Appendix D-1

Assessment of potential effects of Eastwood/Odello Water Rights Change Petition on Carmel River steelhead (HDR, 2014a)

Memorandum

To: Denise Duffy, Denise Duffy & Associates

From: William Snider, Senior Fish Biologist HDR Inc.

Date: January 13, 2014

Subject: Assessment of potential effects of Eastwood/Odello Water Rights Change Petition on Carmel River steelhead (*Oncorhynchus mykiss*)

HDR, Inc. has reviewed the potential effects of the Eastwood/Odello Water Rights Change Petition on flows in the Carmel River and assessed the potential resultant effects on the river's steelhead population. Results reported by Balance Hydrologics, Inc (Balance 2014) on the proposed project's effects on river surface flow show that:

- The maximum sustained rate of additional pumping associated with the proposed project could reduce surface flow by an estimated 0.16 cubic feet per second (cfs). This maximum rate would occur in July and August. During other months, the maximum rates would be between 0.10 and 0.15 cfs (Table 1).
- The proposed project would result in no change or an increase in river flow in the lower Carmel River downstream of the project affected river reach during 6 months of the year (May through October).[1]
- Net reductions in flow downstream of the project affected river reach would be very minor (at most 0.05 cfs) and would occur from November through April when river flows normally are at the highest levels.
- The change in diversion location would increase the duration of zero-flow conditions in the project affected river reach from 37 to 39 percent of the time (Table 2). In most years, no detectable change is expected from December through the end of March.
- The proposed project's effect would only be discernible when river flows are 5 cfs or less. Moving the diversion points upstream has the potential to decrease the occurrence of river flows between zero and five cfs in the project affected river reach from 16 to 14 percent of the time throughout a typical year.

A portion of the existing water right would be dedicated to in-stream uses (Balance 2014). The proposed project will not impact inflows to the lagoon and should result in an increase in surface flow in the lowermost reach of the river, just upstream of the Carmel River lagoon, and in groundwater inflow into the lagoon, during the summer closure period (Watson and Casagrande 2004).

[1] The project affected reach extends from the upstream most well (Pearce at RM 5.68) downstream to the Carmel Lagoon and includes Canada Well No. 2 (RM 3.13) and the Cypress well (RM 5.41)

Table 1. Estimated monthly changes in Carmel river flows resulting from the proposed project.

Reach	Change in flow (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project affected reach (RM 1.09 to RM 5.68)	0.10	0.10	0.10	0.13	0.15	0.15	0.16	0.16	0.15	0.14	0.11	0.11
Downstream of project affected reach (Lagoon to RM 1.09)	0.05	0.05	0.04	0.02	0.00	-0.03	-0.02	-0.02	-0.01	0.00	0.02	0.04

Source: Balance (2014)

Table 2. Effect of project diversion (adjusted) on monthly frequency of low and zero flows in the lower Carmel River as measured at the Near Carmel flow gage[2] (RM 3.24) (from Table 3.2 in WYA 2013).

Month	**Percent of time 0<Q<5 cfs**		**Change due to Project**	**Percent of time Q = 0 cfs**		**Change due to Project**
	Unadjusted	Adjusted	% of time	Unadjusted	Adjusted	% of time
January	7%	7%	0%	21%	21%	0%
February	2%	2%	0%	12%	12%	0%
March	4%	4%	0%	9%	9%	0%
April	5%	5%	0%	8%	9%	1%
May	11%	9%	-2%	13%	15%	2%
June	22%	21%	-1%	29%	30%	1%
July	27%	24%	-3%	50%	53%	3%
August	30%	24%	-5%	62%	68%	5%
September	26%	20%	-6%	69%	76%	7%
October	21%	18%	-3%	70%	74%	3%
November	20%	20%	0%	61%	61%	0%
December	13%	13%	0%	41%	41%	0%
Annual	**16%**	**14%**	**-2%**	**37%**	**39%**	**2%**

Riverine Habitat

The riverine reach of the proposed project area (River Mile [RM] 1.09 to RM 5.68) has been designated critical habitat for the South-central California Coast steelhead distinct population segment (NMFS 2005). NMFS (2005, 2002) described the reach as primarily a migration corridor for adult and juvenile steelhead. Migration can occur from October through June. The upper part of this reach (upstream of Potrero Creek, RM 3.88), is also considered to be potential

[2] The USGS gage is a suitable indicator of the presence of flow in the affected reach (Balance 2014).

spawning habitat (NMFS 2005). Spawning can occur from mid-December through mid-April (NMFS 2002).

The reach is typically dry during the low flow period (i.e., 50 percent of the time in July to 70 percent of the time in October). Smith and Huntington (2004) provide a qualitative description of non-flow related habitat and fish conditions within the lower Carmel River that they observed during a survey of large woody debris (LWD) during fall 2003. For example, they found that LWD accumulations, a significant component of steelhead habitat in the Carmel River, gradually disintegrate into single pieces of LWD downstream from RM 5. Likewise single pieces associated with rootballs appear to lose their rootballs as they move downstream. Riffle habitat becomes less prevalent downstream as cobble and gravel substrates give way to sand. Run habitat takes the place of riffle in the river, especially after sand becomes the dominant substrate near RM 5. Overall, Smith and Huntington (2004) determined that aquatic habitat availability and utility, assessed in terms of LWD, substrate, channel morphology, and flow, decreased moving downstream from RM 15, and was of very low quality downstream of RM 5.

Lagoon Habitat

The Carmel River lagoon, like many lagoons throughout the range of steelhead in California, provides an important function for the steelhead population (Bond 2006, Bond et al. 2008). The lagoon provides over summer rearing and generally supports enhanced growth, which increases the potential survival of steelhead when they migrate into the ocean and then return as adult spawners. Increased lagoon salinity may adversely affect steelhead habitat. Availability of fresh water is a key, limiting factor in lagoons with respect to steelhead rearing habitat. Without fresh water, stratification is enhanced, leading to poor mixing below the surface, low dissolved oxygen, and high temperatures (Watson and Casagrande 2004).

Watson and Casagrande (2004) evaluated the Carmel River lagoon and provided the following description. A relatively fresh layer is normally maintained near the surface of the lagoon. This originates as the residual from the last river flows of spring. Data also suggest that the freshwater layer is maintained by shallow groundwater inputs from the lower Carmel Valley aquifer. The relatively fresh layer fluctuates in thickness during the summer, apparently being dissipated by saltwater ocean inputs through and over the sandbar, and being re-established by both local and distant groundwater inputs once the ocean inputs subside.

Current pumping of approximately 5 cfs in the Rancho Canada area several miles upstream leads to an annual cycle – with pre-winter groundwater depressions extending west to above Rio Road, followed by rapid wintertime recovery. If similar pumping in the Odello area is causing similar depressions, the primary source of summer freshwater flow into the lagoon currently is being reduced by this pumping. Because the project will eliminate pumping in the Odello area, it will slightly increase surface flow immediately upstream of the lagoon during pre-winter conditions, potentially improving steelhead habitat in the lagoon.

Steelhead Spawning

Adult sea-run steelhead enter the Carmel River once the sand bar breaches at the river's mouth. Typically, spawning occurs after December even when the mouth opens before then, and spawning can extend into April. Until recently, nearly all spawning occurred upstream of the Narrows (MPWMD 2013). Spawning habitat did historically not exist in the lower Carmel River (RM 0—5). Recent improvements in sediment management however, have resulted in exposure of some gravel. MPWMD (2013) observed some spawning in this lowermost reach during 2011(8 redds downstream of RM 3.24 including 1 redd observed near RM 2.0).

The proposed project would result in negligible decreases in flow in the affected river reach during the spawning period (< 0.13 cfs) (Table 1). Because the relationship between flow and spawning habitat availability is undefined for this reach, we used Balance's (2014) analysis of the effect of flow reduction on water depth over riffles within the reach to assess effects on spawning habitat. Balance (2014) calculated the change in depth for flows between 11 and 60 cfs that would result from a reduction of 0.16 cfs, which corresponds to the proposed project's maximum sustained pumping rate. The analysis was conducted to evaluate the potential effect of flow reduction on fish passage. They estimated that decreases in water depth at the riffles within the project reach ranged from no detectable change to a maximum of 0.02 feet (ft). (Note that the 0.16 cfs reduction in flow is associated with the maximum estimated pumping rate, which would occur in July, well after the spawning period has ended and when the stream is dry or nearly dry in most years). Steelhead spawning habitat is typically 0.5 ft deep or deeper (Barnhart 1986). A reduction in depth of less than 0.02 ft, associated with the maximum projected reduction in flow of 0.13 cfs during the steelhead spawning period would not adversely affect spawning habitat. Given the estimated maximum level of reduction in flow during the steelhead spawning period (0.13 cfs) (Table 1) and the associated negligible decrease in depth (< 0.02 ft), as well as the infrequent reduction in flow and poor quality of spawning habitat within the project reach, the project will not adversely affect steelhead spawning in the Carmel River.

Juvenile Steelhead Rearing

Juvenile steelhead rearing is seasonally distributed along the Carmel River. Juvenile steelhead rarely occur in the lowermost river (downstream of Schulte Road, [RM 6.7]) year round (NMFS 2002, MPWMD 2013) due to low flow or no flow, and warm temperatures during the summer. Historically, monthly average river flows in the project area (measured at the Near Carmel Gauge) were zero approximately 37 percent of the time. Zero flows occurred much more often during the months of July through November (WYA 2013).

During the fall, fish produced in the upper watershed descend into the lower reaches when evapotranspiration declines, flow connects the upper and lower reaches, and seasonal water temperatures drop. These fish typically leave the Carmel River within the next few months. In the spring, fish spawned in the lower watershed can distribute throughout the lower reach. However, they are generally lost (or rescued) when flow in these areas drops or disappears altogether, and water temperature increases - typically anytime between late spring and early summer.

Jones and Stokes (2006) determined that juvenile rearing habitat is constrained in the lower Carmel River when flow at the Near Carmel gage falls below one cfs during the months of June-December. As discussed above, the lower Carmel River is completely dry during much of this period. When flow does occur at the Near Carmel gage during this period, the project could decrease surface flow in the project reach by up to a maximum instantaneous rate of 0.16 cfs. Balance (2014) determined that a 0.16 cfs reduction in flow would increase the time that rearing habitat is constrained by less than 1 percent.

Historically, monthly average river flows are greater than zero but less than five cfs approximately 16 percent of the time. Flows in that range are most common during the months of June through November. The proposed project would decrease the frequency of flows between 0 and 5 cfs to 14 percent. The net effect on surface flow is an increase in the frequency of zero flow (from 35 to 37 percent of the time) essentially when flow without the project would be less than 0.16 cfs. The project will not adversely affect summer rearing during the rare occasions when flows in the project affected reach persist through the summer.

Steelhead Migration

Adult upstream migration can occur from November through May, but primarily occurs from January through March (Dettman and Kelly 1986). Juvenile migration, including smolt downstream migration, can occur from October through June. The proposed project would reduce flow by up to 0.15 cfs (Table 1) during much of the adult and juvenile migration period (October through June).

Both upstream and downstream migration can be physically hindered or halted by flow. MPWMD (2013) reports that when flows were 20 cfs an increased flow release (28 cfs) provided conditions that allowed adult steelhead to migrate from the lower reaches. Jones and Stokes (2006) identified a minimum flow condition (10 cfs measured at the Near Carmel gage) for downstream migration. Balance (2014) determined that the minimum flow that met upstream fish passage criteria (CDFW 2013) at critical riffles within the project reach ranged from 25 to 60 cfs.

As discussed above, Balance (2014) evaluated fish passage by estimating the reduction in depth associated with a 0.16 cfs reduction in flow when flows were considered critical for fish passage at several riffles within the project reach[3]. Under such conditions, the project-related reduction in flow during the period of upstream migration (November through May) was determined to have no effect (no change in depth over critical riffles at critical flow (25 to 60 cfs). Because the estimated reduction in flow during the adult migration period would be 0.15 cfs or less, the project would have no effect on adult migration.

Similar evaluations of project-related flow reductions on downstream migration found that the number of days that the Jones and Stokes (2006) criteria for downstream passage (10 cfs) was constrained increased less than 1 percent (Balance 2014). Balance (2014) determined that the

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[3] Balance (2014) estimated the minimum (i.e., critical) flow required to meet fish passage criteria defined by California Department of Fish and Wildlife (2013) for both upstream adult migration and downstream juvenile/smolt migration.

minimum flow that met downstream fish passage criteria (CDFW 2013) at critical riffles within the project reach ranged from 11 to 16 cfs. Assessment of the effect of a 0.16 cfs flow reduction on downstream passage at the critical riffles identified within the project reach showed that passage criteria were met at two of four riffles and fell short by 0.01 ft at two riffles. In as much as the criteria were essentially met at a flow reduction of 0.16 cfs, the projected flow reduction of 0.14 cfs (Table 1) during the October through March period will have no adverse effect on steelhead migration.

Conclusion

Based upon: 1) the location of the project and the habitat in the potentially affected reach of the Carmel River, 2) the timing of potential impacts relative to steelhead life-stage periodicity in the potentially affected reach, and 3) the typically unobservable change in surface flow in the reach, the proposed project as described by WYA (2013) and Balance (2014), will have no effect on the Carmel River steelhead population or its designated critical habitat. The reduction in flow is not appreciable enough to prevent or interfere with steelhead or their various life stages or habitat requirements, including particularly, migration in a manner that substantially reduces their numbers or restricts their range.

References

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Appendix D-2

Carmel River steelhead evaluation addendum providing review of public comments submitted regarding Eastwood/Odello Water Rights Change Petition on Carmel River steelhead (Oncorhynchus mykiss) (HDR, 2014b)

Memorandum

To: Denise Duffy, Denise Duffy & Associates

From: William Snider, Senior Fish Biologist HDR Inc.

Date: May 3, 2014

Subject: Carmel River steelhead evaluation addendum providing review of public comments submitted regarding Eastwood/Odello Water Rights Change Petition on Carmel River steelhead (*Oncorhynchus mykiss*)

In a memorandum to Denise Duffy and Associates dated January 2013, HDR, Inc. provided an assessment of the potential effects of the Eastwood/Odello Water Rights Change Petition (Change Petition) on the Carmel River steelhead population. Based on the assessment, HDR concluded that the proposed changes in diversion and use of water associated with the Change Petition would not adversely affect the Carmel River steelhead population resulting from its timing, magnitude, and diversion location. HDR concluded that the proposed location of the diversion would be downstream of the majority of steelhead spawning and year-long rearing habitat, that the timing of the greatest rates of diversion would occur when steelhead are not likely to occur in the potentially affected reach of the Carmel River, and that the magnitude of the greatest rate of the proposed diversion was extremely low and would result in only minimal, essentially undetectable, change in surface flow when flows are at the minimum level needed to maintain the various potentially affected habitat functions (i.e., migration and spawning, as reported from other studies).

In a letter dated April 2, 2014, to Katherine Mrowka of the State Water Resources Control Board, Dr. Roy Thomas provided comments that generally state that the majority of steelhead production in the Carmel River occurs downstream of Schulte Road (River Mile 6.7). Dr. Thomas further stated that: (1) the highest quality and greatest abundance of spawning habitat; and (2) the highest density of juvenile steelhead both occur downstream of Schulte Road; and (3) that the result of the proposed change in diversions resulting from the Eastwood/Odello Change Petition will adversely affect rearing, spawning, and migration within the lower 6.7 miles of the Carmel River.

As part of the Monterey Peninsula Water Management District Mitigation Program (MPWMD 2013), MPWMD has conducted numerous surveys of habitat and steelhead throughout the Carmel River watershed, including annual monitoring of juvenile and adult steelhead abundance and distribution. Results of the fish and habitat investigations and monitoring activities are reported through the 2011- 2012 monitoring period, providing the most up-to-date description of associated trends and current conditions observed in the Carmel River. The following discussion addresses the general conclusions presented in Dr. Thomas's letter, and is based on these most recent monitoring results by the MPWMD.

1. Spawning Distribution and Habitat

MPWMD (2013) has reported that conditions, primarily the increased availability of larger, gravel-sized substrate, have improved in the lower Carmel River, including within and downstream of the Project Area (downstream of RM 5.7), and that steelhead spawning has been observed in this lowermost reach. This observation was recognized by HDR in its January 2014 memorandum. However, MPWMD also reports that the majority of spawning observed during 2012 occurred upstream of Schulte Road and that steelhead spawning downstream of Schulte Road occurred because those individuals did not have access to the upper reaches of the Carmel River during 2012. Specifically, there was insufficient flow to provide access past critical migration riffles within this lowermost reach during most of the monitoring period. MPWMD also noted that there was concern about stranded adults being forced to spawn in "sub-standard habitat" [downstream of critical riffles, thus downstream of the Project Area] and adult fish rescues were being discussed. Conditions were similar to those in 2007 when many adults became trapped and spawned in the lower river where many of those redds were dewatered.

Based on these observations, HDR concludes that:

- Steelhead spawning in the Carmel River is predominantly upstream of the Project Area. Habitat quality has improved, but effective spawning habitat availability, and the ultimate survivability of fish spawned in the available habitat downstream of the Projecte Area is rare.

- Spawning activity observed in the lower Carmel River, downstream of Schulte Road, is inversely related to access to upstream reaches.

- The Eastwood/Odello Change Petition will not result in loss or adverse effects to steelhead spawning habitat in the Carmel River.

2. Juvenile Steelhead Rearing

MPWMD (2013) reports results of juvenile rearing monitoring that has been ongoing since the early 1990s. The results of the monitoring consistently show that juvenile rearing is substantially greater, measured as fish per foot of stream, moving upstream (MPWMD 2013, Table XVI-6). During the 2011-2012 reporting period, juvenile steelhead population density at the five monitoring stations averaged 0.40 fish-per-foot (fpf) of stream and ranged from 0.11 fpf at the downstream most station (Valley Greens Station, RM 4.8) to 1.07 fpf at the Sleepy Hollow Station (RM 17.5).

Based on the 20-plus years of juvenile steelhead monitoring and other information presented by MPWMD (2013), HDR concludes that:

- Juvenile rearing density increases moving upstream and is greatest at the monitoring locations farthest upstream of Schulte Road,

- Year-long juvenile rearing habitat availability also increases upstream of Schulte Road and year-long juvenile rearing is absent from this reach more than 50 percent of the time,

- Juvenile rearing is directly associated with spawning distribution, and the spawning and juvenile rearing distributions observed by MPWMD are consistent with the distribution of spawning and rearing habitats.

- The Eastwood/Odello Change Petition will not result in loss or adverse effects to steelhead rearing habitat in the Carmel River.

3. Steelhead Migration

Balance Hydrologics, Inc. (Balance) provided an addendum dated April 29, 2014, that added evaluation of critical riffles that were not identified in Balance's (2014a) original evaluation of fish passage, which was noted in Dr Thomas's letter. Balance determined that the flow conditions required to provide passage beyond these critical riffles, relative to the timing and rate of diversion associated with the Change Petition, would not adversely affect adult steelhead migration within the Carmel River.

