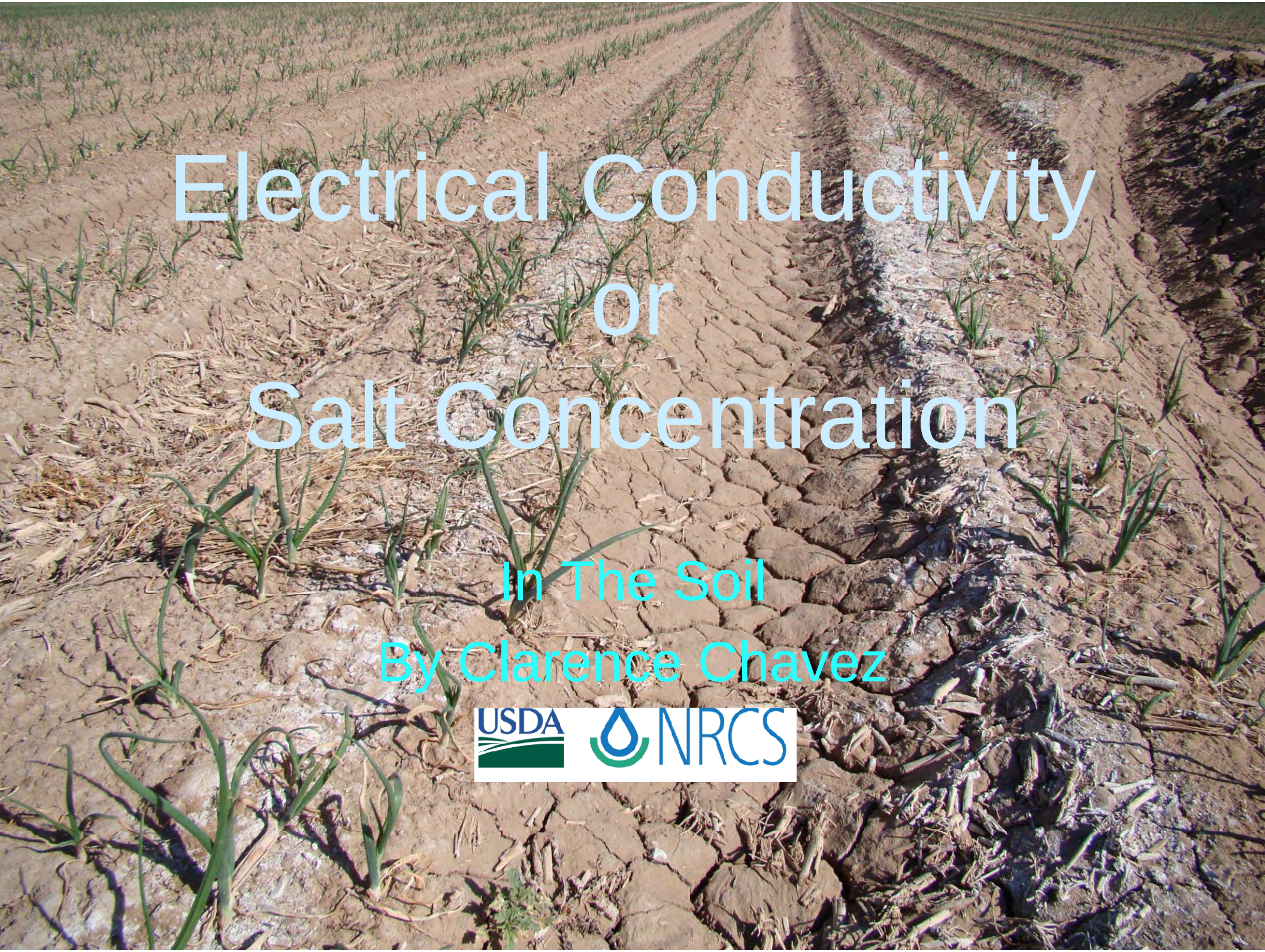

Electrical Conductivity
or
Salt Concentration
In The Soil
By Clarence Chavez
USDA
NRCS

EC Meter detects Salt Concentration

EC - Demo

Na^{+}

CA^{++}

SO_4^{--}

Cations

Mg^{++}

Cl^{-}

K+

Soil EC Meter

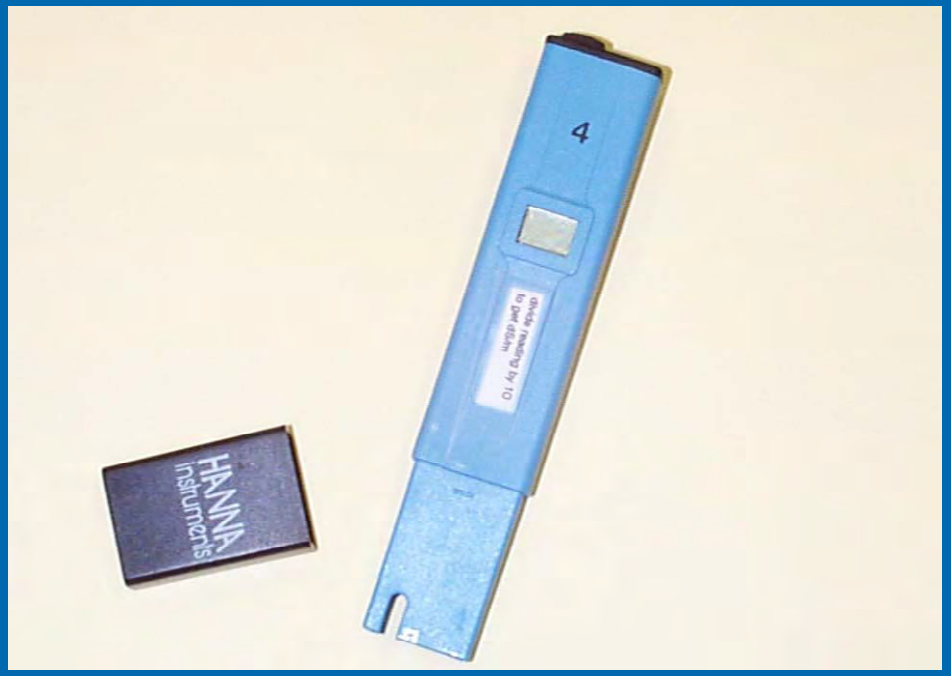
Anions

HCO_3^{-}

CO_3^{--}

Others types of salts at very low concentrations are: Boron, Silicates, etc…

EC = Electrical Conductivity



Irrigation Salinity (pg. 80)	EC	TDS
Classification - Table 11	(dS/m)	(mg/l)
No effects usually noticed	0.75	500
Can have detrimental effects on sensitive crops	0.75 – 1.50	500 – 1,000
Can have adverse effects on many crops	1.50 – 3.00	1,000 – 2,000
Can be used for tolerant plants (on permeable soils)	3.00 – 7.50	2,000 – 5,000

Salts in the soil	EC range for 1:1 soil:water suspension for which yield reductions occur
Rating (Table 6. pg. 61)	
S = Sensitive	> 0.90 dS/m
MS = Mod. Sensitive	> 1.40 dS/m
MT = Mod. Tolerant	> 2.50 dS/m
T = Tolerant	> 4.0 dS/m

Electrical Conductivity

Indicates the amount of salts present in the soil. (K^+, Ca^+, Mg^+, Na^+ ,Cl^-, HCO_3)
Excess salts will hinder plant growth and/or can affect infiltration.
EC = Electrical Conductivity (Soil Extract)
TDS = Total Dissolved Solids (Water)

SOLUBLE SALTS

(Irrigation Water Quality example)

Dominant Cations (Ions with a positive charge)

Calcium	Ca^{++}	80 ppm
Sodium	Na^{+}	115 ppm
Magnesium	Mg^{++}	14 ppm
Potassium	K^{+}	8 ppm

