

**Matching Irrigation Water Delivery on Irrigated Pasture to  
Local Transpiration and a Comparison with the Proposed  
CSKT Compact Water Use Agreement Irrigation Water  
Delivery-St. Ignatius, MT July –September, 2012**

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**Presented to the WIPC CSKT Technical Working Group  
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## Discussion Items

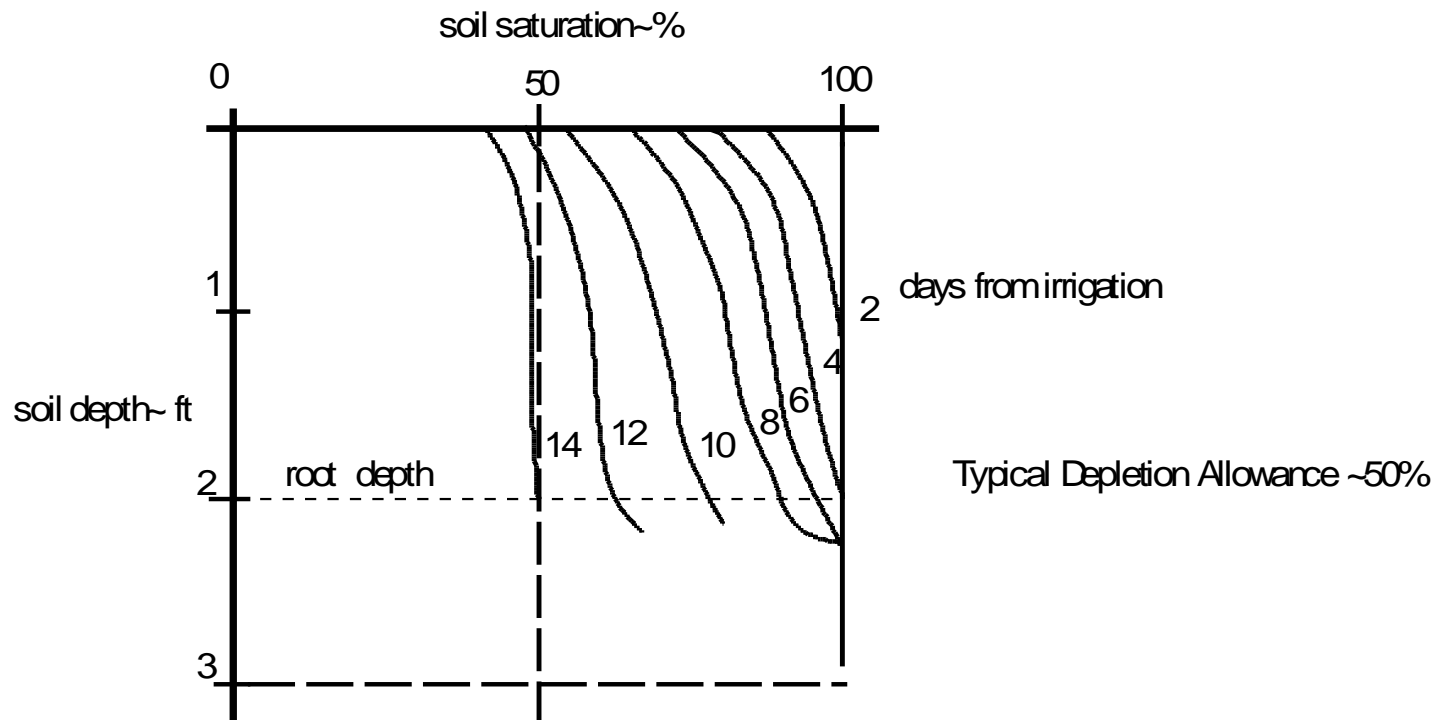
- **The Process of Irrigation**
- **Key parameters**
- **Property Layout and Water Delivery System Schematic**
- **Scheduling Irrigation Methodology**
- **Transpiration Data July-September, 2012**
- **Measuring Applied Water**
- **Comparison of CSKT Compact Proposal Water Allocation vs Actual Usage**
- **Discussion of Maximum Water Use Allowance Proposal**
- **Summary & Conclusions**

## The Process of Irrigation

Irrigation is the process of filling the soil profile with the amount of water that is lost to evapotranspiration in order to keep plants growing and productive.

