LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

GROUND-WATER RESOURCES
HYDROLOGY • DEVELOPMENT • MANAGEMENT

March 22, 2010
File No. 10-1-031

Mr. Todd Johnson
Resource Land Holdings, LLC
619 N. Cascade Avenue, Suite 200
Colorado Springs, CO 80903

SUBJECT: REVIEW OF PROPOSED ESTRELLA RIVER VINEYARD AGRICULTURAL CLUSTER

Dear Mr. Johnson:

In response to your request, Luhdorff & Scalmanini, Consulting Engineers have undertaken a review of the subject proposed project, all based on available documents directly related to the proposed project and documents related to water requirements and groundwater conditions in the Paso Robles Groundwater Basin where the project is located. Primarily due to the short time available for our review, we have not yet visited the site, developed any new information or data, or conducted any independent analyses other than the items discussed herein.

As requested, our review has primarily focused on potential water requirements and alternative mitigation measures, including consideration of County staff's expression of concern and/or conclusion that proposed mitigation measures are infeasible for project-specific mitigation. To place some of our review of those topics in a context, however, we have also reviewed pertinent reports on groundwater conditions prepared for the County, notably those prepared by Fugro West, Inc. (2002 & 2005) on the perennial yield of the groundwater basin, and by Todd Engineers (2007 & 2009) on pumping in the groundwater basin relative to the reported perennial yield. Todd (2009) also includes some appendix material that would appear to be the beginnings of so-called "cones of depression" discussed by County staff when concluding its concerns and/or infeasibility of proposed mitigation measures.

Based on the preceding, our following review comments are organized to address groundwater basin conditions, water requirements at the project site, and the applicability and feasibility of proposed mitigation measures.

Paso Robles Groundwater Basin

The California Department of Water Resources (DWR) identifies the Paso Robles Area as one of eight subbasins of the Salinas Valley Groundwater Basin. As defined by DWR, the Paso Robles Area Subbasin contains 597,000 acres (932 square miles). In its *Phase I Paso Robles Groundwater Basin Study* (2002), Fugro defined the Paso Robles area as a separate groundwater basin (the "Paso Robles Groundwater Basin") containing 505,000 acres (790 square miles); Fugro also subdivided the "basin" into eight "subbasins". The proposed project site is located in the

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eastern portion of the Estrella "subbasin". As far as can be interpreted from the Fugro report, as well as subsequent reports, there is nothing geologically or hydrogeologically "separate" about the Estrella subbasin; the subbasins would appear to be divisions of the larger Paso Robles "basin' for study and discussion purposes only. Fugro's 2002 report includes some focused attention on the Atascadero subbasin, within the overall Paso Robles Groundwater Basin, but does not otherwise focus "separate" attention on any other subbasin, particularly with regard to yield as further discussed below.

Of note for purposes of this review is Fugro's conclusion in 2002 that the perennial yield of the Paso Robles Groundwater Basin, including the Atascadero subbasin, was about 94,000 acre-feet per year (afy). Calculated separately, Fugro reported the perennial yield of the Atascadero subbasin to be approximately 16,500 afy. In its 2002 report, Fugro defined the perennial yield of a basin to be "the rate at which water can be pumped over a long-term without decreasing the groundwater in storage." Fugro went on to note that many definitions of perennial yield (or safe yield) tie the concept of basin yield to the rate of groundwater extraction that will not create an economic impact. However, for the purposes of its study, Fugro tied the concept of perennial yield to the natural rate of replenishment or recharge to the basin, such that there is no decrease in groundwater storage.

Based on the definition of perennial yield utilized by Fugro, with which we would agree, the resultant reported value, about 94,000 afy (later increased to 97,700 afy as noted below), can be considered to be the volume of water which can be extracted (pumped) annually, on average, over a long-term period and result in long-term sustainable groundwater conditions, i.e. no ongoing depletion of the groundwater resource.

