Small-Scale Micro Irrigation Design and Components

<u>PART I: Design Considerations & Components</u>

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<u>PART II: Introduction to NRCS Design Tool</u>

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Webinar – 10 September, 2013

Objective

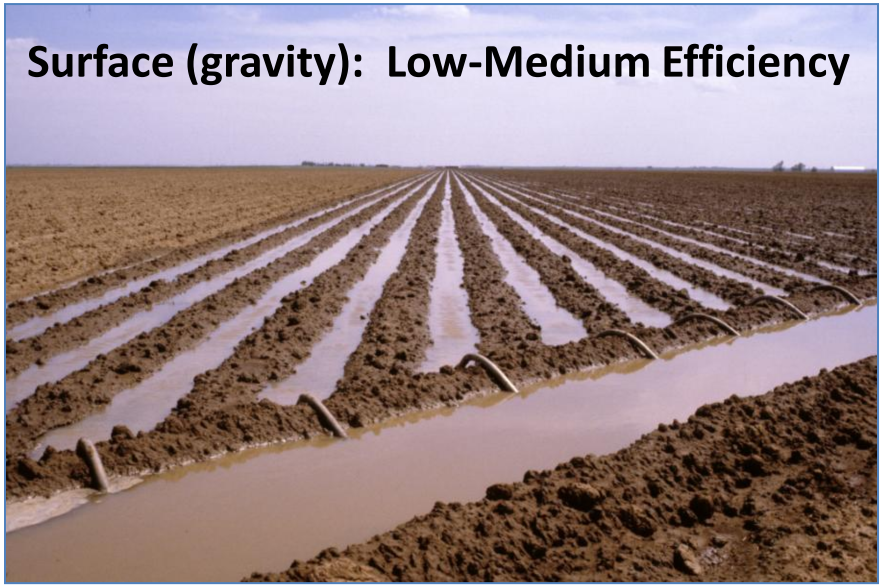
To provide the participants with basic knowledge of micro irrigation systems and the available resources for use in system planning and design.

Specifically:

1. System design considerations and components within the context of Conservation Practice Standard 441 (Irrigation System, Microirrigation)
2. Introduction to NRCS micro irrigation design spreadsheet tool

Small-scale is considered as systems with a fraction of an acre to a few acres in size including high tunnels (0.07 ac).

IRRIGATION SYSTEMS



Background

- Small-scale micro-irrigation is on the rise, especially in the South and East.
- Producers are taking advantage of NRCS' programs to install micro-irrigation systems to enhance conservation, produce quality, and income.
- Regardless of how small the micro-irrigation system is, it must be planned, designed, installed, and maintained properly or the system will perform poorly or even fail.
- Regardless of the size, design concepts, criteria, procedures, and components are for the most part the same.
- Regardless of the size, NRCS must ensure designs meet standard 441.

NRCS Needs

- Need adequate knowledge to engage the producers and third-party designers /distributors for proper design.
- Need to possess some design capabilities for small-scale systems.
- Need to know how to verify third-party designs and installations for compliance with NRCS standards.

Design Verification Checklist

AgWRAP Micro-irrigation System
Review Checklist

The purpose of this checklist is to determine a micro-irrigation system design's conformance with USDA-NRCS Conservation Practice Standards #441 (Irrigation System, Microirrigation) and #449 (Irrigation Water Management). Positive response to all questions confirms compliance. Any negative responses indicate additional information is necessary.

Applicant Name:

County:

Designer: B. B. Hobbs Company

Reviewed by: Date:

Question		
Is crop type indicated on design?	☑ YES	☐ NO
Is the discharge at each point less than 60 gal/hr?	☑ YES	☐ NO
Is the type of water source indicated on the plans?	☑ YES	☐ NO
Is backflow prevention included in the design?	☑ YES	☐ NO
Is a water meter included in the design?	☑ YES	☐ NO
Is the discharge rate of the emitter/bubbler/sprayer/spinner listed?	☑ YES	☐ NO
Is the number and spacing of emitters shown on the drawing(s)?	☑ YES	☐ NO
Is the design operating pressure listed?	☑ YES	☐ NO
Is the coefficient of variation (Cv) for the emitter less than 7%?	☑ YES	☐ NO
Is the mainline size and maximum flow rate listed in the design?	☑ YES	☐ NO
Is the pipeline velocity below 5 feet/second?	☑ YES	☐ NO
Are filters included in the design?	☑ YES	☐ NO
Is filter selection based on a pressure drop of 3 psi or less across the filter?	☑ YES	☐ NO
Will backwashing of the filters occur when the pressure drop reaches 10 psi?	☐ YES	☑ NO

Filter is a manual disk and as such cannot automatically flush

Question		
Does the micro-irrigation design include air/vacuum relief valves?	☑ YES	☐ NO
Are air/vacuum relief valves installed on both sides of control valves?	☑ YES	☐ NO
Is the flow variability along the lateral and across the blocks 20% or less?	☑ YES	☐ NO
Does the micro-irrigation design include pressure regulators?	☐ YES	☑ NO

Pressure Compensating drip line is used so regulators are not necessary.

Question		
Is there documentation supporting the system will meet peak water demand	☑ YES	☐ NO

IRRIGATION WATER MANAGEMENT

Question		
Is there an Operation & Maintenance Plan?	☑ YES	☐ NO
Does the plan indicate when irrigation should occur?	☑ YES	☐ NO
Is the volume of water for each irrigation cycle listed?	☑ YES	☐ NO
Does the plan discuss how to perform system maintenance?	☑ YES	☐ NO
Is the application rate per irrigation cycle included in the plan?	☑ YES	☐ NO
Does the plan address how to manage salinity and shallow water tables?	☐ YES	☑ NO

Not applicable

Question		
Does the plan explain the frequency of irrigation and application rates?	☑ YES	☐ NO
Is system operation such as start-up, shut-down, flushing, winterizing, and trouble-shooting included in the plan?	☑ YES	☐ NO

THIS PLAN **MEETS** **DOES NOT MEET** (circle one) APPLICABLE STANDARDS.

Comments:

NRCS Irrigation Resources

- NEH - Irrigation Guide (Part 652, 1997)
- NEH - Section 15 - Irrigation (Part 623, 1991)
- NEH - Chapter 15 – Irrigation (Part 650, EFH)

- NRCS Irrigation Training Toolbox
- NRCS Science & Technology Training Library
- NRCS State Irrigation Guides

http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17837.wba

Section 15 - Irrigation (NEH Part 623)

http://directives.sc.egov.usda.gov/viewDirective.aspx?hid=21440

Chapter 1 - Soil-Plant-Water Relationships
Chapter 2 - Irrigation Water Requirements
Chapter 4 - Border Irrigation
Chapter 5 - Furrow Irrigation
Chapter 7 - Trickle Irrigation ← In final revision
Chapter 8 - Irrigation Pumping Plants
Chapter 9 - Water Measurement
Chapter 11 - Sprinkle Irrigation
Chapter 12 - Land Leveling

NRCS Science & Technology Training Library

https://nrcs.sc.egov.usda.gov/st/ntsc_training/Shared%20Documents/Water.aspx

Topic : Water Management (12)

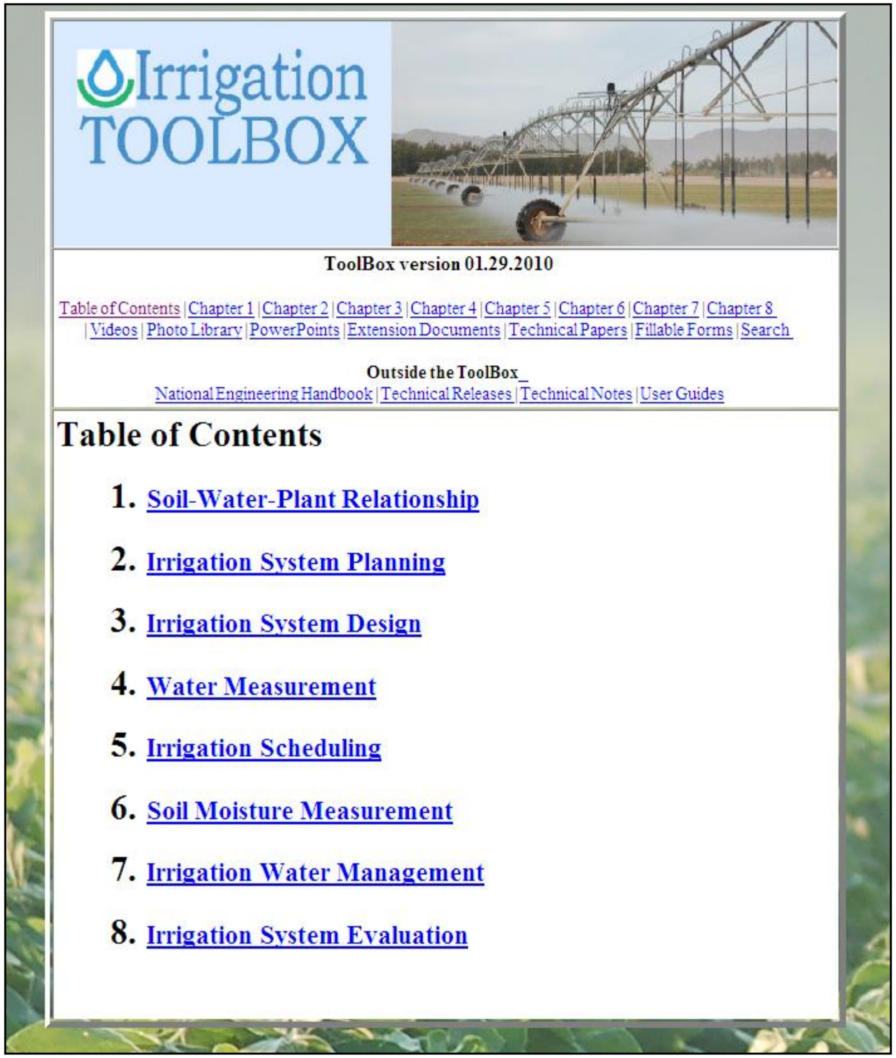
Soil Plant Air Water Hydrologic Analysis Model	Learn to use the Soil Plant Air Water (SPAW) Hydrologic Analysis Model to conduct water budgets of farm fields and simulate hydrologic performance of existing or planned ponds, waste storage facilities, and wetlands.	Presentation	Download
Designing Micro-irrigation Systems ←	Learn the basics of micro-irrigation and begin learning how to put newfound knowledge to work with a spreadsheet for designing small micro-irrigation systems.	Webinar	Download
Evaluation of Magnetic Meters for Irrigation Pipeline Measurement	This webinar discusses how a magnetic flow meter works, advantages and disadvantages of this type of meter, test results, and new guidelines for field applications.	Webinar	Download
Introduction to Micro-irrigation ←	Irrigation systems can be expensive to install and operate; learn about micro-irrigation as an alternative to save water and money.	Webinar	Download
Introduction to the Irrigation ToolBox	Viewers learn about the Irrigation ToolBox and are introduced to a collection of irrigation related lesson plans, books, videos, and photos.	Webinar	Download
Irrigation for Small Farms	Reliable harvests can be the difference between success and failure for small-scale farmers; learn about irrigation alternatives for small-scale farmers to help them along the pathway to success.	Webinar	Download
Manure Application through Center Pivots	Viewers of this webinar learn about the considerations and data needs related to selecting sprinkler packages for the application of agricultural wastewater.	Webinar	Download
MRBI: Drainage Water Management Awareness – Basic Principles and Practices	Participate in this training to raise your awareness level of basic agricultural drainage water management principles and practices.	Webinar	Download
Subsurface Drip Irrigation ←	Viewers learn about the basics of design, operation, and maintenance of Subsurface Drip Irrigation (SDI) systems.	Webinar	Download
The Terrace Design Tool	Take this training to learn the capabilities of the new Terrace Design Tool (TDT) and the basics of how TDT functions.	Webinar	Download
Utah's Grade Plane Solution for Land Leveling	Viewers learn about the Land Leveling standard (464) and tools and programs available to assist NRCS planners and engineers design and apply this practice.	Webinar	Download
Variable Frequency Drives for Irrigation Pumping	Viewers are introduced to a Techical Note on Variable Frequency Drive pumps.	Webinar	Download

