2009 Southern Region Small Fruit Consortium Berry Crop Irrigation Agent Training

Table of Contents

(Draft: 12/01/08)

2009 Southern Region Small Fruit Consortium
Berry Crop Irrigation Agent Training

Wed, Jan. 7, 2009, 3:00 to 6:00 p.m.

Room 205, Savannah International Trade and Convention Center

This is the big convention center on the North side of the Savannah River. There is a ferry across the river to the hotel.

2:45-3:00 pm Refreshments available

Welcome: Dr. Tom Monaco, Exec. Director, Southern Region Small Fruit Consortium, Raleigh, N.C.

3:00-4:30 p.m. Irrigation Basics, Dr. Allen Straw, SW-VA AREC, Glade Spring, VA.

4:30-6:00 p.m. Irrigation Components and Scheduling for Berry Crops, Dr. Allen Straw, SW-VA AREC, Glade Spring, VA.

6:00 p.m. Ride ferry across river, check into hotel and dinner on your own

Thurs., Jan. 8, 2009

7:30 a.m.	Load bus in front Day's Inn for trip to the UGA Bamboo Station Station
7:45 a.m.	Bus departs
8:15 a.m.	Convene: UGA Bamboo Station and Coastal Gardens, junction of Cane Brake Rd. and US 17 south of Savannah, Ga. (If you have to drive to the Bamboo Station: http://ugaextension.com/bamboo/Directions.html)
8: 15 a.m.	Introduction to the UGA Bamboo Station and Coastal Gardens, Dr. Stephen Garton, Director
8:25 a.m.	Large Scale Commercial Installation and Fertigation – Mr. Erwin Newell and Mr. T. Denman Isgett, B.B. Hobbs Co., Darlington, SC
9:45 a.m.	Coffee and Beverage Break

10:00 a.m.	Wrap up and Review of Irrigation Basics, Dr. Allen Straw, SW-VA AREC, Glade Spring, VA
11:00 a.m.	Demonstration of Sprinkler Types – Naan-Dan, Mr. Giles Padgett-Wilkes, Point Source Irrigation, Mt. Dora, Fla.
11:30 a.m.	Demonstration of Sprinkler Types – Rain Bird, Mr. Ed Anderson, Azusa, Cal.
12:00 noon	Lunch at Bamboo Station
12:45 p.m.	Getting water to the field:
	Small Scale Field Installation:
	Demonstration of trencher operation and water delivery options besides PVC such as lay flat, oval hose, etc.
	Installation over head irrigation for freeze control on jatroba (a subtropical biodiesel crop)
	Installation of drip irrigation system
4:00 p.m	Bus departs Bamboo Station for Day's Inn

Southeastern Fruit and Vegetable Convention

Rough outline of program, times are not exact- see www.gfvga for details

Thurs, Jan. 8, 2009 **Blackberry and Raspberry Program**, 6 to 7:30 p.m.

Friday, January 9, 2009

7 AM – 9:30 AM	Exhibitor Set Up
8 AM – 11 AM	Educational Sessions-**1. Organic Blueberries and Veggies 2.Blackberry and Raspberry (continued)**
10 AM – 6:15 PM	Trade Show OPEN (approx. 8 hours)
11 AM – Noon	Special Interest Forum – TBD
	Lunch available in Trade Show Hall (incl. in Reg. Fee)
2:00 – 5:00 PM	Educational Sessions- **Blueberry**
4:45 – 6:15 PM	Welcome Reception – Trade Show Hall (Live Auction)

Saturday, January 10, 2009

8:30 AM – 10:30 AM	General Session
10:00 AM	Trade Show Opens (approx. 4 hours)
	Lunch available in Trade Show Hall (incl. in Reg. fee)
2:00 – 5:00 PM	Educational Sessions- **1. Blueberry, 2. Muscadine, 3. Strawberry**
2:30 PM	Trade Show Closes
6:00 – 7:00 PM	Reception at the Westin (located next to the Convention Center)

Sunday, January 11, 2009

8:00 AM	Worship Service
8:30 – 10:30 AM	Industry Roundtable

Irrigation Basics

R. Allen Straw

Area Specialist

SW VA AREC

Virginia Cooperative Extension

Disclaimer

- I am not an engineer!
- I may not have all of the lingo “just right”!
- I am an Extension Specialist that feels like my mission is to help people!
- Helping growers make wise choices is my passion!

Introduction

- Passionate about Irrigation
  - Most berry crop growers need irrigation
  - Many small berry crop growers are new to agriculture
  - Budget constraints are limiting specialist visits
  - Many rural and “limited” production areas are not serviced by irrigation “engineers”

Introduction (cont.)

- Passionate about Hands-on Training
  - "Experience is the best teacher!"
  - "But it can almost be the most expensive!"
    - Most of us learn best by doing!
    - The more we do something, the more comfortable we are in teaching and training others.

Goals / Objectives

- To become familiar with the basics of irrigation.
- To become more comfortable in assisting growers with irrigation recommendations.
- To obtain some comfort with basic irrigation design.

Goals / Objectives (cont.)

- To obtain a glimpse of large scale irrigation design.
- To see various types of irrigation “nozzles” demonstrated.
- To “get” dirty doing some irrigation installation, which in turn should make you more comfortable in showing and telling others.

Two “Uses” of Irrigation

- In “berry crops” we use water for two different purposes:
  - “Watering the Crop”
  - Frost / Freeze Protection
    - We will touch on the parameters for both scenarios, but will focus for now on the first.

“Watering the Crop”

- This is actually a misnomer.
- Our goal with irrigation is to restore or maintain soil water!

Water Balance

- Similar to a Checking Account
  - Maximum amount (FDIC)
  - Minimum

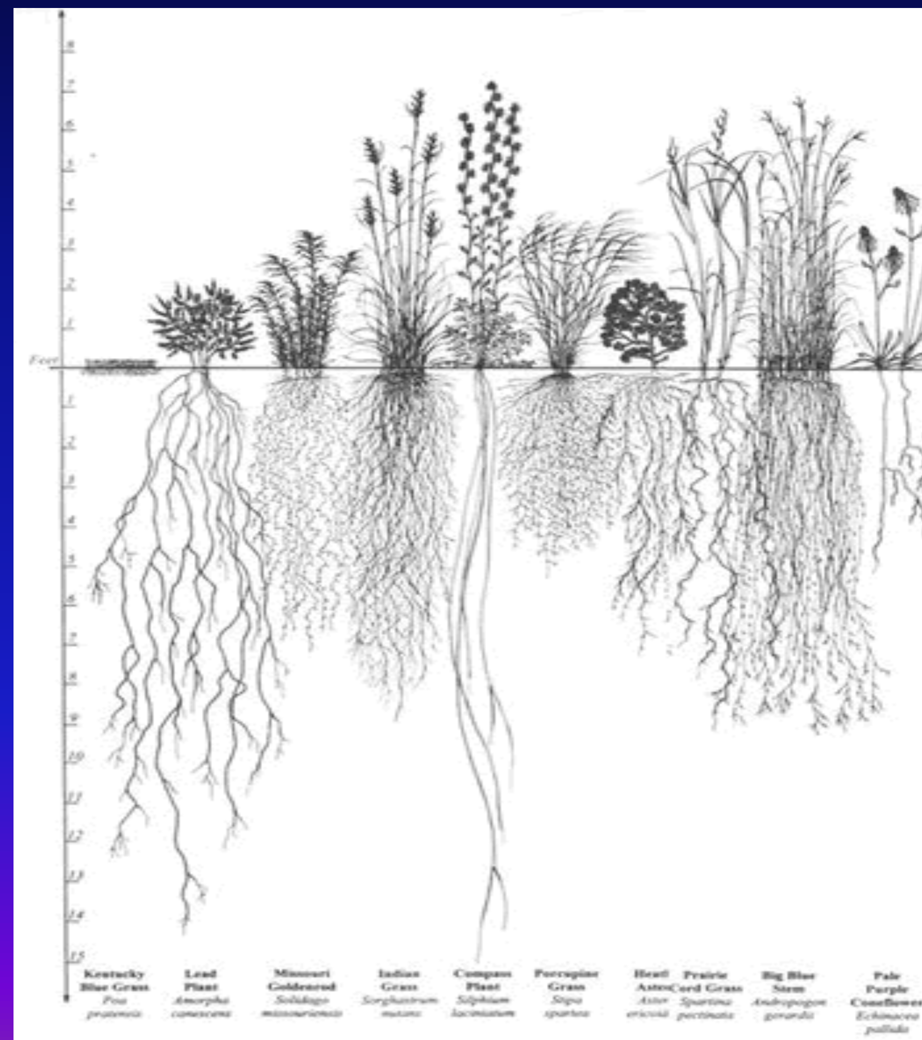
    ($0.00 balance)
  - Make deposits
  - Make withdrawals

Soil Water Holding Capacity

- Soil Survey
  - Soil Description
    - Water Holding Capacity
    - Inches of water held by the entire profile or per unit area
    - Only a portion is available to the plant

Available Water

- How much water is available to the plant?
  - Rooting Depth
  - Rooting Density
  - Root Hairs



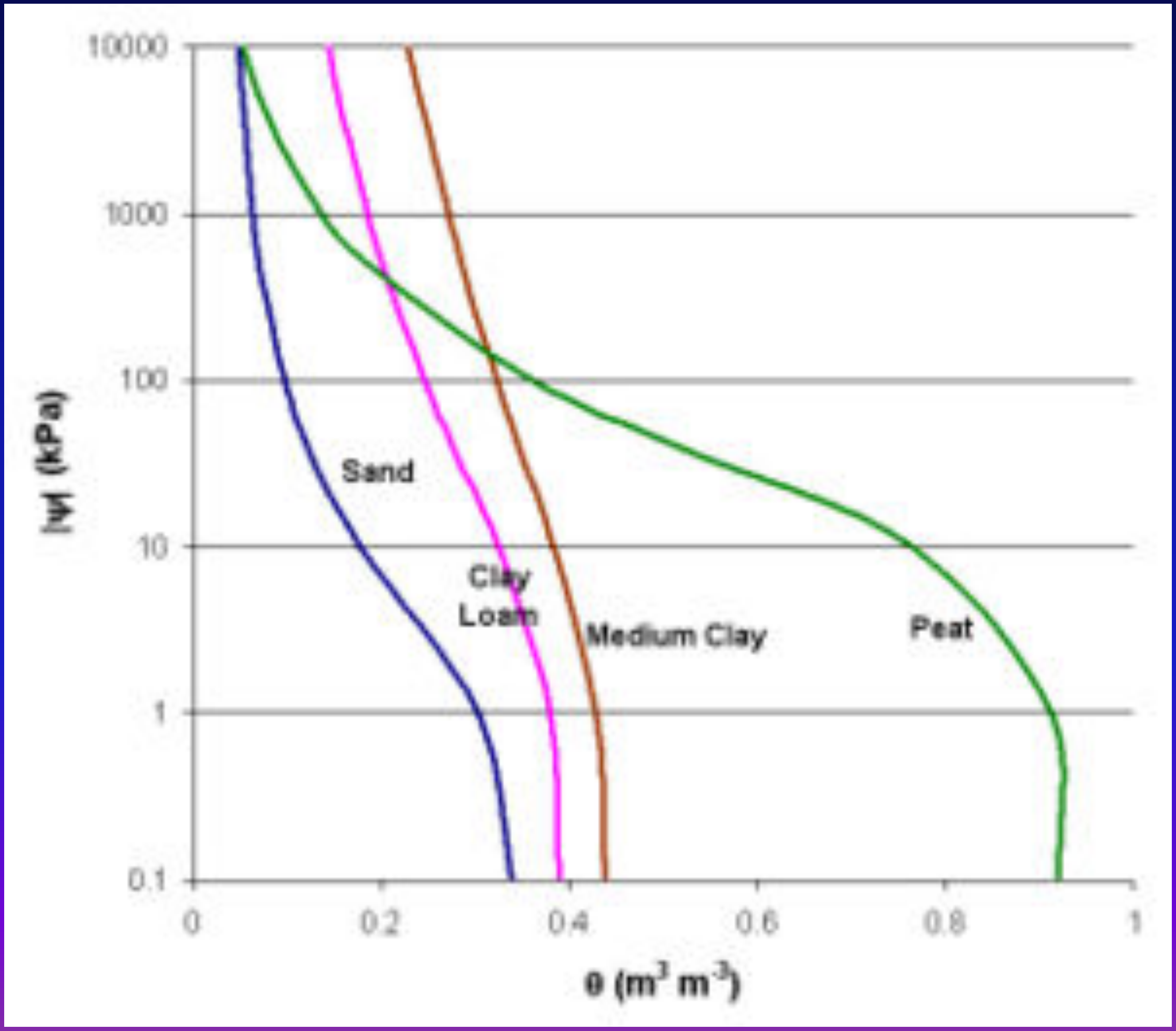
Root Systems of Prairie Plants

Available Water (cont.)

- How much water is available to the plant?
  - Soil Depth
  - Texture
    - Sand
    - Silt
    - Clay
  - Organic Matter

- Soil Water
  - 0 bar (0 psi)
    - Gravitational Water
  - 1/3 bar (5 psi)
    - Field Capacity
  - 15 bars (225 psi)
    - Permanent Wilting Point

Soil Moisture Retention Curve



Real Life Example

How much water is available?

- Frederick Silt Loam
  - Slope
    - 7 to 15%
  - Depth
    - 70 inches (?)
  - Water Holding Capacity
    - 8.8 inches
  - Infiltration Rate
    - 0.57 to 1.98 in./hr
- 8.8 in. / 70 in. = 0.125 in./in.
- Rooting depth of 12 in. = 1.5 inches of available water
- 10 days of ET @ 0.15 in./day = 1.5 inches of water

Deposits / Withdrawals

- Deposits
  - Natural Precipitation (Rainfall)
  - Supplemental Irrigation
- Withdrawals
  - Transpiration
  - Evaporation

“Watering the Crop”

- This is actually a misnomer.
- Our goal with irrigation is to restore or maintain soil water!

Engineering Issues

$$H_f = \left[\frac{\text{Flow}}{C}\right]^{1.85} \bullet (\text{length}) \bullet (\text{diameter})^{-4.866}$$

Hydraulic Principles

- We must treat irrigation systems as a closed-conduit system.
  - Therefore, flow rate is important.
  - Therefore, pressure is important.

Hydraulics of Closed-Conduit Flow

- Flowrate
  - Must satisfy the crop demand
  - Must satisfy the need of the system
- Pressure
  - Must be sufficient to operate the tape, emitter, nozzle as specified by the manufacturer
  - Can be too high and can be too low

Flowrate

- Volume of water per unit time
  - Gallons per minute
  - Gallons per hour
  - Cubic feet per sec

- **7.481 gallons per cubic foot**

Flowrate and Velocity

- Velocity
  - Length traveled per unit time
- Velocity and flowrate are related
  - $Q = V \cdot A$
  - Where A is the cross-sectional area of the pipe
  - $A = [(d^2/4) \cdot 3.14]$ (d = diameter in feet)

Whoa, Wait a Minute

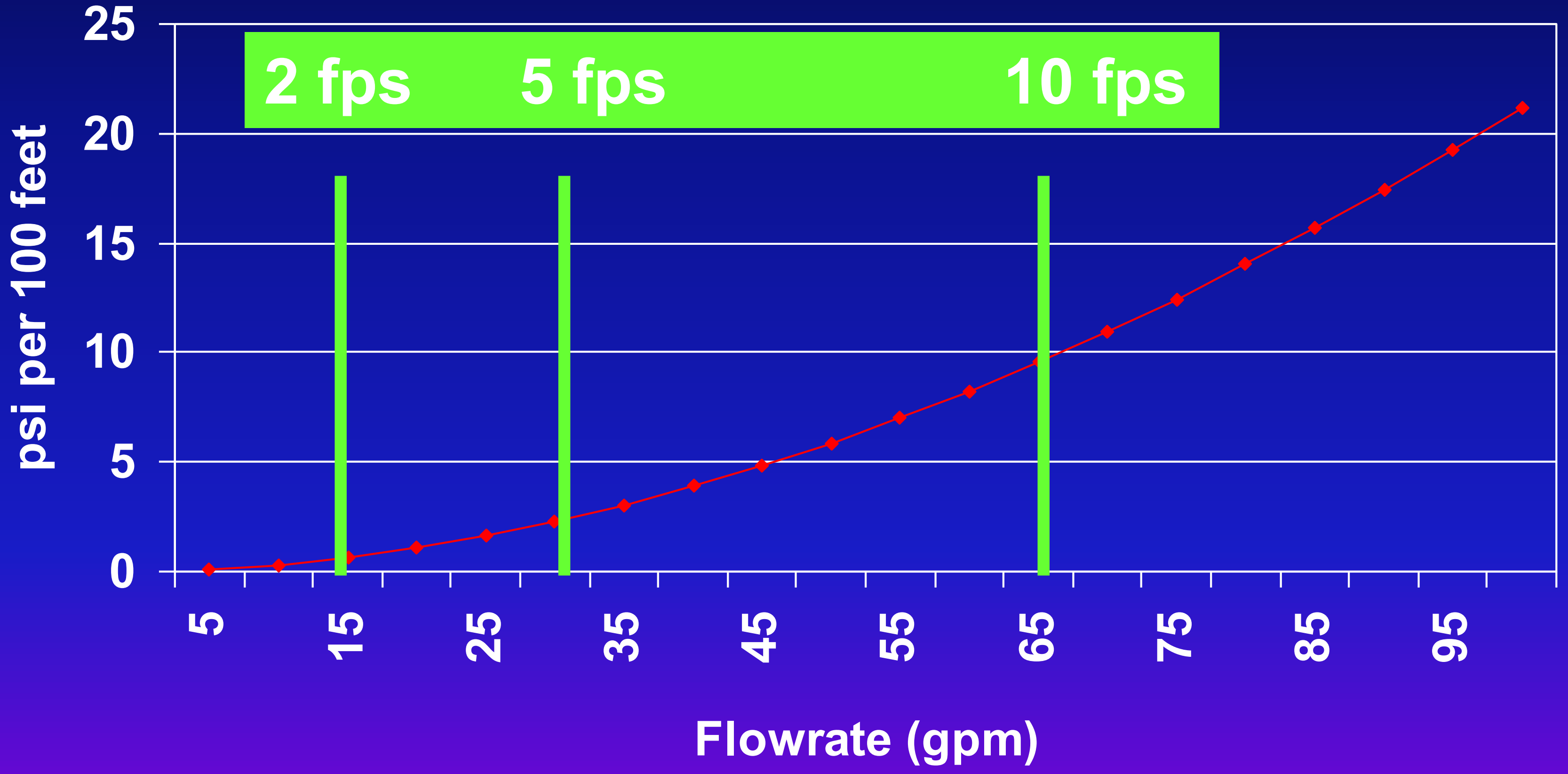
- Use pipe tables to get this information
  - Almost all irrigation catalogs have pipe tables in the back pages
  - The previous information is to make sure you know how this information is derived and why it is important

Flowrate Determines Pipe Diameter

- Goal is to have water velocity between 2 feet per second and 5 feet per second
- Less than 2 fps will not scour solids
  - May allow solids to settle to bottom of pipe
- Greater than 5 fps adds too much friction
  - Too much pressure drop
  - Water hammer

1-1/2” Diameter Sch. 40 PVC

Friction Loss Per 100 Feet of Pipe



Pressure

- Must have enough pressure to get the water to the most distant point in the system
- Must have enough extra pressure to make the tape (emitters) work as designed

Pressure and Friction

- Friction is resistance to flow
  - Function of velocity
  - Function of pipe diameter
  - Function of pipe material
- Hazen-Williams equations

$$H_f = \left[\frac{\text{Flow}}{C}\right]^{1.85} \bullet (\text{length}) \bullet (\text{diameter})^{-4.866}$$

Wait, Don’t Panic !

