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On behalf of South Delta Water Agency, Central Delta Water Agency, Lafayette Ranch, Heritage Lands, Mark Bachetti Farms and Rudy Mussi Investments L.P.

[ADDITIONAL PARTIES AND COUSNEL LISTED ON FOLLOWING PAGE]

STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

Hearing in the Matter of California Department of Water Resources and United States Department of the Interior, Bureau of Reclamation Request for a Change in Point of Diversion for California Water Fix

SUR REBUTTAL TESTIMONY OF MICHELLE LEINFELDER-MILES

Sur Joint Rebuttal: Protestants South Delta Water Agency, Central Delta Water Agency, Lafayette Ranch, Heritage Lands, Mark Bachetti Farms And Rudy Mussi Investments L.P. and Local Agencies of the North Delta, Delta Watershed Landowner Coalition, Bogle Vineyards, Diablo Vineyards, Stillwater Orchards and Islands, Inc.

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I, Michelle Leinfelder-Miles, do hereby declare:

I. INTRODUCTION

I am the Delta Crops Resource Management Advisor with the University of California Cooperative Extension, based in San Joaquin County. I have five years of experience working in this capacity and a total of fourteen years of research experience in agricultural cropping systems, including work in grains and forages, vegetable crops, and tree and vine fruit crops. I received my B.S. in Crop Science and Management from UC Davis (2001), my M.S. in Horticulture from Cornell University (2005), and my Ph.D. in Horticulture from Cornell University (2010). As the Delta Crops Resource Management Advisor, I conduct an applied science, multidisciplinary research and outreach program on agricultural production and resource stewardship. My research projects center on row crops and the management of water and soil resources in those agricultural systems. I conduct research projects in cooperation with Delta growers, on their farms, in order to gain an understanding of how scientific principles apply in the field. To expand our understanding of science in the field and accomplish the goal of extending new knowledge requires mutual respect and trust between cooperating growers and the farm advisor. A description of my research projects is included in my statement of qualifications (II-12). My outreach program is directed toward agricultural producers, allied industry representatives, and natural resource managers. I conduct instructional meetings and demonstration field meetings where I communicate research results from my own program and those of my UC colleagues to the agricultural community. These are the major roles of a UC Cooperative Extension farm advisor—to conduct applied research and to extend the findings of research to the local community.

This sur rebuttal testimony has been developed in response to the rebuttal testimony of Dr. Joel Kimmelshue (DWR-85), and specifically addresses his opinions on the following:

- Peer review;
- Experimental methodology, including site locations, repeatability, and one-time versus multi-year sampling;
- Sources of salinity in agricultural systems;

- Precipitation and leaching;
- Other arguments.

Below I describe the relevance of each of these arguments.

II. Peer review

Dr. Kimmelshue is critical of my testimony (II-13, II-14) because it "draw[s] conclusions from research that has not been independently peer reviewed" (DWR 85, page 5, line 20). In the future, I intend to publish my study "Leaching Fractions Achieved in South Delta Soils under Alfalfa Culture" in a refereed journal. The manuscript is still under development, as evidenced by the updated versions entered as exhibits in this hearing (SDWA-139, SDWA-140, LAND-79). The data in these versions have not changed, and these data are informative since the Petitioners have failed to present any soil salinity data. It is not typical for a scientist to release drafts of a manuscript, but I have done so for this hearing because the data are relevant to this discussion. Updated versions of my report include additional references to scientific literature, which Dr. Kimmelshue acknowledged is important for scientific manuscripts (Transcript 5/10/2017, page 89, lines 19-20 and page 100, line 12).

Given my recent projects evaluating salinity in the Delta, I believe I have the experiences and qualifications to provide expert opinion on how changes in water quality may impact soil salinity in Delta agricultural systems, regardless of whether my studies have been formally peer reviewed. Of note, Dr. Kimmelshue had no knowledge of the Department of Water Resources doing any sampling (Transcript 5/10/2017, page 29, lines 16-17), was not aware of any study that would meet the specifications he provided in testimony (Transcript 5/10/2017, page 33, lines 2-5), and was not asked to do any field studies himself by the Petitioners (Transcript 5/10/2017, page 27, lines 18-20), so the criticism of my work not yet being peer reviewed obscures the fact that the Petitioners have failed to provide data contrary to what I have presented.

In cross examination, when Dr. Kimmelshue was asked of his understanding of the peer review performed on the Hoffman (2010) report (DWR-580) – a report upon which he heavily relies for his opinions – twice he stated that having colleagues read a document is a form of peer review (Transcript 5/10/2017, page 51, lines 6-7 and page 56, lines 14-16). It was not elucidated in rebuttal testimony whether the Hoffman report was peer reviewed in ways that are typical for refereed journals, namely, a single- or double-blind review, typically by two or more reviewers (LAND-96 and LAND-105). While the reports that I have written have not yet been published in a refereed journal, they have been read by academic colleagues. So, if the Petitioners wish to rely on Hoffman and accept their witness's definition of peer review as being 'read by one's peers', then this argument against my work is null.

In cross examination, Dr. Kimmelshue testified that he relied on the Hoffman (2010) report to provide his opinions at the hearing (Transcript 5/10/2017, page 61, lines 21-22). I, too, have referenced the Hoffman (2010) report in my work (DWR-580). The report contains a comprehensive literature review and contextualizes the literature for south Delta conditions. I, however, disagree with Hoffman's assumptions on water quality and leaching fractions, and I discuss this further in Section V.