http://conservationwebinars.net/

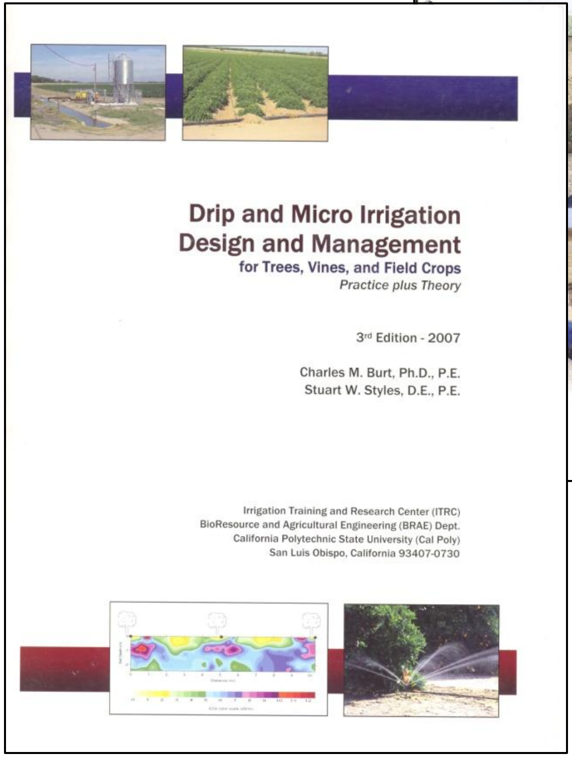
NRCS Irrigation Toolbox

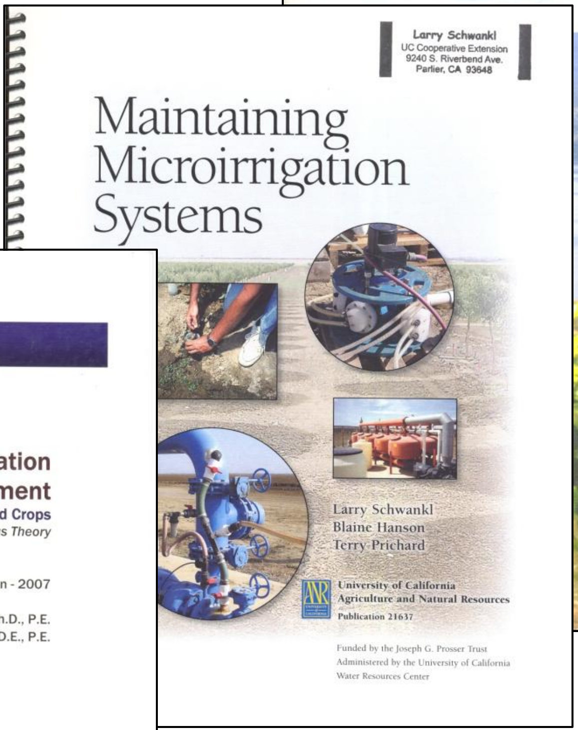
http://irrigationtoolbox.com/WebPages/Chapter%207.html

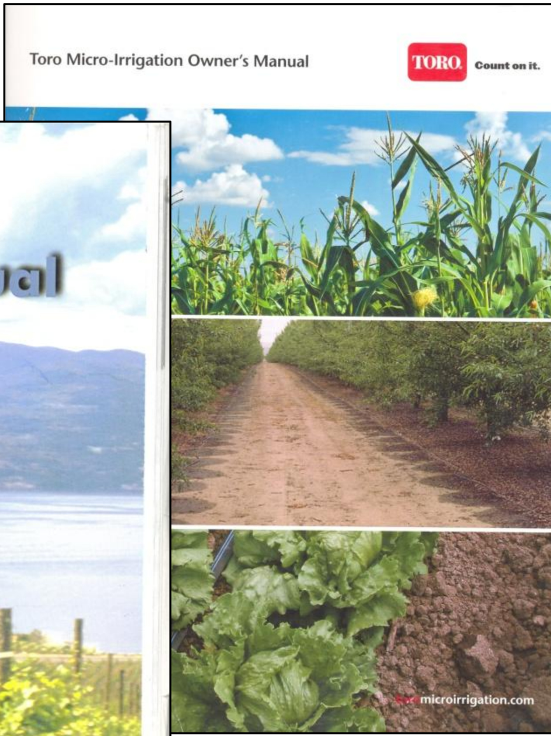
Watch "Video 020
"Micro Irrigation Management"