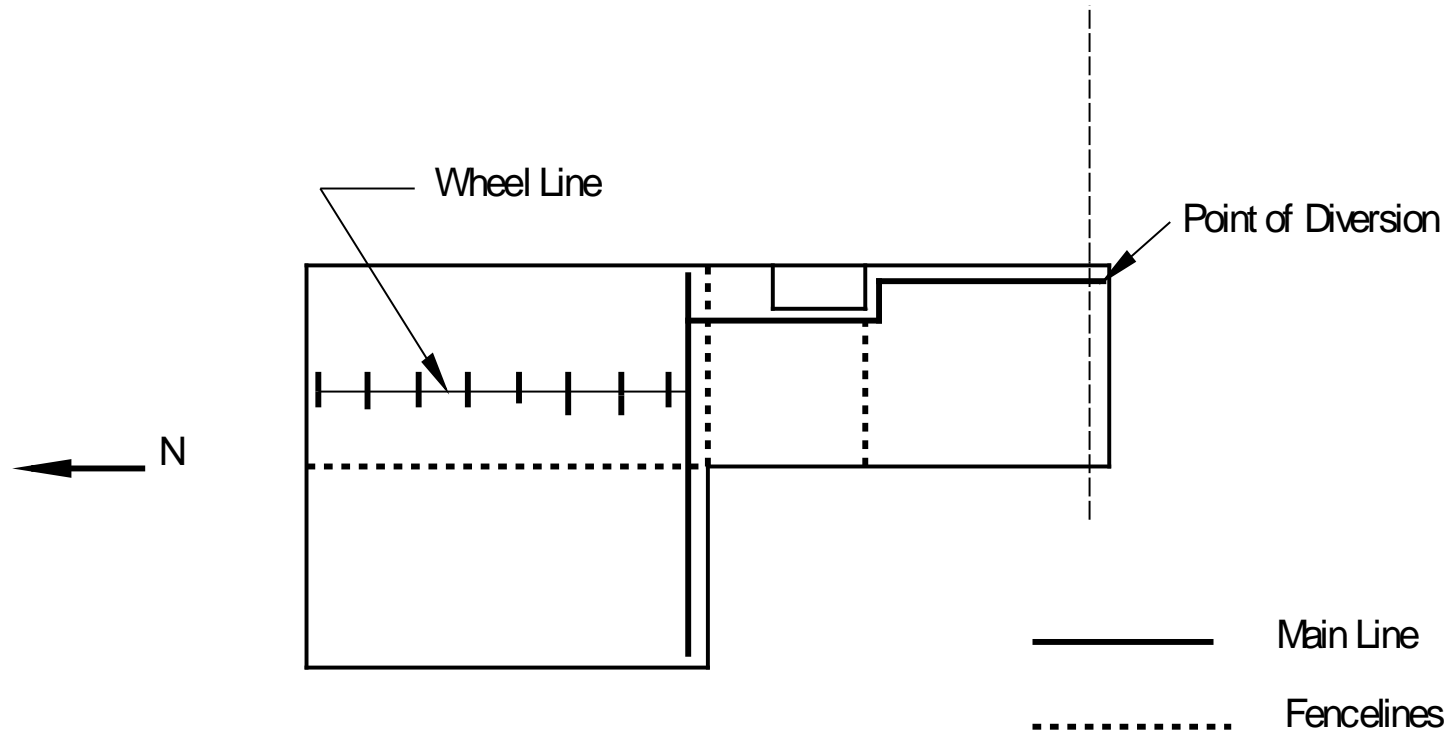
In order to do this, we must know how much water was initially stored in the soil and available to be used by the plants and how much water is evaporated from the soil and transpired by the plant (evapotranspiration).

