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September 14, 2016

Thomas Lippe
Law Offices of Thomas N. Lippe APC
201 Mission St., 12th Floor
San Francisco, CA 94105

Subject: Review of Draft EIR for General Waste Discharge Requirements for Vineyard Dischargers in the Napa River and Sonoma Creek Watersheds.

Dear Mr. Lippe:

I have reviewed the DEIR dated July 15, 2016 for the General Waste Discharge Requirements for Vineyard Properties located in the Napa River and Sonoma Creek Watersheds and have the following comments.

1. Inadequate Performance Standards

In my professional opinion the DEIR or Draft Order do not present complete or reliable methods that evaluate Performance Standards for Farm Plan BMPs installed and maintained to control runoff and erosion at vineyard properties. The Performance Standards are presented in Attachment A of the Draft Order, while the monitoring and reporting requirements for vineyard Farm Plans at achieving Performance Standards are presented in Attachment E of the Draft Order. The following subsections present the Performance Standard followed by my comments.

a) Soil erosion in the Farm Area: soil loss rate ≤ tolerable soil loss rate. The tolerable soil loss rate is as defined by the USDA Soil Conservation Service (1994).

The 1994 USDA Soil Conservation Service report cited in this Performance Standard reports that the tolerable soil loss rate for most Napa County hillside soils ranges from 2 to 4 tons of tolerable soil loss per acre-year. Nowhere in the DEIR or Draft Order is there an explanation on how the Farm Area "soil loss rate" will be quantified for comparison to the USDA tolerable soil loss rates. Standard methods for quantifying soil loss include monitoring and modeling, however neither of these approaches are presented in the DEIR or Draft Order. Thus, I see no feasible way this Performance Standard can be evaluated or applied given the lack of guidance in the Draft Order.

b) Sediment delivery from existing unpaved roads: a) culvert inlets have a low plug potential; b) critical dips shall be installed at culverted crossings that have a diversion potential; and c) ≤ 25 percent of the total length of unpaved roads are hydrologically connected.

The Performance Standards associated with erosion and sediment transport for existing unpaved roads are qualitative in nature and don't actually evaluate the performance of any independent road BMP. As indicated in Attachment E of the Draft Order, the monitoring of this Performance Standard is referred to as "BMP Implementation Monitoring" for all (Tier 1-3) Dischargers. BMP Implementation Monitoring consists of establishing and monitoring Photo-points, "to document winter readiness, demonstrate annual maintenance practices and BMP implementation, and to document habitat and water quality conditions in receiving waters at and/or near points of discharge from the vineyard" (page 23 Attachment E, Draft Order). Photo-point records and field notes are to be appended to the Farm Plan. This type of monitoring can verify that a BMP measure was installed, but it does not evaluate if the BMP is functioning as intended and reducing sediment loads sourced from the unpaved roads. In short, this Performance Standard assumes that if the BMP is installed, it is functioning to provide the desired erosion control benefits – there is no requirement or guidance in the Monitoring Plan or Performance Standard to actually verify that the BMP is reducing erosion. Even if we assume the monitor makes a qualitative assessment on how the BMP is functioning, this is an unguided subjective opinion made by a "Qualified Professional" hired by the vineyard owner. Clear and more precise success criteria based on site specific monitoring is required in this Performance Standard to make consistent and reproducible determinations amongst different "Qualified Professionals".

c) Sediment delivery from new roads: all new roads (unpaved and/or paved) shall be storm-proofed roads.

See comments for item b) above.

d) Storm Runoff from an existing Hillslope Vineyard: shall not cause or contribute to downstream increases in bed and/or bank erosion.

To evaluate this storm runoff Performance Standard, Tier 1 Discharges need only comply with the BMP Implementation (Photo-point) Monitoring described above. The Draft Order does not explain how photographs would be used to determine if an existing vineyard is causing or contributing to downstream increases in erosion. I assume such an approach would require comparison of pre- and post-project photographs of receiving channels as a means to identify and estimate changes in bed or bank erosion. Pursuant to this level of qualitative monitoring, only a subjective conclusion, at best, can be made about storm runoff effects on receiving channels for Tier 1 Dischargers. Even if through Photo-point Monitoring it is concluded that the receiving bed or channel is eroding, how does one determine if erosion rates are increasing? This determination can't be made without first determining the existing rate of erosion. Further, how will it be determined if the existing erosion rate is acceptable (i.e., natural) versus elevated as compared to pre-existing vineyard runoff? A literal interpretation of this monitoring method for existing vineyards means that current erosion rates in channels downstream of vineyard outfalls are acceptable (even if they are elevated above natural levels as a result of vineyard installation or operations and causing adverse impacts) and only further increase in the erosion rate would trigger non-compliance of this Performance Standard. It is my opinion that the BMP Implementation Monitoring approach and methods are not capable of determining: a) existing erosion rates (i.e., existing baseline conditions used to determine change); b) whether the existing erosion rates are elevated above desired levels, causing adverse impacts, or caused by vineyard installation or operations; and c) increases to the existing erosion rate. Therefore, the BMP Implementation Monitoring approach is not capable of evaluating this Performance Standard.

In addition to the BMP Implementation (Photo-point) Monitoring described above, the Monitoring Plans for Tier 2 and 3 Dischargers include requirements for BMP Effectiveness Monitoring. The BMP Effectiveness Monitoring approach for Tier 2 and 3 dischargers as described in Attachment E (pg. 25-26) of the Order only evaluates one of several variables controlling runoff from vineyards. . This effectiveness monitoring approach defines a field method to characterize hillslope vineyard soil infiltration capacity and assumes that once post-project infiltration capacity values are statistically similar or greater than values at paired sites under natural vegetation cover (i.e., representative of pre-project conditions), the performance standards for Hillslope Vineyard storm runoff shall be considered achieved. In summary, the BMP Effectiveness Monitoring assumes that if there is no change in vineyard infiltration capacity between pre- and post-project conditions, there will be no change in storm runoff rates, which, in turn, means no increase in erosion potential. We have demonstrated on the Walt Ranch project (and as described in detail on pages 245-246 of DEIR) that the presence of engineered drainage features can contribute significant increases in storm runoff and erosion potential for vineyards that display no difference in pre- and post-project infiltration rates. As presented in Section 2.0 of my comment letter on the Walt Ranch Erosion Control Plan dated August 26, 2016 (see Attachment A), integrating engineered drainage elements into storm runoff modeling of a new vineyard block results in storm runoff rates significantly higher than those modeled solely with altered and unaltered runoff curve numbers (i.e., infiltration capacity). The integration of engineered drainage features in this example resulted in vineyard runoff rates higher than the pre-project rates. Any analysis of runoff rates and BMP effectiveness that does not factor in the effect of engineered drainages or is based solely on an estimation of soil infiltration capacity of the vineyard does not consider all variables at play in characterizing runoff magnitude and erosion potential. Thus, this BMP Effectiveness monitoring approach should not be considered adequate at evaluating the impacts of runoff rates based on a single (of many) parameter affecting that rate.

The field method for the BMP Effectiveness Monitoring described in Attachment E of the Draft Order that outlines a method to estimate pre- and post-project soil infiltration capacities is highly subjective and easily manipulated to provide biased outcomes. As someone who could be hired as a "Qualified Professional", I am confident that through preferred soil-testing site selection and/or elimination of "anomalous results" and retesting, I could easily bias results to provide a desired outcome. Therefore, I believe the BMP Effectiveness Monitoring protocol requires refinement or agency field supervision to eliminate what I see as an easily manipulable analysis.

e) **Storm runoff from a new Hillslope Vineyard: a) peak storm runoff in 2-, 10-, 50-, and 100-year (24-hour duration) rainfall events following vineyard development shall not be greater than pre-development peak storm runoff; and b) shall not cause or contribute to downstream increases in bed and/or bank erosion.**

The storm runoff Performance Criteria for new Hillslope Vineyards is expanded over that for existing vineyards to include quantification of peak storm runoff for rainfall events of selected recurrence intervals. I agree that this model-based quantification is a good approach towards identifying, quantifying and guiding mitigation for potential increases in storm runoff. However, in order to avoid the opportunity to manipulate the outcome, the Performance Standard needs to provide further guidance and direction on how to incorporate engineered drainage elements and clarify what drainage areas need to be modeled.

Based on my experience described above under item d), not incorporating engineered drainage elements into the rainfall-runoff modeling can significantly underestimate peak runoff rates. In order to capture the effects of engineered drainage elements, it is important to model runoff from the pre- and post-project watershed area above each proposed vineyard drainage outfall, whether the outfalls discharge on- or off-site. This scale of modeling avoids masking the effects of engineered drainage elements by modeling a larger project drainage, where vineyards do not lie within the primary modeled flow path. This scale of modeling also provides the required level of detail to effectively design runoff and erosion control BMPs.

An example on the importance in selecting representative model areas is provided in Section 10 of my comment letter on the Walt Ranch Project DEIR, dated November 20, 2014 and included as Attachment B. Although this example pertains to soil loss modeling, the concept of masking potential significant impacts through inappropriate sizing of model area is applicable to all types of numerical modeling including storm runoff modeling. The Walt Ranch DEIR conclusions regarding project-induced changes in erosion potential are based on summing vineyard block soil loss subtotals within the Milliken and Capell Creek watersheds and presenting the total (net) change for each watershed (Milliken and Capell). The net results indicate that there are 44- and 13-percent reductions in potential soil loss from the Milliken and Capell Creek watersheds, respectively. However, this type of lumping of results masks localized impacts, which when considered alone, could be considered a significant impact. A more thorough review of changes in modeled soil loss results indicates localized increases in erosion potential from multiple vineyard blocks that contribute drainage and sediment to onsite Corps designated waters and wetlands located downstream of the proposed vineyards. These downstream creek, riparian and wetland areas host potentially sensitive biological resources, which would be potentially adversely impacted by increases in water and sediment runoff.

f) **f) Pesticide management: An integrated pest management program shall be developed and implemented for the vineyard (UC Statewide IPM Program, 2015), and effective practices shall be implemented to avoid mixing, storage, or application of pesticides near wells and surface waters, or in ways that could contribute to receiving water toxicity.**

The development and implementation of an integrated pest management program (IPMP) does not guarantee the elimination of agrochemical and pesticide loadings to surface waters. This Performance Standard lacks any means (e.g., monitoring) to evaluate if the IPMP is actually working.

g) Stream-Riparian Habitat Protection and Enhancement Actions

A required element of the Farm Plan includes (item 4e. page 5 of Attachment A, Draft Order), “Conservation practices to protect and/or enhance stream-riparian habitat complexity and connectivity.” This element is addressed on page 7 (Attachment A, Draft Order) under the heading, “Stream-Riparian Habitat Protection and Enhancement Actions” and includes a list of channel conditions that need to be delineated and “assessed.” It is not clear to me how this inventory of channel conditions is supposed to be assessed and translated into “conservation practices” or “habitat protection and enhancement actions.” Nor does the Draft Order or DEIR provide Performance Standards with respect to the “actions” directed under this Farm Plan element.

2. Inappropriate Application of Performance Standards to Groundwater Recharge Assessment (DEIR Impact 8.2)

The assumption, presented in discussion of DEIR Impact 8.2, that meeting Performance Standards to reduce storm runoff result in increased infiltration and groundwater recharge is oversimplified and not entirely valid. BMPs such as gravel berms and basins that detain runoff during storm events can lead to increases in infiltration and groundwater recharge. However, these BMPs are commonly installed in response to other vineyard elements such as engineered drainage systems that collect and accelerate runoff through vineyards during all rain events. Engineered drainage systems reduce the residence time and opportunity for infiltration and groundwater recharge. To what degree these competing vineyard drainage enhancements and runoff/erosion BMP elements effect the net increase or reduction in infiltration requires more detailed analysis before making blanket assumptions on the effectiveness of runoff performance standards.

Other professionals reporting on the linkage of hydrologic processes between runoff and infiltration have also called into question the assumption that increased infiltration leads to reduced runoff and increased groundwater recharge. In his January 26, 2013 comment letter on Napa River Sediment TMDL Vineyard Waiver and ISMND (included as Attachment C), Dennis Jackson (hydrologist) provides considerable background and hydrologic explanation on accepted principals of surface and subsurface storm runoff. Mr. Jackson presents several examples of subsurface pipe flow contained in hydrologic literature that demonstrates infiltrated water does not uniformly reduce surface runoff rates, nor does all infiltrated water go to groundwater recharge.