Finally, in cross examination, Dr. Kimmelshue was presented with peer review policies for California Agriculture (LAND-96) and guidelines for Agronomy Journal editors and reviewers (LAND-105). Dr. Kimmelshue stated that he had submitted a manuscript to California Agriculture (Transcript 5/10/2017, page 49, lines 4-18); however, his statement of qualifications lists the manuscript as "to be submitted." It cannot both be true that the manuscript was submitted and that it is "to be submitted." Furthermore, it is uncharacteristic to list manuscripts in a bibliography that one plans to submit. Follow up communication between myself and the Managing Editor of California Agriculture (attached herewith as Exhibit "A") states that the manuscript has not yet been submitted. Dr. Kimmelshue relies heavily on a lack of peer review to attempt to discredit my study as submitted for this hearing; however upon further investigation, Dr. Kimmelshue's statement of qualifications and testimony regarding his own history in producing peer reviewed manuscripts is misleading at best. Thus, in my opinion, this diminishes Dr. Kimmelshue's credibility and expertise on the matter of peer review.

III. Experimental methodology: site locations, repeatability, and one-time versus multi-year sampling

Dr. Kimmelshue is critical of my testimony and studies for lack of specific site identification (DWR-85, page 6, line 1). In oral testimony, he expressed that it would be “helpful” to have sampling locations identified on a map (Transcript 5/10/17, page 6, line 25 through page 7, line 8), and he expressed concern “that the validation of results need to be verified against location.” (Transcript 5/10/17, page 7, lines 18-19.) While having sampling locations identified on a map might be interesting to the Petitioners, not specifically identifying the locations does not invalidate a scientific study. LAND-105 provides the Guidelines for Agronomy Journal Editors and Reviewers. The guidelines state, “A fixed factor can be repeated exactly if the experiment were to be run again. Examples of fixed factors are fertilizer rates or selection of a specific cultivar. A random factor is best thought of as coming from a distribution and thus cannot be necessarily repeated exactly. Years and locations are usually, but not always, considered as random factors.” (LAND-105, page 4.) These definitions explain why naming the specific locations of my studies is unnecessary for a scientific audience, and lack of specifying the exact location in no way invalidates the results.

Furthermore, Dr. Kimmelshue emphasizes “repeatable conclusions” in his written (DWR-85, page 9, line 15 and lines 26-28) and oral (Transcript 5/10/17, page 100, lines 10-12) testimonies. He provided an example of what he characterizes as repeatable. He described a hypothetical experiment in which nitrogen fertilizer rates were studied. He went on to describe the trial results showing, and scientific literature reporting, similar optimal nitrogen rates, ranging from 100 to 105 pounds, and the same 2-ton peach yield (Transcript 5/10/17 page 100, lines 13-22). As a scientist, I would not expect to see the same crop yield from California to Utah to Georgia, to use his example. While the similar nitrogen rates are illustrative of repeatability, having the same 2-ton yield is not prerequisite to repeatability. The guiding principles document of the Agronomy Journal states, “Sound methodology was used and is explained with sufficient detail so that other capable scientists could repeat the experiments.” (LAND-105, page 1.) Dr. Kimmelshue apparently does not understand a guiding principle of reviewing scientific literature – that it is the methodology that must be repeatable, not the conclusions.

On the matter of soil sampling on Ryer Island, Dr. Kimmelshue critiqued that the results of the study were invalid because it was a one-time sampling, and that sampling took place in August during a drought. He stated, “When you’re doing a salinity study, you need to track things over longer periods of time and have multiple samples in a study.” (Transcript 5/10/17, page 30, lines 18-20.) He also stated, “So when you don't have anything to compare it to, how do you know if it's high or low? She compared it to literature values that said, are we in exceedance of a threshold value on vineyards or are we in exceedance on a threshold value on pears?” (Transcript 5/10/2017, page 31, lines 1-5.) I would agree with Dr. Kimmelshue that a one-time sampling prevents me from being able to discuss trends or changes over time, but a one-time sampling does not render the data invalid. Dr. Kimmelshue provided no critique of the methods I used to obtain my data, and he provided no critique of my comparison to published crop salinity tolerance thresholds. Regarding performing the sampling in August, I would argue that the best time to characterize soil salinity in a Mediterranean climate would be to sample after rainfall and irrigation have ceased for the season – a season which we characterize as a water year running from October 1st through September 30th. Thus, data from my Ryer Island study accurately reflect the soil salinity condition in the vineyard and pear orchard at the end of water year 2015-16.

IV. Sources of salinity in agricultural systems

In cross examination, Dr. Kimmelshue was asked what other sources of salinity may impact crops besides salinity from applied irrigation water, and he provided the following other sources: rainfall, soil mineral weathering, and brackish shallow groundwater. (Transcript 5/10/2017, page 72, lines 4-15.)

Regarding rainfall, Dr. Kimmelshue contextualized that rainfall may contribute to soil salt-loading in some environments (Transcript 5/10/2017, page 72, lines 7-8). In my review of scientific literature, I have not found any references that describe rainfall as a source of salinity. Furthermore, in the Hoffman (2010) report, rainfall is described as mediating soil salinity because it 1) can substitute for irrigation water in meeting crop evapotranspiration, 2) can be stored in the soil and used by a subsequent crop, and 3) "…dilutes the salinity of the soil water in the upper reaches of the crop root zone and if the rainfall is sufficient it can leach salts from the root zone" (DWR-580, page 31). For these reasons, we can dismiss rainfall as being a source of salinity in the Delta.

Regarding mineral weathering, Hoffman (2010) stated "In studies using simulated irrigation waters from the western U.S., Rhoades and colleagues (Rhoades et al., 1973, 1974) showed that the dissolution of primary minerals is most important when the irrigation water's salt content is low – less than 100 to 200 mg/l (ECi = 0.15 to 0.3 dS/m) and when the leaching fraction is at least 0.25. For example, irrigation with water from California's Feather River, which has a salt content of 60 mg/l, results in more salt in the drain water due to dissolution (weathering) than due solely to the salt content of the irrigation water at high leaching fractions (Rhoades et al., 1974)." (DWR-580, page 44.) In my sampling of applied irrigation water in south Delta alfalfa fields, seasonal average salinity ranged from 0.36 to 1.93 dS/m, and leaching fractions were lower than 0.25 in all but one site. Thus, the evidence does not support the contention that soil mineral weathering substantially contributes to soil salinity in the south Delta. Of note, Hoffman (2010) also had the same conclusion (DWR-580, page 44).

