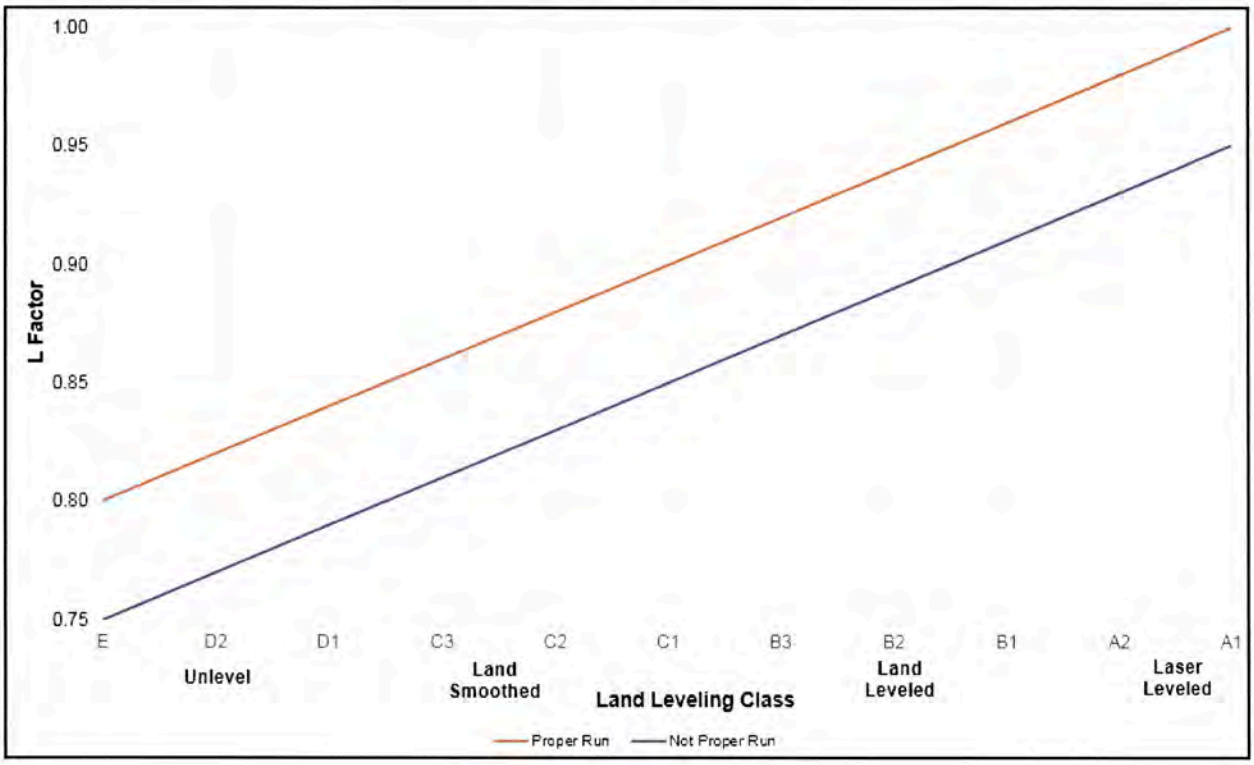


Table FL15-4 – Relief Classes for Surface Irrigated Land

Class	Irrigation Slope [1/]	Cross Slope	Possible Irrigation Water Efficiencies	Irrigation Operation Labor Requirements	Method Limitations	Leveling requirement
A_1	Uniform but not more than 0.05 percent	None	High	Very Low	None	None
A_2	Uniform	Uniform but not more 0.3 percent			Length of level borders is restricted.	
B_1		Variable but not more than 0.3			Length of level borders restricted. Border widths are restricted.	Leveling desirable to increase length or width of level borders.
B_2		Either uniform or variable and more than 0.3 percent but not more than 0.5 percent.		Low		Leveling desirable to reduce labor requirement.
B_3				Moderately Low	Border widths are very restricted. Level borders not permissible. Shallow furrows not permissible on coarse or very coarse textured soils. Corrugations must have down-slope of at least four times cross slope.	
C_1	Fairly uniform – (When slopes are over 0.5 percent, convex slopes have maximum grades not over twice minimum; concave slopes have a maximum grade not over 1 ½ times minimum. Undulating slopes not permissible.)	Uniform or variable but not more than 0.3 percent	Good		Level borders not permissible. Border widths are restricted.	Leveling desirable to reduce labor requirement and improve irrigation efficiencies.
C_2		Uniform or variable but not more than 0.5 percent.			Border widths are very restricted. Level borders not permissible. Shallow furrows not permissible on coarse or very coarse textured soils. Corrugations must have down-slope of at least four times cross slope.	
C_3	Either uniform or fairly uniform as defined above.	Either uniform or variable and more than 0.5 percent.		Moderate to High	Applicable only for contour ditches or to cross slope or contour furrow irrigation within special limitations of furrow depth and soil texture.	