Dominant Anions (Ions with a negative charge)

Sulfate	$SO4^{--}$	192 ppm
Chloride	Cl^{-}	92 ppm
Bicarbonate	$HCO3^{-}$	183 ppm
Carbonate	$CO3^{--}$	6 ppm

Total ppm: 217 ppm (cations) + 473 ppm (anions) = 690 ppm = 690 mg/l (Soluble Salts)

TDS (ppm) = EC (dS/m) x 640, for EC between 0.1 and 5.0 dS/m
TDS (ppm) = EC (dS/m) x 800, for EC > 5.0 dS/m

- TDS = Total Dissolved Solids
- ppm = parts per million; mg/l = milligrams/liter (ppm = mg/l)
- EC = Electrical Conductivity

690 ÷ 640 ≈ 1.08 dS/m (EC)
(dS/m = mmhos/cm = mS/cm)
dS/m = deciSiemens/meter
mmhos/cm =milliMhos/centimeter
mS/cm = milliSiemens/centimeter
2.72 x ppm = lbs. of salts/ac-ft
(2.72 x 690 ppm = 1,877 lbs/ac-ft)

Section 2 of 22 (2j - Irrigation Water Salinity & Sodium Adsorption Ratio (SAR) Assessment Guide)

Irrigation Water Lab Analysis for Soluble Salts and SAR (mg/l = milligrams/liter; meq/l = milliequivalents/liter)

	Major Cations (ions with a positive charge)	example		Enter Lab Results			Major Anions (ions with a negative charge)	example		Enter Lab Results	
		mg/l	meq/l	mg/l	meq/l			mg/l	meq/l	mg/l	meq/l
Hardness	Calcium (Ca^{++}) 20.04 mg/meq	80	4				Chloride (Cl^{-}) 35.46 mg/meq	92	2.6		
Hardness	Magnesium (Mg^{++}) 12.16 mg/meq	14	1.2				Sulfate ($SO4^{--}$) 48.03 mg/meq	192	4		
	Sodium (Na^{+}) 22.99 mg/meq	115	5			Alkalinity	Bicarbonate (HCO_3^{-}) 61.02 mg/meq	183	3		
	Potassium (K^{+}) 39.10 mg/meq	8	0.2			Alkalinity	Carbonate (CO_3^{--}) 30.01 mg/meq	6	0.2		
	Sum of Total Cations:	**217**	**10.4**				Sum of Total Anions:	**473**	**9.8**		

Total Dissolved Solids (i.e., Soluble Salts) is: 217 mg/l + 473 mg/l = 690 mg/l (or 690 ppm). 0.23 x TDS (ppm) = lbs. of salts/ac-in
690 mg/l ÷ 640 ≈ ECiw of 1.1 dS/m (i.e., Electrical Conductivity of Irrigation Water in decisiemens/meter)

Irrigation Water Salinity Assessment

Salinity (Soluble Salts): affects crop water availability

Note: Be sure to compare the Irrigation Salinity (ECiw) with the Soil Test (ECe), in order to evaluate the potential yield reduction of your crop (i.e., Refer to a Crop Threshold Soil Salinity (ECe(ct)) Table)

Degree of Restriction on Use – ECiw (dS/m)		
None	Slight to Moderate	Severe
< 0.7	0.7 – 3.0	> 3.0

Facts You Must Know

Converting TDS to EC

1 mg/L = 1 ppm (Irrigation Water)

- TDS = Total Dissolved Solids (water)
- ppm = Parts per million,
- mg/L = milligrams/Liter (ppm = mg/L)
- EC = Electrical Conductivity

TDS (ppm)= EC (dS/m) X 640, for EC between 0.1 and 5.0 dS/m

- 690ppm / 640 = 1.08 dS/m (EC)
- 1.08 dS/m X 640 = 690 ppm or TDS

TDS (ppm) = EC (dS/m) X 800, for EC > 5.0 dS/m

- 690ppm / 800 = 0.86 dS/m (EC)
- 0.86 dS/m X 800 = 690 ppm of TDS

- Note: 640 for EC <5.0 dS/m and 800 for EC>5.0 dS/m are just conversion factors based on total salt content

How Much is That?

dS/m = mmhos/cm = mS/cm (Soil EC)

- ✓ dS/m = deciSiemens/meter
- ✓ mmhos/cm = milliMhos/centimeter
- ✓ mS/cm = milliSiemens/centimeter

Example: to calculate TDS (Total Dissolved Salts) to pounds per acre foot of salt.

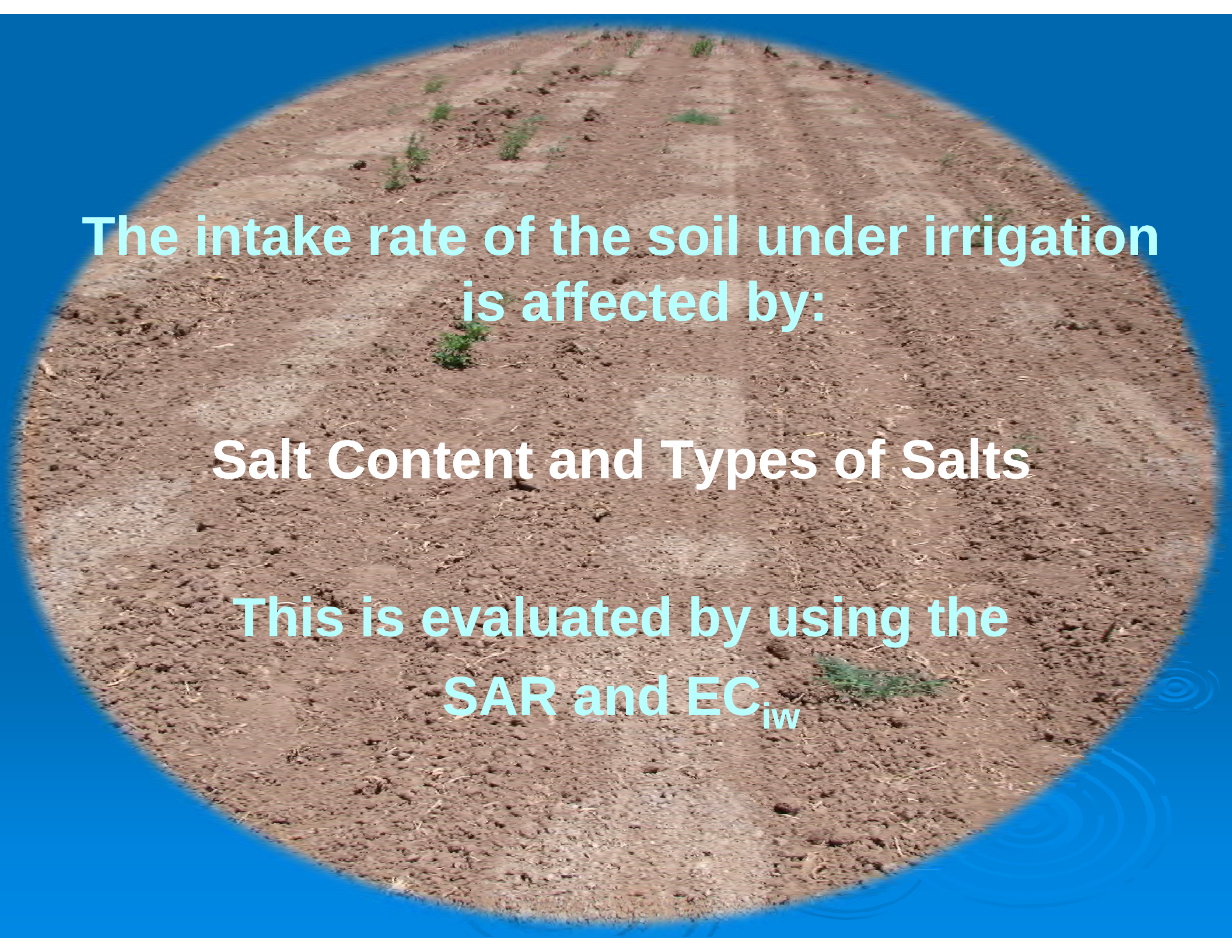
2.72 X ppm = lbs. of salt / ac-ft

2.72 X 690 ppm = 1,877 lbs/ac-ft of TDS or Salt

2.72 is a conversion factor that

= 2,720,000 pounds of water per ac/ft

690ppm from previous slide


The intake rate of the soil under irrigation is affected by:
Salt Content and Types of Salts
This is evaluated by using the SAR and EC_{iw}