Other References

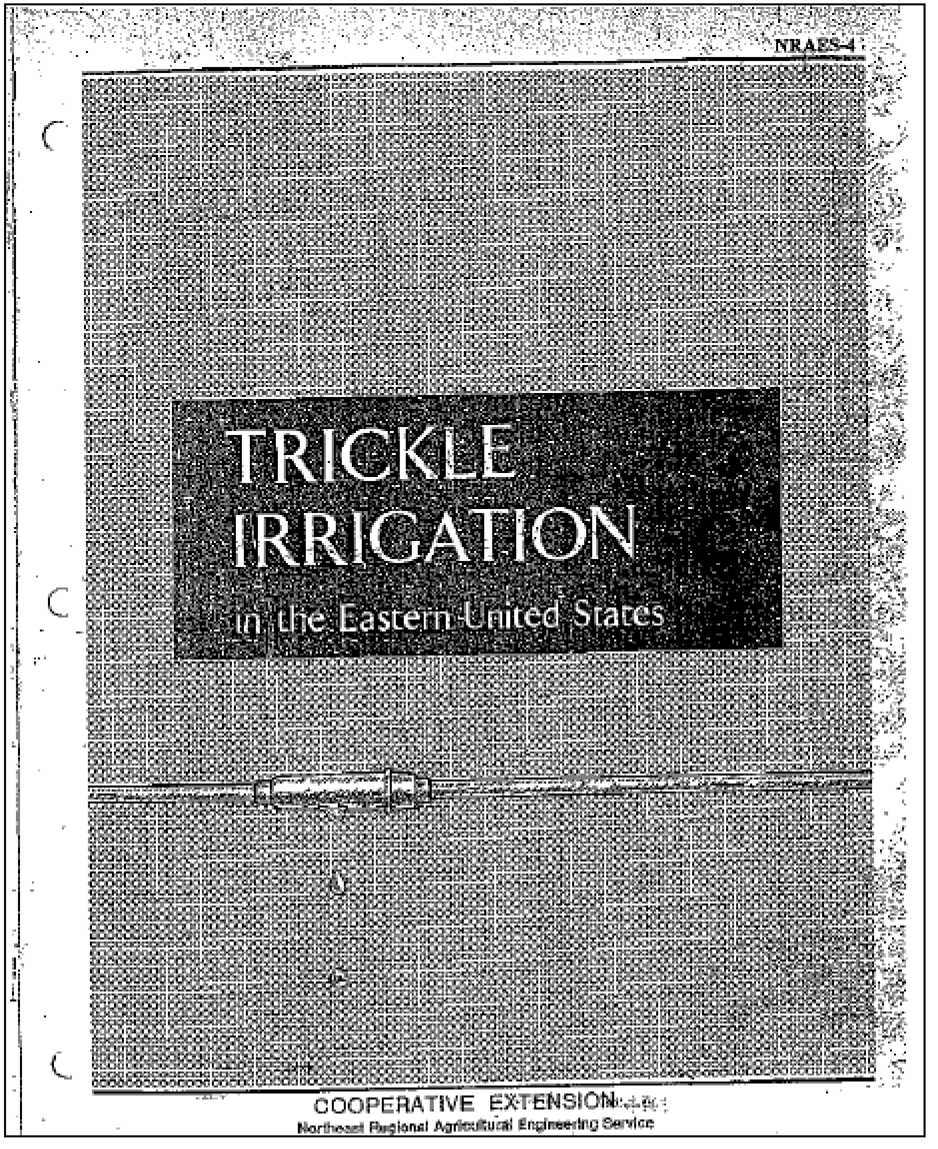




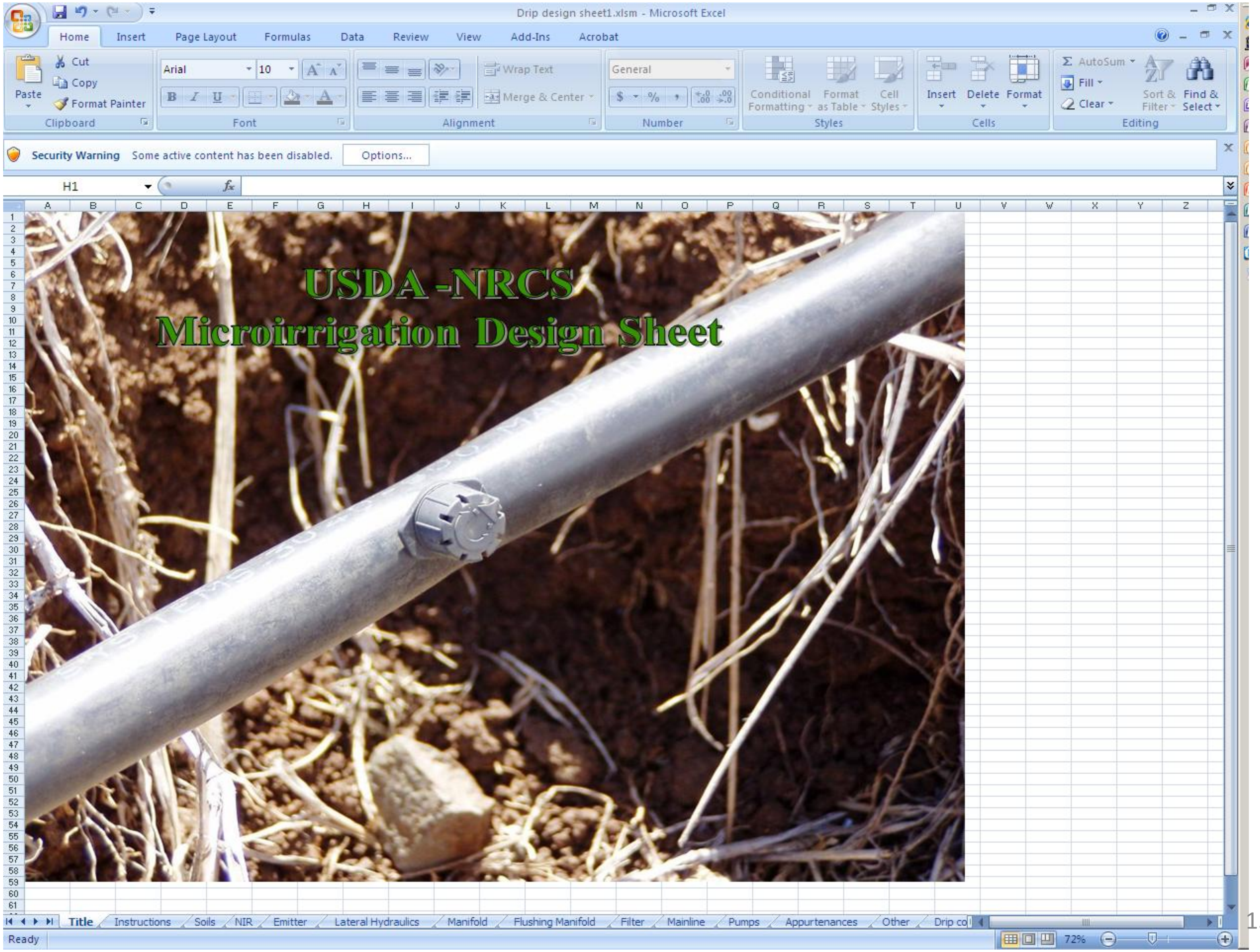


AquaFlow 3
Design Software

Other References



USDA-NRCS Micro Irrigation Design Tool

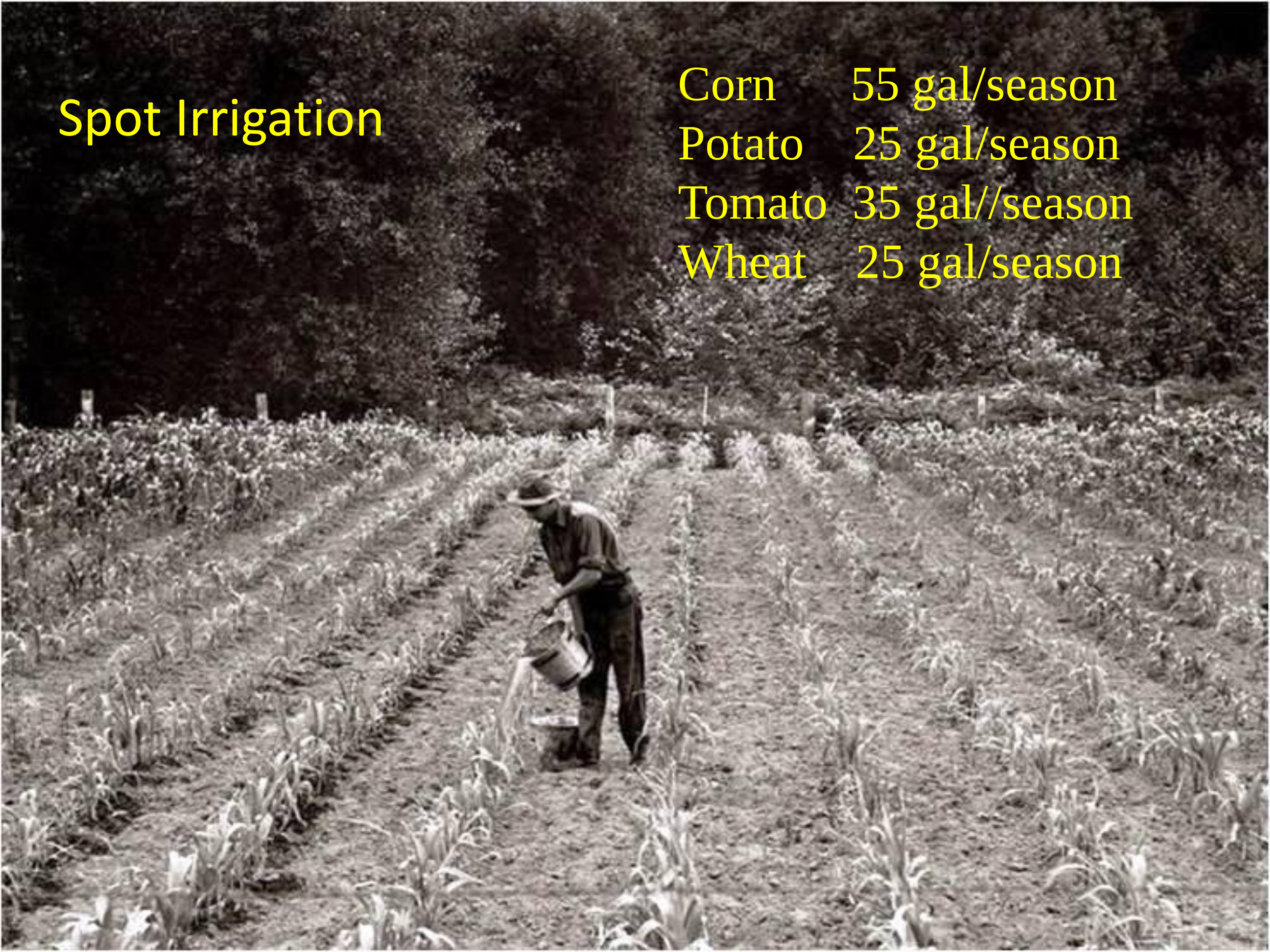


Recent Micro-Irrigation Activities

– Ruben Perez	Hammonton, NJ
– Barbara Broxterman	Morgantown, WV
– Yasmin Bennett	Walterboro, SC
– Anthony Harvey	Gainesville, FL
– Joy Sherrod, John Clark	Tarboro, NC
– Jill Malton	Salisbury, NC
– Leslie Wright	Rutland, VT
– Daniel DePietro	Tolland, CT
– Clare Prestwich	WNTSC, Portland, OR

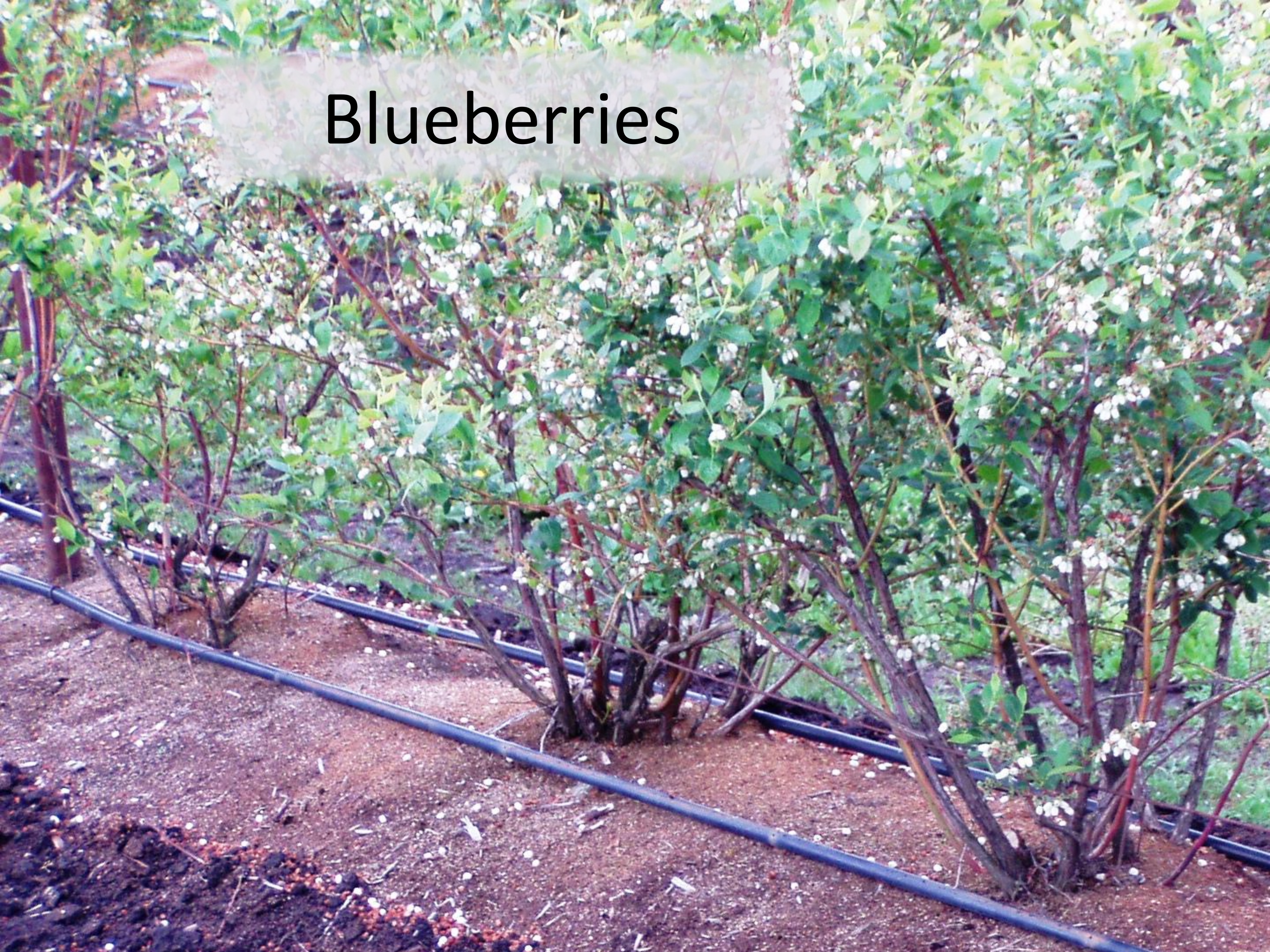
Definition

Micro irrigation is the broad classification of frequent, low volume, low pressure application of water on or beneath the soil surface by drip emitters, spaghetti tubes, drip tubes, basin bubblers, and spray or mini sprinklers.


Spot Irrigation
Corn 55 gal/season
Potato 25 gal/season
Tomato 35 gal//season
Wheat 25 gal/season

