Thomas Howard, Executive Director
Members of the Board
State Water Resources Control Board
Clerk to the Board, (916) 341-5600
1001 I Street Sacramento, CA 95814
Sent via email to Rich.Satkowski@waterboards.ca.gov

RE: Livestock Feed Crop Production in the San Joaquin Valley, 2014

Thank you for the opportunity to comment on the important issue of livestock feed crop-related agricultural water use in the San Joaquin Valley.

To start, we wish to formally incorporate into this comment, by reference, the 6 July 2015 comment to the SWRCB titled "June 8, 2015 Temporary Urgency Change Petition Concerning SWP/CVP and Water Deliveries, in relation to the April 6, 2015 TUCO," submitted by Ara Marderosian (Sequoia ForestKeeper), Guy Saperstein, Alexandra Paul, Jon Marvel, Connie Hanson, Mike Hudak, Lorelei Plotczyk, Lorin Lindner, Marcia Hanscom, Robert Roy van de Hoek, and Todd M. Shuman (Wasteful UnReasonable Use), as well as the Objection/Protest respectfully submitted to the SWRCB by Sequoia ForestKeeper (SFK) and Wasteful UnReasonable Use (WURU) regarding the 8 June 2015 Notice of Request Filed by the California Department of Water Resources and the United States Bureau of Reclamation to modify and renew a Temporary Urgency Change Order regarding permits and license of the State Water Project and the Central Valley Project (filed initially on May 21, 2015).

We wish to formally incorporate into this comment, by reference, the 16 August 2015 comment to the SWRCB titled "Unreasonable and Wasteful Water Use: Rice Cultivation, Livestock Feed Crop Production, the Sacramento River Settlement Contractors, and the July 3, 2015 TUCO", submitted by Ara Marderosian (Sequoia ForestKeeper), Todd M. Shuman (Wasteful UnReasonable Use), Mike Hudak (Ph.D., author), and Megan E. Gallagher, Esq. (Attorney at Law).

We wish to formally incorporate into this comment, by reference, the 16 October 2015 comment to the SWRCB titled "Five Counties, Five Numbers: Livestock Feed Crop Production in the S. San Joaquin Valley, 2014", submitted by Ara Marderosian (Sequoia ForestKeeper), Todd M. Shuman (Wasteful UnReasonable Use), Mike Hudak (Ph.D., author), and Megan E. Gallagher, Esq. (Attorney at Law).

LFC Production and California Law

Livestock feed crop (LFC) production in California sustains cattle-related commodity production in California. As we have argued previously, global climate change and drought conditions in California have likely been exacerbated and intensified by the methane that is emitted when livestock feed crops are consumed and digested by dairy cows and other cattle.

We have also argued previously that livestock (especially cattle) are notoriously inefficient at converting water and other natural resources into protein available for human consumption, relative to plant-based sources of protein.

We, therefore, again argue that the use of water drawn from surface flows and extracted from increasingly-depleted groundwater aquifers in the San Joaquin Valley to irrigate acreage that *results* in livestock feed crop production is unreasonable and wasteful in California. Use of water drawn from surface flows and groundwater extracted from increasingly depleted aquifers to irrigate acreage that *results* in livestock feed crop production in California conflicts with the "waste or unreasonable use" section of the California Constitution. (See Article 10, Section 2, which declares that "the waste or unreasonable use … of water be prevented … The right to water or to the use or flow of water ... does not and shall not extend to the waste or unreasonable use … of water.")

Moreover, the continued extraction of groundwater from increasingly-depleted San Joaquin Valley aquifers to irrigate acreage that *results* in livestock feed crop production appears inconsistent with legal requirements that have been incorporated into The Sustainable Groundwater Management Act of 2014. In Section10720.1, it is stated that "it is the intent of the Legislature to do all of the following . . . (b) To enhance local management of groundwater consistent with . . . Section 2 of Article X of the California Constitution." In Section 10720.5, it is stated that "(a) Groundwater management pursuant to this part shall be consistent with Section 2 of Article X of the California Constitution."

LFC Production in SJV 2014

The counties of Kern, Tulare, Kings, Fresno, Madera, Merced, Stanislaus, and San Joaquin released 2014 Annual Crop reports during the second half of 2015. Based on the information within these reports, in combination with other sources (including information from Mariposa, Tuolumne, and Calaveras counties), we have compiled and calculated a set of numbers that constitutes the basis for a concise narrative concerning water, livestock feed crop production, and methane gas emission in the San Joaquin Valley (SJV) during 2014. In short, approximately 2.4 million acres were devoted to (or *resulted* in) livestock feed crop (LFC) production in these counties in 2014. Approximately 7.5 million acre-feet (MAF) of water was used to cultivate acreage that *resulted* in LFC production in 2014. Approximately 28 million tons of livestock feed crop forage were produced from the application of this amount of water to the acreage cultivated in 2014.[1] (See Appendix A and attached spreadsheet set, LFC SJV 2014 sprdsht.)

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1. Twenty eight million tons of forage could have theoretically fed approximately three million lactating cows for a full year, and three million lactating cows would have likely emitted (through the process of enteric fermentation) an annual quantity of methane that is equivalent to approximately 62 billion pounds of carbon dioxide trapping heat in the atmosphere over the next 20 years. See spreadsheet set, LFC SJV 2014 sprdsht.]