Sodium Adsorption Ratio

$$SAR = \frac{[Na^+]}{\sqrt{([Ca^{2+}] + [Mg^{2+}])/2}}$$

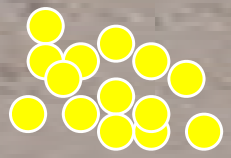
(concentrations are in meq/L)

- **High SAR = Unstable Soil (>15)**
- **Low SAR = Stable Soil (<6)**
- **Gypsum or Elemental Sulfur additions usually start at SAR = 6 or greater**
- **Must have calcareous soils to use sulfur**


Soil with high concentrations of salts force the clay to be dispersed
Infiltration is poor in this small area.

Flocculated vs Dispersed

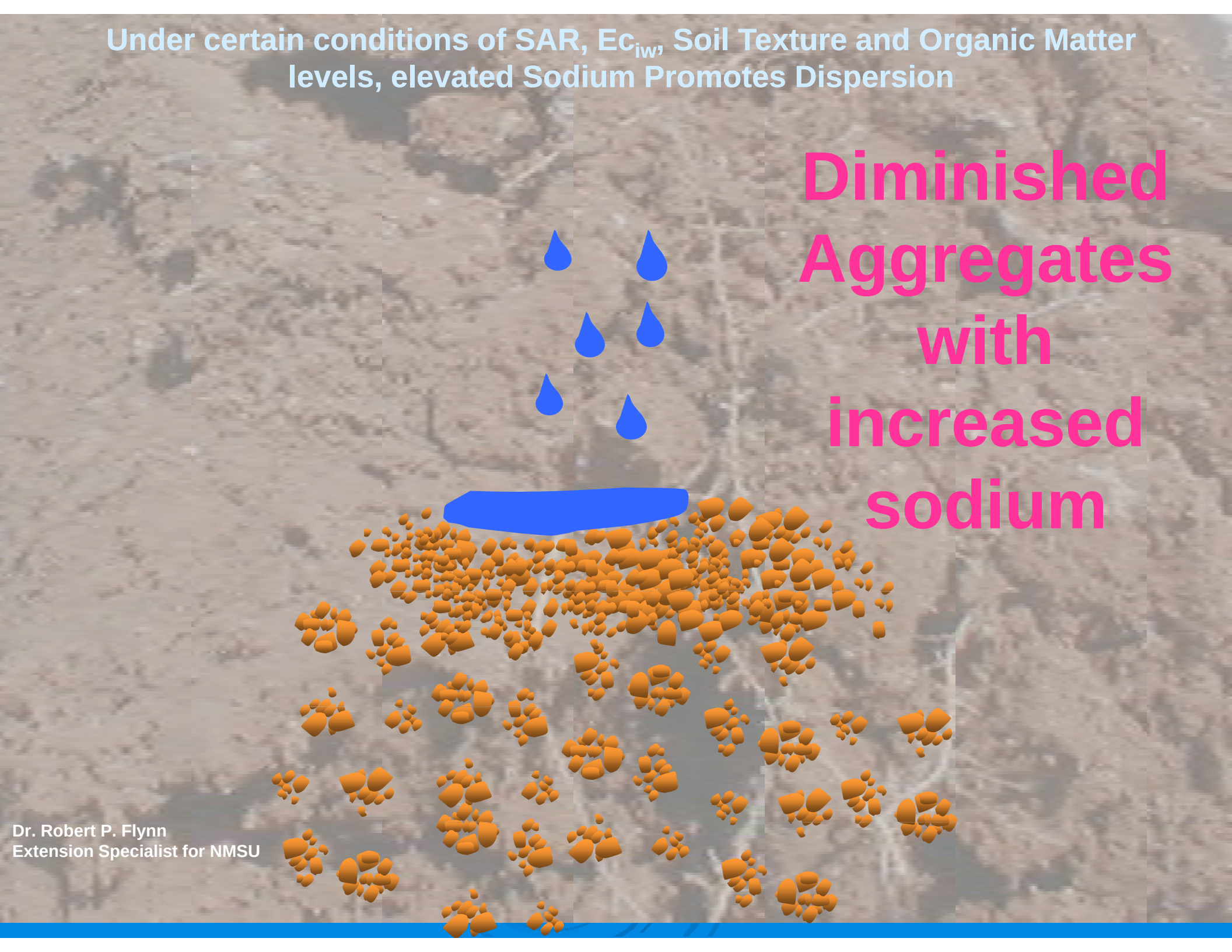
Flocculated or aggregated clay particles



Dispersed clay particles

Dr. Robert P. Flynn
Extension Specialist for NMSU

Under certain conditions of SAR, Ec_{iw}, Soil Texture and Organic Matter levels, elevated Sodium Promotes Dispersion



Dr. Robert P. Flynn
Extension Specialist for NMSU

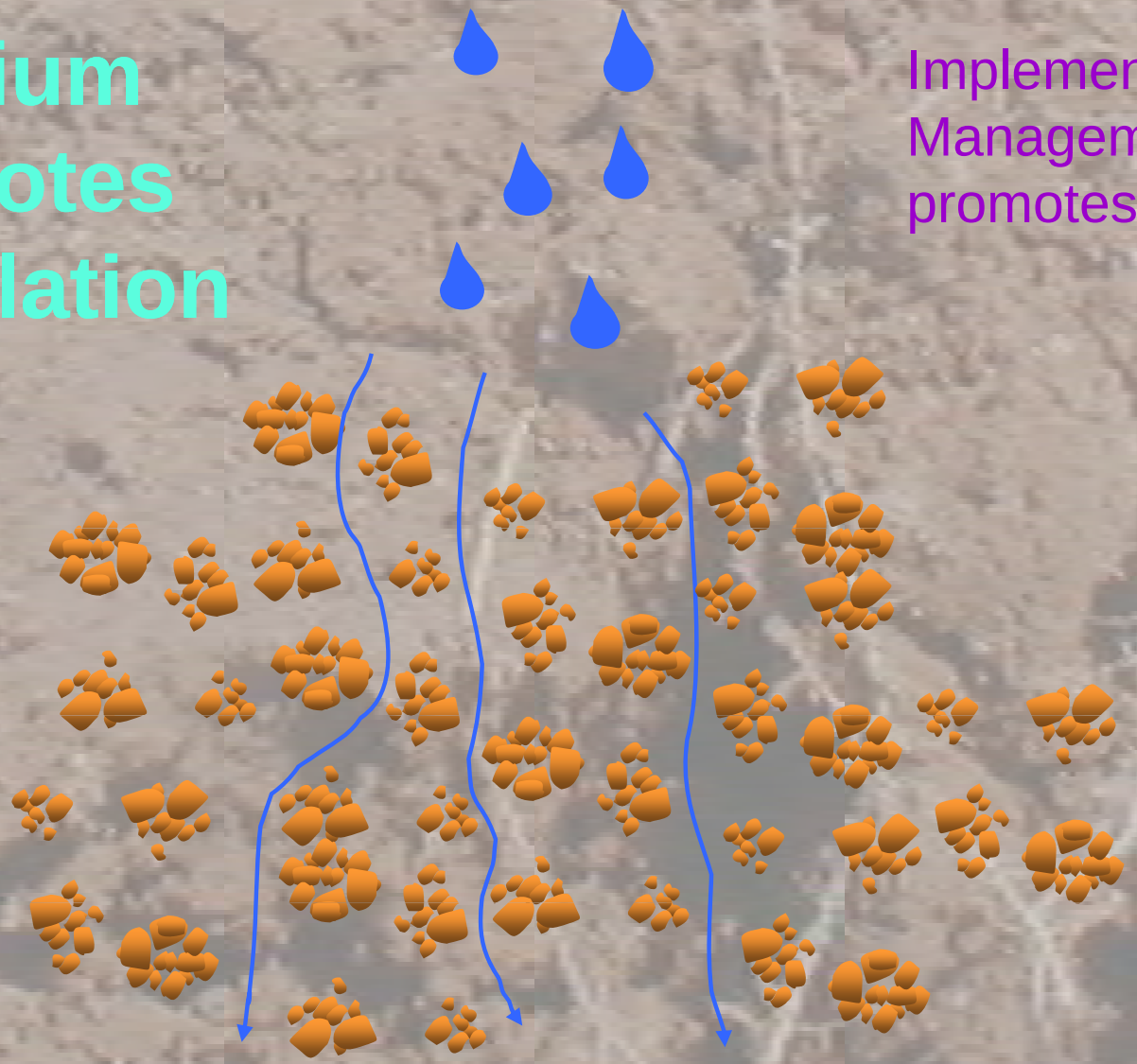
Table 2. Soil Salinity Classes and EC Values Based on Saturated Paste vs. 1:2 Dilution Methods

