Deficit Irrigation Options in Colorado and Need for ET Monitoring

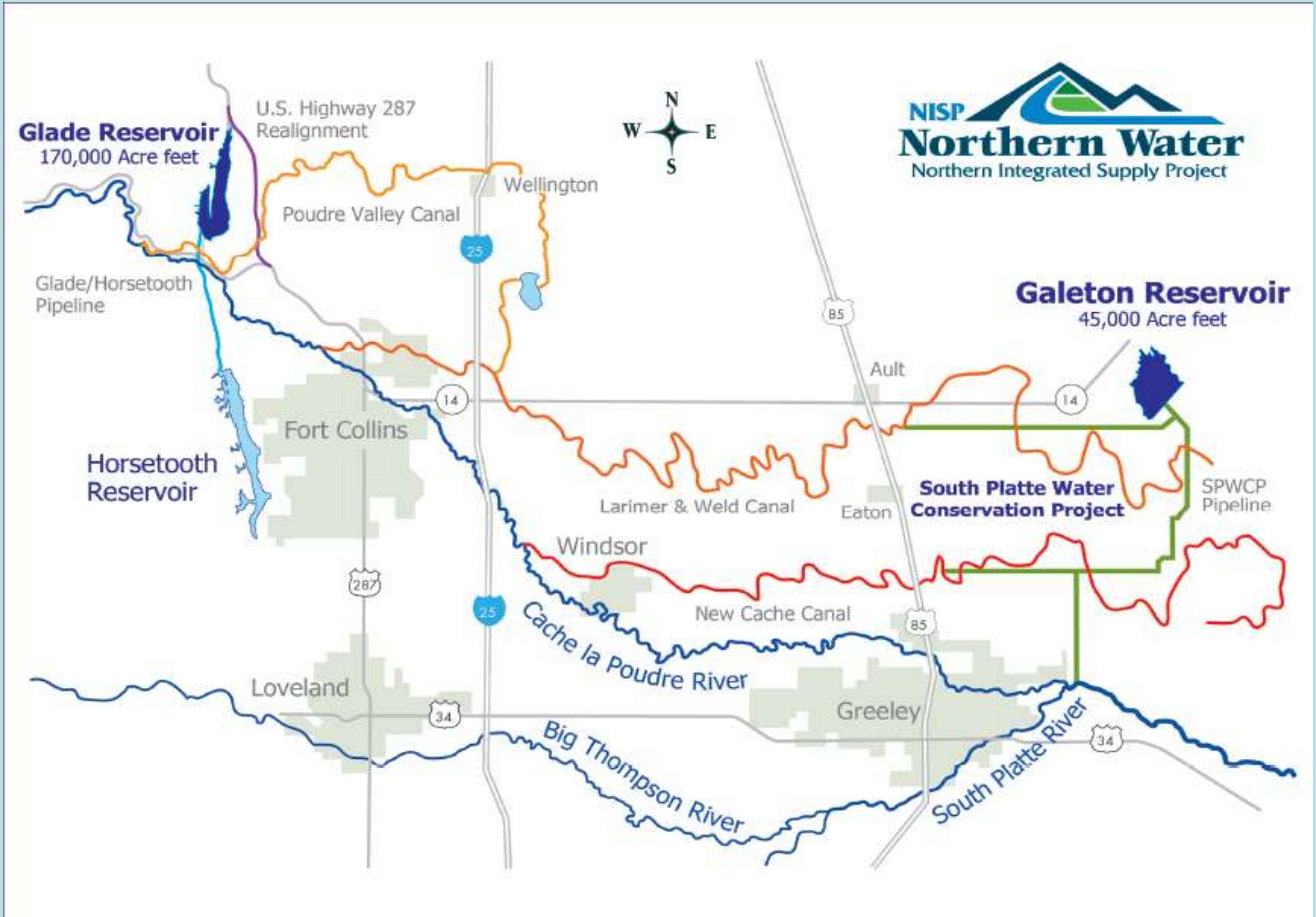
ADI (Augmented Deficit Irrigation) ATM

"Saving CU/ET (for lease to cities) through water stress of deficits while augmenting to maintain historic return flows"