Modern Spot Irrigation

Blueberries

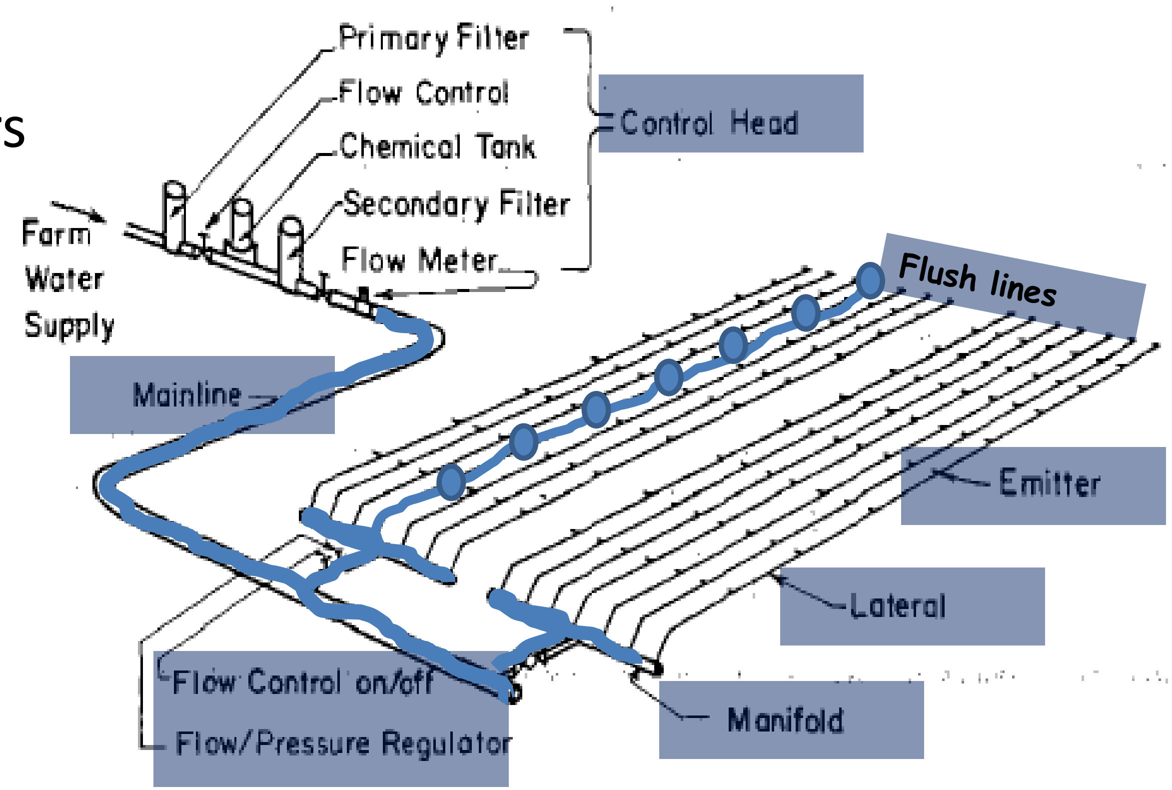



Strawberries


Tomatoes

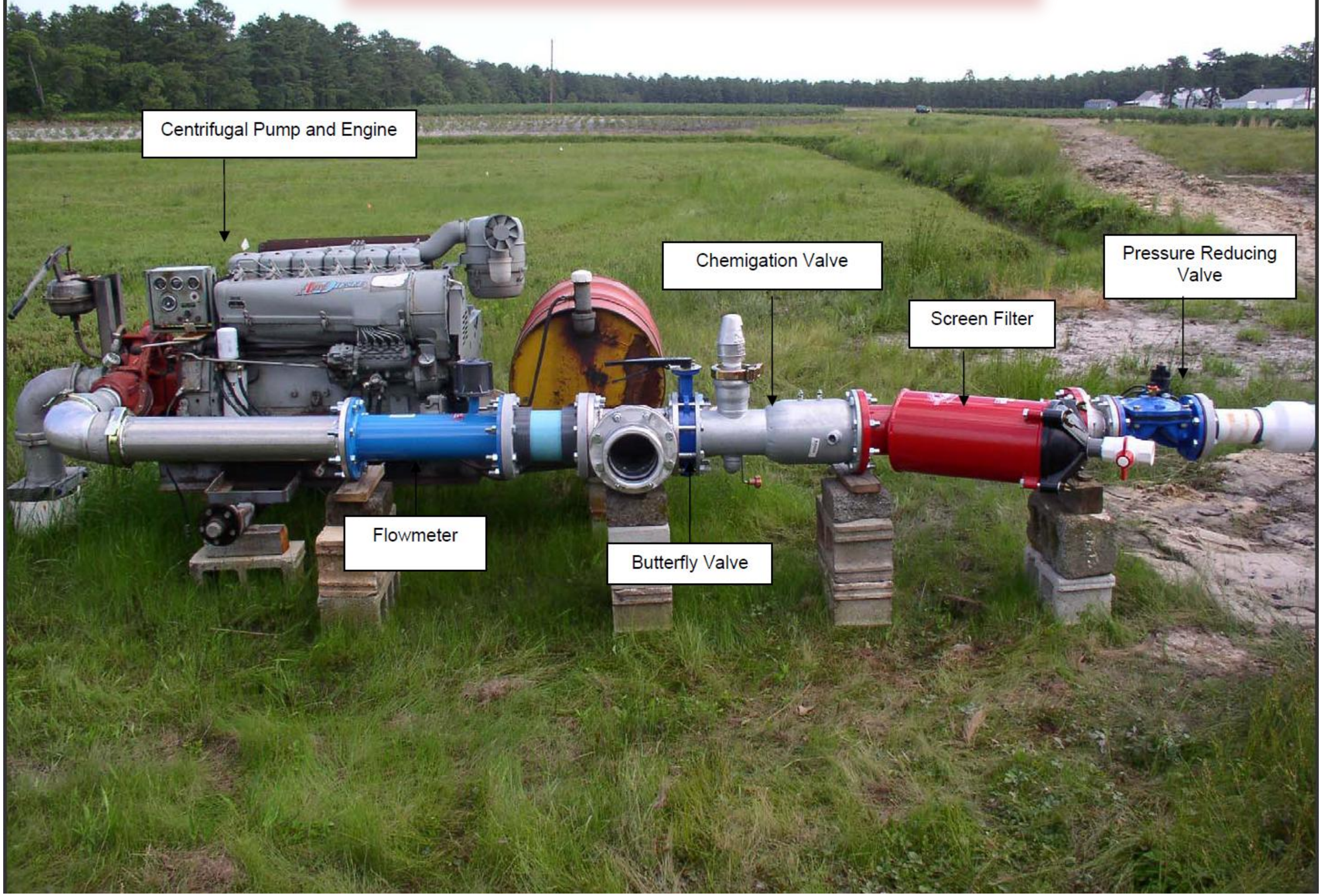
Basic Micro Irrigation System Components

- Control Head
- Mainline
- Manifolds
- Laterals/Emitters
- Flush lines
- Valves & else

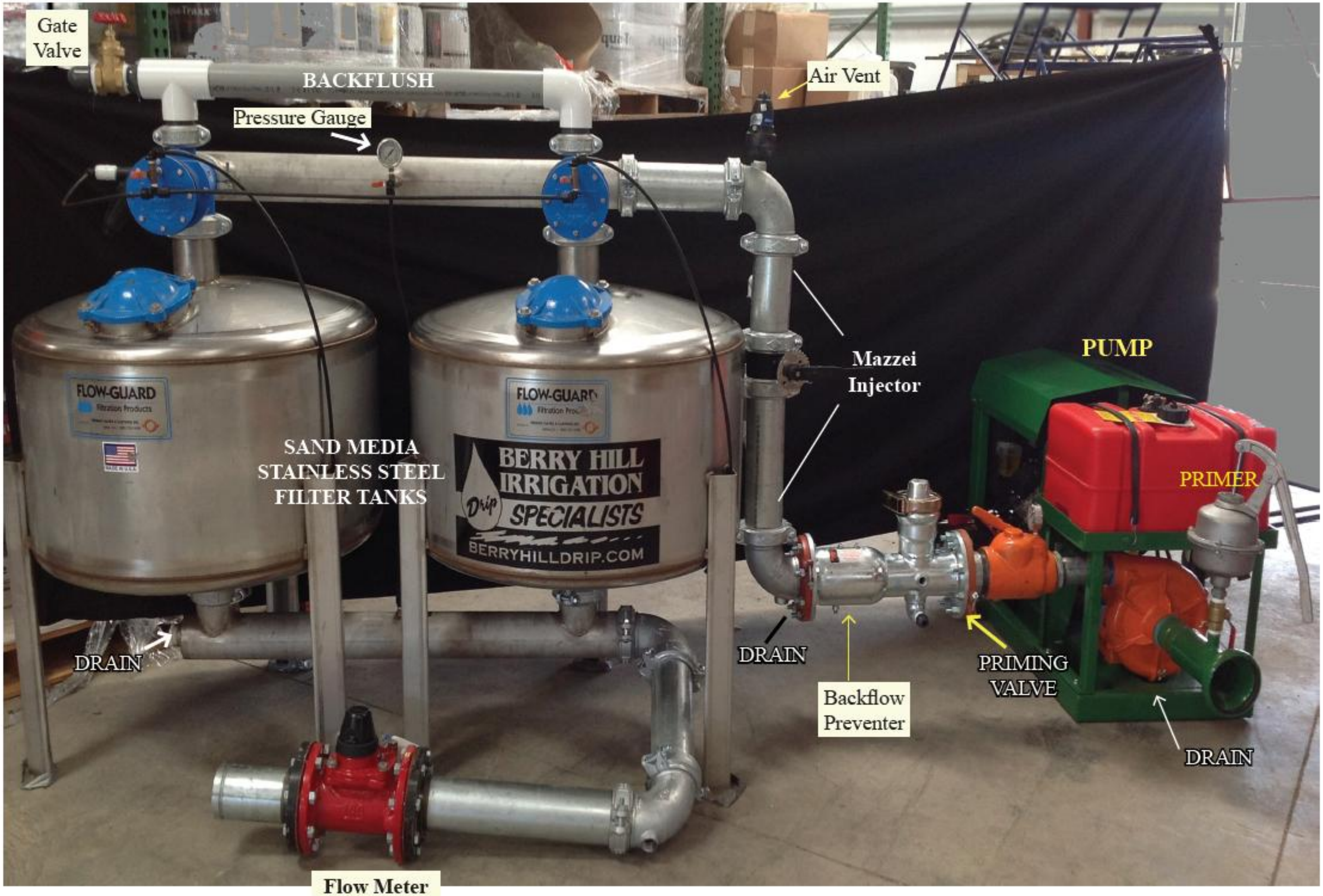


Filtration and Emitter

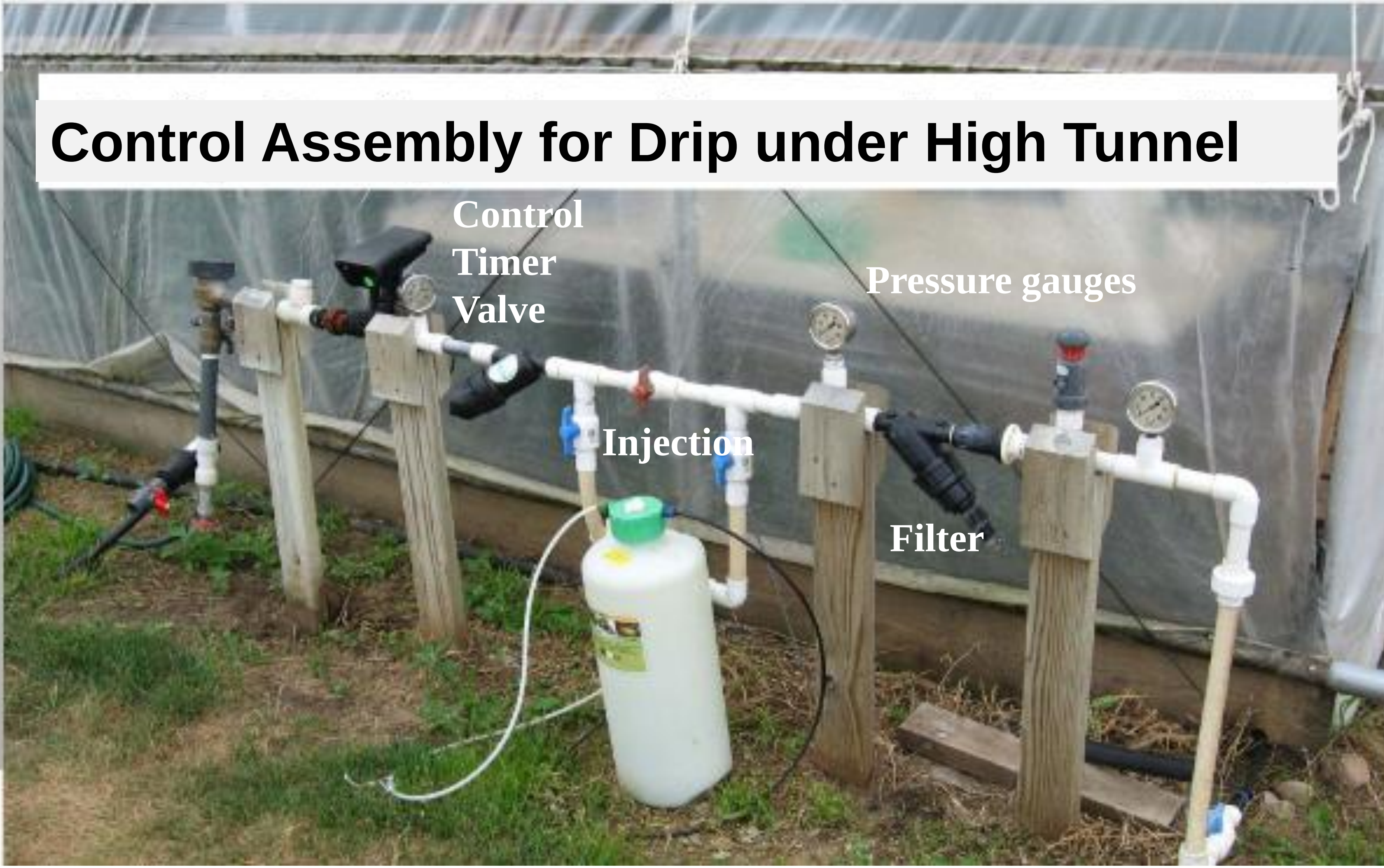
Control Head




Vacuum relief valve
Fertilizer Injector
Back flow prevention double check valve
Master valve
Pressure Regulator
Pressure Gages
Low pressure drain
Filter: Disc, screen or sand media tank
From Well


Gate Valve
BACKFLUSH
Air Vent
Pressure Gauge
Mazzei Injector
PUMP
FLOW-GUARD
Filtration Products
FLOW-GUARD
Filtration Products
SAND MEDIA
STAINLESS STEEL
FILTER TANKS
BERRY HILL
IRRIGATION
Drip
SPECIALISTS
BERRYHILLDRIP.COM
PRIMER
DRAIN
DRAIN
PRIMING VALVE
Backflow Preventer
DRAIN
Flow Meter