Balance concluded that its original evaluation of critical riffles may have overestimated the estimated potential changes in passage conditions (i.e., depth). Although Balance (2014b) did not directly assess juvenile migration in its addendum, it may be concluded that the effects to downstream migration originally estimated by Balance (2014a) also were overestimates, and that the Project would not affect flow and associated depth conditions characterizing juvenile migration within the Project Area. However, Dr. Thomas states that "Even at very low flows that happen most every year, tens of thousands of young of the year steelhead migrate to the lagoon often at flows of .1cfs."

The criteria for successful downstream migration, used by Balance (2014a) in its assessment of passage at critical riffles, is the approach defined by California Department of Fish And Wildlife and has been routinely used by fish agencies along the Pacific Coast for decades. Absent additional information regarding the conditions during the reportedly vast number of migrating young-of-year (YOY) steelhead at such low flows, the Balance's assessment of the Project-related effects on downstream migration is the most appropriate.

As such, HDR concludes that the evaluations conducted by Balance (2014 a, b) are the best available information on fish passage in the Project Area and that the Project will not adversely affect juvenile or adult migration in the Carmel River.

Conclusion

Based on the foregoing, it remains our opinion that the Eastwood/Odello Change Petition: (1) will not result in loss or adverse effects to steelhead spawning habitat in the Carmel River, (2) will not result in loss or adverse effects to steelhead rearing habitat in the Carmel River, and (3) will not adversely affect juvenile or adult migration in the Carmel River.

References

Balance Hydrologics, Inc. 2014a. Geomorphic and hydrologic context' memorandum for Eastwood/Odello water rights change petition, Monterey County, California. January 2014.

Balance Hydrologics, Inc. 2014b. Addendum to 'Geomorphic and hydrologic context' memorandum for Eastwood/Odello water rights change petition, Monterey County, California. April 2014.

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Appendix E

Odello Ranch Crop ET and ET of Applied Water Estimates (Davids Engineering, Inc., 2013)

Specialists in Agricultural Water Management
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Technical Memorandum

To: Macaulay Water Resources

From: Davids Engineering

Date: April 15, 2013

Subject: **Odello Ranch Crop ET and ET of Applied Water Estimates**

Overview and Results

This memorandum provides a summary of activities conducted to develop estimates of long-term crop evapotranspiration (ET) and ET of applied water (ET_{aw}) estimates for the Odello Ranch in Carmel, California (Latitude 36.5343 N, Longitude 121.9072 W, Elevation 25 ft). The work included the following:

- Site Reconnaissance
- Preparation of Weather Data for ET Calculations
- Application of a Daily Root Zone Water Balance Model over the 26-year Period from January 1, 1987 to December 31, 2012 to Calculate ET and ET_{aw} under Current and Future Management

The Odello Ranch is located immediately east of Highway 1 and south of the Carmel River. Irrigated pasture has or will be established on approximately 40.6 acres at the Ranch[1]. Based on discussion with owner representatives, the pasture will be divided into six, approximately equally-sized paddocks and rotational grazing of cattle will be implemented. Irrigation will be accomplished using above-ground solid-set sprinklers supplied by a groundwater well located at the Ranch.

Annual crop (pasture) ET_{aw} varies between approximately 60.7 and 98.9 acre-feet, and averages 85.6 acre-feet, over the period of analysis. Annual applied water varies between approximately 91.9 and 131.8 acre-feet and averages approximately 124.0 acre-feet.

Site Reconnaissance

A site visit was conducted on February 27, 2013 to discuss irrigation and grazing management practices with owner representatives, to inspect the irrigation well and sprinkler system, and to characterize the pasture and soils. Additionally, local California Irrigation Management Information System (CIMIS) weather stations used to estimate crop ET rates were visited to evaluate station conditions and possible issues affecting the estimation of ET rates for the Ranch. The weather stations are discussed in a subsequent section.

[1] The approximate irrigated area was delineated in a geographic information system (GIS) based on aerial imagery and discussion with the owner representative. The estimated irrigated area represents a gross area of 41.08 acres, minus an estimated 0.48 acres of farm roads.

Irrigation and Grazing Practices

Irrigation and grazing practices have been developed to ensure long term productivity and sustainability of the pasture to support rotational grazing of cattle. Implications of this objective are that irrigation must be managed to prevent crop water stress through under-irrigation, and grazing must be managed to avoid overgrazing and deterioration of the pasture stand. To that end, the current plan is to divide the pasture into six, approximately seven-acre paddocks. Approximately 20 cow-calf pairs will be rotated from one paddock to the next every week, resulting in a total grazing cycle of 42 days, providing 35 days of pasture re-growth between grazings. Grazing will occur from approximately February through November. While the stocking rate, rotation duration, and overall grazing period may be refined over time based on field observations to maintain optimal pasture conditions, it is not expected that such refinements will change the estimates of applied water, ET and ET_{aw} that are discussed in this memorandum.

Irrigation Well

Water for irrigation is supplied by a submersible well located south of the Carmel River, approximately 300 yards east of Highway 1. The well was constructed in approximately 2000 and provides approximately 500 gallons per minute (gpm), according to owner representatives. Pumpage is measured using a propeller meter installed downstream of the well discharge. The well was not operating at the time of the site visit.

Sprinkler Irrigation System

Water pumped at the well is conveyed via a combination of steel and PVC 6-inch diameter mainline to 6-inch diameter aluminum sprinkler mainline pipe with ring-lock coupling and 4-inch risers. The mainline is laid along the north edge of the field in 40-foot lengths. Aluminum lateral lines of 3-inch diameter and 30-foot length run south from each mainline into the field. Each 30-foot lateral pipe includes an 18-inch riser and Buckner 17023W full-circle impact sprinkler with a 7/64-inch nozzle diameter.

Based on an assumed operating pressure of 45 pounds per square inch (psi), each sprinkler head discharges approximately 2.3 gpm, resulting in a water application rate of approximately 0.19 inches per hour.

For a given paddock, the sprinklers will be removed prior to grazing to avoid damage by the cattle and reinstalled immediately following grazing to allow for irrigation to support pasture re-growth prior to the next grazing.

Pasture

The pasture consists of a mixture of perennial grasses and clover and was planted in the latter half of 2012. At the time of the site visit, the grasses were at full cover and relatively tall, ranging from an average of approximately 16 inches at the west end of the field to 26 inches at the east end of the field. Root depths estimated based on soil sampling (described below) were approximately 2 to 3 feet. Photos of pasture conditions during the site visit February 27, 2013 are provided in Figure 1.

Figure 1. Odello Ranch Pasture, February 27, 2013.

Soils

According to the USDA Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service) soil survey of Monterey County, California (Cook, 1978), the pasture area consists primarily of Pico Fine Sandy Loam (Map Unit Symbol "Pf") (Figure 2). Soil samples were collected to a depth of four feet to verify available soils data at three locations spanning the area from west to east, as shown in the Figure.

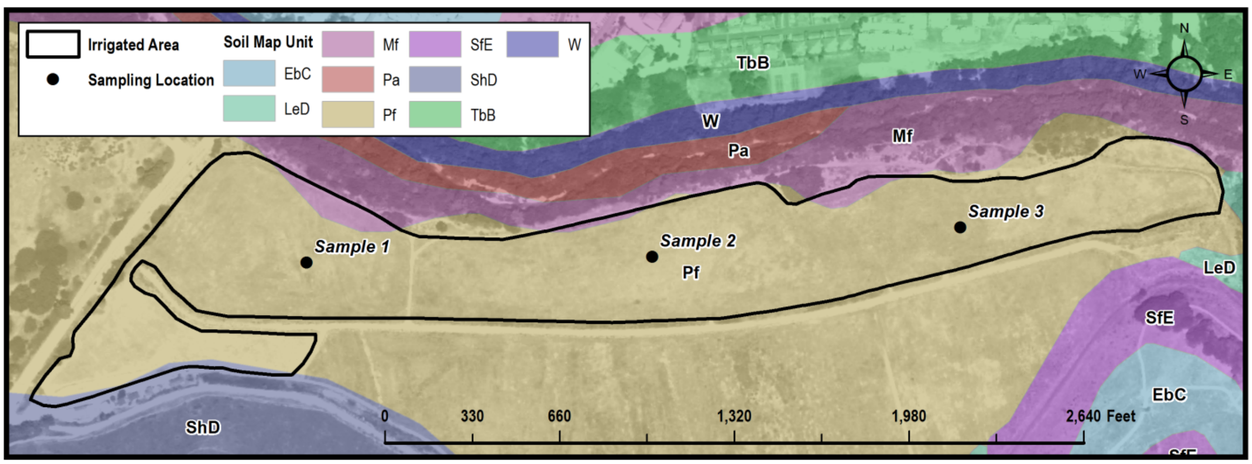

Figure 2. Odello Ranch Irrigated Area Soil Map Units and Sampling Locations.

Pf is described in the soil survey as follows:

> *The Pico series consists of well drained soils that formed on flood plains in alluvium derived from sedimentary rocks. Slopes are 0 to 2 percent….*
>
> *In a representative profile, the surface layer is grayish brown, mildly alkaline and moderately alkaline fine sandy loam about 18 inches thick. The underlying material is light brownish gray and pale brown, strongly calcareous stratified fine sandy loam, silty clay loam, sandy loam, very fine sandy loam, and sand that extends to a depth of 72 inches or more.*
>
> *Permeability is moderately rapid, and the available water capacity is 7.5 to 9 inches. Roots penetrate to a depth of more than 60 inches….*
>
> ***Pf—Pico fine sandy loam.** This is a nearly level soil on flood plains. It has the profile described as representative of the series….*

A summary of observed soil textures based on soil sampling at the three locations shown in Figure 2 is provided in Table 1. In general, the observed soil textures are consistent with the soil survey. Soil hydraulic parameters and classifications reported by the soil survey are suitable for estimation of crop ET and ET_{aw}.

Preparation of Weather Data for ET Calculations

In order to estimate long term crop ET and ET_{aw} under planned irrigation and grazing management practices, a daily root zone water balance model was parameterized and applied based on historical hydrologic information (i.e., atmospheric water demand and precipitation) for the 26-year period from January 1, 1987 to December 31, 2012. Primary drivers of the ET and ET_{aw} estimates are reference ET (ET_o), an estimate of atmospheric water demand; basal crop coefficients (K_{cb}) for pasture, as influenced by irrigation and grazing practices; and precipitation, in addition to soil characteristics. This section describes the development of estimates of daily weather parameters used to calculate ET_o and to estimate precipitation at the Odello Ranch for the 26-year period from 1987 through 2012.

Table 1. Summary of Observed Soil Textures at Sampling Locations.

Location	Latitude/ Longitude	Depth (ft)	Observed Texture
1	36.5342 N / 121.9121 W	0 - 1	Loam
		1 - 2	Fine Sandy Loam
		2 - 3	Fine Sandy Loam
		3 - 4	Fine Sandy Loam
2	36.5343 N / 121.9077 W	0 - 1	Fine Sandy Loam
		1 - 2	Fine Sandy Loam
		2 - 3	Fine Sandy Loam
		3 - 4	Fine Sandy Loam
3	36.5347 N / 121.9037 W	0 - 1	Fine Sandy Loam
		1 - 2	Sandy Loam
		2 - 3	Sand
		3 - 4	Sand

ET_o was calculated using the American Society of Civil Engineers Standardized Reference ET Equation for a short reference crop (ET_{os}, i.e., grass) (Allen et al., 2005), which is consistent with the United Nations Food and Agricultural Organization Irrigation and Drainage Paper 56 Equation for ET_o (Allen et al, 1998). The equation represents a national and international standard for the estimation of ET_o.

Precipitation for the period 2009 to 2012 was estimated directly based on data recorded by the rain gage at the CIMIS station at Carmel. Data for the period 1987 to 2008 were estimated based on linear regression with the Global Historical Climatology Network (GHCN) station at Monterey (Station ID GHCND:USC00045795), established in 1906. The Monterey GHCN station was selected based on its proximity to the Ranch and the availability of data for the full analysis period.

Station Descriptions and Site Characteristics

Carmel and Castroville CIMIS

The primary weather station selected for the analysis is the Carmel CIMIS station (CIMIS Station No. 210), located approximately 1.4 miles ENE of the Ranch at the Rancho Cañada golf course. According to the California Department of Water Resources (DWR), the station was activated July 22, 2008[2]; however, data are not available prior to October 24, 2008.

In order to develop long-term ET and ETaw estimated for the Ranch, a correlation was developed between ET_o at the Carmel CIMIS station and the Castroville CIMIS station (CIMIS Station No. 19), located approximately 17.7 miles NNE of the Ranch in an agricultural area. The Castroville station was activated November 18, 1982 and was selected based on its long available weather record, proximity to the Carmel CIMIS station, and similar distance from the Pacific Ocean.

Siting Characteristics

According to CIMIS and ASCE guidelines, weather stations should be sited within relatively large, level areas with well-watered, uniform vegetation cover similar to the reference surface that the ET_o calculation is meant to represent. Generally, obstructions affecting airflow upwind of the site should be at least 100 yards (300 feet) from the sensors or 10 times the height of the obstruction.

For each selected CIMIS weather station, site conditions were inspected, and factors to be considered when using the site records to estimate ET_o for the Ranch were evaluated.

Carmel CIMIS

The Carmel CIMIS station is located at the Rancho Cañada golf course, approximately 1.4 miles ENE of the Ranch (Latitude 36.5409 N, Longitude 121.8821 W, Elevation 66 ft). A map of the station location is shown in Figure 3. Photos of the station and its surroundings, taken February 27, 2013, are provided in Figure 4.

As shown in Figure 4 and Figure 3, the station is sited on well-maintained, clipped grass; however, obstructions possibly affecting airflow at the site exist within 300 feet, including the following:

- Maintenance building 105 feet to the northeast,
- Residential fence 125 feet to the east,
- Large tree 85 feet to the southwest,
- Golf course weather station with tall chain link fence 70 feet to the west,
- Tall trees 155 feet to the west, and
- Wall 90 feet to the northwest

A wind rose showing the direction and magnitude of hourly wind speed measured at the site between January 1, 2010 and December 31, 2012 indicates that the predominant wind direction is from the northwest, west southwest, and west (Figure 5). Based on nearby obstacles to airflow, the anemometer at the site may be underestimating wind speed, as compared to a situation where no obstacles were present. In particular, it appears that the two large trees to the west and relatively tall fence of the golf course weather station may be resulting in underestimation of wind speed.

Obstacles at the site potentially affecting wind speed measurement are not expected to substantially affect the measurement of incoming solar radiation, temperature, or relative humidity, the other weather parameters used in the calculation of ET_o. In particular, the close proximity of the Pacific Ocean and resulting dominant influence of the marine layer during most days of the year on these parameters likely compensates for potential limitations in site characteristics resulting from limited fetch.

Underestimation of wind speed at the Carmel CIMIS station relative to ideal site conditions may lead to underestimation of ET_o representative of the Odello Ranch.

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[2] Listed activation date at CIMIS website (wwwcimis.water.ca.gov).

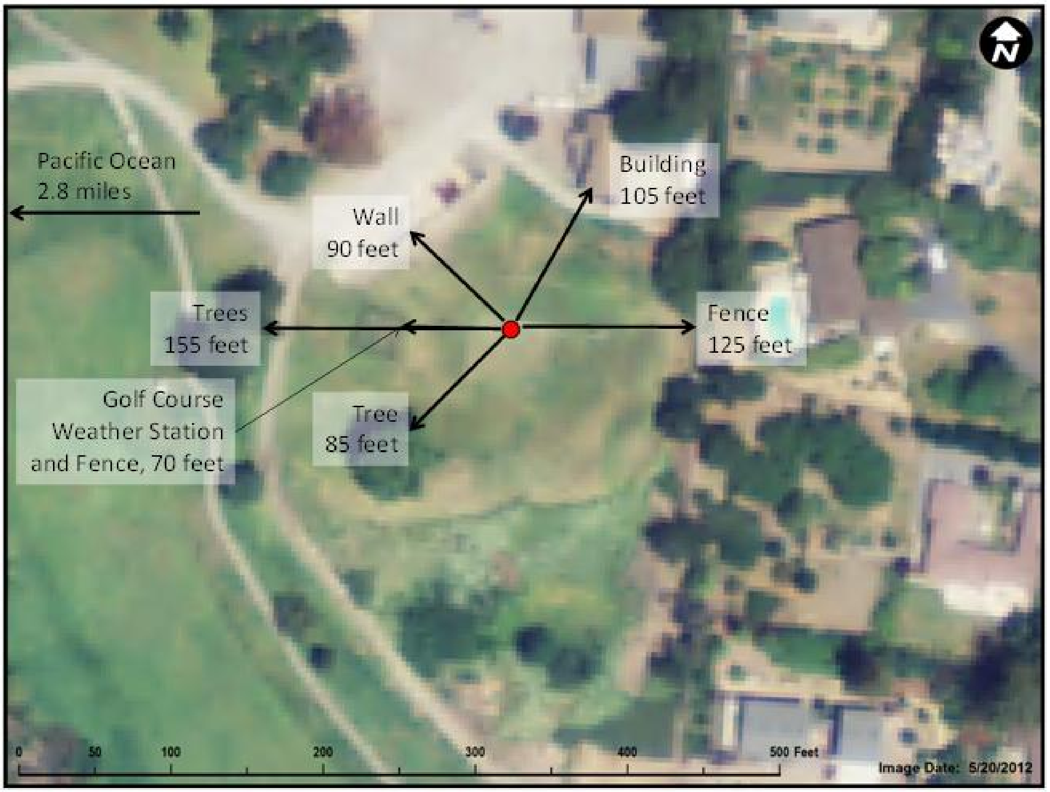

Figure 3. Carmel CIMIS Station Location and Surroundings.