Table FL15-4 – Relief Classes for Surface Irrigated Land Continued

Class	Irrigation slope1/	Cross slope	Possible irrigation water efficiencies	Irrigation operation labor requirements	Method Limitations	Leveling requirement
D_1	Variable but without level reaches or reverse grades	Variable but not more than 0.3 percent.	Poor	Moderate	Border widths are restricted. Level borders or corrugations not permissible.	Leveling required for conservation irrigation.
D_2		Variable but not more than 0.5 percent.		High	Border widths are very restricted. Level borders or corrugations not permissible. Shallow furrows not permissible on coarse or very coarse textured soils.	
E		Variable and more than 0.5 percent.	Very Poor	Very High	Applicable only for contour ditches or furrows within special limitations of furrow depth and soil texture.	

1/ Maximum and minimum downfield grades are limited by (1) requirements for drainage, (2) protection from erosion by storm runoff, and (3) the criteria for the irrigation.

Figure FL15-10 – Tailwater Reuse Factor, R

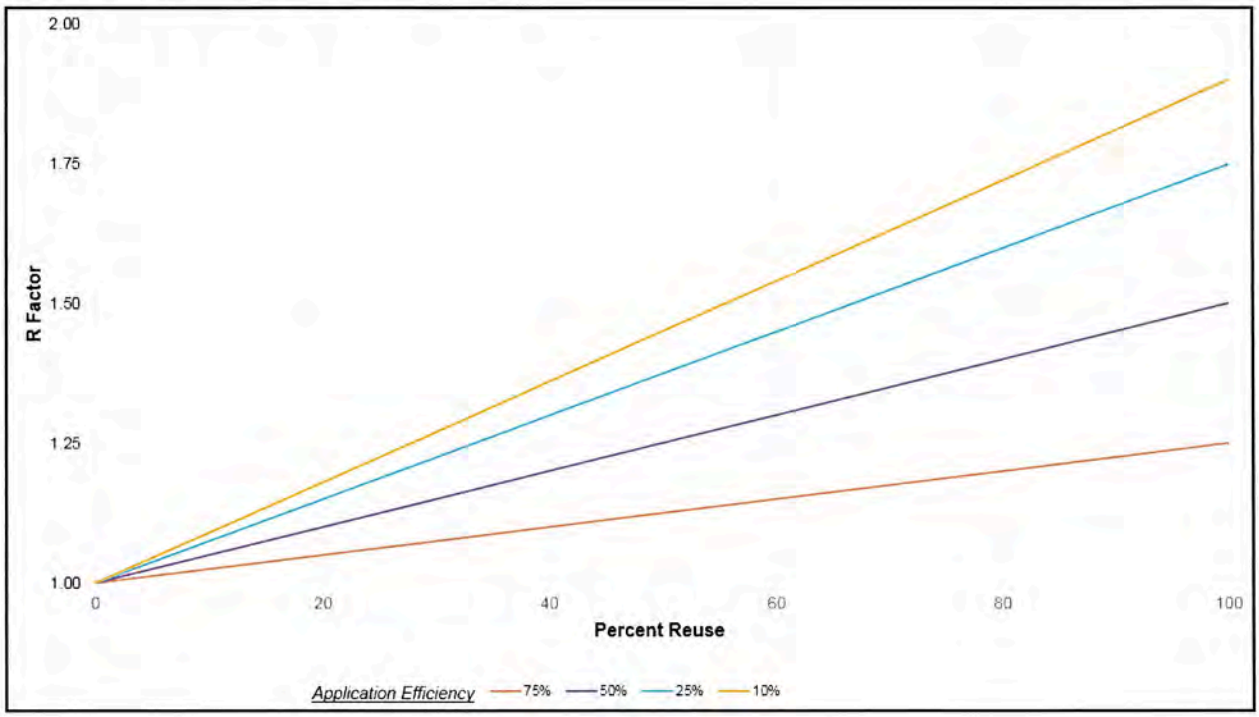


Figure FL15-11 – Climatic Factor, C

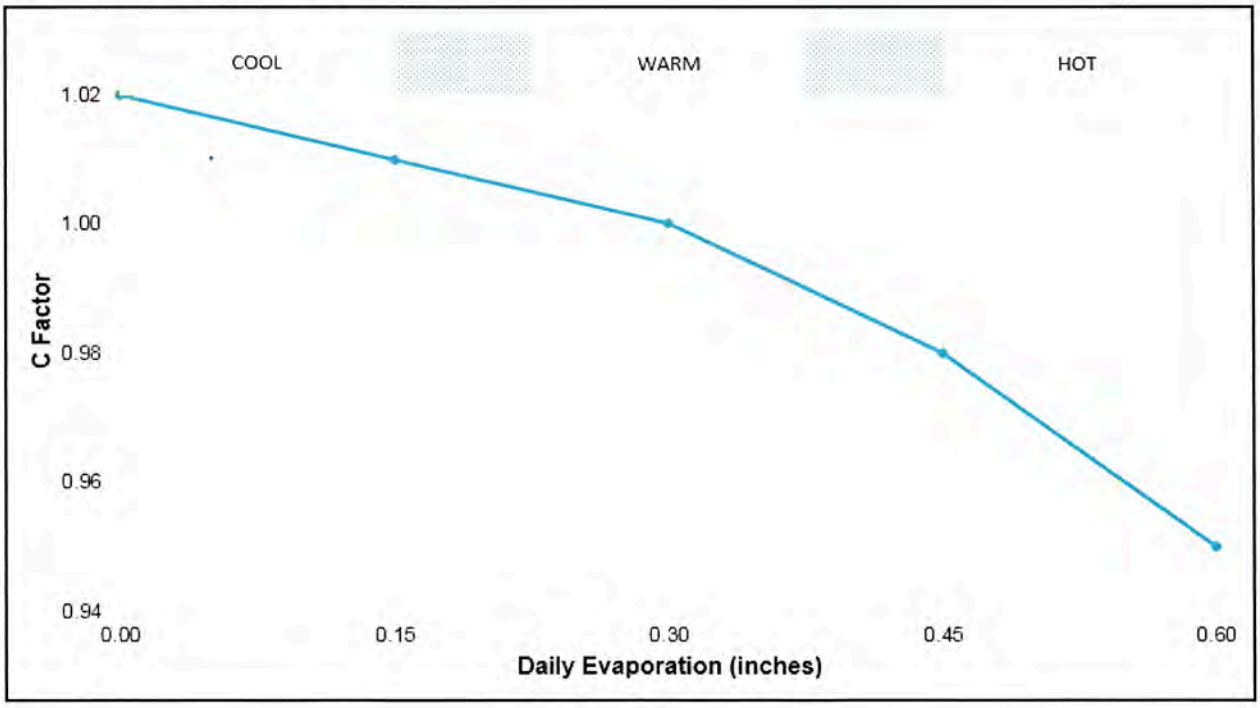


Figure FL15-12 – Wind Factor, W

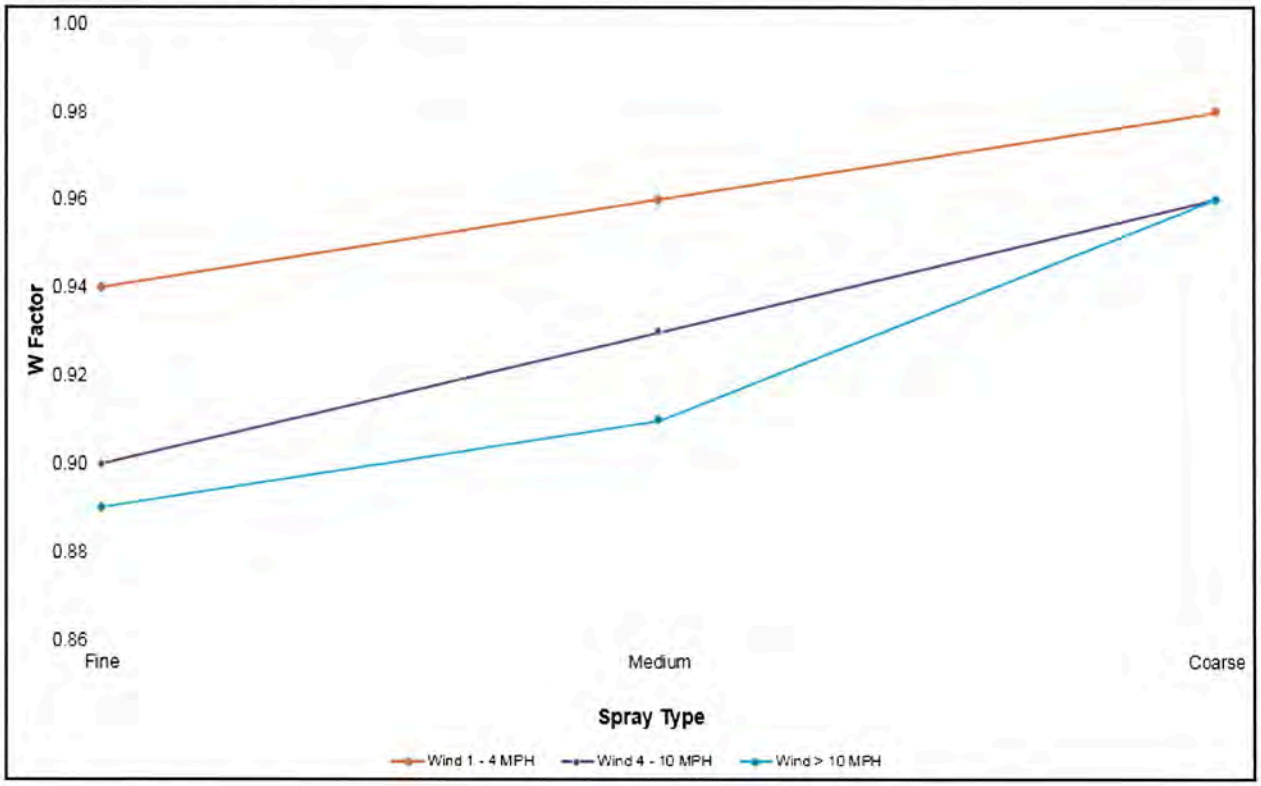