Regarding shallow groundwater being a potential source of salinity, I agree with Dr. Kimmelshue that this point needs addressing; however, I would disagree that the depth of groundwater in the Delta invalidates the use of a leaching fraction equation that relates applied water salinity and soil salinity. (Dr. Kimmelshue's quote was, "It was indeed an inappropriate application of the formulas." (Transcript 5/10/2017, page 5, lines 10-11).) Keep in mind that Dr. Kimmelshue relies on Hoffman (2010) for many of his opinions, and Hoffman used the same leaching fraction equation that I have used. Furthermore, I also disagree that groundwater is contributing to the root zone soil salinity profile as he suggests, or that salts in the groundwater are coming from a source other than applied water.

On the matter of groundwater depth invalidating the leaching fraction equation, Dr. Kimmelshue stated, “And I'd like to simply quote a couple statements from Ayers and Westcot when using those formulas, one quote under site conditions and assumptions in the guidelines that say (reading): ‘When using these formulas, drainage is assumed to be good with no uncontrolled shallow water table present within two meters of the surface.’” (Transcript 5/10/2017, page 5, lines 15-21.) Within this quote, Dr. Kimmelshue misquoted an assumption of Table 1 in Chapter 1.4 of Ayers and Westcot (1985) (II-15). Dr. Kimmelshue took the liberty of adding the phrase “when using these formulas,” which is not in the original text. Table 1 provides values of electrical conductivity and other salinity metrics at which a water manager may wish to restrict using water for irrigation, and qualifies the values with the assumptions that there is not an uncontrolled shallow water table within two meters of the soil surface. The table does not show – and the assumption does not state – that these site conditions are requisite to applying the leaching fraction equation.

Dr. Kimmelshue cited one refereed journal article (Sreenivas and Reddy, 2008; LAND-103) to support his misquoted statement. Dr. Kimmelshue stated, “Peer reviewed research has shown that this empirical ratio does not apply to high water table soils. (Sreenivas and Reddy, 2008.)” (DWR-85, page 18, lines 2-4). In this paper, however, researchers determined a leaching requirement – not leaching fraction – for rice seedlings in a soil where the water table was at a depth of 60 cm or less. They determined a leaching requirement equation by ponding water on the soil surface and sampling soil to a depth of 15 cm. In other words, their interests were in determining how much water would need to be applied to leach the upper 15 cm of soil so that rice seedlings could suitably grow at this site. Based on my experiences in the Delta, I have never observed groundwater to be as shallow as 60 cm, and I have sampled soil well below 15 cm in order to gain an understanding of the soil salinity profile, determine the base of the root zone, and calculate the leaching fraction achieved. Thus, while Dr. Kimmelshue used this article to support his argument that shallow groundwater invalidates using the leaching fraction equation that Hoffman and I have used, by confusing leaching fraction and leaching requirement, he has failed to support his argument.

On the matter of brackish groundwater contributing to the soil salinity profile, Ayers and Westcot (1985) (II-15, Chapter 2.4.1) stated, "Salinization from this source [shallow water table] can be rapid in irrigated areas in hot climates where portions of the land remain fallow for extended periods." The manuscript goes on to describe a "safe depth" for the water table to ensure adequate drainage as being "usually at least two metres." (Ayers and Westcot, 1985, Chapter 2.4.1.) Hoffman (2010) stated, "As the water table is lowered below 3 ft. the upward flow becomes limited by the hydraulic properties of the soil and decreases markedly with increasing soil depth." (DWR-580.) He also stated that upward movement of water is possible even when the water table depth is 13 feet "…if the groundwater is sufficiently saline, if sufficient time is allowed, and if rainfall and irrigation amounts are low." (DWR-580.) The language in both of these reports is far from absolute, and despite the potential for groundwater to be as shallow as 3-4 feet, Hoffman (2010) used the standard leaching fraction equation in his south Delta analysis.

My studies on soil salinity in the Delta have been conducted in irrigated cropland where groundwater depth and quality have been presented. In the south Delta alfalfa study (LAND-79), across seven sites and five seasons (with two sites having only four seasons due to crop changes), groundwater was never measured at less than 1 meter (3.3 feet). In LAND-79 Figure 2, the soil salinity profiles and groundwater depths and quality are graphed for the seven sites. Trend lines show that soil salinity increases with depth to the base of the root zone, which is what we would expect to see in a border-flood or sprinkler irrigated system (Hoffman, 2010; DWR 580, page 37). In Figures 2A, 2B, and 2G, groundwater was observed to rise to the base of the root zone in some seasons, and I have discussed how fluctuating groundwater appears to be impeding leaching, particularly for Sites 1 and 2 (LAND 79, page 8). At these sites, because the groundwater salinity generally had the same electrical conductivity as the soil, there is no suggestion that groundwater salinity was coming from anywhere but the applied water. In Figures 2C and 2E, the soil salinity was low relative to the other sites, and the leaching fractions were high. This suggests to me that salts from the applied water were being leached to the groundwater. In contrast, Figures 2D and 2F illustrate sites where soil salinity was high, and leaching fractions were low. Groundwater depth was observed below the root zone at each of the five samplings, and groundwater salinity was less than the soil salinity. The low leaching fractions and low groundwater salinity suggest that applied water salinity was not getting leached to the depth of groundwater. Thus, Figure 2 illustrates trends we would expect to see for flood irrigated systems, the variability of salinity conditions, and the complexity of managing salinity in the Delta.

V. Precipitation and leaching

Dr. Kimmelshue stated in his written rebuttal that my work “fail[s] to recognize the significant impact of natural leaching of salts during the winter season caused by precipitation and that associated variability by year.” (DWR-85, page 5, lines 12-13.) I agree with Dr. Kimmelshue that precipitation should be addressed, and “update[ing] the state of knowledge on how surface water quality and rainfall affect the leaching fraction” has been an explicit objective of my south Delta alfalfa study in all project report updates (SDWA-139, SDWA-140, and LAND-79, page 1).