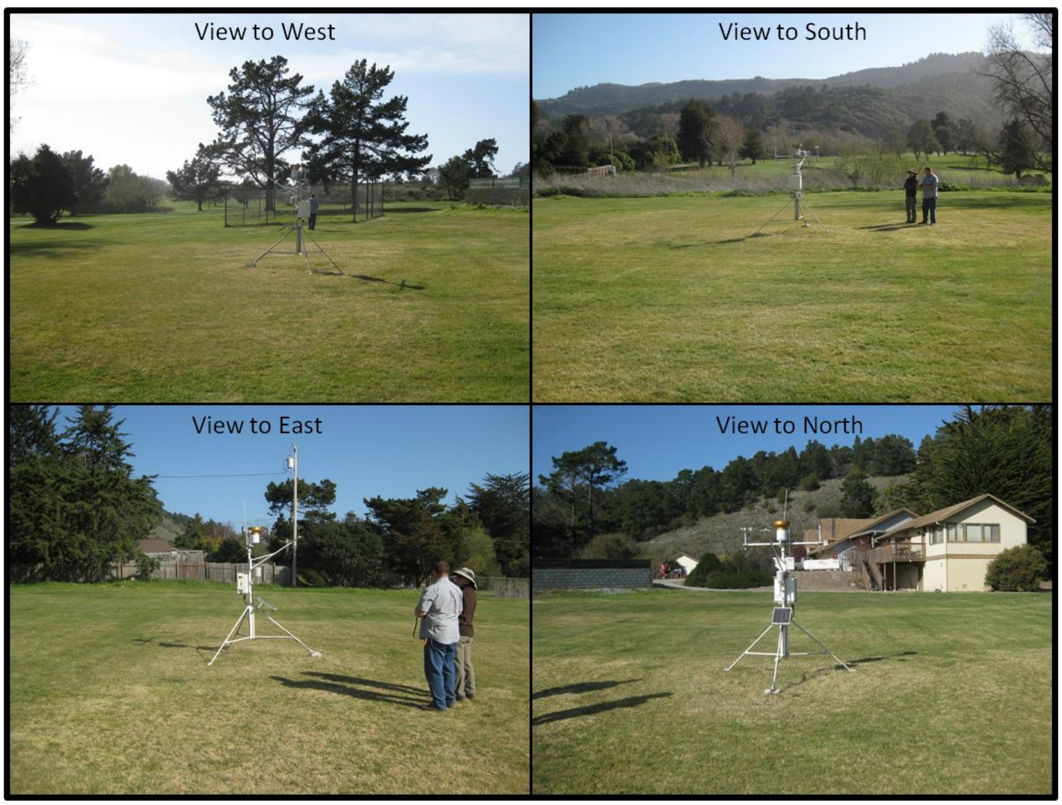

Figure 4. Carmel CIMIS Station Surroundings.

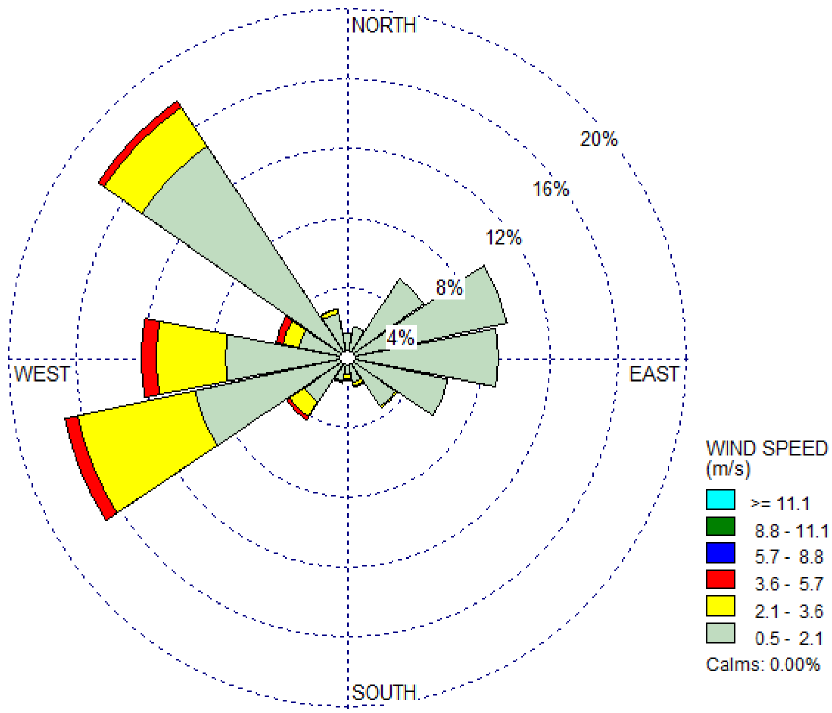

Figure 5. Carmel CIMIS Hourly Wind Rose, January 2010 through December 2012.

Castroville CIMIS

The Castroville CIMIS station is located in an agricultural area, approximately 0.6 miles west of Castroville (Latitude 36.7682 N, Longitude 121.7738 W, Elevation 9 ft). A map of the station location is shown in Figure 6. Photos of the station and its surroundings, taken February 27, 2013, are provided in Figure 7.

As shown in Figure 7 and Figure 6, the station is sited on a small area of poorly maintained grass. At the time of the field visit (and aerial image), an artichoke field was located immediately south of the station, with farm roads, a drain ditch, and an open agricultural field immediately north of the station. Conditions are similar to the east and west of the site.

There are no large obstructions in the immediate vicinity of the site, suggesting that wind speed measurements are not biased as may be the case for the Carmel CIMIS station. Additionally, the lack of well-watered, uniform vegetation cover similar to grass surrounding the site is not expected to substantially affect the measurement of incoming solar radiation, temperature, or relative humidity. In particular, the close proximity of the Pacific Ocean and resulting dominant influence of the marine layer during most days of the year on these parameters likely compensates for potential limitations in site characteristics.

A wind rose showing the direction and magnitude of hourly wind speed measured at the site between January 1, 2010 and December 31, 2012 indicates that the predominant wind direction is from the west, west, west southwest, and northwest (Figure 8), similar to the Carmel CIMIS site and reflecting the dominance of onshore wind from the Ocean. The wind speed at the site is significantly greater than for the Carmel CIMIS station.

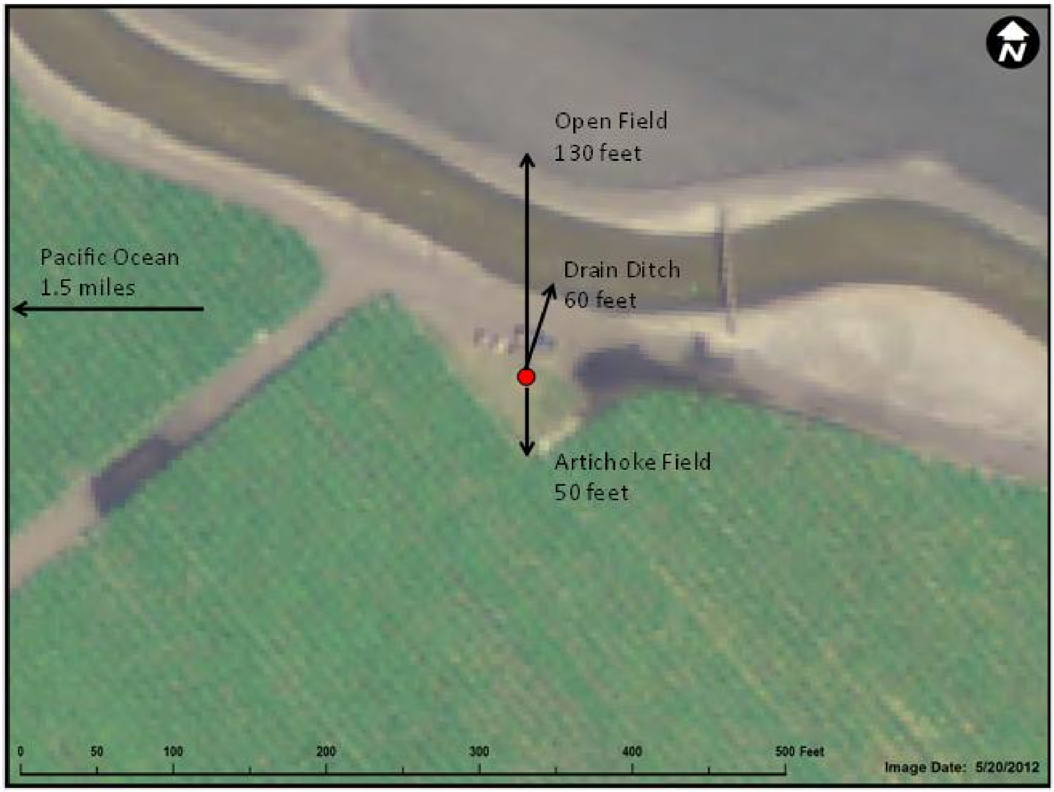

Figure 6. Castroville CIMIS Station Location and Surroundings.

Figure 7. Castroville CIMIS Station Surroundings.

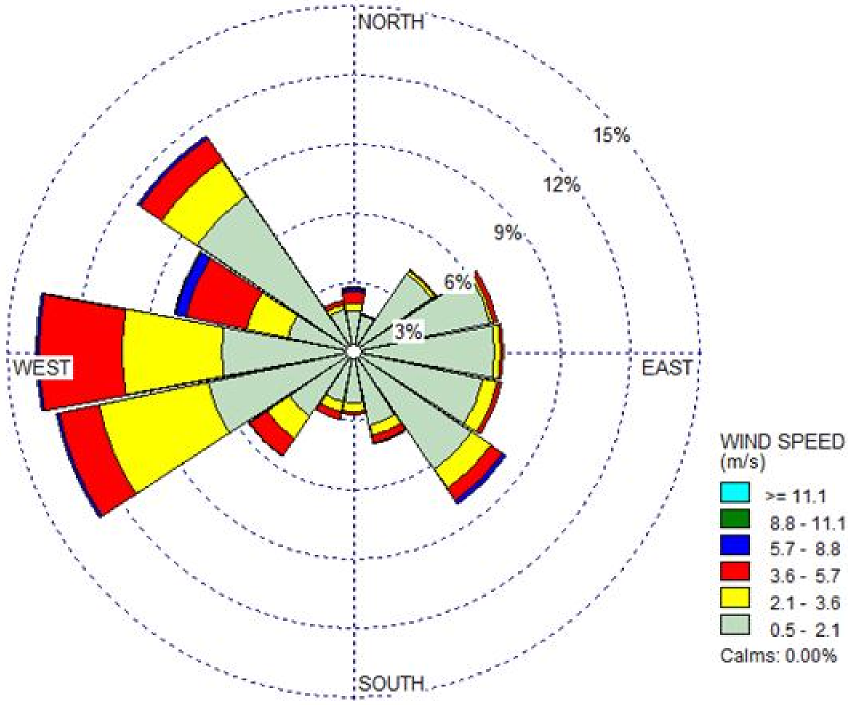

Figure 8. Castroville CIMIS Hourly Wind Rose, January 2010 through December 2012.

Site Maintenance

Both stations are maintained by CIMIS staff at the DWR South Central Division Office in Fresno. According to site maintenance personnel, site data are checked remotely each day, and the sites are inspected every four to six weeks. Some assistance is provided with maintenance of the Carmel CIMIS site by MPWMD. Sites inspection and maintenance practices include the following (Galyon, 2013):

- Check rain gage and clean as needed
- Check all four directions of wind vane
- Check anemometer (stop and confirm zero windspeed)
- Clean pyranometer and re-level as needed
- Pull out temperature/relative humidity sensor, clean, and replace as needed. The sensor is typically swapped out for recalibration annually.

Monterey GHCN

The Monterey GHCN station is located in Monterey (Latitude 36.5902 N, Longitude 121.9102 W, Elevation 385 feet), approximately 4 miles north of the Ranch. The station was established in 1906 and provides records of daily minimum and maximum temperature and precipitation. The station is operated and maintained by the National Weather Service (NWS).

Quality Control of Historical Data Used to Estimate Reference Evapotranspiration

Quality control procedures were applied to data used to estimate ET_o for each of the CIMIS weather stations based on the techniques described by Allen (1996), Snyder and Eching (2004), and Allen et al. (2005). The procedures applied are summarized as follows:

- Review weather station siting characteristics as related to estimation of ET_o
- Review of quality control flags assigned by CIMIS to the data and removal of records with missing values or for which estimated values are reported based on historical average conditions

- Solar radiation
  - Plot measurements of incoming solar radiation (R_s) against clear-sky solar radiation (R_{so}) for daily and hourly time steps.
  - Observe whether R_s reaches clear sky values some of the time, indicating proper sensor calibration.
  - For periods in which R_s routinely lies substantially above or below R_{so}, review hourly data for selected days. If review of hourly data supports the determination that the selected days were clear, adjust R_s for the period such that $R_s = R_{so}$ on the clearest days.
  - Following adjustment based on review of hourly data, if any daily values of Rs continue to exceed R_{so} (perhaps due to computational errors in determining daily Rs from hourly values), limit R_s on those days to R_{so}.
- Relative Humidity (RH)
  - Examine diurnal variation of hourly RH over time to verify that maximum and minimum values of RH occur at times of minimum and maximum temperature, respectively.
  - Identify RH values in excess of 100 percent, if any.
  - Identify prolonged periods where hourly maximum RH does not reach 95 to 100 percent. Adjust RH for the period such that maximum hourly values of RH approach 100 percent on the most humid days.
  - Identify minimum hourly RH values less than the one percentile historically observed value and adjust to the one percentile value[3].
- Air Temperature (T_{air})
  - Review daily air temperature values over time, and compare extreme values to nearby weather stations (e.g. NWS station at Monterey Peninsula Airport)
    - Adjust extreme values not supported by other nearby data through correlation to nearby stations.
  - Review hourly temperature data for days when the difference between average daily T_{air} calculated based on minimum and maximum hourly values differs by more than 3°C (5.4°F) from average daily T_{air} calculated based on hourly values.
  - Review hourly temperature data to confirm that minimum T_{air} tends to occur shortly before sunrise and that maximum T_{air} tends to occur in mid-afternoon.
- Wind Speed
  - Review daily wind speed over time, and identify periods of consistently low values, suggesting anemometer failure.
  - Calculate a gust factor (maximum hourly wind speed divided by mean daily wind speed) and review over time[4]. Increases in the gust factor suggest bearing friction. Seizing of the anemometer results in a gust factor of 1. Review hourly data for days with high or low gust factor.
  - Examine consistent wind speeds less than 2 miles per hour and flagged by CIMIS as being outside of historic range.
  - Replace suspect wind speed values with average historical values for the corresponding day of year.

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[3] This approach is similar to that described by Eching and Snyder (2004), but avoids the assumption of a normal distribution.

[4] Ideally, the gust factor is calculated based on the maximum recorded instantaneous gust over the course of a day; however, this information is not provided by CIMIS for the Carmel and Castroville stations.

A summary of adjustments to historical weather data for the Carmel CIMIS station is provided in Table 2. A summary of adjustments to historical weather data for the Castroville CIMIS station is provided in Table 3. Samples of weather parameters for each station are provided in Appendix A for the 2009 to 2012 period. Daily R_s and RH values prior to and following adjustment are shown. Although a relatively large number of daily values were adjusted for R_s and RH, such adjustments are not atypical and are generally small. For air temperature, daily minimum, maximum, and average values are shown in Appendix A, along with the difference between average daily T_{air} calculated based on minimum and maximum hourly from average daily T_{air} calculated based on individual hourly values. Daily wind speed measurements and gust factors for each station are also provided.

For the Monterey GHCN station, temperature and precipitation records were reviewed to identify extreme values. For the approximately 26-year period of record for the station used in the analysis (1/1/1987 to 9/30/2012), two daily records were found to contain extreme values, most likely due to user entry error.

Table 2. Summary of Adjustments to Daily Weather Parameters for Carmel CIMIS Station, 2009 to 2012.

	Incoming Solar Radiation[1]			Relative Humidity[2]			Air Temperature			Wind Speed		
Year	No. of Records	No. of Records Adjusted	Percent Adjusted	No. of Records	No. of Records Adjusted	Percent Adjusted	No. of Records	No. of Records Adjusted	Percent Adjusted	No. of Records	No. of Records Adjusted	Percent Adjusted
2009	361	266	74%	339	339	100%	341	0	0%	364	0	0%
2010	361	123	34%	343	343	100%	351	0	0%	365	0	0%
2011	365	12	3%	361	361	100%	361	0	0%	365	0	0%
2012	364	4	1%	344	344	100%	357	0	0%	365	0	0%
Overall	1,451	405	28%	1,387	1,387	100%	1,410	0	0%	1,459	0	0%

1. Adjustments to solar radiation, when warranted, are typically relatively small adjustments applied over a series of months.

2. Adjustments to minimum and maximum relative humidity were applied over extended periods of time. For the analysis presented herein, minimum and maximum relative humidity were increased between one and three percent based on review of daily maximum realtive humidity values over time.

Table 3. Summary of Adjustments to Daily Weather Parameters for Castroville CIMIS Station, 1987 to 2012.

Year	Incoming Solar Radiation[1]			Relative Humidity[2]			Air Temperature			Wind Speed		
	No. of Records	No. of Records Adjusted	Percent Adjusted	No. of Records	No. of Records Adjusted	Percent Adjusted	No. of Records	No. of Records Adjusted	Percent Adjusted	No. of Records	No. of Records Adjusted	Percent Adjusted
1987	361	229	63%	361	315	87%	361	0	0%	362	0	0%
1988	358	175	49%	347	135	39%	353	3	1%	349	0	0%
1989	333	119	36%	268	0	0%	349	0	0%	356	0	0%
1990	346	204	59%	295	155	53%	346	0	0%	285	0	0%
1991	311	301	97%	295	144	49%	321	6	2%	309	0	0%
1992	348	342	98%	338	163	48%	363	5	1%	363	0	0%
1993	354	273	77%	355	222	63%	359	7	2%	332	0	0%
1994	364	364	100%	363	0	0%	364	3	1%	364	0	0%
1995	359	330	92%	349	0	0%	356	3	1%	363	0	0%
1996	359	359	100%	353	0	0%	358	1	0%	366	0	0%
1997	356	192	54%	349	0	0%	356	2	1%	364	0	0%
1998	345	169	49%	347	0	0%	355	3	1%	331	0	0%
1999	353	159	45%	351	0	0%	352	0	0%	354	0	0%
2000	356	16	4%	355	110	31%	359	4	1%	365	0	0%
2001	337	29	9%	331	169	51%	335	4	1%	342	0	0%
2002	364	300	82%	348	0	0%	360	3	1%	365	0	0%
2003	361	172	48%	353	0	0%	356	3	1%	357	0	0%
2004	355	355	100%	351	0	0%	351	4	1%	366	0	0%
2005	363	220	61%	362	0	0%	357	2	1%	365	0	0%
2006	361	331	92%	336	244	73%	362	3	1%	365	0	0%
2007	364	145	40%	360	360	100%	361	1	0%	366	0	0%
2008	360	360	100%	352	352	100%	355	1	0%	366	0	0%
2009	352	287	82%	332	285	86%	336	1	0%	363	0	0%
2010	360	124	34%	358	345	96%	357	0	0%	365	0	0%
2011	360	5	1%	358	89	25%	361	0	0%	365	0	0%
2012	364	4	1%	352	219	62%	356	1	0%	342	0	0%
Overall	9,204	5,564	60%	8,919	3,307	37%	9,199	60	1%	9,190	0	0%

1. Adjustments to solar radiation are typically relatively small adjustments applied over a series of months.
2. Adjustments to minimum and maximum relative humidity are common and were applied over extended periods of time. Minimum and maximum relative humidity, when adjusted, were increased by four percent of the raw values on average based on review of daily maximum relative humidity values over time. These adjustments result in a slight reduction in estimated ET_o.

Estimation of Missing Data Used to Estimate Reference Evapotranspiration

Daily weather data missing from the CIMIS records or flagged due to sensor malfunction or other issues were estimated based primarily on the procedures described by Allen (1996) and Allen et al. (2005). A summary of missing records by station is provided in Tables 4 and 5 for the Carmel and Castroville weather stations, respectively.