- Use the pipe tables to get this information
  - Friction loss is usually given in “pressure loss” per 100 feet of pipe (psi)
    - Sometimes given as flowrate that produces 2 or 4 psi loss/100 feet
    - Sometimes given as PSI loss/100 feet at a given flowrate

Pressure and Elevation

- Elevation is the vertical difference across the system
  - It takes pressure to move water uphill
  - Water gains pressure as it moves downhill

- Function of gravity and the density of water

Water Is Heavy

- Water weighs 62.4 pounds per cubic foot
  - Water will move from a location with more pressure to a location with less pressure
- Each foot of elevation-increase requires 0.43 psi
  - **OR** each psi is equivalent to 2.31 feet of water head

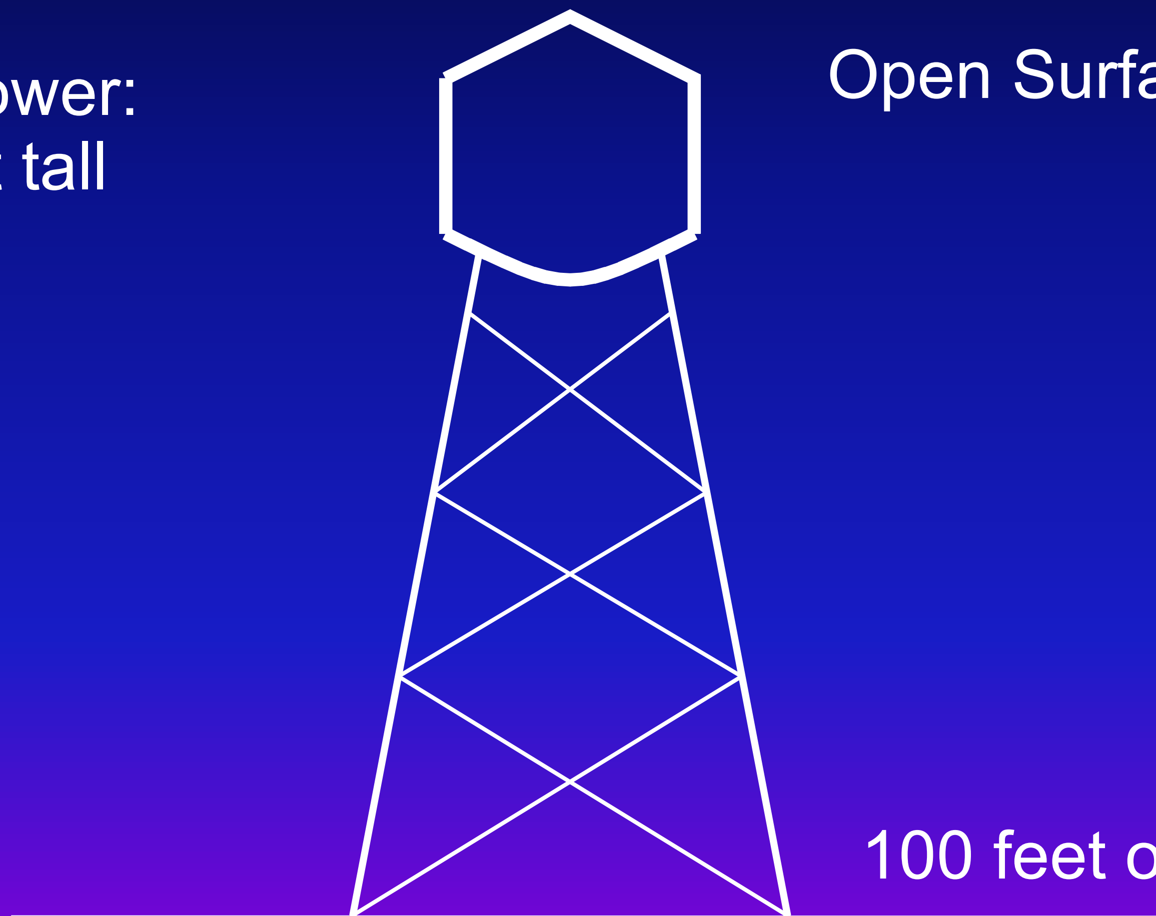
Head Is a Pressure Term

- Pump and pipe information is often given in terms of "feet of head"
  - Easy to use in when working with elevation changes
  - A 15-foot change in elevation is "15 feet of water head" **or 6.5 psi**
- Must be careful not to mix these "units"

Water Towers Provide Pressure

Water tower:
100 feet tall

Open Surface 0-psi

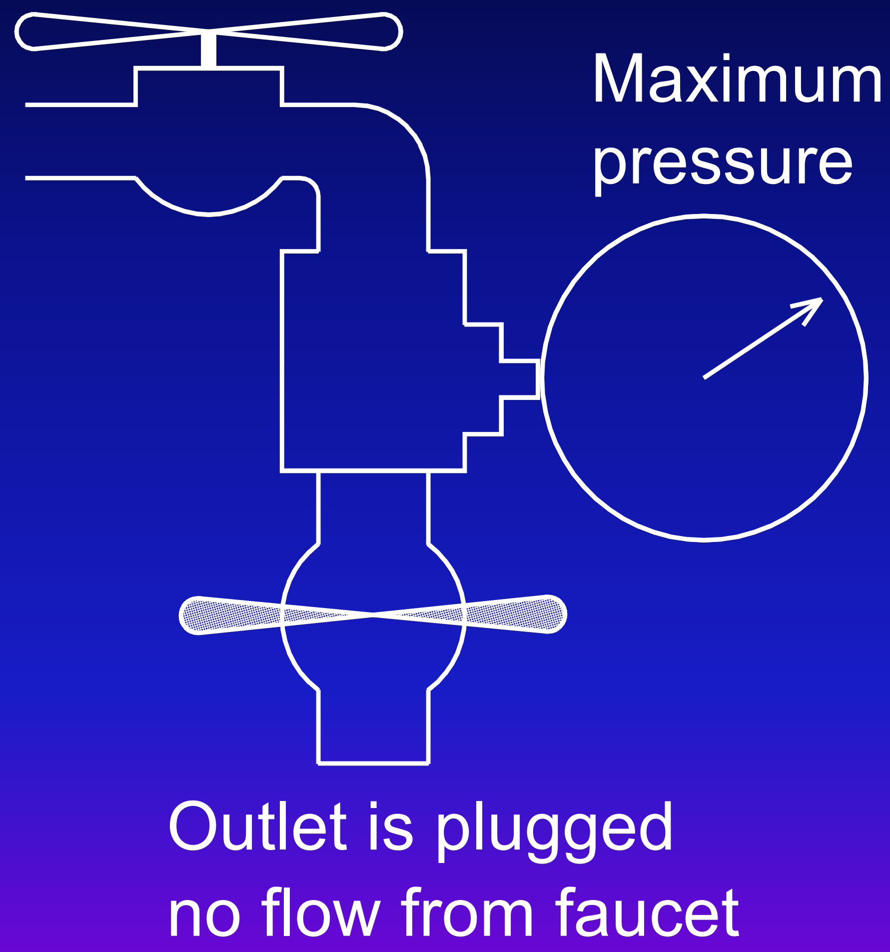


100 feet of head

43-psi

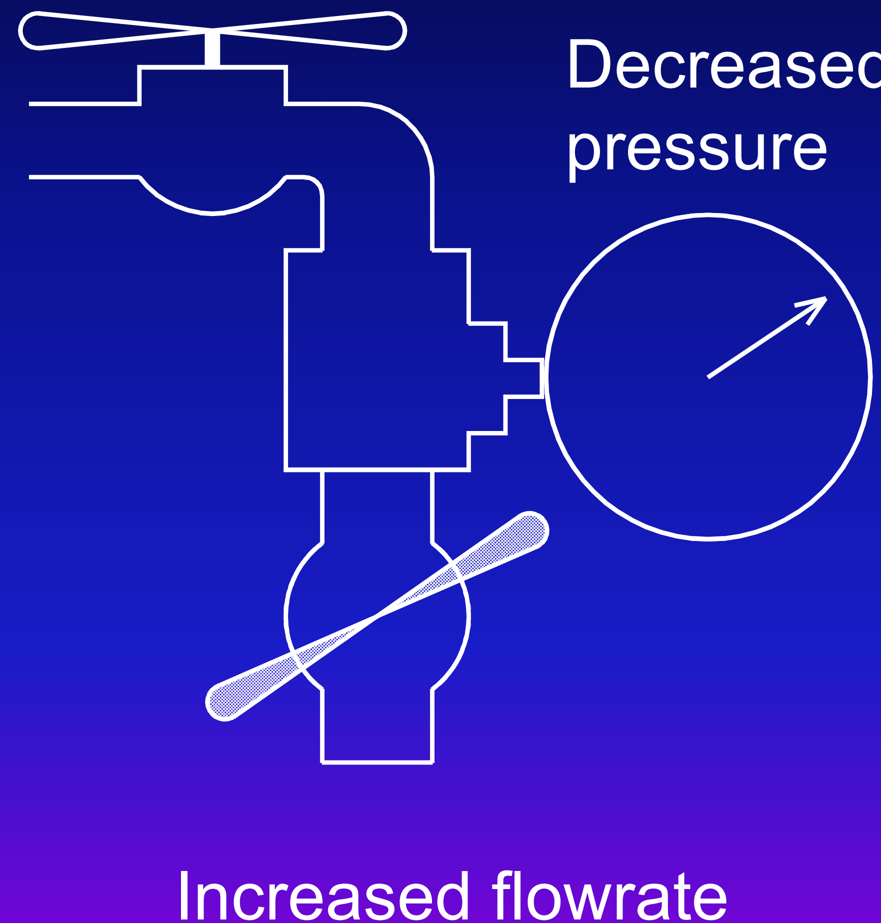
Static Pressure

- Static is the pressure when water is not flowing
  - Such as putting a pressure gage on your hydrant
  - Maximum pressure available



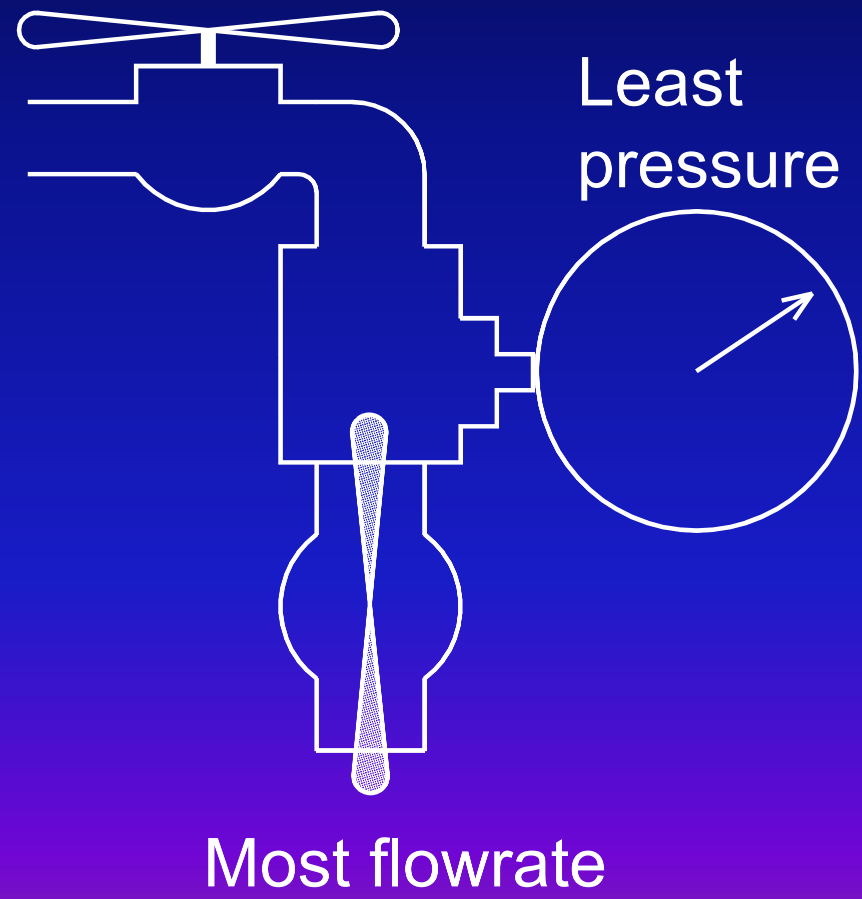
Dynamic Pressure

- Pressure is lost due to friction in the pipeline
  - the measured pressure changes as the flowrate changes



Maximum Flowrate

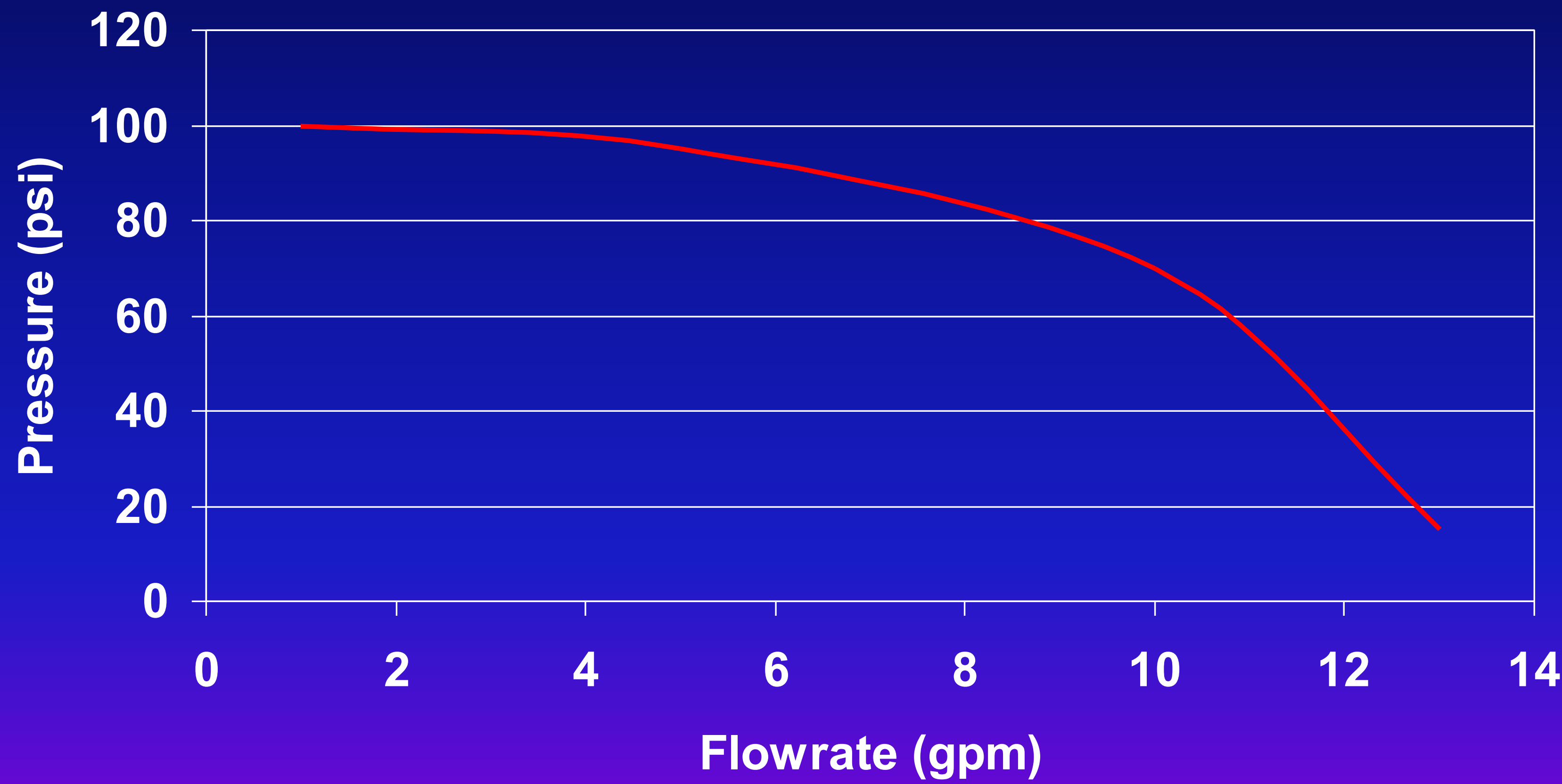
- With the valve wide open
  - Maximum flowrate
  - Minimum available pressure



Measuring Flowrate

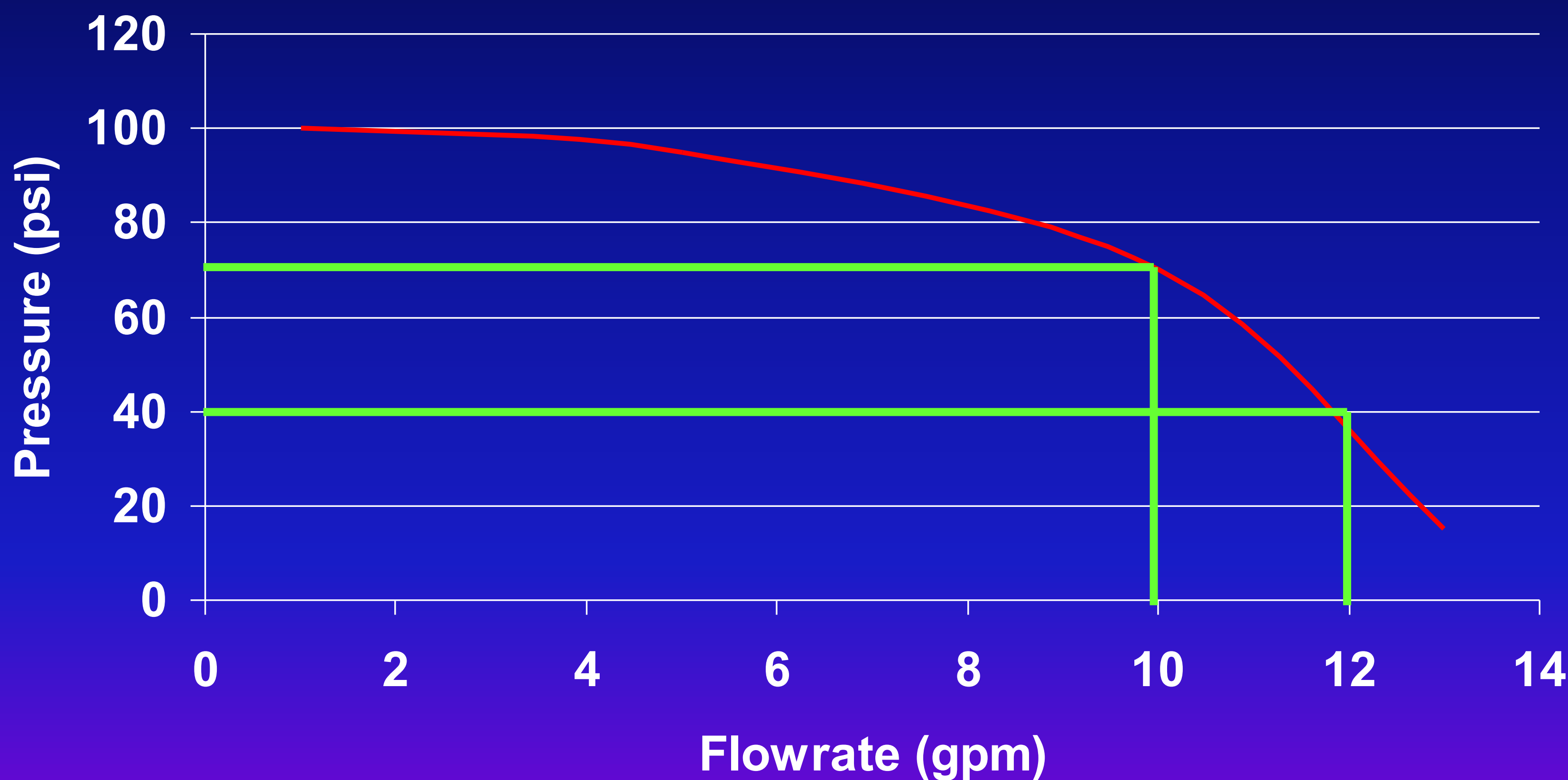
- Bucket method
  - Five gallon bucket and stopwatch
  - Measure the time to fill bucket
  - Divide gallons by minutes to get “gpm”
- Water meters
  - You have a water meter at the curb
  - Typically, each turn of the needle is 10 gallons (sometimes 1 gallon)
  - Measure the time for the needle to go around