On page 29 of their 2013 Hydrology Report[1] completed on behalf of the Walt Ranch vineyard expansion project EIR, RiverSmith Engineering reports on the fate of additional infiltration gains associated with vineyard development in the Milliken Creek watershed. They state the following.

> *The modeling results show a consistent pattern of a modest reduction in rainfall runoff within the Milliken watershed of Walt Ranch for the proposed vineyard blocks and the associated vineyard development practices. This is consistent for all modeled storm frequencies, 2-yr through the 100-yr event as shown in Tables 5, 6, 7 and 8.*
>
> *The reduction in the runoff peaks and associated runoff volumes is due to an increase in soil infiltration rates, primarily associated with the deep ripping practice. However, credit for the increased rate was only taken in the rocky soil groups where the ripping practice effectively changes the soil classification from Hydrologic Group D to Group C (higher infiltration rate).*
>
> *However, it is believed that much of this additional infiltration volume will return over time as "quick return flow" leading into the local drainages following the storm event. Also see discussion in Section 5.0 regarding rainfall infiltration into the rocky soil groups (Slade, 2013). Based on their estimate that 7% of the rainfall deep percolates into the underlying aquifer, about 90% of the additional infiltration due to ripping is likely to resurface as "quick return flow".*

Although the GWDR Draft Order stipulates that deep ripping of soils cannot be credited for a reduction in peak runoff, the process and fate of subsurface "pipe" or "quick return flow" is what is important here. Similar to the processes reported by Jackson, the RiverSmith findings indicate that significant volumes of infiltrated water actually resurfaces shortly after infiltration and contribute to surface runoff. These examples demonstrate that the assumption that increased infiltration rates reduce runoff is

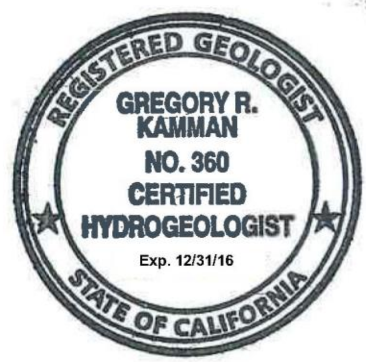
[1] RiverSmith Engineering, 2013, Hydrologic analysis of proposed vineyard blocks within the Walt Ranch Property, Napa County, California. Prepared for: PPI Engineering, March, 130p.

unjustified and certainly should not serve as the sole Performance Standard associated with the GWDR Order runoff BMP Effectiveness Monitoring.

Please feel free to contact me with any questions regarding the material and conclusions contained in this letter report.

Sincerely,

Greg Kamman, PG, CHG
Principal Hydrologist



ATTACHMENT A

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August 26, 2016

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Subject: Landslide Hazard Assessment
Walt Ranch Erosion Control Plan (P11-00205-ECPA)
Walt Ranch Project, Napa, CA

Dear Tom:

I have reviewed the Responses to Final EIR Comments report prepared by Analytical Environmental Services (July 2016) and don't feel there is anything presented that alters my conclusions provided in my prior 2014 and 2016 comment letters. Review of some responses has stimulated more thought and research on my part and I would like to share some new information in the following sections.

1.0 Runoff Curve Number Adjustments by Ripping Soil

A significant assumption made throughout the hydrologic analyses to quantify runoff from the project site is that deep ripping certain soils will alter their hydrologic soil group (HSG) and associated runoff curve number (CN) in a manner that increases infiltration and reduces runoff. This assumption results in reducing the CN and post-project storm runoff in many project areas. As reported in the EIR, this assumption comes from a letter prepared by Ken Oster, soil scientist with the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) to Dave Steiner of the Napa RCD dated February 28, 2014. Because I could not find Mr. Oster's letter in any of the EIR documents, I contacted him for a copy to review. He responded indicating that his 2014 letter gave only a theoretical effect of ripping and that he sent a clarifying letter to Charles Shembre, Dave Steiner's successor, on June 2, 2016 explaining that any change in HSG in response to ripping needs to be verified by an on-site investigation pursuant to NRCS guidelines. The 2016 letter states that it supersedes the opinion contained in the 2014 letter. Copies of both letters prepared by Mr. Oster are provided in Attachment A.

Having reviewed Mr. Oster's 2014 letter, it is important to point out that it contains a statement regarding the longevity of the assumed increase in infiltration rate that was not acknowledged in the EIR. He states, "*Ripping may not permanently change the K_{sat}[1] of soils. Ripping may shatter, but may not mix them. The increase in K_{sat} would then be temporary, because soils may*

[1] K_{sat} of soil is defined as the saturated hydraulic conductivity or permeability of the soil. The higher the K_{sat} value, the higher the rate of water movement through the soil. Soils with relatively high K_{sat} values have higher infiltration rates than soils with low K_{sat} values.

reconsolidate after a few wetting and drying cycles." I had repeatedly made this same statement in my 2014 and 2016 EIR review comments.

I have obtained and reviewed a number of papers/reports on studies pertaining to how tilling[2] of soil alters infiltration/runoff rates and soil CN. A common conclusion from these studies is that tilling increases runoff and the long-term effect of not tilling leads to higher infiltration and lower runoff (Deck, 2010; Rust and Williams, 2010; Bonta and Shipitalo, 2013; Volkmer, 2014; Endale et al., 2011). Licht and Al-Kaisi (2012) present findings that deep ripping results in the lowest infiltration rate over several less intrusive tilling methods and non-tilled soil had the highest infiltration rate. Some studies also conclude that tilling increases both runoff rates and soil erosion (Jin et al., 2008; Battany and Grismer, 2000; Delaune and Sij, 2012). A few studies point out that tilling can increase poor infiltration by breaking up surface crusts or other compacted layers by deep tillage (USDA-NRCS, 2008; Allen and Musick, 1997; Volkmer, 2014). However, these same studies stress that this is only a short-term phenomenon and bare soil subjected to the direct impact and erosive forces of raindrops dislodge soil particles that fill in and block surface pores, contributing to the development of surface crusts that restrict water movement into soil. Allen and Musick (1997) found the increased infiltration rates ceased after a single irrigation cycle. Thus, the authors recommend that long-term solutions for maintaining or improving infiltration include practices that decrease disturbance to the macropore network (predominantly created by earthworms), increase surface and soil organic matter and aggregation, and reduce soil disturbance and compaction.

The findings from these studies and statements in Oster's 2014 letter are clear. The increase in infiltration associated with deep ripping is short-lived and infiltration rates will revert back towards original pre-tillage values. Thus, the estimated project runoff rates will occur only immediately after vineyard construction and the EIR fails to accurately assess/quantify the long-term changes in runoff rates and the associated erosion potential. Regardless, pursuant to NRCS guidance provided in Mr. Oster's 2016 letter, assumed changes in soil HSG due to ripping are only justified if they are verified by an on-site investigation. In his 2016 letter, Mr. Oster indicates that the actual HSG of the disturbed soil condition resulting from ripping should be verified by an on-site investigation as required by the National Engineering Handbook, Part 630.0702 (USDA-NRCS 2009), which pertains to "Disturbed Soil." Chapter 7, entitled Hydrologic Soil Group of Part 630 of the Handbook is provided in Attachment A. The entire text of Part 630.0702 of the Handbook includes the following.

> *"As a result of construction and other disturbances, the soil profile can be altered from its natural state and the listed group assignments generally no longer apply, nor can any supposition based on the natural soil be made that will accurately describe the hydrologic properties of the disturbed soil. In these circumstances, an onsite investigation should be made to determine the hydrologic soil group. A general set of guidelines for*

[2] For the purposes of this letter, tilling refers to the mechanical preparation of land for growing crops by plowing, discing, chiseling and/or ripping. My understanding of the deep ripping process is that bull dozer's equipped long steel shank(s) break up the surface soil and rock to a desired depth in order to prepare fields for vineyard planting. After ripping, soil amendments may be added and the soil is disced, breaking the large chunks of earth into smaller chunks. Finally, the vineyard is planed smooth to level the soil in preparation of planting vines and installing irrigation.

estimating saturated hydraulic conductivity from field observable characteristics is presented in the Soil Survey Manual (Soil Survey Staff 1993)."

Pages 36 to 41 of the Soil Survey Manual (USDA-NRCS 1993) cited in Part 630.0702 Handbook contains a description of the field method to estimate saturated hydraulic conductivity (K_{sat}) based on observation and measurement of various soil properties. This section of the Soil Survey Manual pertaining to the guidelines for field estimates of K_{sat} is also provided in Attachment A. Pursuant to these guidelines, the project would need to complete the field estimate procedure on each of the different HSG's after they have been deep ripped. The EIR does not present the results of any on-site soil field tests on ripped soil types that verify deep ripping will alter site soil HSG's. Therefore, their hydraulic analyses using non-verified HSG designations to estimate peak storm runoff rates should be considered invalid.

2.0 Effect of Vineyard Drainage Elements on Storm Runoff Rates

A critique I have presented to you in the past is the lack of integrating the project vineyard drainage elements into the post-project storm water runoff estimates. The DEIR does not present storm water runoff estimates from vineyard blocks. Their peak storm runoff estimates are calculated for and representative of much larger drainage areas. However, they do conclude that runoff from 41 vineyard blocks will be higher because the representative runoff curve numbers for those blocks will be higher than pre-project conditions[3]. They base their erosion control measures and designs on this qualitative assessment of changes in vineyard block runoff curve number – they do not attempt to model or quantify peak storm runoff rates form vineyard blocks. They state (Appendix F of DEIR [pdf p. 588]), "*Where the proposed blocks are small (less than 5 acres) and the change in curve number less than 4, any increase in runoff will also be very small. However, all blocks with any increase in the developed curve numbers will have some recommended runoff mitigation measure even though the actual impact would be extremely difficult to corroborate by a numeric hydraulic model because the change is so small*." Even more troubling is the fact that their qualitative conclusion for higher flows is based solely on a higher runoff curve number and they do not factor in the effect the drainage elements have on concentrating and increasing peak flow rates from individual vineyard blocks.

To better understand and quantify the different effect runoff curve number and drainage elements have on storm runoff, we completed a hydrologic modeling analysis on a proposed drainage outfall in Vineyard Block 21B. We chose this site because the EIR concludes that the drainage area to this outfall does not change between pre- and post-project conditions [cite to page number] and the vineyard block includes drainage elements including internal diversion ditches that feed into a surface drainage pipeline [cite to page number]. Figure 1 presents the 2.17-acre drainage area contributing to the outfall. Approximately two-thirds of the drainage area lies north of the proposed vineyard block while the lower third of the drainage area lies within the vineyard.

[3] Appendix F to the DEIR, presents a comparison of changes in curve numbers on a block by block basis and relates this to a relative change in runoff. RiverSmith states, "*In general, an increase in runoff curve number relates to less infiltration (more runoff) and a decrease in runoff curve number relates to an increase in infiltration (lower runoff)*."

Our hydrologic analysis follows the same modeling approach and methods, rainfall intensities, NRCS TR-55 travel time computation and other model assumptions as those used by RiverSmith in their hydrologic analysis. However, in lieu of using the same USACE HEC-HMS computer program, we used the StormCAD module integrated with our AutoCAD computer design program. The StormCAD program contains the same time of concentration and rainfall runoff equations/methods used in the RiverSmith hydraulic analysis. Using these tools, we developed three model scenarios as part of our analysis: 1) existing conditions (pre-project); 2) post-project without any drainage elements; and 3) post-project including the proposed drainage elements. Figure 2 depicts the model configuration of the third model scenario. Consistent with the curve numbers presented by RiverSmith in Appendix F of the DEIR, we assume a pre-project curve number of 78.2 for the entire water shed area, including vineyard. Under post-project conditions, we assume the curve number within the vineyard area is lowered to 75 while curve number for the rest of the watershed remains at 78.2. Thus, the composite curve number decreases under the post-project model scenarios. We simulated three of the RiverSmith 24-hour precipitation events for each model scenario including the 2-, 10- and 100-year storm events. The simulated peak storm runoff rates from this analysis are presented in Table 1.

TABLE 1: Simulated peak runoff rates (in cfs) for Vineyard Block 21B outfall.