Table 4. Summary of Missing Daily Weather Parameters for Carmel CIMIS Station, 2009 to 2012.

Year	Incoming Solar Radiation		Relative Humidity		Air Temperature		Wind Speed	
	Missing Records	Percent Missing	Missing Records	Percent Missing	Missing Records	Percent Missing	Missing Records	Percent Missing
2009	4	1%	26	7%	24	7%	1	0%
2010	4	1%	22	6%	14	4%	0	0%
2011	0	0%	4	1%	4	1%	0	0%
2012	2	1%	22	6%	9	2%	1	0%
Overall	10	1%	74	5%	51	3%	2	0%

Table 5. Summary of Missing Daily Weather Parameters for Castroville CIMIS Station, 1987 to 2012.

Year	Incoming Solar Radiation		Relative Humidity		Air Temperature		Wind Speed	
	Missing Records	Percent Missing	Missing Records	Percent Missing	Missing Records	Percent Missing	Missing Records	Percent Missing
1987	4	1%	4	1%	4	1%	3	1%
1988	8	2%	19	5%	13	4%	17	5%
1989	32	9%	97	27%	16	4%	9	2%
1990	19	5%	70	19%	19	5%	80	22%
1991	54	15%	70	19%	44	12%	56	15%
1992	18	5%	28	8%	3	1%	3	1%
1993	11	3%	10	3%	6	2%	33	9%
1994	1	0%	2	1%	1	0%	1	0%
1995	6	2%	16	4%	9	2%	2	1%
1996	7	2%	13	4%	8	2%	0	0%
1997	9	2%	16	4%	9	2%	1	0%
1998	20	5%	18	5%	10	3%	34	9%
1999	12	3%	14	4%	13	4%	11	3%
2000	10	3%	11	3%	7	2%	1	0%
2001	28	8%	34	9%	30	8%	23	6%
2002	1	0%	17	5%	5	1%	0	0%
2003	4	1%	12	3%	9	2%	8	2%
2004	11	3%	15	4%	15	4%	0	0%
2005	2	1%	3	1%	8	2%	0	0%
2006	4	1%	29	8%	3	1%	0	0%
2007	1	0%	5	1%	4	1%	-1	0%
2008	6	2%	14	4%	11	3%	0	0%
2009	13	4%	33	9%	29	8%	2	1%
2010	5	1%	7	2%	8	2%	0	0%
2011	5	1%	7	2%	4	1%	0	0%
2012	2	1%	14	4%	10	3%	24	7%
Overall	293	3%	578	6%	298	3%	307	3%

The procedures used to estimate missing data are summarized as follows:

- Solar radiation
  - Average daily R_s estimated based on average historical values for the corresponding day of year.
- Relative humidity
  - Minimum RH estimated based on maximum hourly air temperature as described by Allen et al. (2005).
  - Maximum RH estimated as 97 percent (average historical value).
  - Average daily RH estimated as average of minimum and maximum values.
- Air temperature
  - Minimum T_{air} estimated by correlation to Monterey Peninsula Airport NWS station.
  - Maximum T_{air} estimated by correlation to Monterey Peninsula Airport NWS station.
  - Average daily T_{air} estimated as average of minimum and maximum values.
- Wind speed
  - Average daily wind speed estimated based on average historical values for the corresponding day of year.

It was not necessary to estimate missing data for the Monterey GHCN weather station as it was used to estimate missing data for the CIMIS stations and to estimate daily precipitation at Carmel prior to 2009 (the period during which data from the Carmel CIMIS station were not available). Minimum and maximum daily air temperature and precipitation data were available for all days in which data from the station were required for the analysis.

Development and Parameterization of Daily Root Zone Water Balance Model

This section describes the development of the daily root zone water balance model used to estimate the following surface layer fluxes of water into and out of the root zone, along with the amount of stored applied water and precipitation within the root zone over time:

- Precipitation (Pr)[5];
- ET of applied water (ET_{aw}), portion of total crop ET (ET_c) derived from applied water;
- ET of precipitation (ET_{pr}), portion of total crop ET (ET_c) derived from precipitation;
- Runoff of precipitation (RO_{pr});
- Tailwater (TW), assumed to be zero;
- Applied Irrigation Water (AW);
- Subsurface Inflow and Outflow, assumed to be zero;
- Deep percolation of applied water (DP_{aw}); and
- Deep percolation of precipitation (DP_{pr}).

The model is implemented in Microsoft Excel and is consistent with typical root zone water balance models developed for irrigation scheduling purposes, such as described in FAO Irrigation and Drainage Paper No. 56: Crop Evapotranspiration (Allen et al. 1998). The model utilizes the dual crop coefficient approach of Allen et al. to estimate the portion of crop ET derived from crop transpiration (the “T” component of ET) and evaporation from the crop and soil surface (the “E” component of ET). A

[5] Estimated from local weather stations, as described previously.

conceptual diagram of the various surface layer fluxes of water into and out of the crop root zone is provided in Figure 9.

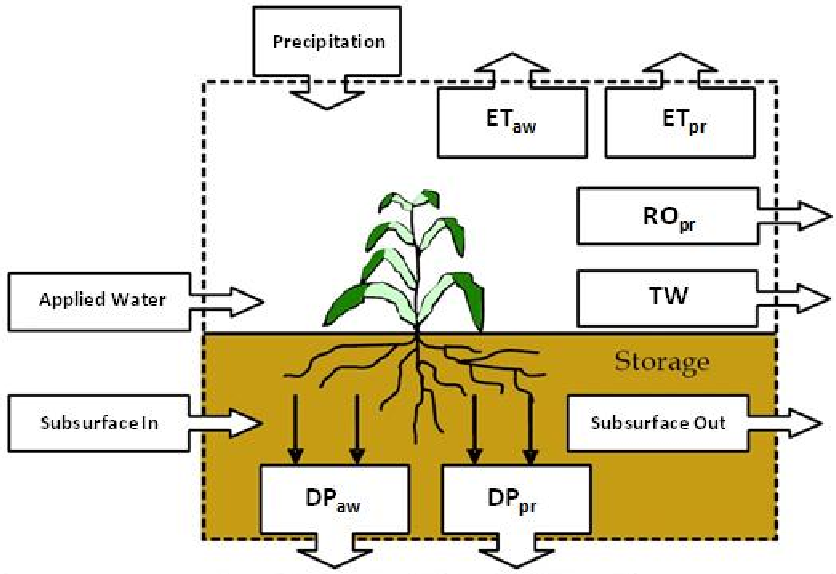

Figure 9. Conceptualization of Fluxes of Water Into and Out of the Crop Root Zone.

Similar to ET and DP, stored soil moisture is partitioned into stored precipitation and stored applied irrigation water. For each daily time step, the fraction of ET derived from precipitation or applied water is assumed to be proportional to the amount of stored precipitation or applied water in the root zone. Deep percolation of precipitation and applied water are calculated in the same manner.

Estimation of Daily Reference Evapotranspiration

Daily reference evapotranspiration (ET_o) was estimated based on quality-controlled weather data from CIMIS weather stations. As described previously, ET_o was calculated based on the ASCE Standardized Reference ET Equation for a short reference crop (ET_{os}, i.e., grass) (Allen et al., 2005). In order to estimate ET_o at the Ranch prior to the period of record for the Carmel CIMIS station, a correlation to ET_o at the Castroville CIMIS station was developed for the 2009 to 2012 period. The relationship between ET_o at the two stations used to estimate historical ET_o at Carmel is shown in Figure 10. Summary statistics of mean daily ET_o by month for the 1987 to 2012 analysis period are provided in Table 6, along with summary statistics of annual total ET_o.

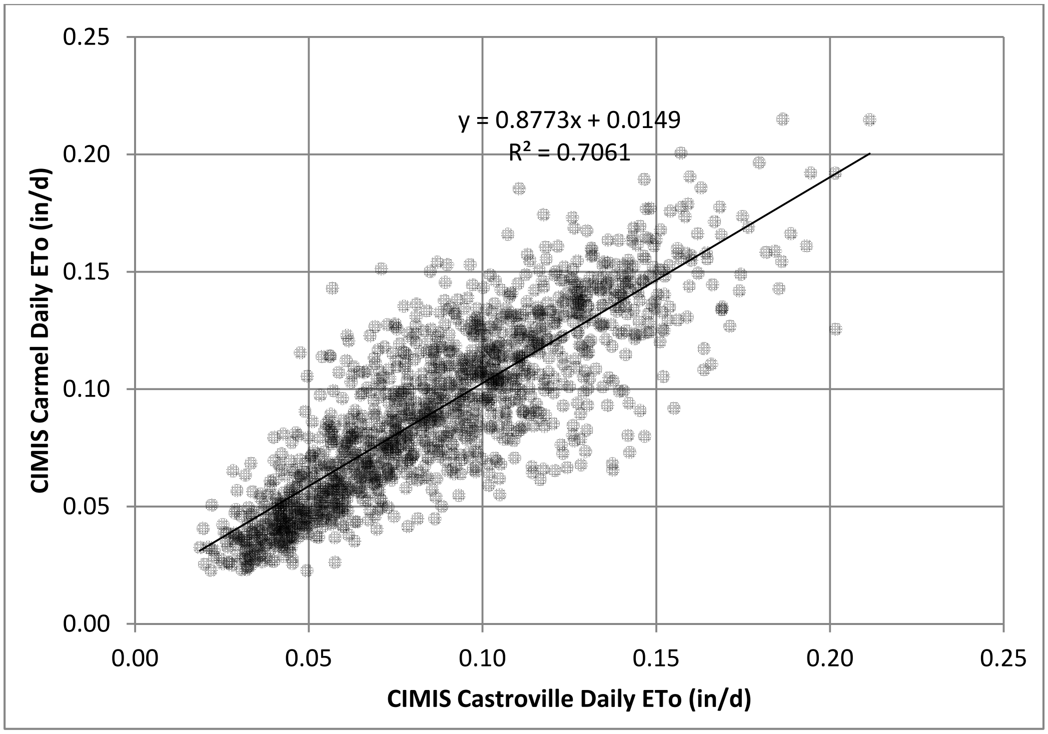

Figure 10. Linear Regression to Estimate ET_o at Carmel from ET_o at Castroville CIMIS.

Table 6. Summary Statistics of Estimated Mean Daily and Annual ET_o at Carmel, 1987 to 2012.

Statistic	Mean Daily ETo by Month (in/d)												Annual ETo (in)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
No. of Months	26	26	26	26	26	26	26	26	26	26	26	26	
Minimum	0.04	0.05	0.07	0.09	0.11	0.11	0.09	0.08	0.08	0.06	0.05	0.04	30.56
Maximum	0.08	0.10	0.11	0.14	0.14	0.15	0.13	0.12	0.11	0.09	0.08	0.08	36.60
Mean	0.06	0.07	0.09	0.11	0.12	0.13	0.11	0.10	0.09	0.08	0.07	0.06	33.10
Median	0.06	0.07	0.09	0.11	0.12	0.12	0.11	0.10	0.09	0.08	0.06	0.06	33.07
Standard Deviation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1.42

Estimation of Daily Precipitation

Daily precipitation at the Ranch was estimated based on precipitation records from the Carmel CIMIS station for the period from January 2009 to December 2012. According to staff at the Monterey Peninsula Water Management District (MPWMD), there were issues initially with sprinklers at the station site leading to overestimation of precipitation through early 2009 (Christensen, 2013). Based on review of hourly precipitation records, it was confirmed that the precipitation gage was affected by sprinklers in portions of October 2008, November 2008, and April 2009. These records were corrected based on correlation to precipitation records reported for the Monterey GHCN station for the period of overlap. Precipitation at Carmel prior to 2009 was estimated using the same correlation. The results of the linear regression to correlate precipitation at Carmel to the Monterey GHCN station is provided in Figure 11. Note that the correlation was performed using mean daily precipitation amounts by month to compensate for potential differences in the timing of recording precipitation between the stations[6]. The intercept of the regression was forced to be zero based on the assumption that rainfall occurred on the same day at each station.

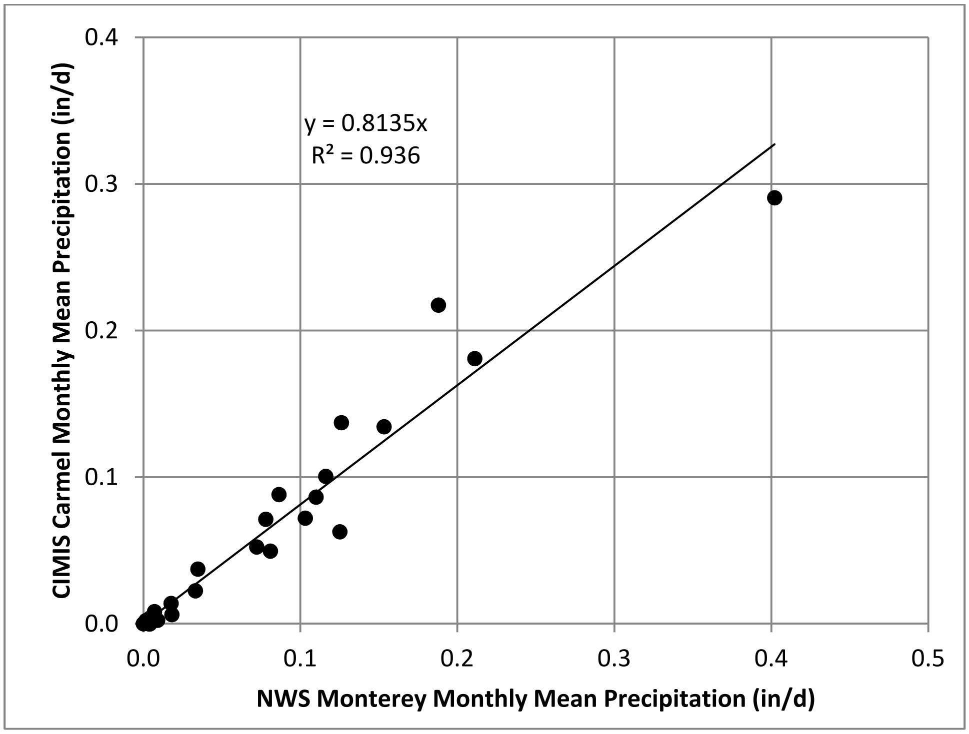

Figure 11. Linear Regression to Estimate Daily Precipitation at Carmel from Precipitation at Monterey GHCN Station.

Summary statistics of total precipitation by month are provided in Table 7, along with summary statistics by year for the 26-year analysis period.

Table 7. Summary Statistics of Estimated Monthly and Annual Precipitation at Carmel, 1987 to 2012.

Statistic	Precipitation by Month (in)												Annual Precip. (in)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
No. of Months	26	26	26	26	26	26	26	26	26	26	26	26	
Minimum	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	9.2
Maximum	8.6	11.6	6.7	4.1	2.2	1.3	0.2	0.2	0.8	3.6	6.1	6.5	33.4
Mean	3.5	3.3	2.4	1.2	0.5	0.2	0.0	0.1	0.1	0.8	1.4	2.9	16.4
Median	2.8	2.8	2.3	0.8	0.4	0.1	0.0	0.0	0.0	0.4	1.4	2.8	16.3
Standard Deviation	2.5	2.6	1.9	1.0	0.5	0.3	0.0	0.1	0.2	1.0	1.2	1.9	5.4

Estimation of Soil Hydraulic Parameters

Root zone parameters that influence the amount of available soil moisture storage were estimated based on soils present at the Ranch. Soil hydraulic parameters of interest include field capacity (% by

[6] The recorded time of observation at the Monterey GHCN station is 1800 hours, while the CIMIS precipitation totals are for the period from midnight to midnight. Only months with at least 15 days of coincident data for the two stations were used for the analysis.

vol.), available waterholding capacity (in/ft), wilting point (% by vol.), depth of evaporable water (z), readily evaporable water (REW), and total evaporable water (TEW). Estimated root zone soil parameters and sources of the estimates are summarized in Table 8.

Table 8. Estimated Root Zone Soil Parameters and Estimation Sources.

Parameter	Value	Units	Source
Field Capacity	20	% by vol.	Saxton and Rawls (2006) based on sand and clay percentages from NRCS soil survey of Monterey County
Available Waterholding Capacity	14	% by vol.	NRCS soil survey of Monterey County.
	1.68	in/ft	
Wilting Point	6	% by vol.	Field Capacity - Wilting Point
Depth of Evaporable Water	4	inches	Approximately 0.1 meter, per Allen et al. (1998)
Total Evaporable Water	17	% by vol.	Field Capacity - 0.5*Wilting Point, per Allen et al. (1998)
	0.68	inches	TEW (%) * Depth of Evaporable Water
Readily Evaporable Water	8	% by vol.	Allen et al. (1998) (Table 19)
	0.32	inches	REW (%) * Depth of Evaporable Water

Estimation of Crop Parameters

Crop parameters of interest include basal crop coefficients, root depth, NRCS curve number[7], soil moisture depletion fraction at the onset of water stress, and crop height following grazing and at full cover.

Basal crop coefficients were estimated to be 0.5 following grazing and 1.1 at effective full cover for pasture in arid environments with moderate winds based on NRCS Part 623 National Engineering Handbook (NEH) Chapter 2 (NRCS, 1993). Typical re-growth periods for grass pasture are expected to be 7 to 10 days in typical irrigated settings. For the Odello Ranch, which is located in a coastal environment, it is assumed that re-growth to effective full cover will require approximately 14 days. It is assumed that grazing will begin in February and continue through November, resulting in seven grazings on a typical paddock. The resultant estimated basal crop coefficients for a typical paddock with grazing beginning in early March and ending in mid-November year are shown in Figure 12. As indicated, the basal crop coefficient is assumed to decrease from 1.1 to 0.5 over the course of a seven day grazing and then increases from 0.5 to 1.1 over the 14-day re-growth period. The paddock remains at full cover for the remaining 21 days prior to start of the next grazing cycle. For purposes of applying the daily root zone water balance model for the 26-year analysis period, the basal crop coefficients for the typical paddock shown in Figure 12 are considered representative of the Ranch as a whole.

[7] The curve number runoff estimation method developed by the Natural Resources Conservation Service (NRCS) was used to estimate runoff from precipitation in the model. For additional information, see NRCS NEH Part 630 Chapters 9 and 10 (NRCS, 2004) and Schroeder et al. (1994).