In the most recent report on groundwater pumping in the Paso Robles Groundwater Basin (*Evaluation of Paso Robles Groundwater Basin Pumping, Water Year 2006* prepared by Todd, May 2009, for the City of Paso Robles and San Luis Obispo County Department of Public Works), Todd reports estimated total groundwater pumping to be 88,154 af in 2006, which it also reports to be 90 percent of the estimated perennial yield of 97,700 afy for the Paso Robles Groundwater Basin (Fugro increased the initially reported perennial yield to 97,700 afy in its 2005 *Phase II Paso Robles Groundwater Basin Study*). There is a small amount of confusion in the 88,154 af total pumping number by Todd in that it reflects a combination of "net" agricultural pumping (after return flows of an estimated 2.2 percent of total agricultural pumping) and "gross" pumping for all other categories, e.g. municipal, small community systems, small commercial, and rural domestic (no return flow accounting for any of the latter categories).

On an as-reported basis, groundwater pumping represents about 90 percent of the estimated perennial yield, meaning that there is theoretically a "surplus" equal to about 10 percent of perennial yield, or about 9,700 afy, available for pumping and beneficial use of groundwater before the basin would be in "overdraft" (recognizing that perennial yield is expressed in terms of what can be pumped, i.e. gross pumping; use of the gross agricultural pumping reported by Todd would still result in a "surplus"). Todd (2009) also reports some basin pumping history, e.g.

74,061 af in 1997 and 82,638 af in 2000. Those values, while showing an overall increasing trend from 1997 through 2006, are all less than the reported perennial yield of 97,700 afy.

Finally, Todd (2009) discusses potential future groundwater pumping and reports that: a) if the rate of annual increase in groundwater pumping from 2000 to 2006 were to continue with no water management actions (including delivery of Nacimiento Project water), the basin would reach overdraft conditions by 2017; and b) a 2025 projection of groundwater pumping of 106,797 af (accounting for Nacimiento delivery) would exceed perennial yield by 8,641 afy.

Based solely on the published perennial yield values and reported actual pumping, the basin as a whole is well short of "overdraft" status and has apparent "surplus" available for pumping to meet demands like those of your proposed project, which represent a minimal increase compared to the reported "surplus" available perennial yield.

Complicating the preceding simplified comparison of reported pumping versus perennial yield is a combination of what is actually happening in the groundwater basin and the concept of "cones of depression". The term "cone of depression" describes the conical shape of the drawdown pattern created by a pumping well. If groups of wells are considered together, the respective individual cones of depression can overlap to form a combined area of drawdown, sometimes still called a "cone", of depression. Cones of depression are generally localized in the vicinity of a pumping well(s), but larger areas of depression can readily be identified on groundwater elevation contour maps, as discussed below.

In this case, it appears that the term "cones of depression" is being used to describe localized areas where groundwater levels have been in some state of decline over a recent time period(s) rather than actual pumping depressions. The "cones of depression" mentioned in the County Planning Commission Staff Report are based on Appendix Figure B-1 of the Todd (2009) report. Todd's Figure B-1 is entitled "Change in Groundwater Storage (Spring 1997-Spring 2006)" but it only reflects change in groundwater levels over that period, and does not convey any quantitative change in groundwater storage. This figure shows changes in groundwater levels in selected individual wells over a nine-year period (Spring 1997 to Spring 2006). These areas of groundwater level decline are not "cones of depression" and are not labeled as such by Todd. According to the Todd (2009) map, groundwater levels have declined throughout most of the southern portion of the Estrella subbasin. The largest declines in the Estrella subbasin (30-40 feet) occurred beneath the City of Paso Robles (City) to the southwest of the proposed project site.

The Fugro (2002) report contains four contour maps of historical groundwater elevations in the Paso Robles Groundwater Basin (1954, 1980, 1990, and 1997). The 1997 groundwater elevation contour map shows two pumping depressions in the Estrella subbasin, one beneath the City and the other north of the City. A more recent report (*Update for the Paso Robles Groundwater Basin*, Todd Engineers, 2007) includes the 1997 groundwater elevation contour map and a more recent contour map for Spring 2006 (attached). The pumping depression beneath the City is larger in 2006, with groundwater flowing into this area from the east, west, and south. One effect of large pumping depressions such as the one beneath the City is that they result in groundwater level declines over a larger region, as groundwater flows into the depression from surrounding areas. There is no cone of depression near the proposed project site, but the direction of groundwater flow beneath the site is to the southwest toward the depression underlying the City. As further discussed below, this can be interpreted to mean that mitigation measures designed to reduce groundwater pumping by the City will be effective in improving groundwater conditions in the basin by focusing on the area where the declines have been greatest.