	A	B	C
Storm Event	**Pre-Project Conditions**	**Post-Project Conditions (no drainage improvements)**	**Post-Project Conditions (with drainage improvements)**
2-year	6.94	6.71	7.80
10-year	10.73	10.47	12.18
100-year	21.02	20.79	24.32

As predicted by RiverSmith, simulated project runoff rates with no drainage improvements (column B, Table 1) are slightly lower than pre-project condition peak flow rates (column A, Table 1) due to a reduction in the composite runoff curve number. These changes equate to a 3%, 2.5% and 1% reduction in the 2-, 10- and 100-year peak storm flow rates, respectively. However, integrating the vineyard drainage elements into the runoff model results in peak flow rates that are notably higher (column C, Table 1) than those under pre-project conditions. Increases in post-project flow rates from the Block 21B outfall that also consider the internal drainage elements are 12.4%, 13.5% and 15.7% higher than pre-project 2-, 10- and 100-year peak storm flow rates, respectively This means that the flow reductions realized with a reduction in runoff curve number are negated and reversed by the effects of the internal drainage ditches and pipelines designed to collect, concentrate and accelerate flow off the vineyard block.

The results of our hydraulic analysis of Block 21B highlight the deficiencies of the EIR in accurately identifying areas of increased runoff and erosion potential. This example illustrates that a determination on the changes in runoff from vineyard blocks based solely on a qualitative analysis of runoff curve number can lead to incorrect conclusions and unmitigated impacts. This also calls into question the suitability of the EIR in identifying and evaluating the potential adverse impacts associated with project erosion control measures/structures as discussed below.

3.0 Project Effects on Landslide Potential

You have asked that I review the FEIR for the Walt Ranch project and evaluate if the project increases the potential for landslide hazards. This review comes in light of the recent landslide damage to Highway 121 a short distance south of the project site located approximately 0.9 miles north of Wooden Valley Road (Figure 3). The site of the Hwy 121 slide is located in an area mapped as "Mostly Landslide" by Wentworth et al. (1997), indicated by the red shading on Figure 4. The Mostly Landslide designated area presented on Figure 4, defined by drawing envelopes around groups of mapped landslides, extends northward into the Walt Ranch Project site. Wentworth et al. state, "The best available predictor of where movement of slides and earth flows might occur is the distribution of past movements." The Site Geologic Map, prepared by Gilpin (2013) and presented in Appendix F of the DEIR, maps the location of active and dormant landslides at the project site. A number of proposed vineyard blocks overlap and/or drain runoff to the landslides mapped by Gilpin as well as the "Mostly Landslide" areas mapped by Wentworth et al. The following text describes how project activities may increase the potential to reactivate these slides.

Results of the hydrologic analysis completed by RiverSmith (2013; Appendix G of DEIR) indicate that peak storm runoff from 41 of the 69 project vineyard blocks will be greater than pre-project conditions based on an increase in runoff curve number associated with the change in vegetation type and land use. RiverSmith (2013) along with PPI Engineering (2013) propose a number of drainage and erosion control measures to mitigate for this increase. One objective of the drainage and erosion control measures in vineyard blocks is to mitigate for the increased channel erosion potential associated with the increased storm runoff rates. This is accomplished by installing rock energy dissipaters and/or berms and detention basins to store water to reduce predicted increases in runoff to pre-project levels. Both slow the rate of runoff, while the berms and detention basins actually pond and store water. With respect to reducing the landslide potential associated with vineyard development, mitigation measures also include installing drainage elements that help dewater the vineyards and reduce soil saturation and associated pore water pressure. These drainage elements act to accelerate the drainage of surface water from the vineyards to a downstream discharge point further adding to increases over pre-project runoff rates that are solely associated with the increased vineyard runoff curve numbers.

In their engineering geology report, Gilpin (2013) provide the following statements.

- (Pages 8-9) *We mapped approximately 278 active landslides on the site. This does not include active creek bank failures. Of these 278 landslides we mapped approximately 149 (54%) active debris flows or slides. The folded bedrock, steep hillslopes and deeply weathered bedrock are susceptible to the erosion caused by intense storm-related runoff that causes debris slide failures. Typically the landslides are elongate and narrow, and often confined to pre-existing swales or drainage courses. We believe the Erosion Control Plan (ECP) for the proposed* *vineyard development will significantly reduce the new occurrence, as well as the reactivation of existing debris slides on the property.*

The ECP vineyard development process controls surface water flow, and addresses unwanted groundwater seepage and poor drainage with appropriate construction of subdrains. These two improvements reduce the debris slide hazard. In addition, vineyard block setbacks from large erosional gullies, combined with control of surface water runoff reduce the likelihood of future slope movement, and increased sediment yields from large storm events.

- (Page 16) *The ECP (PPI Engineering, Inc. 2013) adequately addresses erosion control issues on proposed Blocks 1-69. The ECP, in general, improves the existing runoff and erosion control of the site slopes on the proposed vineyard Blocks. However, because of the complex landslide deposits and history of slope instability additional precautions should be taken during vineyard construction on Blocks located on the east- and northeast –facing slopes of the two areas of the site: 1) the east edge of the volcanic upland; and, 2) the slopes rising from Monticello Road.*

- (Page 17) *We have reviewed the details shown for storm water drainage outlets and other water diversion facilities. These have appropriate armored, erosion-resistant surfaces that do not direct surface or subsurface runoff into slopes susceptible to landslide failure.*

Contrary to the statements by Gilpin, we have identified a number of vineyard blocks that discharge runoff from vineyard blocks directly onto mapped landslides. We identified these vineyards by georeferencing and overlaying project erosion control plans and the site geologic map. We evaluated a subset of the 69 vineyard blocks, focusing only on the 41 blocks where post-project storm runoff rates exceed pre-project rates as estimated by RiverSmith (2013). Of these blocks, we found that drainage from blocks 31A, 40B, 50, 52, 54, 57 and 61 will be directed directly onto mapped landslides. A comparison of erosion control plans[4] and landslide conditions at each of these vineyard blocks are presented in Figures 5 through 10. In order to mitigate for the increased flow rates from these blocks (i.e., reduce them to pre-project levels), the following mitigation measures are proposed: installation of small detention structure or gravel berm on downslope edge of the turnaround avenue at Blocks 31A and 40B; installation of localized detention structure of appropriate size at Blocks 50 and 52; and installation of a gravel berm on the downslope edge of the turnaround avenue at Blocks 54, 57, and 61. All of these proposed berm and detention structures will be located on mapped landslides (Figures 5-10). This will result in water being ponded and possible dispersed more widely on landslide deposits if a structure is overtopped. These mitigations will promote and concentrate infiltration into landslide deposits to a greater degree than would occur under pre-project conditions. Thus, proposed project mitigations are increasing the potential to reactive landslides in these seven specific areas. Although the remaining 34 berm and/or detention sites are not located on active or dormant landslides, they occur in geology and soils prone to sliding and also introduce an

[4] The quality of the Erosion Control plans provided in the EIR are poor and do not reproduce well. Thus, they are hard to read/interpret in Figures 5-10.

increased risk of landsliding. It is also important to point out that given the steep slopes and propensity for landslides to occur during large storm events, sediment mobilized by landslides at the project site would significantly increase sediment delivery to off-site creeks as well as the potential to adversely impact infrastructure downstream of the slides including, but not limited to: the Circle Oaks development; utilities; roadways including Highway 121; and by filling/plugging roadway drainage features such as ditches and culverts.

4.0 Stream Flow and Sediment Yield Monitoring

The Appendix to the Responses to Final EIR Comments report contains a memorandum from Whit Manley of Remy, Moose and Manley LLP (RMM) to Brian Bordona (dated December 18, 2015) which discusses the request from the City of Napa for post-project stream flow monitoring of Milliken Creek. On page 3 of this memorandum, he states, "*In order to obtain meaningful data, it would be necessary to install two in-stream check dams…*" The paragraph then continues to describe the adverse impacts, difficulties, delays, expense and permits associated with the installation of check dams to help rationalize eliminating the need for stream flow monitoring.

I have extensive experience in continuously measuring creek flows in California coastal mountain watersheds and disagree that check dams are required for stream flow gauging. It is my experience that, more times than not, check dams do not aid in stream flow monitoring. Monitoring of selected sections of undisturbed, stable channel is not only sufficient for monitoring but preferred, for many of the very reasons outlined in the RMM memorandum.

It is my opinion that the project Water Quality Monitoring Program should include the measurement of sediment yields entering and exiting the project site as a necessary approach at monitoring erosion from the site and potential impacts to aquatic and riparian resources in Milliken Creek downstream of the Project. The August 2016] version of the Water Quality Monitoring Program proposes to complete discrete measurements of turbidity as part of this Program to assist in evaluating potential impacts to the water quality entering Milliken Reservoir. Their proposed approach at monitoring turbidity (suspended solids) as discrete measurements only provides a snap-shot of concentrations at a single point in time. In order to quantify the changes in the volume of total sediment derived from the Project site, measurements of suspended (turbidity) <u>and</u> bedload sediment concentrations are required <u>in combination with</u> continuous stream flow monitoring. Continuous stream flow monitoring is required component in quantifying sediment yields. Similar to the groundwater monitoring component of the MMRP, pre-project stream flow and sediment monitoring would also provide a baseline for comparison to post-project conditions.

5.0 Recharge to the Sonoma Volcanics Groundwater Aquifer

The project wells will pump water solely from the Sonoma Volcanics groundwater aquifer to meet project demands across the site. This aquifer underlies less than half the project area. In their response to comments on the FEIR, Richard C. Slade & Associates (RCS) continue to defend using a recharge rate for the Sonoma Volcanics at the site based on a composite recharge rate derived from watershed areas that, in addition to Sonoma Volcanics, include large areas of alluvium and other rock types that have recharge rates far higher than that of the Sonoma Volcanics. As I've described in my previous 2014 and 2016 comment letters, this composite recharge rate is higher than that for the Sonoma Volcanics alone. Given the lack of recharge rate estimates specific to individual rock/aquifer types in the area, a measured or focused study recharge rate to the Sonoma Volcanics remains elusive.

In an effort to identify a recharge rate representative of the Sonoma Volcanics, I obtained and reviewed a number of studies focused on estimating recharge rates exclusive to volcanics in other parts of the Western United States. There are numerous studies that have been completed, but they tend to be focus on areas underlain by volcanics (dominated by lave flows) with very different physical and hydrogeologic properties than the Sonoma Volcanics or occur in arid regions (e.g., Columbia River Plateau in Washington, Oregon and Idaho; Upper Deschutes River Basin, Oregon; Goose Lake Basin, Oregon and California; Yakama River Basin, Washington; and Hanford Waste Disposal Site, Washington).

A study by the USGS to estimate groundwater recharge to volcanic bedrock aquifers in the San Juan Islands area of Washington is better suited for comparison to the Sonoma Volcanics (Orr, Bauer and Wayenberg, 2002). This water-balance modeling study focused on estimating recharge from precipitation to groundwater aquifers. They developed models for four independent drainage basins underlain by volcanic bedrock similar to the Sonoma Volcanics. The bedrock consists of sedimentary and volcanic rocks that is metamorphosed in many areas. Well yields are generally small, usually sufficient only for single-family domestic use. Most of the bedrock is nonporous and water occurs primarily in joints and fractures. The mean annual rainfall (ranging from 26 to 35 inches per year) characteristics are similar to Napa County. Based on two years of available meteorological and hydrologic data, the authors estimated annual groundwater recharge rates as 1.4%, 1.5%, 1.0% and 4.8% of average annual precipitation. These rates are more in keeping with the recharge rates I've previously estimated for the Sonoma Volcanics as presented in my prior comment letters. Based on available data and varying techniques, I estimated annual groundwater recharge rates of 2% (2016 letter) and 4% (2014 letter) of mean annual total rainfall, whereas The EIR uses an annual recharge rate 7%.

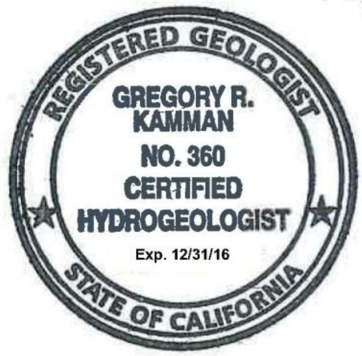
6.0 Conclusions

In closing, our continued review of EIR documents identifies deficiencies in a complete and accurate assessment of runoff rates and increased erosion potential from vineyard blocks. Therefore, the EIR should be considered inadequate at identifying potential adverse impacts from runoff and erosion. The Project has not implemented standard field analyses prescribed by the NRCS to justify the soil runoff coefficients applied to soil. Nor has it factored in the decrease in ripped soil infiltration rates (as informed by Mr. Oster, USDA-NRCS soil scientist) over the long-term. We have demonstrated that the incorporation of vineyard drainage elements into RiverSmith's hydrologic analyses reverse their results with respect to changes in runoff magnitude from vineyard blocks. Incorporating the proposed drainage elements of Vineyard Block 21B into the hydrologic model results in post-project storm runoff rates much higher than presented in the EIR. This calls into question the suitability of erosion control measures in mitigating (unquantified) impacts from increased runoff. The mitigation measures can't be designed to perform as desired without quantifying the flow magnitudes they are intended to treat. For example, proper sizing, design and function of a detention structure intended to reduce runoff to pre-project levels requires accurate quantification of the project flows it is intended to mitigate. We've also identified how some erosion control measures intended to mitigate the adverse effects of increased runoff rates from vineyard blocks lead to unintended increases in potential landslide hazards. I have not found any reference in the EIR pertaining to an evaluation of potential landslide impacts associated with installation of the erosion control elements (detention structures and gravel berms) in Mitigation Measure 4.6-1. This is another omission of the EIR fully evaluating potential impacts associated with the Project.