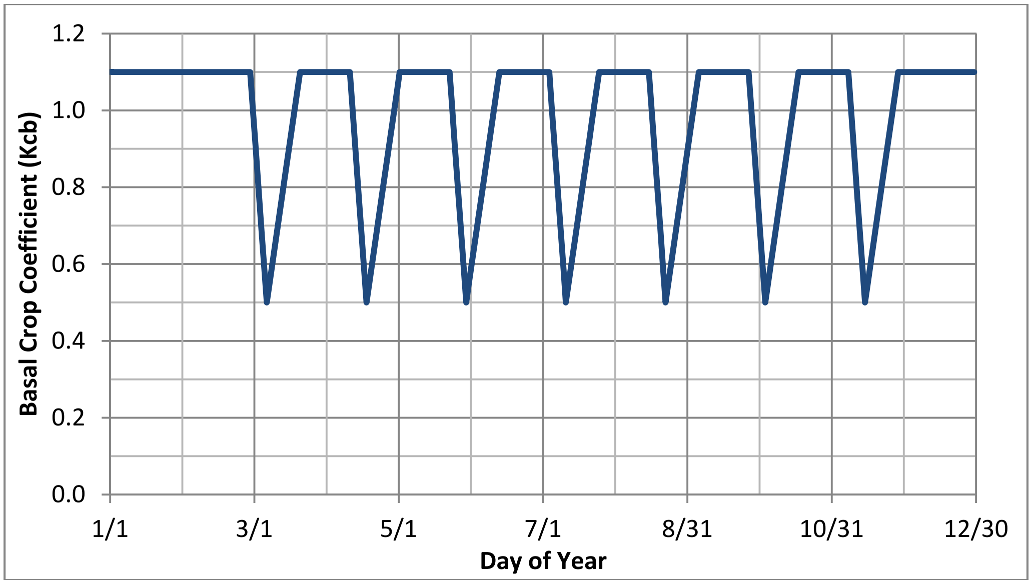

Figure 12. Estimated Basal Crop Coefficients for Typical Paddock with Rotational Grazing.

Root depth was estimated to be 2.5 feet based on observed rooting depths determined by soil augering performed during the field visit conducted February 27, 2013 and is consistent with published root depths for pasture as described by Allen et al. (1998).

The curve number used to estimate runoff of precipitation was selected as 61 based on NRCS (2004), which is equivalent to the curve number for pasture in good hydrologic condition and soils of hydrologic group B (applies to Pico Fine Sandy Loam based on Cook, 1978).

The soil moisture depletion fraction at the onset of water stress (p) was estimated to be 0.6 or 60% of total available water based on Allen et al. (1998).

Estimation of Sprinkler Application Efficiency and Tailwater Production

The application efficiency of the existing sprinkler system reflects a combination of the distribution uniformity of the sprinkler system and the ability of Ranch personnel to accurately and precisely estimate irrigation requirements at the time of irrigation. When irrigating for full crop production, as is the objective of irrigation at the Ranch, the maximum application that can be theoretically achieved is the distribution uniformity of the irrigation system. In practice, perfect knowledge of irrigation requirements is not available, and application efficiency is typically less than distribution uniformity.

For the Odello Ranch, the application efficiency was estimated to be 65 percent, which is consistent with typical distribution uniformities and application efficiencies reported for sprinklers by Leutzow (1994), ITRC (2003), and Canessa et al. (2011). Leutzow reported an average distribution uniformity for sprinklers of 67 percent based on data collected by the Monterey County Water Resources Agency and the University of California Cooperative Extension between 1990 and 1992. The average distribution uniformity based on ITRC data for distribution uniformity evaluations conducted in California between 1997 and 2002 for 63 sprinkler systems was 61 percent. Canessa et al. compiled the results of additional studies and reported minimum typical application efficiencies for sprinklers of 70 percent.

Due to the use of sprinkler irrigation, moderate slopes at the Ranch, and expected soil infiltration rates that are greater than the application rate of the system, tailwater production is assumed to be zero.

Estimated Irrigation Requirements

Based on irrigation practices at the Ranch, it is assumed that irrigation will occur at regular pre-defined intervals and that the soil will be returned to the field capacity moisture content at each irrigation event. Irrigation will begin in mid January to supplement precipitation and increase in frequency from once every three weeks to once weekly after the start of grazing, with the exception that paddocks being grazed in a given week will not be irrigated to avoid wet soil compaction and crop and sprinkler damage by the cattle. The sprinklers will be removed prior to grazing and reinstalled for irrigation immediately following grazing to stimulate re-growth. An irrigation calendar for a typical paddock grazed from early March to mid-November is provided in Table 9. Irrigation hours for the sprinkler irrigation system and corresponding applied water amounts represent mean values based on the 26-year root zone water balance simulation. Annual results are summarized in the following section.

Table 9. Irrigation Calendar for Typical Paddock.

Date	Days Since Last Irrigation	Irrigation Amount*	
		Hours	Inches
18-Jan	29	5.4	1.0
8-Feb	21	5.1	1.0
22-Feb	14	3.2	0.6
8-Mar	14	3.7	0.7
15-Mar	7	3.2	0.6
22-Mar	7	3.3	0.6
29-Mar	7	3.4	0.6
5-Apr	7	4.5	0.8
19-Apr	14	8.0	1.5
26-Apr	7	4.5	0.8
3-May	7	5.9	1.1
10-May	7	6.0	1.1
17-May	7	5.7	1.1
31-May	14	10.6	2.0
7-Jun	7	5.7	1.1
14-Jun	7	6.8	1.3
21-Jun	7	6.5	1.2
28-Jun	7	6.5	1.2
12-Jul	14	11.5	2.1
19-Jul	7	5.6	1.0
26-Jul	7	6.0	1.1
2-Aug	7	5.6	1.0
9-Aug	7	5.7	1.1
23-Aug	14	10.0	1.9
30-Aug	7	5.3	1.0
6-Sep	7	5.6	1.0
13-Sep	7	5.2	1.0
20-Sep	7	4.8	0.9
4-Oct	14	8.1	1.5
11-Oct	7	4.4	0.8
18-Oct	7	4.2	0.8
25-Oct	7	3.4	0.6
1-Nov	7	3.3	0.6
15-Nov	14	3.1	0.6
29-Nov	14	3.7	0.7
20-Dec	21	3.3	0.6
	TOTALS	196.8	36.7

* Based on average amounts over 26-year analysis period from 1987 to 2012.

Root Zone Water Balance Model Results

Annual and Daily Results

Results of the daily root zone water balance analysis are provided on a calendar-year basis for the period from 1987 to 2012 in Table 10. Specifically, the results include precipitation (net of runoff of precipitation, which is generally negligible), applied irrigation water, total crop ET, crop ET of precipitation, and crop ET of applied water. Results are reported as a flux depth (inches) and as total acre-feet for the approximately 40.6-acre irrigated area. To estimate flux volumes for the Ranch as a whole, flux depths calculated in inches for the typical paddock were converted to feet and multiplied by the irrigated area to provide volume estimates in acre-feet. For any given year, the modeled amount of water applied was limited to the Ranch's water right of 131.8 acre-feet. This was accomplished in the model by tracking applied water on a daily basis over time and limiting the cumulative applied water within a calendar year to the water right limit of 131.8 acre-feet (equivalent to 39.0 inches of depth over the full irrigated area).

Table 10. Summary of Root Zone Water Balance Analysis Results, 1987 to 2012.

	Precipitation		Applied Water		Evapotranspiration		ET of Precipitation		ET of Applied Water	
Year	inches	acre-feet	inches	acre-feet	inches	acre-feet	inches	acre-feet	inches	acre-feet
1987	13.1	44.2	35.5	120.0	33.1	112.0	8.5	28.6	24.6	83.4
1988	10.1	34.1	39.0	131.8	33.9	114.6	6.4	21.7	27.4	92.8
1989	10.0	33.9	39.0	131.8	36.2	122.5	8.5	28.8	27.7	93.7
1990	10.8	36.5	38.2	129.4	37.2	126.0	8.0	27.1	29.2	98.9
1991	13.4	45.2	39.0	131.8	34.7	117.6	7.4	25.0	27.3	92.5
1992	16.3	55.0	39.0	131.8	37.4	126.6	9.0	30.5	28.4	96.1
1993	22.0	74.5	38.6	130.6	36.5	123.5	10.8	36.7	25.7	86.8
1994	12.5	42.4	37.9	128.3	34.2	115.8	7.7	25.9	26.6	89.9
1995	20.4	68.9	36.4	123.1	33.9	114.6	10.8	36.5	23.1	78.1
1996	24.0	81.3	33.7	113.9	33.5	113.4	10.6	35.8	22.9	77.6
1997	17.4	59.0	39.0	131.8	34.7	117.2	7.9	26.8	26.7	90.4
1998	33.0	111.6	27.2	91.9	32.1	108.7	14.2	48.1	17.9	60.7
1999	13.7	46.2	35.1	118.8	32.5	109.9	9.2	31.1	23.3	78.8
2000	19.7	66.5	35.3	119.4	33.7	113.9	10.0	33.7	23.7	80.2
2001	19.0	64.4	35.8	121.0	34.2	115.7	8.9	30.1	25.3	85.6
2002	12.8	43.2	38.2	129.1	34.3	116.1	8.2	27.8	26.1	88.4
2003	14.3	48.3	37.5	126.7	35.5	120.2	9.3	31.4	26.2	88.8
2004	16.2	55.0	36.8	124.6	33.8	114.3	8.8	29.8	25.0	84.5
2005	20.1	68.0	32.1	108.7	32.9	111.3	11.7	39.6	21.2	71.8
2006	19.5	65.9	33.1	112.0	34.9	118.0	12.1	41.0	22.8	77.0
2007	9.2	31.2	38.1	129.1	34.5	116.8	7.4	24.9	27.1	91.9
2008	13.5	45.5	38.7	130.8	34.0	115.0	6.7	22.8	27.3	92.2
2009	16.2	54.7	39.0	131.8	34.9	118.0	9.2	31.0	25.7	87.0
2010	21.1	71.5	34.1	115.4	33.6	113.8	10.3	34.7	23.4	79.0
2011	16.1	54.4	38.3	129.7	34.6	117.1	10.5	35.5	24.1	81.6
2012	11.0	37.2	39.0	131.8	34.8	117.8	5.7	19.5	29.1	98.3
Minimum	9.2	31.2	27.2	91.9	32.1	108.7	5.7	19.5	17.9	60.7
Maximum	33.0	111.6	39.0	131.8	37.4	126.6	14.2	48.1	29.2	98.9
Mean	16.4	55.3	36.7	124.0	34.4	116.6	9.1	30.9	25.3	85.6
Median	16.1	54.6	38.0	128.7	34.3	116.0	8.9	30.3	25.7	86.9

Annual crop ET_{aw} varies between approximately 60.7 and 98.9 acre-feet and averages 85.6 acre-feet over the period of analysis. Annual applied water varies between approximately 91.9 and 131.8 acre-feet (the water right limit) and averages approximately 124.0 acre-feet. The full water right of 131.8 acre-feet would not have been used in 19 of 26 years (73 percent of the time) of the modeled period due to the contribution of precipitation to crop water requirements to maintain full ET.

Estimates of annual applied water, precipitation minus runoff, and ET_{aw} are shown graphically in Figure 13. Detailed daily results of the analysis are shown in Figures 14, 15, and 16 for wet, typical, and dry years based on precipitation amounts, respectively.

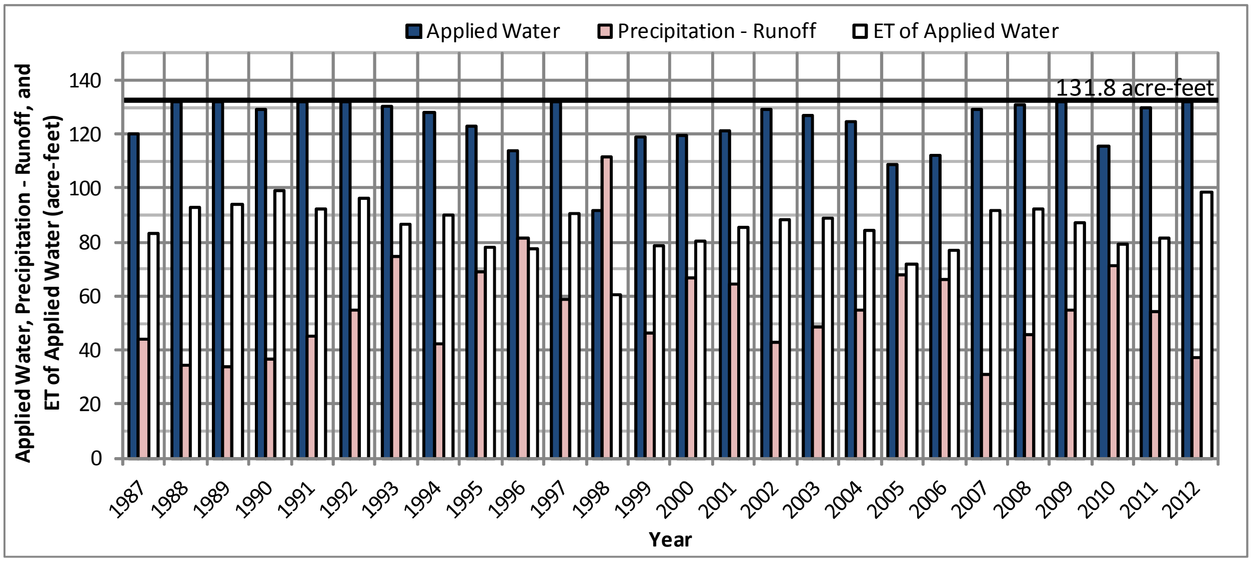

Figure 13. Estimates of Annual Applied Water, Precipitation minus Runoff, and ET_{aw}, 1987 to 2012.

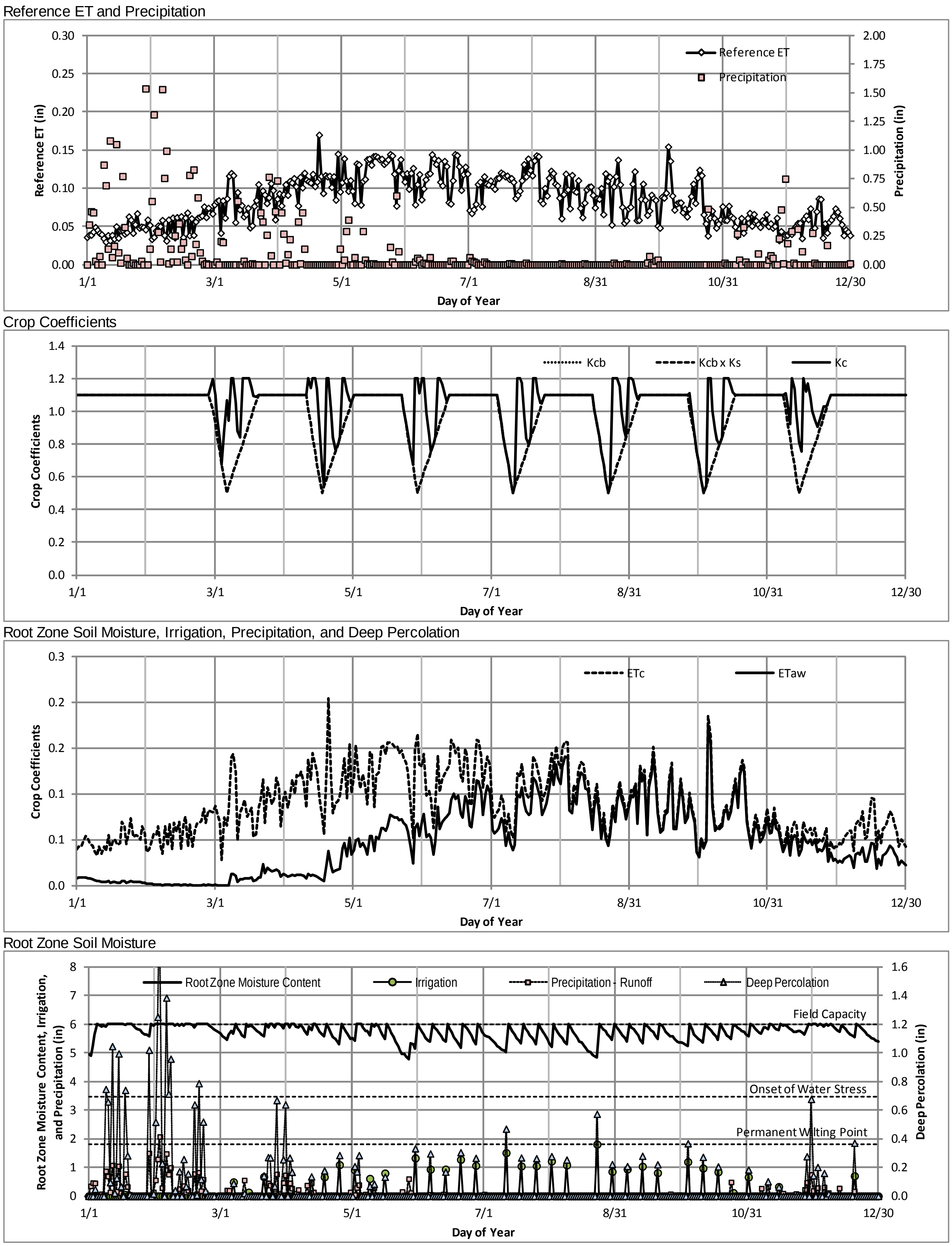

Figure 14. Root Zone Water Balance Analysis Results for Wet Year (1998).

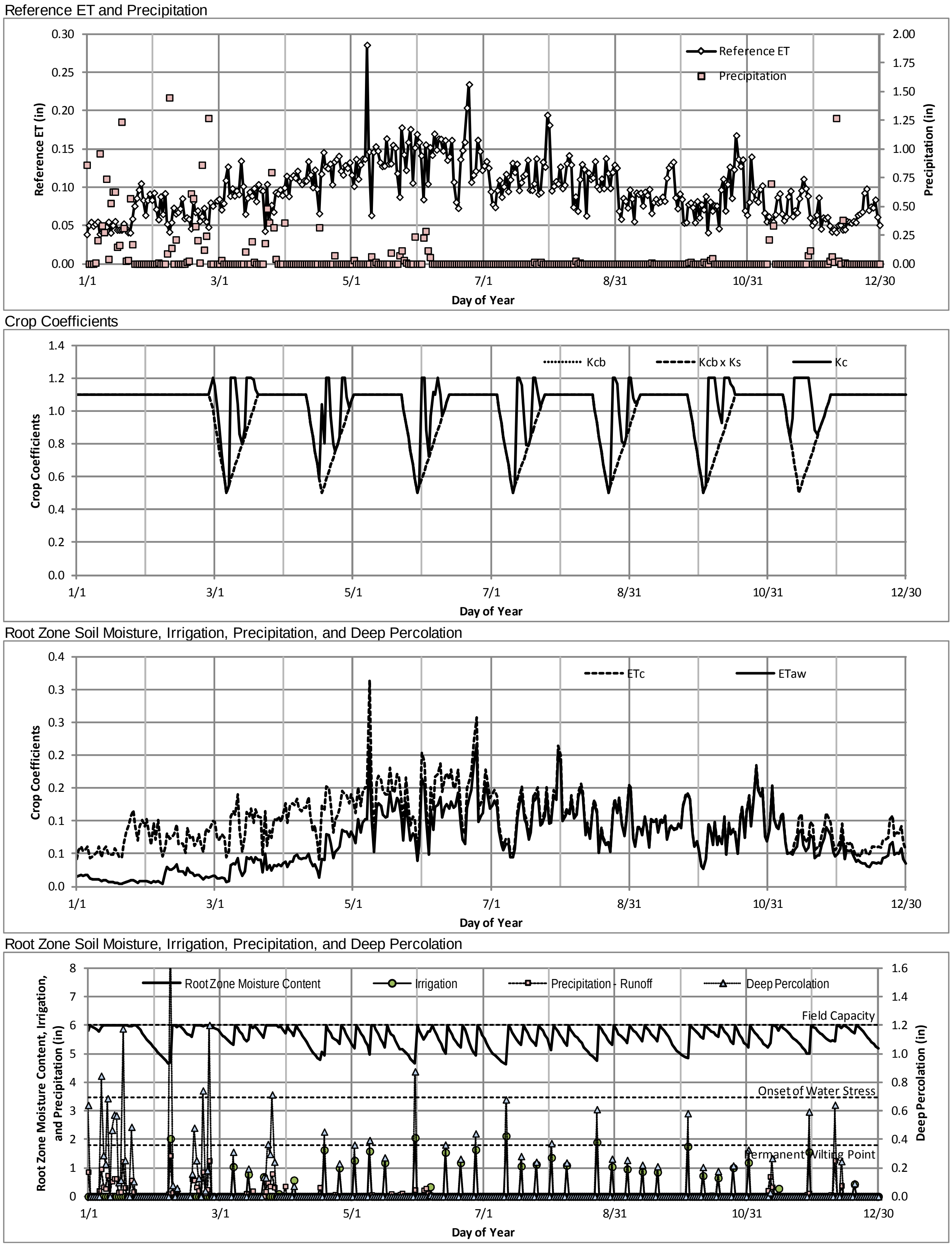

Figure 15. Root Zone Water Balance Analysis Results for Typical Year (1993).