To model soil salinity in alfalfa with and without precipitation (DWR-580, page 87), Hoffman (2010) used two plant water uptake models – the 40-30-20-10 and exponential models – an assumed water quality, and an assumed leaching fraction. I have previously stated that I disagree with Hoffman’s assumptions on water quality and leaching fractions. In contrast, I measured and reported data on water and soil salinity and calculated leaching fractions from those data.

In previous testimony, I reported leaching fractions as calculated without precipitation. I used the EC of the irrigation water applied to the fields and the soil salinity at the base of the root zone. I have now calculated leaching fractions taking into account precipitation, which are presented in Table 1 a of Exhibit “B” attached herewith. The notation ECi refers to the EC of the applied irrigation water, not accounting for precipitation, and ECaw refers to the EC of the applied water from irrigation and precipitation. By factoring in precipitation, the ECaw falls below ECi for the seven alfalfa sites. Factoring in precipitation results in a lower leaching fraction because soil salinity does not change in the leaching fraction equation. In other words, we are now calculating leaching fractions with a smaller numerator but a denominator that does not change, so the leaching fraction is lower when precipitation is taken into account.

We can visualize why precipitation is not contributing more to leaching by observing the daily water balance of the soil and the change in soil moisture from field capacity for the seven alfalfa sites. Figures 1-4, attached herewith as Exhibit "C," present this for water years 2012-13, 2013-14, 2014-15, and 2016-17. These graphs were created using California Irrigation Management Information System (CIMIS) data for precipitation and reference crop evapotranspiration (ETo), an alfalfa seasonal crop coefficient (Kc) of 0.9 (Hanson et al., 2008), and soil moisture data from the seven alfalfa sites. CIMIS data for the Manteca, Tracy, and Brentwood stations were averaged to represent south Delta conditions for water years 2012-13, 2013-14, and 2014-15. New CIMIS stations have been installed in the Delta since the completion of the alfalfa leaching fraction study; CIMIS data for the Jersey Island, Holt, and Ripon stations were averaged for water year 2016-17. Total rainfall for water years 2012-13, 2013-14, 2014-15, and 2016-17 (to June 6th) was 8.8, 8.2, 11.8, and 18.5 inches, respectively. (As a point of comparison, rainfall data reported by Hoffman (2010) for the years 1952-2008 had an average of 10.9 inches.) The ETo was multiplied by the alfalfa Kc to determine crop evapotranspiration (ETc), which was 53.0, 53.5, 52.4, and 24.5 inches, for the 2012-13, 2013-14, 2014-15 and 2016-17 (to June 6th) water years, respectively. On a daily basis, we can subtract the ETc from the precipitation to determine the daily water balance in the soil. When the daily water balance is positive, daily precipitation exceeds daily ETc, and water is stored in the soil profile. When that stored water reaches the field capacity of the soil – or the amount of water in the soil before free drainage commences – then any additional water is available for leaching.

The field capacity of the soils at the seven alfalfa sites were determined using soil moisture data across the five sampling seasons. The highest soil moisture contents per foot-depth increment were summed for each soil profile to represent the soil moisture content at field capacity. Soil moisture contents per foot-depth increment were summed for each soil in each fall season to determine the soil moisture content for the root zone at the end of the water year. The fall soil moisture contents were subtracted from the soil's field capacity to determine the amount of water that would need to be added to reach field capacity at the end of the water year. For all soils, this difference represented a deficit because all soils were drier than field capacity at each fall sampling. This concept can also be considered in this way: the higher the soil moisture content in the fall, the smaller the soil moisture deficit, and the lower the amount of rainfall needed to attain leaching. The daily water balance was then cumulatively added to the soil moisture deficit to show how soil moisture changed over time with precipitation and ETc. Field capacity is zero on the Y axis. When the daily water balance was negative, meaning ETc exceeded precipitation, soil moisture decreased. When the daily water balance was positive, soil moisture increased. If there was enough precipitation to increase soil moisture above field capacity, then water was available for leaching.

We can observe whether water was available for leaching in Figures 1-4. In Figure 1, the daily water balance is represented by the line "Precipitation – ETc." Because the alfalfa project commenced in the spring of 2013, no fall 2012 soil moisture data are available, so no other data are presented in that figure. Figure 1 serves to show a detailed representation of the daily water balance. For water year 2013-14 (Figure 2), precipitation rarely exceeded ETc, and each alfalfa site remained at a soil moisture deficit over the entire year. In other words, precipitation was never high enough to fill the soil profiles, exceed the soils' field capacity, and leach salts. Figure 3 represents conditions for water year 2014-15. Precipitation exceeded ETc more frequently than in water year 2013-14, and there was a period starting on December 11th where soil moisture exceeded field capacity (for all but one site, Site 5), providing water for leaching. The highest peak on each site's line represents the total water available for leaching after accounting for ETc and filling the soil profile to field capacity. This peak occurred on December 20th and was 0.6, 3.1, 0.7, 1.5, 0, 1.1, and 0.9 inches, for Sites 1-7, respectively. (Site 5 was 0 inches because the soil moisture deficit remained the entire year; thus, zero water was available for leaching.) As this water was available for leaching, we assume that this water drained from the profile, and the lines drop to zero, or field capacity. Beyond December 20th, the daily water balance was never enough to exceed field capacity, so no other water was available for leaching over the remainder of the year.

