Watermelon Irrigation & Water Quality Management

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Plants are 80-95% Water

(Watermelon = 90-91% M.C.)

- Water shortages early in crop development = delayed maturity, reduced yields, production gaps
- Water shortages later in the growing season = quality often reduced, even if yields not hurt
- Short periods of 2-3 days of stress can hurt marketable yield
- Irrigation increases size & weight of individual fruit & helps prevent defects like toughness, strong flavor, poor tipfill & podfill, cracking, blossom-end rot and misshapen fruit

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The Two Major Factors in Irrigation System Planning

1. How much <u>water</u> do you need?

2. How much <u>time</u> do you have?

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Is a Rain Barrel Enough?

- 1" of rain from a 1,600 sq. ft. house roof = 1,000 gallons
- Elevation dictates pressure
  - 2.3 feet of head = 1 psi pressure

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Basic Watering Facts

- Plants need 1.0"-1.5" of water per week
  - 624 - 935 gallons (83-125 cu. ft.) per 1,000 sq.ft.
  - 27,154 - 40,731 (3,360 – 5,445 cu. ft.) per acre
- Can survive drought on half that rate
- Deep infrequent waterings are better than several light waterings
- Deeper roots require less supplemental irrigation
- Taller plants have deeper roots
  - Lowers tendency to wilt
  - Shades soil surface
  - Controls weeds by competition
  - Makes water "go farther"

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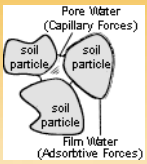
Irrigation Definitions

- Saturation
  - When all soil pore space is filled with water
- Field capacity
  - When a soil is sufficiently wet, its capillary forces can hold no more water
  - Soil M.C. varies with soil texture, ranging from 15-45% by volume
- Permanent wilting point
  - Soil moisture content at which plants can no longer get water from the soil and will wilt and die
  - Soil M.C. ranges from 5-25% by volume
- Plant available water
  - The portion of the soil water that can be taken up by plants; ranges by crop from 20-75% of the water holding capacity of the soil



References: www.extension.umn.edu/distribution/cropsystems/dc7644.html and www.ces.ncsu.edu/depts/hort/hil/hil-33-e.html

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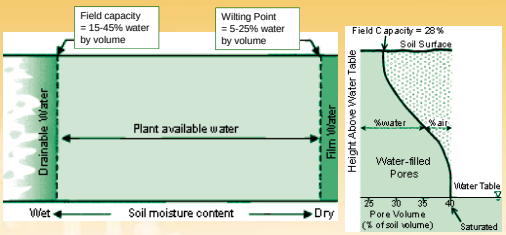
Irrigation Definitions



Reference: www.extension.umn.edu/distribution/cropsystems/dc7644.html

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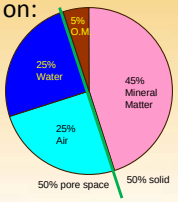
If you take care of your soil, the soil will take care of your plants.

- Plant available water depends on:
  - Soil structure & texture
  - Soil organic matter
  - Plant rooting depth
  - Soil type
  - Water infiltration



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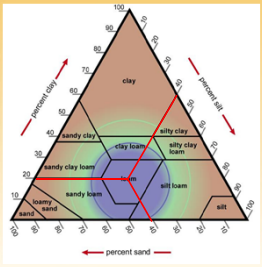
USDA Soil Texture Classes

- Particle size
  - Sand = 2.0-0.05 mm
  - Silt = 0.05-0.002 mm
  - Clay = <0.002 mm
- Characteristics
  - Sand adds porosity
  - Silt adds body to the soil
  - Clay adds chemical & physical properties



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Determining Soil Texture

- By feel
  - Gritty, smooth, sticky
- Using the jar method
  - Fill a 1-quart jar ¼ full of soil
  - Fill the jar with water to ¾ full
  - Add 1 teaspoon of dishwashing detergent
  - Shake very well to suspend soil
  - Place on a flat surface and allow soil to settle for 2 days
  - Measure % thickness of each layer relative to all

