Real Time (RT) Snow Water Equivalent (SWE) Simulation
April 14, 2014
Sierra Nevada Mountains, California

Abstract

On April 14th, percent of average SWE values for this date have decreased to 10% for the Northern watersheds, 26% for the Central, and 18% for the Southern watersheds (see map at right). 82 snow sensors in the Sierra network were recording snow out of a total of 99 sensors. The locations of sensors that aren't recording snow (shown in yellow in Figure 3, left map) are lower elevation and a few that are offline in other strategic locations.

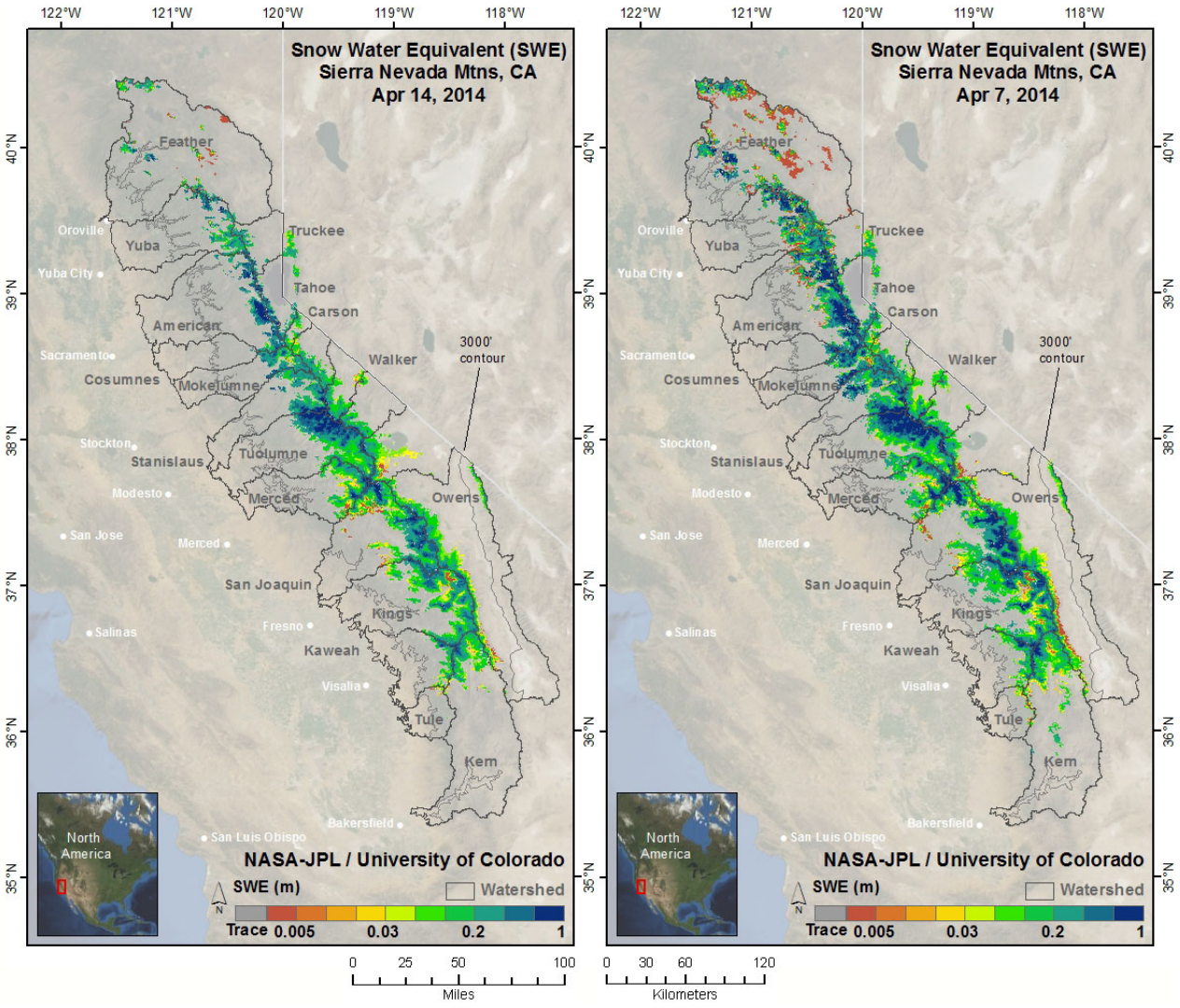

Figure 1. RT simulated SWE amounts for Apr 14, 2014 are shown on the left and for Apr 7, 2014 are shown on the right. SWE depths have decreased at all elevations and snow extent has decreased since the last report.