Please feel free to contact me with any questions regarding the material and conclusions contained in this letter report.

Sincerely,

Greg Kamman, PG, CHG
Principal Hydrologist



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5.0 Recharge to the Sonoma Volcanics Groundwater Aquifer

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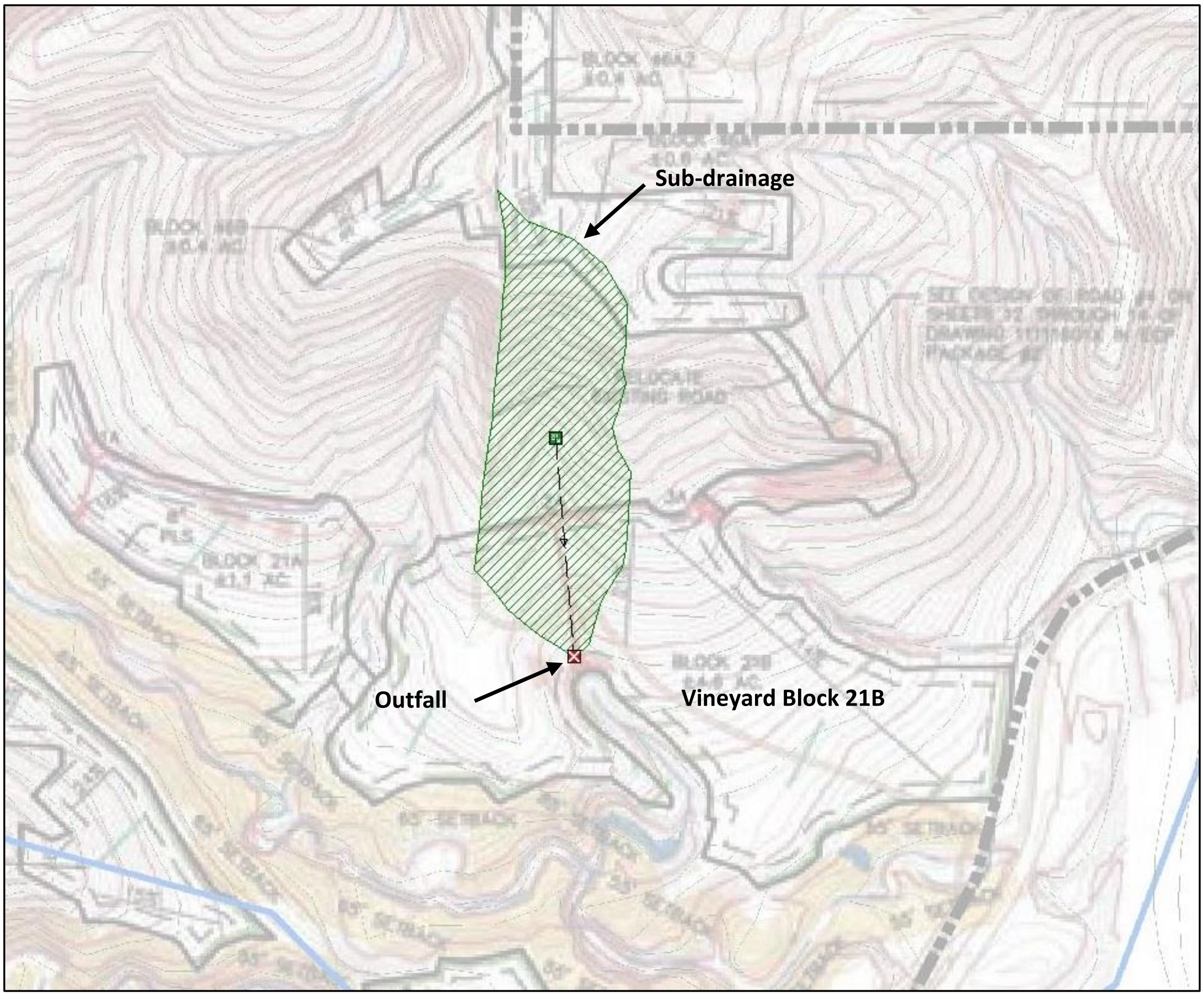

FIGURE 1: Hydrologic model configuration for existing conditions (no drainage improvements) drainage outfall from Vineyard Block 21B.

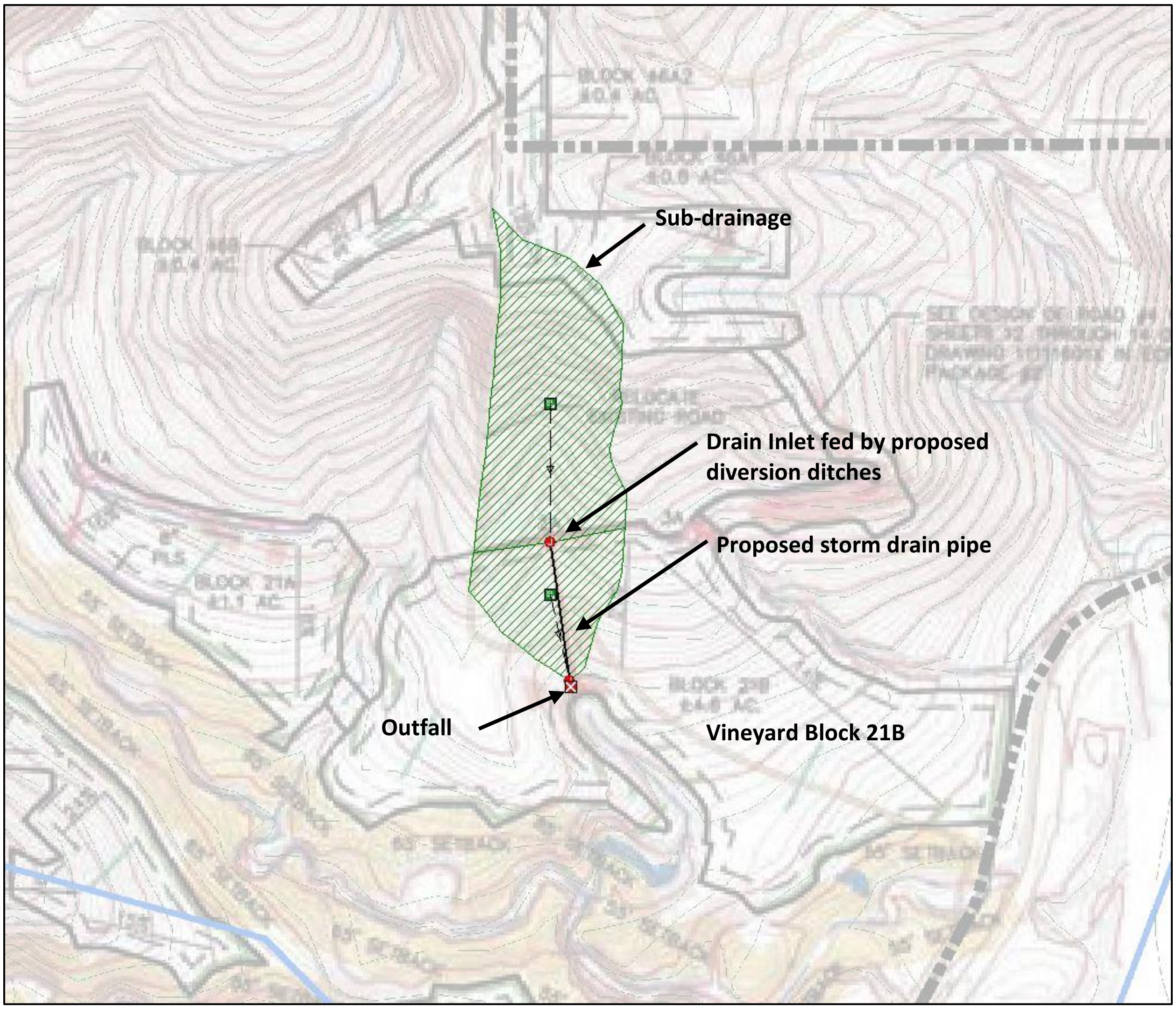

FIGURE 2: Hydrologic model configuration for proposed conditions (no drainage and with drainage improvements) drainage outfall from Vineyard Block 21B.

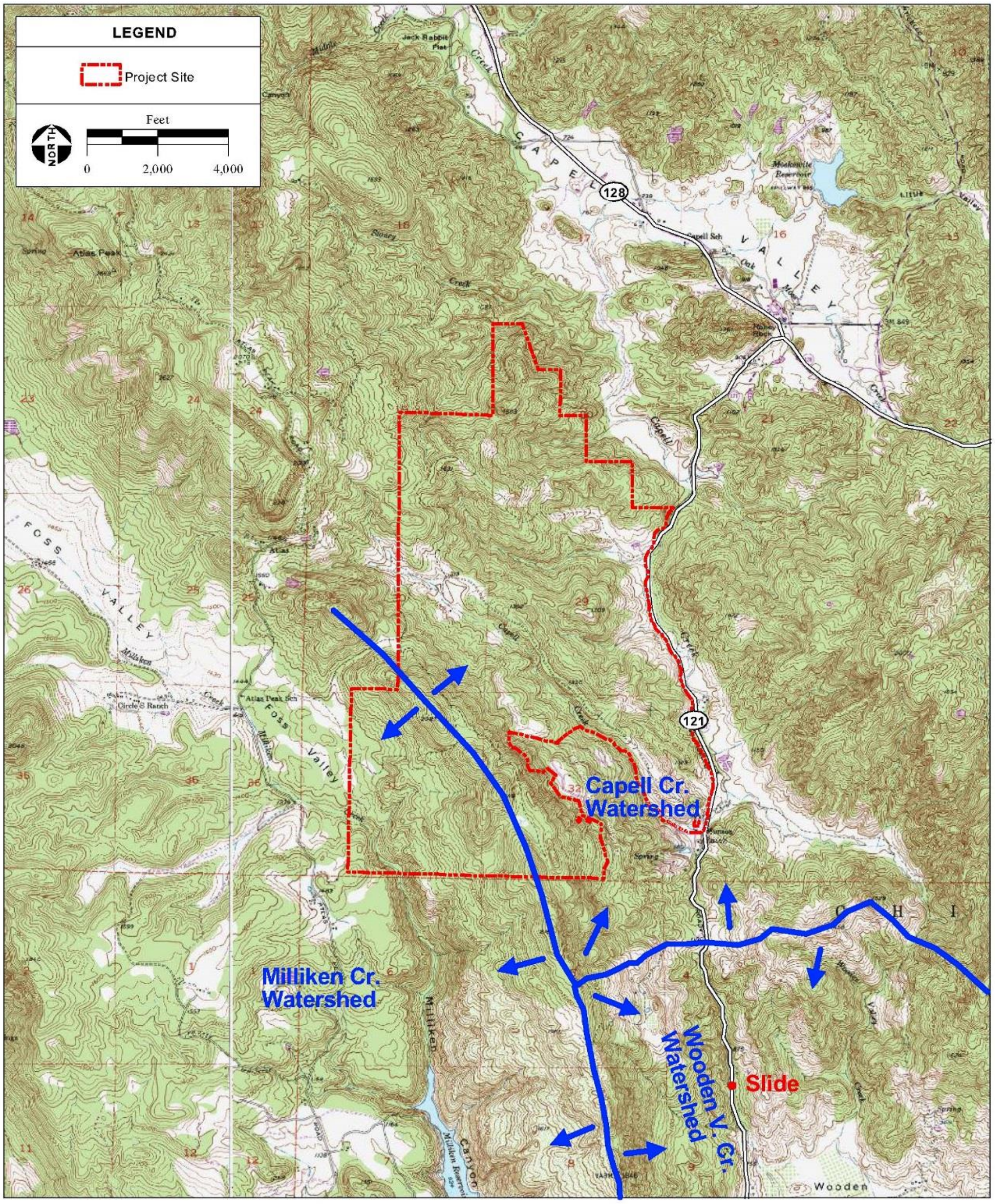

FIGURE 3: Location of recent landslide road failure on Highway 121.