At first glance, the water available for leaching at each site does not appear to be substantial. We can use an equation to calculate the depth of water that would need to be applied to lower the average root zone salinity of these soils to the soil salinity crop tolerance threshold for alfalfa, which is 2.0 dS/m (Ayers and Westcot, 1985) (II-15, Table 4). Above 2.0 dS/m, alfalfa yield declines are expected. The equation is:

Dw = (k x Ds x ECi)/ECf

where ECf is the final average root zone salinity after leaching, k is a constant, Ds is the depth of soil to be leached, ECi is the initial average root zone salinity, and Dw is the depth of water applied (Hanson et al., 2006). Table 2 of Exhibit “B” attached herewith depicts the model inputs and the resulting Dw values, which represent the amount of water that would need to be available to leach the root zone and achieve soil salinity that matches the alfalfa crop tolerance threshold. The amounts for Sites 1-7 were 13.3, 12.9, N/A, 10.7, 5.6, 12.4, and 4.5 inches, respectively. (Site 3 was N/A because the ECi was already below the threshold.) These values illustrate that, while there was water available for leaching during the 2014-15 water year, the amounts were far less than what would be needed to bring the average root zone salinity of these soils to the alfalfa crop tolerance threshold.

Dr. Kimmelshue pointed out that my study took place during drought years and that he presumed soil salinity would be lower after the rainfall of 2016-17 (paraphrased from Transcript 5/10/17, page 154, lines 22-25). While I do not have soil salinity data for the spring of 2016, we can model how much of the rainfall would be available for leaching in the alfalfa sites (Figure 4) and how that rainfall would change the average root zone salinity from where it was in the most recent soil salinity data from spring 2015 (Table 3). In water year 2016-17, precipitation exceeded ETc where peaks in the “Precipitation – ETc” line rise above zero on the Y axis. The most dramatic lines, however, are those for the change in soil moisture from field capacity at each site. (The smallest soil moisture deficit for each site across the fall 2013 and 2014 seasons was used in these calculations to provide a “best case scenario” for leaching.)

Soil moisture remained at a deficit for most sites until around January 7th. Site 5 was the last site to remain at a deficit, until February 7th. The total water available for leaching at Sites 1-7, as represented by the highest peak on February 21st, was 5.0, 6.0, 6.3, 5.0, 2.3, 5.7, and 6.4 inches, respectively. Again, as this water was available for leaching, we assume that this water drained from the profile, and the lines drop to zero. Beyond February 21st, the daily water balance was never enough to exceed field capacity, so no other water was available for leaching over the remainder of the year.

Comparatively, the water available for leaching was much higher in water year 2016-17 than in water year 2014-15. We can derive the equation above to the following equation, which is used to determine how well the soil would be leached with this higher amount of water available for leaching:

ECf = (k x Ds x ECi)/Dw,

where the variables are as previously defined. Table 3 depicts the model inputs and the resulting ECf values after the 2016-17 rainfall. The final average root zone salinity values for Sites 1-7 were 3.8, 3.9, 0.5, 3.7, 1.9, 3.0, and 1.4 dS/m, respectively. This is a notable reduction in salinity, but Sites 1, 2, 4, and 6 still exceed the 2.0 dS/m soil salinity threshold above which we expect yield declines.

Thus, while I agree with Dr. Kimmelshue that considering precipitation in the leaching calculations is appropriate and informative, the data show that rainfall is not substantially contributing to leaching during low rainfall years, and even in high rainfall years, we cannot assume that salinity is no longer of concern. This emphasizes the importance of maintaining water quality (i.e. low salinity) for irrigation, irrespective of rainfall amounts.

VI. Other arguments

Dr. Kimmelshue presented other arguments in his written testimony, which can be easily dismissed.

- Regarding providing “limited recognition of the significant impact of irrigation method and management on leaching of salts below the root zone” (DWR-85, page 5, lines 14-

15), my testimony (II-13 and II-14) and project report (SDWA-139 SDWA-140, LAND-79) provide in-depth description of my methods and explanation for how and why I sampled soil as I did for the various irrigation systems.

- Regarding using “incorrectly applied standard leaching fraction calculations” (DWR-85, page 5, line 19), a scientific discussion of that concern is provided in Section IV above. Nevertheless, in written testimony, Dr. Kimmelshue quoted UC ANR Publication 3375 which states, “No method has yet been developed to adjust the traditional estimating methods for the effect of shallow groundwater on soil salinity.” (DWR-85, page 22, lines 22-24.) The leaching fraction equation that I used in my studies is the same equation used by Hoffman in his 2010 analysis of south Delta conditions (DWR-580), a reference upon which Dr. Kimmelshue heavily relied.
- In his written testimony, Dr. Kimmelshue stated that I did not propose “any grower management options to mitigate any increase in salinity regardless of water quality used for irrigation or environmental conditions” (DWR-85, page 6, lines 7-9), but later in his testimony, he acknowledged that I did by quoting an entire paragraph from my alfalfa project report where I describe grower management options (DWR-85, page 16, lines 3-8). Thus, this argument is without merit. Nevertheless, as stated in my rebuttal testimony, “if a grower must change practices to adapt to increases in water salinity in order to prevent reaching the soil salinity threshold, then the cost associated with those changes is also impact.” (Transcript 5/19/2017, page 33, line 23 through page 34, line 1.)
- Regarding “new varieties of some crops have been developed specifically for salt tolerance” (DWR-85, page 17, lines 14-15), Dr. Kimmelshue references Benes et al., 2014, which was entered as LAND-104. The varieties tested as part of the Benes et al. (2014) study have fall dormancy ratings of 8 or 9, which means they are non-dormant varieties. Non-dormant varieties are appropriate for hot climates like Arizona, the Imperial Valley, and the southern San Joaquin Valley, where the Benes et al. study took place. Non-dormant varieties are not appropriate for the Delta. Additionally, while the

study characterized irrigation water salinity as 6.5 dS/m, when the study concluded in the month of June – well before the end of the growing season – soil was only sampled down to 12 inches. The study provides insights into what water salinity alfalfa varieties may tolerate in the short-term, but it falls short in collecting enough data required to make any conclusions on alfalfa salinity tolerance and how irrigation water salinity affects the soil salinity profile. Ayers and Westcot (1985) (II-15, Chapter 2.4) put it this way, "In dealing with a major salinity problem related to water quality, a cropping change is considered a drastic step and will only be taken when less severe options have failed to maintain economic production."