Benefits of Cover Crops / Compost

- Improves drainage & aeration of heavy clay soils
- Increases moisture-holding ability of sandy soils
- Increases earthworm and soil microbial activity that benefit plant growth
- Improves soil structure and makes it easier to work
- Contains nutrients needed for plant growth

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Effective Rooting Depth of Selected Vegetables

Shallow (6-12")	Moderate (18-24")	Deep (>36")
Beet	Cabbage, Brussels Sprouts	Asparagus
Broccoli	Cucumber	Lima Bean
Carrot	Eggplant	Pumpkin
Cauliflower	Muskmelon	Sweet Potato
Celery	Pea	Watermelon
Greens & Herbs	Potato	Squash, Winter
Onion	Snap Bean	
Pepper	Squash, Summer	
Radish	Sweet Corn	
Spinach	Tomato	

Most of the active root system for water uptake may be in the top 6"-12"

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Vegetable Crops & Growth Period Most Critical for Irrigation Requirements

Crop[1]	Most Critical Period
Broccoli, Cabbage, Cauliflower, Lettuce	Head development
Carrot, Radish, Beet, Turnip	Root enlargement
Sweet Corn	Silking, tasseling, and ear development
Cucumber, Eggplant, Pepper, Melon, Tomato	Flowering, fruit set, and maturation
Bean, Pea	Flowering, fruit set, and development
Onion	Bulb development
Potato	Tuber set and enlargement

[1] For transplants, transplanting & stand establishment represent a most critical period for adequate water.

Reference: irrigationtraining.tamu.edu/docs/irrigation-training/south/crop-guidelines/estimatedwaterrequirementsvegetablecrops.pdf

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Table 1. Soil moisture content in inches of water per foot of soil.

Soil Texture	Field Capacity	Permanent Wilting Point (15 Bars)	Plant Available Water (in./ft.)
Sand	1.2 (10)*	0.5 (4)	0.7 (6)
Loamy sand	1.9 (16)	0.8 (7)	1.1 (9)
Sandy Loam	2.5 (21)	1.1 (9)	1.4 (12)
Loam	3.2 (27)	1.4 (12)	1.8 (15)
Silt loam	3.6 (30)	1.8 (15)	1.8 (15)
Sandy clay loam	4.3 (36)	2.4 (20)	1.9 (16)
Sandy clay	3.8 (32)	2.2 (18)	1.7 (14)
Clay loam	3.5 (29)	2.2 (18)	1.3 (11)
Silty clay loam	3.4 (28)	1.8 (15)	1.6 (13)
Silty clay	4.8 (40)	2.4 (20)	2.4 (20)
Clay	4.8 (40)	2.6 (22)	2.2 (18)

*Numbers in parentheses are volumetric moisture contents in percent.
Source: Hanson 2000.

Reference: www.extension.org/mediawiki/files/d/db/SoilWaterSensors.pdf

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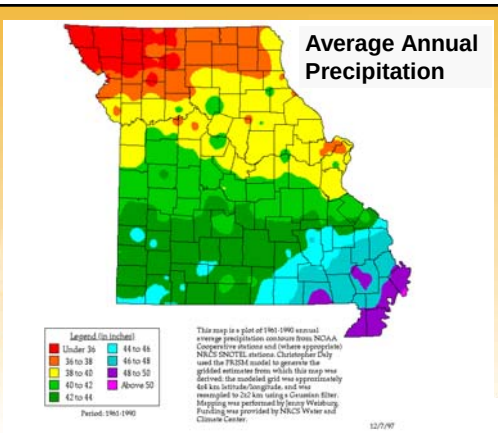

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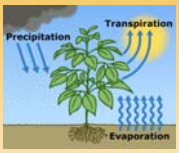
Evapotranspiration (ET)