Ultimately, regardless of their locations or terms used to describe declining groundwater levels (e.g. "cones of depression"), there is a fundamental disconnect between the combination of reported perennial yield, reported pumping less than perennial yield, and observed groundwater level declines in the Estrella subbasin. Except for short-term conditions affected by exceptional hydrologic or other factors (which do not appear to be the case here), there cannot be a "surplus" condition where pumping is notably less than long-term perennial yield and, at the same time, actual decline in groundwater levels. In simplest summary, it is logical that, under such actual basin response, the perennial yield is over-estimated and/or pumping is underestimated. Resolution of those possibilities is well beyond the scope of this review; perhaps they will be addressed in the "pending Paso Robles Groundwater Basin Study" mentioned in the Planning Commission Staff Report on the proposed project (prepared for the March 25, 2010 Planning Commission meeting, pg. 9).

In summary, the estimated pumping associated with your proposed agricultural cluster project could be considered to be "in the noise" relative to the reported perennial yield of the groundwater basin, and could be considered to have substantially more than sufficiently available groundwater in light of the reported "surplus" between estimated pumping and perennial yield, i.e. nearly 9,700 afy. However, in light of actual groundwater conditions, regardless of terminology, it appears appropriate to carefully assess the water requirements of the proposed project, including their "net" effect on groundwater, and to apply one or more mitigation measures that result in an offset of at least any net increase in groundwater use.

Project Water Requirements

Residential Water Demand – Cleath-Harris Geologists (Cleath) prepared a Water Adequacy Assessment for the proposed Agricultural Cluster on July 27, 2009. Cleath estimated the residential water demand to be 1.7 af per unit without water conservation measures. Proposed conservation measures include limiting residential landscaping to no more than 5,000 square feet of low-water used plants and 500 square feet of turf. These measures were projected to reduce the residential demand to 0.63 af/unit, consisting of 0.392 afy for indoor use (based on 350 gallons per day) and 0.234 afy for outdoor use. Cleath estimated the outdoor water requirements using a widely accepted method based on monthly reference evapotranspiration (ETo) values and crop coefficients. The application of this approach to landscape water requirements is documented in a report by the University of California Cooperative Extension (Costello and Jones, 1994), which is cited in the Cleath report. The outdoor water requirements calculated by Cleath using this method appear to be reasonable. Cleath thus estimated the total residential water demand for the 18 proposed units to be about 11.3 afy.

County Planning staff did not specifically review the Cleath water demand estimates but generally considered them to be too low based on data from an agricultural cluster subdivision located in a different part of the County (the Edna Valley). There is no mention in the Staff Report about whether the Edna Valley subdivision utilizes any of the water conservation measures proposed for your project. Based on the Edna Valley example, the County Planning staff proposed to use a water demand estimate of 1.27 af per unit (approximately double the Cleath estimate). The County Planning staff did not distinguish between indoor and outdoor use, but the indoor use would presumably be similar to the conservative estimated used by Cleath (350 gallons per day or 0.392 afy per unit). Therefore, the remaining water (0.878 afy per unit) would be used outdoors. The total residential water demand for 18 units would be about 22.9 afy based on the County Planning staff's estimate.

The above water demand estimates represent gross water demand, i.e. the requirements to be delivered to the proposed residences. However, a significant fraction of the residential water usage would be returned to the aquifer as deep percolation. The return flow is estimated to be almost 100 percent of the indoor water usage (returned via proposed on-site septic systems) and about 15 percent of the outdoor usage. Based on the Cleath water demand estimate, the return flow would be about 0.392 afy per unit (total of 7.1 afy) for indoor use and 0.035 afy per unit (total of 0.6 afy) for outdoor use. The total return flow would thus be about 7.7 afy, and the consumptive use would be about 3.6 afy. That consumptive use, or net water demand, is the amount that the proposed project would need to offset in order to mitigate the impact of the proposed agricultural cluster on the groundwater basin.