Control Assembly for Drip under High Tunnel



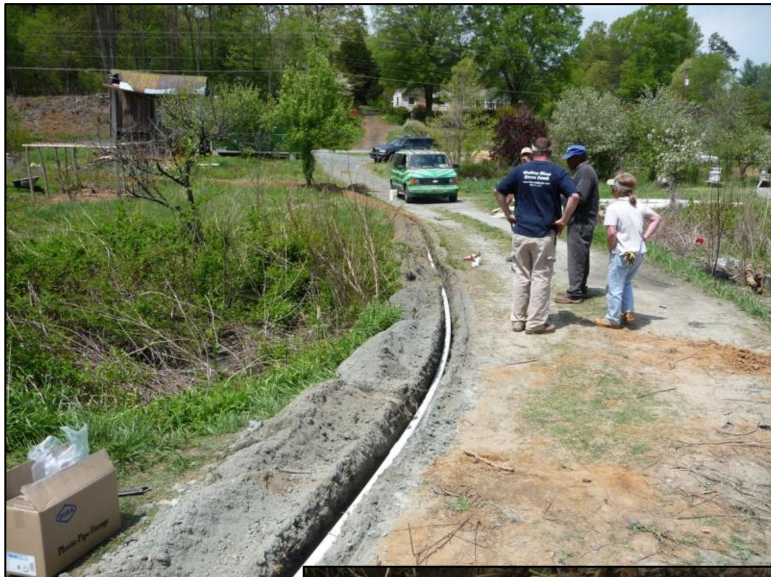
Typical Small-Scale Site

Typical Small-Scale Site

Water Source: Stream or Pond

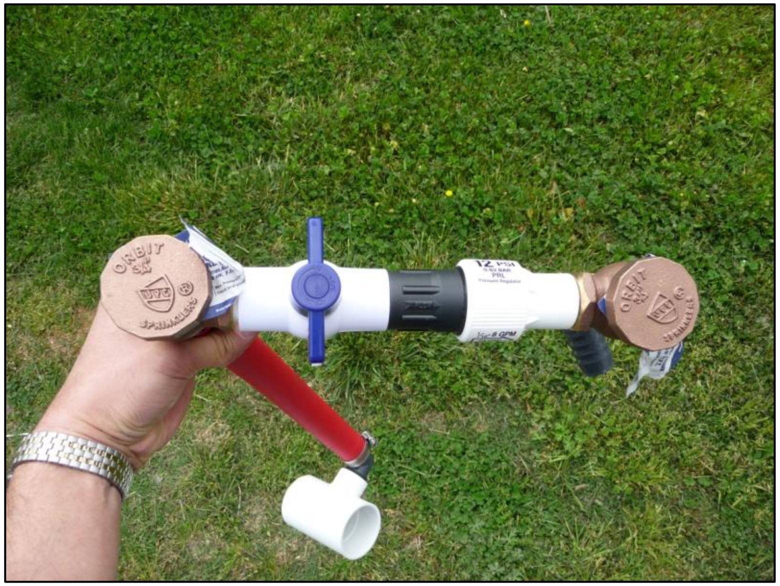
Typical Small-Scale Site

Buried PVC Mainline



Typical Small-Scale Site

Hydrants/Zone Controls



Typical Small-Scale Site
Tubing

Typical Small-Scale Site

Manifold-Lateral Connection

Control Head with Sand Media Filter

Why Pressure Tank?

Zone Control and Lay flat Mains and Manifolds

Paired Laterals with Lay flat

Double Chemigation Valve

Lateral Material/Types

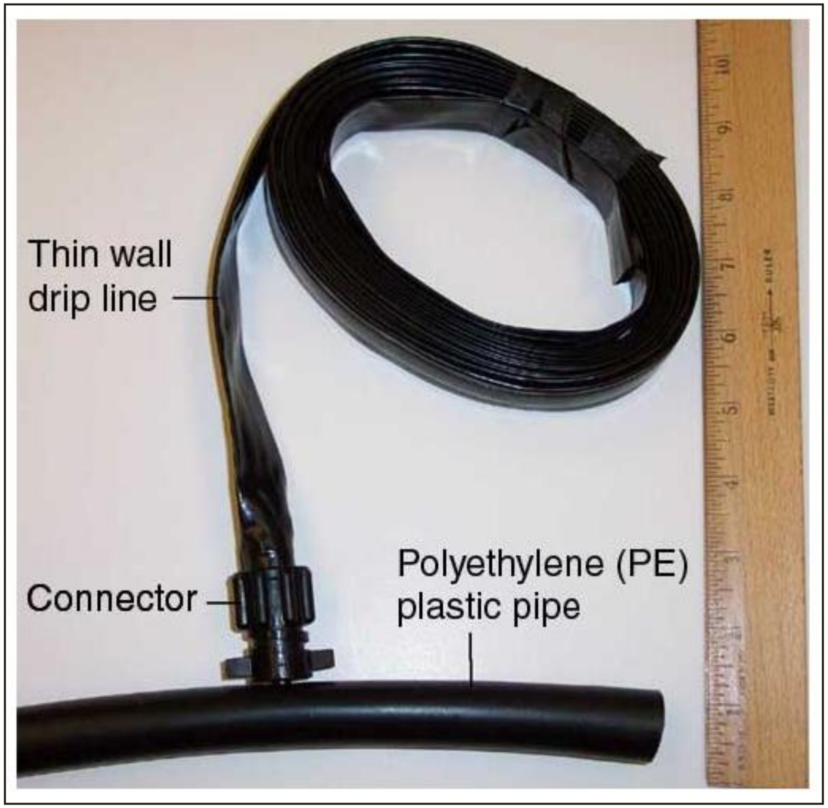
- Drip tape

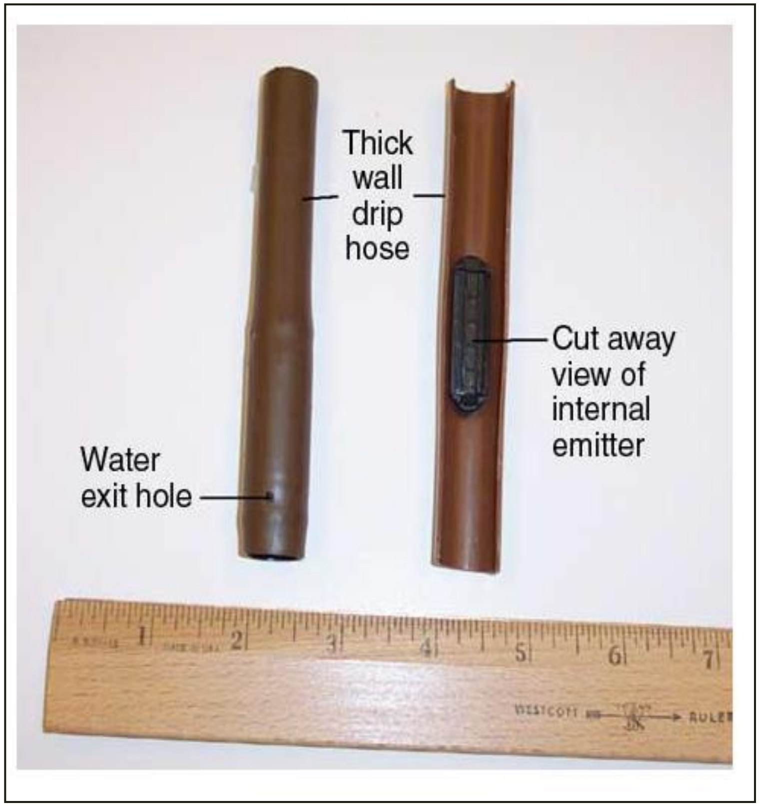
- Thin wall drip line

- Heavy wall drip line

- Polypipe with punch emitters
- Polypipe with sprays

Line source





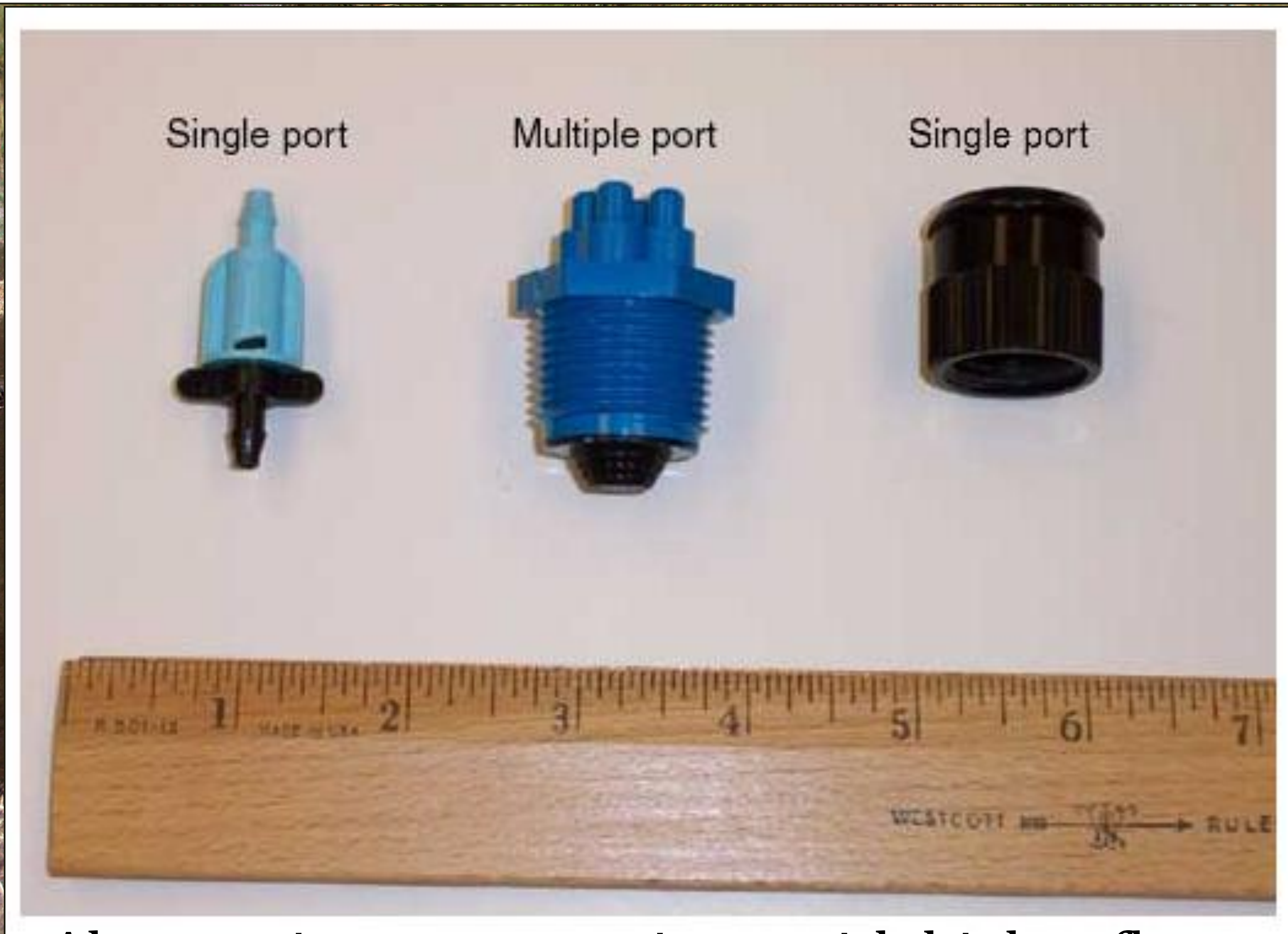
Line source emitters are suitable for closely spaced row crops in fields and gardens.

Thick line is more robust than thin, with higher pressure and flow ratings. Both types can be used above or below ground.

Point source

The point source mode is suited to wider-spaced plants such as fruit trees and in vineyards.

Basin Bubbler



Also a point source emitter, with higher flows and discharge patterns. 2 to 20 gph

Sprayers & Mini Sprinklers

Depending on the water throw patterns, the micro-sprinklers are referred to as mini-sprays, micro-sprays, jets, or spinners.

The flow rates of micro-sprinkler emitters vary from 3 gph to 30 gph depending on the orifice size and line pressure.