October 13, 2016
Colorado ET Workshop 2016

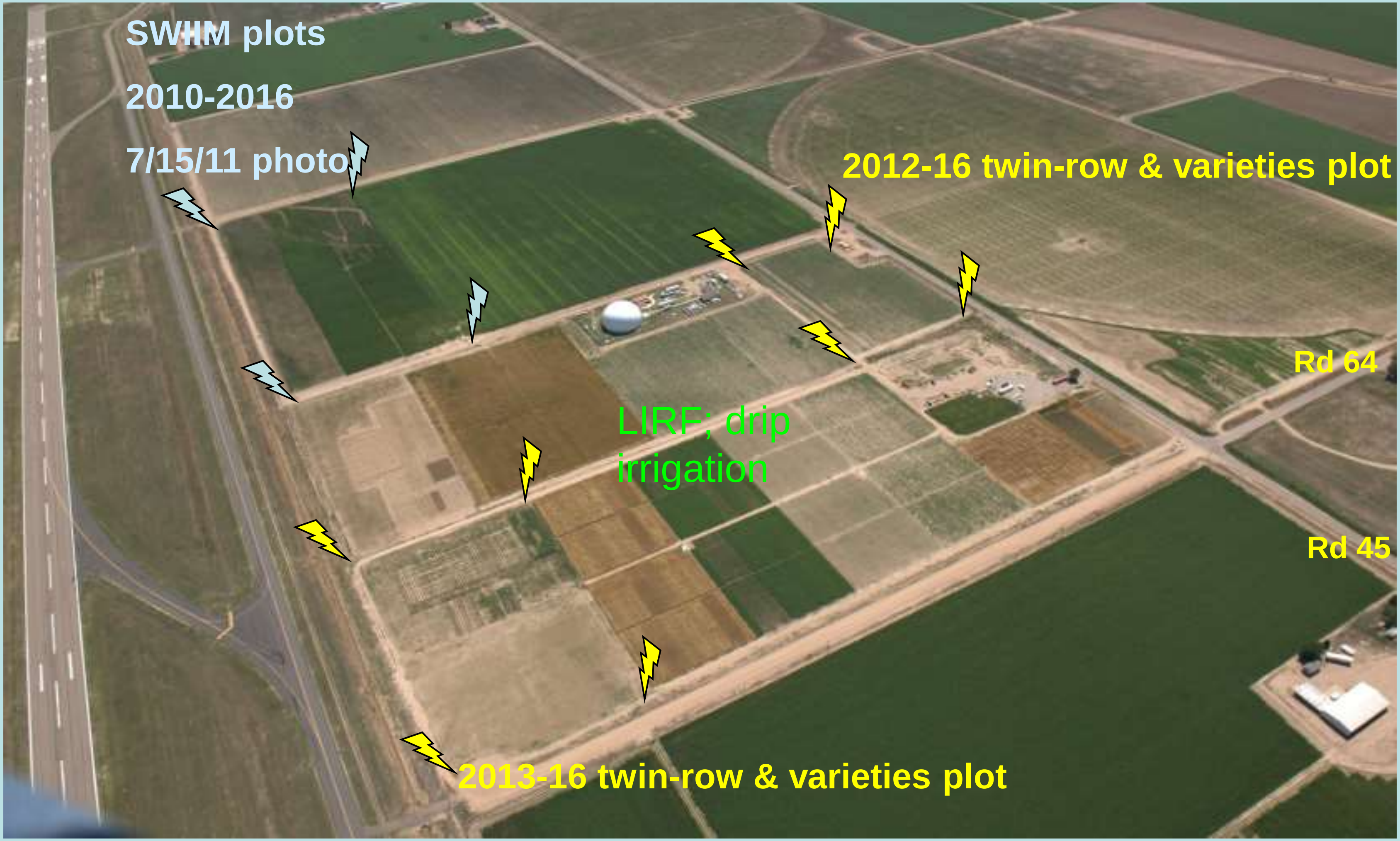
Jon Altenhofen, PE
South Platte Projects Manager,
Northern Colorado Water Conservancy District (Northern Water, NW)

Why a Northern Water ADI Program: Firming water supply for NISP instead of "Buy-and-Dry"



Northern Water Augmented Deficit Irrigation Research, NE of Greeley

USDA-ARS LIRF (Limited Irrigation Research Farm) with CSU & Regenesis (SWIIM) 2010-2016



NW ADI Studies on Low Frequency Deficit Irrigation (LFDI) by furrows on loam soils for grain corn production every year compared to LIRF HFDI by drip

Colorado Context for ADI:

Prior Appropriation Doctrine, a Tributary Aquifer and the Colorado Water Court System

S. Platte River Basin defined by returnflow hydrology—gaining river (5 to 10 cfs per mile) from draining tributary aquifer; downstream water rights depend on returnflows and all changes must be augmented

Any ADI Project starts with a historic use analysis of the ditch/reservoir company

DRAFT REPORT

DITCH-WIDE HISTORICAL USE ANALYSIS FOR

NEW CACHE LA POUDRE IRRIGATING COMPANY

AND

CACHE LA POUDRE RESERVOIR COMPANY

SHARES USED IN THE GREELEY CANAL NO. 2

CASE NOS. 06CW295 AND 04CW025

Prepared for

NEW CACHE LA POUDRE IRRIGATING COMPANY
CACHE LA POUDRE RESERVOIR COMPANY
LOWER POUDRE AUGMENTATION COMPANY

Prepared by

HRS WATER CONSULTANTS, INC.
8885 W. 14th Avenue
Lakewood, CO 80215
(303) 462-1111