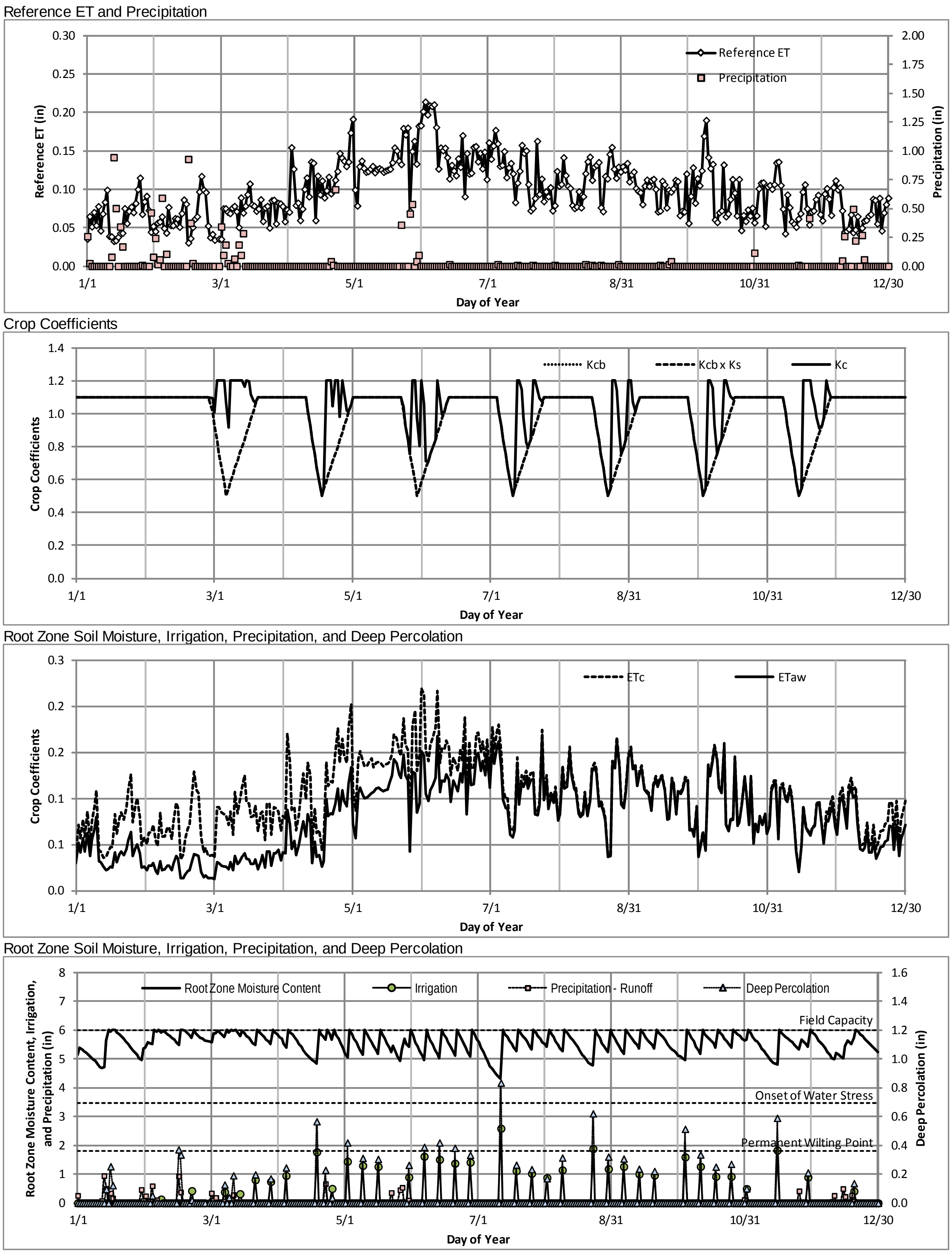

Figure 16. Root Zone Water Balance Analysis Results for Dry Year (1990).

Estimation of Monthly Applied Water and ET_{aw} Volumes

Long-term mean monthly volumes of applied water and ET_{aw} were estimated based on mean annual volumes from Table 10 and the percent of annual ET_{aw} occurring in each month, developed from a composite run of the daily root zone water balance model reflecting the combined effect of grazing on all six paddocks, each with a grazing cycle offset by one week. It is expected that the long-term mean monthly applied water volumes will be approximately proportional to monthly ET_{aw} volumes. Monthly estimates of applied water volumes are presented in Table 11, along with the estimated percentage of ET_{aw} and the corresponding ET_{aw} volume for each month.

Table 11. Estimated Long-Term Mean Monthly Applied Water and ET_{aw}.

Month	Applied Water (ac-ft)[1]	Monthly ET_{aw} Percentage[2]	Estimated Monthly ET_{aw} (ac-ft)[3]
January	4.1	3.3%	2.8
February	4.2	3.4%	2.9
March	5.8	4.7%	4.0
April	9.3	7.5%	6.4
May	13.6	11.0%	9.4
June	16.0	12.9%	11.0
July	16.0	12.9%	11.1
August	15.6	12.6%	10.8
September	13.8	11.1%	9.5
October	12.2	9.8%	8.4
November	8.0	6.5%	5.5
December	5.5	4.4%	3.8
TOTAL	124.0	100.0%	85.6

1. Estimated long-term monthly average applied irrigation water from Table 6, distributed by month.

2. Percent of long term annual ETaw by month for composite model run.

3. Estimated long-term monthly average ETaw from Table 6, distributed by month.

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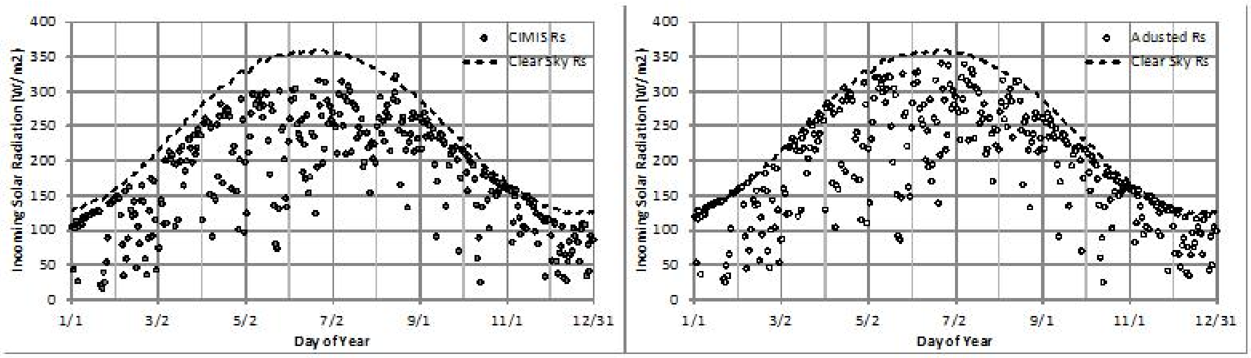
Appendix A: Sample Weather Parameters, 2009 to 2012

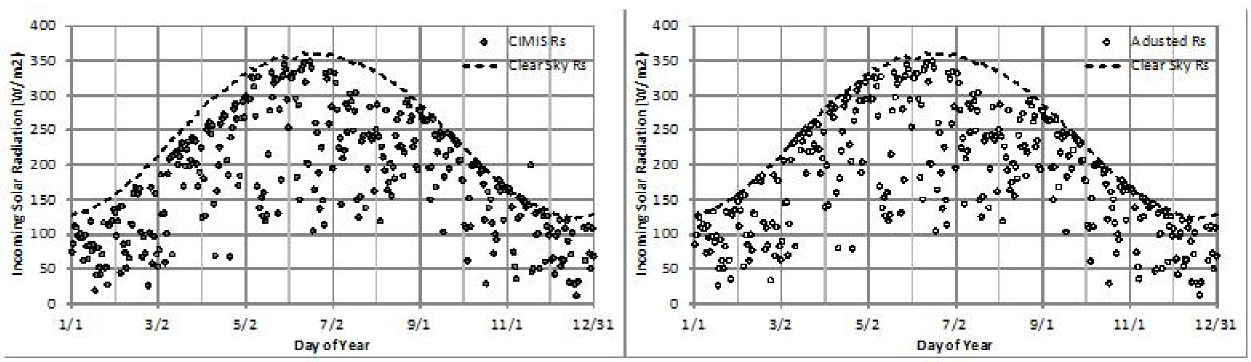
Solar Radiation (Prior to and Following Adjustment)

Carmel

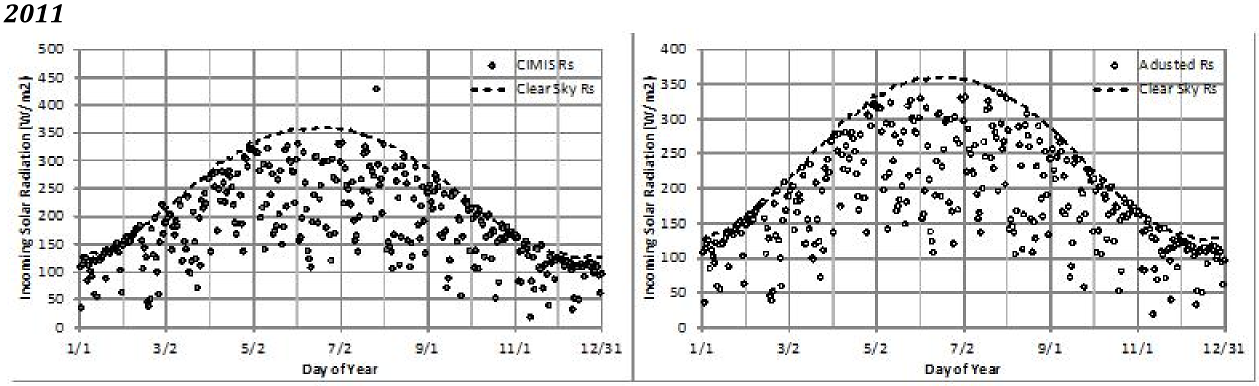
2009



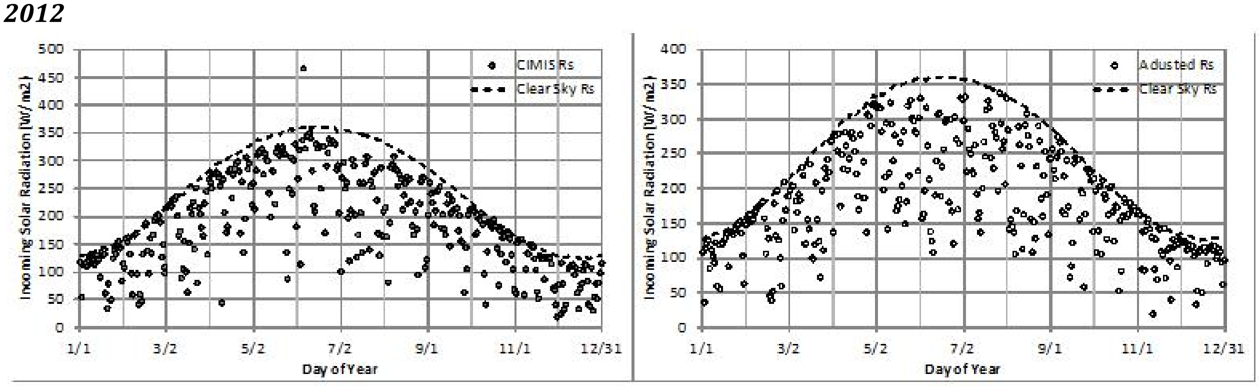
2010



2011

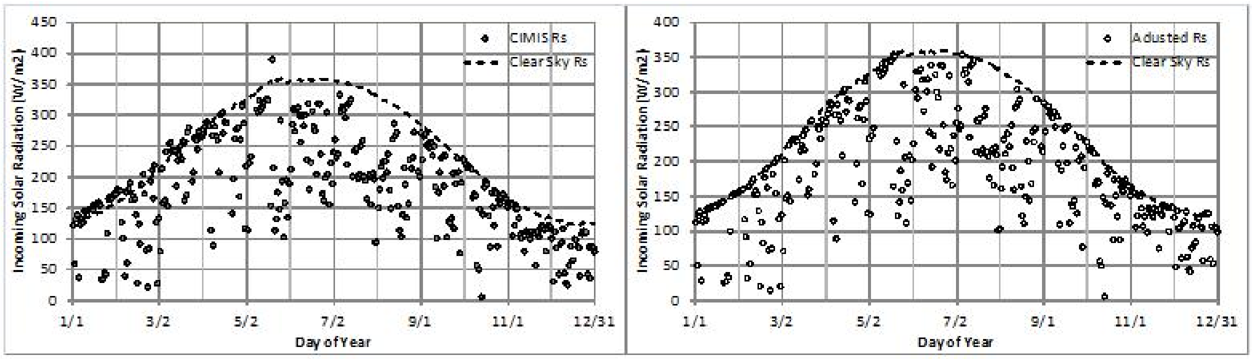


2012

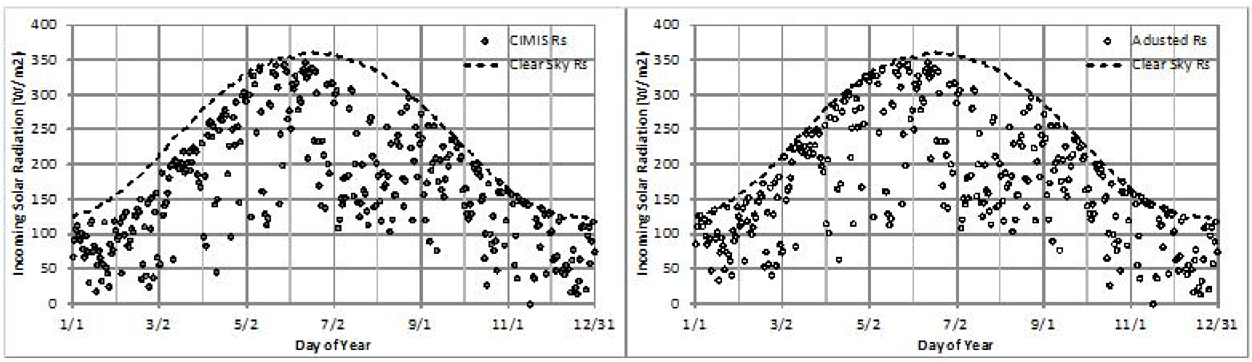


Castroville

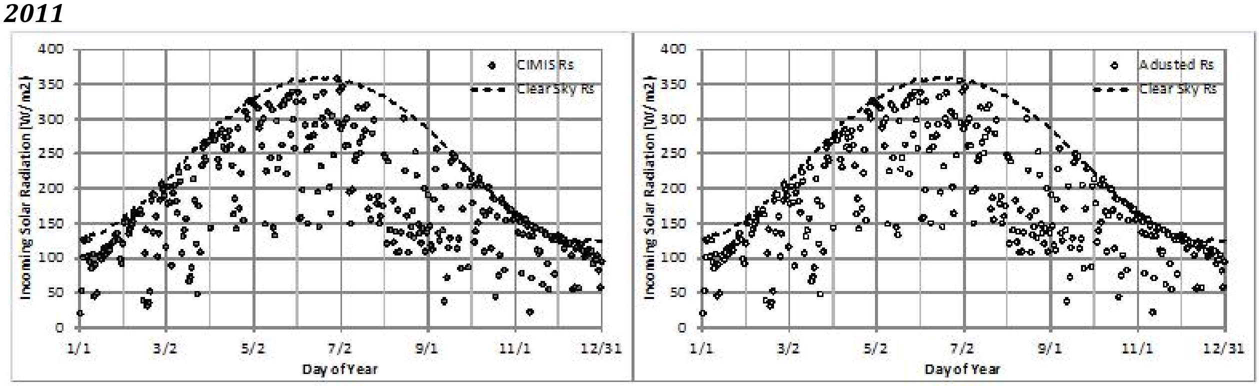
2009



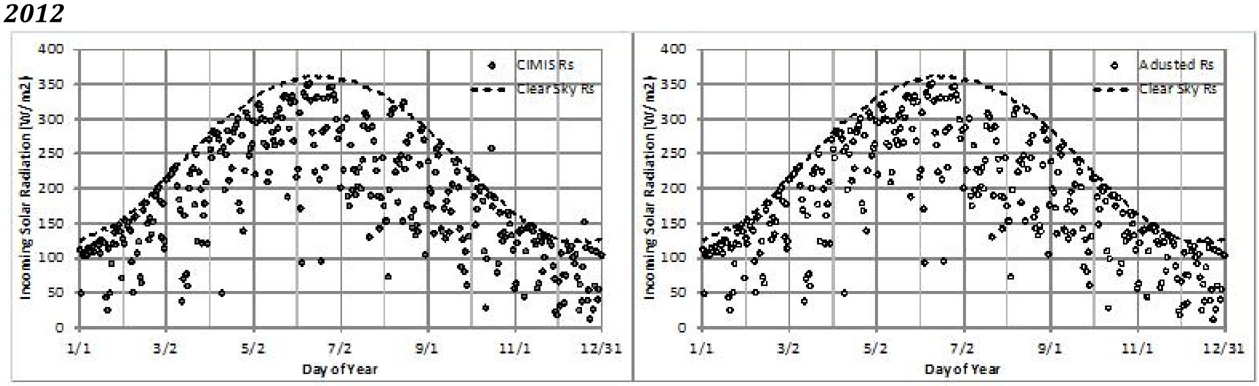
2010



2011



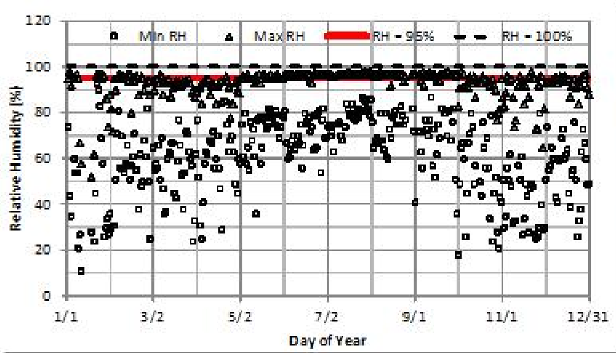
2012

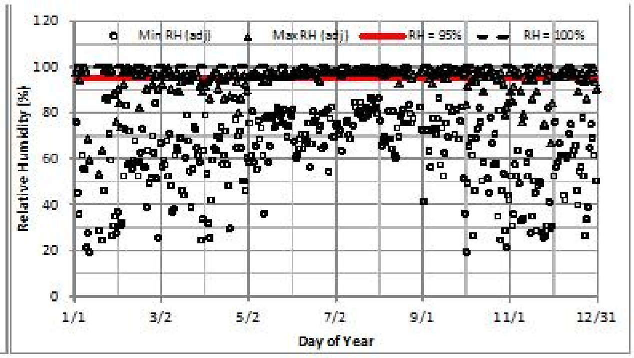


Relative Humidity (Prior to and Following Adjustment)