Emitter Flow-Pressure Relationship

$$Q = k\,(P)^x$$

Q = Flow rate (gph)

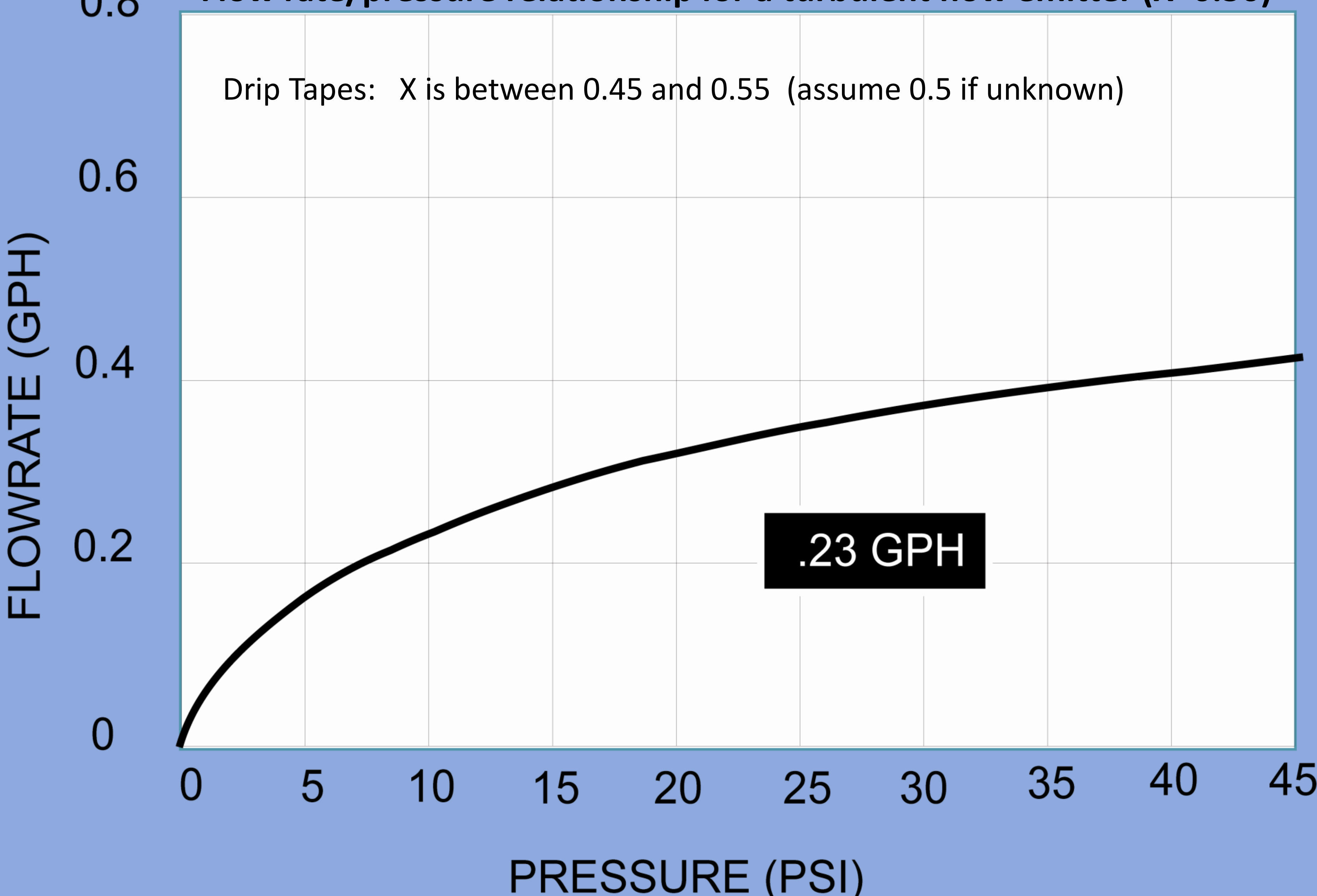
P = Pressure (psi)

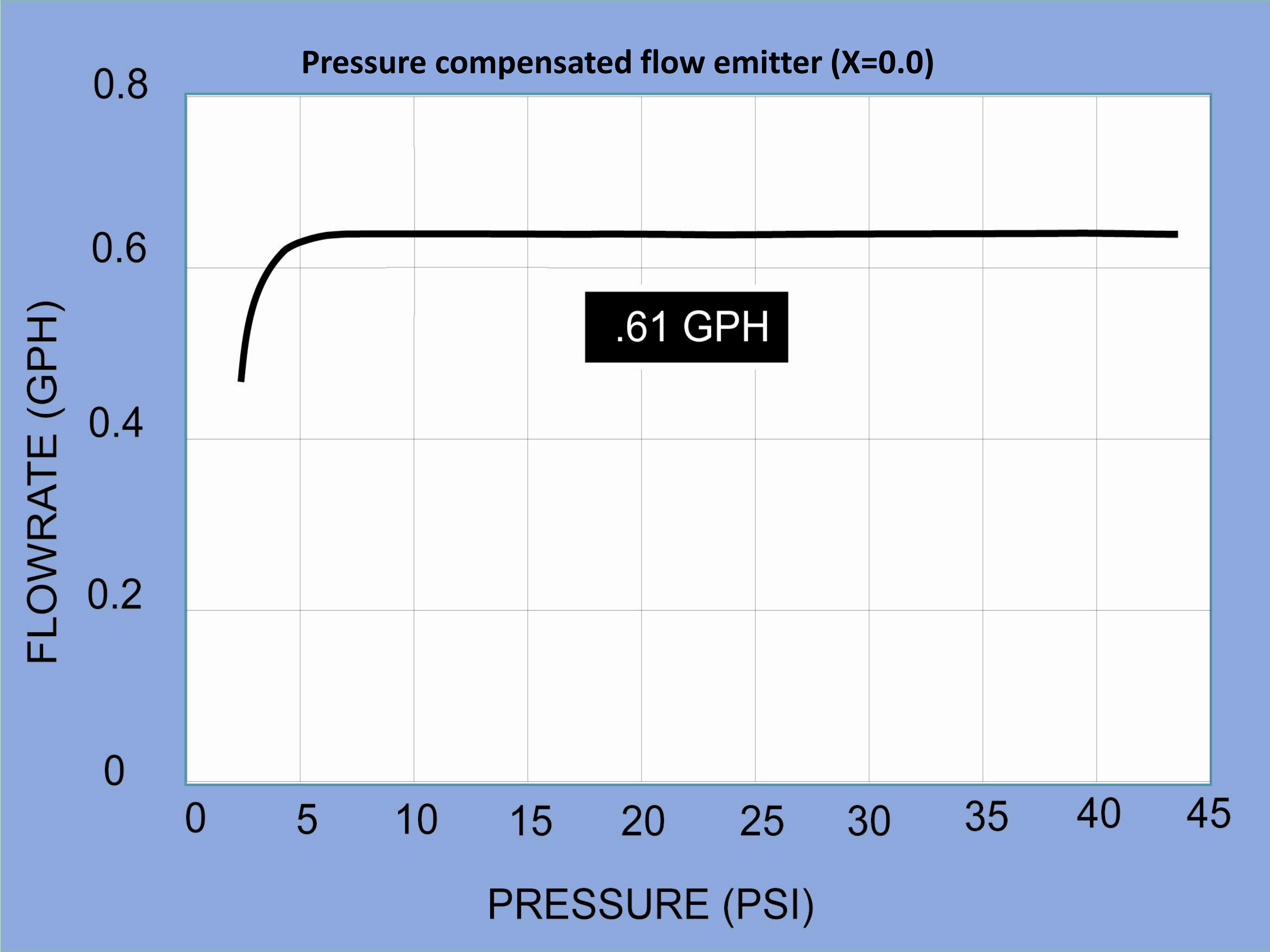
x = Emitter discharge exponent (0-1)

k = A constant (depends on units & emitter geometry)

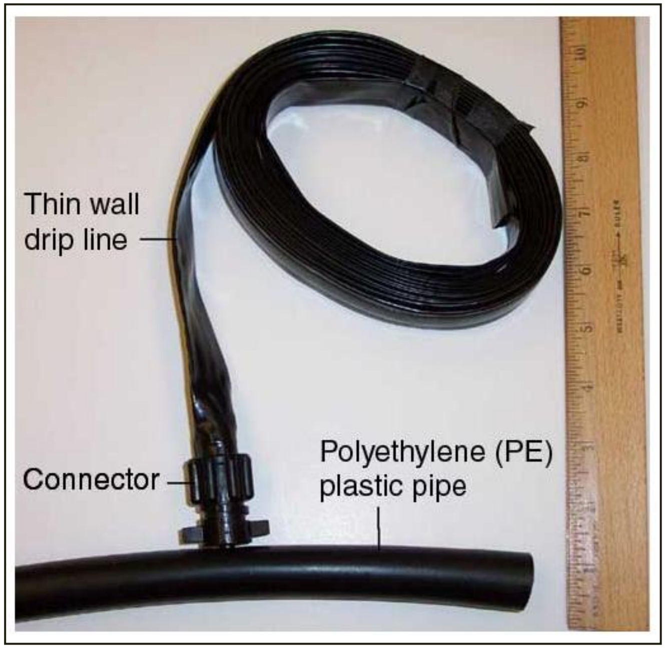
The lower the exponent, the more turbulent and thus more efficient flow.

Flow rate/pressure relationship for a turbulent flow emitter (X=0.50)




Pressure compensated flow emitter (X=0.0)
0.8
0.6
0.4
0.2
0
FLOWRATE (GPH)
.61 GPH
0
5
10
15
20
25
30
35
40
45
PRESSURE (PSI)

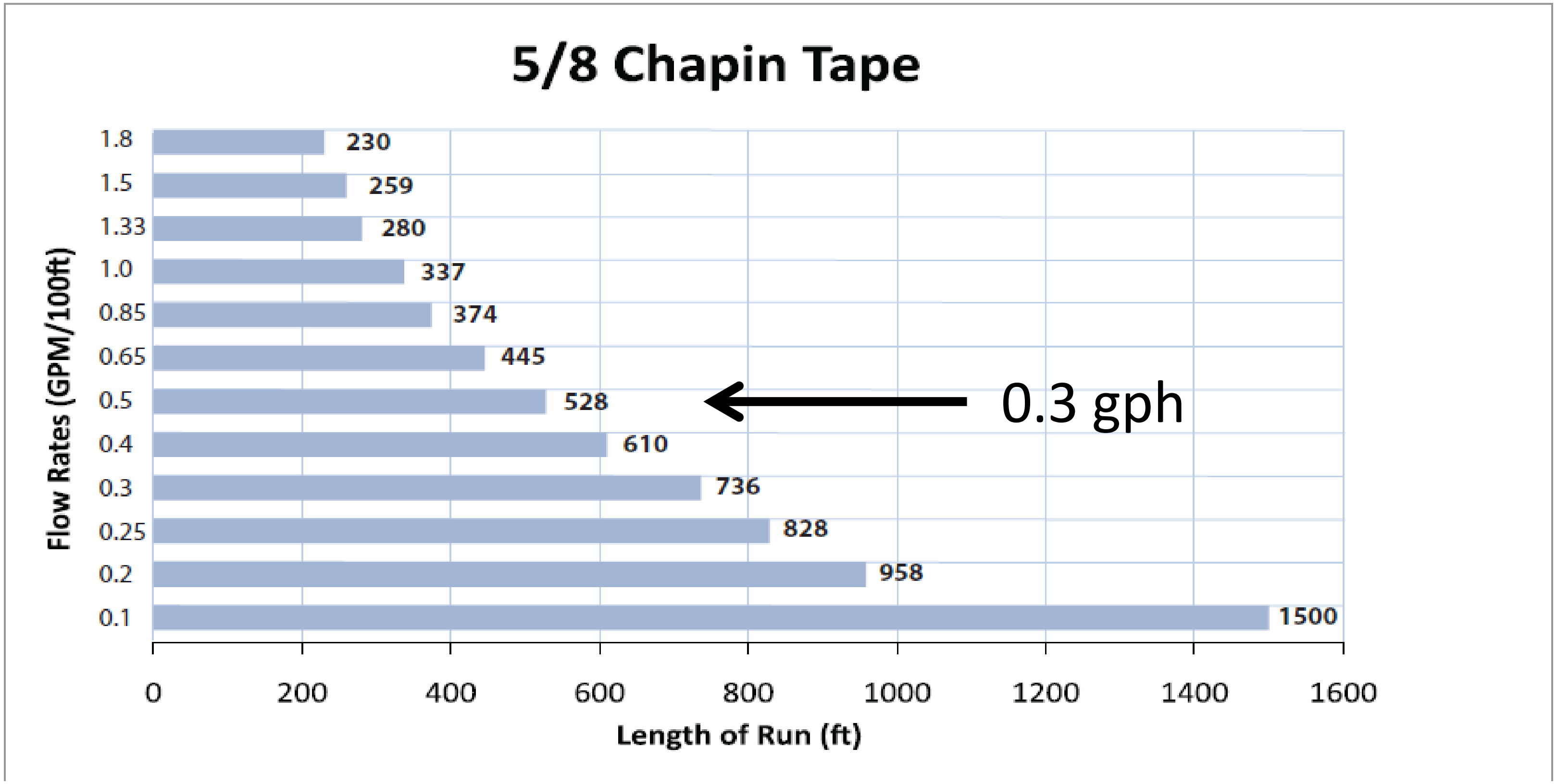
Example Drip Tape – Chapin BTF 5/8”, 8 mil, 12” emitter spacing, 0.5 gpm/100 ft, 10 psi



Emitter	CV	K	x	Flow path width (in)	Flow path depth (in)
Chapin	0.03	0.068	0.525	.028	.024

Example Drip Tape – Chapin BTF 5/8”, 8 mil, 12” emitter spacing, 0.5 gpm/100 ft, 10 psi

Maximum Length of Run for 90% Uniformity — 0% Slope



NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION SYSTEM, MICROIRRIGATION

(Ac.)