Introduction

We have developed a real-time SWE estimation scheme based on historical SWE reconstructions between 2000-2012, a real time MODIS/MODSCAG image (Painter et al, 2009), and daily in situ SWE measurements for the Sierra Nevada in California (Molotch, 2009; Molotch and Margulies, 2008; Molotch and Bales, 2006; Molotch and Bales, 2005, Molotch, et. al., 2004 and Guan). Real-time SWE will be released on a weekly basis during the maximum snow accumulation/ablation period.

Discussion

The most recent cloud-free MODIS/MODSCAG image available is for April 14, 2014. The percent of average values regional map (shown at the beginning of the report) was derived from the data shown in table 1. Figure 1 shows SWE amounts for April 14, 2014 and for Apr 7, 2014. On April 14, 2014, snow depths have decreased from the last report, 88 snow sensors in the Sierra network were operational and 82 were recording snow out of a total of 99 sensors. For comparison in 2012, a very dry year, 76 were operational and 75 recorded snow out of 99 total on April 14th, and in 2009, a normal year, 81 were operational and 78 recorded snow out of 99 total on April 14th. Note the locations of sensors that aren't recording snow (shown in yellow in Figure 3, left map) are lower elevation sensors and a few that are offline in other strategic locations, so calculations from sensors alone do not accurately calculate SWE for each watershed. Figure 2 shows the percent of average SWE for April 14, 2014 for the snow-covered area on left and on the right is the mean percent of average for April 14, 2014 shown by watershed for all model pixels above 3000' (shown as gray elevation contour line on left map). Note that watershed averages are much lower than those calculated using snow sensors alone. Snow sensors produce a point value whereas the spatial SWE allows for areal calculations. Every square foot above 3000' in the watershed can be used to calculate the mean, therefore the mean value will be different than those calculated by snow sensor point data. Figure 3 shows the 13 year modeled average SWE for April 14th on the left with snow sensors shown in yellow that recorded no snow and in red for sensors that recorded snow on April 14, 2014; and a banded elevation map on the right. Table 1 shows mean SWE and mean % of average SWE for 4/14/2014, mean SWE for 4/7/2014, change in SWE between 4/7/2014 and 4/14/2014 for each watershed, summarized for each watershed above 3000'. Table 2 shows mean SWE and mean % of Average SWE for 4/14/2014, mean SWE for 4/7/2014, change in SWE between 4/7/2014 and 4/14/2014, and area in square miles for each elevation band inside each watershed, summarized for each watershed above 3000'.