Based on the water demand estimate in the County Planning Commission Staff Report, the return flow for indoor use would be about the same (0.392 afy per unit or total of 7.1 afy). The return flow from outdoor use would be about 15 percent of 0.878 afy or 0.132 afy per unit (total of 2.4 afy). In this case, the total return flow would be about 9.5 afy, and the consumptive use would be about 13.4 afy. The latter would then be the net amount that the proposed project would need to offset in order to mitigate the impact of the proposed agricultural cluster on the groundwater basin based on the County Planning staff's water demand estimate.

Agricultural Water Demand – Cleath (2009) also summarized agricultural water demands under existing and future conditions. At present, agricultural land use consists of 229 gross acres of vineyards, 41 gross acres of blueberries, and 80 gross acres of spinach. In the future, the gross vineyard acreage is projected to increase to about 319 acres with the conversion of spinach acreage and additional irrigated uses, and the gross blueberry acreage would remain the same (41 acres).

Cleath (2009) computed the average existing applied water demand to be about 1.23 af/ac for vineyards (total of 281 afy), 1.38 af/ac for blueberries (total of 57 afy), and 0.61 af/ac for spinach (total of 49 afy) based on single cropping. The total existing applied water demand is about 387 afy. Cleath (2009) also provides estimates of future applied water demand with and without proposed water conservation measures. Without water conservation, the water duties would remain at 1.23 af/ac for vineyards and 1.38 af/ac for blueberries. With the proposed water conservation measures, these duties would decrease to 1.01 af/ac for vineyards and 1.15 af/ac for blueberries. The proposed reduction in vineyard irrigation is conservative compared to data available for other vineyards in the Paso Robles area. One estimate of applied water demand for eight mature vineyards near Paso Robles is available from Mark Battany (2007) of the University of California Cooperative Extension Service (attached). Battany calculated an irrigation rate of 154 gallons per vine between May 1 and September 30, 2006. For the vine density on the proposed project site (908 plants per acre), this would represent an irrigation rate of 0.43 af/ac during the six-month period when most irrigation occurs. Frost control applications would increase this total slightly in some years, but the total vineyard water demand would still be much less than 1.0 af/ac.

Cleath estimated the total future applied water demand to be about 449 afy without water conservation and 369 afy with the proposed water conservation measures. If the water conservation measures are implemented, the future applied water demand would be less than the existing demand, and there would be no net increase in the overall water demand at the proposed project site. Based on the Battany (2007) study and data cited by Cleath from the Paso Robles Wine Country Alliance, the water conservation measures proposed for the proposed project site are reasonable and should not be considered any type of restriction on agricultural use of the property.

County Planning staff disagreed with the Cleath applied water demand estimates and presented very different estimates in the Staff Report. The staff's estimated water duties are 2 af/ac for vineyards, 2.5 af/ac for blueberries, and 0.8 af/ac for spinach. No studies were cited to support these estimates, but the values are very high for vineyards and blueberries and totally inconsistent with the actual water use on the project site. The staff's conclusion that future applied water demands would increase by about 114 afy, based on these estimates, appears to be arbitrary and indefensible.

Mitigation Measures

We understand that you have proposed four mitigation measures to offset at least the water requirements associated with the agricultural cluster project, and to also potentially reduce total water requirements on the overall project site. Those mitigation measures are most recently described, discussed, and rejected in the above-noted staff report for the March 25, 2010 Planning Commission meeting. The four mitigation measures include: 1) reduced agricultural water use; 2) water conservation in Paso Robles; 3) wheeling of Nacimiento water; and 4) lining of on-site reservoirs. The first three of the proposed mitigation measures are discussed below. We will defer commenting on the fourth mitigation measure until we've had an opportunity to visit the site and learn more about the operation of the reservoirs.

Reduced Agricultural Water Use – This mitigation measure includes a number of individual measures that can collectively add up to an ability to reduce applied water for agricultural irrigation. County staff does not appear to debate whether such measures can achieve the net effect of no net increase in water use on the project site, as quantified by Cleath (2009). Rather, it notes that County staff would encourage you to voluntarily implement some or all of the conservation measures. However, it then notes them to be, if required, "potentially problematic" and "infeasible" because they would "impose restrictions" on agriculture, would require "County oversight", and would lack enforcement mechanisms and be difficult to accomplish because they would require both funding and staffing to achieve.