Water Depletion After An Irrigation Set



## Key Parameters:

- Soil water capacity (SWC)..... the ability of the soil to hold water ~ inches of water /foot depth
- Root Zone ..... the depth above which most of the roots are found~ feet
- Water Depletion Allowance..... the max amount of water a plant can extract from soil~ % SWC
- Infiltration Rate(IR)..... the rate at which water can enter the soil ~ inches/hr
- Irrigation Efficiency (eta)..... water delivered to the root zone/applied water
- Evapotranspiration (ET)..... the rate at which evaporated and transpired water returns to  
the atmosphere~ inches/day
- Effective Precipitation (EP)..... rainfall that is absorbed by the soil~ inches
- Net Irrigation Requirement (NIR).....  $ET - EP$  ~inches
- Water Application Rate (WAR)..... the rate at which water is applied ~ inches/hr  
( $WAR \leq IR$ )
- Applied Water Target.....  $NIR/eta$  ~inches



Property & Irrigation System Schematic

- My soil type is cobbly silt loam (MacDonald) and the referenced irrigation guides list this type of soil having a 2in/foot water capacity.
- The max allowable depletion is dependent on the crop but for grass it is generally considered to be 50% of the available water capacity.
- My grass has a two foot root zone so it can only extract water from the top two feet of soil (soil capillarity can provide some additional amount of water from deeper soil but this is not accounted for in this analysis)
- Assuming no precipitation, I will need to irrigate whenever 2 inches of evapotranspiration occurs ( $2 \text{ ft of soil} * 2 \text{ inches of water /ft} * 0.50 \text{ (depletion allowance)} = 2 \text{ inches of evapotranspiration}$ ).

- Since my irrigation efficiency is not 100 %, I will have to apply more than 2 inches of water in order to get 2 inches into the root zone.
- How often will I irrigate? That depends on the daily evapotranspiration. By checking the local Agrimet weather station, I can get an idea of the daily local evapotranspiration. By summing the daily evapotranspiration and subtracting any precipitation from the beginning of the previous irrigation, I know that I will have to irrigate when the **equals 2 inches less any EP.**

## EXAMPLE

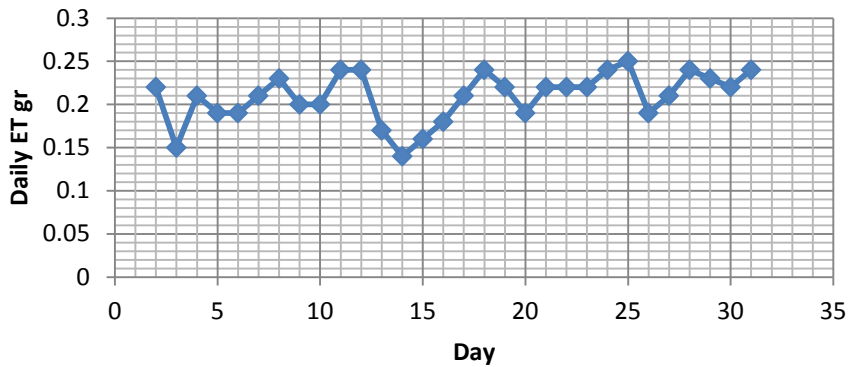
-  $\sum ET_{gr} = 2.0$  Begin irrigating 8 days from the beginning of the previous irrigation.

<u>Day</u>	<u>ET<sub>gr</sub></u>	(EP=0)
1	0.23	
2	0.24	
3	0.25	
4	0.28	
5	0.23	
6	.025	
7	0.25	
8	0.27	

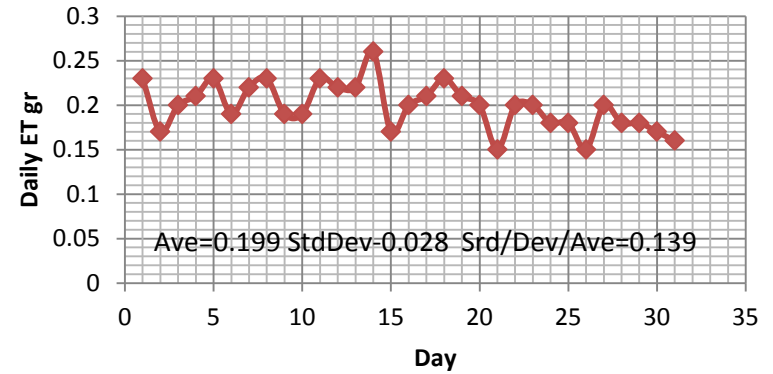


	July '12	Aug '12	Sept '12		tot Etostr		Net Etostr		eta*	Applied H2O	Actual Appld
ave Etostr	0.209	0.199	0.145		14.67	inches T	13.87			7/2 to9/16	H2O
sum Etostr	6.270	6.160	2.24						0.6	23.12	
std dev	0.028	0.028	0.034						0.65	21.34	22.4
stdev/ave	0.134	0.139	0.238						0.7	19.81	
Precip	0.8	0	0								