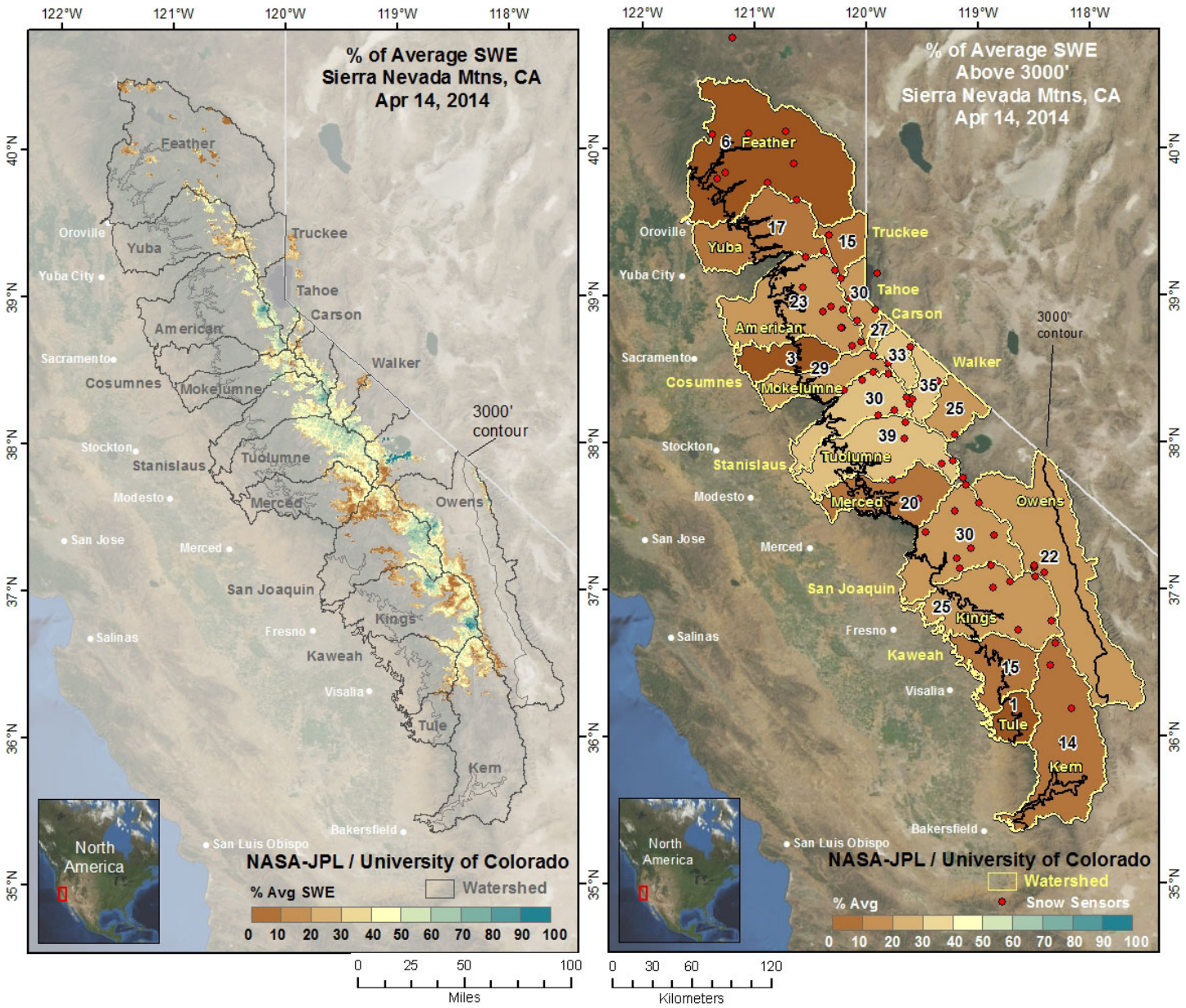

Figure 2. Percent of average RT simulated SWE for April 14, 2014 for the entire Sierra (on left) and by watershed (on right). Watershed percentages are calculated for all model pixels above 3000' (shown as gray line on left map). SWE snow sensors that had snow on April 14, 2014 have been added to the map on the right.