VII. Conclusions

In conclusion, this sur rebuttal testimony has been developed in response to the rebuttal testimony of Dr. Joel Kimmelshue (DWR-85), to specifically address his opinions on peer review, experimental methodology, sources of salinity, precipitation and leaching, among other arguments. My experiences evaluating salinity in Delta agricultural systems have given me an understanding for how scientific principles apply in the field. My projects illustrate how soil salinity is influenced by applied water salinity, and my calculations of leaching fractions are based on this data, not on assumptions. Dr. Kimmelshue has not criticized my methods in attaining the data, and the Petitioners have not provided data to the contrary. I agree with Dr. Kimmelshue that other sources of salinity and the effect of precipitation on leaching should be addressed. As described above, examination of these factors gives further credence to the results of my studies. Dr. Kimmelshue, however, reduced his credibility by making spurious statements about the status of his own manuscript and also mischaracterized a renowned text on agricultural water quality. For all of these reasons, I consider the testimony of Dr. Kimmelshue unreliable.

I declare under penalty of perjury under the laws of the State of California that the foregoing statements are true and correct.

Executed on the 9th day of June 2017, at Stockton, California.

Michelle Leinfelder-Miles

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Michelle Leinfelder-Miles

REFERENCES

Ayers, R. S. and D. W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29 Rev. 1. FAO, United Nations, Rome. 174 p.

Hanson, B. R., K. M. Bali, and B. L. Sanden. 2008. Irrigating alfalfa in arid regions. In: C. G. Summers and D. H. Putnam (eds.). Irrigated Alfalfa Management for Mediterranean and Desert Zones. The Regents of the University of California Agriculture and Natural Resources. Oakland, CA. p. 89-111.

Hanson, B., S.R. Grattan, and A. Fulton, 2006. Agricultural Salinity and Drainage. Publication 3375. University of California Agriculture and Natural Resources. Oakland, CA.

Hoffman, G. J. 2010. Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta. Final Report for the California Environmental Protection Agency, State Water Resources Control Board, Division of Water Rights. January 5, 2010.

Exhibit "A"

SDWA 263
Exhibit "A"

Michelle M. Leinfelder-Miles

Subject: FW: Cal Ag submission

From: Deborah A Thompson
Sent: Tuesday, May 30, 2017 4:38 PM
To: Michelle M Leinfelder-Miles
Subject: Re: Cal Ag submission

Hi,

This MS hasn't been submitted yet.

Best,
Debbie

From: Michelle M Leinfelder-Miles <mmleinfeldermiles@ucanr.edu>
Date: Tuesday, May 30, 2017 at 4:29 PM
To: Debbie Thompson <dthompson@ucanr.edu>
Subject: Cal Ag submission

Hi Deborah,
I'm trying to locate a paper in Cal Ag. The reference states "to be submitted" and has the year listed as 2016, but I'm not finding it in any issue. Is it possible for you to tell me whether it has been submitted? In press?

Kimmelshue, J., M. Heilmann, Z. Wang, S. Mulder, C. Stall, M. Twietmeyer, G. Ludwig, R. Klein, C. Eidsath, G. Obenauf. 2016. California Statewide Crop Mapping for Resource Management and Regulatory Compliance. Manuscript in Development. To be submitted to California Agriculture.

Many thanks,
Michelle

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http://ucanr.org/sites/deltacrops/

Exhibit “B”

Table 1. Leaching fractions calculated without precipitation and with precipitation for seven south Delta alfalfa fields.

	2013				2014			
	without precipitation		with precipitation		without precipitation		with precipitation	
Site	ECi (dS/m)	Lf (%)	ECaw (dS/m)	Lf (%)	ECi (dS/m)	Lf (%)	ECaw (dS/m)	Lf (%)
1	0.6	3	0.5	2	0.5	3	0.5	2
2	0.7	3	0.6	2	0.9	5	0.8	4
3	0.6	21	0.5	18	0.4	19	0.4	17
4	0.5	3	0.4	2	0.6	2	0.5	2
5	1.8	25	1.5	22	1.9	26	1.7	23
6	0.9	6	0.7	5	0.9	5	0.8	4
7	0.4	7	0.3	6	0.5	8	0.4	7

Table 2. Depth of leaching water required to bring the average root zone salinity of seven south Delta alfalfa sites to the alfalfa crop tolerance soil salinity threshold (2.0 dS/m) for water year 2014-15.

Site	ECi¥ (dS/m)	k†	Ds (ft)	ECf‡ (dS/m)	Dw (in)
1	7.4	0.1	3	2.0	13.3
2	7.2	0.1	3	2.0	12.9
3	1.0	0.1	3	2.0	N/A*
4	6.0	0.1	3	2.0	10.7
5	3.1	0.1	3	2.0	5.6
6	6.9	0.1	3	2.0	12.4
7	2.5	0.1	3	2.0	4.5

¥These data were the average root zone salinity for each soil in the fall of 2014.

†A constant of 0.1 is used when leaching occurs by intermittent ponding or sprinkling.
‡The value 2.0 dS/m is the threshold (Ayers and Westcot, 1985) above which we would expect yield declines for alfalfa.

*Not applicable because ECi is already below the threshold.

Table 3. Average root zone salinity for seven south Delta alfalfa sites after 2016-17 winter precipitation.

Site	ECi¥ (dS/m)	k†	Ds (ft)	Dw* (in)	ECf (dS/m)
1	5.3	0.1	3	5.0	3.7
2	6.6	0.1	3	6.0	3.9
3	1.0	0.1	3	6.3	0.5
4	5.2	0.1	3	5.0	3.7
5	1.9	0.1	3	2.3	1.9
6	4.8	0.1	3	5.7	3.0
7	2.5	0.1	3	6.4	1.4

¥ These data were the average root zone salinity for each soil in the spring 2015 (fall 2014 for Sites 3 and 7).

†A constant of 0.1 is used when leaching occurs by intermittent ponding or sprinkling.

*Water available for leaching in water year 2016-17.

Exhibit "C"

Figure 1. Daily water balance for water year 2012-13.