First of all, mitigation measure feasibility does not require "County oversight" and does not change to infeasible due to lack of County funding and staffing. Applied water reductions in vineyards are recognized in Todd (2009) as agricultural land use has converted to vineyards from cropping with higher applied water requirements. Cleath's estimates of total applied water requirements with conservation (i.e. with "mitigation measures") are based on vineyard irrigation at about 1.0 af per acre per year, a reduction of about 20 percent from recent actual applied water. Such would not reflect a "restriction" on agriculture but would, instead, reflect implementation of irrigation practices which are already being practiced in the basin and which can result, in case like this, in continued viable use of the overall project site for existing (and even increased, as noted in Cleath) agricultural land use while also accommodating an additional land use, e.g. the proposed cluster, with no increase in overall water requirements. Ironically, as noted above, there is reported potentially greater reduction in applied vineyard water requirements in the greater Paso Robles area (Battany, 2007), significantly below the applied water duties used by Cleath, which are still viably sustaining vineyards and which would even more than "mitigate" the proposed project as well as additional plantings on the overall project site. In summary, it is feasible to reduce applied irrigation on existing vineyards on the proposed project site, and thus "mitigate" the water requirement of the proposed cluster project. It is further feasible to reduce the applied irrigation rate from current levels when additional vineyard acreage is planted on the project site, resulting in basically no net change in overall water use on the property, when compared to recent/current irrigation, despite accommodating both the proposed project as well as increased vineyard planting. This proposed mitigation measure can thus feasibly accomplish it intended purpose while not imposing any "restrictions" on the agricultural use of the property.

Water Conservation in the City of Paso Robles – This mitigation measure would involve your cooperation in underwriting water conservation measures in the City of Paso Robles to reduce groundwater requirements for City irrigation and to reduce domestic water use within the City. Water conservation options that have been proposed include the following:

- installation of more efficient turf grass irrigation systems in City parks;
- conversion of roadway medians to drought-tolerant plants; and
- installation of low-flow toilets or other water fixtures in residential or commercial buildings.

Each of these options is reasonable and, if implemented, could result in substantial water savings. However, additional study will be require to document the specific water savings that would be expected from each option.

County staff identified two "concerns" with this proposed mitigation measure, that it would "duplicative" and that it would "not necessarily address the Estrella area decline." While our comments are primarily focused on the Estrella area decline, as discussed below, we would note that it appears presumptuous on the part of the County to claim them to be duplicative because they are included in the City's UWMP and thus "already proposed to be conducted by the City". While we can't comment on how conservation measures get counted or credited, our understanding is that the City has expressed interest in your cooperation and underwriting of the proposed measures because, apparently, it needs the financial support to achieve implementation. In other words, they may be listed and already proposed, but they are not yet implemented and, based on the City's expressed interest, would not appear to be implemented in a timely manner without your cooperation.

On a more technical aspect of this proposed mitigation measure, County staff's reaction is that it would "not necessarily address the Estrella area decline", that it would "theoretically reduce the City of Paso Robles' need to pump groundwater", but that it is unknown if the reduction in City pumping would affect the decline in groundwater levels in the Estrella area. The magnitude of the benefit that might derive from the proposed mitigation measure is beyond the scope of this review. However, as descried above, the mapped depression(s) in the basin, i.e. the so-called "cones of depression", are specifically beneath the City area, west of the proposed project. While mitigation that reduces pumping is logically to be beneficial almost anywhere in the area of the City and proposed project, the most probable location of benefit from reduced City pumping would be where the "decline in the Estrella area" is specifically identifiable.

Wheeling Nacimiento Water – This mitigation measure would involve your underwriting the delivery of Nacimiento water to the City as an offset for the water requirements for the proposed agricultural cluster project. County staff expresses a continuing concern about this measure for some of the same as the above stated reasons, specifically County's ability to "monitor and enforce" the delivery of the Nacimiento water, whether the offsetting use in the City would address the declines in the Estrella area, as well as the lack of a "guarantee" that the importing of additional Nacimiento water "would cause the City to pump less groundwater".