Salinity Class	EC by Saturated Paste dS/m or mmhos/cm	~EC 1:2 Dilution Method For Clay Loam Soils	Potential Tree and Shrub Use Restrictions
Non-Saline	<2	0.15 - 0.25	None
Very Slightly Saline	2 to <4	>0.25 - 0.30	Limited
Slightly Saline	4 to <8	>0.30 - 0.50	Moderate to Severe
Moderately Saline	8 to <16	>0.50 - 1.00	Severe
Strongly Saline	16 or Greater	>1.00	Extremely High

Dr. Robert P. Flynn
Extension Specialist for NMSU

Importance of Aggregates

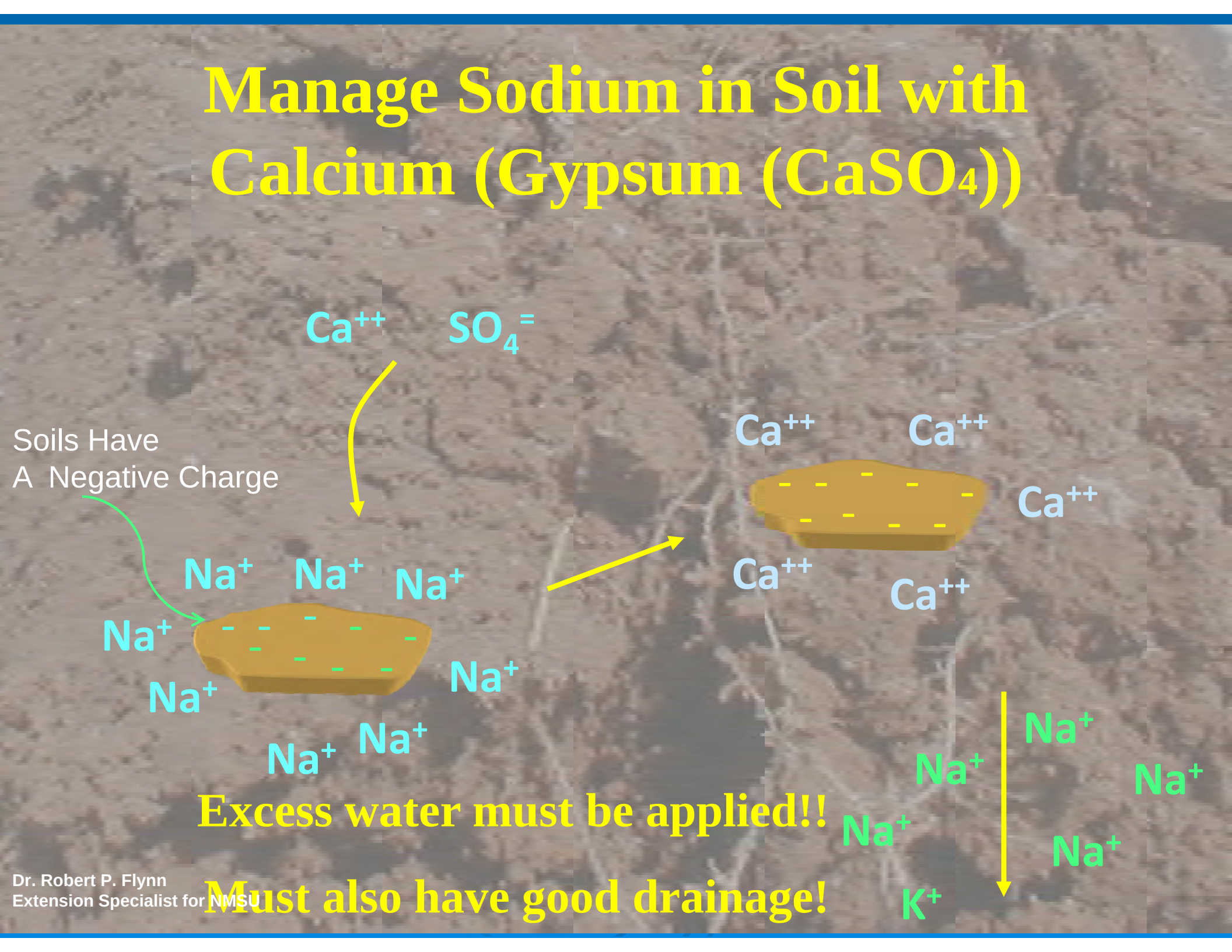
Calcium Promotes Flocculation



Implementing Soil Health Management System also promotes Aggregation

Dr. Robert P. Flynn
Extension Specialist for NMSU

Manage Sodium in Soil with Calcium (Gypsum ($CaSO_4$))



Excess water must be applied!!

Must also have good drainage!

Dr. Robert P. Flynn
Extension Specialist for NMSU

Example gypsum requirement calculation:

- your soil has a CEC (cation exchange capacity) of 18 milliequivalents per 100 grams and SAR (sodium adsorption ratio) of 26, and you desire an SAR of approximately 10 following treatment. (In these calculations it is correct to assume SAR is roughly equivalent to ESP (exchangeable sodium percent).
- ESP of 26% – desired ESP of 10% = ESP of 16, or 16% exchangeable Na must be replaced with calcium (Ca) to achieve the desired SAR.
- 0.16 x 18 meq CEC /100g = 2.88 meq Na/100 g soil that must be replaced.
- *1.7 tons $CaSO_4$/meq Na x 2.88 meq Na = 4.9 tons of gypsum.
- Thus, about 5 tons of pure gypsum per acre would be required to reclaim the top 12 inches of this soil. Be sure to adjust this calculation for lower grades of gypsum and different soil depths.
- *As a general rule of thumb, 1.7 tons of gypsum is required per meq of sodium.

Section 2 of 22 (2j – Infiltration guide as affected by water quality.

Irrigation Water Quality and its potential effects on Infiltration

The amount of **Sodium** and **soluble salts** in the Irrigation Water affects the rate of water infiltration into the soil. This is evaluated using the **SAR** (**Sodium Adsorption Ratio**) and Electrical Conductivity of the Irrigation Water (**ECiw in dS/m**).