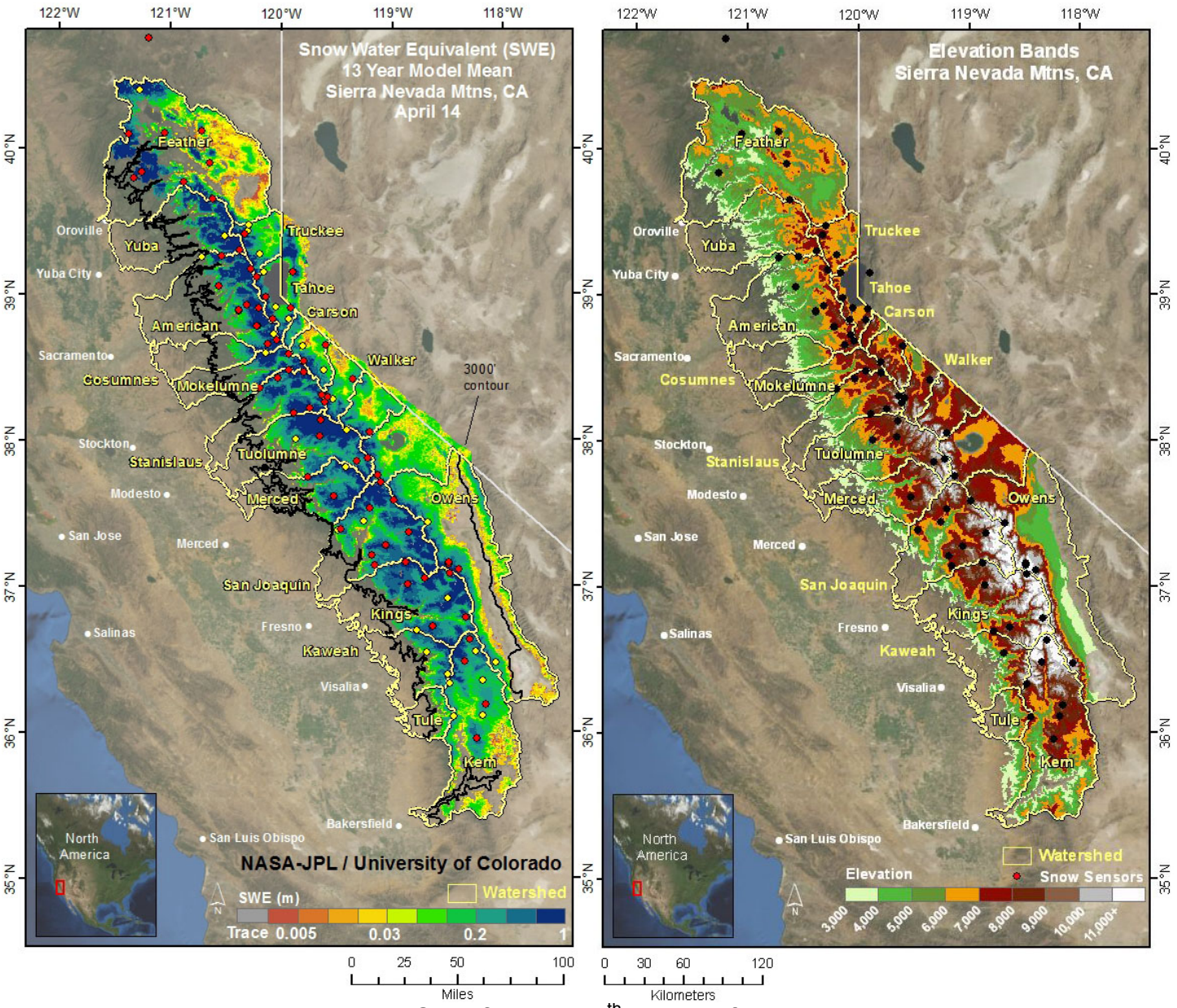

Figure 3. 13 year modeled average SWE for April 14th on the left with snow sensors shown in yellow that recorded no snow (see discussion above for an explanation) and in red for sensors that recorded snow on April 14, 2014; and a banded elevation map on the right.

Methods

Results for the date of April 14, 2014 are based on April 14, 2014 real-time data from 99 in situ SWE measurements distributed across the Sierra Nevada, one Moderate Resolution Imaging Spectroradiometer (MODIS)/Terra Snow cover daily cloud-free image which has been processed using the MODSCAG fractional snow cover program (Painter, et. al. 2009, snow.jpl.nasa.gov), a normalized reconstructed spatial SWE image for March 1, 2009, and an anomaly map based on 13 years of modeled SWE (2000-2012). Relative to snow stations and the NWS SNODAS product, the spatial reconstructed SWE product correlates strongly with full natural flow, especially late in the snowmelt season (Guan, et. al. 2013).

Table 1. All calculations are for elevations above 3000'. Shown are mean SWE and mean % of Average SWE for 4/14/2014, mean SWE for 4/7/2014, and change in SWE between 4/7/2014 and 4/14/2014 for each watershed.