03-12
January, 2010

Table 13
Ditch-Wide Historical Use Analysis
Irrigated Acreage by Crop Type

Year	Alfalfa	Grain Corn	Dry Beans	Grass	Small Vegetables	Spring Grain	Sugar Beets	Total
1993	4753	18688	4608	1470	0	1239	2174	32933
1994	4730	18762	4578	1567	0	1291	2174	33101
1995	4758	18841	4779	1476	0	1279	2174	33307
1996	4745	18754	4826	1434	0	1291	2153	33204
1997	4778	18581	4822	1381	0	1227	2153	32942
1998	10596	14374	2714	1750	1117	1663	1163	33377
1999	9065	15289	2723	1276	1195	2127	1071	32746
2000	9085	15496	2734	1207	1195	2102	1139	32959
2001	9149	15502	2727	1271	981	2072	1139	32843
2002	9310	15565	2715	1199	981	2177	1139	33086
2003	7821	13242	2669	3410	2144	777	564	30626
2004	8162	13253	2618	3386	2184	777	609	30731
2005	8309	13515	2595	3410	2280	777	664	31221
2006	8064	13092	2641	3410	2245	777	664	31156
2007	8245	13303	2560	3410	2162	873	619	31138
Average	7438	15750	3354	1981	1099	1363	1307	32358
Percent	23.0%	48.7%	10.4%	6.1%	3.4%	4.2%	4.0%	100.0%

Source: CDSS South Platte basin study, irrigated acreage GIS database for 1987, 2001 and 2005
Mapped crops were compiled and adjusted to reflect farms with water deliveries each year.

Table 14
Ditch-Wide Historical Use Analysis
Annual Crop Irrigation Water Requirements by Crop Type
(inches)

Year	Alfalfa	Grain Corn	Dry Beans	Grass	Small Vegetables	Spring Grain	Sugar Beets
1993	23.63	15.79	10.13	23.37	11.37	19.21	17.80
1994	30.02	20.20	12.87	28.98	15.51	19.77	21.87
1995	19.29	15.42	7.56	21.73	10.62	11.91	17.93
1996	24.61	16.11	9.62	24.08	11.34	17.17	17.68
1997	22.97	16.09	8.20	23.74	10.96	13.19	17.78
1998	27.78	20.68	10.96	27.60	15.17	19.14	22.09
1999	22.76	15.86	10.47	24.05	10.85	15.75	17.61
2000	29.57	20.38	12.12	30.39	15.36	19.12	23.13
2001	25.13	17.99	9.05	25.45	12.68	14.66	19.33
2002	26.51	19.71	11.64	24.41	14.34	23.16	19.66
2003	28.31	18.63	11.11	29.78	13.34	16.50	22.26
2004	25.63	16.50	9.59	25.92	11.76	15.77	18.72
2005	25.80	19.16	10.40	25.68	13.46	19.29	20.43
2006	31.11	21.03	13.92	29.75	15.62	20.80	22.98
2007	28.22	19.12	11.59	28.85	13.74	17.23	22.03
Average	26.09	18.18	10.62	26.25	13.07	17.51	20.09

Colorado Options for ADI -- (2 Approaches):

(1) Maintain Returnflows (historic non-CU of deep percolation and surface runoff) as part of the on-Farm Deficit Irrigation applications

---Applicable to LFDI on furrow/flood

2 irrigations on loam soils that overfill the profile so DP

---Most monitoring; DP=Inflow-RO-ET+Rain between irrigations

---ET monitoring daily of water stressed corn essential to confirm 9” of deficit ET (other 9” leased to city)

This approach focus of Northern Water ADI research

(2) Develop groundwater recharge ponds and river augmentation flumes to maintain Returnflows (Farm receives only a portion of historic CU due to irrigation water – i.e., receives 9” versus historic full IWR of 18”)