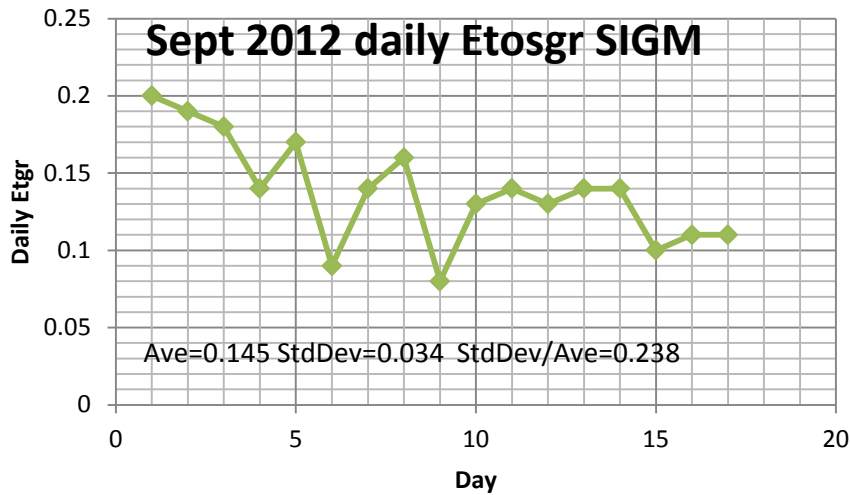
**July 2012 daily Etostr SIGM**



**Aug 2012 Daily Etostr SIGM**



**Sept 2012 daily Etostr SIGM**



## Measuring Applied Water and Determining 2012 Seasonal Usage

- 0-100 psig Pressure gauge was installed at the mid-point of the wheel line next to the mover
- Pressure was measured after water was turned on and pressure stabilized
- The pressure varied by field position due to distance from mainline, field elevation changes and total pump flow.
- The mean pressure was 48.6 psig and the std dev was +/-5.0 psig
- The nozzle size was 13/64 inches. Entering the tables at the appropriate pressure and linearly interpolating yielded an average flow rate of 8.6 gpm +/- 0.4 gpm and an application rate (40' x 60') of 0.34 +/- 0.02 inches/hr
- This yields 3.74 +/- 0.22 inches of water per 11 hour set.
- At 6 sets per season, this yields 22.4 +/- 1.3 inches between July 2nd and September 16<sup>th</sup> adding in a single irrigation in May 2012, yields another 3.74 inches
- Total 2012 usage was 26.2 +/- 1.5 inches.