This large amount of forage would have been primarily used to feed the cumulative California beef, dairy, heifer, bull, and steer populations in 2014. The cumulative 2014 California cattle population was 5.1 million, with the beef, dairy, heifer, bull, and steer populations cumulatively accounting for approximately 4.03 million, while calves accounted for the remaining 1.07 million. (See Appendix A.)

As we noted in earlier comments to the SWRCB, livestock feed crops consumed by cows are partially converted (through enteric fermentation) into significant direct atmospheric methane emissions. Cattle manure channeled into anaerobic manure lagoons and liquefied slurry storage constitutes a second major source of atmospheric methane emission.

Cumulative cattle-associated methane emission values for California during 2013 have been released by the California Air Resources Control Board. Approximately 1,911,000,000 pounds of cattle-associated methane were released into the atmosphere in 2013---997,000,000 pounds by way of enteric emissions and 914,000,000 pounds by way of manure-related emissions. Using an IPCC AR^{5th} 20-year interval methane GWP, the carbon dioxide equivalent (CO2e) value associated with this mass of methane is comparable to an amount of carbon dioxide that would be annually released by 19.1 coal-fired electricity generation (CFEG) plants that would then trap heat in the atmosphere for 20 years before being sequestered. Using an IPCC AR^{5th} 100-year interval methane GWP, the CO2e value associated this mass of methane is comparable to an amount of carbon dioxide that would be annually released by 6.36 CFEG plants that would then trap heat in the atmosphere for 100 years before being sequestered. (See Appendix A and spreadsheet set, LFC SJV 2014 sprdsht.)

LFC Production, Methane Emission, and Extreme Weather

It is likely that livestock-associated methane emissions generated in California in 2014 have already contributed to the further warming of our planet. It is also likely that such livestock-associated methane-related atmospheric heat trapping has increased the probability that certain types of extreme weather-related events will become even more likely to occur in California and the U.S. in the future. It is also likely that these types of extreme weather-related events (triggered in part by livestock-related methane emission) will generate significant adverse impacts on human health, essential infrastructure, and vulnerable coastal populations. A number of recently published studies over the last eight months provide evidentiary support for the latter two claims:

1: A recent peer-reviewed study has directly linked human-caused global warming to the catastrophic flooding in Texas and Oklahoma in spring of 2015. (In May, more than 35 trillion gallons of water fell on Texas—enough to cover the entire state in eight inches of water. More than two dozen people were killed, and it was the wettest single month on record in both Texas and Oklahoma.) The new peer-reviewed study from Utah State and Taiwanese researchers concluded, "There was a detectable effect of anthropogenic [manmade] global warming in the physical processes that caused the persistent precipitation in May of 2015 over the southern

Great Plains."[2] (See Simon Wang, S.-Y., W.-R. Huang, H.-H. Hsu, *and* R. R. Gillies *(*2015*), Role of the strengthened El Niño teleconnection in the May 2015 floods over the southern Great Plains,* Geophys. Res. Lett*.*, 42, 8140–8146*, doi:*10.1002/2015GL065211.)

2: A recently-published study by Swain, Horton, Singh, and Diffenbaugh (2016) has documented that the number of very dry atmospheric patterns in California has increased in recent decades, while the number of "average" moisture atmospheric patterns has declined. Swain noted: "We're seeing an increase in certain atmospheric patterns that have historically resulted in extremely dry conditions…What seems to be happening is that we're having fewer 'average' years, and instead we're seeing more extremes on both sides. This means that California is indeed experiencing more warm and dry periods, punctuated by wet conditions." https://www.sciencedaily.com/releases/2016/04/160401144457.htm)

While the authors of this study have deployed careful and highly technical language in their study, they have, nonetheless, written a crucially important statement concerning an apparent positive statistical relationship between global greenhouse gas forcing and the specific extreme atmospheric configurations that have been manifest in the northeastern Pacific over the last 65 years:

"The results presented in the current study therefore confirm that the observed pattern of the long-term GPH [geopotential height field] trend in the NPD [Northern Pacific domain] is spatially nonuniform, strongly positive in the mean, driven by the specific pattern of lower tropospheric warming, and characterized by an amplification of the West Coast mean ridge highly reminiscent of that which occurred during historical dry and warm years in California. These empirical findings demonstrate a complex evolution over the northeastern Pacific between 1949 and 2015, with 500-mb GPH and SLP [sea level pressure] trends of generally the same sign occurring "in-phase" with the mean West Coast cool-season ridge (Fig. 1, A to C, and fig. S1) and the largest trends occurring just east of the terminus of the East Pacific storm track (33). This is especially interesting in light of recent investigations into the physical structure of anthropogenically forced trends in regional atmospheric circulation, which have suggested that changes in mean flow (via momentum/energy fluxes driven by embedded transient cyclones) may reinforce planetary-scale stationary waves in the upper atmosphere under certain conditions (37, 45, 54, 56)."