---Least Monitoring; Water inflow measurement to fields

---Knowing ET useful for scheduling and relation to Yield

MONITORING

LIRF CoAgMet Grl04 for ETref and Canopy Temp for well irrig

Field inflow meter and RO ramp flume

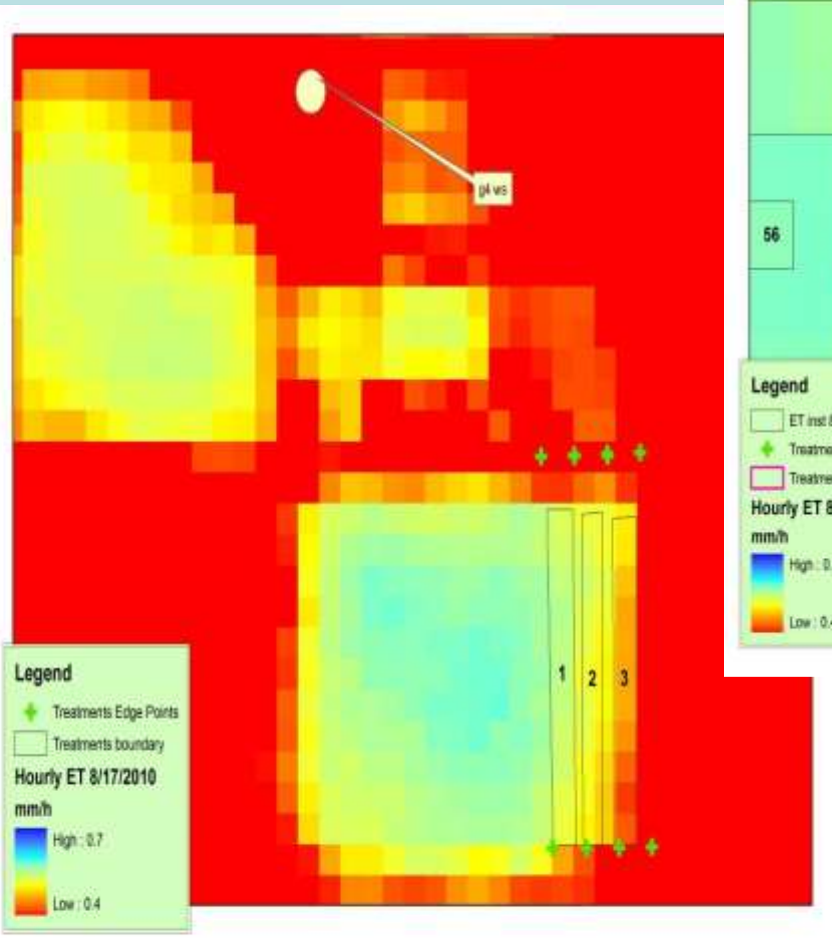
Recharge Pond and Augmentation station to river

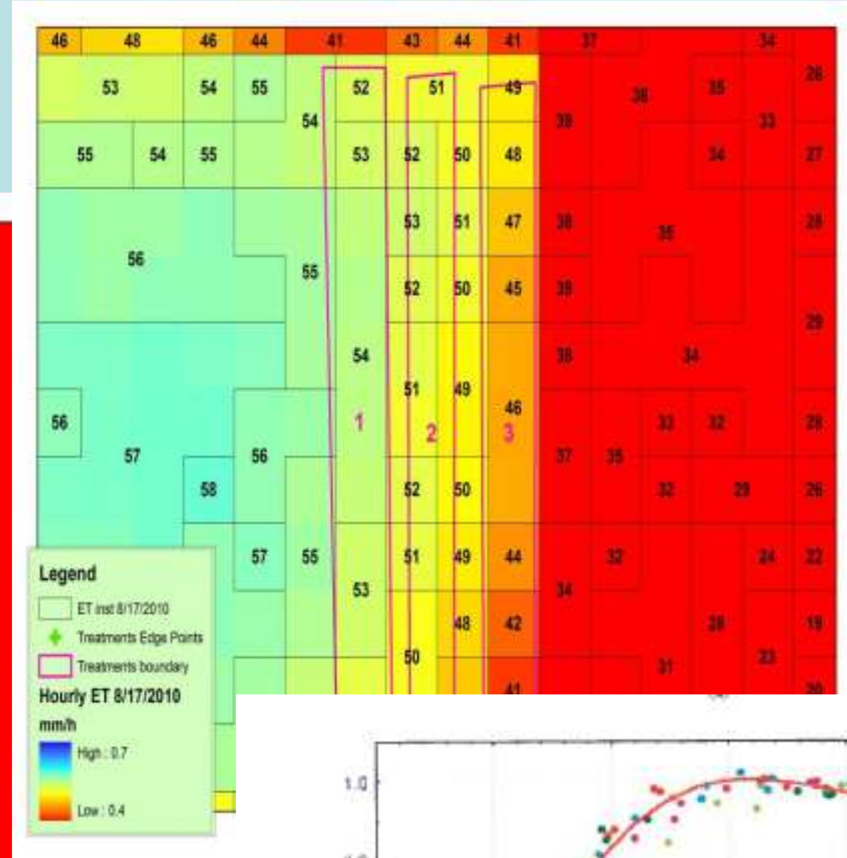
Some soil monitoring

Deficit Irrigation Monitoring via Satellite (CSU-ReSET)

ETc by Satellite

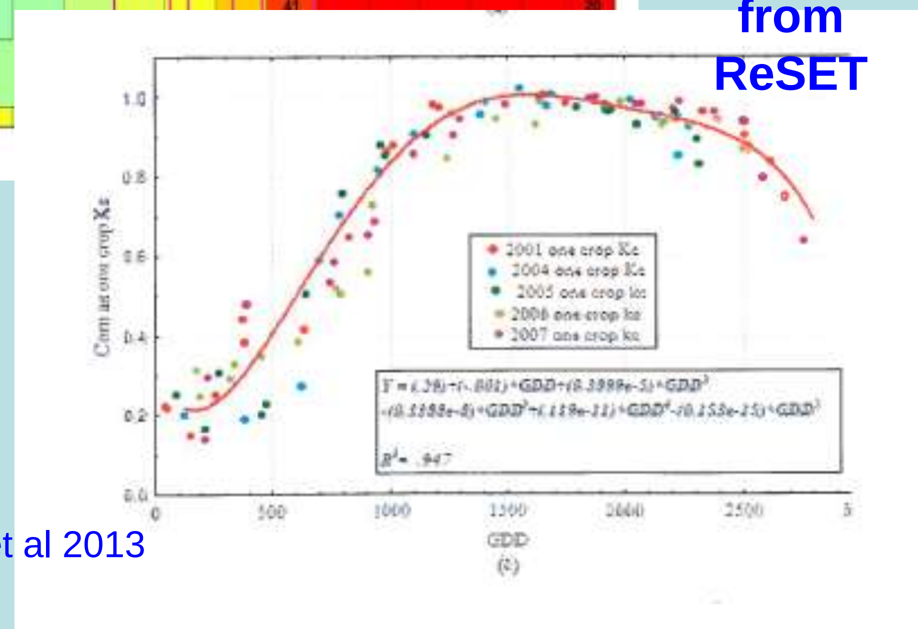
Ks (=ETc/ETref)