Pressure and Flowrate



Water Supply Response Curve

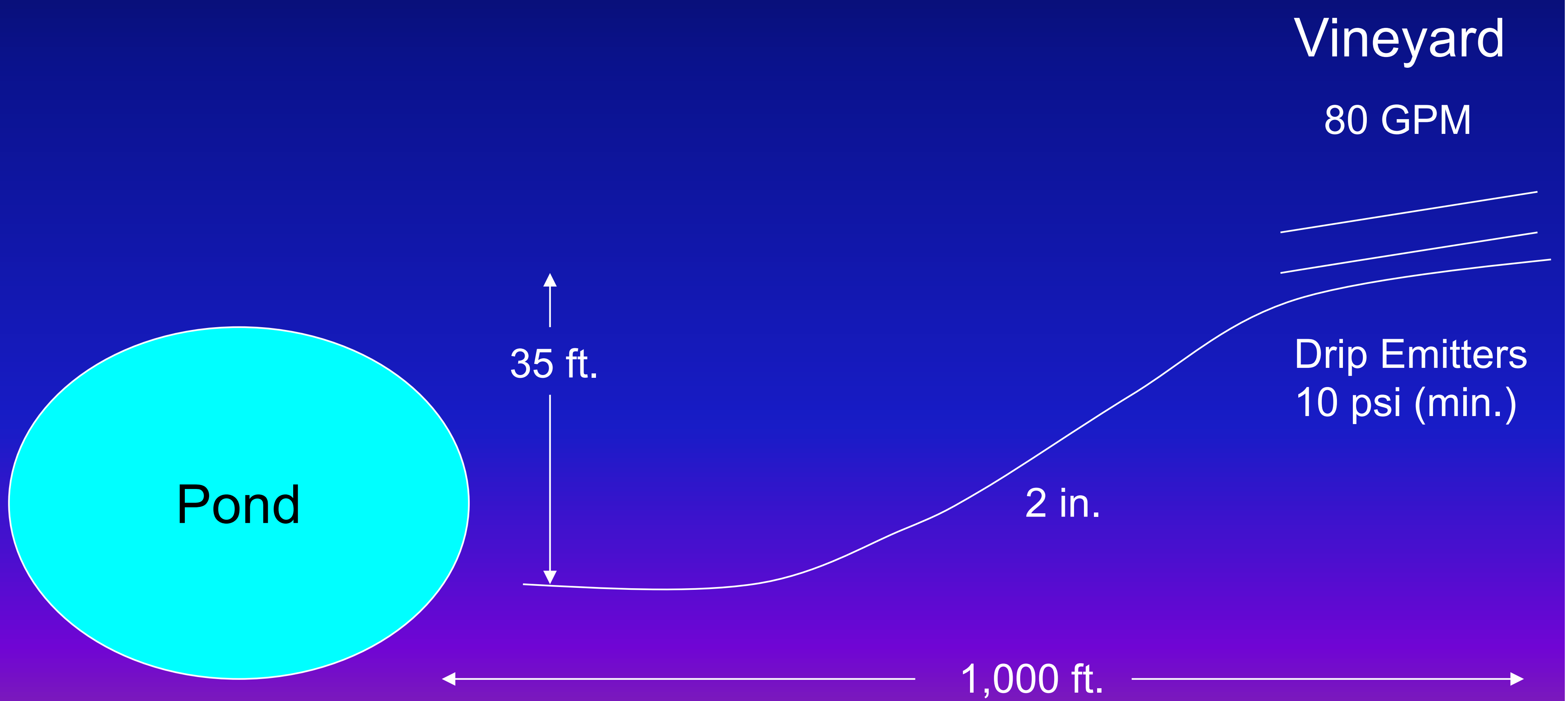
If I need a flow of 10 gpm, then I will have 70 psi available
Likewise If I need 40 psi, I can get 12 gpm



Pressure

- Three components that dictate the pressure required to operate a system:
  - Elevation change between the water source and the field.
  - Friction loss in pipe transporting water to the field.
  - Pressure required to operate the nozzle, emitter, etc. in the field.

Pressure Example



Pressure Example (cont.)

- Total Head Needed
  - 35 ft of elevation change
  - 23.1 ft of head to operate emitters
    - (10 psi of pressure to operate emitters)
  - 92.4 ft of head in friction loss
    - (1,000 ft @ 4 psi pressure loss /100 ft)
- **150.5 feet of head** to supply water to the top of the vineyard.

Pressure Example (cont.)

- Total Pressure Needed
  - 15.2 psi in elevation change
    - 35 ft of elevation change
  - 10 psi of pressure to operate emitters
  - 40 psi in friction loss
    - 4 psi/100 ft friction loss over 1,000 ft
- **65.2 psi** to supply water to the top of the vineyard.

Summary

- Flowrate and pressure are related!
- Head x 2.31 = psi
- We need to know both flowrate and pressure to:
  - Choose the correct pipe size
  - Choose the correct pump

Questions?

- R. Allen Straw

  SW VA AREC

  12326 VPI Farm Rd.

  Glade Spring, VA 24340

  Mobile: 931.261.0973

  E-mail: astraw@vt.edu

  Fax: 276.944.2206

  Phone: 276.944.2202

Irrigation Basics (cont.) and Scheduling

R. Allen Straw

Area Specialist

SW VA AREC

Virginia Cooperative Extension

Types of Irrigation

- Overhead
  - Sprinkler
  - Traveling Gun
  - Traveling Boom
  - Center Pivot
- Furrow
- Flood / Seep
- Sub-surface Drip (SDI)
- Micro Irrigation
  - "Drip"
  - Micro-Sprinkler

Our Focus

- Focus for Berry Crops
  - "Drip"
  - Sprinkler

A Typical "Drip" System

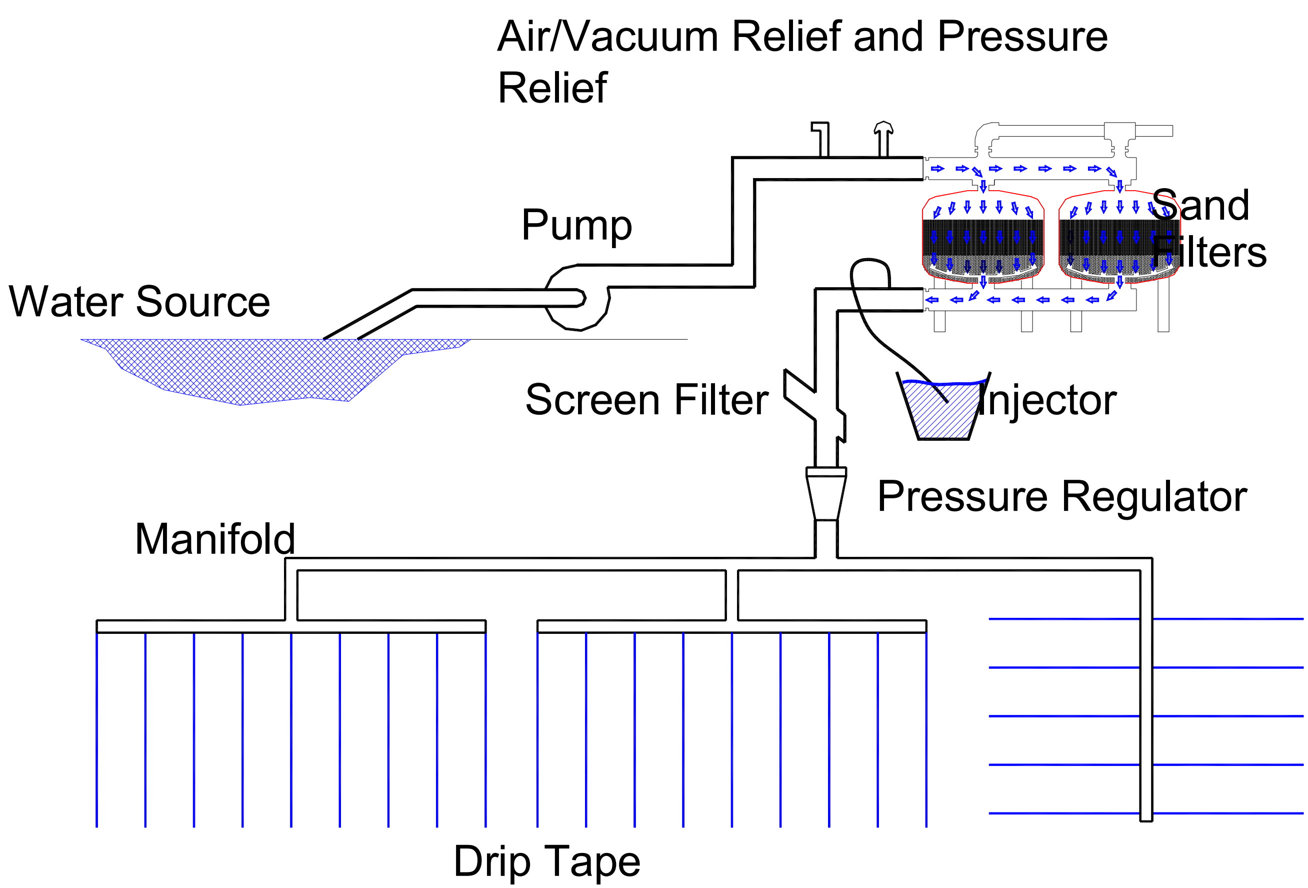
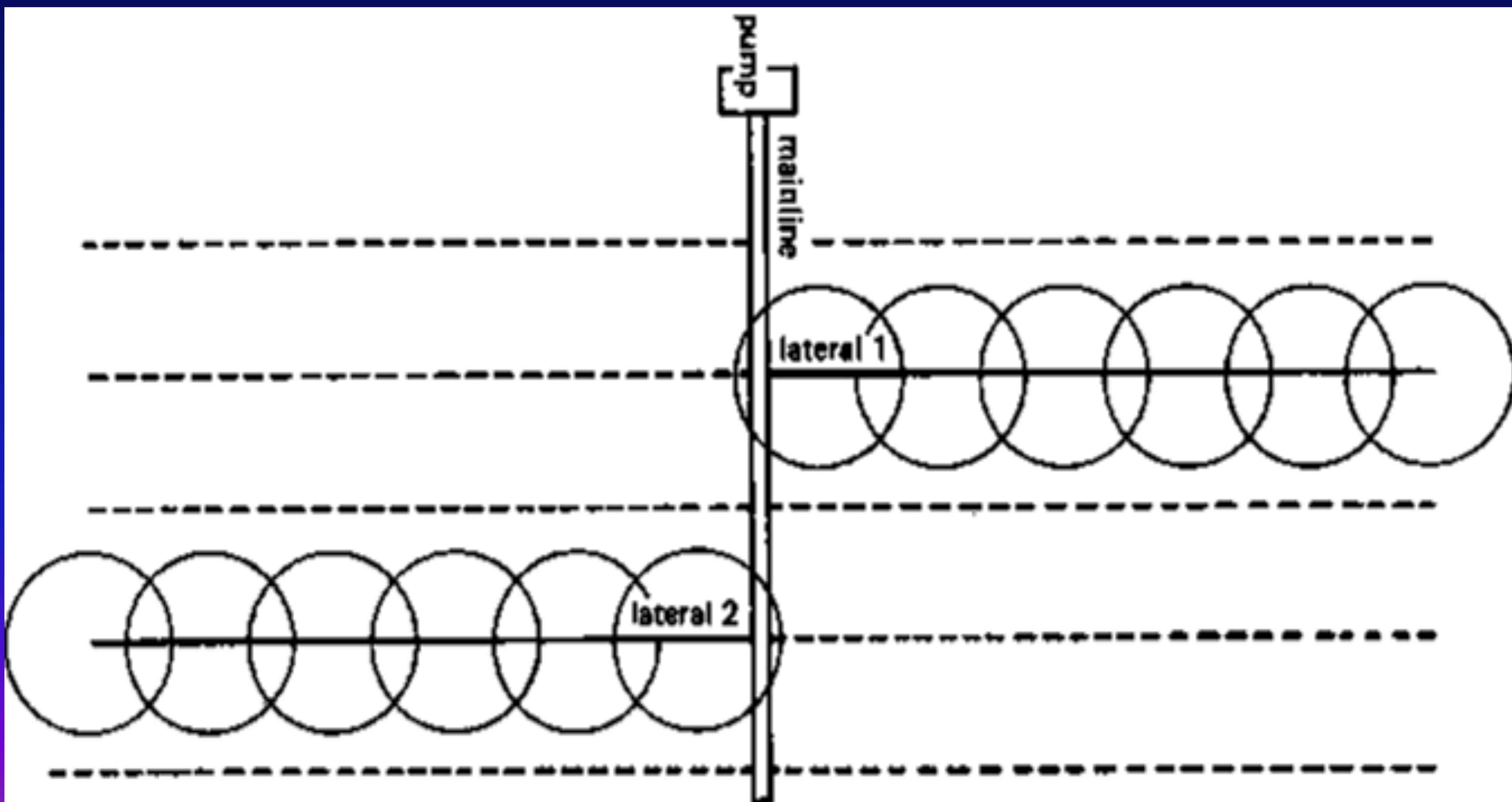


Figure 5. Typical Layout for Trickle Irrigation using Media Filters

A Typical Sprinkler System



Basic Irrigation Components

- Irrigation Components:
  - Water Source
  - Pump
  - Backflow Preventer
  - Injector
  - Filter
  - Pressure Regulator
  - Header Line
  - Laterals
  - "Outlet"
  - Gauges
- Fertigation
- Irrigation Scheduling

Water Sources

- Surface
  - Pond
  - Lake
  - River
  - Creek
- Sub-surface
  - Well
- Municipal
  - Utility

- Surface sources:
  - Require the most filtration
  - Generally provide the highest volume
- Sub-surface and municipal sources:
  - Require less filtration
  - May provide limited volume

Which Source is Right?

- Questions:
  - How much water do I need?
  - Which source (s) can I utilize?
  - How much water does that source provide?
  - How clean is that source?

- Which source should you utilize?
  - Cost and availability of utility water
    - Depends on location in the state
  - Output of well
    - Pump capacity
    - Aquifer
  - Cost of pump and filtration equipment

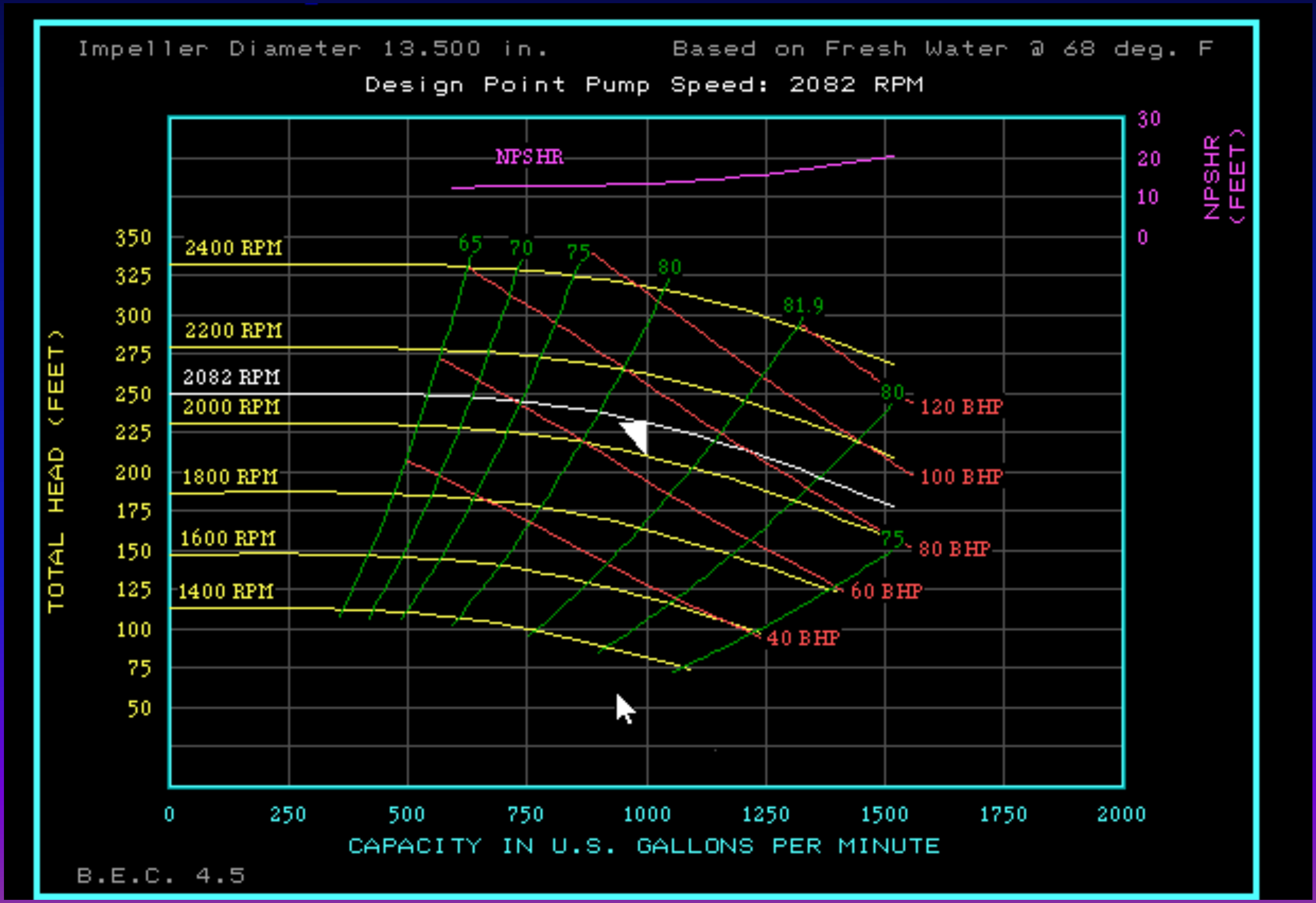
Pumps

- Municipal Source
  - No pump needed on your end
- Sub-surface Source
  - Probably an electric pump
- Surface Source
  - Petroleum powered pump
    - Tractor Driven
    - Self-Contained
  - Electric
  - Gravity (?)

Which Pump Do You Need?

- How much area are you going to irrigate at once?
- How much water will be required to irrigate that area?
- How much friction loss will be experienced?