2: A recently released National Academies of Science study notes the high confidence level of extreme event attribution modelling studies that are clearly related to heat and temperature, such as the Wang et al. study summarized above: "**Confidence in attribution findings of anthropogenic influence is greatest for those extreme events that are related to an aspect of temperature, such as the observed long-term warming of the regional or global climate, where there is little doubt that human activities have caused an observed change**. For example, a warmer atmosphere is associated with higher evapotranspiration rates and heavier precipitation events through changes in the air's capacity to absorb moisture. . .**Confidence in attribution analyses of specific extreme events is highest for extreme heat and cold events, followed by hydrological drought and heavy precipitation.**" (National Academies of Sciences, Engineering, and Medicine. 2016. *Attribution of Extreme Weather Events in the Context of Climate Change*. Washington, DC: The National Academies Press. doi: 10.17226/21852. Page 106.)]

“Additionally, because the location and amplitude of atmospheric stationary waves are dictated by the relative placement and orography of global landmasses, *the observed alignment of the nonuniform spatial pattern of thermal dilation with the North American continent (Fig. 1B) supports the notion that at least some of the observed trend in GPH—and thus specific extreme atmospheric configurations—may be due to increasing land-sea thermal contrasts. Enhanced warming over the continents is a predicted (and observed) response to global greenhouse forcing and has the potential to influence broader circulation regimes* (57, 58).” [emphasis added, see Daniel L. Swain, Daniel E. Horton, Deepti Singh, and Noah S. Diffenbaugh. *Trends in atmospheric patterns conducive to seasonal precipitation and temperature extremes in California*. Science Advances, March 2016, page 9 DOI: 10.1126/sciadv.1501344]

3: A comprehensive meta-study recently released by the Federal Government (U.S. Global Change Research Program, April 2016) has documented numerous significant adverse impacts associated with “Extreme Events” driven by anthropogenic forcing (greenhouse gas emissions). The key findings of this study, summarized on page 100, are provided below:

“Increased Exposure to Extreme Events - Key Finding 1: Health impacts associated with climate-related changes in exposure to extreme events include death, injury, or illness; exacerbation of underlying medical conditions; and adverse effects on mental health [High Confidence]. Climate change will increase exposure risk in some regions of the United States due to projected increases in the frequency and/or intensity of drought, wildfires, and flooding related to extreme precipitation and hurricanes [Medium Confidence]. . . Key Finding 2: Many types of extreme events related to climate change cause disruption of infrastructure, including power, water, transportation, and communication systems, that are essential to maintaining access to health care and emergency response services and safeguarding human health [High Confidence]. . . Key Finding 3: Coastal populations with greater vulnerability to health impacts from coastal flooding include persons with disabilities or other access and functional needs, certain populations of color, older adults, pregnant women and children, low-income populations, and some occupational groups [High Confidence]. Climate change will increase exposure risk to coastal flooding due to increases in extreme precipitation and in hurricane intensity and rainfall rates, as well as sea level rise and the resulting increases in storm surge [High Confidence].”

(See Bell, J.E., S.C. Herring, L. Jantarasami, C. Adrianopoli, K. Benedict, K. Conlon, V. Escobar, J. Hess, J. Luvall, C.P. Garcia-Pando, D. Quattrochi, J. Runkle, and C.J. Schreck, III, 2016: *Ch. 4: Impacts of Extreme Events on Human Health. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program,* Washington, DC, 99–128. http://dx.doi.org/10.7930/J0BZ63ZV.)

Unreasonable Water Use and Extreme Weather

On the basis of all of the studies that we have summarized and cited in all of our SWRCB comments since June 19, 2015, we re-assert our previous claim: it is profoundly unreasonable—indeed, intensely irrational—for the SWRCB to continue to allow California water to be used for activities that are likely to promote an increased frequency of drought events in California's future, and hence, further water scarcity in California. We add to our assertion that it is unreasonable for the SWRCB to continue to allow California water to be used for activities that are likely to promote extreme weather conditions throughout California, the United States, and the rest of the planet. Given the severe adverse impacts that have been, and will likely be, partially generated by anthropogenically-forced extreme weather events, we assert that it is unreasonable (and hence unconstitutional) for California water to be used for agricultural production when such production is likely to *result* in livestock feed crops -- *even when drought conditions in California are absent*.

Wasteful, Unreasonable Use: Groundwater Depletion

As we stated in previous comments to the SWRCB, we view the use of water to irrigate acreage that *results* in livestock feed crop production as wasteful and unreasonable due to its association with the depletion of scarce groundwater in the San Joaquin Valley (SJV). Again, it is likely that much of the water used to irrigate acreage that *resulted* in livestock feed crop production in 2014 came from local groundwater sources, as the San Joaquin Valley received little precipitation in 2014. Groundwater depletion in the Southern San Joaquin Valley was likely extensive in 2014, as the area received almost no surface water allocation from the Central Valley Project and the State Water Project in 2014. In addition, groundwater depletion was also likely significant in the central San Joaquin Valley, in part due to resale of CVP/SWP surface water quantities from senior water rights holders to junior water rights holders further south that had received minimal or no CVP/SWP surface water quantities in 2014. Acreage in these mid-SJV areas was then likely partially irrigated through utilization of increasingly overdrawn local groundwater sources. (For more on "groundwater substitution transfers" involving the SJRECWA, see *San Joaquin River Exchange Contractors Water Authority 25-Year Water Transfer Program Water Resources Analysis*, Prepared for San Joaquin River Exchange Contractors Water Authority, by Daniel B. Steiner, Consulting Engineer March 2012, page 10)