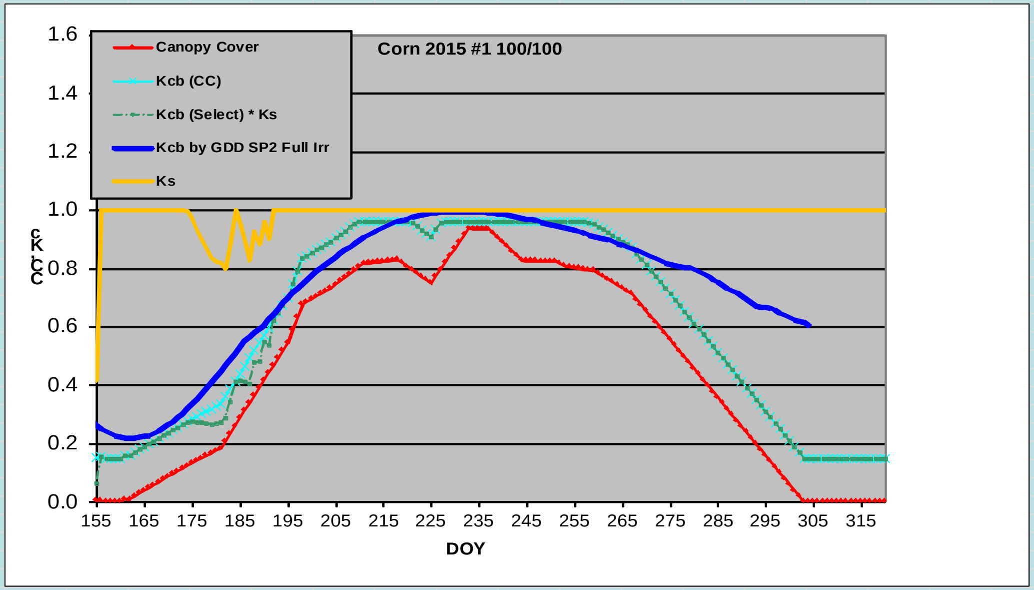
30 meters per pixel

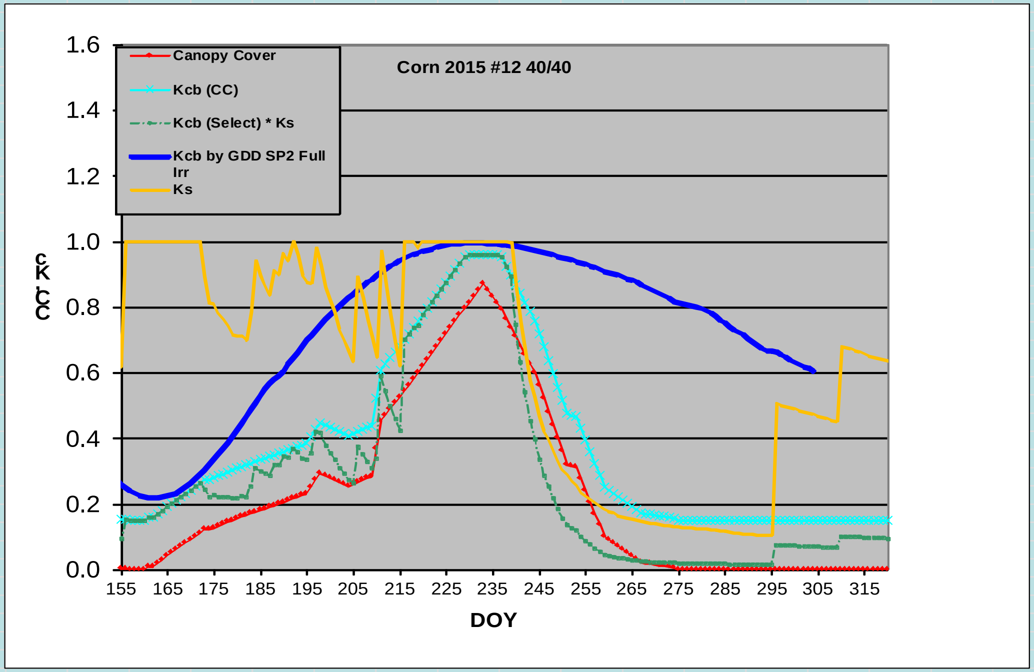
Regional crop coeff. from ReSET



UAVs in the future

Garcia, Elhaddad et al 2013





Difference between Full Irrig ET and deficit ET is water saved for transfer in an ADI ATM