As discussed above, "monitoring and enforcement" do not affect the feasibility of mitigation measures (ironically, the delivery of supplemental surface water by pipeline is one of the easiest things to "monitor"; and "enforcement" provisions are regularly written as conditions to project approvals in countless locations, commonly at the applicant's expense). The applicability of this mitigation measure to address the Estrella area groundwater depression is identical to that discussed for water conservation in Paso Robles above. Finally, the lack of a "guarantee" that the delivery of additional supplemental water (Nacimiento water) "would cause the City to pump less groundwater" is almost incomprehensible. If the City has a certain water demand and a component of that demand is met by a newly acquired supplemental water source, it defies logic to think that the City would then continue to pump the same amount of groundwater, i.e. not pump less. City water supplies are driven by water requirements. If part of its requirements are met by supplies other than groundwater, its groundwater pumping will be reduced by that amount. The "guarantee" is built into the fundamental precept that municipal water purveyors utilize supplies to meet municipal demands, and do not unnecessarily continue to pump groundwater at previous rates when new supplemental supplies are secured to replace some of the previous pumping. In the simplest of terms, there is no place to put (use) continued pumping of water that has been replaced by a new supplemental supply.

Conclusion

Based on our review of the available documentation on your proposed project and available reports on the Paso Robles Groundwater Basin, we would conclude that, as analyzed and reported for the County over about the last eight years, the basin has not been pumped to near its perennial yield; the largest reported pumping has been about 10 percent, or about 9,700 af, less than the reported perennial yield of 97,700 afy. That condition would suggest that, by itself, there is a "surplus" yield that is available to meet the small water requirements associated with your proposed project. However, in light of actual declining groundwater level conditions in the basin near the proposed project, irrespective of reported perennial yield, it appears appropriate to propose the kinds of mitigation measures that you have already proposed to offset the projected water requirements of your project. As already in practice in other vineyards in the area, the first of your proposed mitigation measures is feasible and can offset both the projected water requirements of the proposed agricultural cluster, as well as the potential difference between existing irrigation and that which would be required to irrigate expanded vineyard plantings on the project site. The second and third proposed mitigation measures are also feasible to offset the projected water requirements (gross or net), while focusing the offset on groundwater pumping in the area of the groundwater basin where groundwater depressions are most notable, i.e. beneath and near the City of Paso Robles.

We appreciate the opportunity to undertake the review of your proposed project, and proposed mitigation related to the project and to future use of the rest of the property on which the project is located. We trust that this summary of our review will be of use as you move forward in the application process. If we can provide further detail or respond to questions about any of the above, we would be pleased to respond.