While groundwater depletion in Tulare County tends to get most of the public attention, serious groundwater depletion and accompanying land subsidence has also occurred in the central and northern parts of the San Joaquin Valley, well to the north of Tulare County. (See http://www.sacbee.com/news/local/article2594798.html, and http://www.modbee.com/news/business/agriculture/article3156994.html)

Conclusion

The use of pumped groundwater from already-depleted groundwater aquifers to irrigate acreage that *results* in livestock feed crop production is a wasteful, unreasonable use of water. A small fraction of that water could have been used to grow drought-tolerant beans that humans could have directly consumed. It was not. Water was, instead, wasted on irrigation of crops (especially alfalfa and irrigated pasture) that will be partially converted into significant amounts of methane and then emitted by livestock into the atmosphere. Such emissions will likely contribute to an increased frequency of extreme weather events that will impose significant adverse social and economic impacts on California, the U.S., and beyond.

Sincerely,

Mr. Ara Marderosian, Sequoia ForestKeeper®
P.O. Box 2134 Kernville, CA 93238
(760) 376-4434, (760) 382-1534, ara@sequoiaforestkeeper.org

Todd M. Shuman, Wasteful UnReasonable Use
Camarillo, CA, (805) 987-8203, (805) 236-1422 (cell), tshublu@yahoo.com

Jan Dietrick, MPH, Steering Committee, Ventura County Climate Hub, Ventura, CA
(805) 746-5365, jdietrick9@gmail.com

Mike Hudak, BA (Math), PhD (Advanced Technology/Computer Science) 38 Oliver Street
Binghamton, NY 13904 (607) 240-5225 mike.hudak@gmail.com http://mikehudak.com/

Submitted April 13, 2016

Appendix A

Notes for LFC categories by county are in column N of LFC SJV 2014 sprdsht.

LFC - Livestock Feed Crop
AWC - Applied Water Constants taken from 2010 DWR spreadsheet
TAF - Thousand Acre Feet
MAF - Million Acre Feet

2014	**Acres**	Alm Meats	Alm Hulls	Alm Shells	Alm AcresBrg	AWC	**Acre Feet**	**TAF**		LFCUnitValue	**Tonnage**
Kern LFC										in dollars $	
Alm Hull Shr	87,560	201000 T	329000 T	214000 T	199000	4.54	397522.4	397.52		170/ton	329000
Alfalfa, Hay	109,000					5.08	553720	553.72		247/ton	922000
Hay, Grain	9210					1.86	17130.6	17.13		212/ton	47800
Hay, Other	7400					2.87	21238	21.23		192/ton	25200
Pasture, Irr	7000					4.61	32270	32.27		140/acre	14000
Silage/Forage	85000					3.39	288150	288.15		49.8/ton	1632000
Misc	16700					2.87	47929	47.92		178.9/ton	64640
Subtotal	321,870						1357960	1357.94			3034640
Tulare LFC											
Alm Hull Shr	24453	48700 T	97500 T	n/a	46400	3.89	95122.17	95.12		152/ton	97500
Alfalfa, Hay	60000					5.13	307800	307.79		222/ton	612000
Alfalfa, Silage	0									64/ton	492000
Corn (Gr)	947					3.16	2992.52	2.99		276/ton	4920
Corn (Silage)	117000					3.16	369720	369.72		63.4/ton	2948000
Hay, Other	14400					2.81	40464	40.46		90/ton	39900
Pasture, Irr	93000					4.96	461280	461.28		193/acre	186000
Silage Sm Gr	75100					1.86	139686	139.68		51/ton	1232000
Sudan Grass	168					2.81	472.08	0.47		173/ton	675
Subtotal	385068						1417536.77	1417.51			5612995
Kings LFC											
Alm Hull Shr	11098	21558 T	43116 T	10779 T	19422	3.88	43060.24	43.06		150/ton	43116
Alfalfa, Hay	36597					4.95	181155.15	181.15		252/ton	298997
Alfalfa Silage	6432					4.95		31.83		55.3/ton	16916
Alf Silage All Yr	1927					4.95	9538.65	9.53		54.2/ton	68197
Alf Stubble	9149					4.95	45287.55	45.28		25/ton	9160
Corn Silage	51121					2.98	152340.58	152.34		65.2/ton	1309209
Oat Hay	1085					1.47	1594.95	1.59		188/ton	4058
Oat Silage	593					1.47	871.71	0.87		42.2/ton	8545
Sorghum Silage	13064					2.49	32529.36	32.52		49.4/ton	211637
Sudan Hay	274					2.49	682.26	0.68		162/ton	1474
Triticale Silage	3037					1.47	4464.39	4.46		49.5/ton	46861
Wheat Hay	549					1.47	807.03	0.79		216/ton	2212
Wheat Silage	44684					1.47	65685.48	65.68		51.3/ton	769905
Other	38391					2.49	95593.59	95.59		538.9/acre	76782
Subtotal	218001						633610.94	665.37			2867069
Fresno LFC											
Alm Hull Shr	89965	184000 T	326000 T	n/a	170711	3.52	316676.8	316.67		163/ton	326000
Alfalfa, Hay	52200					4.59	239598	239.59		238/ton	338000
Hay, Wheat	9190					1.26	11579.4	11.57		209/ton	37400
Hay, Other	10600					2.54	26924	26.92		169/ton	21300
Corn, Silage	28100					2.74	76994	76.99		62/ton	649000
Wheat, Silage	8960					1.26	11289.6	11.28		55/ton	163000
Other	33390					2.54	84810.6	84.81		527/acre	66780
Subtotal	232405						767872.4	767.83			1601480
Madera LFC											
Alm Hull Shr	55862	99640 T	195294 T	n/a	106000	3.34	186579.08	186.57		145/ton	195294
Alfalfa, Hay	16,000					4.32	69120	69.12		231/ton	108800
Alfalfa, Silage	0					0	0	0		70/ton	20287
Corn, Grain	600					2.55	1530	1.53		230/ton	4530
Corn, Silage	18,300					2.55	46665	46.66		59/ton	473238
Oat, Hay	800					1.03	824	0.8		185/ton	2824
Pasture, Irr	1,500					4.21	6315	6.31		150/acre	3000
Wheat, Silage	18,200					1.03	18746	18.74		38/ton	270452
Winter Forage	3,300					1.03	3399	3.39		48/ton	57618
Misc	2,300					2.52	5796	5.79		1559/acre	4600
Subtotal	116,862						338974.08	338.91			1140643
Kern LFC	321870						1357960	1357.96			3034640
Tulare LFC	385068						1417536.77	1417.53			5612995
Kings LFC	218001						665449.34	665.44			2867069
Fresno LFC	232405						767872.4	767.87			1601480
Madera LFC	116862						338974.08	338.97			1140643
Total KTKFM	**1274206**						**4547792.59**	**4547.77**			**14256827**
LFC - 5 Cty	**1,274,206 acres**							**4.54777MAF**			**14,256,827 tons of LFC**