Kcb via %canopy cover tracks well with GDD Kc from CSU ReSET effort

Determining ETstressed---

Crop transpiration = Ks x Gc x ETref

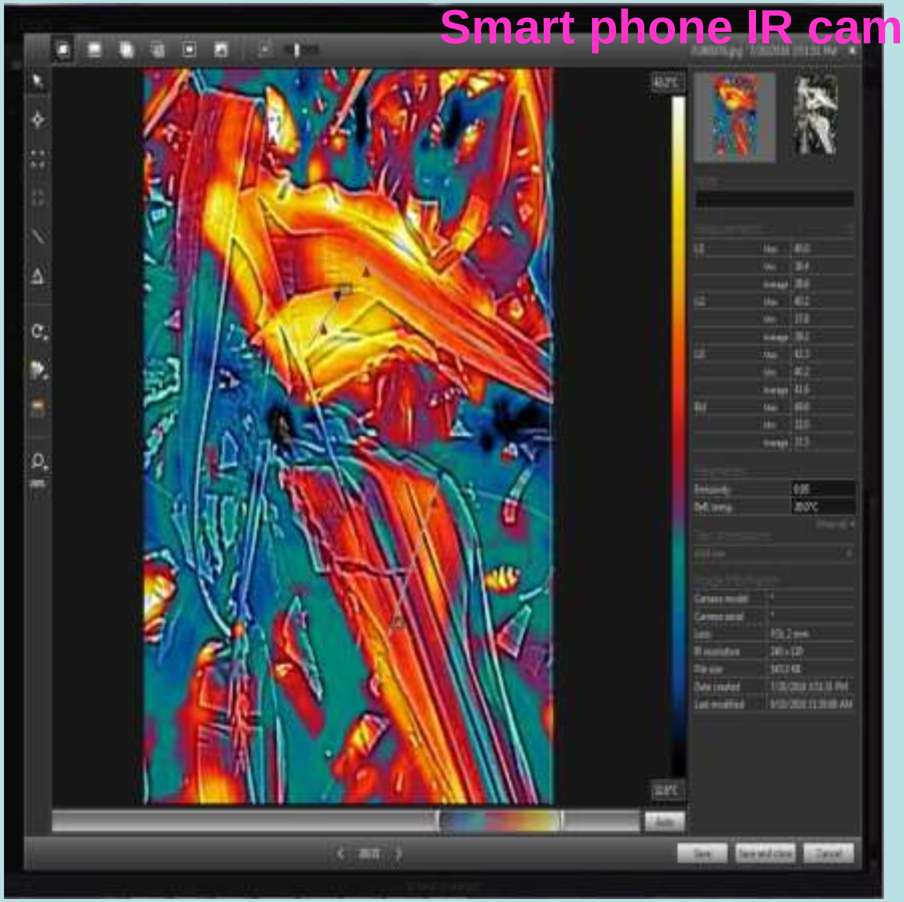
CWSI = (Tleaf-Twet) / (Tdry-Twet) and

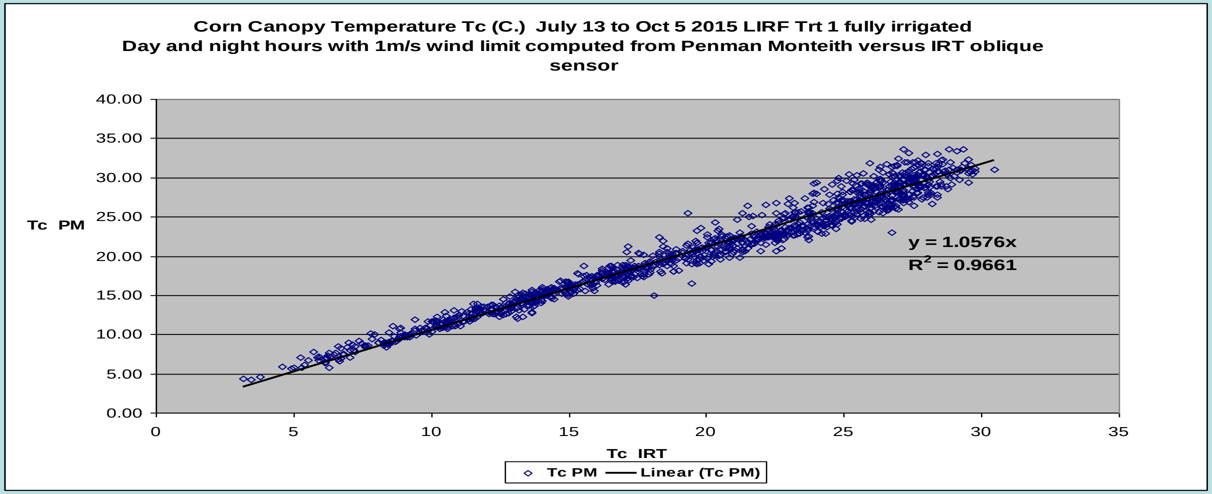
Ks = 1 - CWSI

Gc (% ground cover) by light stick

Visual Index for stress and Ks; leaves upright and curling

Smart phone IR camera for sunlit leaf temps



