North-to-South Water Transfers Encourage Inefficient Use of Agricultural Water

According to the California Department of Water Resources' (DWR) 2009 CA Water Plan Update, Agricultural Water Use Efficiency (WUE) was presumed to be primarily problems of irrigation technology and crop choice. However, the 2013 Update states that *"Improvements in agricultural water use efficiency are expressed as yield improvements for a given unit amount of water, and can be estimated over individual fields or entire regions."*[1] California is well-known for its microclimates, and that is certainly true of the Central Valley particularly when comparing production at both ends using orchard water requirements and including supplemental water to facilitate transfers.

'Crop per drop' is the agricultural equivalent of 'bang for your buck" i.e. pounds of product per applied water. Although, the San Joaquin Valley appears to be more productive than the Sacramento, by water use efficiency standards, it is only 39% as productive.

Total Moisture Required

The long, dry summer of the southern San Joaquin Valley means less frost or fungus damage and less chance of rain during harvest than in the Sacramento Valley, but also means more irrigation is required. Evapotranspiration (ET) represents water demand by crops, in this case almonds. Producing almonds in the San Joaquin Valley requires on average about 52 inches of moisture per growing season (regardless of whether the source is rainfall, surface water or groundwater), whereas producing the same almonds in the Sacramento Valley requires only 48 inches of moisture. [2]

Applied Water to Meet ET Requirements

Applied water is estimated by subtracting Effective Precipitation (EP) from the ET. EP is the portion of total rainfall available for plants water requirements. However EP is extremely site specific so this paper uses average rainfall (Tables 2-4). Kern County averages 5.24 inches of rainfall, resulting in a requirement for 46.76 inches per acre of supplemental irrigation. Butte County receives an average of 26.02 inches resulting in a requirement for only 21.98 inches of additional irrigation. By this calculation Kern County requires more than twice as much water (213%) as needed in Butte County to support an acre of orchard. But this is not all.

Additional Water to Support Transfers

The inefficiency of growing almonds in Kern County increases when north-to-south water transfers are included in this comparison. Table 1 shows that adjusting for Delta carriage water (for salinity control), other seepage and leaching losses, due to water transfers by DWR and the Bureau adds an additional 2 feet per acre foot to transferred water. Therefore, to support almonds grown in Kern County, a total of 69 inches of water would have to be transferred from north to south of the Delta. This is more than three times as much water as required to grow the same crop in Butte County (313%) .

Crop per Drop

Even though almond yields may be larger per acre in Kern County, when using "crop per drop" as a criteria, Kern County orchards are only 39% as water use efficient as orchards in Butte County. (Table 1)

Barbara Hennigan, Butte-Sutter Basin Area Groundwater Users, norcalgroundwater@gmail.com

Barbara Vlamis, AquAlliance, info@aqualliance.net

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[1] Ca. Water Plan Update, 2013, Vol 3, Chapter 2, page 5.

[2] S Martin, D. L. and J. R. Gilley 1993. *Irrigation Water Requirements.* Chapter 2 of the SCS National Engineering Handbook, Soil Conservation Service, Washington D.C., 284 pp. 623.0201 Crop water use (b) Evapotranspiration processes page 2-4

Table 1. Comparative Water Use Efficiency of Growing Almonds in Kern County and in Butte County

	Acre-Inches per acre		
Water requirement to produce almonds	**Kern County**	**Butte County**	**Kern County as % of Butte County**
Crop Evapotranspiration (ET) or Water Consumption	52.00	48.00	
Average rainfall available	5.24	26.02	
Add'l irrigation required to meet ET requirements	**46.76**	**21.98**	**213 %**
Losses with transferred Irrigation Water:			
Adjustment for Delta Carriage Losses at 30% of transferred water from NOD	15.12	N/A	
DWR Conveyance (Seepage) Losses 2%	1.01	N/A	
Warren Act (Seepage) Conveyance 3%	1.51	N/A	
Leaching Water Fraction 12% (salinity)	6.05	N/A	
Total Transferred Water Required to Grow Almonds in Kern County	**68.74**		
Total Irrigation Water Needed to Grow Almonds in Butte County		**21.98**	
Difference in Total Irrigation (incl. additional water required to support transfers)			**313%**
Average Yield	**Pounds per acre**		
County Ag. Crop Reports 2013 *CA Food &Ag Code (Sec. 2279)*	**2,290**	**1,860**	**123%**
Almond Board of California 2013 ***Note:*** *Almond Board numbers & County Ag Commissioners yields for the San Joaquin Valley differ significantly.*	**2,944**	**1,801**	**163%**
Crop per Drop, avg. lbs/inch of water –using 2013 Crop Reports & total required for transferred water)	**33.31**	**84.62**	**39%**

Sources; University of California, Cooperative Extension, Crop Production Studies; 2013 County Annual Crop Reports, California Data Exchange Center

Tables 2 and 3 provide a broader perspective of the annual precipitation data used in Table 1's total applied water analysis.

Table 2. Precipitation Characteristics of Kern County Gages Used in Time Series Analysis of Total Applied Water for Crops

	Bakersfield Airport (BFK)	Wasco (WSC)	Average Precipitation of Kern County Gages (in.)
16-year Average, 2000-2015 (YTD)	5.45	5.03	**5.24**
Median	4.77	4.58	4.75
Lowest Precipitation	1.77	2.14	2.10
Highest Precipitation	13.85	10.44	12.15

Source: California Data Exchange Center.

Table 3. Precipitation Characteristics of Butte County Gages Used in Time Series Analysis of Total Applied Water for Crops

	Oroville Dam (ORO)	Chico (CHI)	Chico University Farm (CES)	Average Precipitation of Butte County Gages (in.)
16-year Average, 2000-2015 (YTD)	29.79	25.93	22.35	**26.02**
Median	28.68	25.35	22.68	25.98
Lowest Precipitation	20.16	11.10	6.62	15.85
Highest Precipitation	47.36	39.70	36.92	40.39

Source: California Data Exchange Center.

Table 4. Effective Precipitation and other comments

1) Groundwater substitution is used with some north-to-south water transfers and adds at a minimum of 13% more water to a Kern County almond crop due to impacts to area-of-origin streams.
2) Effective precipitation (EP) is the portion of total rainfall that is actually available for plants to help meet their consumptive water requirements. Factors affecting EP are (1) slope/runoff, (2) soil characteristics (sand/gravels allow moisture to penetrate below the root zone, clay holds moisture where it evaporates) (3) timing and rate of rainfall, (4) age of trees and size of canopy and (3) temperature/humidity (rain evaporates in warm air before plants can utilize the moisture). EP is highly variable region to region and field to field.
3) Some non-water collateral costs not included in this discussion, but which could be included for full disclosure are capital and operational expenses associated with moving water, environmental studies, mitigation, and legal expenses for agencies and contractors.