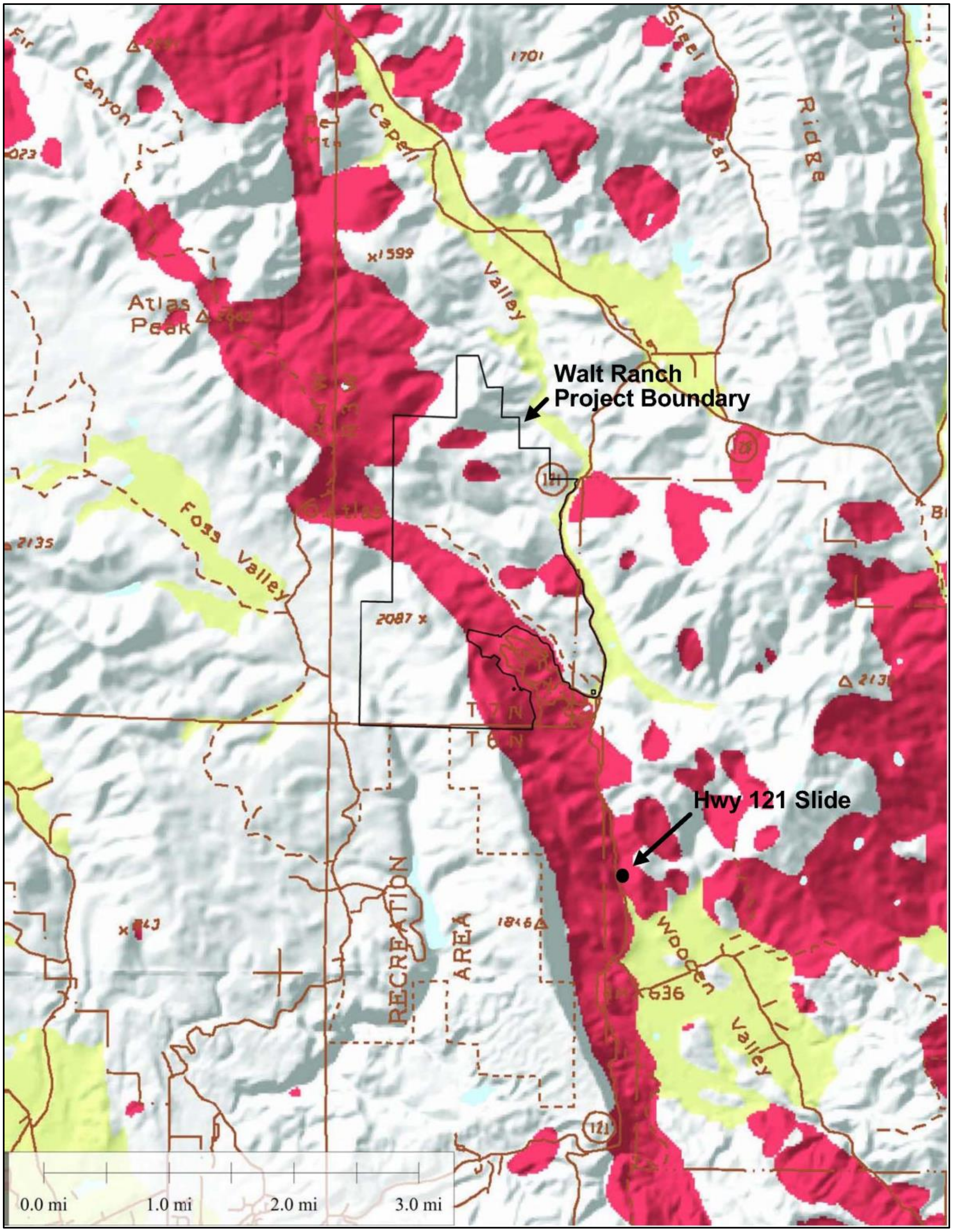

FIGURE 4: Distribution of slides and earth flows in Napa County, CA. Red shading indicates areas of mostly landslides. Source: Wentworth et al., 1997.

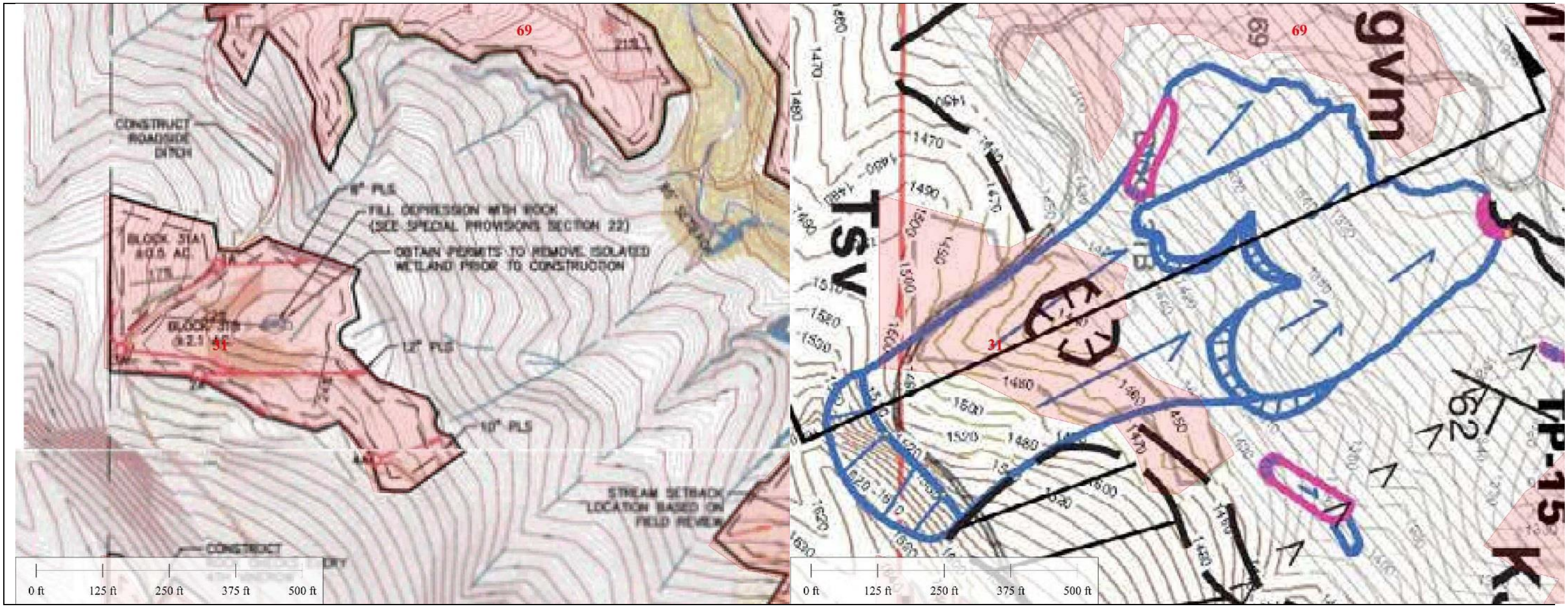

FIGURE 5: Vineyard Block 31A erosion control plan (left) and geologic map (right). Figures are aligned with north towards top of page. Vineyard blocks shaded red in both graphics. Dormant slides outlined in blue and active slides outlined in pink. Runoff flows from left to right (W-E) in vineyard block, discharging onto dormant landslide. Mitigation for increased runoff from Block 31A includes a small detention structure or gravel berm on downslope (right or East) edge of turnaround avenue. Sources: erosion control plans from PPI (2013) and geology map from Gilpin (2013).

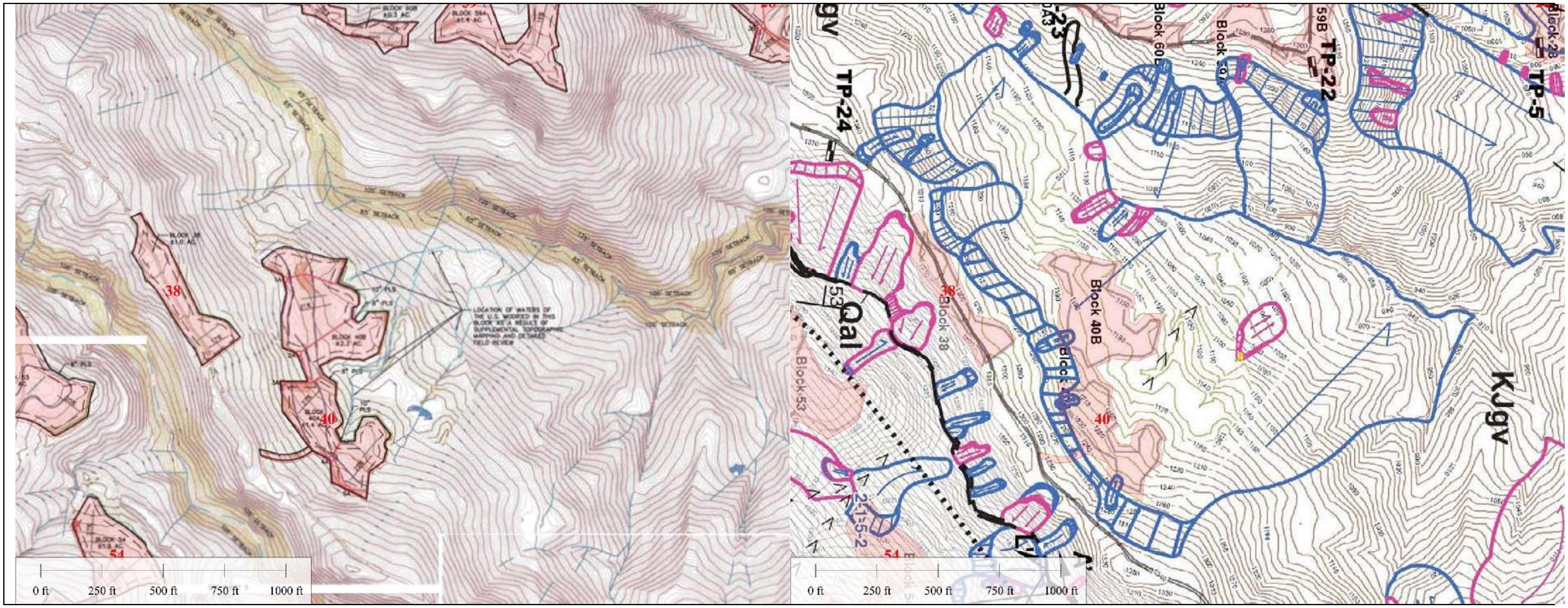

FIGURE 6: Vineyard Block 40B erosion control plan (left) and geologic map (right). Figures are aligned with north towards top of page. Vineyard blocks are shaded red in both graphics. Dormant slides outlined in blue and active slides outlined in pink. Runoff flows to the NE in vineyard block, discharging onto dormant landslide. Mitigation for increased runoff from Block 40B includes a small detention structure or gravel berm on downslope (right or East) edge of turnaround avenue. Sources: erosion control plans from PPI (2013) and geology map from Gilpin (2013).