Watershed	4/14/14 % Avg to Date	4/14/14 SWE (in)	4/7/14 SWE (in)	4/7 thru 4/14 Change in SWE (in)
AMERICAN	23.37	2.62	5.43	-2.81
FEATHER	6.02	0.61	1.83	-1.22
KAWEAH	14.97	1.11	1.86	-0.76
KERN	13.88	1.03	1.70	-0.67
KINGS	24.68	3.97	5.55	-1.58
TAHOE	29.52	6.72	11.28	-4.56
MERCED	19.94	2.42	3.61	-1.19
OWENS	22.42	1.27	1.68	-0.41
SAN JOAQUIN	29.55	5.18	6.82	-1.64
STANISLAUS	30.49	4.49	7.08	-2.59
TRUCKEE	14.65	2.25	4.18	-1.92
TUOLUMNE	39.44	6.09	8.04	-1.95
YUBA	17.34	1.96	4.10	-2.14
COSUMNES	2.84	0.08	0.84	-0.77
MOKELUMNE	28.53	3.04	5.40	-2.36
TULE	1.49	0.06	0.20	-0.13
WEST WALKER RIVER	35.44	4.22	5.06	-0.83
EAST WALKER RIVER	24.85	2.50	3.39	-0.89
WEST FORK CARSON RIVER	26.94	4.34	6.54	-2.20
EAST FORK CARSON RIVER	32.70	3.94	5.18	-1.24

Table 2. Mean SWE and mean % of Average SWE for 4/14/2014, mean SWE for 4/7/2014, change in SWE between 4/7/2014 and 4/14/2014, and area in square miles for each elevation band inside each watershed.

Watershed	Elevation	4/14/14 % Avg to Date	4/14/14 SWE (in)	4/7/14 SWE (in)	4/7 thru 4/14 Change SWE (in)	Area Sq Mi
AMERICAN	3000-4000'	0.00	0.00	0.00	0.00	191.9
	4000-5000'	0.00	0.00	0.08	-0.08	249.3
	5000-6000'	0.31	0.04	1.86	-1.82	294.8
	6000-7000'	9.67	2.58	12.73	-10.15	296.4
	7000-8000'	39.11	14.96	24.65	-9.69	175.7
	8000-9000'	53.71	23.47	30.10	-6.63	74.2
	9000-10,000'	59.40	30.84	38.62	-7.78	8.9
COSUMNES	3000-4000'	0.00	0.00	0.00	0.00	77.8
	4000-5000'	0.00	0.00	0.00	0.00	84.7
	5000-6000'	0.00	0.00	0.68	-0.68	63.6
	6000-7000'	2.04	0.41	11.92	-11.51	28.1
	7000-8000'	13.29	4.54	21.01	-16.47	8.6
E CARSON	5000-6000'	0.00	0.00	0.00	0.00	32.7
	6000-7000'	3.62	0.15	0.33	-0.18	77.7
	7000-8000'	16.80	1.81	3.01	-1.20	102.6
	8000-9000'	37.53	7.12	9.33	-2.21	96.5
	9000-10,000'	49.71	11.29	13.58	-2.29	29.7
	10,000-11,000'	55.25	12.42	13.98	-1.56	13.5
	> 11,000'	65.14	22.43	26.40	-3.97	0.3
E WALKER	6000-7000'	0.00	0.00	0.00	0.00	73.6
	7000-8000'	2.82	0.15	0.29	-0.14	157.4
	8000-9000'	9.44	0.91	1.49	-0.57	154.9
	9000-10,000'	32.38	5.64	7.69	-2.05	63.1
	10,000-11,000'	48.26	12.98	16.63	-3.64	48.8
	> 11,000'	50.10	14.80	19.05	-4.25	7.8
FEATHER	3000-4000'	0.00	0.00	0.00	0.00	286.2
	4000-5000'	0.12	0.01	0.09	-0.08	735.8
	5000-6000'	1.46	0.15	1.51	-1.36	1305.1
	6000-7000'	10.48	1.67	4.25	-2.58	871.3
	7000-8000'	16.21	4.08	7.13	-3.05	124.6
	8000-9000'	18.34	5.79	8.75	-2.97	5.2
KAWEAH	3000-4000'	0.00	0.00	0.00	0.00	74.4
	4000-5000'	0.00	0.00	0.00	0.00	64.8
	5000-6000'	0.00	0.00	0.00	0.00	60.9
	6000-7000'	0.51	0.05	0.28	-0.23	63.1
	7000-8000'	2.57	0.40	2.29	-1.88	63.5
	8000-9000'	12.02	2.44	6.37	-3.93	56.3
	9000-10,000'	21.81	5.00	8.15	-3.15	38.8
	10,000-11,000'	37.98	13.61	18.37	-4.75	36.6
	> 11,000'	44.88	18.19	24.03	-5.83	8.9
KERN	3000-4000'	0.00	0.00	0.00	0.00	175.2
	4000-5000'	0.00	0.00	0.00	0.00	221.9
	5000-6000'	0.00	0.00	0.00	0.00	273.6
	6000-7000'	0.00	0.00	0.04	-0.04	391.9
	7000-8000'	0.29	0.02	0.25	-0.22	334.9
	8000-9000'	0.49	0.05	0.96	-0.91	308.7
	9000-10,000'	4.00	0.51	2.15	-1.64	166.3
	10,000-11,000'	26.35	4.85	7.45	-2.60	149.7
	> 11,000'	40.87	11.03	14.68	-3.65	142.5