Pump Curve



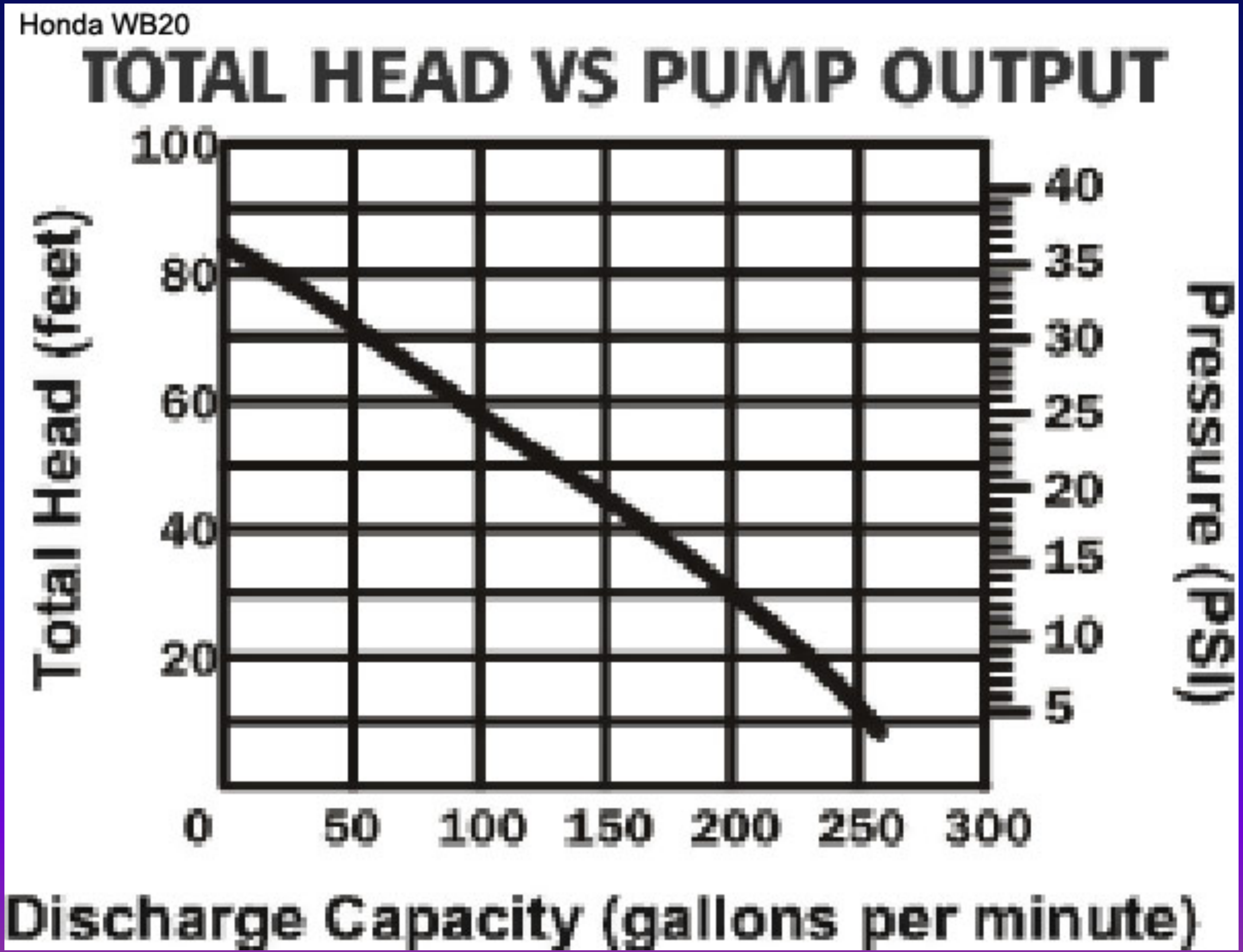
Impeller Diameter 13.500 in.
Based on Fresh Water @ 68 deg. F
Design Point Pump Speed: 2082 RPM
NPSHR
2400 RPM
2200 RPM
2082 RPM
2000 RPM
1800 RPM
1600 RPM
1400 RPM
65
70
75
80
81.9
80
75
120 BHP
100 BHP
80 BHP
60 BHP
40 BHP
350
325
300
275
250
225
200
175
150
125
100
75
50
TOTAL HEAD (FEET)
30
20
10
0
NPSHR (FEET)
0
250
500
750
1000
1250
1500
1750
2000
CAPACITY IN U.S. GALLONS PER MINUTE
B.E.C. 4.5

2” Self Priming Pump

80 GPM

150 feet of head
(63 psi)

Will this pump
Irrigate the
Vineyard?



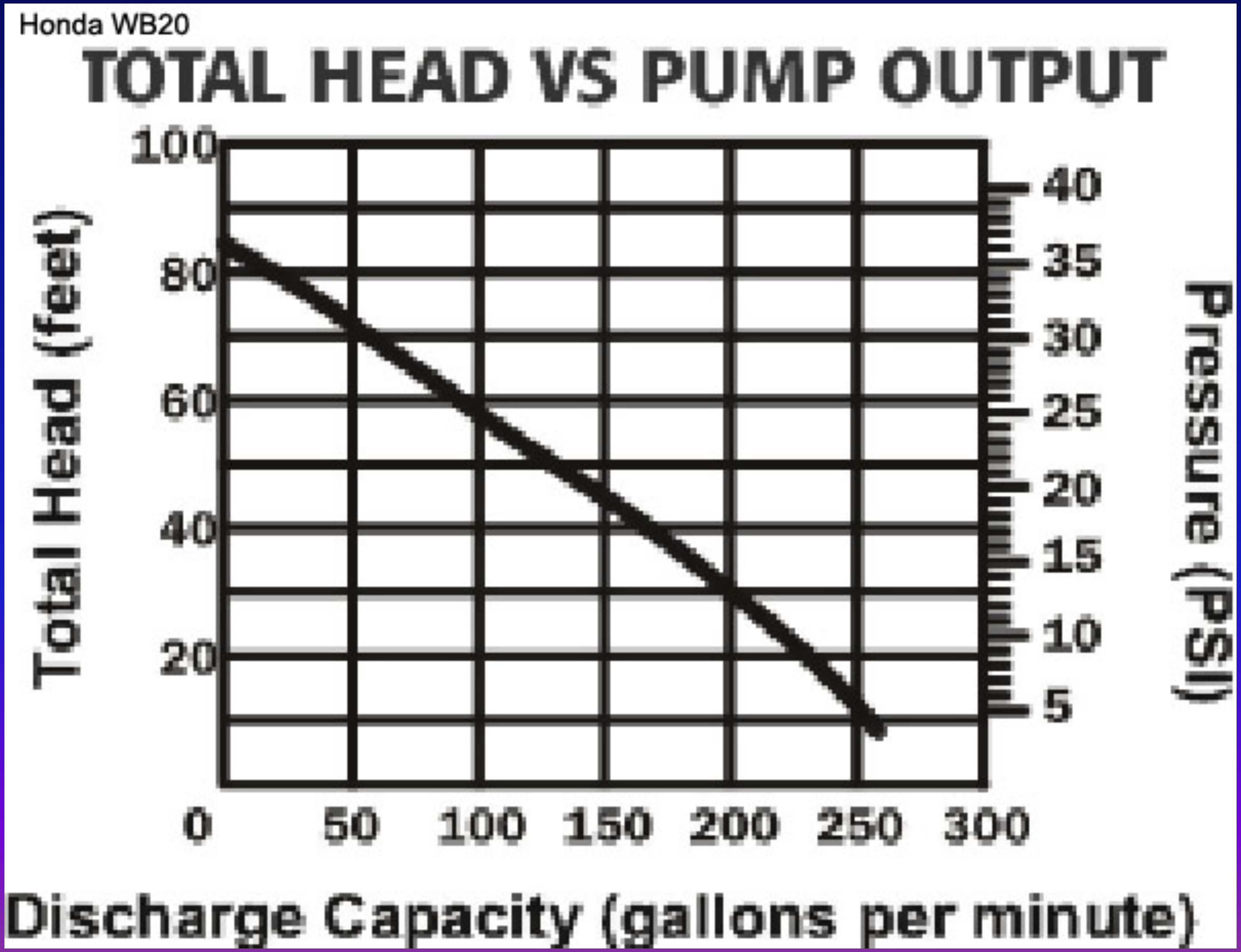
2” Self Priming Pump (cont.)

80 GPM

150 feet of head
(63 psi)

Will this pump
Irrigate the
Vineyard?

NO!

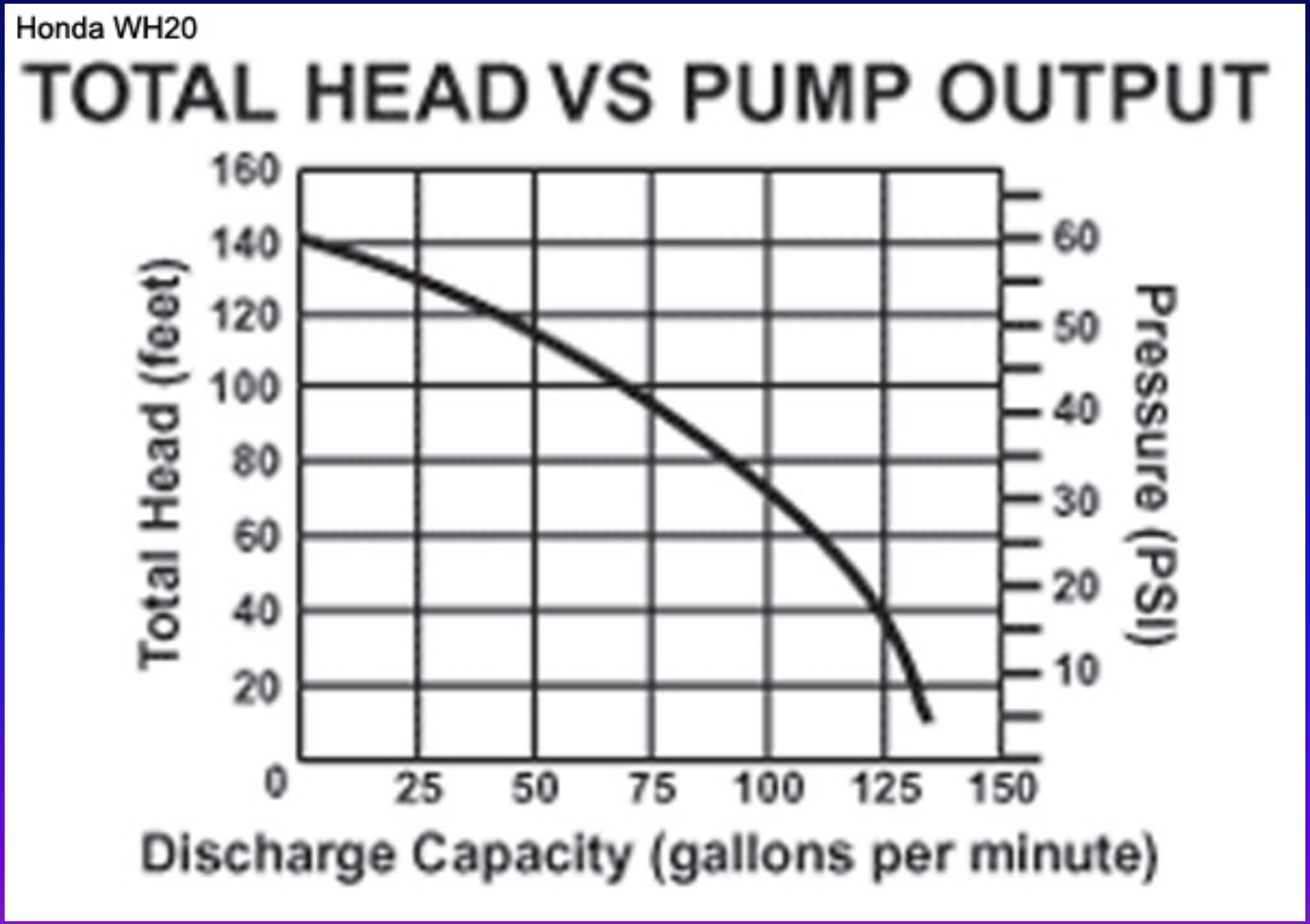


2" Pressure Pump

80 GPM

150 feet of head (63 psi)

Will this pump Irrigate the Vineyard?



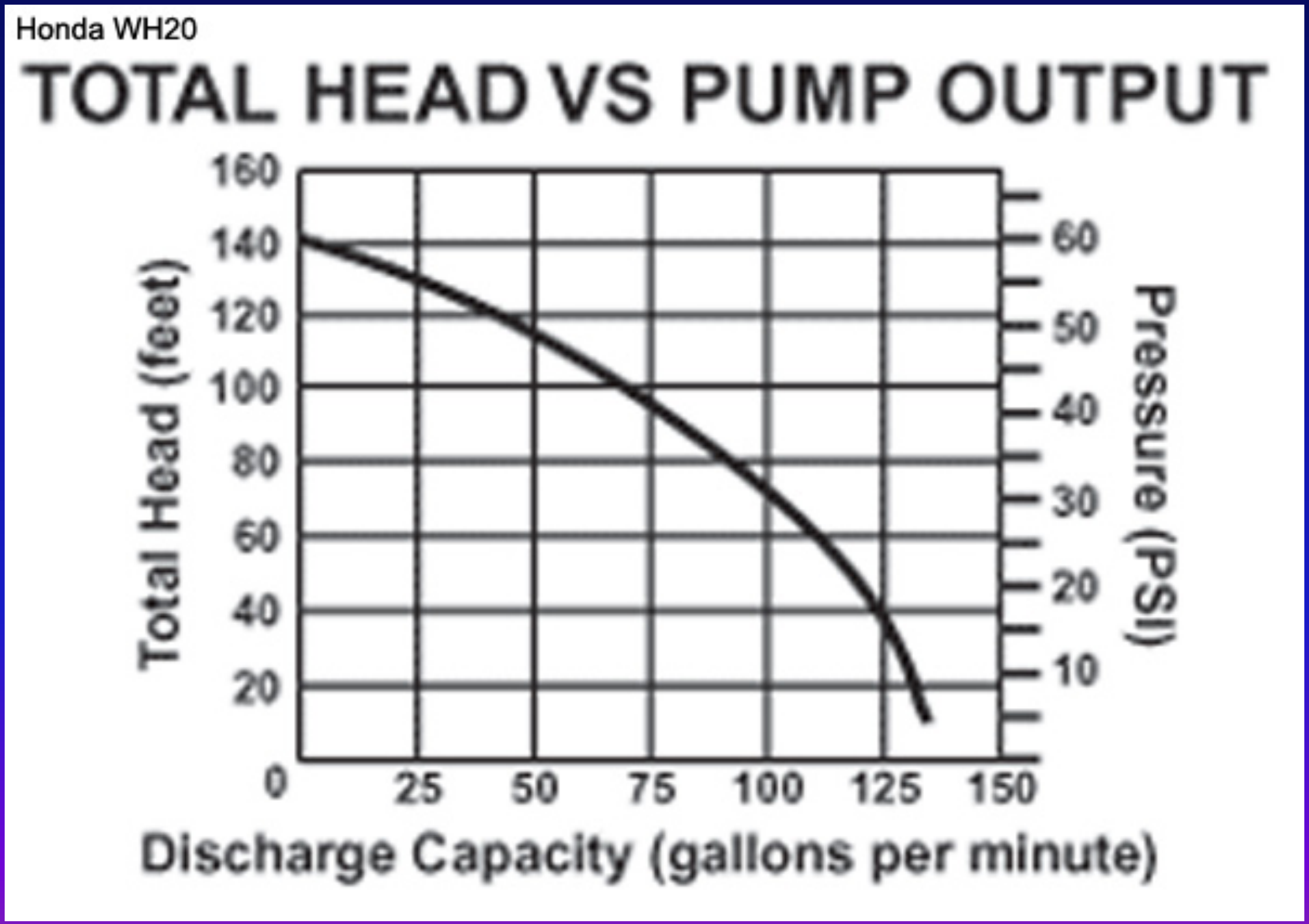
2” Pressure Pump (cont.)

80 GPM

150 feet of head
(63 psi)

Will this pump
Irrigate the
Vineyard?

Probably not.

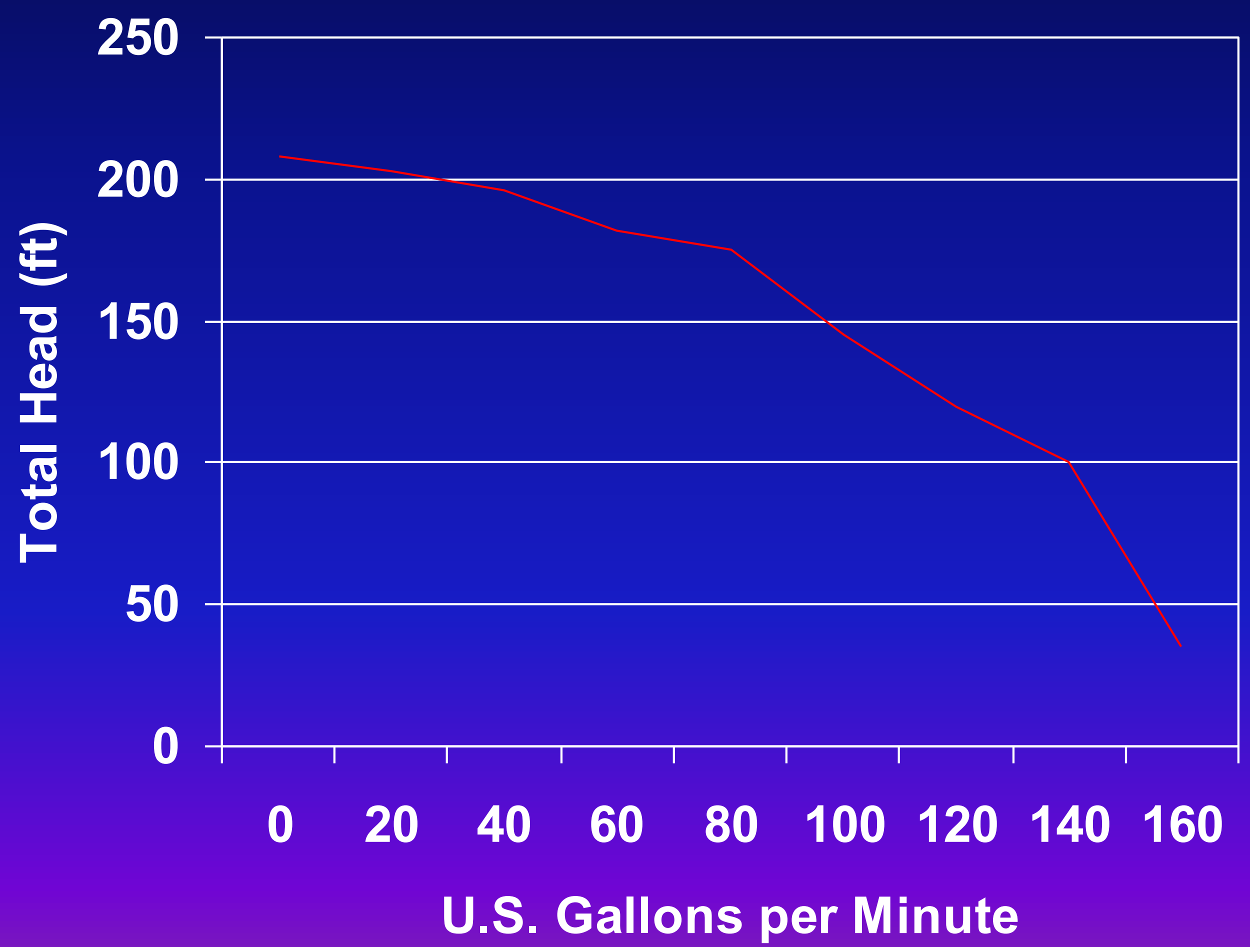


9 HP / Monarch Pump

80 GPM

150 feet of head
(63 psi)

Will this pump
Irrigate the
Vineyard?



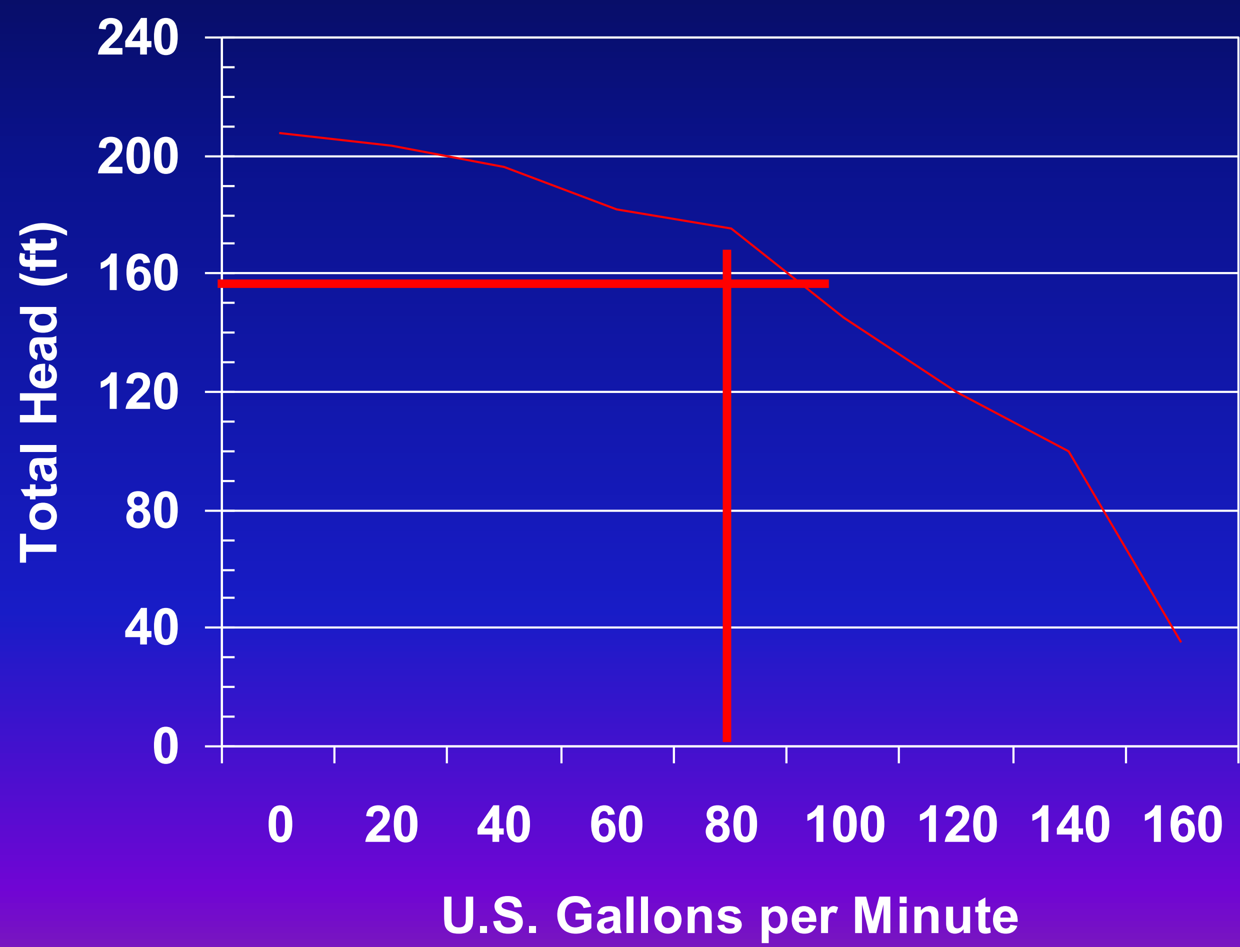
9 HP / Monarch Pump (cont.)