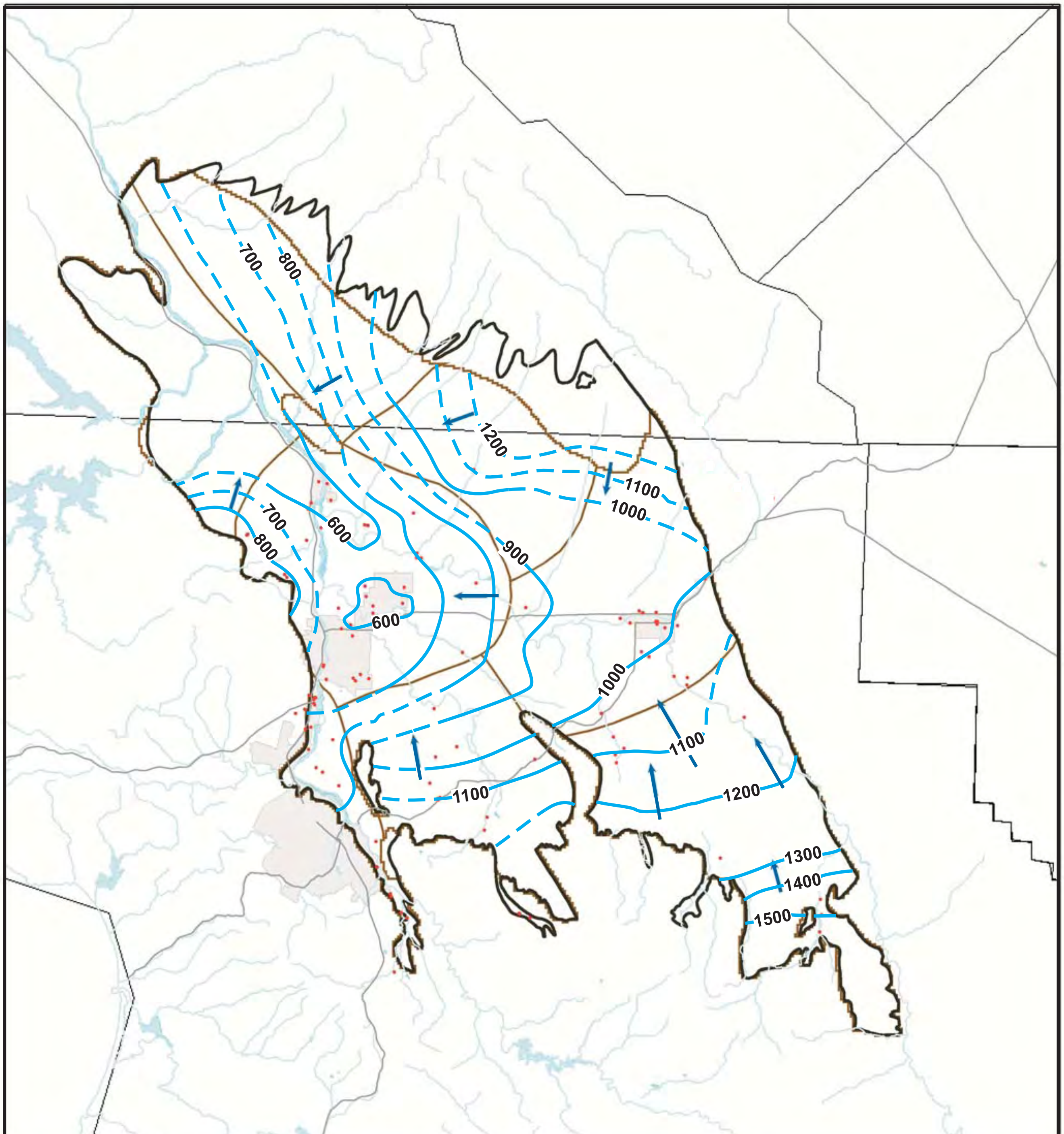
Sincerely,

LUHDORFF AND SCALMANINI
CONSULTING ENGINEERS

Joseph C. Scalmanini

Glenn Browning

JCS/GB:kk



Legend

- Wells
- Direction of Groundwater Flow
- Streams
- State Highways
- Spring 2006 Groundwater Elevation (feet MSL)
- Basin Boundary
- Cities/Communities
- Subareas
- Counties

N

0 3 6

Scale in Miles

December 2007

TODD ENGINEERS
Emeryville, California

Figure 6
Groundwater Elevation Map (Spring 2006)

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Water use by Paso Robles area vineyards

Mark Battany, Farm Advisor

Most growers know how many gallons of water they apply to their vineyards, but knowing how much of the potential vine water consumption this water represents has been difficult to measure. The primary difficulty in making accurate assessments has been the lack of crop coefficients which are representative of individual vineyards.

In 2006 I worked with a new method for measuring local irrigation crop coefficients at eight mature vineyards east of Paso Robles; the method allowed me to measure the crop coefficient over a relatively large number of vines at each site (40), at five or more times between budbreak and harvest. Additionally I also monitored the irrigation system operation with pressure switches connected to dataloggers at each site. Seven of the sites had little to moderate vertical shoot positioning, while one site was a low-vigor sprawl canopy, similar in size to the others.

With this data, I was able to: 1) estimate the full potential vine water requirement (i.e. 100% ETc) for each vineyard from budbreak to harvest, and 2) determine what percentage of this theoretical amount was met by the growers' actual irrigation applications. Note that I only measured irrigation applications between budbreak (approx. May 1) and the end of September. As such, this analysis does not take into account any irrigation which was applied earlier or later in the season. The spring of 2006 was quite wet, so little if any irrigation was likely applied prior to budbreak; however, many growers would have applied some fall irrigation which was not captured by this analysis.