- Rate of water loss changes as plant grows and sets fruit
- Peak water use is during bloom, fruit set and ripening
- Factors that affect ET
  - Type of crop or vegetation cover
  - Stage of crop growth
  - Temperature, wind, relative humidity
  - Soil moisture content
  - Mulches and ground covers



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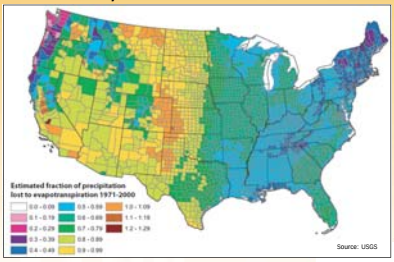
Evapotranspiration (ET)

- Missouri – Annual ET is 60-70% of precipitation
- Maximum daily ET can exceed 0.25”



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Soil & Climate Properties

- Soils store 0.25”-2.5” of water per foot of depth
  - 1.2” of water per foot of depth is common (Check Dunklin County USDA-NRCS Soil Survey)
- Intake rate by soil type:
  Malden-Canalou-Bosket = 2.0”- 6.0” per hour
  Crowley = 0.2”-0.6” per hour, rest is runoff
- Summer E.T. rate can be 0.25” per day
  - Can be as high as 0.30” per day with low humidity & high temperature with wind

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Physical & Chemical Properties

(from USDA Soil Survey – Dunklin County, MO)

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Wind erodibility group
							K	T	
	In	In/hr	In/in	pH	Mmhos/cm				
Ma Malden	0-4 4-50 50-69	6.0-20 6.0-20 6.0-20	0.02-0.06 0.04-0.10 0.02-0.06	5.1-6.5 5.1-6.5 5.1-6.5	<2 <2 <2	Very low Very low Very low	0.17 0.17 0.17	5	1
Cn Canalou	0-24 24-39 39-70	2.0-6.0 2.0-6.0 2.0-6.0	0.10-0.12 0.12-0.14 0.05-0.10	4.5-6.5 5.6-7.3 5.6-7.3	<2 <2 <2	Low Low Low	0.17 0.17 0.17	5	2
Bk Bosket	0-18 18-50 50-62	2.0-6.0 0.6-2.0 >2.0	0.10-0.15 0.10-0.20 0.02-0.15	5.1-6.5 5.1-6.5 5.1-6.5	<2 <2 <2	Low Low Low	0.24 0.32 0.24	4	3
Db Dubbs	0-14 14-47 47-60	0.6-2.0 0.6-2.0 2.0-6.0	0.20-0.22 0.18-0.22 0.05-0.10	4.5-6.0 4.5-6.0 4.5-6.0	<2 <2 <2	Low Moderate Low	0.37 0.37 0.37	5	---
Cw Crowley	0-19 19-51 51-69	0.2-0.6 <0.06 0.06-0.2	0.22-0.24 0.11-0.13 0.10-0.20	4.5-8.4 4.5-6.5 5.6-8.4	<2 <2 <2	Low High Moderate	0.43 0.32 0.32	4	---

Reference: soildatamart.nrcs.usda.gov/Manuscripts/MO069/0/dunklin_MO.pdf

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Watermelon Production

- Soil pH = 5.8 to 6.6
- Seed germinates at soil temperatures of 68-95° F
- Use uniform, disease free, certified seed with at least 85-90% germination, or vigorous transplants
- Plant seed 0.5-1.0 inch deep, at 1-2 lbs./acre, depending upon seed size, germination and plant spacing
- Transplants:
  - 3.5' x 10' spacing = 1,245 plants per acre (35 sq. ft./plant)
  - 2.5' x 10' spacing = 1,742 plants per acre (25 sq. ft./plant)

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Overhead Irrigation

- Watermelons need system capable of delivering 1" of water every 4 days at <2.0" per hour
- 25-45 psi system operating pressure
- 5-6 feet spacing between hills and 10 feet between rows
- Center pivot
- Linear move
- Traveling gun
- Permanent set
- Portable pipe with sprinklers