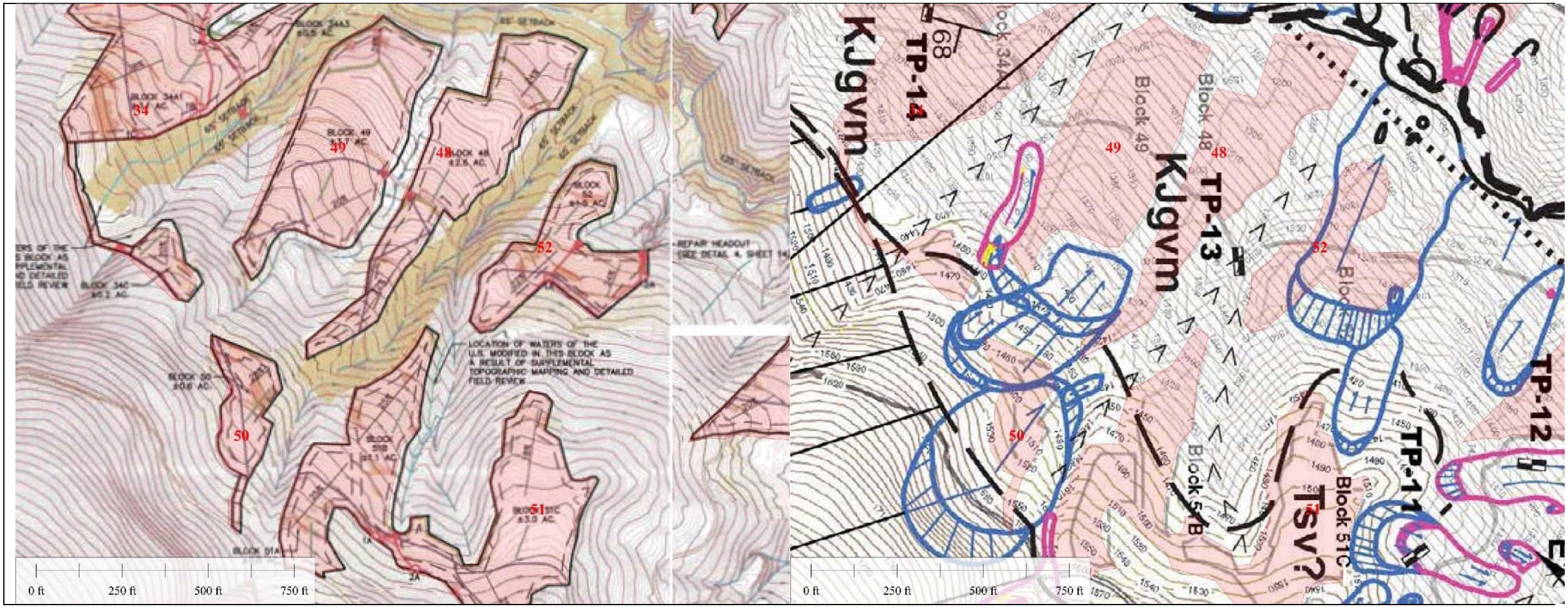

FIGURE 7: Vineyard Block 50 & 52 erosion control plans (left) and geologic map (right). Figures are aligned with north towards top of page. Vineyard blocks are shaded red in both graphics. Dormant slides outlined in blue and active slides outlined in pink. Runoff flows to the NE in both vineyard blocks, discharging onto dormant landslide. Mitigation measure at each block includes installation of localized detention structures of appropriate size to reduce predicted increases in runoff to pre-project levels. Sources: erosion control plans from PPI (2013) and geology map from Gilpin (2013).

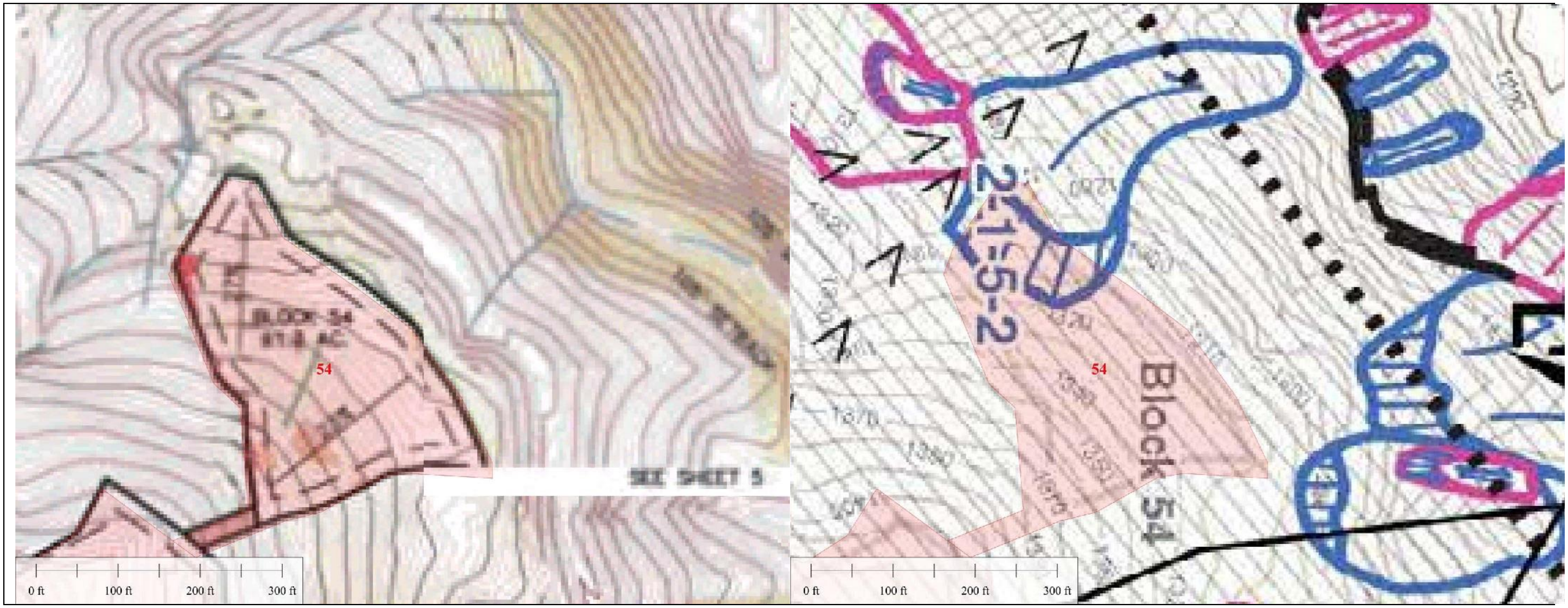

FIGURE 8: Vineyard Block 54 erosion control plan (left) and geologic map (right). Figures are aligned with north towards top of page. Vineyard blocks are shaded red in both graphics. Dormant slides outlined in blue and active slides outlined in pink. Runoff flows to the N-NE in vineyard block, discharging onto dormant landslide. Mitigation for increased runoff from Block 54 includes installing a small gravel berm on downslope (N-NE) edge of turnaround avenue. Sources: erosion control plans from PPI (2013) and geology map from Gilpin (2013).

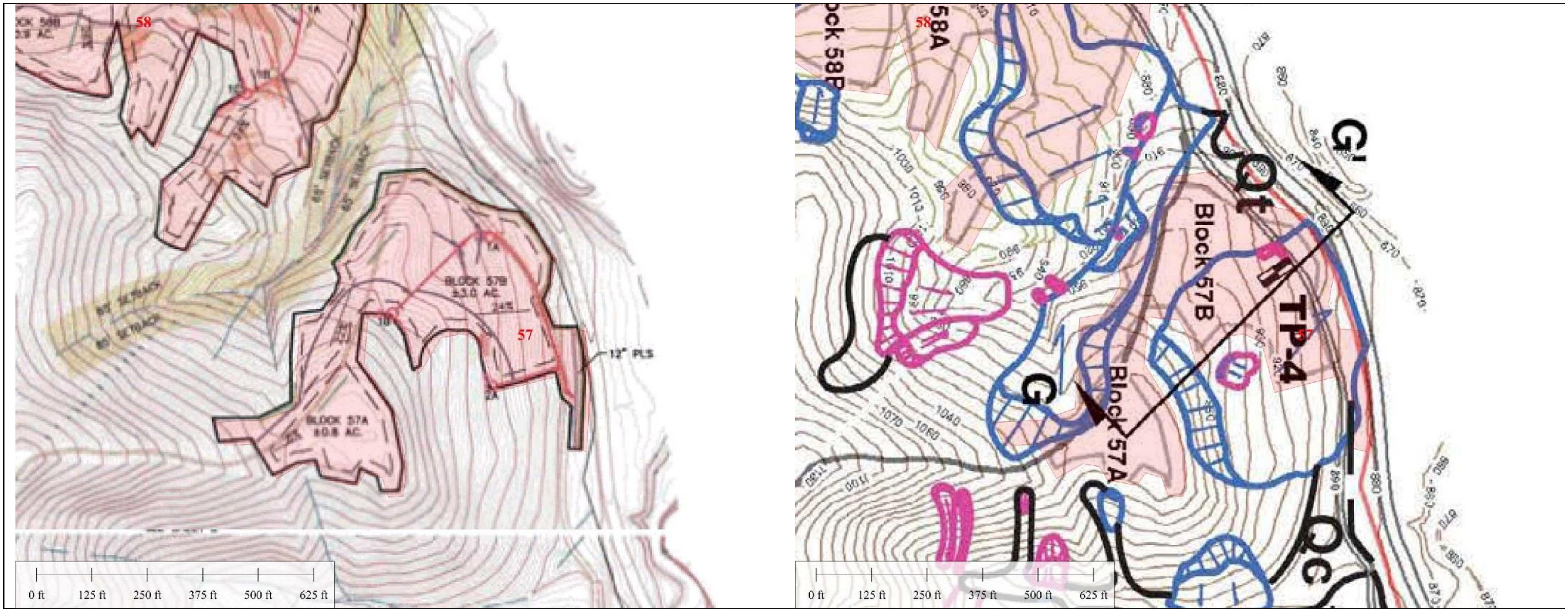

FIGURE 9: Vineyard Block 57 erosion control plan (left) and geologic map (right). Figures are aligned with north towards top of page. Vineyard blocks are shaded red in both graphics. Dormant slides outlined in blue and active slides outlined in pink. Runoff directed to the East in vineyard block, discharging at toe of dormant landslide. Mitigation for increased runoff from Block 57 includes installing a small gravel berm on downslope (East) edge of turnaround avenue. Sources: erosion control plans from PPI (2013) and geology map from Gilpin (2013).

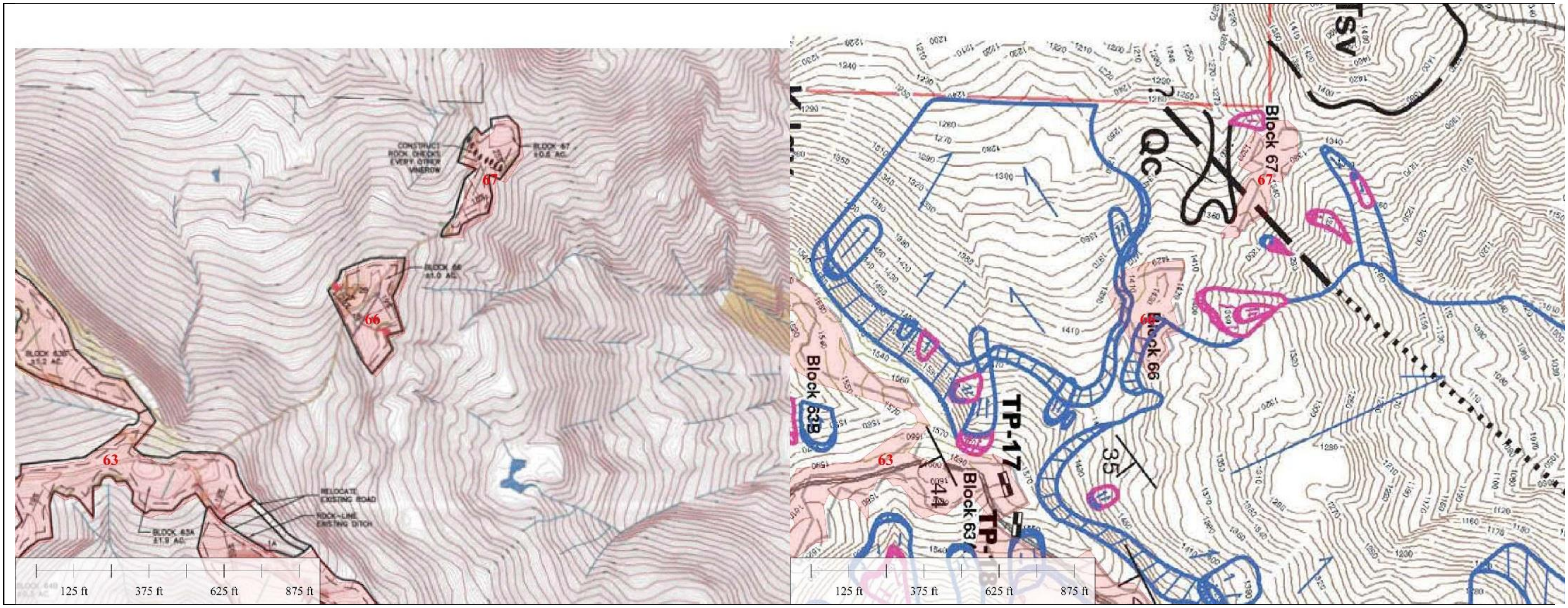

FIGURE 10: Vineyard Block 66 erosion control plan (left) and geologic map (right). Figures are aligned with north towards top of page. Vineyard blocks are shaded red in both graphics. Dormant slides outlined in blue and active slides outlined in pink. Block 66 centered on ridgeline and runoff is directed to the Northwest and Southeast sides of vineyard block, discharging onto bordering dormant landslides. Mitigation for increased runoff from Block 57 includes installing a small gravel berm on downslope edges of turnaround avenues on NW and SE sides of block. Sources: erosion control plans from PPI (2013) and geology map from Gilpin (2013).