# AgriMet Irrigation Guide Data

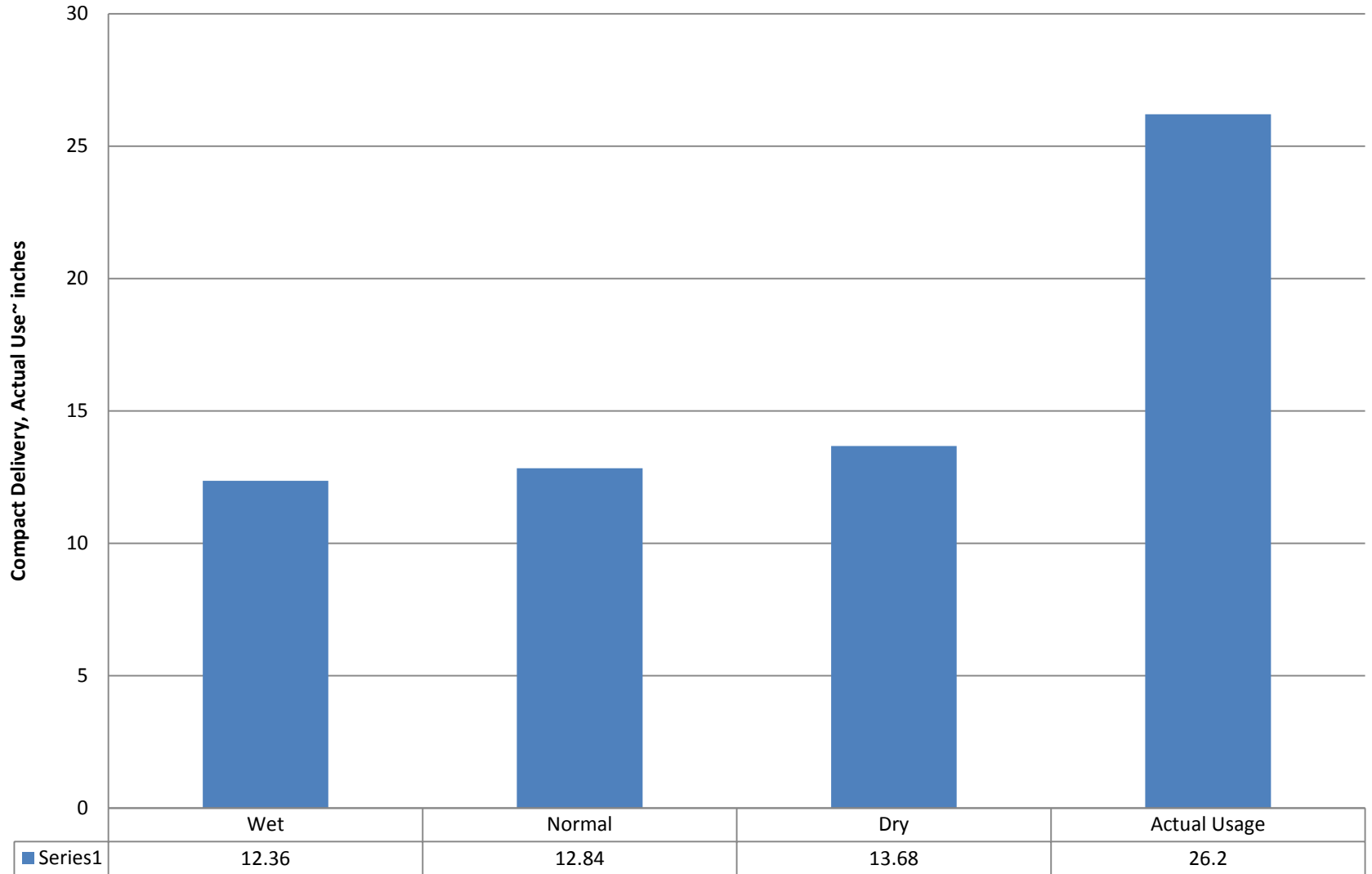
## Nozzle Discharge vs. Pressure for Various Nozzle Sizes

Nozzle Discharge - Gallons per Minute								
p.s.i.	3/32	1/8	9/64	5/32	11/64	3/16	13/64	7/32
20	1.17	2.09	2.65	3.26	3.92	4.69	5.51	6.37
25	1.31	2.34	2.96	3.64	4.38	5.25	6.16	7.13
30	1.44	2.56	3.26	4.01	4.83	5.75	6.80	7.86
35	1.55	2.77	3.50	4.31	5.18	6.21	7.30	8.43
40	1.66	2.96	3.74	4.61	5.54	6.64	7.80	9.02
45	1.76	3.13	3.99	4.91	5.91	7.03	8.30	9.60
50	1.85	3.30	4.18	5.15	6.19	7.41	8.71	10.10
55	1.94	3.46	4.37	5.39	6.48	7.77	9.12	10.50

## Irrigation Application - Inches per Hour

Sprinkler Spacing	Gallons Per Minute/Sprinkler															
	2	3	4	5	6	7	8	9	10	11	12	15	18	20	25	
30x30	.21	.32	.43													
30x40	.16	.24	.32	.40	.48	.52	.64	.72								
30x50			.25	.32	.38	.44	.51	.57	.64	.70	.76					
30x60				.27	.32	.37	.43	.48	.53	.58	.64	.80				
40x40		.18	.24	.30	.36	.42	.48	.54								
40x50				.24	.29	.33	.38	.43	.48	.53	.58					
40x60				.20	.24	.28	.32	.36	.40	.44	.48	.60	.72	.80		
50x50					.23	.27	.31	.35								