Photo credit: www.waterproblems.net/irrigation.html

Photo credit: http://extension.missouri.edu/p/G1897

Overhead Irrigation Use

- Apply water at rate to avoid puddling and runoff
- Water early morning (4 a.m. to 8 a.m.)
  - Less evaporation loss (no sun, calmer winds)
  - Knocks dew and guttation fluid off leaf blades
  - Lets plant leaves dry before evening to discourage fungal growth and infection

Overhead Irrigation Rates

- **From planting until plants begin to run**
  - Apply 0.5" whenever soil in top 6" becomes dry
- **From time plants begin to run until first bloom**
  - Apply 0.75" every five days during dry weather
  - If wilting occurs before noon, increase irrigation frequency
- **From first bloom until harvest**
  - Apply 1.0" every four days during dry weather
  - When more than 95° F), frequency may need to be increased to every three days to avoid stress

Reference: www.caes.uga.edu/applications/publications/files/pdf/B%20996_2.PDF

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Drip Irrigation

- Drip tape or drip pipe with emitters
  - Point use gives less runoff, less evaporation, easier weed control, saves 30%-50% water
  - 6-20 psi operating pressure means smaller pumps & pipes
  - Can fertilize through system
  - Do field work while irrigating
  - Can automatically control
  - Susceptible to clogging
  - Must design system to elevation
    - 2.3 feet of head = 1 psi pressure
  - Requires diligent management
  - Cost = $1,200 - $1,500 for 1st acre; $900 - $1,100/acre for rest

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Advantages of Plastic Mulch, Raised Beds & Drip Irrigation

- Soils warm up faster (+5° F)
- Soil moisture is conserved
- Nutrient leaching is prevented
- Weeds are controlled
- Raised beds encourage earlier maturity and improves soil drainage
- Drip irrigation increases fruit quality and quantity
- Fertilizer can be injected through the irrigation system

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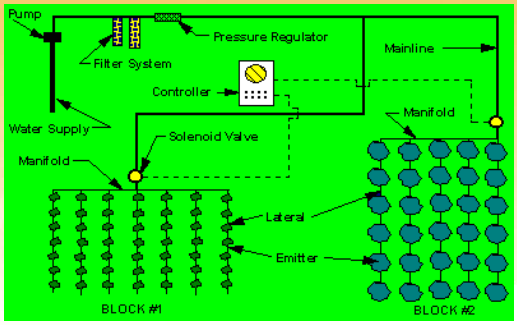
Example Layout of Drip Irrigation System



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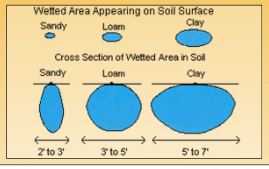
Line Source Drip Tape

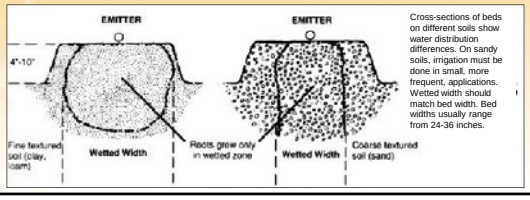
- Wall thickness = 6, 8, 10, 15-mil; 1-2 year life
- Surface or sub-surface installation
- Emitters manufactured within the tape wall
  - Common spacing = 4", 8", 12", 16" 18" 24"
  - Max. operating pressure
    = 6-mil @ 10 psi
    = 8-mil @ 12 psi
    = 10-mil @ 14 psi
    = 15-mil @ 25 psi
- More animal damage outdoors

Drip Tape for Watermelons

- Space plants 2.5-3.0 feet apart in beds and 8-10 feet between beds = 25-35 sq. ft./plant
  - Icebox watermelons = space 2 feet apart in beds and 5 feet between beds
  - Install drip tape (8 to 10 mil thickness; 8 to 12 inch dripper spacing) 1" below ground under plastic and 3" from the centerline of the bed
  - Design system to use 80% or less of your available water

Know the Soil Rooting Depth & How Water Will Re-Distribute





Cross-sections of beds on different soils show water distribution differences. On sandy soils, irrigation must be done in small, more frequent, applications. Wetted width should match bed width. Bed widths usually range from 24-36 inches.