ATTACHMENT A

- **USDA-NRCS Correspondence (2 letters)**
- **Part 630 Hydrology, Chapter 7 (Hydrologic Soil Groups) of National Engineering Handbook (USDA-NRCS, 2003)**
- **Excerpt from USDA-NRCS Soil Survey Manual (pg. 36-41, Chapter 3; 1993) Field Estimate Procedure for Estimating Saturated Hydraulic Conductivity.**

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June 2, 2016

Charles Schembre
Napa County Resource Conservation District
Napa, California

Subject: Effect of Ripping on Hydrologic Soil Groups, Updated

This letter gives policy and recommendations from NRCS on changing Hydrologic Soil Groups after the ripping of shallow soils.

On February 28, 2014 I wrote a letter to Dave Steiner describing how it was possible to change Hydrologic Soil Groups by ripping them. This letter supersedes that opinion.

1. The letter dated February 28, 2014 gives the <u>theoretical</u> effect of ripping based on the decision matrix in the NRCS National Engineering Handbook. Part 630, Chapter 7, page 7-4, Table 7-1 "Criteria for assignment of hydrologic soil groups (HSG)."

2. The <u>actual</u> HSG of the disturbed soil condition resulting from ripping should be verified by an on-site investigation as required by the National Engineering Handbook, Part 630.0702, which states: "Disturbed soils. As a result of construction and other disturbances, the soil profile can be altered from its natural state and the listed group assignments generally no longer apply, nor can any supposition based on the natural soil be made that will accurately describe the hydrologic properties of the disturbed soil. In these circumstances, an onsite investigation should be made to determine the hydrologic soil group."

3. When not using the hydrologic soil groups given in the current soil survey report for Napa County, the HSGs of the soils at the proposed vineyard sites should be determined on a case by case basis by the consultants.

I have attached the letter dated February 28, 2014.

Ken Oster
Area Resource Soil Scientist

cc: Rita Steiner, District Conservationist, NRCS, Napa, CA
Tony Rolfes, State Soil Scientist, NRCS, Davis, CA

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February 28, 2014

Dave Steiner
Napa County Resource Conservation District
Napa, California

Subject: Effect of Ripping on Hydrologic Soil Group, Updated

I have updated my analysis of data from the Soil Survey of Napa County to determine the effect of ripping soils to 36 inches depth on the Hydrologic Soils Group (HSG). This analysis replaces the letter written to Phill Blake on February 12, 2008.

Summary of Findings
I find that upon ripping to 36 inches deep the HSG of the following soils would change from D to C: Hambright, Lodo, Maymen and Millsholm. The HSG for the Kidd soil would change from D to B. Increases in soil depth from less than to more than 20 inches can change HSG even without changes in saturated hydrologic conductivity (Ksat).

Ripping through the lithic bedrock on the following soils may be difficult: Hambright, Kidd, Maymen and Millshlom. Ripping through paralithic bedrock on the following soils may be easier: Lodo.

Principles of Analysis
I determined HSG from the current criteria in the NRCS National Engineering Handbook dated January 2009. I have attached the criteria to this report. In some cases this does not agree with the data in the Soil Survey Reports.

Ripping may not permanently change the Ksat of soils. Ripping may shatter, but may not mix them. The increase in Ksat would then be temporary, because soils may reconsolidate after a few wetting and drying cycles. Nevertheless, the deepening of the soil alone would change the HSG.

I have no Ksat data for Rock Outcrop, and so cannot assess the effect of ripping on their HSG. Nevertheless I would expect water infiltration into bedrock to improve upon ripping.

I excluded the Henneke and Montara soils as candidates for vineyard development because of the infertility of soils developed from serpentinite.

Details of Findings
See the attached table "Effect of Ripping Soils on Hydrologic Soil Group."

Ken Oster
Area Resource Soil Scientist

United States Department of Agriculture
NRCS Natural Resources Conservation Service

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Effect of Ripping Soils on Hydrologic Soil Group									
Map Unit Symbol	Soil Name	Natural or Ripped Soil?	Soil Texture least transmissive layer	% Clay in least transmissive layer	Depth to water impermeable layer (inches)	Depth to high water table (inches)	Saturated hydraulic conductivity (Ksat) of the least transmissive layer (micro m/sec)	Ksat Depth Range (inches)	HSG (1)
116, 117	Clear Lake	Natural	clay	40-60	>60	>36	.42-1.40	0	C
		Ripped to 36"	clay	40-60	>60	>36	.42-1.40	0	C
126, 127, 128, 129	Diablo	Natural	clay	35-60	40-80	None	.42-1.40	0	C
		Ripped to 36"	clay	35-60	40-80	None	.42-1.40	0	C
148, 149	Forward	Natural	loam	10-18	25-29	None	14-42	0	B
		Ripped to 36"	loam	10-18	36	None	14-42	0	B
143	Guenoc	Natural	clay loam	35-45	25-40	None	1.4-4	12	C
		Ripped to 36"	clay loam	35-45	36	None	1.4-4	12	C
151, 152, 176	Hambright	Natural	loam	20-27	10-20	None	4-14	0	D
		Ripped to 36"	loam	20-27	36	None	4-14	0	C
142, 153,	Henneke	Natural	clay loam - clay	35-55	10-20	None	1.4-4	7	D
		Ripped to 36"	clay loam - clay	35-55	36	None	1.4-4	7	C
134, 141, 148, 155, 156, 177	Kidd	Natural	sandy loam	10-20	13-20	None	14-42	0	D
		Ripped to 36"	sandy loam	10-20	36	None	14-42	0	B
157, 163	Lodo	Natural	loam	18-27	6-20	None	4-14	0	D
		Ripped to 36"	loam	18-27	36	None	4-14	0	C
161	Maxwell	Natural	clay	40-55	>60	None	.01-.42	0	D
		Ripped to 36"	clay	40-55	>60	None	.01-.42	0	D
157, 163	Maymen	Natural	loam	10-25	10-16	None	4-14	0	D
		Ripped to 36"	loam	10-25	36	None	4-14	0	C
163, 164, 165	Millsholm	Natural	loam	20-27	10-20	None	4-14	0	D
		Ripped to 36"	loam	20-27	36	None	4-14	0	C
166, 167	Montara	Natural	clay loam	27-35	10-15	None	1.4-4	0	D
		Ripped to 36"	clay loam	27-35	36	None	1.4-4	0	C
142	Rock Outcrop	Natural			0	None			No Data
		Ripped to 36"				None			No Data
151	Rock Outcrop	Natural			0	None			No Data
		Ripped to 36"				None			No Data
152	Rock Outcrop	Natural			0	None			No Data
		Ripped to 36"				None			No Data
175	Rock Outcrop	Natural			0	None			No Data
		Ripped to 36"				None			No Data
175	Rock Outcrop	Natural			0	None			No Data
		Ripped to 36"				None			No Data
175	Rock Outcrop	Natural			0	None			No Data
		Ripped to 36"				None			No Data
175	Rock Outcrop	Natural			0	None			No Data
		Ripped to 36"				None			No Data
176	Rock Outcrop	Natural			0	None			No Data
		Ripped to 36"				None			No Data

(1) January 2009 criteria in National Engineering Handbook, Chapter 7
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?cid=stelprdb1043063

by Ken Oster, Area Resource Soil Scientist, USDA-NRCS, 2/28/2014

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Table 7–1 Criteria for assignment of hydrologic soil group (HSG)

Depth to water impermeable layer [1/]	Depth to high water table [2/]	K_{sat} of least transmissive layer in depth range	K_{sat} depth range	HSG [3/]
<50 cm [<20 in]	—	—	—	D
50 to 100 cm [20 to 40 in]	<60 cm [<24 in]	>40.0 µm/s (>5.67 in/h)	0 to 60 cm [0 to 24 in]	A/D
		>10.0 to ≤40.0 µm/s (>1.42 to ≤5.67 in/h)	0 to 60 cm [0 to 24 in]	B/D
		>1.0 to ≤10.0 µm/s (>0.14 to ≤1.42 in/h)	0 to 60 cm [0 to 24 in]	C/D
		≤1.0 µm/s (≤0.14 in/h)	0 to 60 cm [0 to 24 in]	D
	≥60 cm [≥24 in]	>40.0 µm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 µm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 µm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 µm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
>100 cm [>40 in]	<60 cm [<24 in]	>10.0 µm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A/D
		>4.0 to ≤10.0 µm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B/D
		>0.40 to ≤4.0 µm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C/D
		≤0.40 µm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D
	60 to 100 cm [24 to 40 in]	>40.0 µm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 µm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 µm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 µm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
	>100 cm [>40 in]	>10.0 µm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A
		>4.0 to ≤ 10.0 µm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B
		>0.40 to ≤4.0 µm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C
		≤0.40 µm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D

1/ An impermeable layer has a K_{sat} less than 0.01 µm/s [0.0014 in/h] or a component restriction of fragipan; duripan; petrocalcic; orstein; petrogypsic; cemented horizon; densic material; placic; bedrock, paralithic; bedrock, lithic; bedrock, densic; or permafrost.

2/ High water table during any month during the year.

3/ Dual HSG classes are applied only for wet soils (water table less than 60 cm [24 in]). If these soils can be drained, a less restrictive HSG can be assigned, depending on the K_{sat}.

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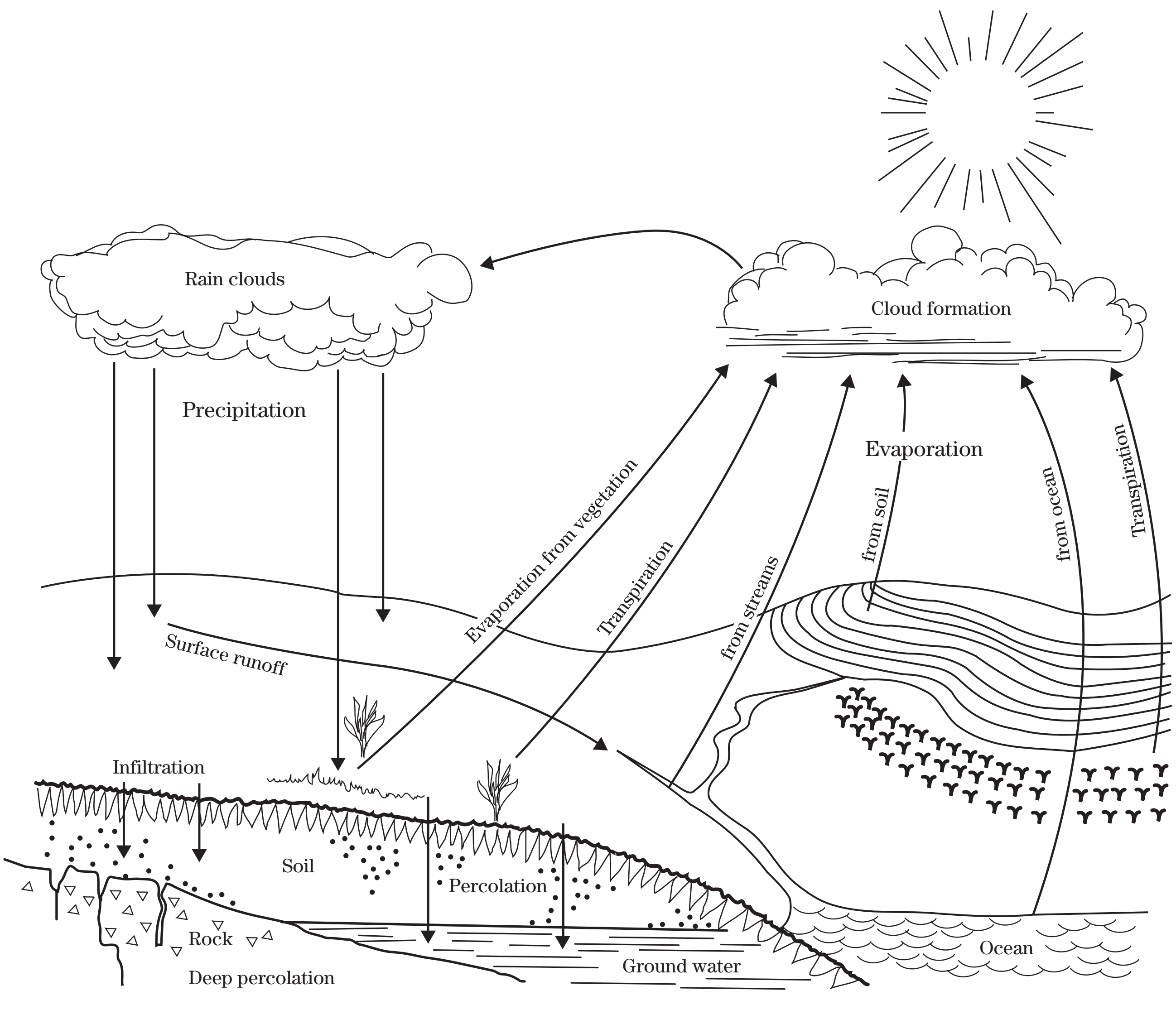
Part 630 Hydrology
National Engineering Handbook

Chapter 7 Hydrologic Soil Groups



Issued January 2009

Acknowledgments

Chapter 7 was originally prepared by **Victor Mockus** (retired) and reprinted with minor revisions in 1972. This version was prepared by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) under guidance of **Jon Werner** (retired), NRCS; with assistance from **Donald E. Woodward** (retired), NRCS; **Robert Nielsen** (retired), NRCS; **Robert Dobos**, soil scientist, NRCS; and **Allen Hjelmfelt** (retired), Agricultural Research Service. It was finalized under the guidance of **Claudia C. Hoeft**, national hydraulic engineer.