CODE 441

DEFINITION

An irrigation system for frequent application of small quantities of water on or below the soil surface: as drops, tiny streams or miniature spray through emitters or applicators placed along a water delivery line.

PURPOSE

This practice may be applied as part of a conservation management system to achieve one or more of the following purposes:

- Efficiently and uniformly apply irrigation water and maintain soil moisture for plant growth.
- Prevent contamination of ground and surface water by efficiently and uniformly applying chemicals.
- Establish desired vegetation.
- Reduce energy use.

CONDITIONS WHERE PRACTICE APPLIES

design discharge less than 60 gal/hr at each individual lateral discharge point.

NRCS Conservation Practice Standard, Irrigation System, Sprinkler (442), applies to systems with design discharge of 60 gal/hr or greater at each individual lateral discharge point.

CRITERIA

General Criteria Applicable to All Purposes

The system shall be designed to uniformly apply water and/or chemicals while maintaining soil moisture within a range for good plant growth without excessive water loss, erosion, reduction in water quality, or salt accumulation.

Microirrigation systems consist of point-source emitter (drip, trickle, and bubbler), surface or subsurface line-source emitter, basin bubbler, and spray or mini sprinkler systems.

The system shall include all irrigation appurtenances necessary for proper operation.

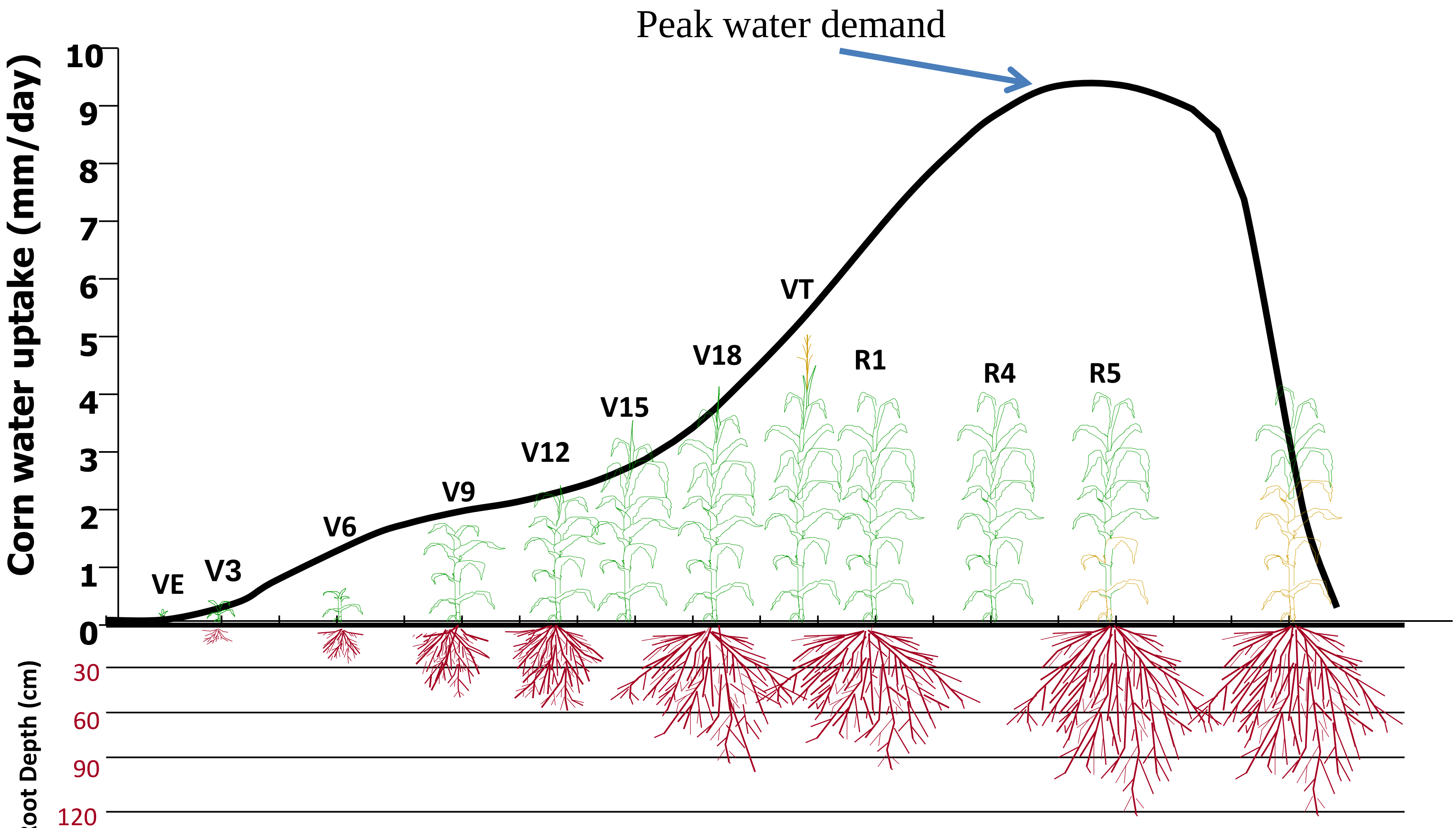
Main Criteria in Micro Irrigation Standard 441

- **Water Quantity:** The water source must be reliable and capable of meeting the peak crop demand for the area to be irrigated.

- **Uniformity of Application:** Emitter discharge in subunits or zones and along laterals shall not exceed a total variation of 20 percent of the average emitter discharge rate.

- **Water Quality:** The irrigation water supply shall be tested and assessed for physical, chemical and biological constituents to determine suitability and treatment requirements (filtration/chemigation) for use in a microirrigation system.

Typical Corn Water Use (Evapotranspiration, ET)



Note: Root depth, root zone, and water use change over time

System Capacity per Acre:

$$\text{gpm per acre} = \frac{453 \times \text{Peak crop water use (ET)}}{\text{hrs of operation} \times \text{Efficiency}}$$

System Capacity Example:

Peak crop water use: 0.25 inch/day

22 hours

80% uniformity

$$\text{gpm/ac} = \frac{453 \times 0.25}{22 \times 0.80} = 6.4 \text{ gpm/acre}$$

Range in the East: 3.5 - 8 gpm/ac

Required pump capacity (gpm) to meet peak daily crop water use of 0.25 inch/day

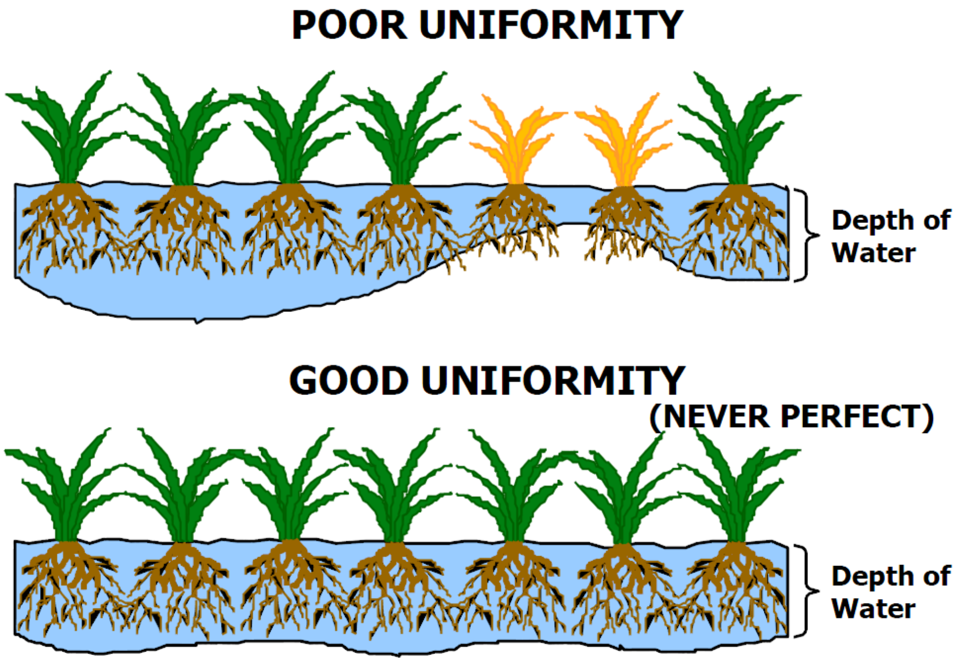
Irrigated Acreage	Hours of Irrigation Per Day				
	2	4	8	12	24
1	72	36	18	12	6
2	144	72	36	24	12
3	216	108	54	36	18
4	288	144	72	48	24
5	360	180	90	60	30
10	720	360	180	120	60

Few Options for Insufficient Water

- Reduce demand
  - Reduce land size
  - Design at below peak crop water use

- Increase supply
  - On-site pond/tank storage
  - Off-season pumping and storage

Uniformity Requirements



For Design Purposes:

Need quantitative criteria for acceptable uniformity.

Why Uniformity is Important?

High Uniformity = expensive

Low Uniformity = Inefficient and wasteful

What Causes Non-uniformity (variability)?