KINGS	3000-4000'	0.00	0.00	0.00	0.00	83.1
	4000-5000'	0.00	0.00	0.01	-0.01	92.8
	5000-6000'	0.25	0.02	0.08	-0.06	95.0
	6000-7000'	0.37	0.05	0.38	-0.33	136.0
	7000-8000'	1.29	0.26	2.50	-2.25	170.0
	8000-9000'	7.14	1.55	5.00	-3.45	209.9
	9000-10,000'	20.01	4.56	7.11	-2.55	187.6
	10,000-11,000'	41.35	11.79	13.90	-2.11	221.4
	> 11,000'	49.82	17.03	20.93	-3.90	199.5
MERCED	3000-4000'	0.00	0.00	0.00	0.00	138.3
	4000-5000'	0.71	0.03	0.01	0.02	88.7
	5000-6000'	0.32	0.02	0.03	0.00	72.9
	6000-7000'	0.61	0.09	1.24	-1.15	78.3
	7000-8000'	5.67	1.22	4.13	-2.91	132.8
	8000-9000'	19.30	4.59	6.62	-2.03	124.1
	9000-10,000'	32.22	8.96	11.59	-2.63	76.2
	10,000-11,000'	42.46	17.37	22.69	-5.32	50.6
	> 11,000'	47.47	26.16	34.10	-7.94	13.5
MOKELUMNE	3000-4000'	0.00	0.00	0.00	0.00	83.3
	4000-5000'	0.00	0.00	0.06	-0.06	87.2
	5000-6000'	0.45	0.05	1.73	-1.68	84.0
	6000-7000'	8.14	1.67	12.29	-10.62	72.7
	7000-8000'	34.91	11.32	18.39	-7.07	85.9
	8000-9000'	45.41	14.76	18.83	-4.07	81.2
	9000-10,000'	50.38	18.79	23.94	-5.15	7.8
	10,000-11,000'	53.58	24.20	30.59	-6.39	0.1
OWENS	3000-4000'	0.00	0.00	0.00	0.00	184.1
	4000-5000'	0.00	0.00	0.00	0.00	428.5
	5000-6000'	0.43	0.00	0.00	0.00	254.6
	6000-7000'	0.80	0.03	0.03	-0.01	255.2
	7000-8000'	1.55	0.09	0.19	-0.10	302.6
	8000-9000'	9.44	1.10	1.40	-0.30	165.3
	9000-10,000'	18.44	2.61	3.34	-0.72	112.4
	10,000-11,000'	31.04	5.61	7.54	-1.93	188.0
	> 11,000'	45.94	12.17	15.92	-3.75	167.2
SAN JOAQUIN	3000-4000'	0.00	0.00	0.00	0.00	76.2
	4000-5000'	0.00	0.00	0.00	0.00	93.8
	5000-6000'	1.00	0.05	0.02	0.04	130.9
	6000-7000'	1.39	0.16	0.21	-0.06	183.9
	7000-8000'	5.56	1.00	1.50	-0.50	214.5
	8000-9000'	16.17	3.94	6.14	-2.21	194.1
	9000-10,000'	28.23	7.95	11.08	-3.13	173.8
	10,000-11,000'	45.96	16.47	20.87	-4.40	188.0
	> 11,000'	55.33	22.00	27.82	-5.82	146.3
STANISLAUS	3000-4000'	0.00	0.00	0.00	0.00	61.6
	4000-5000'	0.00	0.00	0.00	0.00	100.0
	5000-6000'	0.00	0.00	0.33	-0.33	105.7
	6000-7000'	2.43	0.48	8.28	-7.80	142.3
	7000-8000'	28.82	7.79	13.48	-5.69	145.4
	8000-9000'	45.62	14.56	17.33	-2.78	121.9
	9000-10,000'	53.61	20.14	23.60	-3.47	47.1
	10,000-11,000'	61.49	28.03	33.00	-4.97	18.0
	> 11,000'	66.19	23.62	26.55	-2.93	0.7