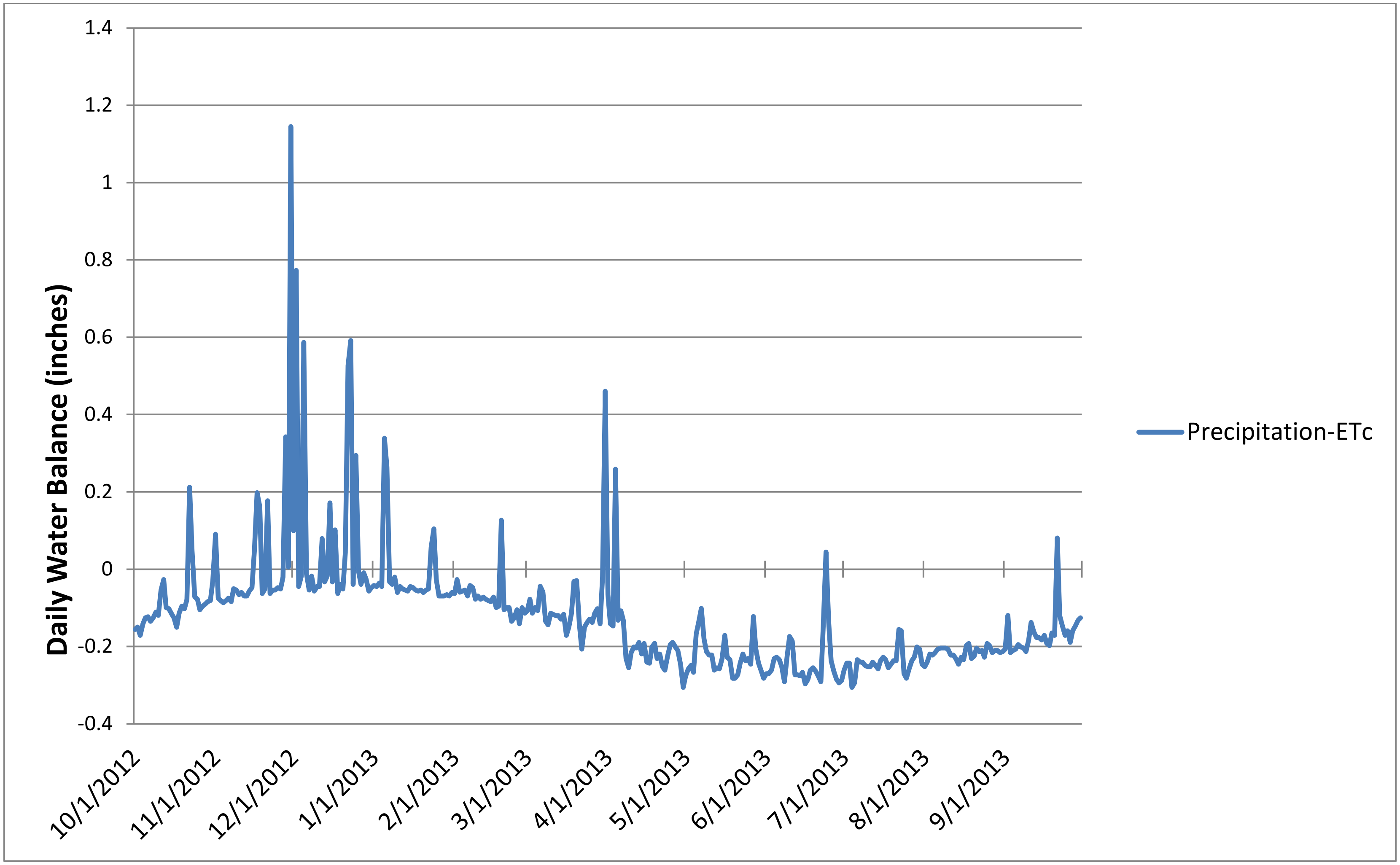

Figure 2. Change in soil moisture from field capacity for water year 2013-14 at seven south Delta alfalfa sites.