In a brand new system

- Manufacturing coefficient of variation of emitters (CV)
- Pressure differences in the system

In an aging system

- Clogging
- Manufacturing coefficient of variation of emitters (CV)
- Pressure differences in system
- Aging of materials
- Unequal set times
- Clogging

Emitter Flow-Pressure Relationship

$$Q = k\,(P)^x$$

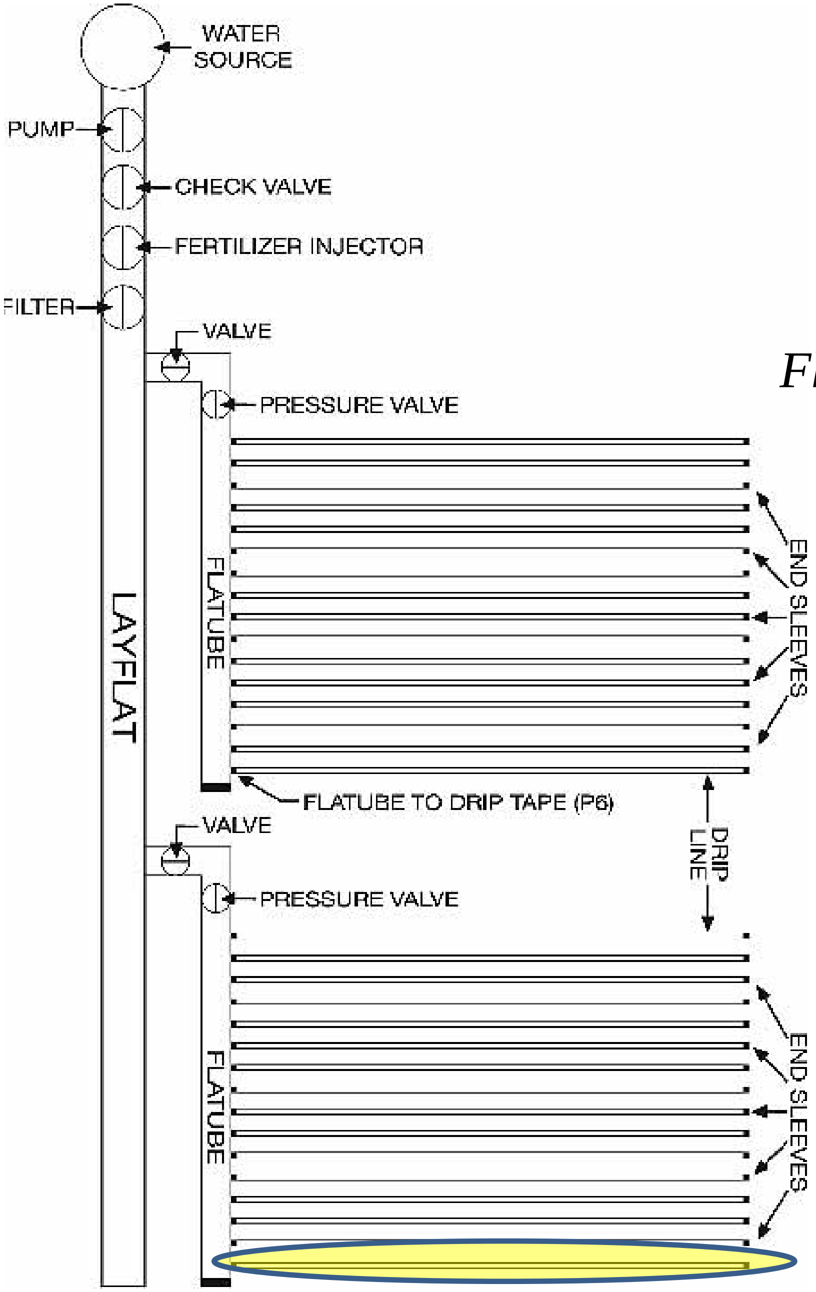
Q = Flow rate (gph)

P = Pressure (psi)

x = Emitter discharge exponent (0-1)

k = A constant (depends on units & emitter geometry)

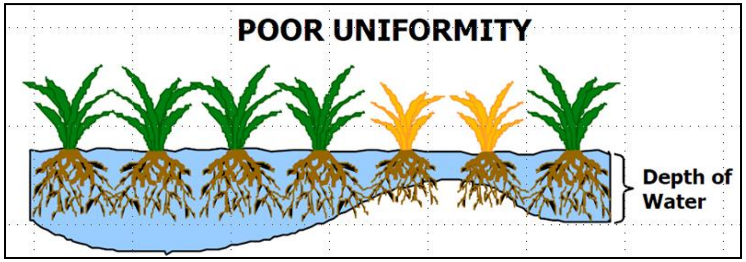
Pressure variations → Flow variations → Non-uniformity.



Variability along Laterals

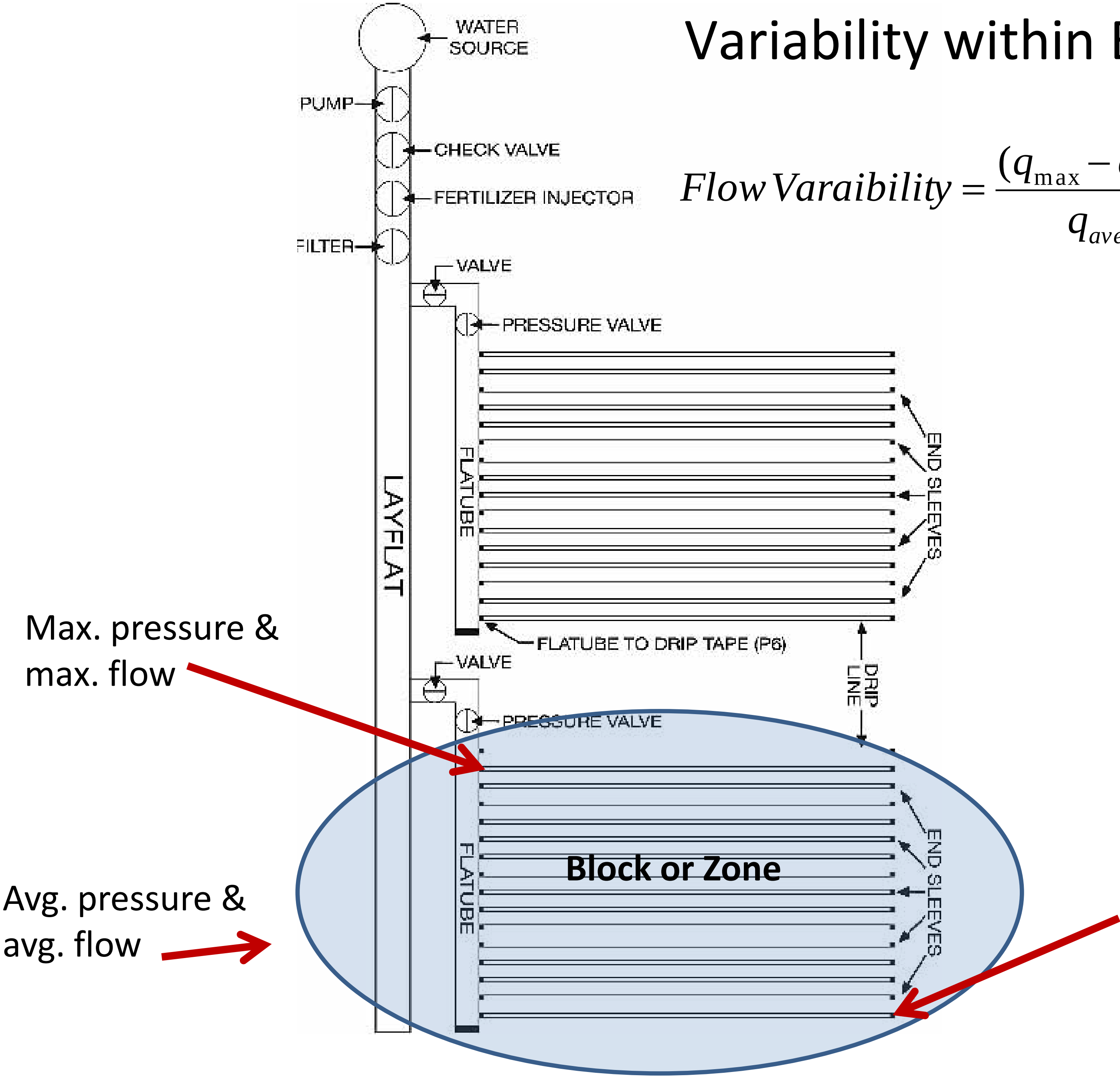
$$Flow\,Varaibility = \frac{(q_{\max} - q_{\min})}{q_{ave}} \times 100 \quad \leq \quad 20\%$$

Single lateral uniformity



Variability within Blocks/Zones

$$Flow\,Varaibility = \frac{(q_{\max} - q_{\min})}{q_{ave}} \times 100 \quad \leq \quad 20\%$$



Emission Uniformity - EU

$$EU = \left(1 - 1.27 * \frac{C_v}{\sqrt{n}}\right)\frac{q_{\min}}{q_{ave}} \times 100$$

90 - 100% Excellent
80 - 90% Good
70 - 80% Fair
Less than 70% Poor

- Typically EU is used as a design target and a means of comparing various products’ hydraulic performance and cost.

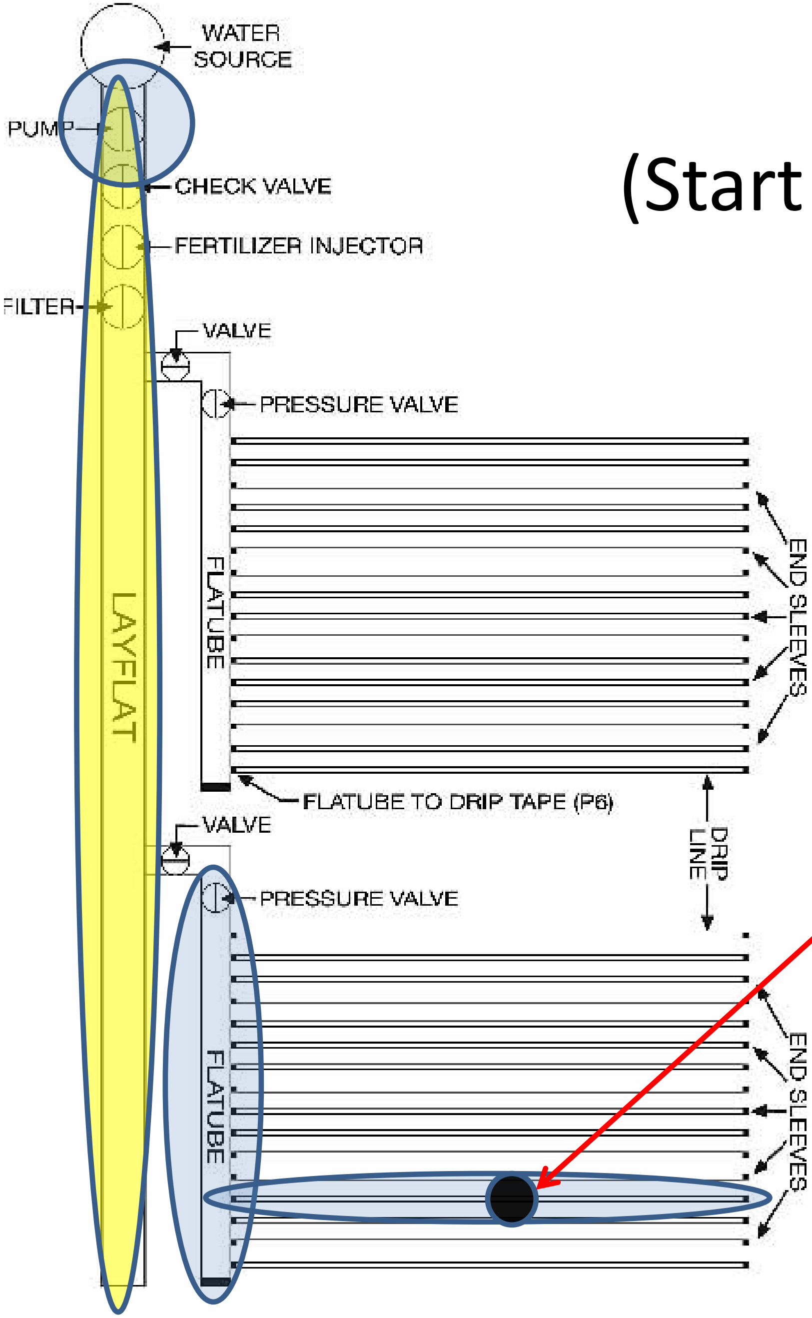
Components of a small-scale micro-irrigation system


Hey Buddy, guess what? I got me a micro irrigation system. Now what?
I don't know Junior. Just turn it on.

IWM & O&M Plans

Proper water management and frequent system maintenance and evaluation are critical to success or failure of an irrigation system regardless of its robustness.

Design Procedure
(Start at Emitter, End at Pump)



Start design at Emitter
- Lateral
- Manifold/block
- Flushing
- Mainline
- Pump
- Filtration

Take Home Messages:

- Regardless of the size, micro irrigation design concepts, criteria, procedures, and components are for the most part the same.
- Work with the industry to do your design.

<u>PART II: Introduction to NRCS Design Tool</u>

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