2014	Acres	Alm Meats	Alm Hulls	Alm Shells	Alm AcresBrg	AWC	Acre Feet	TAF		LFCUnitValue	Tonnage	
Merced LFC										in dollars $		
Alm Hull Shr	55910	98598 T	205013 T	67939 T	101327	3.24	181148.4	181.15		151/ton	205013	
Alfalfa, Hay	84731					4.65	393999.2	393.99		251/ton	597195	
Alfalfa, Silage	0						0	0		65/ton	34740	
Hay, Grain	39220					0.97	38043.4	38.04		236/ton	123770	
Hay, Sudan	11478					2.58	29613.24	29.61		135/ton	45848	
Corn, Grain	14175					2.56	36288	36.29		300/ton	85047	
Corn, Silage	100394					2.56	257008.6	257.01		61/ton	2712645	
Silage, Other	85511					0.97	82945.67	82.95		43/ton	1319795	
Pasture, Irr	25030					4.57	114387.1	114.39		180/acre	50060	
Pasture, Stubble	0						0	0		12/ton	718	
Subtotal	416449						1133434	1133.43			5174831	
Mariposa LFC												
Pasture, Irr	500					3.72	1860	1.86		120/acre	1000	
Hay, misc	702					2.09	1467.18	1.47		611/acre	1404	
Subtotal	1202						3327.18	3.33			2404	
Stanislaus LFC												
Almond Hull Shr	82157	173000 T	346000 T	173000 T	164314	3.38	277690.7	277.69		150/ton	346000	
Alfalfa, Hay	29197					4.57	133430.3	133.43		264/ton	207000	
Hay, Oat	30011					0.93	27910.23	27.91		205/ton	132000	
Hay,Other	12406					2.5	31015	31.01		204/ton	52100	
Corn,Silage	90890					2.52	229042.8	229.04		64/ton	2487000	
Silage,Other	53390					2.5	133475	133.48		45/ton	985000	
Silage,Sudan	4625					2.5	11562.5	11.56		46/ton	58700	
Pasture, Irr	32500					4.52	146900	146.89		213/acre	65000	
Misc	2076					0.93	1930.68	1.93		978/acre	4152	
Subtotal	337252						992957.2	992.94			4336952	
Tuolumne LFC												
Pasture, Irr	1121					3.82	4282.22	4.28		130/acre	2242	
Hay	360					2.09	752.4	0.75		185/acre	936	
Subtotal	1481						5034.62	5.03			3178	
SanJoaquinLFC												
Almond Hull Shr	33814	68100 T	136000 T	34000 T	59200	3.49	118010.9	118.01		145/ton	136000	
Alfalfa, Hay	57700					5.28	304656	304.66		254/ton	421000	
Hay, Other	7700					3.26	25102	25.1		221/ton	28500	
Corn,Silage	50200					2.66	133532	133.53		49/ton	1367000	
Corn, Grain	53000					2.66	140980	140.98		200/ton	248000	
Pasture, Irr	14500					5.14	74530	74.53		165/acre	29000	
Silage,Other	112000					0.72	80640	80.64		41/ton	1537000	
Subtotal	328914						877450.9	877.45			3766500	
Calaveras LFC												
Pasture, Irr	2000					3.48	6960	6.96		130/acre	4000	
Grain-Hay	200					0.26	52	0.05		165/ton	600	
Subtotal	2200						7012	7.01			4600	
Merced LFC	416449						1133434	1133.43			5174831	
Mariposa LFC	1202						3327.18	3.33			2404	
Stanislaus LFC	337252						992957.2	992.94			4336952	
Tuolomne LFC	1481						5034.62	5.03			3178	
SanJoaquin LFC	328914						877450.9	877.45			3766500	
Calaveras LFC	2200						7012	7.01			4600	
Total MMSTSC	1087498						**3019215**	**3019.19**			**13288465**	
LFC - 6 Cty	**1,087,498 acres**							**3.01919 MAF**			**13,288,465**	**tons of LFC**
Approximately	**1.1 million acres**							**3 MAF**			**13.3 million**	**tons of LFC**