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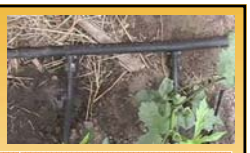
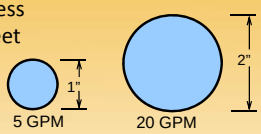
Hours Required to Apply 1" of Water to Mulched Raised Bed



Drip Tube Flow Rate		Width of Mulched Bed		
Gallons per Hour per 100 feet run of drip tape	Gallons per Minute per 100 feet run of drip tape	2 feet	2.5 feet	3 feet
16	0.27	8.0	10.0	11.5
18	0.30	7.0	8.5	10.5
20	0.33	6.0	8.0	9.5
24	0.40	5.0	6.5	8.0
30	0.50	4.0	5.0	6.0
36	0.60	3.5	4.5	5.0
40	0.67	3.0	4.0	4.5
42	0.70	3.0	4.0	4.5
48	0.80	2.5	3.0	4.0

Friction Loss Design

- Size piping for 1 psi or less pressure loss per 100 feet
  - Pipe diameter x 2 = 4X flow rate
- Pipe friction may replace pressure regulators on downhill runs
- Vary flowrate no more than 20% (+/- 10%) within each block of plants
- Manifolds attached to mainline...
  - at center if < 3% slope
  - at high point if 3+% slope



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Friction Loss - PVC Plastic Pipe

	Pipe Diameter, inches			
	0.75"	1"	1.5"	2"
GPM	PSI Loss per 100 ft. of pipe			
5	2.4	0.7	0.1	0.0
10	8.8	2.6	0.3	0.1
15	18.6	5.6	0.7	0.2
20	31.6	9.5	1.2	0.4
25	--	14.4	1.8	0.5
30	--	--	2.4	0.7

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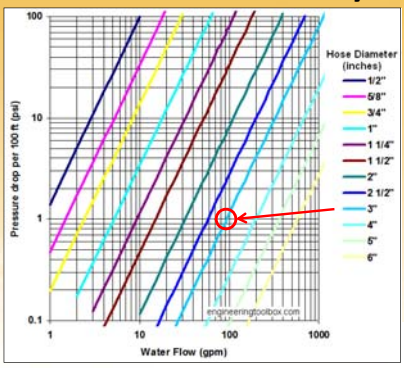
Friction Loss – PVC Layflat Hose



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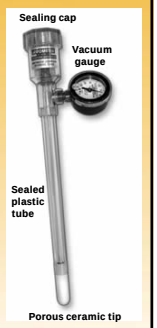
Tensiometers

- Reading is a measure of the energy needed to extract water from the soil
- Work better in sandy soils than gypsum moisture blocks
- Read gauge of 0 (wet) to 100 (dry)
- Place at appropriate depth (8" & 16")
- Cost: $70-90, plus $50 for service unit



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Soil Water Deficits for Typical Soils & Soil Water Tensions

Good Range for High Tunnels = 25-40 Centibars

Soil Texture	Soil Water Tension in Centibars (cb)						
	10	30	50	70	100	200	1500**
	Soil Water Deficit (inches per foot of soil)						
Coarse sand	0	0.1	0.2	0.3	0.4	0.6	0.7
Fine sand	0	0.3	0.4	0.6	0.7	0.9	1.1
Loamy sand	0	0.4	0.5	0.8	0.9	1.1	1.4
Sandy loam	0	0.5	0.7	0.9	1.0	1.3	1.7
Loam	0	0.2	0.5	0.8	1.0	1.6	2.4