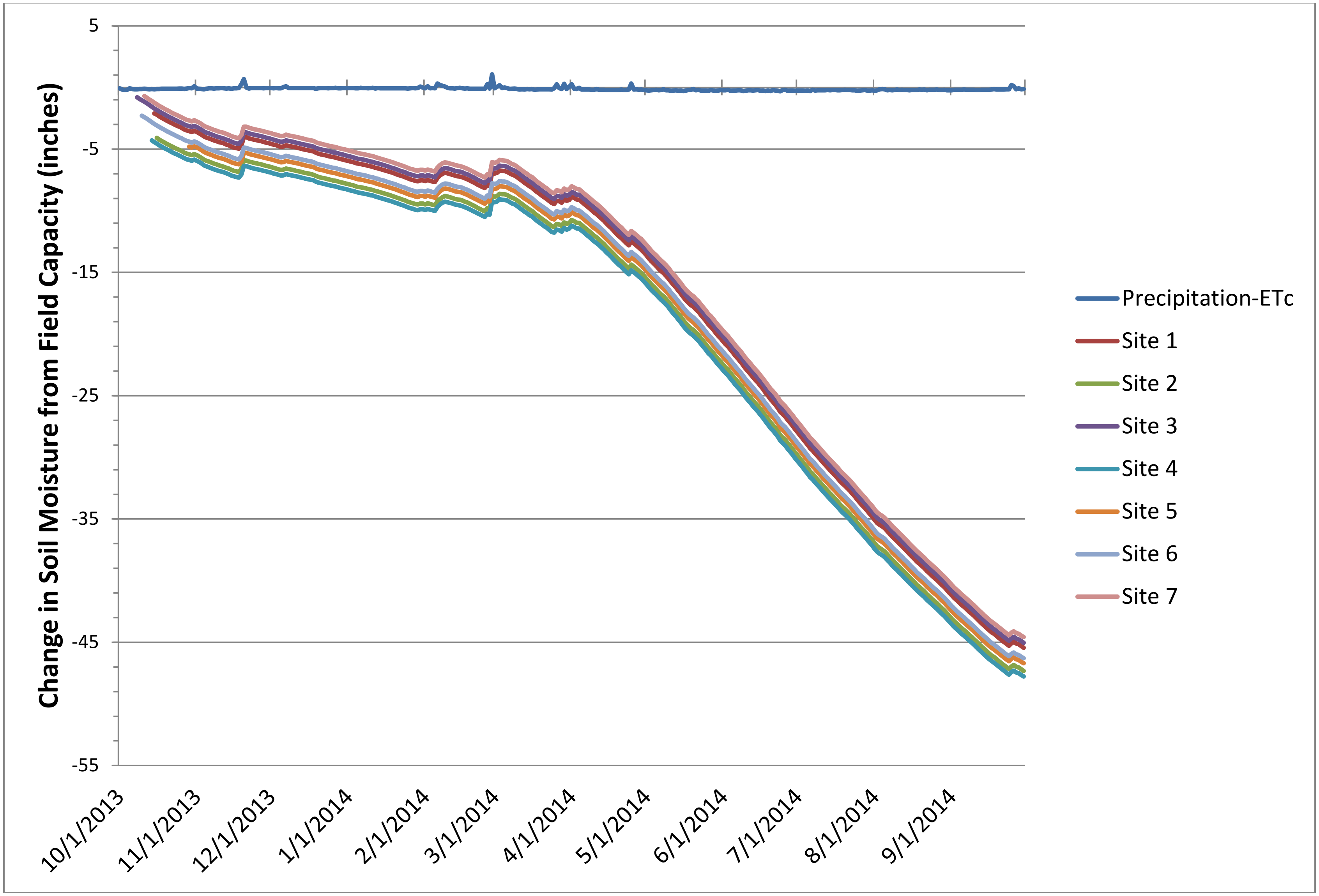

Figure 3. Change in soil moisture from field capacity for water year 2014-15 at seven south Delta alfalfa sites.

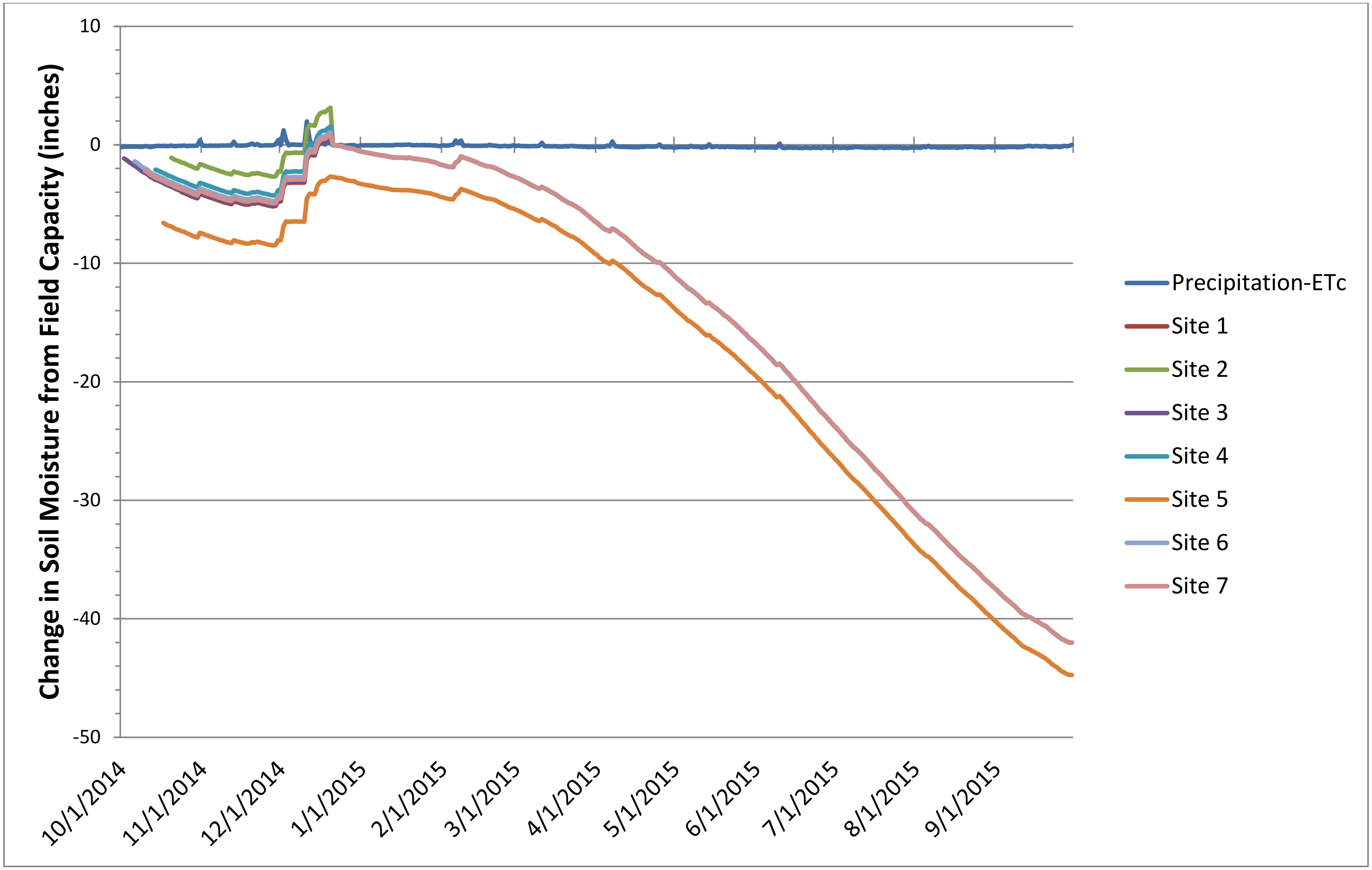

Figure 4. Change in soil moisture from field capacity for water year 2016-17 at seven south Delta alfalfa sites.