The figure below shows the averages of the values for the eight sites; total applied irrigation from budbreak to the end of September equaled **41%** of the theoretical full water consumption over this period. The remainder of vine water needs was met by soil storage of winter rainfall. In most winegrape vineyards, total vine water use is intentionally less than the theoretical full potential water use, to avoid excessive vegetative growth; therefore, the applied irrigation plus soil storage consumption were likely less than the theoretical vine water requirement.

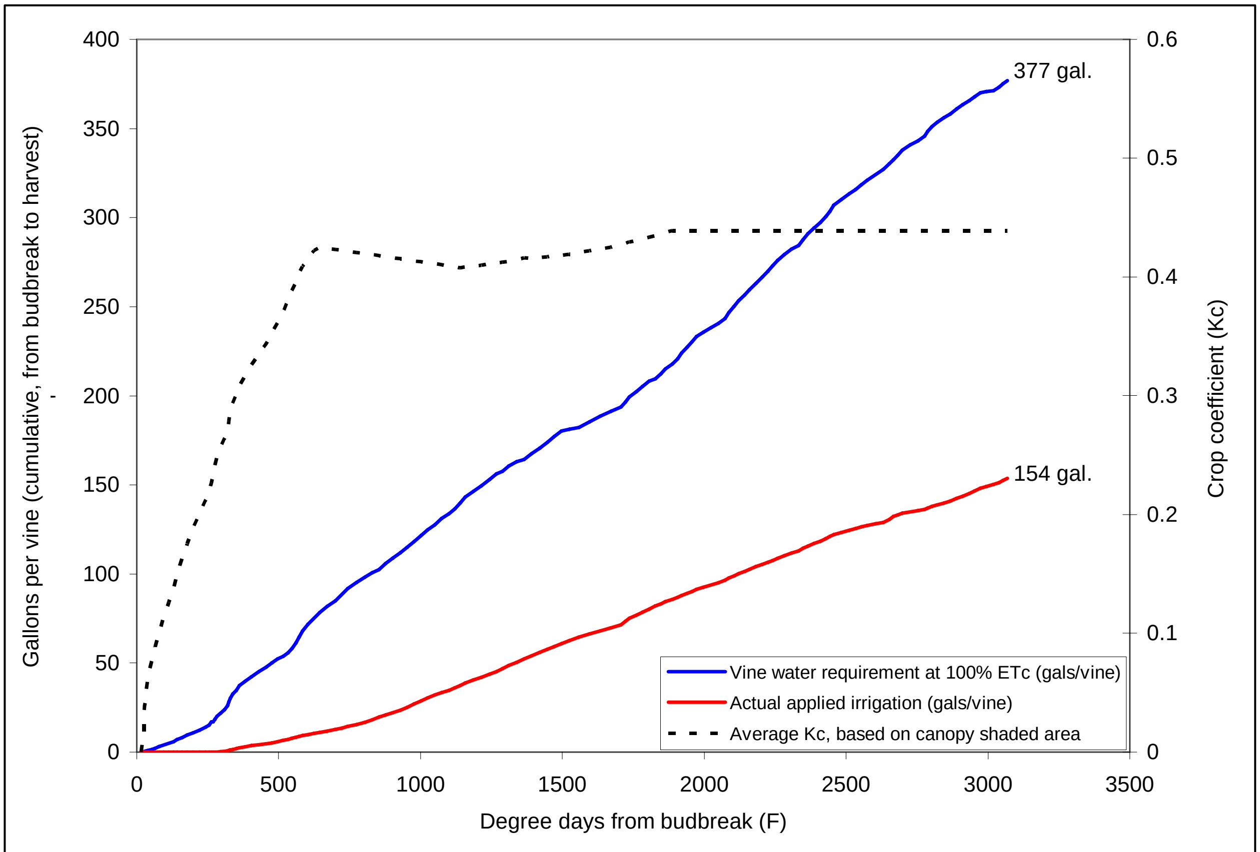

Figure 1. Theoretical vine water requirement, actual applied irrigation, and the average crop coefficient measured at eight mature vineyards in the Paso Robles area from budbreak (May 1) through September 2006.