# CSKT Compact vs Actual Usage-2012



## Discussion of Max Water Use Allowance

- **Requires waiting period to apply**
- **Criteria and methodology not specific-“good intentions”**
- **May require substantial investment in irrigation equipment**
- **Can be cancelled**
- **Limited to a maximum 2 ac-ft/ace**

## WATER USE AGREEMENT PROPOSAL – FEBRUARY 2013

- **The Measured Water Use Allowance may be delivered to farm turnouts after the deferral period described in Articles XV and XVI based on the following criteria:**
  - (a) Water must be available in a given year after meeting the order of priority set forth in Section 22;**
  - (b) In no instance shall the sum of the Measured Water Use Allowance and the Maximum Farm Turnout Allowance exceed 2.0 acre-feet per acre;**
  - (c) The Measured Water Use Allowance may only be applied for after a farm turnout measurement system has been installed and is operating and in no event, more than five years after the end of the deferral period;**

## **WATER USE AGREEMENT PROPOSAL – FEBRUARY 2013 cont.**

- **(d) The Measured Water Use Allowance shall be available only to those irrigators who have diligently pursued on-farm irrigation system efficiency measures to meet agronomic crop water requirements and who have met the following criteria:**
  - ❖ **i. Three to five years of on-farm delivery and run-off measurement, at the discretion of the Project Operator, in consultation with the irrigator;**
  - ❖ **ii. Have met the conditions of an on-farm irrigation efficiency audit; and**
  - ❖ **iii. The Measured Water Use Allowance for any individual irrigator will be based on the average of the on-farm delivery measurements of the water delivered to that irrigator during the measurement period identified in Section 25(d)i.**

## **WATER USE AGREEMENT PROPOSAL – FEBRUARY 2013 cont.**

- **(e) The on-farm efficiency audits shall be completed by the Project Operator, or a third party designee acceptable to the Project Operator and the irrigator, and shall include at a minimum the following criteria:**
  - i. On-farm measurement system;**
  - ii. Quantify the number of irrigated acres;**
  - iii. Type of irrigation system;**
  - iv. Uniformity of irrigation application;**
  - v. On-farm surface run-off; and**
  - vi. Soil moisture content.**



## **WATER USE AGREEMENT PROPOSAL – FEBRUARY 2013 cont.**

**(f) Within 12 months of the passage of the Compact by the Montana Legislature, the Parties will define the application of criteria for the on-farm efficiency audit in Section 25(e).**

- I. The Parties may enter into a contract with the Natural Resources Conservation Service or the Bureau of Reclamation to develop recommendations for the application of the criteria.**
- II. The Parties will review the recommendations and make a decision to adopt or revise the recommendations.**

## **WATER USE AGREEMENT PROPOSAL – FEBRUARY 2013 cont.**

- **(g) If the Parties fail to agree upon the criteria in Section 25(f), the Measured Water Use Allowance shall not be implemented until such time as agreement is reached.**
- **(h) The volume of a MWUA shall be reevaluated by the Project Operator every ten years or at some shorter time period determined by the Project Operator. Based on a reevaluation using the criteria in the on-farm efficiency audit, the Project Operator may modify the MWUA.**
- **(i) If an irrigator fails to meet the efficiency conditions of the audit, access to the Measured Water Use Allowance shall be denied until such time as the efficiency deficiencies are met.**
- **(j) An individual irrigator aggrieved under this Section or any Party to this Agreement may invoke the dispute resolution procedures in Article XXVI of this Agreement.**

## Summary & Conclusions:

- **Irrigation Scheduling and Water Delivery**
  - Use of local ET data together with soil properties can effectively be used to schedule irrigations with reasonable accuracy
  - Water delivery can be quantified utilizing pressure measurements to assure that adequate water is being provided for optimum plant growth
- **Compact Water Allocations**
  - Water allocations proposed in the Compact/Water Use Agreement are significantly less than historical usage (approximately 50% of historic use)
  - The Measured Water Use Allowance methodology proposed in the Water Use Agreement is not specific enough to provide irrigators assurance of actually achieving gains in water deliveries. It needs to be more than “good intentions”.

End of Power Point Presentation.