80 GPM

150 feet of head
(63 psi)

Will this pump
Irrigate the
Vineyard?

It would be the
Smallest I would
Use!



Calculating Pump HP

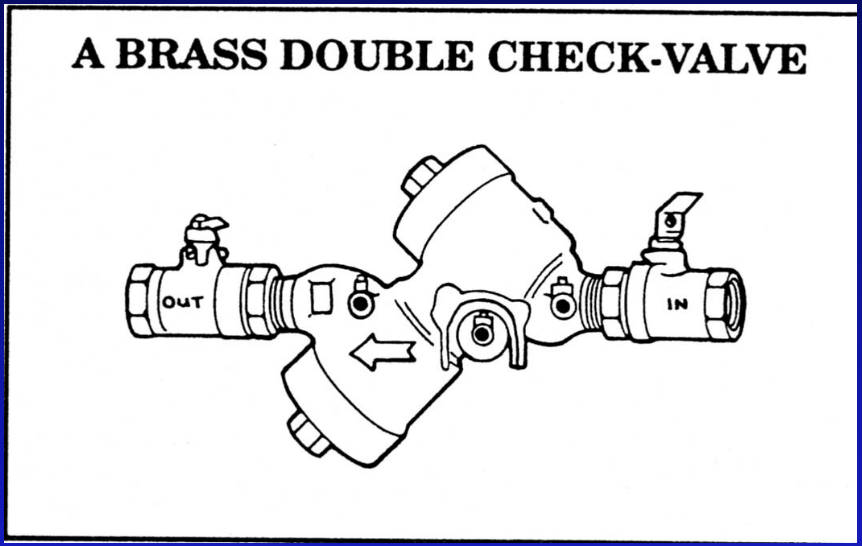
- BHP = Q x h / 3960 x Ef
  - BPH = brake horsepower
  - Q = pump discharge (GPM)
  - h = total dynamic (ft)
  - 3,960 = constant
  - Ef = pump efficiency (decimal)

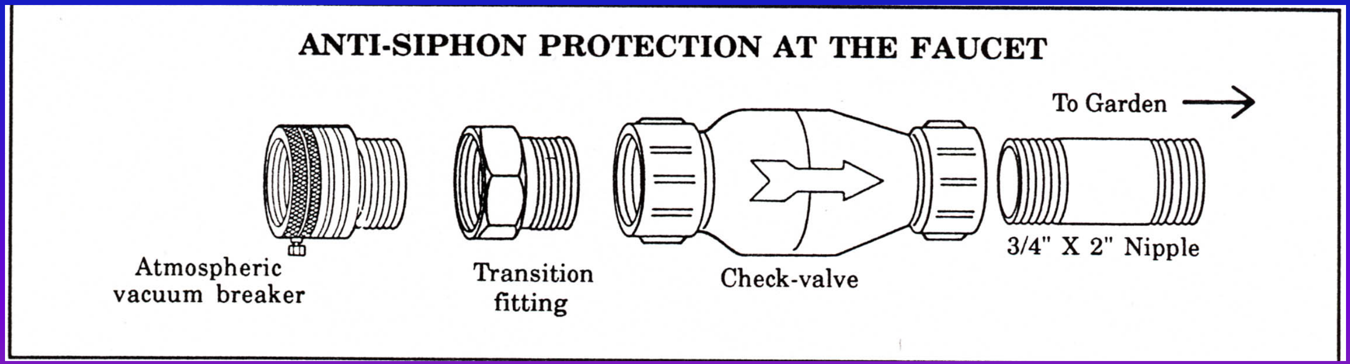
Calculation of Pump HP

- BHP = Q x h / 3960 x Ef
  - Q = 80 GPM
  - H = 150 ft
  - 3,960
  - Ef 0.85
- BHP = 12,000 / 3,366
- BPH = 3.6

Backflow Prevention

- If using potable water . . . You must protect against backflow into potable water source





Injectors

- We often want to apply fertilizer or crop protectants through irrigation water.
- Always place injector in front of a filter.
- Some injectors need a filter before them!

- Types of Injectors
  – Venturi
    - Mazzie
  – Proportioning
    - Electric
    - Non-electric
  – Positive Injection
  – Illegal Methods

Mazzie Injector

Figure 9. Venturi type fertilizer injector

Is This Safe?

Filtration

- All water requires filtration, even municipal and sub-surface sources!!!
- Surface sources require the most filtration, especially “still” bodies with animals nearby.

- Types of Filtration
  - Screen
    - Sediment
    - Algae
  - Disk
    - Sediment
    - Algae
  - Media
    - Heavy Sediment
    - Heavy Algae

Screen Filter

Figure 10. Disassembled screen filter with an incremental adjustable regulator

Disk Filter

Figure 11. Disassembled disk filter with an incremental adjustable regulator

Fiberglass Media Filters

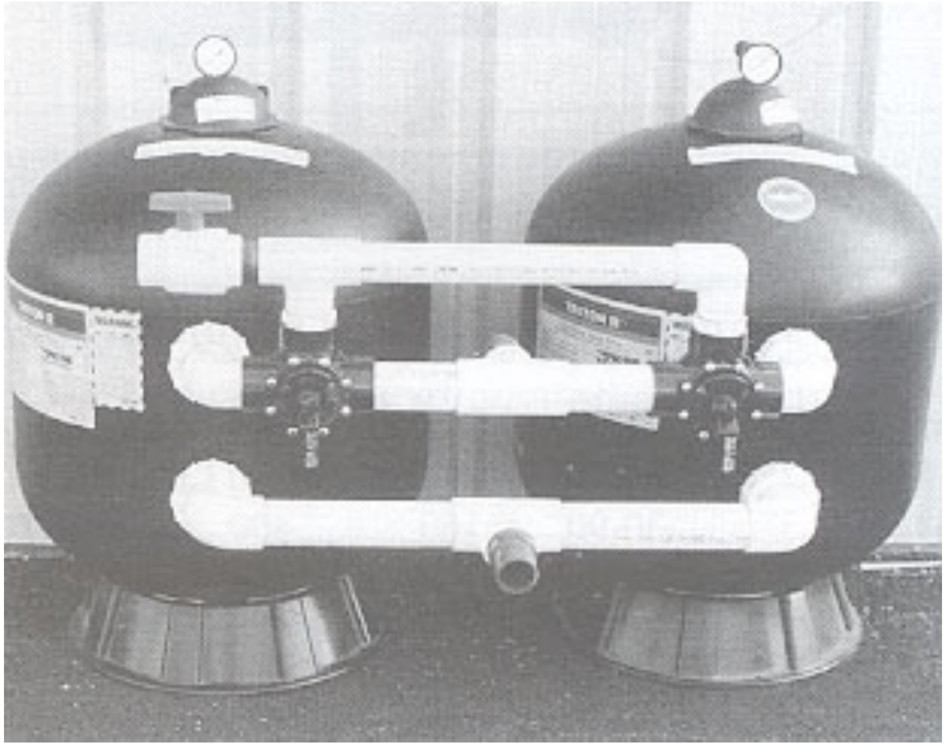


Figure 7. Fiberglass Media Filters

Epoxy Coated Steel Media Filters

Stainless Steel Media Filters

My Favorite

Figure 8. Stainless Steel Media Filters

Media Filters

Pea gravel on bottom and filter sand on top
Backflushing raises the sand layer to release solids

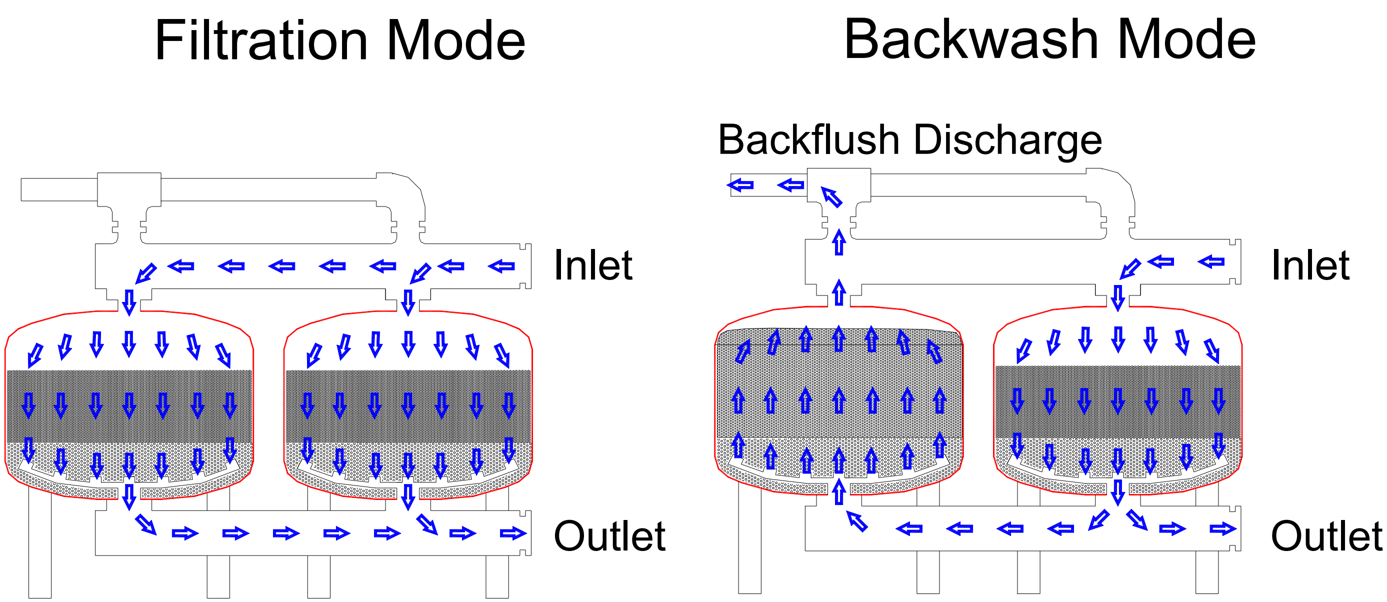


Figure 6. Back-flushing of media filters.

Regulators

- Before we enter our outlet (distribution system) we need some sort of regulator.
- Most trickle systems are designed to operate between 8 and 15 (20) PSI.
- Depending on elevation changes we may want the regulator nearer the distribution system.
- Types of Regulators
  - Preset
  - Adjustable
    - Incremental
    - Continuous

Regulators

Figure 12. Incremental adjustable pressure regulator (left) and a continuous or infinite adjustable pressure regulator (right)

Header Line (Manifold)

- This is the main pipe moving water to the distribution system.
- Types of Header Line:
  - Poly Vinyl
  - Poly Ethylene
  - PVC
  - Aluminum (?)
- Which should you use?
  - Do you need to drive over the header line?
  - Does it need to be relatively free of leaks?
  - Do you want to reuse it?
  - Will the rows remain in the same place?

Laterals

- Laterals supply the water directly to the distribution source.
- Again they may be made from:
  - Poly Vinyl (Lay Flat)
    - Can drive over
    - Easy to roll up
    - Leaks
  - Poly Ethylene (Flat Tube)
    - Can drive over
    - Harder to store
    - Less leaks
  - PVC
    - Cannot drive over without burying
    - Broken down by sunlight
    - Fewest leaks

“Outlet” - Distribution Systems

- Three types of distribution systems in “drip” irrigation systems:
  - Thin wall Trickle or Drip tape
  - Heavy wall Dripper line
  - Poly Ethylene with emitters
- Thin wall drip tape is the most common and affordable!!
- Many brands:
  - AquaTraxx
  - Chapin
  - Netafim
  - Nelson
  - Roberts Ro-Drip
  - T-Tape (most common)

Common Strawberry Drip Tape

- 510-12-450
  - 5 represents the tape diameter
    - 5/8” diameter
  - 10 represents the thickness
    - 10 mil.
  - 12 represents the emitter spacing
    - 12” spacing
  - 450 represents the flow rate
    - 0.45 gallons/minute/100 feet of tape @ 8 PSI

Uses of the Other Types

- Heavy wall dripper line is generally used in:
  - More permanent crops
  - Where slope requires pressure compensation
- Poly Ethylene plus emitters is generally used in:
  - More permanent crops like small fruit
  - Where very uniform water application is required like greenhouse production.

Gauges

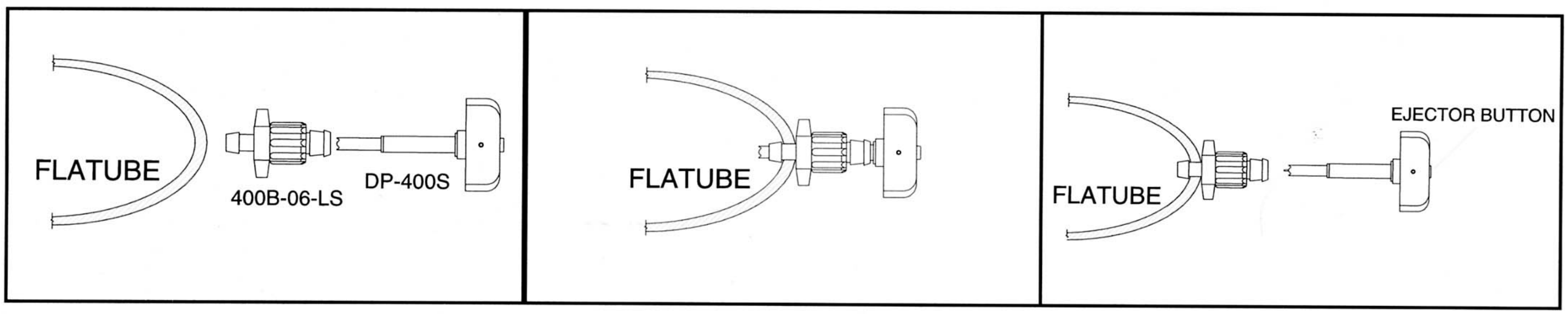
- Make sure you use plenty of gauges to monitor the pressure in the field.
- If you do not know at what pressure you are operating you do not know how much water you are applying!!!

- Gauge Locations
  - Header Lines
  - Laterals
  - End of drip tape
  - At the highest spot in the field!!!

Flat-Tube Manifold and Drip Tape Connectors

Installing Barb End Fittings In API Flatube

400B-06-LS

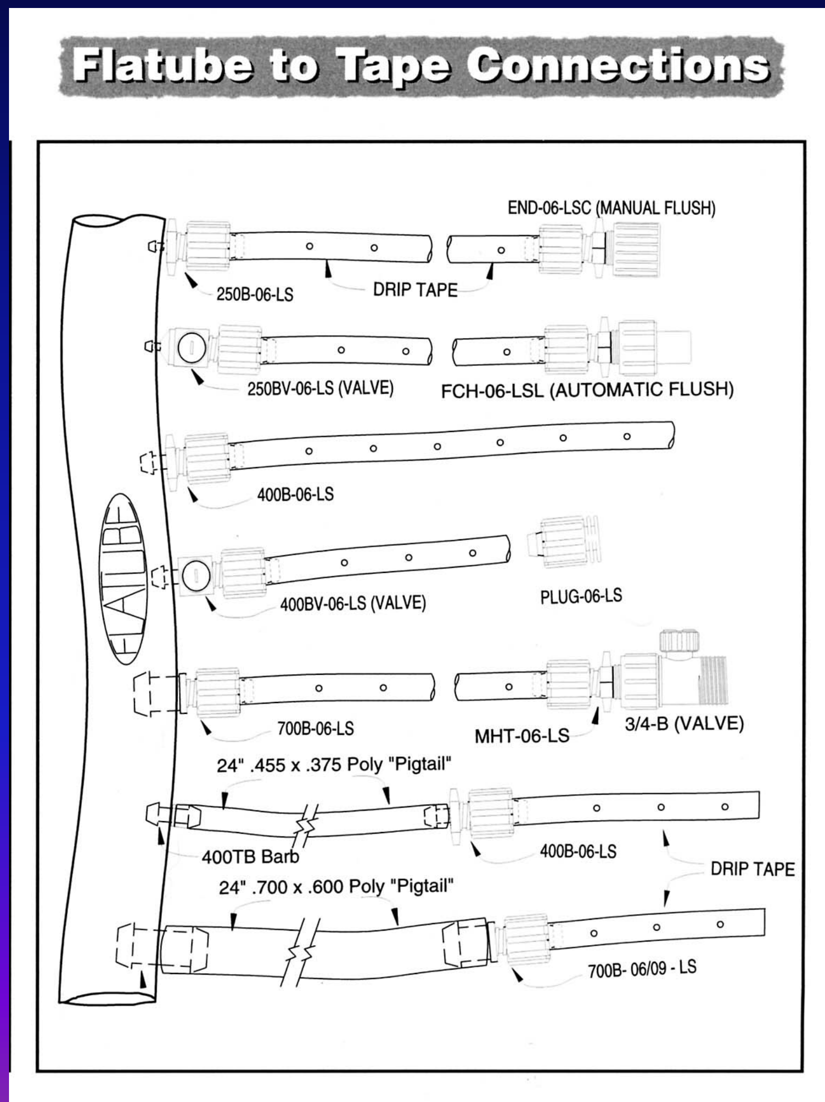


1. Insert punch into barbed fitting.

2. Push and twist to pop barb into API Flatube

3. Remove punch and eject cutout by pushing the ejector button

Additional Fittings



Irrigation Management Level

Level	Irrigation Scheduling Method
0	“Feel Like It” Method (Guessing)
1	“Feel and See” Method
2	Use a Schedule (1/2” every 3 days)
3	Use a Soil Water Tension device
4	Use a Soil Water Tension device to apply water on a schedule
5	Adjust water based on crop need, utilizing Soil Water Tension device

Drip Tape Parameters (0.45 gpm/100 ft.)

Pressure (psi)	GPM/100 ft.	GPM/A (5 ft.)	GPM/A (6 ft.)
8	0.45	39	33
10	0.50	44	36
12	0.55	48	40
14	0.60	52	44
16	0.64	56	46

Drip Tape Parameters (0.34 gpm/100 ft.)

Pressure (psi)	GPM/100 ft.	GPM/A (5 ft.)	GPM/A (6 ft.)
8	0.34	30	25
10	0.38	33	28
12	0.42	37	30
14	0.45	39	33
16	0.48	42	35

Drip Tape Parameters (0.22 gpm/100 ft.)

Pressure (psi)	GPM/100 ft.	GPM/A (5 ft.)	GPM/A (6 ft.)
8	0.22	19	16
10	0.25	22	18
12	0.27	24	20
14	0.29	25	21
16	0.31	27	23

Watering Times (0.45)
(2 ft. beds, 5 ft. centers)

Pressure (psi)	0.10”	0.15”	0.20”	0.25”	0.30”
8	28	42	56	70	84
10	25	37	49	62	74
12	23	34	45	57	68
14	21	31	42	52	63
16	19	29	39	49	58

Watering Times (0.45)
(2.5 ft. beds, 5 ft. centers)

Pressure (psi)	0.10”	0.15”	0.20”	0.25”	0.30”
8	35	52	70	87	104
10	31	46	62	77	93
12	28	42	57	71	85
14	26	39	52	65	78
16	24	36	49	61	73

Watering Times (hours:min.)