Figure FL15-13 – Sprinkler Design Factor, Sd

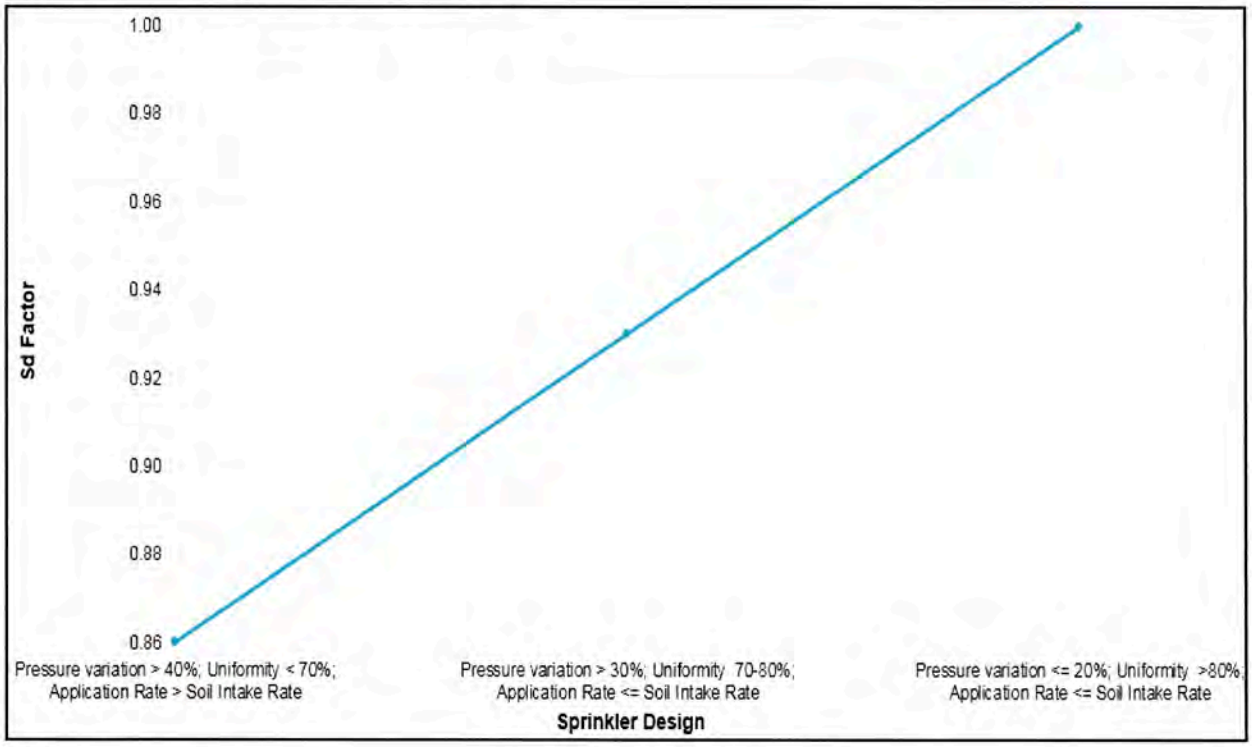


Figure FL15-14 – Emitter Clogging Factor, E

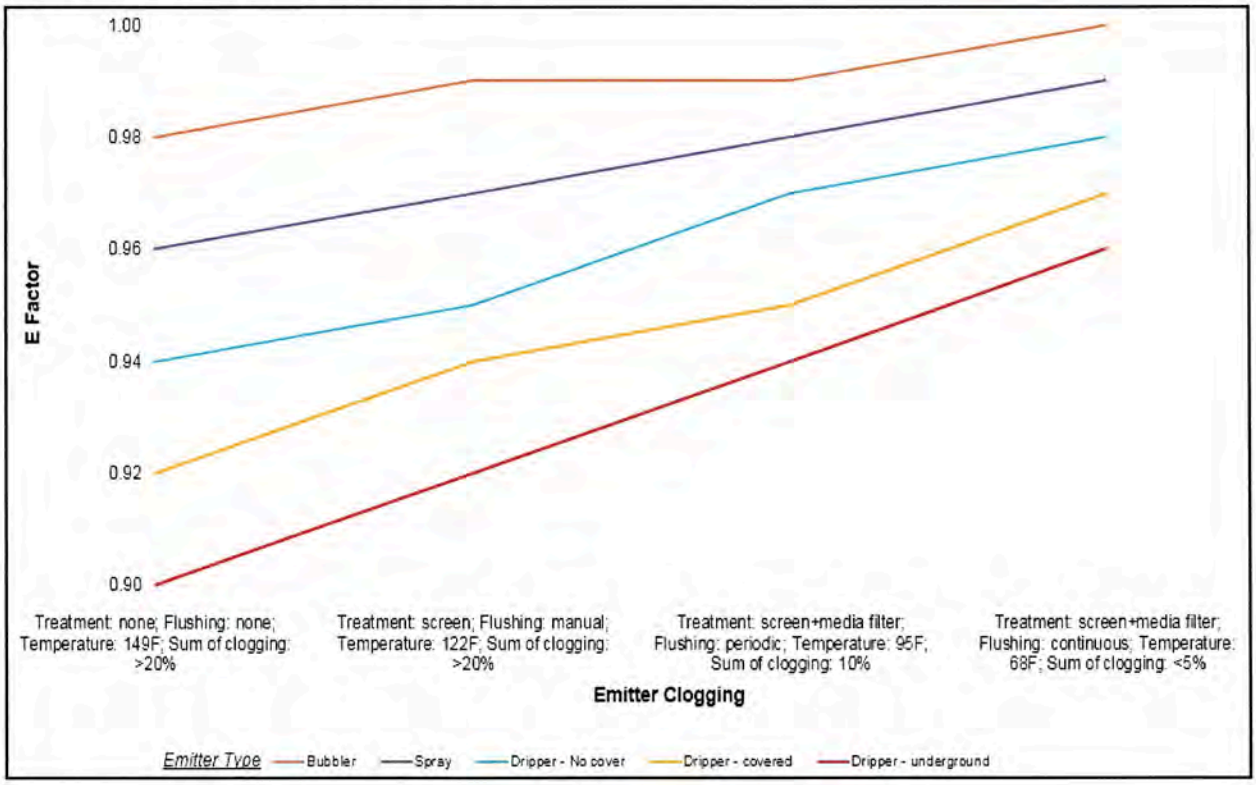
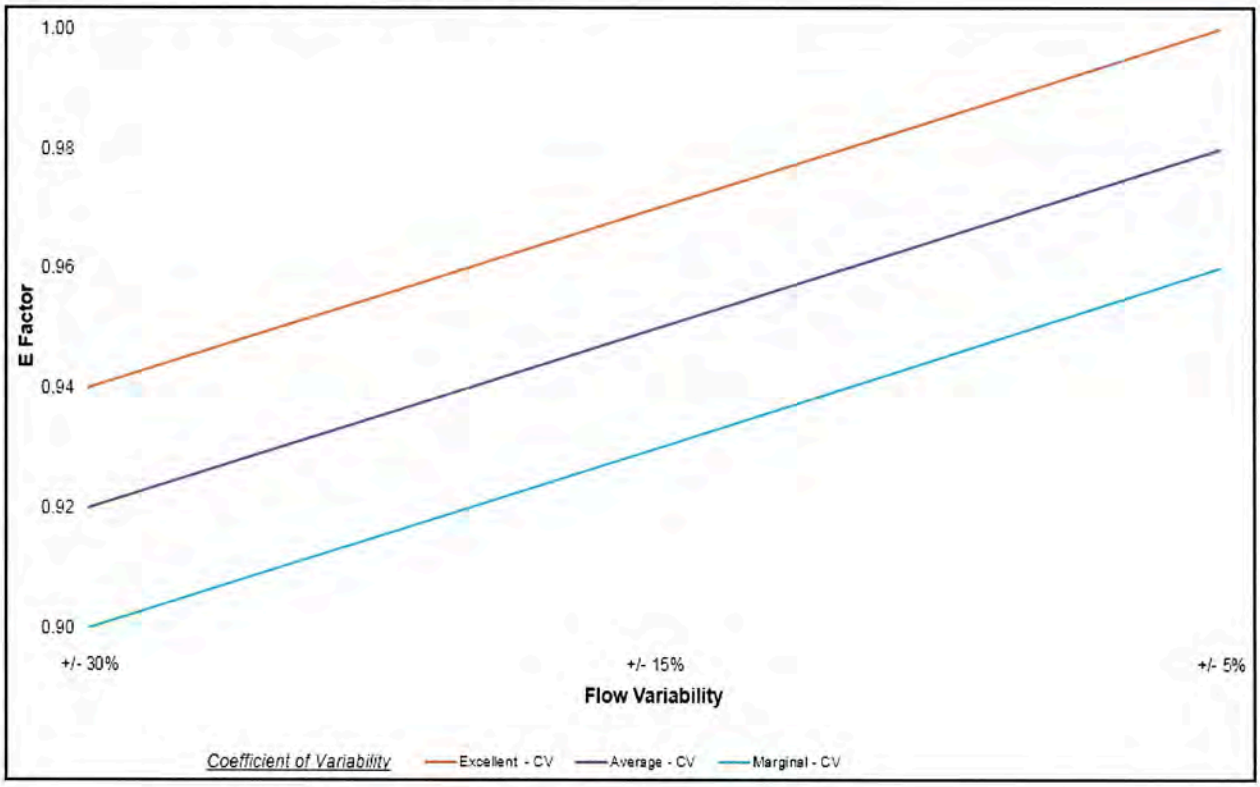


Figure FL15-15 – Drip/Micro Design Factor, T



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