TAHOE	6000-7000'	6.65	0.86	2.89	-2.03	103.2
	7000-8000'	30.39	8.54	14.84	-6.30	74.7
	8000-9000'	41.74	13.46	20.10	-6.63	51.3
	9000-10,000'	47.94	14.79	20.55	-5.76	12.1
	10,000-11,000'	43.69	12.11	16.20	-4.09	0.9
TRUCKEE	5000-6000'	0.00	0.00	0.00	0.00	51.2
	6000-7000'	4.91	0.56	1.66	-1.10	254.6
	7000-8000'	21.89	5.90	10.35	-4.45	111.9
	8000-9000'	31.91	12.15	16.01	-3.85	14.1
TULE	3000-4000'	0.00	0.00	0.00	0.00	34.9
	4000-5000'	0.00	0.00	0.00	0.00	48.0
	5000-6000'	0.00	0.00	0.00	0.00	51.8
	6000-7000'	0.60	0.04	0.13	-0.08	45.2
	7000-8000'	1.36	0.17	0.99	-0.82	27.0
	8000-9000'	3.37	0.51	1.79	-1.28	15.7
	9000-10,000'	11.17	1.95	3.65	-1.70	5.8
TUOLUMNE	3000-4000'	0.00	0.00	0.00	0.00	122.4
	4000-5000'	0.77	0.02	0.02	0.00	149.9
	5000-6000'	1.90	0.13	0.25	-0.12	172.8
	6000-7000'	2.87	0.45	3.71	-3.26	149.0
	7000-8000'	25.68	6.71	11.73	-5.03	151.1
	8000-9000'	46.84	14.86	18.05	-3.19	170.9
	9000-10,000'	54.57	19.87	23.89	-4.01	152.7
	10,000-11,000'	55.59	21.80	26.73	-4.93	116.7
	> 11,000'	51.64	20.62	25.42	-4.80	28.8
W CARSON	4000-5000'	0.00	0.00	0.00	0.00	1.6
	5000-6000'	0.00	0.00	0.00	0.00	16.8
	6000-7000'	1.32	0.14	1.12	-0.98	8.3
	7000-8000'	17.31	2.84	5.35	-2.51	35.6
	8000-9000'	32.46	6.93	9.88	-2.95	32.7
	9000-10,000'	42.33	10.88	14.11	-3.23	9.5
	10,000-11,000'	45.99	14.52	19.45	-4.94	2.3
W WALKER	5000-6000'	0.00	0.00	0.00	0.00	46.8
	6000-7000'	0.00	0.00	0.01	-0.01	60.0
	7000-8000'	2.73	0.16	0.29	-0.13	91.4
	8000-9000'	23.71	2.69	3.11	-0.42	93.8
	9000-10,000'	44.45	10.59	12.63	-2.04	73.3
	10,000-11,000'	50.78	15.73	18.80	-3.07	42.4
	> 11,000'	40.62	9.84	14.09	-4.25	2.6
YUBA	3000-4000'	0.00	0.00	0.00	0.00	168.8
	4000-5000'	0.20	0.01	0.06	-0.05	202.8
	5000-6000'	1.68	0.26	3.90	-3.65	188.0
	6000-7000'	18.21	5.83	13.54	-7.71	238.7
	7000-8000'	29.50	11.66	17.44	-5.78	123.0
	8000-9000'	35.93	16.53	21.24	-4.72	6.3

Location of Reports and Excel Format Tables
ftp://snowserver.colorado.edu/pub/fromLeanne/forCADWR/Near_Real_Time_Reports/

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