Use meq/l for calculating the SAR

$$SAR = Na/\sqrt{(Ca + Mg)/2}$$

SAR	Degree of Restriction on Use – ECiw (dS/m)		
	None	Slight to Moderate	Severe
0 – 3	> 0.7	0.7 – 0.2	< 0.2
3 – 6	> 1.2	1.2 – 0.3	< 0.3
6 – 12	> 1.9	1.9 – 0.5	< 0.5
12 – 20	> 2.9	2.9 – 1.3	< 1.3
20 - 40	> 5.0	5.0 – 2.9	< 2.9

Steps to Calculate the Crop Irrigation Water Requirement

Step 1

$$Fc = ECe(ct)/EC_{iw}$$

Fc = Ratio of the Crop Threshold Salinity (ECe(ct)) to the Electrical Conductivity of irrigation water (ECiw). Units: dS/m

Crop Salt Tolerances section 2b to select your Ec_e

Ec_{iw} = is from a water lab test.

Section 2 of 22 (2b – Crop Salt Tolerances)

Crop (name)	Yield loss 0% ECe[1]	Yield loss 0% ECw[2]	Yield loss 10% ECe[1]	Yield loss 10% ECw[2]	Yield loss 25% ECe[1]	Yield loss 25% ECw[2]	Yield loss 50% ECe[1]	Yield loss 50% ECw[2]	Maximum ECe[3]
Alfalfa	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	15.5
Almond	1.5	1.0	2.0	1.4	2.8	1.9	4.1	2.7	7.0
Apple	1.7	1.0	2.3	1.6	3.3	2.2	4.8	3.2	8.0
Apricot	1.6	1.1	2.0	1.3	2.6	1.8	3.7	2.5	6.0
Barley	8.0	5.3	10.0	6.7	13.0	8.7	18.0	12.0	28.0
Beans	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.5
Beets	4.0	2.7	5.1	3.4	6.8	4.5	9.6	6.4	15.0
Bermuda Grass	6.9	4.6	8.5	5.7	10.8	7.2	14.7	9.8	22.5
Blackberry	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0
Boysenberry	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0
Broccoli	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	13.5
Cabbage	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12.0
Cantaloupe	2.2	1.5	3.6	2.4	5.7	3.8	9.1	6.1	16.0
Carrot	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.1	8.0
Clover	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	10.0
Corn, Grain & Silage	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10.0
Corn Silage	1.8	1.2	3.2	2.1	5.2	3.5	8.6	5.7	15.5
Corn, Sweet	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10.0
Cotton	7.7	5.1	9.6	6.4	13.0	8.4	17.0	12.0	27.0
Cucumber	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10.0
Fescue, Tall	3.9	2.6	5.8	3.9	8.6	5.7	13.3	8.9	23.0
Grape	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12.0
Lettuce	1.3	0.9	2.1	1.4	3.2	2.1	5.2	3.4	9.0
Love Grass	2.0	1.3	3.2	2.1	5.0	3.3	8.0	5.3	14.0
Meadow Foxtail	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.6	12.0
Onion	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.5
Orchard Grass	1.5	1.0	3.1	2.1	5.5	3.7	9.6	6.4	17.5
Peach	1.7	1.0	2.2	1.4	2.9	1.9	4.1	2.7	6.5
Pear	1.7	1.0	2.3	1.6	3.3	2.2	4.8	3.2	8.0
Pecan[4]	1.9	1.3**	2.4*	1.6**	3.2*	2.4**	4.6	3.0**	8.0*
Pepper	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.5
Potato, Irish	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10.0
Potato, Sweet	1.5	1.0	2.4	1.6	3.8	2.5	6.0	4.0	10.5
Radish	1.2	0.8	2.0	1.3	3.1	2.1	5.0	3.4	9.0
Raspberry	1.0	0.7	1.4	1.0	2.1	1.4	3.2	2.1	5.5
Ryegrass, Perennial	5.6	3.7	6.9	4.6	8.9	5.9	12.2	8.1	19.0
Safflower	5.3	3.5	6.2	4.1	7.6	5.0	9.9	6.6	14.5
Soybean	5.0	3.3	5.5	3.7	6.2	4.2	7.5	5.0	10.0
Spinach	2.0	1.3	3.3	2.2	5.3	3.5	8.6	5.7	15.0
Strawberry	1.0	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4.0
Sudan Grass	2.8	1.9	5.1	3.4	8.6	5.7	14.4	9.6	26.0
Sugar Beet	7.0	4.7	8.7	5.8	11.0	7.5	15.0	10.0	24.0
Tomato	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	12.5
Trefoil, Big	2.3	1.5	2.8	1.9	3.6	2.4	4.9	3.3	7.5
Trefoil, Birdsfoot	5.0	3.3	6.0	4.0	7.5	5.0	10.0	6.7	15.0
Vetch	3.0	2.0	3.9	2.6	5.3	3.5	7.6	5.0	12.0
Wheat	6.0	4.0	7.4	4.9	9.5	6.4	13.0	8.7	20.0
Wheatgrass, Crested	3.5	2.3	6.0	4.0	9.8	6.5	16.0	11.0	28.5
Wheatgrass, Fairway	7.5	5.0	9.0	6.0	11.0	7.4	15.0	9.8	22.0
Wheatgrass, Tall	7.5	5.0	9.9	6.6	13.3	9.0	19.4	13.0	31.5
Wild Rye, beardless	2.7	1.8	4.4	2.9	6.9	4.6	11.0	7.4	19.5

[1] ECe is the electrical conductivity of saturated soil extract, reported in millimhos per centimeter at 25°C.

[2] ECw is the electrical conductivity of the irrigation water, reported in millimhos per centimeter at 25°C.

[3] Maximum ECe is the conductivity of saturated soil extract, reported in millimhos per centimeter at 25°C, at which the plant dies.

[4] Complete data is not currently available for pecans. The * is an interpolation between the 0% and 50% range. The ** for ECw is calculated as ECe x 0.67, which is a general rule of thumb for these ratios under average conditions. RDFischer 2/09

Steps to Calculate the Crop Irrigation Water Requirement

- **Step 1**
- **$Fc = ECe(ct)/EC_{iw}$**

(Fc = Ratio of the Crop Threshold Salinity)

Example:

- **Fc = 2.0** dS/m **/ 1.0** ds/m **= 2.0** dS/m
- Alfalfa $EC_{e(ct)}$ = 2.0 dS/m (from Crop Salt Tolerance Table)

EC_{iw} = 1.0 dS/m

From: Section 8 of 22 (8b Gross Crop Irrigation Water Requirement Guide) On our web site.

- **ECiw = Electrical Conductivity of irrigation water / ECe = Electrical Conductivity of the soil saturation extract (units: decisiemens/meter (dS/m), which is equal to millimhos/centimeter (mmhos/cm),**

Steps to Calculate the Crop Irrigation Water Requirement

- **Step 2 if Surface Flood Irrigated (soil EC is about 1.5 times Water EC)**

  $LF = 0.3086/Fc^{1.702}$

  $LF = 0.3086 / 2.0^{1.702}$

  LF = 0.3086 / 3.254

  LF = 0.095

  Or

- **Step 2 if Drip (soil EC is about 3 times Water EC)**

  $LF = 0.1794/Fc^{3.0417}$

  $LF = 0.1794/2.0^{3.0417}$

  LF = 0.1794/8.2346

  LF = 1.47729

Updated Calculations for water requirements

Referenced; **Section 8b of 22 - Gross Crop Irrigation Water Requirement Guide**

- **LF = 0.3086/Fc3.0417 Leaching Fraction (for conventional irrigation; e.g. surface irrigation)**
- **LF = 0.1794/Fc3.0417 (e.g. Drip irrigation)**

Irrigation Water Requirements - Consumptive Use / Evapotransporation

Irrigation Water Requirements
Crop Data Summary

Job: Albuquerque
Location: Albuquerque
By: Rhett
Weather Station: ALBUQUERQUE WSFO AIRPOR
Latitude: 3503 Longitude: 10637
Computation Method: Blaney Criddle (TR21)
Crop Curve: Blaney Criddle Perennial Crop
Begin Growth: 4/16 End Growth: 10/30