(0.45 gpm/100 ft tape, 2.5 ft. beds, 6 ft. centers)

Pressure (psi)	0.10”	0.15”	0.20”	0.25”	0.30”
8	0:35	0:51	1:09	1:26	1:43
10	0:31	0:47	1:03	1:19	1:35
12	0:28	0:42	0:57	1:11	1:25
14	0:26	0:39	0:51	1:04	1:17
16	0:25	0:37	0:49	1:02	1:14

Assumes watering only 2.5 ft. under plastic

Watering Times (hours:min.)

(0.34 gpm/100 ft tape, 2.5 ft. beds, 6 ft. centers)

Pressure (psi)	0.10”	0.15”	0.20”	0.25”	0.30”
8	0:45	1:08	1:31	1:53	2:15
10	0:40	1:01	1:21	1:41	2:01
12	0:38	0:57	1:15	1:34	1:53
14	0:34	0:51	1:09	1:26	1:43
16	0:32	0:49	1:05	1:21	1:37

Assumes watering only 2.5 ft. under plastic

Watering Times (hours:min.)

(0.22 gpm/100 ft tape, 2.5 ft. beds, 6 ft. centers)

Pressure (psi)	0.10”	0.15”	0.20”	0.25”	0.30”
8	1:15	1:50	2:30	3:05	3:40
10	1:05	1:40	2:10	2:45	3:15
12	1:00	1:30	2:00	2:30	3:00
14	0:55	1:25	1:50	2:20	2:50
16	0:50	1:15	1:40	2:10	2:35

Assumes watering only 2.5 ft. under plastic

Fertigation

- Fertigation is the practice of injecting water soluble fertilizer into the irrigation system.
- Make sure the fertilizer is water soluble!!!
- General Practice
  - Pressurize system
  - Inject fertilizer
  - Run system long enough to push the fertilizer out of the system.

Commercial Web Sites

- RainBird Irrigation
  - www.rainbird.com
- Netafim-USA Irrigation
  - www.netafim-usa-landscape.com
- Toro Irrigation
  - www.toro.com/sprinklers/index.html
- Hunter Industries
  - www.hunterindustries.com

Questions?

- R. Allen Straw
  SW VA AREC
  12326 VPI Farm Rd.
  Glade Spring, VA 24340
  Mobile: 931.261.0973
  E-mail: astraw@vt.edu
  Fax: 276.944.2206
  Phone: 276.944.2202

“Freeze Protection” Row Covers and Irrigation

R. Allen Straw

Area Specialist

Virginia Cooperative Extension

Frost and Freeze Protection

- Transitional Zone
  - Significant freezes during fruiting
- Don’t grow strawberries without frost protection
  - Difference between 15% of potential yield to 90% of potential yield
- High-dollar insurance
- No!   It is a necessary investment!

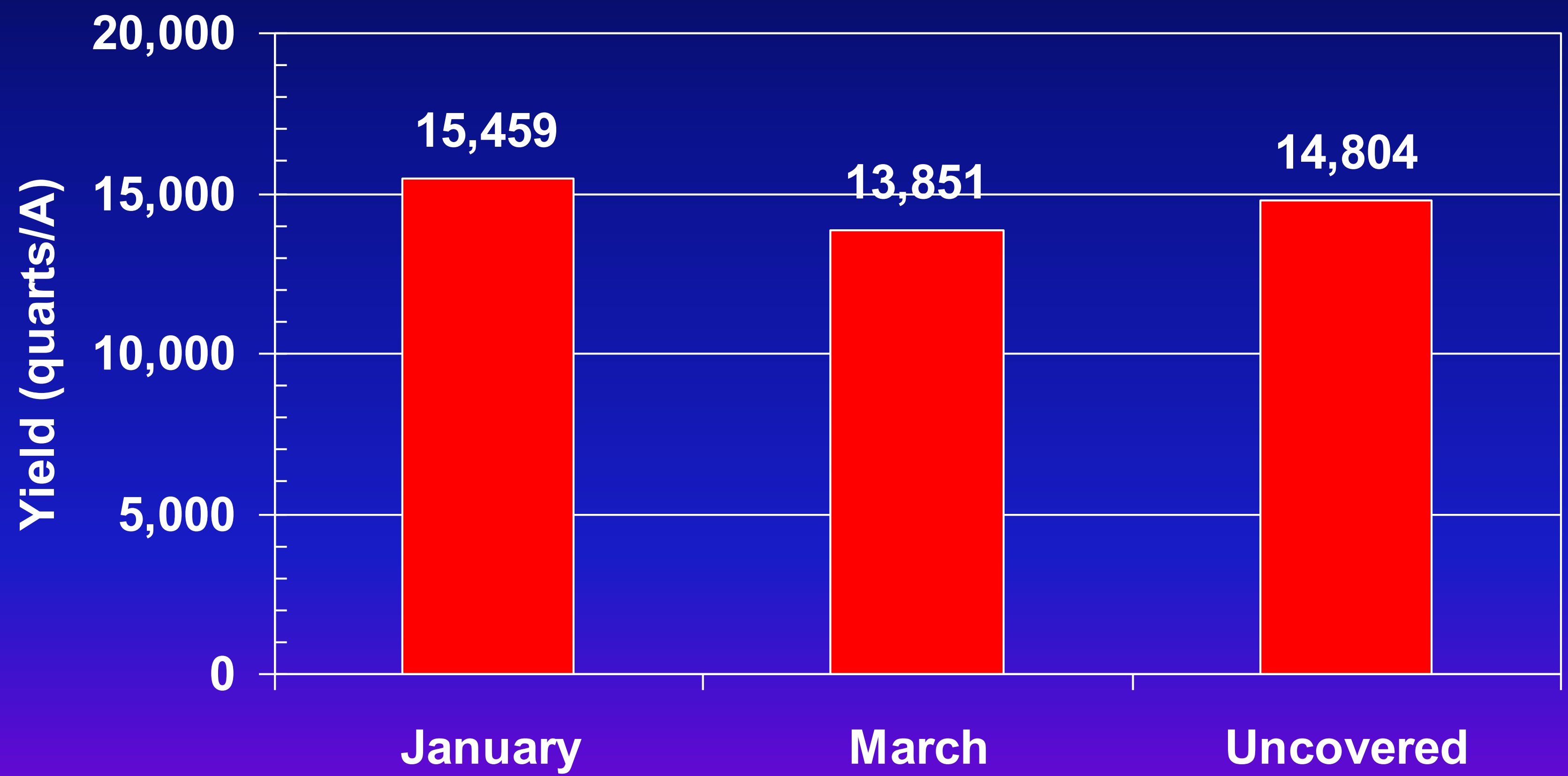
Timing of Row Cover

Covered in January

Uncovered

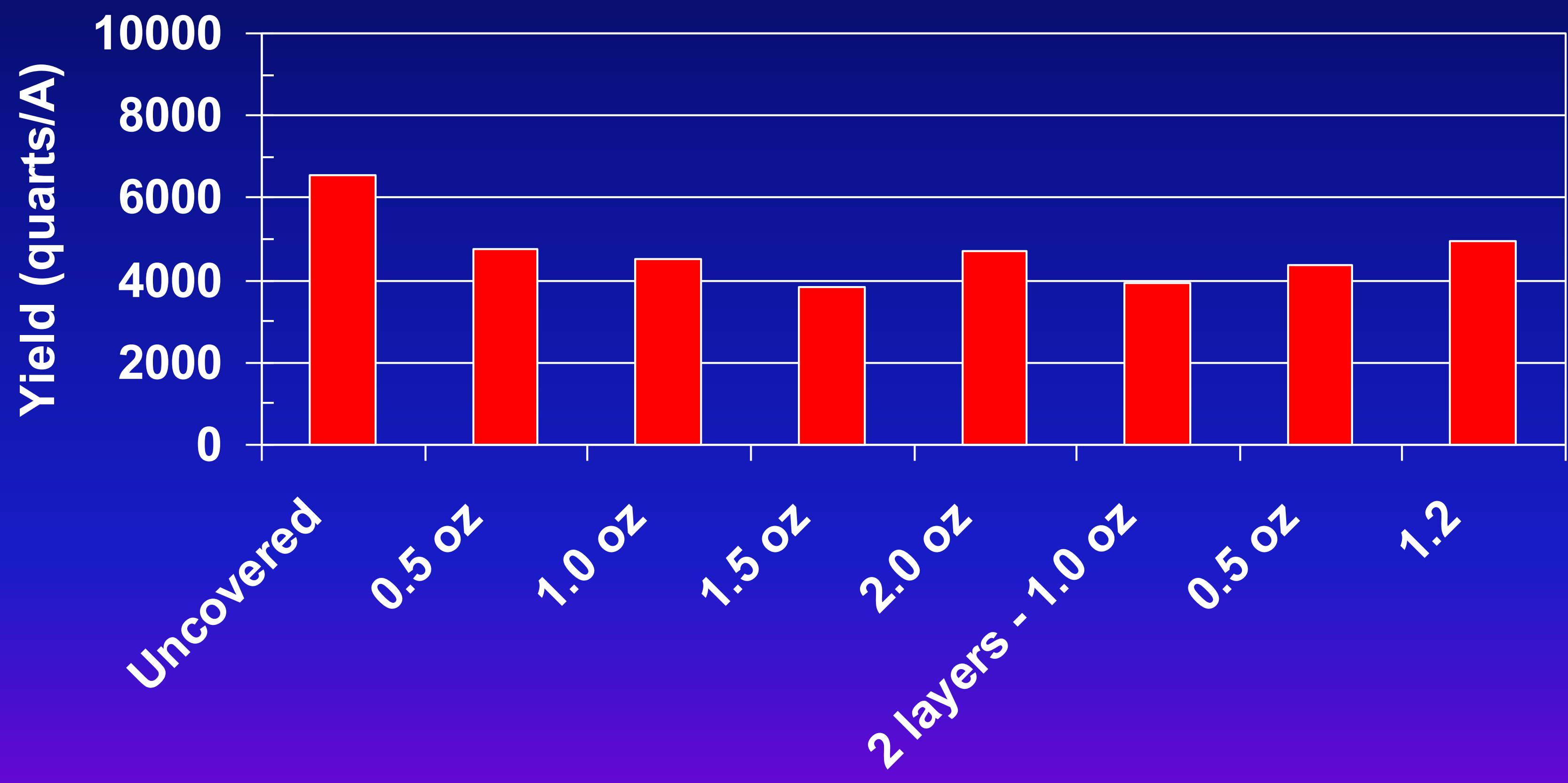
Photos taken mid-April, 2000

Row Cover Trials - 2000



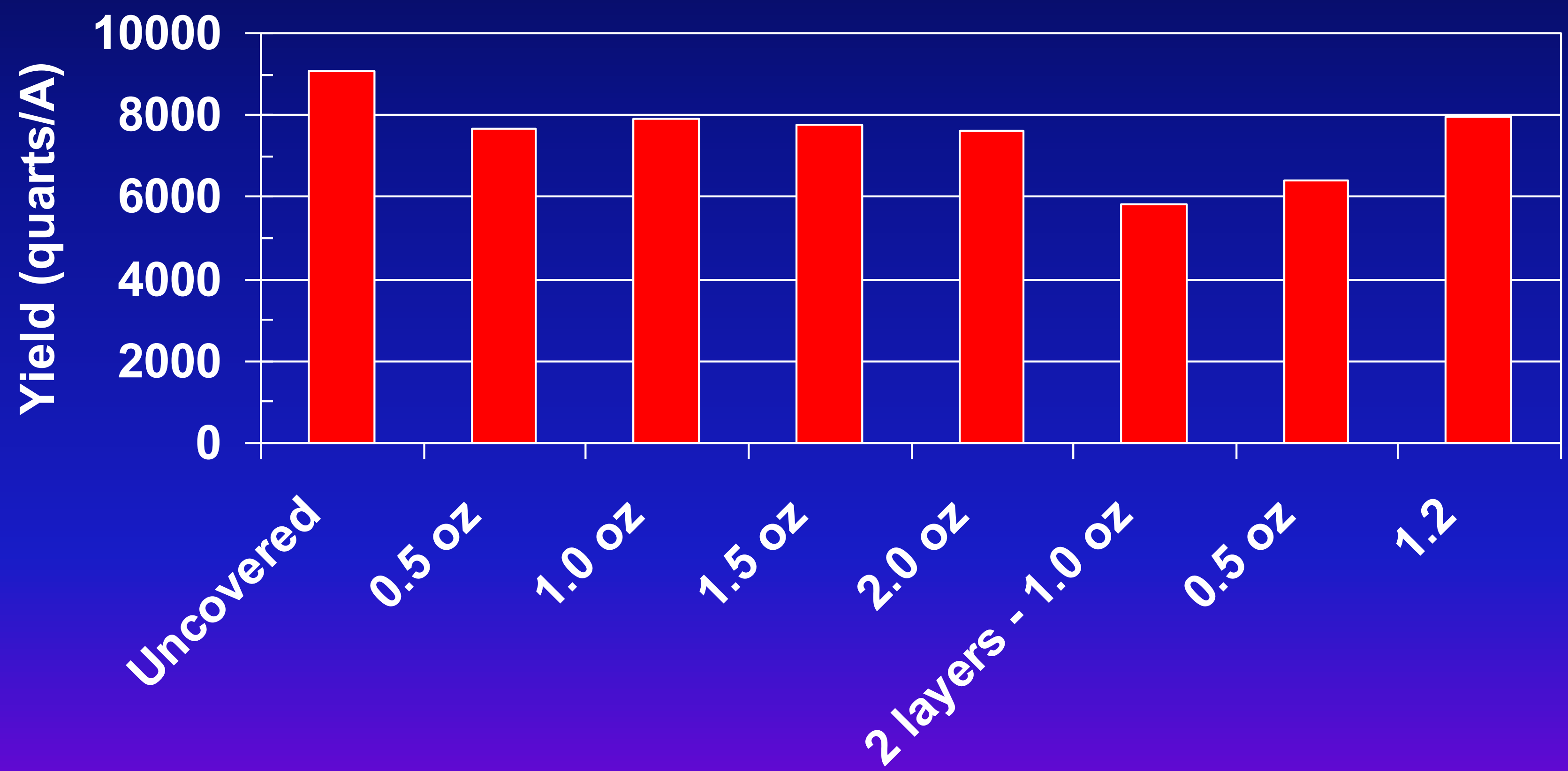
Yield based on 1.25 lb/quart

'Sweet Charlie' Yield - 2003



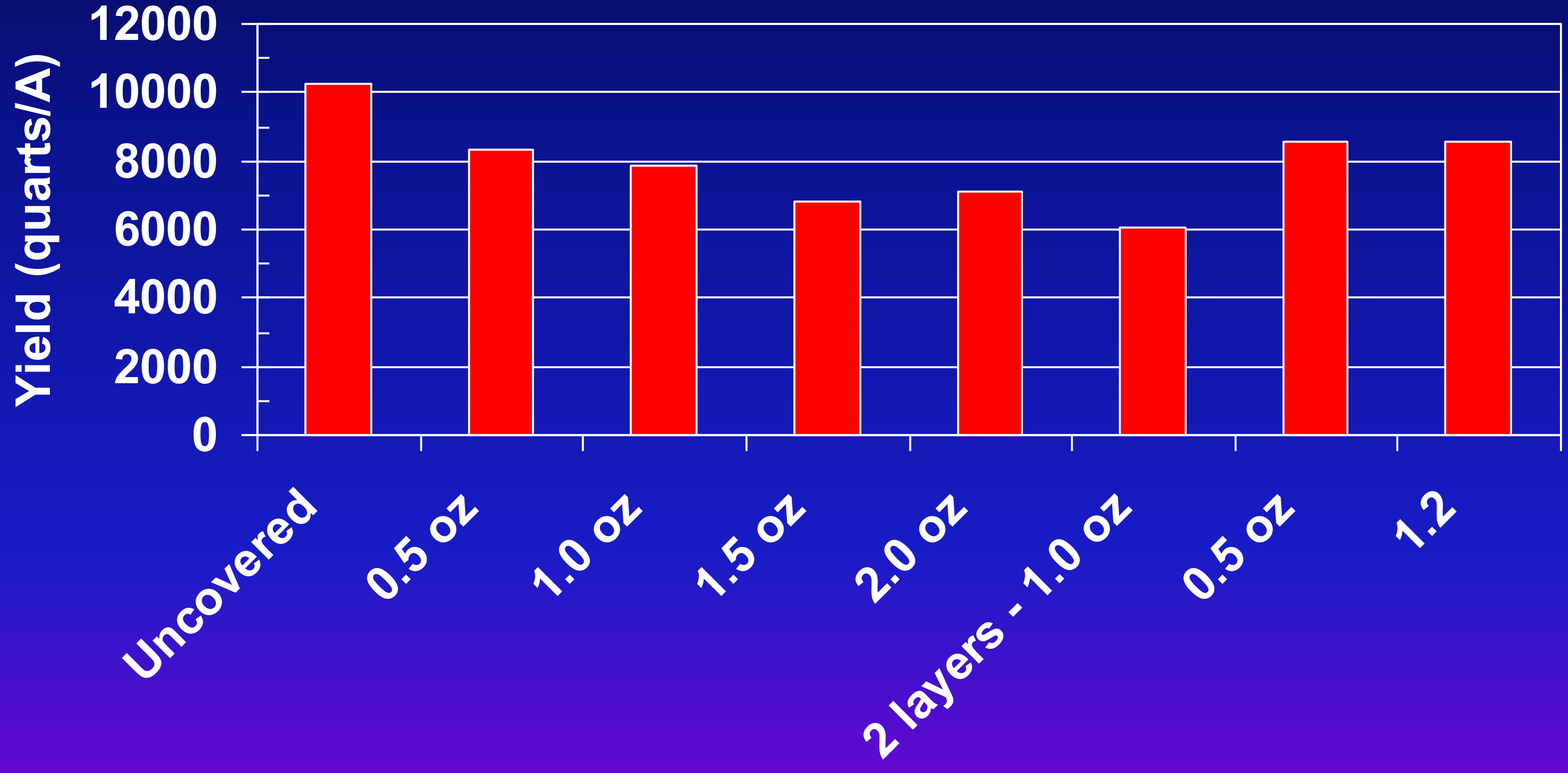
Yield based on 1.25 lb/quart

‘Chandler’ Yield - 2003



Yield based on 1.25 lb/quart

'Camarosa' Yield - 2003



Yield based on 1.25 lb/quart

Results - 2003

- Only 3 nights of frost / freeze protection
- Yield differences were not a result of differences in freeze protection
  - Likely,
    - Lack of light penetration
    - Crown development ?
- Lost temperature data due to equipment malfunction

Row Cover Management

- Three functions of row covers
  - Fall and winter – to promote plant development, especially if late transplanting
  - Winter / spring – to promote bud and bloom development, (use in fall when growing ‘Camarosa’)
  - Winter / spring – to provide protection from cold temperatures, wind, and frost
- Possible use of row covers
  - Manage row covers to extend the harvest season

Frost & Freeze

- Frost
  - Can occur with an air temp above 32ºF and very low dew point
  - Radiation heat transfer to black sky can cause moisture in the air to form frost
- Freeze
  - Air temp drops to freezing or below
  - Frost usually occurs with freeze

Two Types of Freeze Conditions

- Radiation Freeze
  - Heat from air is lost to black, cloudless sky with little or no wind conditions
  - Best case for freeze protection
- Advection Freeze
  - Horizontal movement of cold air into area with wind
  - Worst case for freeze protection

Frost/Freeze Protection Theory

- Not just an insulation effect
  - However, this is important
- Latent heat of fusion
  - As water freezes144 btu per pound of water is released to the environment
- Sensible heat
  - Liquid water cools and releases heat to environment

Sources of Heat

- Liquid water
  - Heat released from water
    - Sensible
    - Latent
- Heat in the soil
  - Water absorbs and holds heat from soil
  - Ice insulates soil heat
    - Little effect if off the soil surface

Heat Transfer

- Air to Water
  - Latent heat of vaporization, evaporative cooling, 1,044 btu per lb of water
  - This is a problem at beginning of water flow
- Water to Air
  - Once air is saturated, sensible heat is transferred to the air
  - 1 btu per pound of water per ºF

Heat Transfer (cont.)