2014 SJV LFC	**LFCAcres**	**Acre Feet**	**TAF**	**Tonnage**
Kern LFC	321870	1357960	1357.96	3034640
Tulare LFC	385068	1417537	1417.53	5612995
Kings LFC	218001	665449.3	665.44	2867069
Fresno LFC	232405	767872.4	767.87	1601480
Madera LFC	116862	338974.1	338.97	1140643
Total KTKFM	**1274206**	**4547793**	**4547.77**	**14256827**
LFC - 5 Cty	**1,274,206 acres**		**4.54777MAF**	**14,256,827 tons of LFC**
Approximately	**1.275 million acres**		**4.55 MAF**	**14.25 million tons of LFC**

Merced LFC	416449	1133434	1133.43	5174831
Mariposa LFC	1202	3327.18	3.33	2404
Stanislaus LFC	337252	992957.2	992.94	4336952
Tuolomne LFC	1481	5034.62	5.03	3178
SanJoaquin LFC	328914	877450.9	877.45	3766500
Calaveras LFC	2200	7012	7.01	4600
Total MMSTSC	1087498	3019215	3019.19	13288465
LFC - 6 Cty	**1,087,498 acres**	**3.01919 MAF**		**13,288,465 tons of LFC**
Approximately	**1.1 million acres**		**3 MAF**	**13.3 million tons of LFC**

SJVCounties	**LFC Acres**	**Water Applied**	**LFC Tonnage**
LFC - KTKFM	1,274,206 acres	4.54777MAF	14,256,827 tons of LFC
LFC - MMSTSC	1,087,498 acres	3.01919MAF	13,288,465 tons of LFC
Total	**2,361,704 acres**	**7.56696MAF**	**27,545,292 tons of LFC**
Approximately	1.275 million acres	4.55 MAF	14.25 million tons of LFC
Approximately	1.1 million acres	3 MAF	13.3 million tons of LFC
ApproxTotal	**2.375 million acres**	**7.55 MAF**	**27.55 million tons of LFC**
RoughTotal	**2.4 million acres**	**7.5 MAF**	**28 million tons of LFC**

# of Milking Cows That *Could* Be Fed/Yr	**CO2e Emission-20yr**
(1.56239 million dairy cows)	32.22 billion lbs
(1.45627 million dairy cows)	30.03 billion lbs
(3.01866 million dairy cows)	**62.25 billion lbs**
3 million dairy cows	**62.25 billion lbs**
3 million dairy cows	**62 billion lbs**
	(7.39 coal plants)

See Supplementary Material, Note 6 for derivation documentation of theoretical emissions table above.

Actual livestock-related methane emissions, 2013: An approximate value for total livestock-related annual methane emissions in California is presented in the CA Air Resources Board Short-lived Climate Pollutants Reduction Strategy draft document (Sept 30, 2015), page 39. The CARB 2013 estimate for total annual methane emissions in CA was 118 MMTCO2e, of which 25 percent comes from dairy manure and 29 percent comes from dairy/livestock enteric, or 54 percent from livestock altogether -- 63.72 MMTCO2e. The methane GWP used by CARB to generate the overall CO2e number is 72, or the 20 year interval methane GWP from the 2007 IPCC AR4th. (See page 6 of CARB report.) x MMTCH4 * 72 = 63.72 MMTCO2e; x= 0.885 MMTCH4 produced by livestock (both enteric and manure) in 2013. (0.885 * 106)(2.20462 * 103 lbs./MT) = 1.9511* 109 lbs. of CH4 produced by livestock (via enteric emissions and anaerobic manure lagoons) in CA in 2013, or approximately 1.95 billion lbs. of CH4*. Using a methane GWP of 84 (IPCC AR5th, 2013 20 yr interval, without climate-carbon feedbacks incorporated) to convert pounds of emitted methane into pounds of emitted CO2e, we get: (1.9511 * 109)(8.4 * 101) = 16.39 * 1010, or 1.639 * 1011, or just under 164 billion lbs. of CO2e (20year interval). That amount is equivalent to annual CO2 emissions from just over 19 coal-fired electricity generation (CFEG) plants that will trap heat in the stratosphere for 20 years and then be almost completely sequestered by vegetation and soil in year 21. Using a methane GWP of 28 (2013 IPCC 100 year methane GWP, without climate-carbon feedbacks incorporated), all values are reduced by two-thirds, resulting in 54.576 billion pounds of CO2e emissions. That amount is equivalent to annual CO2 emissions from just over 6 coal-fired electricity generation (CFEG) plants that will trap heat in the atmosphere for 100 years and then be almost completely sequestered by vegetation and soil in year 101.* [Error note: 29 percent should be 30 percent, 54 percent should be 55 percent, 0.885 should be 0.9014, so the 1.9511 value would be slightly higher.]