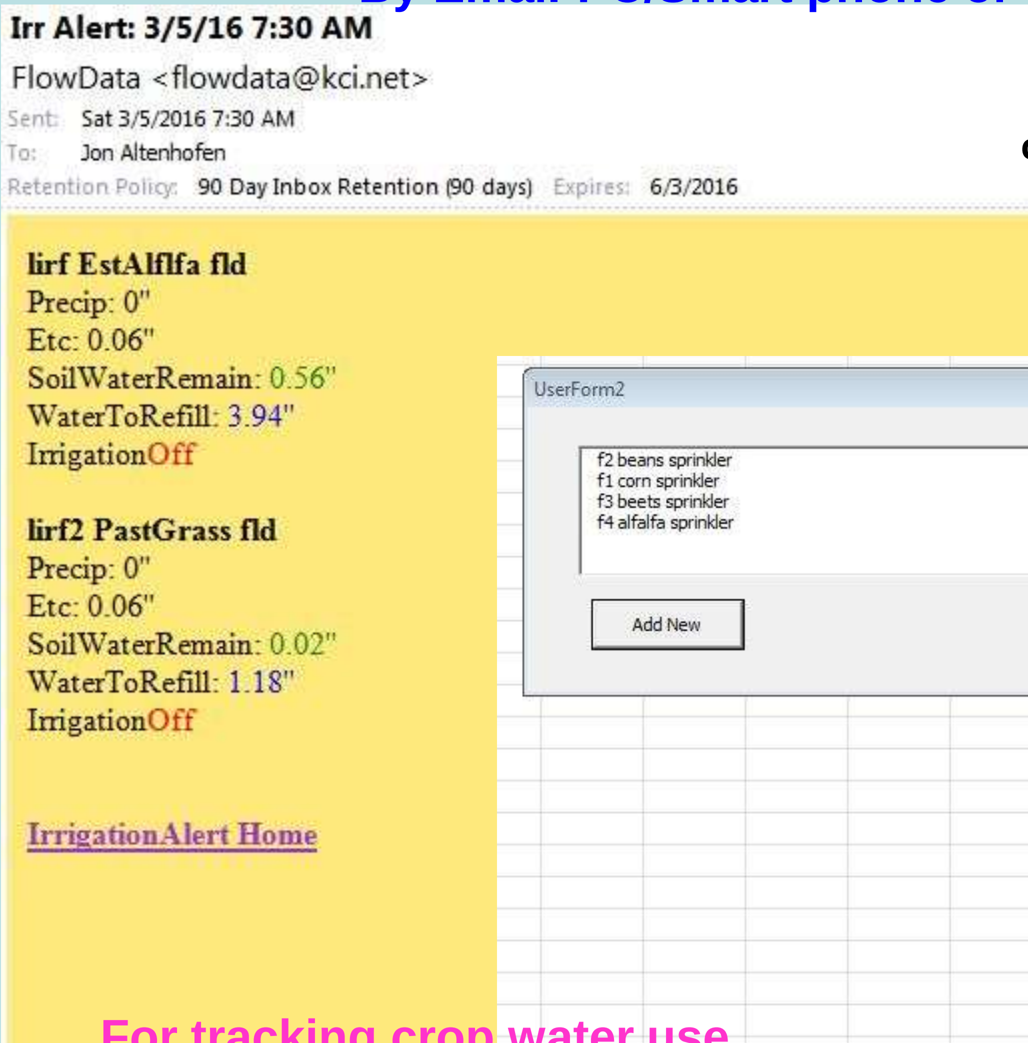


Jackson et al 1981 theoretical CWSI by Penman Monteith energy balance to compute well irrigated canopy Temp

Ks = F x T well irrig / T stressed (Bausch et al 2010)

Ks from canopy conductance ratio (Blonquist et al 2009)

Irrigation Alert Subscription Service-A Real Time Soil Water Balance
By Email-PC/Smart phone or text message daily