- Water to Plant
  - Heat of fusion
    - Transfers some heat to plant surface
    - Transfers some heat to air
- Convection
  - Warm air rises
- Advection
  - Air moves from high pressure to low pressure

Engineering Issues

- Selection of Sprinklers
  - Uniformity
  - Application rate
  - Freezing of heads
- Selection of Pipe Size
  - Friction loss
  - Volume of water
- Sprinkler Layout
  - Overlap of wetted zone
- Selection of Pressure Source (Pump)
  - Elevation
  - Distance
  - Pressure at nozzles

Critical Temperatures

- Different phases of crop growth has different critical temperatures
  - Crown (buds concealed) $10^{o}F$
  - Buds (buds emerged, closed) $27^{o}F$
  - Blooms open $30^{o}F$
  - Fruit $28^{o}F$
- We need more information!!
  - Buds (partially emerged) $15^{o}F$- $25^{o}F$ (?)

Generally Speaking

- As a rule, we do not desire for the crop to drop below 30ºF
  - Remember evaporative cooling
  - Need to start system at 34 to 35ºF
- Application rate of 0.15 inch per hour
  - With no-wind, protection to 22ºF
  - Liquid water should always be available

Water Application Rates (in./hr)

	Wind Speed (mph)				
Temp.	0 - 1	2 - 4	5 - 8	10-14	18-22
27°F	0.10	0.10	0.10	0.10	0.20
26°F	0.10	0.10	0.14	0.30	0.40
24°F	0.10	0.16	0.30	0.40	0.80
22°F	0.12	0.24	0.50	0.60	---
20°F	0.16	0.30	0.60	0.80	---
18°F	0.20	0.40	0.70	1.00	---
15°F	0.26	0.50	0.90	---	---

Volume of Water

- At 0.15 inch per hour
  - 68 gpm per acre
  - 40,800 gallons per acre per 10 hour event
- How many events ?
  - Better plan on 20 - 10 hour events
  - 815,000 gallons per acre of strawberries
  - 2.5 ac-ft of water per acre of crop

Layout of System

- Sprinkler Spacing
  - Traditional spacing is 60’ by 60’
    - Not as many sprinklers required
    - Takes longer for sprinkler to cover area
  - The Closer, The Better
    - 40’ by 40’ is a compromise
    - 30’ by 30’ is best
  - Function of sprinkler type and available water pressure

Types of Sprinklers

- Traditional Impacts
  - Higher pressure
  - Rigid construction
  - Large selection

- Wobblers
  - Excellent uniformity
  - Fast rotation
  - Limited range

Impacts vs. Wobblers

- Impacts
  - Solid body construction
  - Higher pressure requirement, wide range of flow selection
  - Wide range of wetted-diameters
  - Rigid pipe layout, mostly coupled-aluminum
  - More likely to freeze-up (18^{o}F)

Wobblers vs. Impacts

- Wobblers
  - Installation similar to micro-irrigation system
  - Lower pressure, limited wetted diameter
  - For small acreage, same pump and infrastructure can be used for both trickle irrigation and freeze protection
  - Uses more water per head
  - Plastic body

Water Application

Impacts

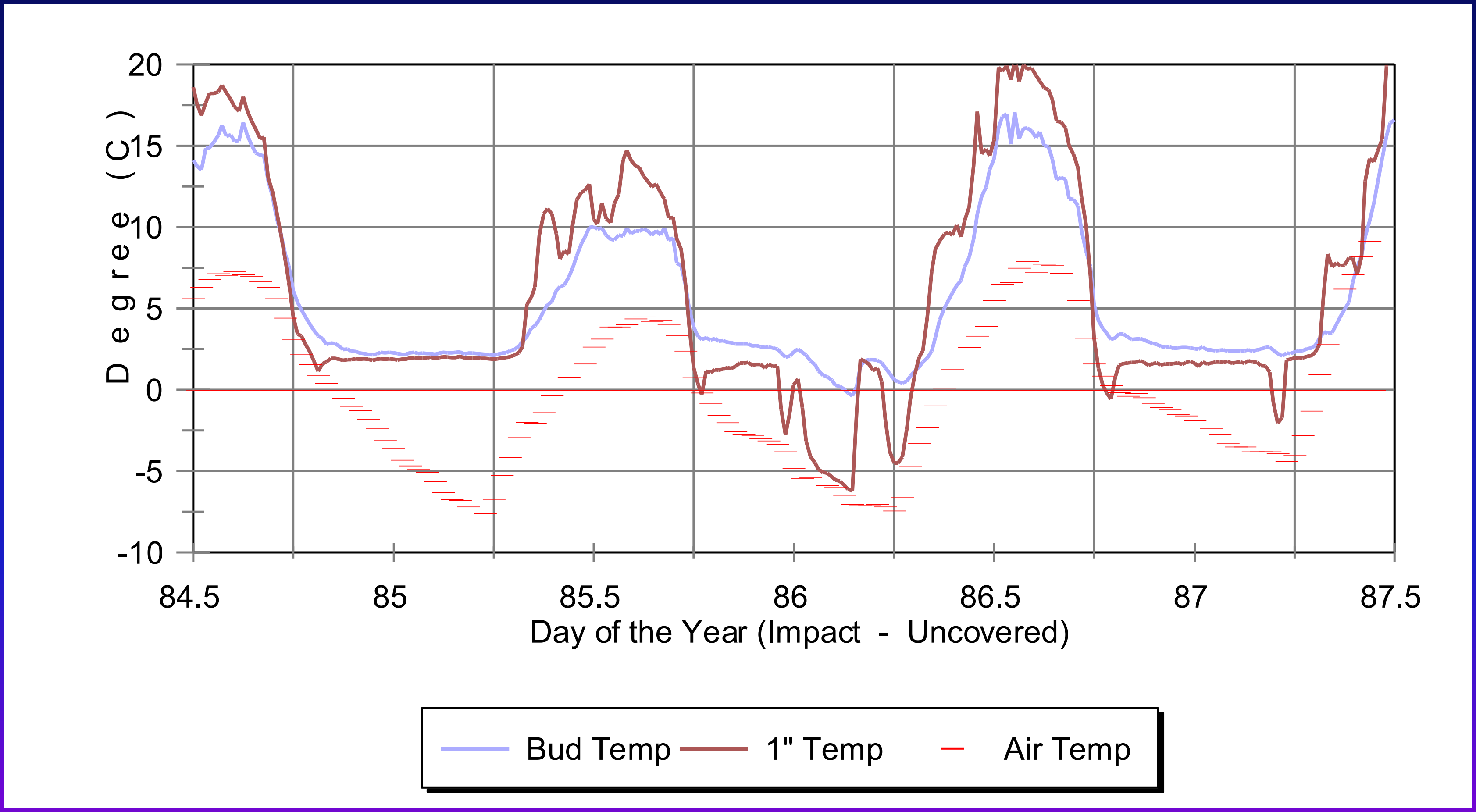
- High spray angle
- Flow is concentrated

Wobblers

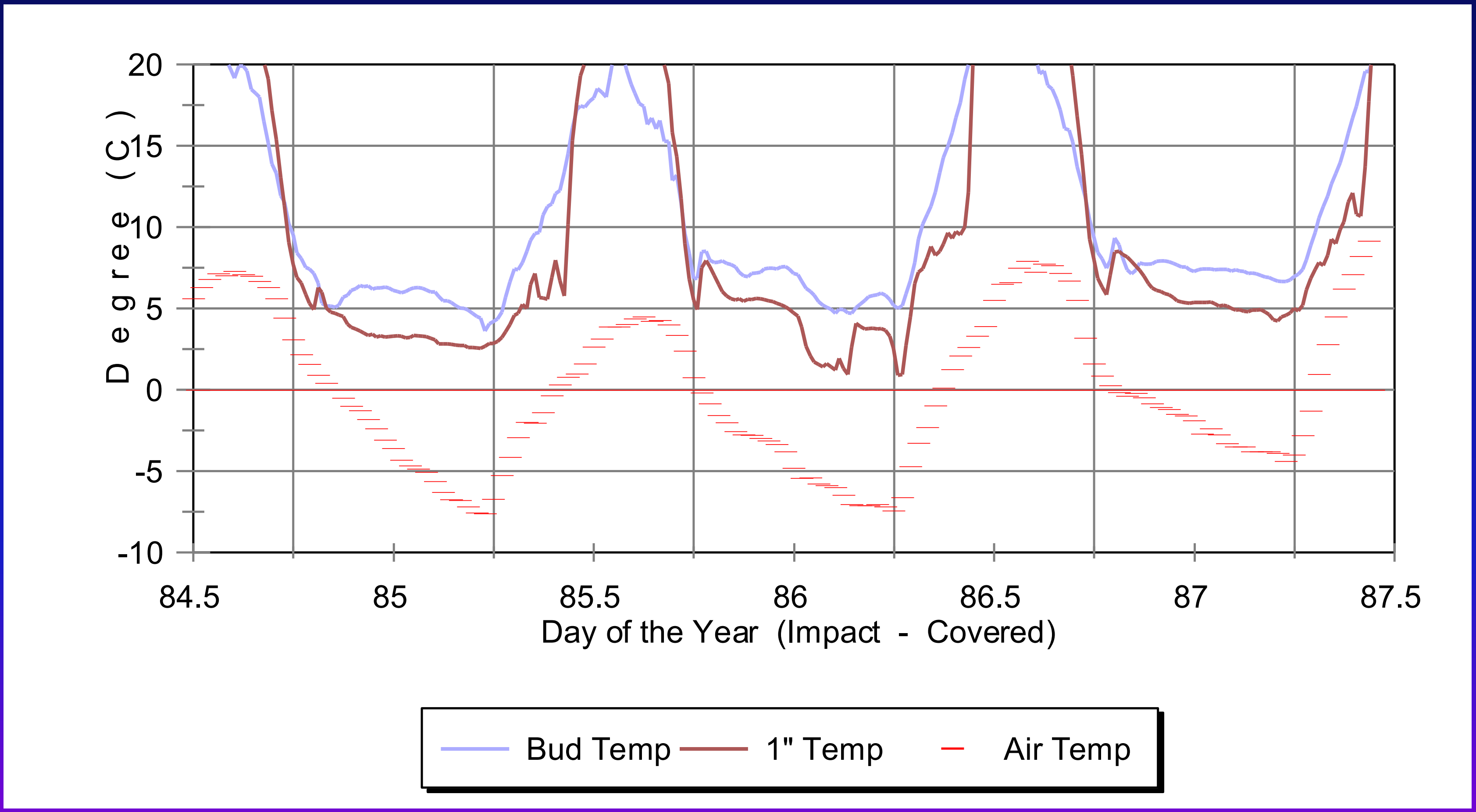
- Low spray angle
- Fast rotation

Combination:
Row Covers and Irrigation

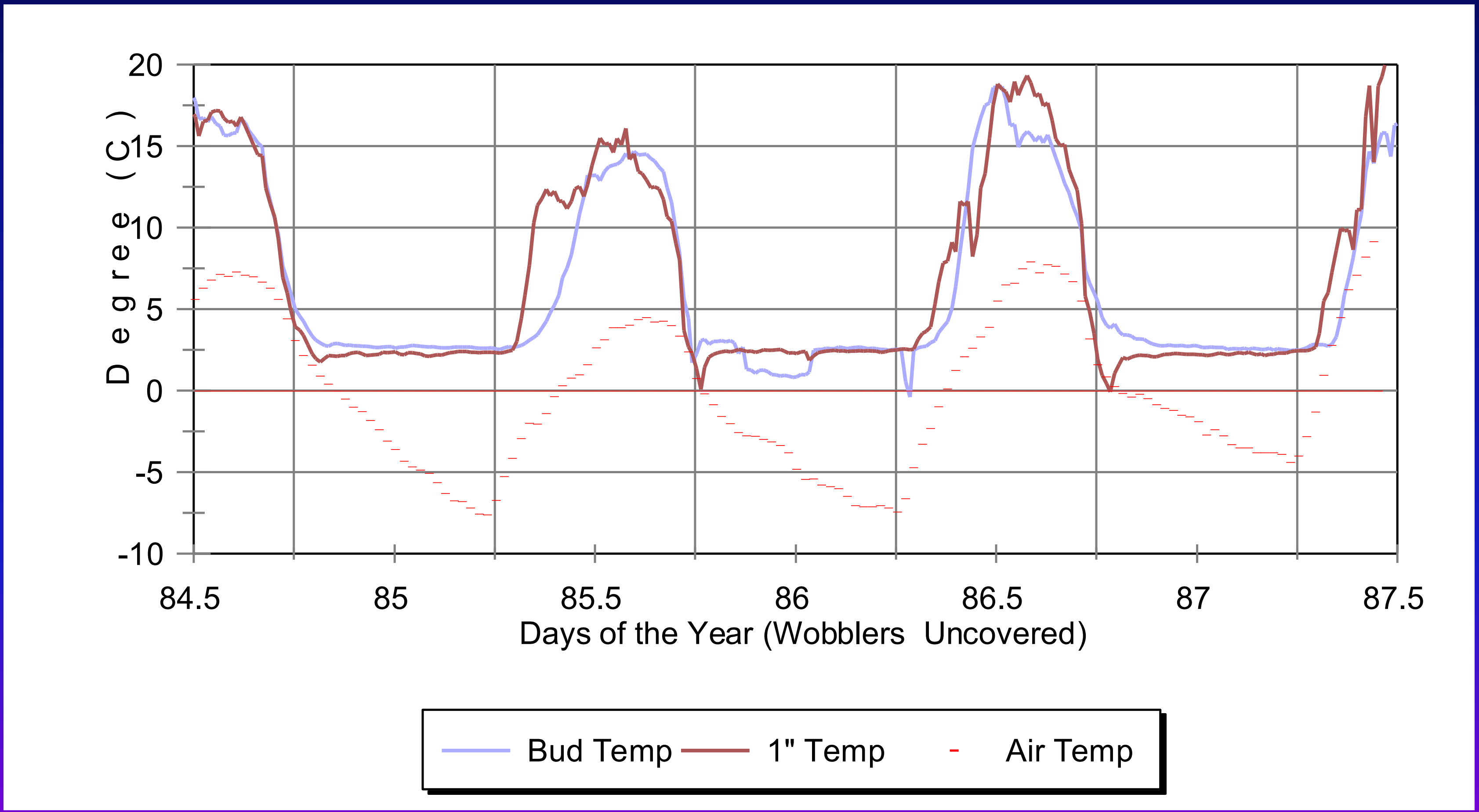
Impact - Uncovered



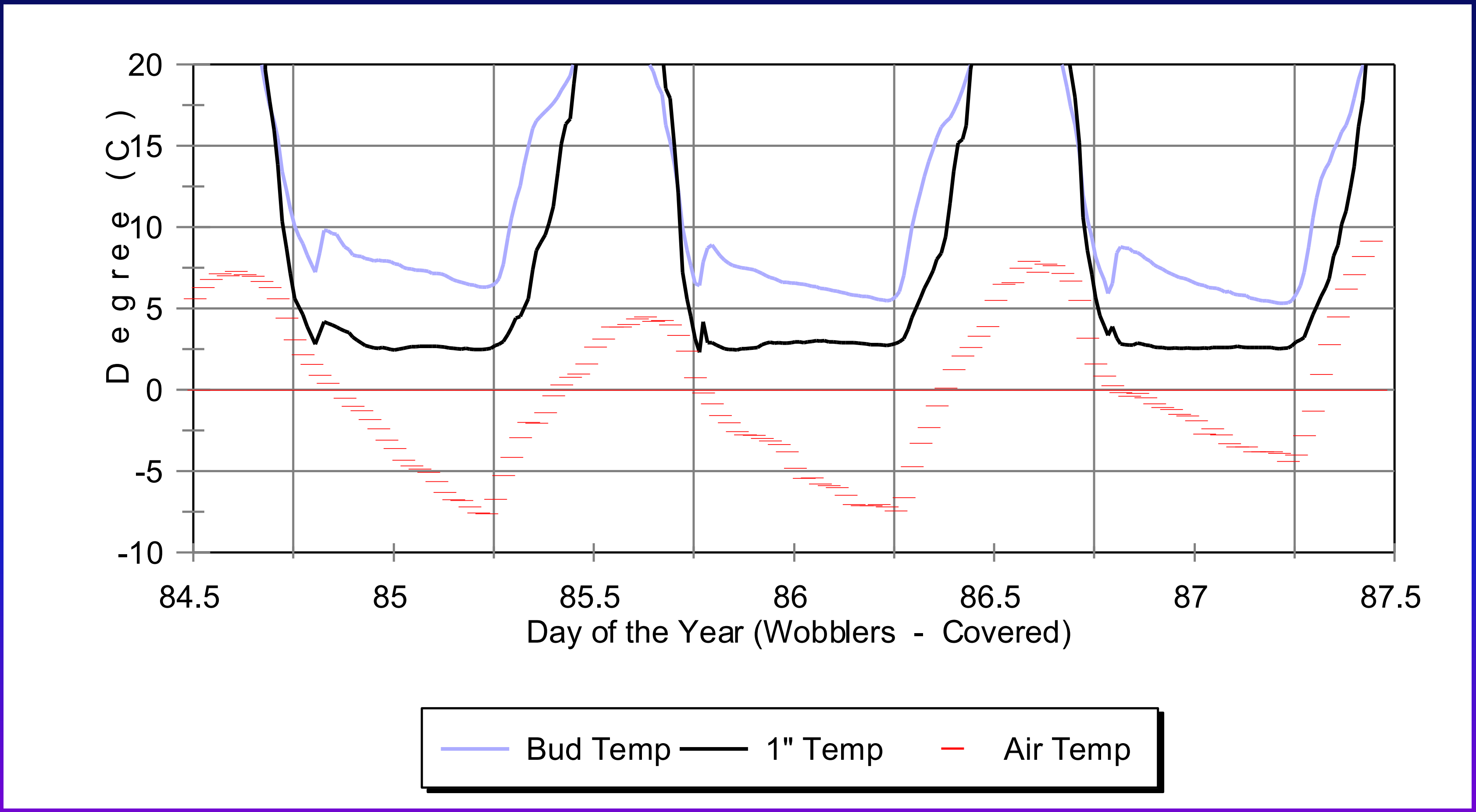
Impact - Covered



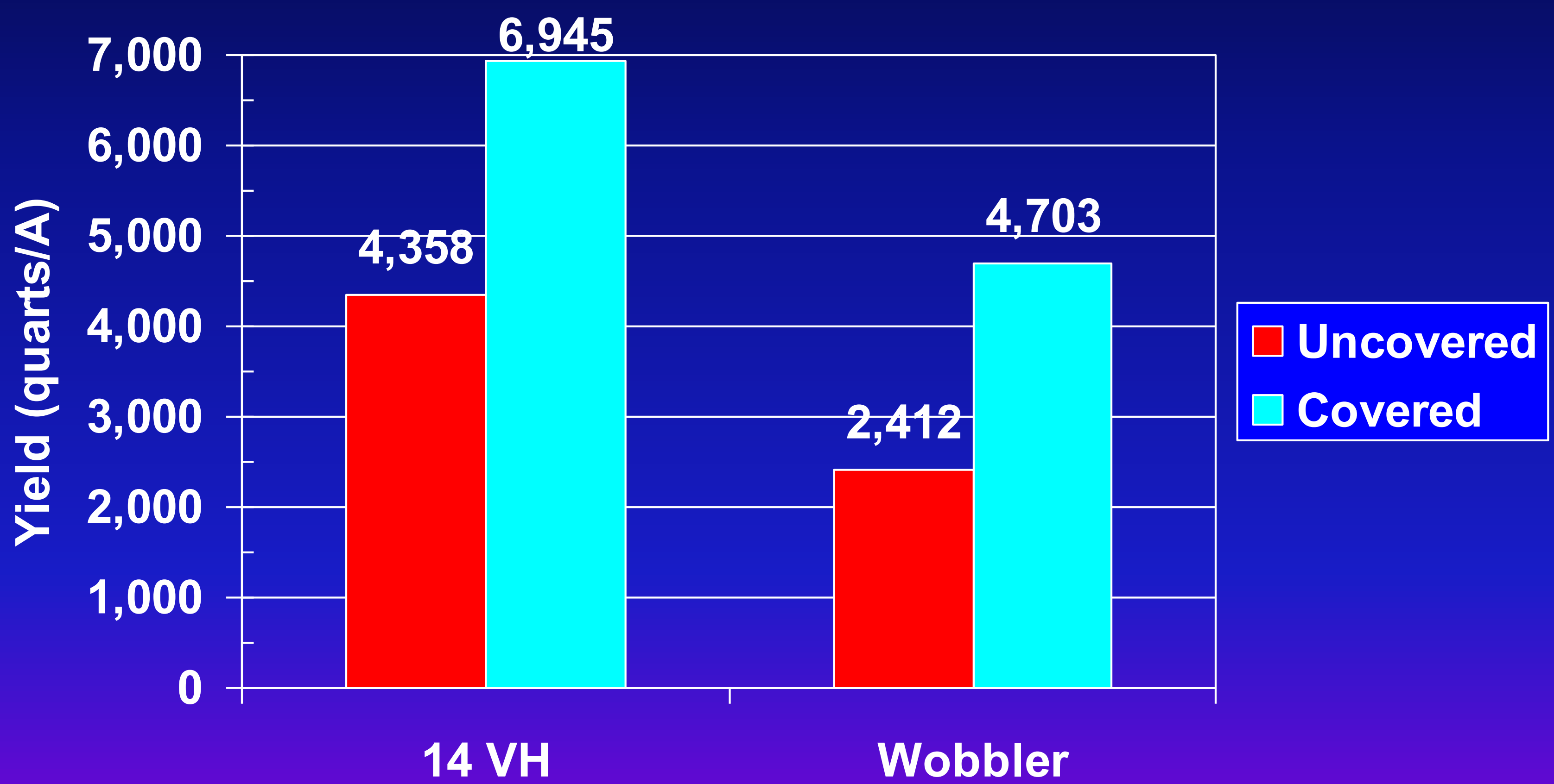
Wobblers - Uncovered



Wobblers - Covered



Yield Data - 2001



Yield based on 1.25 lb/quart

Grower Experiences - 2001

- Valley Home Farm
  - Nancy Edwards and Bob Potts
  - Bedford Co. (Southeast of Nashville)
- Wobblers
  - 30’ X 30’ Spacing
  - 3/32” Nozzles (#6 – Gold)
- Six Nights of Frost Protection
  - **March 24 – March 27**
  - April 17 – April 18