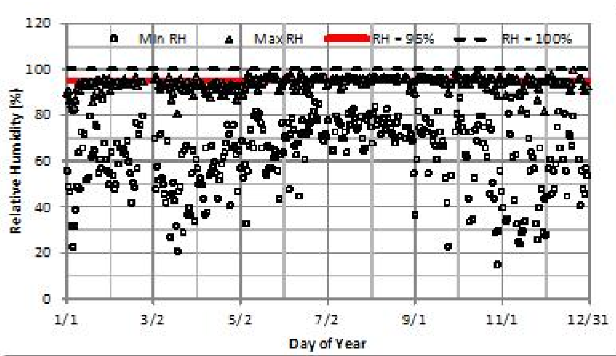
Carmel

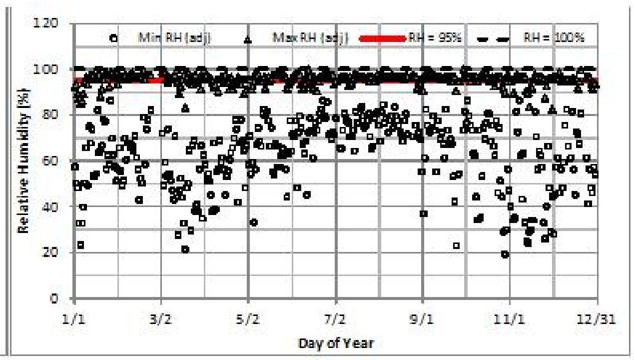
2009



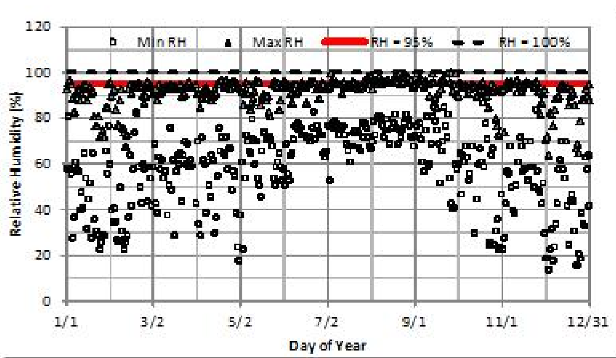


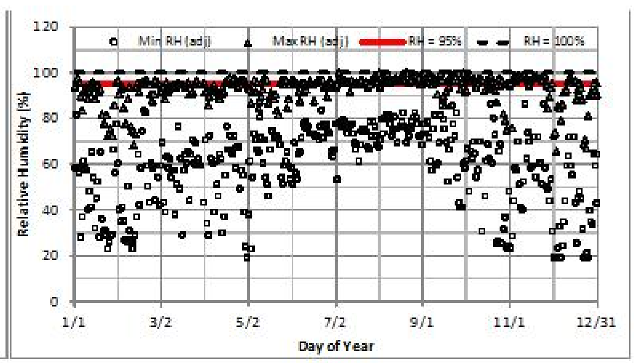
2010



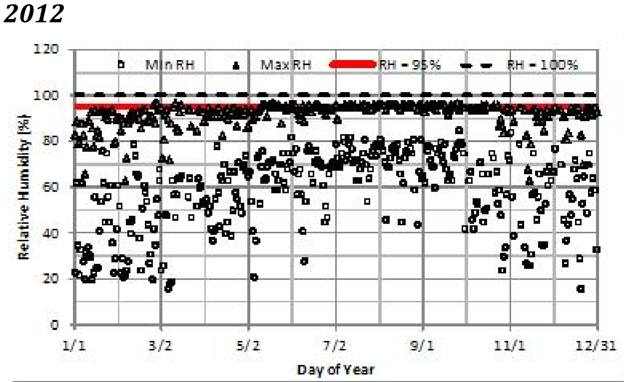


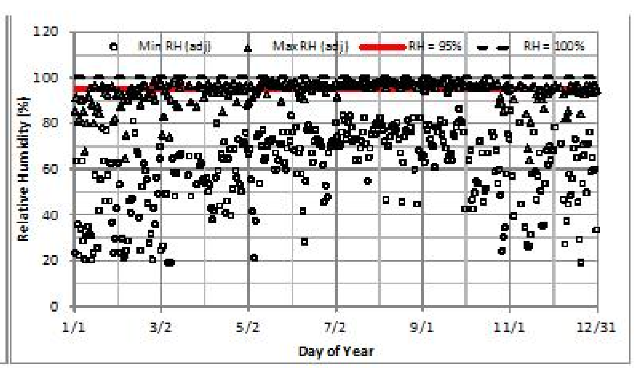
2011





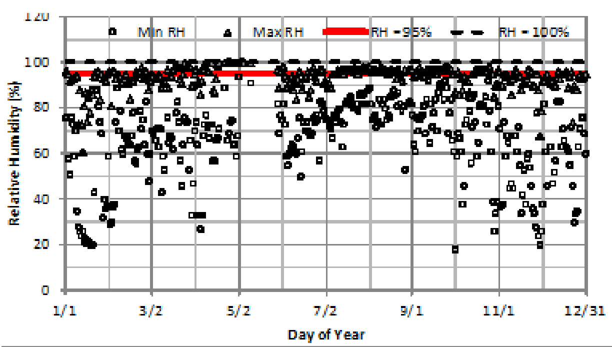
2012

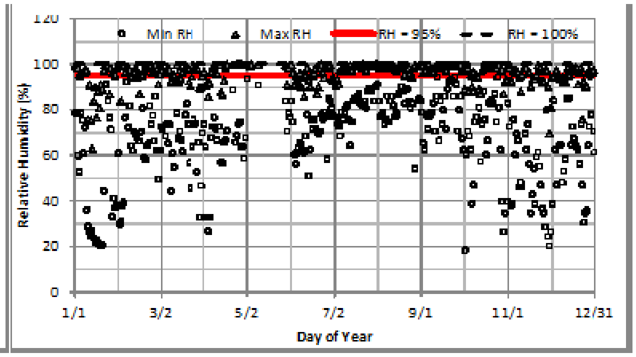




Castroville

2009





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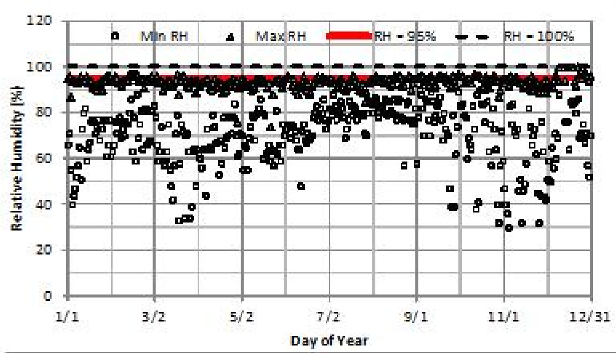

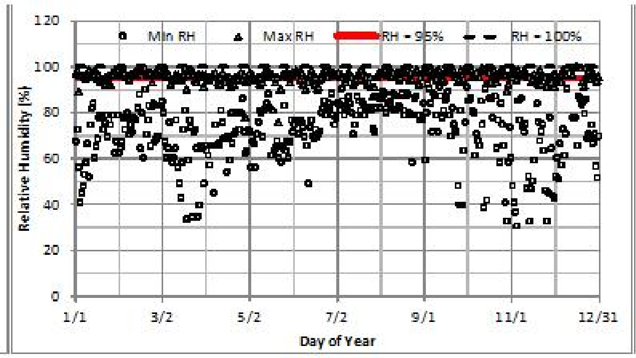

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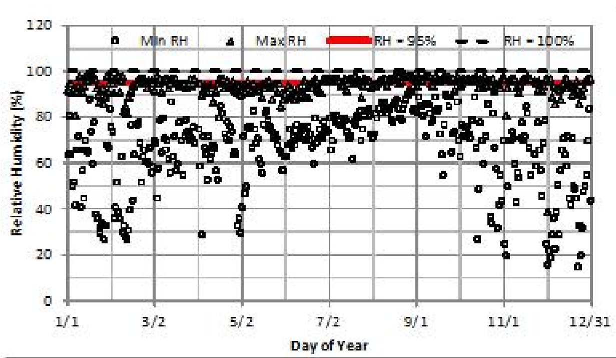

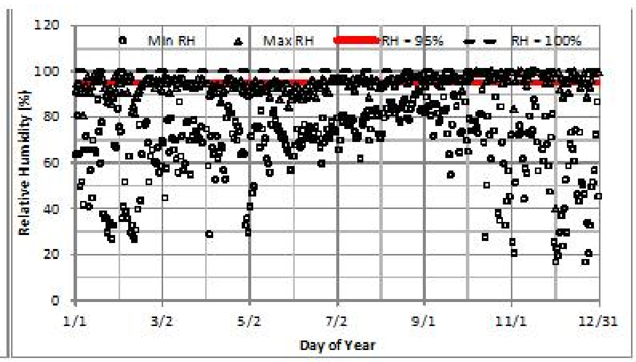

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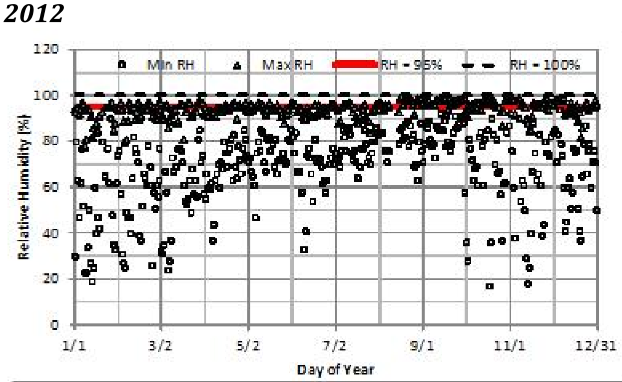
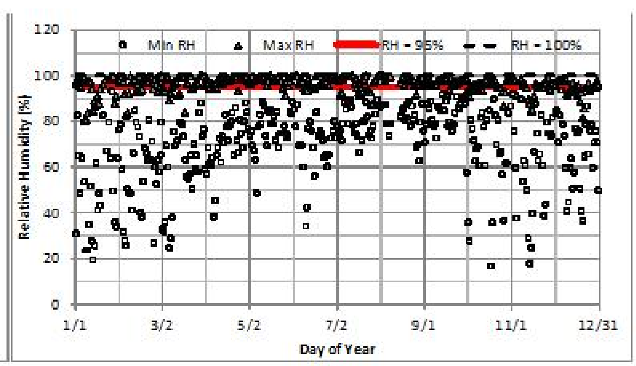
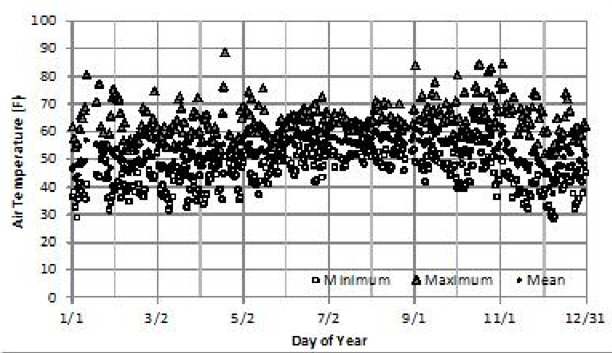


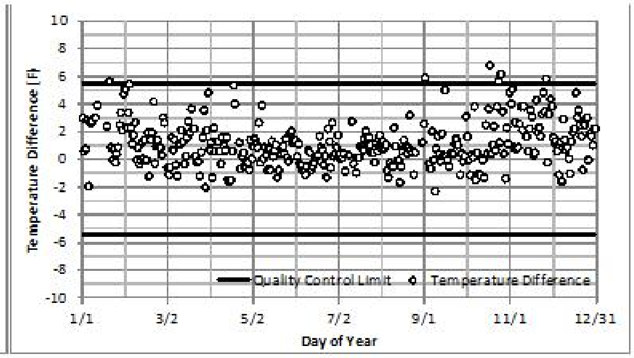


Air Temperature

Carmel

2009





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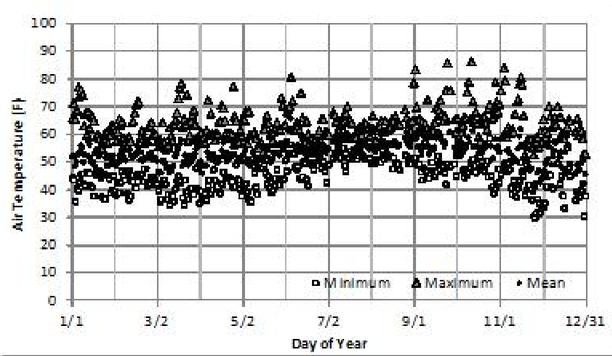

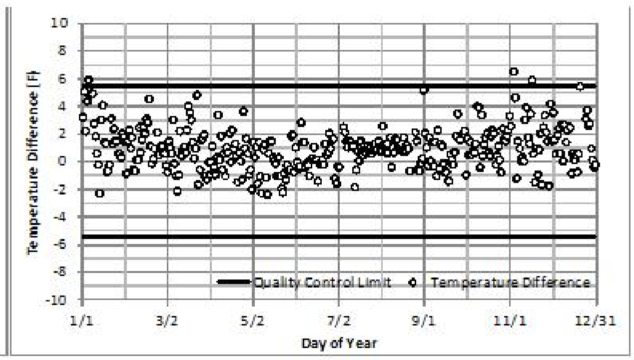

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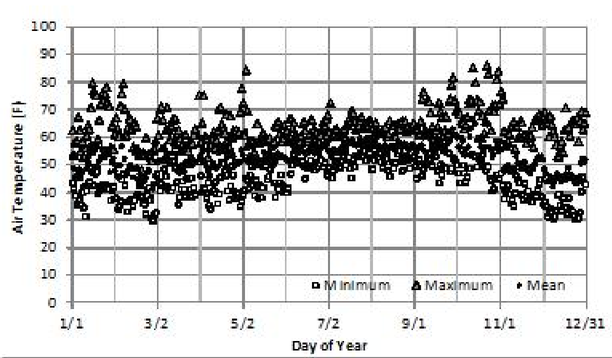

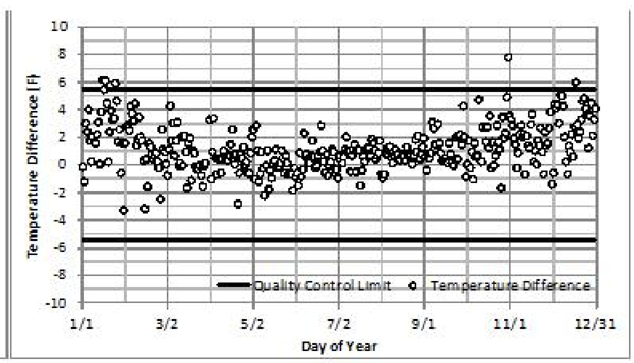

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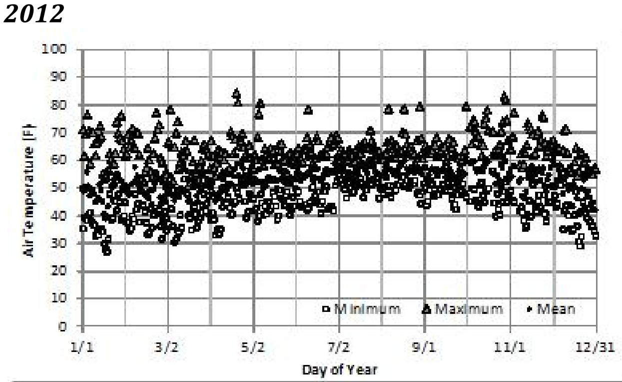
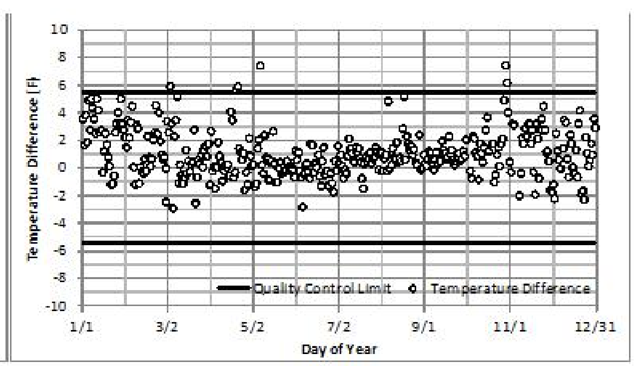
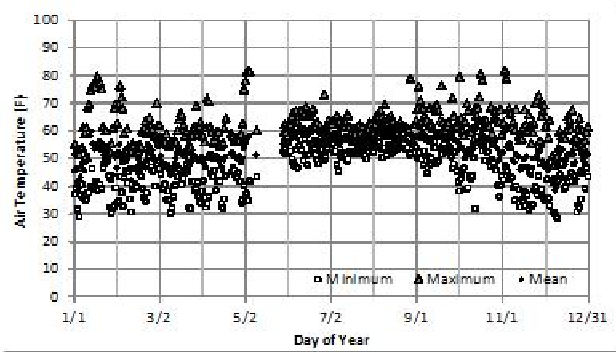
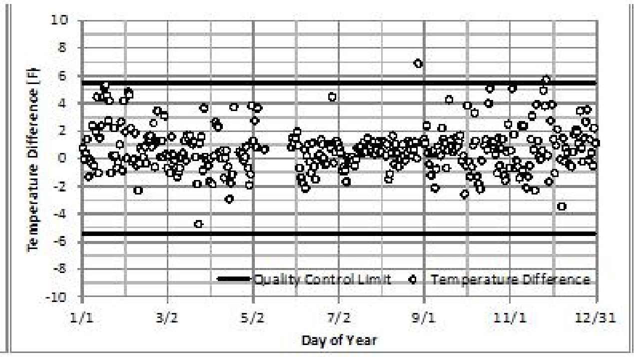