* The 1.9511 estimated value is for all livestock and is 2.1 percent higher (or 40 million lbs. higher) than the cumulative number for cattle alone. The cumulative cattle number is 1.911, or 1.911 billion lbs. of CH4 released. Using the 20 year GWP, the CO2e for this value is associated with 19.1 coal-fired electricity generation (CFEG) plants. Using the 100 year GWP, the CO2e for this value is associated with 6.36 CFEG plants. See summary below for adjusted values.

lbs.				
9.14E+08	Manure	Cattle	Derived from GHG Emission Inventory Summary [2000 - 2013] in lbs of CH4, using the CARB Inventory Query Tool	
9.97E+08	Enteric	Cattle	9-Mar-16	
1.91E+09	Total	Cattle	Unit abbreviations: MMT = million metric tons (tonnes); MMTCO2e = million metric tons (tonnes) of Carbon Dioxide Equivalents	
lbs.	MMT	lbs./Tonne	Million	lbs.
9.14E+08	0.414803	2204.6	1000000	9.14E+08
9.97E+08	0.452022	2204.6	1000000	9.97E+08
1.91E+09				1.91E+09

Supplementary Material

[1] The horizontally-displayed almond-related information (meats, hulls, shells, in tons) in Sheet1 and Sheet2 have been included to disclose how the LFC Almond Hull Share acreage estimate was derived. This methodology was presented in the June 19 and July 6 SWRCB comments in Appendix B. If hulls constituted 50ish percent (plus or minus) of total almond commodity mass sold at the county level, 50ish percent (plus or minus) of the total listed county almond-bearing acreage value was input into the county LFC Almond Hull Share acreage spreadsheet cell. That value was then multiplied by the almond AWC in order to yield a value for estimated total applied water that resulted in almond hull production. Water is applied to almond orchards with the intention of producing almond meats for sale. Almond growers make nearly all of their money by selling the almond meats, not by selling almond hulls or almond shells. However, that applied water results in three commodities that are sold each year. Roughly half of the cumulative mass of all those almond-related commodities that get sold and which result from that application of water are almond hulls, a crop almost exclusively sold to the dairy and livestock industries as a nutritional feed input. In short, half of the water applied to almond orchards results in a livestock feed crop commodity mass that is ultimately sold to dairies and fed to dairy cows. In addition, almond shells are often/usually sold to the dairy industry as a primary component for dairy cow bedding. (Excluded, for analytic purposes, is the amount of water per year that the almond tree needs to remain a functional tree, independent of its function in producing almond meats, almond hulls and almond shells.)

[2] LFC Unit values (in dollars) are included simply to provide perspective in relation to the value of different types of LFC. Almond hulls fetch a substantial price per ton relative to silage. It is, of course, marginal in comparison to almond meats. But compared to every other LFC category, it is significant – it is typically in the middle of the pack – 60 percent of the alfalfa hay/ton value but usually 4X as valuable as the silage/ton value.

[3] This EPA website below documents that a 2010 coal-burning power plant produced, on average, CO2 emissions of approximately 8.4 billion [8.3965 billion] pounds of CO2 (equivalent to 3,808,651 metric tons of CO2).

http://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references

Coal-fired power plant emissions for one year:

In 2010, a total of 454 power plants used coal to generate at least 95% of their electricity (EPA 2014). These plants emitted 1,729,127,770.8 metric tons of CO2 in 2010. Carbon dioxide emissions per power plant were calculated by dividing the total emissions from power plants whose primary source of fuel was coal by the number of power plants. Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

1,729,127,770.8 metric tons of CO2 × 1/454 power plants = 3,808,651 metric tons CO2/power plant
[3,808,651*2,204.62 = 8.396626 billion lbs CO2/power plant/yr]

EPA (2014). eGRID 2010 data. U.S. Environmental Protection Agency, Washington, DC.