Crop: Alfalfa, hay, northern
County: Bernalillo, NM
Date: 01/26/05
Sta No: NM0234
Elevation: 5310 feet above sea level

Net irrigation application: 2 inches
Estimated carryover moisture used at season:
Begin: 0.6 inches End: 0.6 inches

Month	Total Monthly ET (3) inches	Dry Year 80% Chance (1) Effective Precipitation inches	Dry Year 80% Chance (1) Net Irrigation Requirements inches (2)	Normal Year 50% Chance (1) Effective Precipitation inches	Normal Year 50% Chance (1) Net Irrigation Requirements inches (2)	Average Daily ETc inches	Peak Daily ETPk inches
January	0.00	0.00	0.00	0.00	0.00	0.00	
February	0.00	0.00	0.00	0.00	0.00	0.00	
March	0.00	0.00	0.00	0.00	0.00	0.00	
April	1.98	0.10	1.38	0.15	1.33	0.12	
May	6.39	0.29	6.10	0.42	5.97	0.21	0.23
June	9.35	0.38	8.97	0.54	8.81	0.31	0.34
July	10.47	0.79	9.68	1.13	9.34	0.34	0.37
August	8.80	0.96	7.84	1.38	7.42	0.28	0.31
September	5.85	0.52	5.33	0.74	5.11	0.19	0.21
October	3.11	0.41	2.20	0.58	2.03	0.10	
November	0.00	0.00	0.00	0.00	0.00	0.00	
December	0.00	0.00	0.00	0.00	0.00	0.00	
TOTAL	45.95	3.46	41.60	4.94	40.01		

(1) For 80 percent occurrence, growing season effective precipitation will be equaled or exceeded 8 out of 10 years. For 50 percent chance occurrence, effective precipitation will be equaled or exceeded 1 out of 2 years.

(2) Net irrigation requirements is adjusted for carryover moisture used at the beginning of the season and carryover moisture used at the end of the growing season.

(3) ET Evapotranspiration) is adjusted upwards 10% per 1000 meters above sea level.

Date: 7/21/2005

ETc = Crop Evapotranspiration (in.)

FOTG Section 1:
http://www.nm.nrcs.usda.gov/technical/fotg/section-1/consumptive-use/consumptive-use.html

- **Etc = 40.01(in) Crop Evapotranspiration for alfalfa**
- **LF = 0.095 (in) Leaching Factor. (Previous slides)**

Net Irrigation Requirement (NIR) (in.) Used to plan and design irrigation systems & IWM.

- **NIR = Etc/(1-LF)**

- **NIR = 40.01 / (1-0.095)**
- **NIR = 40.01 / 0.905**
- **NIR = 44.21 inches**

Section 8 (8d Irrigation Water Requirement Guide (Calculated at 50% Max., Allowable Depletion (MAD)

Section 8 of 22 (8d – Irrigation Water Requirement Guide) calculated at 50% Maximum Allowable Depletion (MAD) in the upper root zone

Soil Textural Class		AWC (in./ft.)	0 – 12 inch depth (Shallow Roots)			0 – 24 inch depth (Medium Roots)			0 – 36 inch depth (Deep Roots)		
			% Leaching Fraction (LF)								
			10	20	30	10	20	30	10	20	30
			Inches of Water needed at the time of Irrigation								
Coarse Texture	Sands	0.5	0.17	0.19	0.2	0.34	0.38	0.41	0.52	0.56	0.61
	Loamy Sands	1.0	0.34	0.38	0.41	0.69	0.75	0.81	1.03	1.13	1.22
	Fine Sands V. F. Sands Loamy F. Sands Loamy V. F. Sands	1.25	0.43	0.47	0.51	0.86	0.94	1.02	1.29	1.41	1.52
Mod. Coarse Texture	Sandy Loam Fine Sandy Loam	1.5	0.52	0.56	0.61	1.03	1.13	1.22	1.55	1.69	1.83
Medium Texture	V. F. Sandy Loam Loam Silt Loam Silt	2.0	0.69	0.75	0.81	**1.38**	1.5	1.63	2.06	2.25	2.44
Mod. Fine Texture	Sandy Clay Loam Silty Clay Loam Clay Loam	2.2	0.76	0.83	0.90	1.51	1.65	1.79	2.27	2.48	2.68
Fine Texture	Sandy Clay Silty Clay Clay	2.0	0.69	0.75	0.81	1.38	1.5	1.63	2.06	2.25	2.44

Example Calculation of Irrigation Water Requirement:

- Soil: Silt Loam
- AWC = 2.0 in./ft.
- Root Zone: 0 – 24”
- LF = 10%
- MAD = 50% at 0 – 6” depth

Root Zone Depth:	% of Total Soil Moisture Used:	Inches Used:
0 – 6”	40	0.5
6 – 12”	30	0.375
12 – 18”	20	0.25
18 – 24”	10	0.125

Irr. Needed

Total Soil Moisture depleted at irrigation = 1.25 in.

1.25” x 0.10 = 0.125” (LF)
Total Irrigation needed:
1.25” + 0.125” = **1.38”**

*Calculated values were based on the following Crop Root soil moisture extraction patterns (i.e., % of total soil moisture extracted at given depths) for the following root zones: rudy.garcia.2008

1 ft. depth	2 ft. depth	3 ft. depth
40% at 0 - 3”	40% at 0 - 6”	40% at 0 - 9”
30% at 3 - 6”	30% at 6 - 12”	30% at 9 - 18”
20% at 6 - 9”	20% at 12 - 18”	20% at 18 - 27”
10% at 9 - 12”	10% at 18 - 24”	10% at 27 - 36”

NOTE: Site-specific data is needed to estimate actual irrigation water requirements; therefore, this TABLE should be used as a GUIDE.

AWC = Available Water-Holding Capacity

Irrigation Application Efficiency – Calculates the irrigation application efficiency.

- Ea = irr. needed / irr applied
- Irrigation Needed = 2.06
- Irrigation Applied = 2.5in

  7.5 (cfs) X 2.0 (hrs) / 6.0 (ac) = 2.5 irr. Applied

  Q = DA/T Calculation for Irrigation Applied

- Ea = 2.06 / 2.5
- Ea = 0.824 or 82.4% Application Efficiency

Section 2 of 22 (2g - QT = DA Calculations for assessing IWM Requirements)

Section 2 of 22 (2g - QT = DA Calculations for assessing IWM Requirements)

Q is the flow to the border in cubic feet per second (cfs)
T is the inflow time (hours), i.e. the Irrigation Time set
D is the irrigation application depth (inches)
A is the area irrigated (acres)

Example: Alfalfa irrigated with a Hi-flow Turn Out

- available flow per border is 7.5 cfs (Q)
- field took 2.0 hours (T) to irrigate
- 2.5 inches (D) of irrigation water was applied per acre

Continued: i.e., 2.0" was needed ÷ 2.5" applied = 0.80 (irrigation has an 80% application efficiency)

- area irrigated was 6-acres (A); (436 ft. x 600 ft.) ÷ 43,560 = 6.0 acres)

To solve for Q: Q = DA/T

Flow to Border		Application Depth (in.)		Area (acres)		Inflow Time (hours)		
cfs	=	2.5 inches	X	6.0 acres	÷	2.0 hours	=	7.5 cfs

To solve for T: T = DA/Q

Inflow Time		Application Depth (in.)		Area (acres)		Flow to Border (Q)		
hrs.	=	2.5 inches	X	6.0 acres	÷	7.5 cfs	=	2.0 hrs.