Castroville

2009





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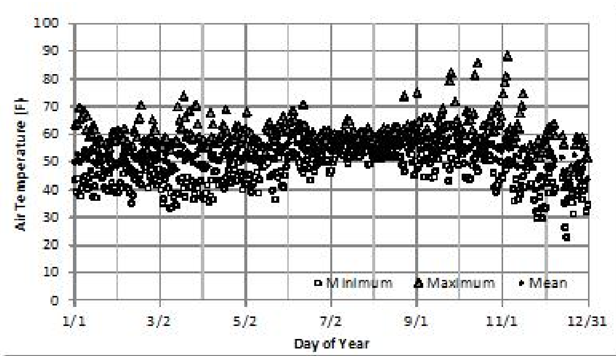

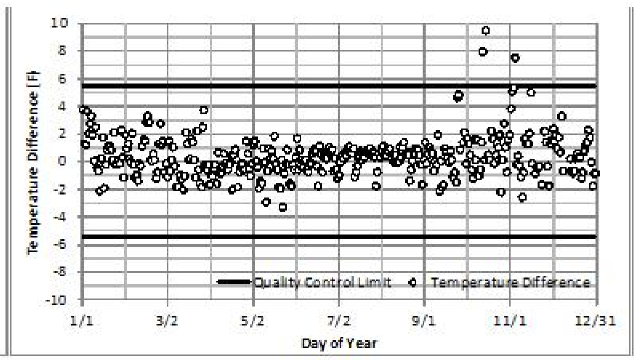

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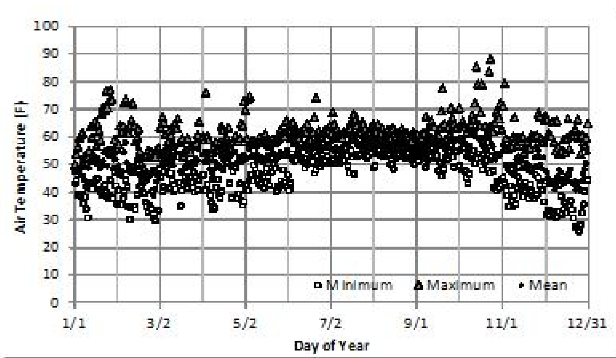

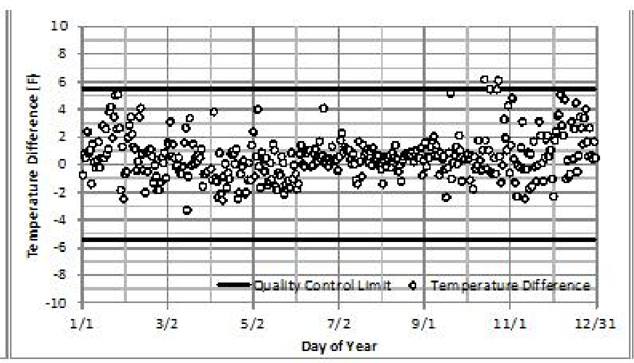

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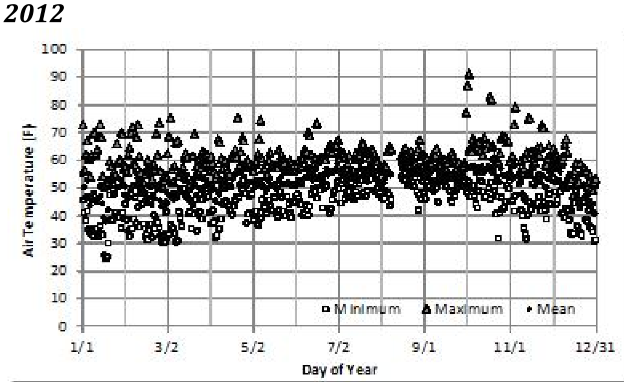
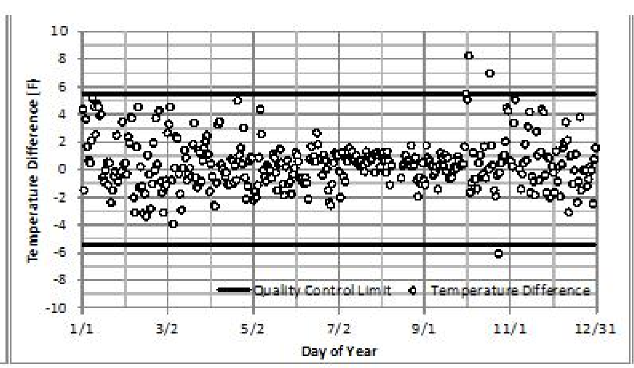
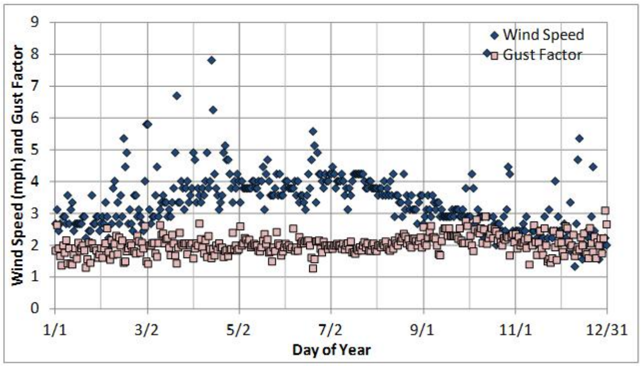




Wind Speed
Carmel

2009



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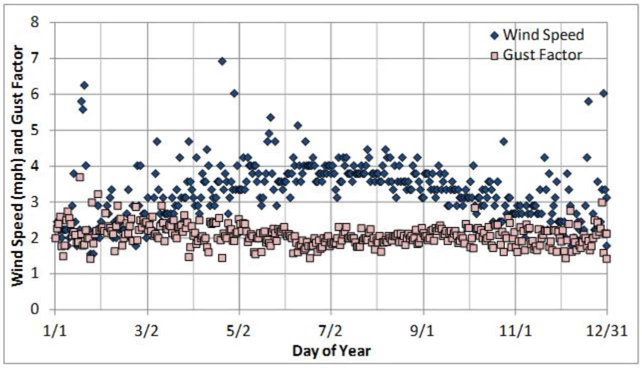

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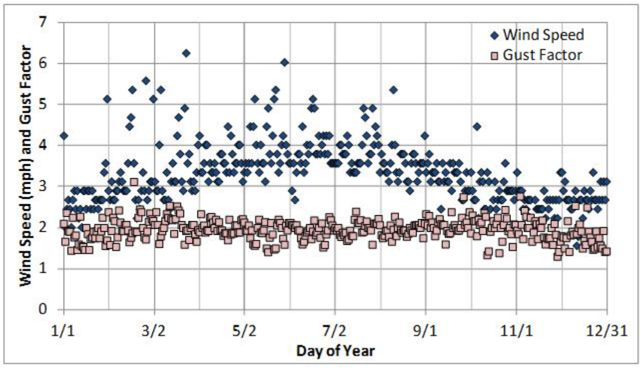

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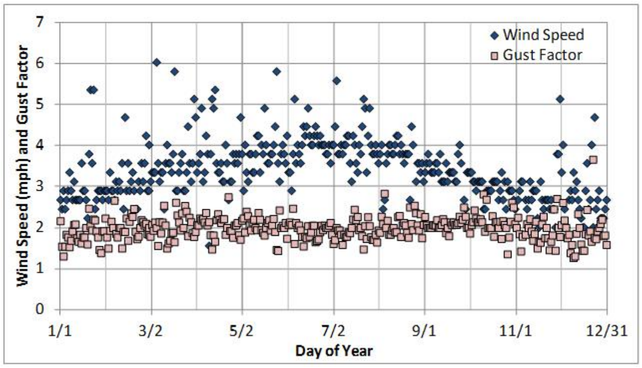
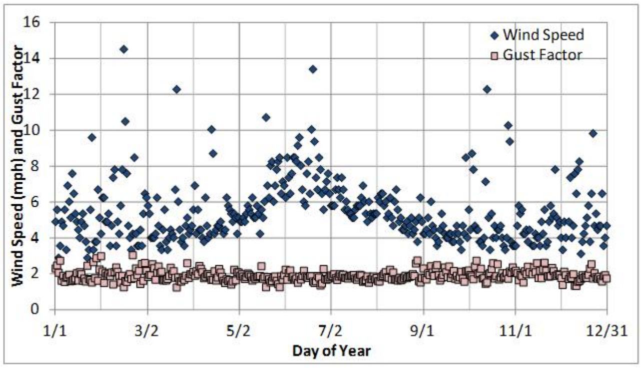


Castroville

2009



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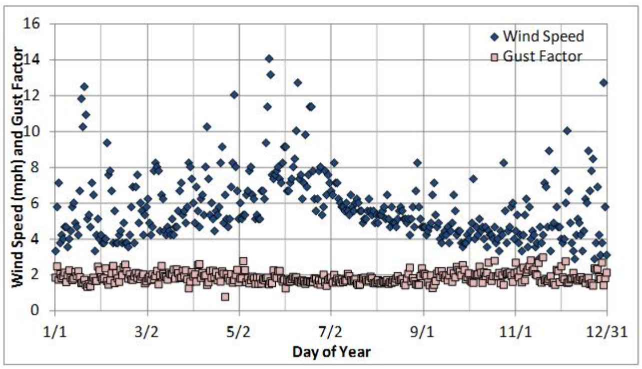

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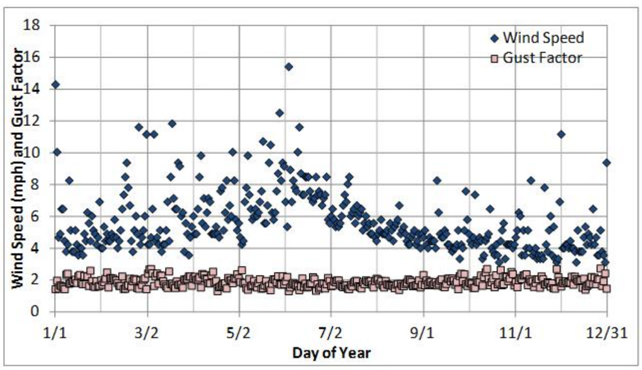

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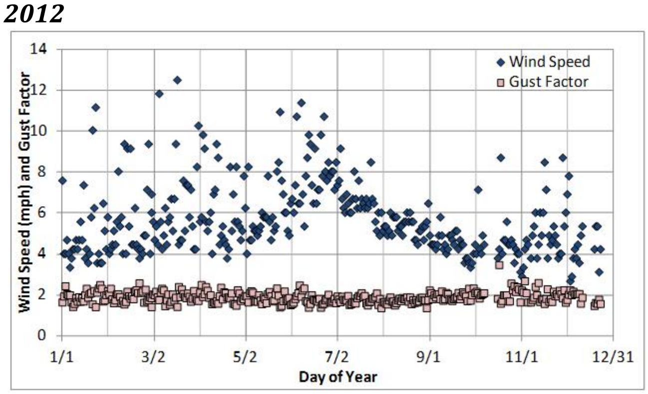

Appendix F

Estimated Ranges of Monthly Pumping Amounts Under Proposed Eastwood Water Right License 13868A (Macaulay Water Resources, 2013)

Macaulay Water Resources
Sustainable Water Solutions

REGISTERED PROFESSIONAL ENGINEER
STEVEN C. MACAULAY
No. 24878
EXP. 12-31-2013
CIVIL
STATE OF CALIFORNIA

TECHNICAL MEMORANDUM

DATE: October 9, 2013

BY: Steve Macaulay, R.C.E. #24878

SUBJECT: Estimated Ranges of Monthly Pumping Amounts Under Proposed Eastwood Water Right License 13868A

BACKGROUND

We previously developed estimated average monthly diversion rates for proposed diversions under Eastwood water-right License 13868A, which Eastwood has asked the State Water Resources Control Board to issue on Eastwood's change petition for water-right License 13868. Those rates were listed in Table 2-3 on page 2-5 of the West Yost Associates Groundwater and Surface Water Evaluation Report for this change petition. These rates also are listed in the following Table 1.

Table 1. Proposed Eastwood/Odello Assignment on Municipal Demand Pattern

Month	Monthly Municipal Demand Pattern (percent)	Well Extraction Rate for Diversion of Proposed Assignment (acre-feet)
January	6.4	5.5
February	5.8	5.0
March	6.7	5.7
April	7.4	6.4
May	9.4	8.0
June	10.0	8.6
July	10.8	9.2
August	10.8	9.2
September	9.8	8.4
October	9.1	7.8
November	7.2	6.1
December	6.6	5.6
ANNUAL	100.0	85.6

We calculated these estimated monthly pumping rates by using the average monthly percentage demand pattern for the main system production of the California-American Water Company (Cal-Am) for water years 1998 through 2007, using data provided by the Monterey Peninsula Water Management District (MPWMD).

For the CEQA analysis for the Eastwood water rights change petition project, the EIR is going to consider how much monthly pumping amounts will vary from year to year. We therefore have developed estimated minimum and maximum pumping amounts for each month. This memorandum describes our analytical methods and the results of our analysis.

ANALYSIS

Table 2 (attached) lists the historical Cal-Am main system monthly pumping amounts for water years 1998 through 2007. Each water year begins in October and ends in the following September. Thus, the entries in Table 2 for October through December for each year are the pumping amounts that occurred during October through December of the preceding calendar year. The monthly percentages in Table 2 are the same as the percentages shown in Table 1, but are listed to two significant figures.

Table 3 lists the percentage of annual pumping by month for each water year, and has the minimum and maximum monthly percentages highlighted. Using June as an example, Table 2 indicates that the average monthly percentage is 10.03 percent, while Table 3 shows a minimum of 9.14 percent and a maximum of 10.71 percent.

Table 4 converts the minimum and maximum percentages in Table 3 to minimum and maximum pumping amounts for proposed Eastwood water right License 13868A, based on the proposed authorized annual diversion of 85.6 acre-feet. Thus, the minimum and maximum percentage amount for each month in Table 3 was multiplied times 85.6 acre-feet to calculate the AF entries in Table 4. The cfs entries in Table 4 are the calculated average rates that would produce the corresponding monthly pumping amounts. For example, for July the minimum and maximum estimated future pumping under License 13868A are 8.47 af and 9.88 af, and these monthly amounts convert to minimum and maximum average monthly pumping rates of 0.14 to 0.16 cfs.

TABLE 2

MONTHLY CALIFORNIA AMERICAN WATER MAIN SYSTEM PRODUCTION:
WATER YEARS 1998 THROUGH 2007 IN ACRE-FEET
Source: Monterey Peninsula Water Management District

WATER YEAR	Amounts in Acre-Feet JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1998	980	891	984	976	1,164	1,285	1,432	1,534	1,367	1,410	1,074	967	14,064
1999	997	791	876	1,075	1,398	1,398	1,613	1,579	1,390	1,290	1,013	946	14,366
2000	1,001	843	1,007	1,221	1,397	1,466	1,477	1,521	1,384	1,365	1,116	1,135	14,933
2001	935	809	935	1,036	1,437	1,561	1,677	1,679	1,447	1,136	950	972	14,574
2002	840	817	945	1,145	1,370	1,460	1,577	1,555	1,443	1,296	1,002	831	14,281
2003	882	868	986	993	1,226	1,498	1,650	1,648	1,512	1,368	1,068	939	14,638
2004	885	852	1,074	1,325	1,606	1,525	1,486	1,473	1,441	1,425	1,008	912	15,012
2005	870	804	919	979	1,287	1,421	1,514	1,474	1,388	1,147	938	937	13,678
2006	834	875	860	812	1,291	1,418	1,594	1,522	1,321	1,314	1,086	878	13,805
2007	935	830	1,032	1,113	1,312	1,349	1,474	1,448	1,358	1,266	1,020	931	14,068
Mean	916	838	962	1,068	1,349	1,438	1,549	1,543	1,405	1,302	1,028	945	14,342
Percentage	**6.39%**	**5.84%**	**6.71%**	**7.44%**	**9.40%**	**10.03%**	**10.80%**	**10.76%**	**9.80%**	**9.08%**	**7.16%**	**6.59%**	**100.00%**

TABLE 3

Percent Monthly Pumping Values Based on Water Year Annual Total

WATER YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1998	6.97	6.34	7.00	6.94	8.28	9.14	10.18	10.91	9.72	10.03	7.64	6.88	100.00
1999	6.94	5.51	6.10	7.48	9.73	9.73	11.23	10.99	9.68	8.98	7.05	6.58	100.00
2000	6.70	5.65	6.74	8.18	9.36	9.82	9.89	10.19	9.27	9.14	7.47	7.60	100.00
2001	6.42	5.55	6.42	7.11	9.86	10.71	11.51	11.52	9.93	7.79	6.52	6.67	100.00
2002	5.88	5.72	6.62	8.02	9.59	10.22	11.04	10.89	10.10	9.07	7.02	5.82	100.00
2003	6.03	5.93	6.74	6.78	8.38	10.23	11.27	11.26	10.33	9.35	7.30	6.41	100.00
2004	5.90	5.68	7.15	8.83	10.70	10.16	9.90	9.81	9.60	9.49	6.71	6.08	100.00
2005	6.36	5.88	6.72	7.16	9.41	10.39	11.07	10.78	10.15	8.39	6.86	6.85	100.00
2006	6.04	6.34	6.23	5.88	9.35	10.27	11.55	11.02	9.57	9.52	7.87	6.36	100.00
2007	6.64	5.90	7.34	7.91	9.33	9.59	10.48	10.29	9.65	9.00	7.25	6.62	100.00
Minimum Monthly	5.88	5.51	6.10	5.88	8.28	9.14	9.89	9.81	9.27	7.79	6.52	5.82	
Max Monthly	6.97	6.34	7.34	8.83	10.70	10.71	11.55	11.52	10.33	10.03	7.87	7.60	

TABLE 4

Eastimated Minimum and Maximum Monthly Future Pumping
Based on Historical Cal-Am Pumping Percentages for Each Month, 1998 - 2007

Pumping Amount	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Min Pumping AF	5.03	4.71	5.22	5.03	7.08	7.82	8.47	8.40	7.93	6.67	5.58	4.98
Max Pumping AF	5.96	5.42	6.28	7.56	9.16	9.17	9.88	9.86	8.84	8.58	6.73	6.51
Min Pumping cfs	0.08	0.08	0.09	0.08	0.12	0.13	0.14	0.14	0.13	0.11	0.09	0.08
Max Pumping cfs	0.10	0.09	0.10	0.13	0.15	0.15	0.16	0.16	0.15	0.14	0.11	0.11