[4]

United States Department of Agriculture, National Agricultural Statistics Service, Pacific Region Livestock Review
Released: February 26, 2016 VOL. 04 NO. 1

Cattle Inventory by Class - California: January 1, 2015
(1000 head)

Cattle and calves 5,100
All cows 2,370
    Beef cows 590
    Milk cows 1,780
Heifers 500 pounds and over 1,040
    Beef cow replacement 130
    Milk cow replacement 770
    Other 140
Steers 500 pounds and over 550
Bulls 500 pounds and over 70
Calves under 500 pounds...........................1,070

http://www.nass.usda.gov/Statistics_by_State/California/Publications/Livestock/201601lvsrv.pdf

Information compiled by the California Beef Council and included in a California Foundation for Agriculture in the Classroom (CFAITC) publication: “There are approximately 583,000 beef cows on about 11,000 ranches in California. In addition, there are 1.81 million dairy cows, which also play an important role in the state’s beef industry.” (Yr 2014). California Beef Council 4640 Northgate Boulevard, Suite 115, Sacramento, CA 95834

California Agricultural Statistics 2013 Crop Year			
USDA National Agricultural Statistics Service			
PACIFIC REGIONAL FIELD OFFICE, CALIFORNIA			
www.nass.usda.gov/ca April 2015			
California Livestock Cash Income, 2012-2013 **			
Source of Income	2012 ($1,000)	2013 ($1,000)	Percent Change
Cattle and calves	3,188,125	3,048,390	-4
Hogs and Pigs	39,001	40,361	3
Dairy products/Milk	6,899,743	7,617,641	10
Poultry and eggs	1,474,002	1,633,959	11
Miscellaneous livestock	496,538	437,267	-12
Total	12,097,409	12,777,618	6
** 2012 & 2013 sheep & lambs included in Miscellaneous Livestock			

[5] For lactating dairy cow annual methane output, we use the 109 KG/yr value (239.8 lbs/yr) from K. A. Johnson and D. E. Johnson, “Methane Emissions from Cattle,” Journal of Animal Science 73(8) (1995): 2483–92.

[6] What follows is the estimated amount of CO2 equivalents (at the 20 year interval) that would likely result from lactating dairy cows eating 14.256827 million tons of irrigated livestock feed crop produced in 2014 in Kern, Tulare, Kings, Fresno, and Madera counties. That amount could feed over 1.56 million milking cows (1.562392 million dairy cows) for a year (50 lbs. of forage/cow/day X 365 days/yr = 18,250 lbs., or 9.125 tons/cow/yr). That number of milking cows would produce and release annual atmospheric methane emissions equivalent to 32.222 billion pounds of CO2 equivalents that trap heat for 20 years. (Lactating cows produce 239.8 lbs. of CH4/yr. Multiply by 86 and you get 20622.8 lbs./yr of CO2 equivalents (20 year interval) released per milking cow. Multiply 20622.8 lbs. of CO2e/yr/cow by 1.562392 million cows, and you get approximately 32.22 billion lbs. of CO2e (20 yr interval) released into the atmosphere by those 1.562392 million milking cows. In short, just over 14 million tons of livestock feed crops can supply feed for just over 1.5 million milking cows for a year, over which time that number of milking cows would likely emit an amount of methane that is equivalent to just over 32 billion lbs. of CO2 that traps heat in the upper atmosphere for 20 years. 32 billion lbs. of heat-trapping CO2 is just under the amount of CO2 that is emitted by four yr2010 coal-fired electricity generation (CFEG) plants (33.6 billion lbs.)

What follows is the estimated amount of CO2 equivalents (at the 20 year interval) that would likely result from lactating dairy cows eating 13.288465 million tons of irrigated livestock feed crop produced in 2014 in Merced, Mariposa, Stanislaus, Tuolumne, San Joaquin, and Calaveras counties. That amount could feed over 1.456 million milking cows (1.45627 million dairy cows) for a year (50 lbs. of forage/cow/day X 365 days/yr = 18,250 lbs., or 9.125 tons/cow/yr). That number of milking cows would produce and release annual atmospheric methane emissions equivalent to 30.0312 billion pounds of CO_2 equivalents that trap heat for 20 years. (Lactating cows produce 239.8 lbs. of CH_4/yr. Multiply by 86 and you get 20622.8 lbs./yr of CO_2 equivalents (20 year interval) released per milking cow. Multiply 20622.8 lbs. of CO_2e/yr/cow by 1,456,270 million cows, and you get approximately 30 billion lbs. of CO_2e (20 yr interval) released into the atmosphere by those 1.45627 million milking cows. In short, just over 13 million tons of livestock feed crops can supply feed for 1.45627 million milking cows for a year, over which time that number of milking cows would likely emit an amount of methane that is equivalent to just over 30 billion lbs. of CO_2 that traps heat in the upper atmosphere for 20 years. 30 billion lbs. of heat-trapping CO_2 is just under the amount of CO_2 that is emitted by four yr2010 coal-fired electricity generation (CFEG) plants (33.6 billion lbs.).

Source for estimate of 50 lbs./day as amount of feed consumed by a dairy cow each day: http://www.ansc.purdue.edu/faen/dairy%20facts.html

[7] SLV Agricultural LFC data sources

2014 Kern County Agricultural Crop Report, August 18, 2015
2014 Tulare County Annual Crop and Livestock Report, August 2015
2014 Annual Agricultural Crop Report for the County of Kings, June 16, 2015
2014 Fresno County Agricultural Crop and Livestock Report, August, 2015
2014 Madera County Agricultural Crop and Livestock Report, August, 2015

2014 Merced County Report on Agriculture, 2015
2014 Mariposa County Agricultural Crop and Livestock Report, 2015
2014 Stanislaus County Agricultural Crop Report, 2015
2014 Tuolumne County Crop and Livestock Report, 2015
2014 San Joaquin County Agricultural Report, 2015
2014 Calaveras County Crop Report, 2015