To solve for D: D = QT/A

Application Depth		Flow to Border (Q)		Inflow Time (hours)		Area (acres)		
inches	=	7.5 cfs	X	2.0 hours	÷	6.0 acres	=	2.5 inches

To solve for A: A = QT/D

Area		Flow to Border (Q)		Inflow Time (hours)		Application Depth (in.)		
acres	=	7.5 cfs	X	2.0 hours	÷	2.5 inches	=	6.0 acres

NOTE: Refer to the **Field Irrigation Evaluation Guide.** This guide is used to assess the actual irrigation application efficiency (Ea), IWM skill & understanding, etc., in order to plan and implement irrigation system and Irrigation Water Management (IWM) improvements.

Irrigation Application Efficiency (Ea): is the ratio of the average depth of irrigation water infiltrated & stored in the root zone to the average depth of irrigation water applied.

USDA-NRCS Surface Irrigation System – Graded Border Program gave the following analysis for irrigated field evaluated:

Inputs:

- cfs = 7.5
- Net application depth = 2"
- Field Slope = 0.001ft/ft
- Soil Intake = 0.6
- Roughness Coefficient = 0.15
- Field width = 436 ft
- Field Length = 600 ft

Results:

- Application Efficiency = 81%
- Gross Application = 2.48"
- Inflow time = 2.0 hrs.
- Runoff = 0.11"
- Deep Percolation = 0.36"

rudy.garcia.2008

Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

Gross Irrigation Application needed

- Fg = NIR/Ea
- Fg = 44.21 / 0.824
- Fg = 53.7 inches

NIR = 44.21 inches

Ea = 0.824 or 82.4%

- Fg = Gross Irrigation Application needed
- Ea = Irrigation Application Efficiency
- NIR = Net Irrigation Requirements

Total Inches of water Applied / Acre / Year

Total inches applied/ac/yr = Irrigations X Irr. App.

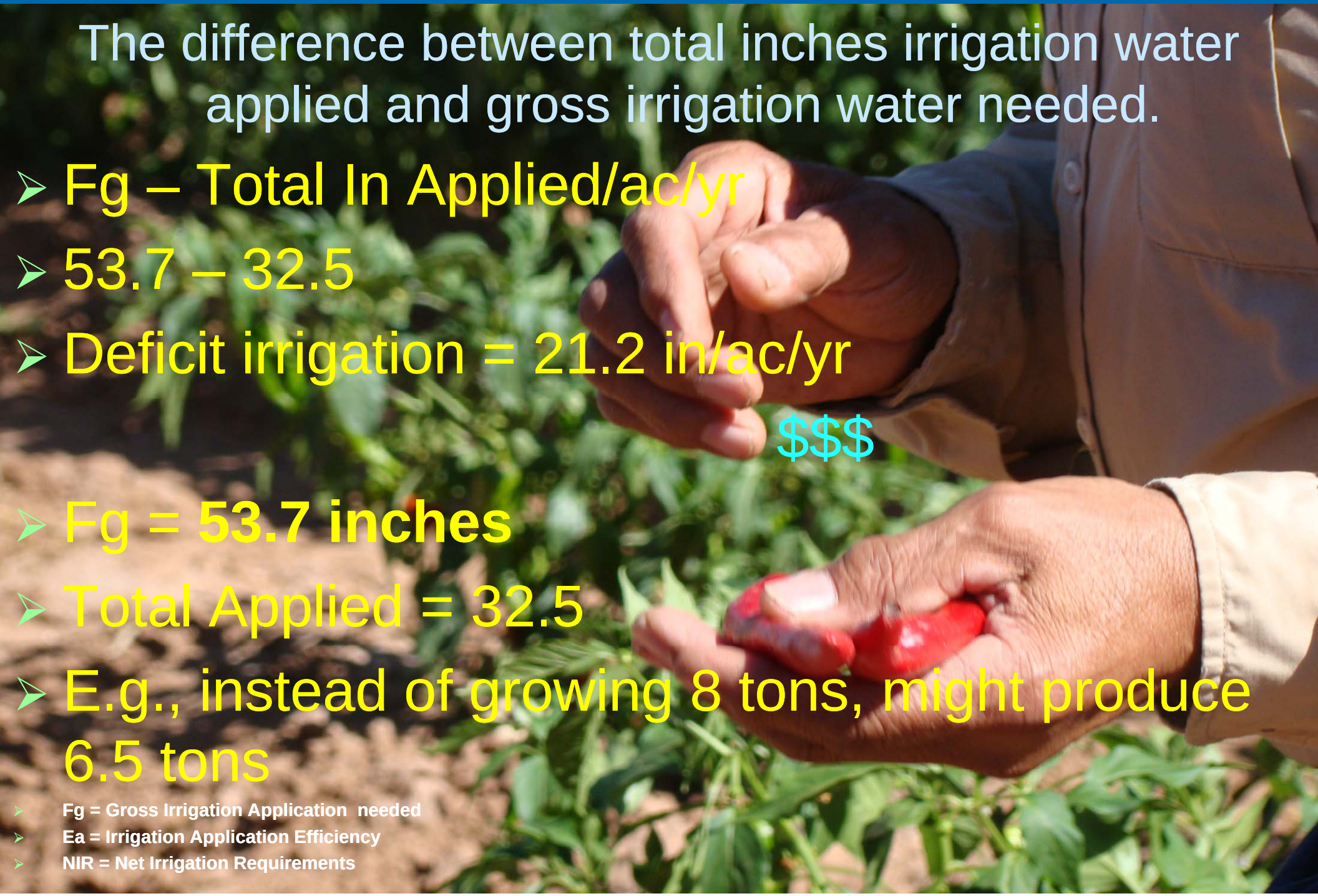
Total Inches Applied = 13 X 2.5

Total Inches Applied = 32.5

13 = Average of Irrigations per year.

2.5 in = Irrigation water Applied


(Las Cruces)



The difference between total inches irrigation water applied and gross irrigation water needed.

- Fg – Total In Applied/ac/yr
- 53.7 – 32.5
- Deficit irrigation = 21.2 in/ac/yr

$$$

- Fg = **53.7 inches**
- Total Applied = 32.5
- E.g., instead of growing 8 tons, might produce 6.5 tons

- **Fg = Gross Irrigation Application needed**
- **Ea = Irrigation Application Efficiency**
- **NIR = Net Irrigation Requirements**

Section 8b – Step by Step

Section 8 of 22 (8b - Gross Crop Irrigation Water Requirement Guide)

	Steps to Calculate the Crop Irrigation Water Requirement	Enter Results	Example Calculation (Alfalfa)	Results	NM IWM Manual References & Notes:
STEP 1	$Fc = ECe(ct)/ECiw$ Fc = Ratio of the Crop Threshold Salinity ($ECe_{(ct)}$) to the Electrical Conductivity of irrigation water (ECiw). Units: dS/m		$Fc = 2.0/1.0 =$ Alfalfa ECe(ct) = 2.0 dS/m ECiw = 1.0 dS/m	2.0	➢ Crop Salt Tolerance Table for NM ➢ Irrigation Water Quality Sampling
STEP 2	$LF = 0.3086/Fc^{1.702}$ LF = Leaching Fraction (for conventional irrigation; e.g. surface irrigation).		$LF =$ $LF = 0.3086/2.0^{1.702}$ LF = 0.3086/3.254	0.095	➢ Salinity Assessment GUIDE for Selected Crops
STEP 3	NIR = ETc/(1 – LF) NIR = Net Irrigation Requirement (in.) ETc = Crop Evapotranspiration (in.)		NIR = NIR = 40.01/(1 – 0.095) NIR = 40.01/0.905 ETc = 40.01 inches for Alfalfa	44.21”	➢ NM Crop Consumptive Use Requirements (NRCS FOTG – Section 1: Irrigation Guide for NM)
STEP 4	Ea = Irrigation needed (in.) ÷ Irrigation applied (in.) Ea = Irrigation Application Efficiency		Ea = Ea = 2.06/2.5 2.06” (Irr. needed) ÷ 2.5” (Irr. applied) Irr. applied: 7.5 (cfs) x 2.0 (hrs.) ÷ 6.0 (acres) = 2.5” applied.	0.824 (82.4%)	➢ Irrigation Water Req. Guide (e.g. 3’ root zone & Silt Loam soil @ 10% LF = 2.06” needed) ➢ QT = DA Calculations for Assessing IWM Requirements
STEP 5	Fg = NIR/Ea Fg = Gross Irrigation Application needed		Fg = Fg = 44.21/0.824	53.7”	➢ The calculation of Fg is used in the Planning & Design of Irrigation Systems and the development of IWM Plans
STEP 6	(# Irr. /yr.) x (in. applied/Irr.) = Total in. applied/ac./yr. (Note: in. applied/Irr. is based on an avg.)		13 Irrigations x avg. of 2.5”/Irr. = (e.g., Irrigated field approximately every 2-wks on a fixed schedule (Apr. – Oct.)	32.5”	➢ Amount of Irr. Water applied can differ substantially from the planned Gross Irrigation application needed
STEP 7	Fg – (Total in. applied/ac./yr.) = (Note: evaluate reason(s) for the difference between Fg & Total in. applied/ac./yr.)		53.7” (Fg) – 32.5” (Total in. applied/ac./yr.) =	21.2”	➢ In this example, it is clear that consumptive use is not being met.