***1500 cb is approximately the permanent wilting point for most plants, and the soil water deficit values equal the soil's available water holding capacity.*

Water Source Quality

Good

Poor

- Well = check pH & hardness
- Municipal = may be expensive
- Spring = may not be dependable
- River or stream = depends on runoff
- Lake or pond water = sand filters

Water Quality Analysis

- Inorganic solids = sand, silt
- Organic solids = algae, bacteria, slime
- Dissolved solids (<500 ppm)
  - Carbonates (calcium)
  - Iron & Manganese
  - Sulfates & Chlorides
- pH (5.8-6.8 preferred)
- Hardness (<150 ppm)

PVC Casing Steel Casing

Resource: soilplantlab.missouri.edu/soil/water.aspx

Domestic suitability test = Hardness, pH, nitrate-N, sulfate, chloride, sodium, carbonate, bicarbonate, iron, manganese, copper, electrical conductivity, total dissolved solids

Plugging Potential of Drip Irrigation Systems

Factor	Moderate (ppm)*	Severe (ppm)*
Physical		
Suspended solids	50-100	>100
Chemical		
pH**	7.0-7.5	>7.5
Dissolved solids	500-2000	>2000
Manganese	0.1-1.5	>1.5
Iron	0.1-1.5	>1.5
Hardness***	150-300	>300
Hydrogen sulfide	0.5-2.0	>2.0

* ppm = mg/L ** pH is unitless *** Hardness: ppm = gpg x 17

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Growing Season Maintenance

- Water supply
- Flush physical contaminants
  - Cleaning the filter (150-200 mesh)
  - Flushing the system
- Check for excessive leakage
- Repair breaks or lost emitters
- Fertilizer injection

Growing Season Maintenance: Fertigation

- Drip irrigation can supply soluble materials such as fertilizers by chemigation
- Analyze water source for precipitate potential through water/fertilizer interactions
- Test fertilizers for solubility, especially P sources
- Backflow prevention is critical
- Use proper equipment and procedures
  - Inject upstream of filters
  - Allow for complete mixing
  - Pressurize system before injection
  - Flush lines at the end of injection to remove residue

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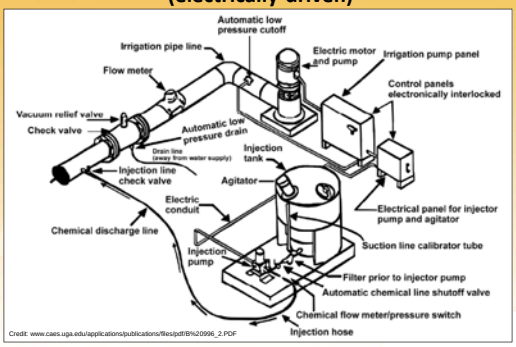
Typical Chemigation System (electrically-driven)



Credit: www.caes.uga.edu/applications/publications/files/pdf/B%20996_2.PDF

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Growing Season Maintenance: Water Troubleshooting Guide

Problem	Cause
Green or slimy matter in surface water	Algae or fungi
Turbidity	Suspended clay and silt
White precipitate	Carbonate precipitation
Reddish precipitate (red rust color)	Oxidized (ferric) iron precipitation
Water initially clear (no oxygen), but turns red/orange in presence of air	Clearwater dissolved (ferrous) iron
Black sandy particles	Iron sulfide precipitation
Black precipitate	Manganese precipitation
Reddish brown slime near emitters	Bacteria feeding on iron
White stringy masses of slime near emitters	Bacteria feeding on sulfur

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Growing Season Maintenance:

Chemical Water Treatment

- Useful to manage both inorganic and organic problems
- Goals of chemical treatment
  - Cause some particles to settle out or precipitate
  - Cause some particles to remain soluble or to dissolve
- Place filtration after chemical treatment
- Backflow prevention is critical

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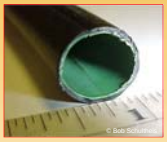
Growing Season Maintenance:

Chemical Water Treatment

- Chlorine
  - Kills microbial activity (algae, bacteria)
  - Decomposes organic materials
  - Oxidizes soluble minerals, causing them to precipitate out of solution
  - Chlorine needs "contact time"
  - Chlorine concentration of 10-20 ppm for 30-60 minutes daily
  - Work by sections through the system, flushing out lines after treatment
  - If emitters are plugged, higher concentrations of chlorine may be needed to decompose organic matter



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Growing Season Maintenance:

Chemical Water Treatment

- Acid treatment
  - Lowers water pH, and maintains solubility or dissolves Fe, Mn, and Ca precipitates
- Acid injection rate calculation
  - Amount of acid needed to treat a system
    - Strength of acid used
    - Buffering capacity of the irrigation water
    - Desired pH of water
  - Perform a titration to determine the acid volume : water volume ratio
- Calibration of injection pumps is critical

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Resource: www.caes.uga.edu/applications/publications/files/pdf/B%201130_2.PDF

Growing Season Maintenance:

Chemical Water Treatment

- Calcium salts (carbonates, phosphatics)
  - Water pH >7.5, bicarbonate levels >100ppm
  - Acid injection
    - Target pH 4.0 or lower for 30 to 60 minutes/daily
    - Hydrochloric, phosphoric, or sulfuric acid used
    - Flush and clean injector
  - Water softening (household systems)

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Growing Season Maintenance:

Three Steps for Iron Removal

- An **oxidizer** is added to the water, which induces **precipitation** of the iron and hydrogen sulfide, and the precipitated contaminant is then **filtered** out of the water
- pH control
  - Low pH (2.0) – iron dissolves
  - High pH (7.2+) – iron precipitates

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Growing Season Maintenance:

Iron Removal Options [1]

- Iron bacteria
  - Chlorine + retention + filtration
- Ferric (red rust) iron
  - Filter, but may require use of coagulant
- Ferrous (clear water) iron < 5 ppm
  - Ion exchange with resin bed, fouls easily

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Growing Season Maintenance:

Iron Removal Options ₂

- Ferrous (clear water) iron 5+ ppm
  - Aeration + retention + filtration
  - Hydrogen peroxide + retention + filtration
  - Ozone (strong oxidizer) + retention + filtration
  - Chlorine (as a gas, calcium hypochlorite, or sodium hypochlorite at 1 part Cl : 1 part Fe) + retention + filtration (by manganese greensand, anthracite/greensand or activated carbon) Greensand is then regenerated by using potassium permanganate (at 0.2 parts of pot. perm. : 1 part of iron)
  - Oxidizing filter media (pyrolusite ore) + backwash it at 25 to 30 gallons per sq. ft.
  - Manganese greensand (high capacity & high flow). Regenerate it with potassium permanganate at 1.5 to 2 oz. per cubic foot of greensand

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End-of-Season Maintenance:

Winterizing Irrigation Equipment

- Park pivots in a safe location
- Remove brush and branches near equipment
- Lower the water levels in underground piping
- Drain roll-up hoses, travelers, and big guns
- Check for water pockets in drip lines and tape
- Drain or pump down underground pipelines
- Drain the pumping plant
- Inspect and lock down electrical power supplies
- Catalogue improvements and repairs on each system with a winter work list

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Irrigation Resources on the Web

- This presentation and related resources extension.missouri.edu/webster/publications
- Irrigation System Planning & Management Links extension.missouri.edu/webster/irrigation/

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Questions??

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Program Complaint Information
To file a program complaint you may contact any of the following:

University of Missouri
- MU Extension AA/EEO Office
  109 F. Whitten Hall, Columbia, MO 65211
- MU Human Resources Office
  130 Heinkel Bldg, Columbia, MO 65211

USDA
- Office of Civil Rights, Director
  Room 326-W, Whitten Building
  14th and Independence Ave., SW
  Washington, DC 20250-9410