Irr Alert: 3/5/16 7:30 AM

FlowData <flowdata@kci.net>

Sent: Sat 3/5/2016 7:30 AM

To: Jon Altenhofen

Retention Policy: 90 Day Inbox Retention (90 days) Expires: 6/3/2016

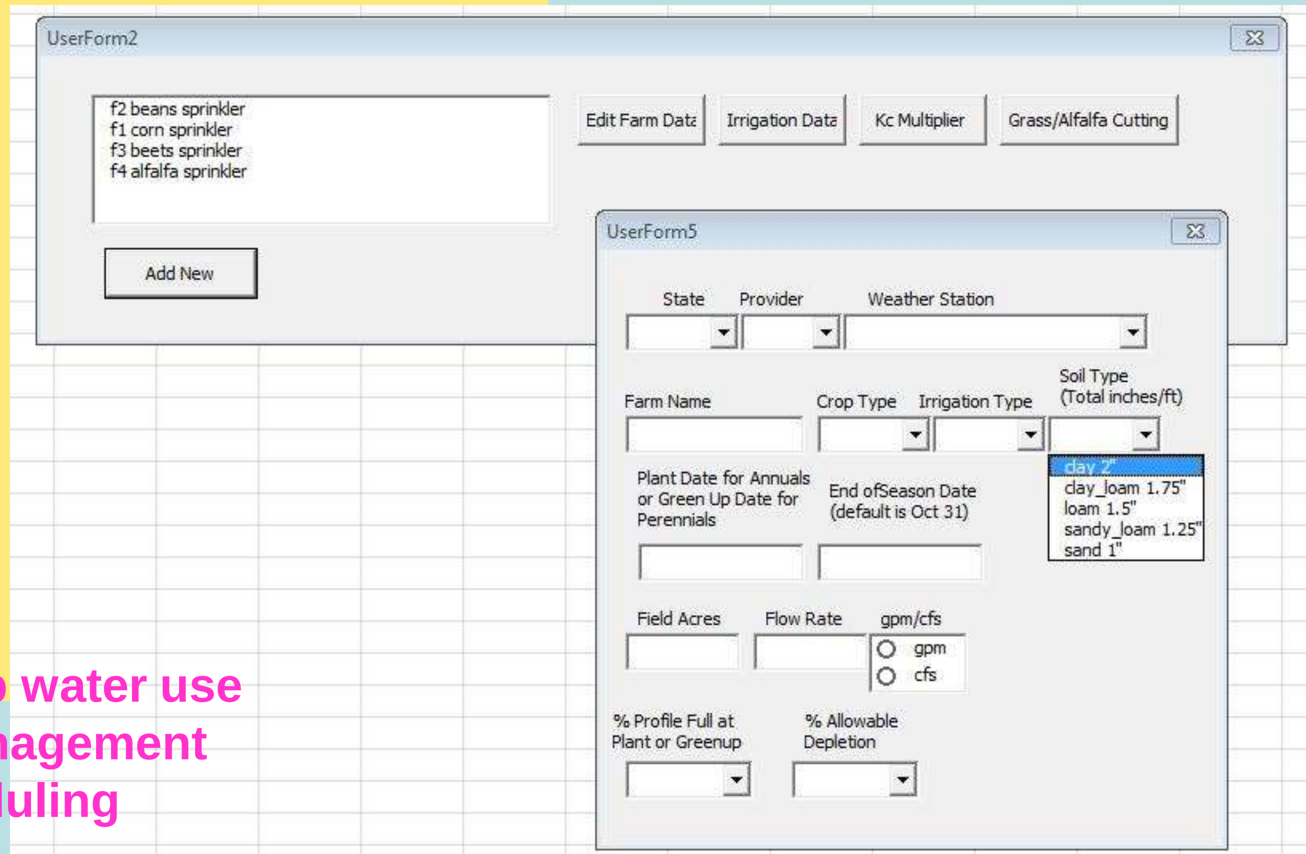
Iirf EstAlflfa fld
Precip: 0"
Etc: 0.06"
SoilWaterRemain: 0.56"
WaterToRefill: 3.94"
IrrigationOff

Iirf2 PastGrass fld
Precip: 0"
Etc: 0.06"
SoilWaterRemain: 0.02"
WaterToRefill: 1.18"
IrrigationOff

IrrigationAlert Home

Developed in 2016 by 2 Sterling, CO companies (KFI and KCI) with NW funding
-Access to all CoAgMet / NW stns

-Allows user to enter different Ks



For tracking crop water use for Irrigation management and deficit scheduling

NW Studies on Practices to maintain water productivity:

Twin row corn and drought tolerant varieties assure getting to full ground cover with deficit—the biggest factor in maintaining grain corn yield

Best WPR=85% yield / 63% ET=1.35

Drought Tolerant corn has horizontal laid-out leaves

Augmented Deficit Irrigation Economics

Net Profit on Farm with deficit irrig.	+	Lease of saved CU by M&I	=	Net Profit for fully irrigated **increased by X%**

EXAMPLES FOR 20% INCREASE IN NET PROFIT; Lease rates $/af of CU/ET

	Lease indexed to the price of corn	
	$3.40 / Bu corn	$5.00 / Bu corn
78% Yld at 63% ET (WPR=1.24)	$133/af	$345/af
85% Yld at 63% ET (WPR=1.35)	$111/af	$288/af
80% Yld at 50% ET (Target, WPR=1.6)	$94/af	$243/af
Fallow (no yield on farm)	$187/af	$487/af

----Increases in water productivity (more Bu/ET") on farm with deficit means more affordable to M&I

----M&I gets the certainty/security for a firm future supply because always farmer interest from incentive due to X% increase in net profits