ECe(ct) is taken from a soil saturation extract & the ECiw value is taken from a water test (EC units: dS/m = mmhos/cm = mS/cm).

The LF equation used for High Frequency Irrigation is: $LF = 0.1794/Fc^{3.0417}$ (e.g. Drip irrigation)

rudy.garcia.2008

Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

Section 7 of 22 (7a - Soil Moisture Monitoring and Irrigation Record keeping Form)

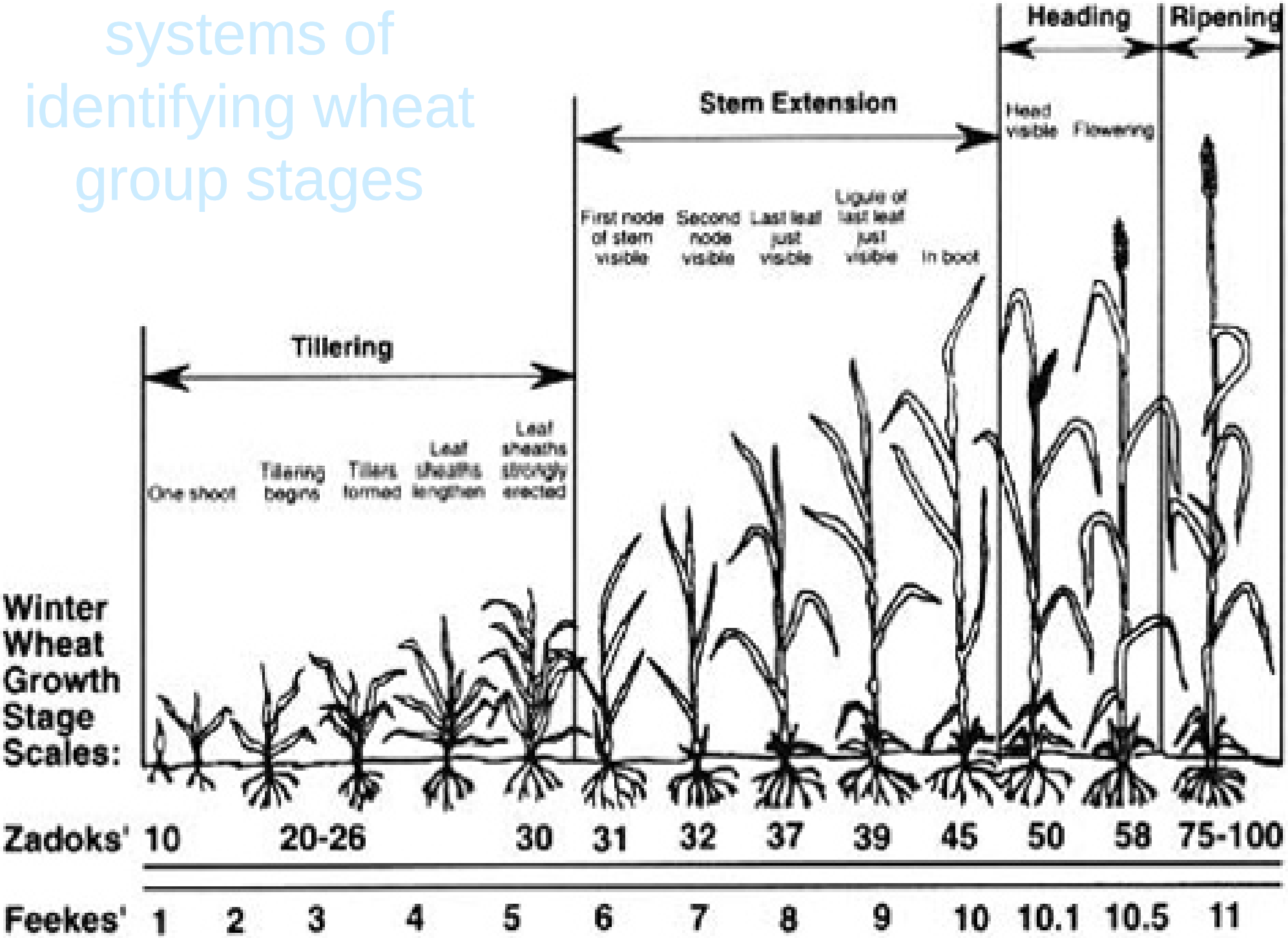
Important: Monitoring the rate of change of the soil moisture tension, is just as important as the actual reading used to schedule the irrigation.	**Coarse:** Sands, f. sands, very f. sands, Loamy sands, Loamy f. sands & Loamy very fine sands	**Moderately Coarse:** Sandy loam fine Sandy loam	**Medium:** v. f. Sandy loam Loam Silt loam Silt	**Moderately Fine:** Sandy clay loam Silty clay loam Clay loam	**Fine:** Sandy clay Silty clay Clay
	*Approximate Soil Moisture Sensor readings at the time of Irrigation (Units: centibars - cb) (NOTE: Irrigation scheduling is typically based on sensor readings in the 6" – 9" root zone depth)				
	30 – 40 cb	40 – 50 cb	50 – 60 cb	60 – 70 cb	70 – 80 cb
	Enter the date of Irrigation and the sensor reading (read at least once a week)				
April					
May					
June					
July					
August					
September					
October					

* i.e., For Tensiometers & Electrical Resistance Blocks or other type of soil moisture sensors.

rudy.garcia.2008

Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)

systems of identifying wheat group stages



Zadoks decimal growth scale is based on ten cereal growth stages.


Soil and Water EC
The bottom line
Timing and amount of watering will help in the management of salts in any soil.
Soil Health Management system.

Salt: IWM & Soil Health

(Irrigation Water Management)

Soil Health will have an affect on…

- ***Increased Infiltration***
- ***Increased Leaching potential***
- ***Increased Aggregate Stability***
- ***Increasing Reactive Carbon***
- ***Increased Nutrient Cycling***
- ***Increased and Diverse Soil Biota Habitat***
- ***Increased Root Expansion***

Low Equipment Cost
&
Good Return on Investment

SHMS = Soil Health Management System

For more information Please Contact Your Local Office of the:

Natural Resources Conservation Service

or

Soil and Water Conservation District

USDA NRCS

Non-Discrimination Statement

- "The U.S. Department of Agriculture (USDA) prohibits discrimination in all of its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex (including gender identity and expression), marital status, familial status, parental status, religion, sexual orientation, political beliefs, genetic information, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD)."

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service