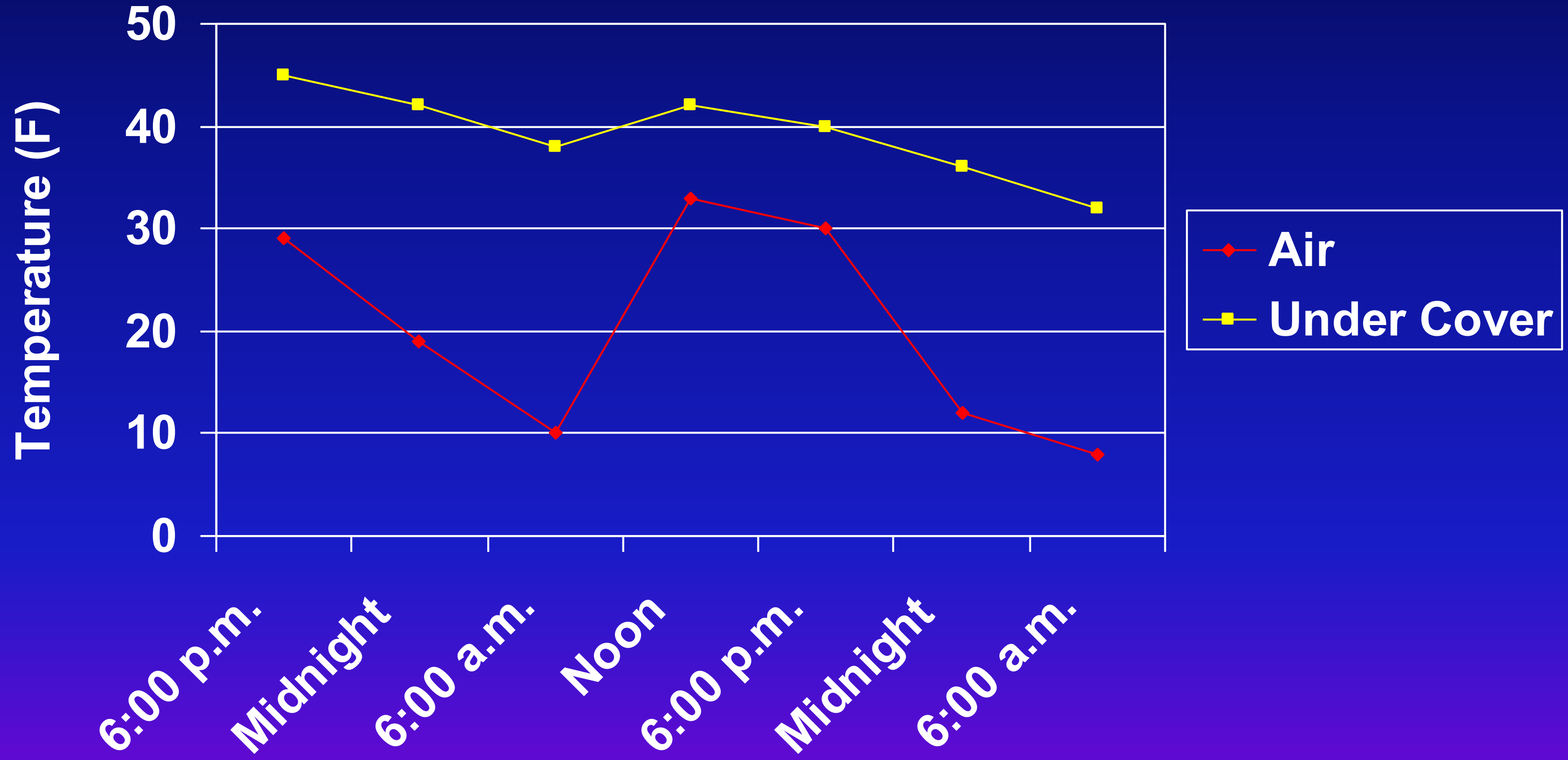
Grower Data - 2001

Temp. / Press.	3/24	3/25	3/26	3/27
Air Temp @ Startup (^oF)	32	30	24	27
Blossom Temp @ Startup (^oF)	34	33	32	33
Average Blossom Temp after Icing (^oF)	39	38-40	40	40
Low Temp (^oF)	27	20	16	18
Pressure @ Head (PSI)	20	15	30	25
Application Rate (in./A)	0.12	0.10	0.14	0.13

Grower Experiences - 2002

- Valley Home Farm
  – Nancy Edwards and Bob Potts
  – Bedford Co. (Southeast of Nashville)
- Wobblers
  – 30’ X 30’ Spacing
  – 3/32” Nozzles (#6 – Gold)
  – 27 -28 psi (0.13 in./hr)
- Cold Snap – Late February
  – Buds emerging from crowns
  – Forecast low teens

Grower Data - 2002



February 26 – 28, 2002

Evidence

Overall Results - 2002

- Impacts Only
  - Froze at 18°F
  - Lost 5 to 20% of yield
- Impacts / Covers
  - Froze at 18°F
  - Minor losses
- Wobblers / Cover
  - No loss

Frost / Freeze Protection Recommendations

- Frost above freezing
  - Water or row covers alone
- Temperatures mid- to high 20's
  - Water or row covers alone
- Temperatures low 20's
  - Use both water and row covers
- I believe we could protect fruit to $0^{o}F$

Other “Tricks”

- One grower has all of the nozzles to fit the Wobblers, he changes them based on the forecast.
- Two growers have limited water supplies:
  - Run the system until ice forms
  - Turn it off (one by-passes the water leaving the pump running)

Questions ?

Irrigation Design

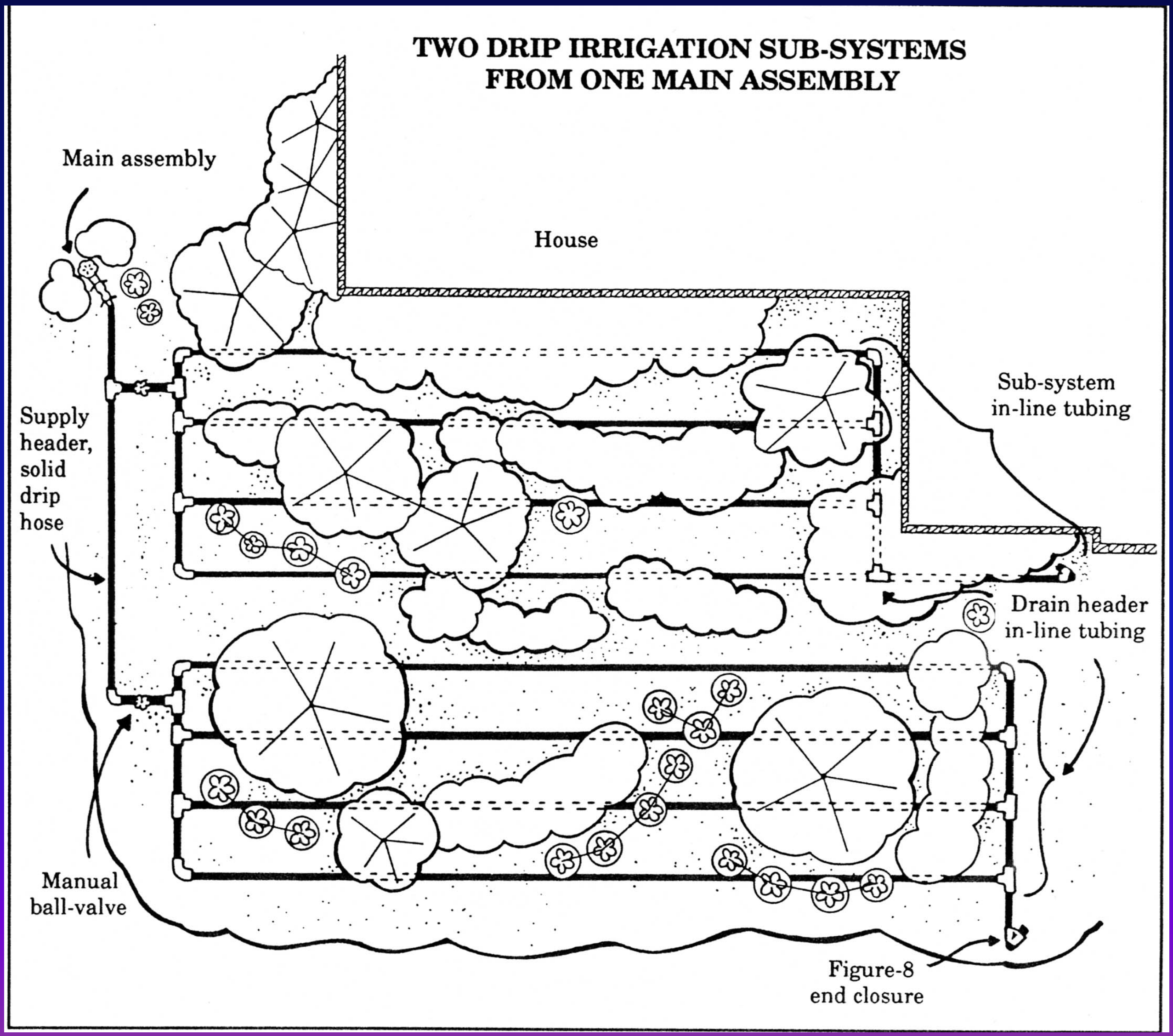
R. Allen Straw

Area Specialist

SW VA AREC

Virginia Cooperative Extension

Designing a System



Two Approaches to Irrigation Design

- Assume that water-supply is not a limiting factor
  - If you live next to a river or stream
  - Design water supply for the system
- Assume that the water-supply will limit your design
  - Using utility water or low-production well
  - Design system for the water supply

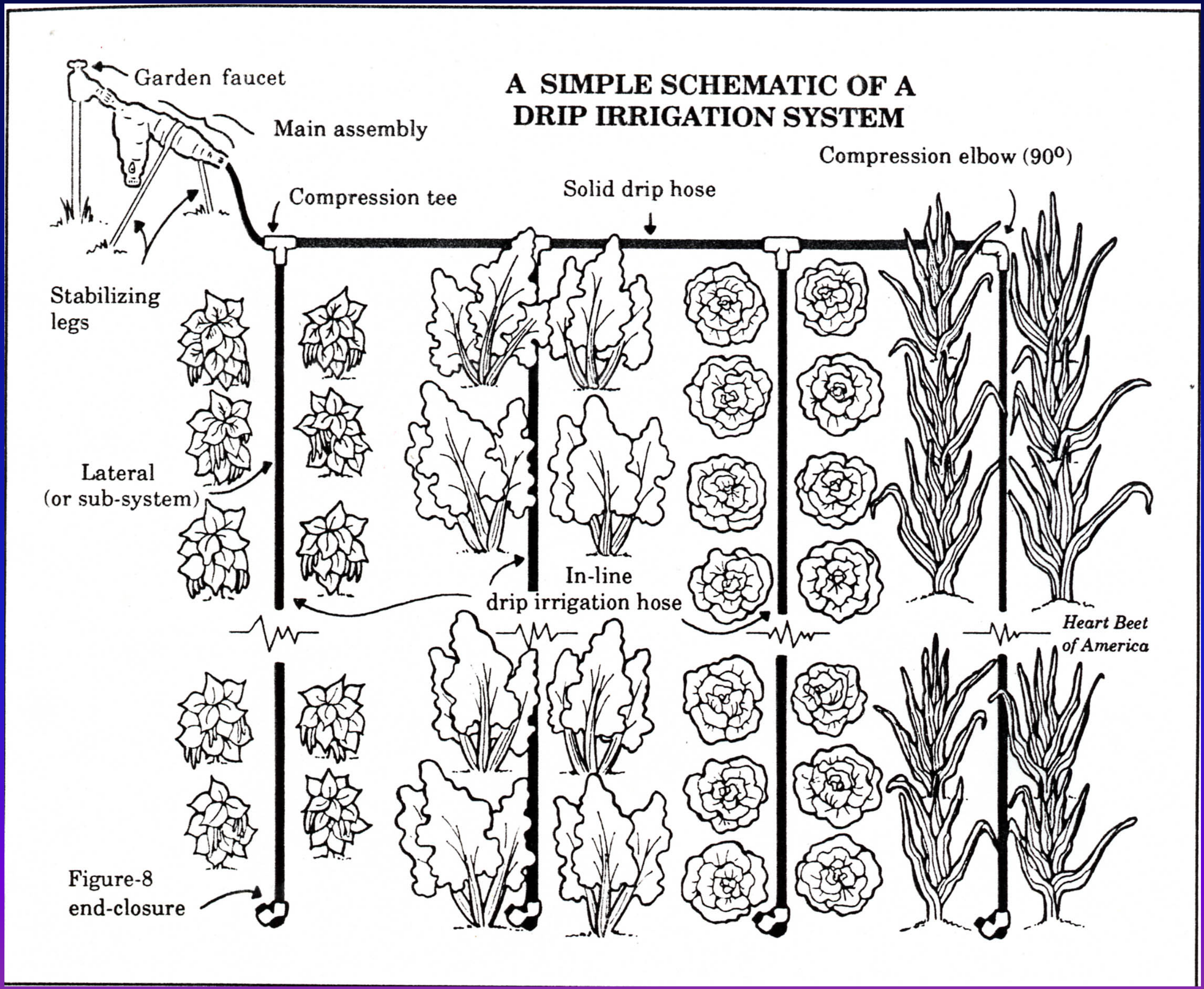
Focus on Water Supply Being the Limiting Factor

- Utility water
  - Standard water meter for home is 3/4-inch
    - Maximum flowrate is about 15 gpm
  - Next size is 1-inch
    - Maximum flowrate is about 25 gpm
    - More expensive than 3/4-inch meter
- Typical residential well
  - Produces 5 to 20 gpm

Distributing the Water

- Once we know our available pressure and flowrate
  - distribution system can be designed

How Much Area?



Area Determines Volume of Irrigation Water

- During bloom, fruit set, and ripening
  - may need 0.2 inch of water per day
  - or about 1.5 inches per week
- Acre-Inch
  - one inch of water over one acre
  - 27,156 gallons
- This is the crop demand for water

Irrigation System Must Supply the Water

- Therefore
  - water supply must have volume, pressure and flow
  - distribution system must cover the area

- Must be able to recharge soil moisture of whole area on a timely basis

A Blueberry / Blackberry Example

- A grower has municipal water to the edge of the blueberry field.
- They have about 6 GPM at the field.
- At present they have 6 rows of blueberries.
- They want to add 1 more row of blueberries and a row of blackberries.

Blueberry / Blackberry (cont.)

- Each row is about 250 feet long.
- Blueberries are spaced 5 feet apart.
- Blackberries will be spaced 2.5 to 3 feet apart.
- The plants are on a slope of 2 to 4%.

- **How would you proceed?**

Blueberry / Blackberry Design

- Bury ¾ inch Sch. 40 PVC to the high end of the field.
- Bring ¾ inch Sch. 80 PVC out of the ground about 18 inches.
- Reduce to ½ inch FPT.
- Utilize 5/8 inch drip fittings or ½ compression fittings.

Blueberry Design

- Use flat tube with 0.5 GPH emitters, 2 at each plant for blueberries.
- If there are 50 plants per row and 2 emitters/plant, how much water will each row require?

Blueberry Design

- Use flat tube with 0.5 GPH emitters, 2 at each plant for blueberries.

- If there are 50 plants per row and 2 emitters/plant, how much water will each row require?

- **50GPH or 0.83 GPM**

Blackberry Design

- Use Drip-in pressure compensating dripper line with 1 GPH emitters spaced every 12 inches for the blackberries.
- How much water will the row of blackberries use?

Blackberry Design

- Use Drip-in pressure compensating dripper line with 1 GPH emitters spaced every 12 inches for the blackberries.
- How much water will the row of blackberries use?

- **250 GPH or 4.2 GPM**

Blueberry / Blackberry Design

- With the existing water supply can this grower irrigate all 8 rows (7 rows of blueberries and 1 row of blackberries)?

Blueberry / Blackberry Design

- With the existing water supply can this grower irrigate all 8 rows (7 rows of blueberries and 1 row of blackberries)?

- **No**, the blueberries will require **5.8 GPM** and blackberries will require **4.2 GPM** = 10 **GPM** (They only have 6 GPM).

Blueberry Watering

- How long will it take to add 1.5 inches of water to the blueberries?
- Do we need to water the entire field?
- Probably not, but how much area do we water?

Blueberry Watering

- I like to use the diameter of the drip line of the bush.
  - A young plant might only have a diameter of 2 feet.
  - A mature plant might have a diameter of 4 to 5 feet.
- Let’s assume these bushes are 3 feet in diameter.

Blueberry Watering

- Area = ¶r^2
  - Area = 3.14(1.5^2)
  - Area = 7.1 ft
- 1.5 inches = 0.125 ft
- 7.1 ft^2 x 0.125 ft = 0.9 ft^3
- 0.9 ft^3 x 7.481 gallons/ft^3 = 6.6 gallons

Blueberry Watering

- 6.6 gallons per plant
- 2 emitters @ 0.5 GPH / emitter / plant
- **6.6 hours is required to apply 1.5 inches of water.**

- Should this all be applied in one application per week? Or spread out? **Depends on soil type, time of year, etc.**

Blackberry Watering

- 250 ft of row x 3 ft wide = 750 ft^2
- 750 ft^2 x 0.125 ft (1.5 in) = 93.75 ft^3
- 93.75 ft^3 x 7.481 gallons / ft^3 = 701 gallons

- 701 gallons / 250 GPH = 2.8 hours

Questions & Thank You!

- R. Allen Straw

  SW VA AREC

  12326 VPI Farm Rd.

  Glade Spring, VA 24340

  Mobile: 931.261.0973

  E-mail: astraw@vt.edu

  Fax: 276.944.2206

  Phone: 276.944.2202