Preface

This chapter of the National Engineering Handbook (NEH) Part 630, Hydrology, represents a multi-year collaboration between soil scientists at the National Soil Survey Center (NSSC) and engineers in the Conservation Engineering Division (CED) at National Headquarters to develop an agreed upon model for classifying hydrologic soil groups.

This chapter contains the official definitions of the various hydrologic soil groups. The National Soil Survey Handbook (NSSH) references and refers users to NEH630.07 as the official hydrologic soil group (HSG) reference. Updating the hydrologic soil groups was originally planned and developed based on this perspective.

Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, no such lists will be maintained. All such references are obsolete and their use should be discontinued.

Instructions for obtaining HSG information can be found in the introduction of this chapter.

Chapter 7 Hydrologic Soil Groups

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Chapter 7 Hydrologic Soil Groups

630.0700 Introduction

This chapter defines four hydrologic soil groups, or HSGs, that, along with land use, management practices, and hydrologic conditions, determine a soil's associated runoff curve number (NEH630.09). Runoff curve numbers are used to estimate direct runoff from rainfall (NEH630.10).

A map unit is a collection of areas defined and named the same in terms of their soil components or miscellaneous areas or both (NSSH 627.03). Soil scientists assign map unit components to hydrologic soil groups. Map unit components assigned to a specific hydrologic soil group have similar physical and runoff characteristics. Soils in the United States, its territories, and Puerto Rico have been assigned to hydrologic soil groups. The assigned groups can be found by consulting the Natural Resources Conservation Service's (NRCS) Field Office Technical Guide; published soil survey data bases; the NRCS Soil Data Mart Web site (*http://soildatamart.nrcs.usda.gov/*); and/or the Web Soil Survey Web site (*http://websoilsurvey.nrcs.usda.gov/*).

The NRCS State soil scientist should be contacted if a soil survey does not exist for a given area or where the soils within a watershed have not been assigned to hydrologic groups.

630.0701 Hydrologic soil groups

Soils were originally assigned to hydrologic soil groups based on measured rainfall, runoff, and infiltrometer data (Musgrave 1955). Since the initial work was done to establish these groupings, assignment of soils to hydrologic soil groups has been based on the judgment of soil scientists. Assignments are made based on comparison of the characteristics of unclassified soil profiles with profiles of soils already placed into hydrologic soil groups. Most of the groupings are based on the premise that soils found within a climatic region that are similar in depth to a restrictive layer or water table, transmission rate of water, texture, structure, and degree of swelling when saturated, will have similar runoff responses. The classes are based on the following factors:

- intake and transmission of water under the conditions of maximum yearly wetness (thoroughly wet)
- soil not frozen
- bare soil surface
- maximum swelling of expansive clays

The slope of the soil surface is not considered when assigning hydrologic soil groups.

In its simplest form, hydrologic soil group is determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and depth to any layer that is more or less water impermeable (such as a fragipan or duripan) or depth to a water table (if present). The least transmissive layer can be any soil horizon that transmits water at a slower rate relative to those horizons above or below it. For example, a layer having a saturated hydraulic conductivity of 9.0 micrometers per second (1.3 inches per hour) is the least transmissive layer in a soil if the layers above and below it have a saturated hydraulic conductivity of 23 micrometers per second (3.3 inches per hour).

Water impermeable soil layers are among those types of layers recorded in the component restriction table of the National Soil Information System (NASIS) database. The saturated hydraulic conductivity of an impermeable or nearly impermeable layer may range from essentially 0 micrometers per second (0 inches per hour) to 0.9 micrometers per second (0.1 inches per hour). For simplicity, either case is considered impermeable for hydrologic soil group purposes. In some cases, saturated hydraulic conductivity (a quantitatively measured characteristic) data are not always readily available or obtainable. In these situations, other soil properties such as texture, compaction (bulk density), strength of soil structure, clay mineralogy, and organic matter are used to estimate water movement. Table 7–1 relates saturated hydraulic conductivity to hydrologic soil group.

The four hydrologic soil groups (HSGs) are described as:

Group A—Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group A are as follows. The saturated hydraulic conductivity of all soil layers exceeds 40.0 micrometers per second (5.67 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a water impermeable layer and a water table are in group A if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 10 micrometers per second (1.42 inches per hour).

Group B—Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group B are as follows. The saturated hydraulic conductivity in the least transmissive layer between the surface and 50 centimeters [20 inches] ranges from 10.0 micrometers per second (1.42 inches per hour) to 40.0 micrometers per second (5.67 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a water impermeable layer and a water table are in group B if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 4.0 micrometers per second (0.57 inches per hour) but is less than 10.0 micrometers per second (1.42 inches per hour).

Group C—Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group C are as follows. The saturated hydraulic conductivity in the least transmissive layer between the surface and 50 centimeters [20 inches] is between 1.0 micrometers per second (0.14 inches per hour) and 10.0 micrometers per second (1.42 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a restriction and a water table are in group C if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 0.40 micrometers per second (0.06 inches per hour) but is less than 4.0 micrometers per second (0.57 inches per hour).

Group D—Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential. All soils with a depth to a water impermeable layer less than 50 centimeters [20 inches] and all soils with a water table within 60 centimeters [24 inches] of the surface are in this group, although some may have a dual classification, as described in the next section, if they can be adequately drained.

The limits on the physical diagnostic characteristics of group D are as follows. For soils with a water impermeable layer at a depth between 50 centimeters and 100 centimeters [20 and 40 inches], the saturated hydraulic conductivity in the least transmissive soil layer is less than or equal to 1.0 micrometers per second (0.14 inches per hour). For soils that are deeper than 100 centimeters [40 inches] to a restriction or water table, the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface is less than or equal to 0.40 micrometers per second (0.06 inches per hour).

Dual hydrologic soil groups—Certain wet soils are placed in group D based solely on the presence of a water table within 60 centimeters [24 inches] of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 60 centimeters [24 inches] below the surface in a soil where it would be higher in a natural state.

Matrix of hydrologic soil group assignment criteria—The decision matrix in table 7–1 can be used to determine a soil's hydrologic soil group. If saturated hydraulic conductivity data are available and deemed to be reliable, then these data, along with water table depth information, should be used to place the soil into the appropriate hydrologic soil group. If these data are not available, the hydrologic soil group is determined by observing the properties of the soil in the field. Factors such as texture, compaction (bulk density), strength of soil structure, clay mineralogy, and organic matter are considered in estimating the hydraulic conductivity of each layer in the soil profile. The depth and hydraulic conductivity of any water impermeable layer and the depth to any high water table are used to determine correct hydrologic soil group for the soil. The property that is most limiting to water movement generally determines the soil's hydrologic group. In anomalous situations, when adjustments to hydrologic soil group become necessary, they shall be made by the NRCS State soil scientist in consultation with the State conservation engineer.

Table 7–1 Criteria for assignment of hydrologic soil group (HSG)

Depth to water impermeable layer [1]	Depth to high water table [2]	K_{sat} of least transmissive layer in depth range	K_{sat} depth range	HSG [3]
<50 cm [<20 in]	—	—	—	D
50 to 100 cm [20 to 40 in]	<60 cm [<24 in]	>40.0 µm/s (>5.67 in/h)	0 to 60 cm [0 to 24 in]	A/D
		>10.0 to ≤40.0 µm/s (>1.42 to ≤5.67 in/h)	0 to 60 cm [0 to 24 in]	B/D
		>1.0 to ≤10.0 µm/s (>0.14 to ≤1.42 in/h)	0 to 60 cm [0 to 24 in]	C/D
		≤1.0 µm/s (≤0.14 in/h)	0 to 60 cm [0 to 24 in]	D
	≥60 cm [≥24 in]	>40.0 µm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 µm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 µm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 µm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
>100 cm [>40 in]	<60 cm [<24 in]	>10.0 µm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A/D
		>4.0 to ≤10.0 µm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B/D
		>0.40 to ≤4.0 µm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C/D
		≤0.40 µm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D
	60 to 100 cm [24 to 40 in]	>40.0 µm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A
		>10.0 to ≤40.0 µm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B
		>1.0 to ≤10.0 µm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C
		≤1.0 µm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D
	>100 cm [>40 in]	>10.0 µm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A
		>4.0 to ≤ 10.0 µm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B
		>0.40 to ≤4.0 µm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C
		≤0.40 µm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D

1/ An impermeable layer has a K_{sat} less than 0.01 µm/s [0.0014 in/h] or a component restriction of fragipan; duripan; petrocalcic; orstein; petrogypsic; cemented horizon; densic material; placic; bedrock, paralithic; bedrock, lithic; bedrock, densic; or permafrost.

2/ High water table during any month during the year.

3/ Dual HSG classes are applied only for wet soils (water table less than 60 cm [24 in]). If these soils can be drained, a less restrictive HSG can be assigned, depending on the K_{sat}.

630.0702 Disturbed soils

As a result of construction and other disturbances, the soil profile can be altered from its natural state and the listed group assignments generally no longer apply, nor can any supposition based on the natural soil be made that will accurately describe the hydrologic properties of the disturbed soil. In these circumstances, an onsite investigation should be made to determine the hydrologic soil group. A general set of guidelines for estimating saturated hydraulic conductivity from field observable characteristics is presented in the Soil Survey Manual (Soil Survey Staff 1993).

630.0703 References

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Water Movement

Water movement concerns rates of flow into and within the soil and the related amount of water that runs off and does not enter the soil. Saturated hydraulic conductivity, infiltration rate, and surface runoff are part of the evaluation.

Saturated Hydraulic Conductivity

Water movement in soil is controlled by two factors: 1) the resistance of the soil matrix to water flow and 2) the forces acting on each element or unit of soil water. Darcy's law, the fundamental equation describing water movement in soil, relates the flow rate to these two factors. Mathematically, the general statement of Darcy's law for vertical, saturated flow is:

$$Q/At = -K_{sat}\, dH/dz$$

where the flow rate Q/At is what soil physicists call the flux density, i.e., the quantity of water Q moving past an area A, perpendicular to the direction of flow, in a time t. The vertical saturated hydraulic conductivity K_{sat} is the reciprocal, or inverse, of the resistance of the soil matrix to water flow. The term dH/dz is the hydraulic gradient, the driving force causing water to move in soil, the net result of all forces acting on the soil water. Rate of water movement is the product of the hydraulic conductivity and the hydraulic gradient.

A distinction is made between saturated and unsaturated hydraulic conductivity. Saturated flow occurs when the soil water pressure is positive; that is, when the soil matric potential is zero (satiated wet condition). In most soils this situation takes place when about 95 percent of the total pore space is filled with water. The remaining 5 percent is filled with entrapped air. If the soil remains saturated for a long time (several months or longer) the percent of the total pore space filled with water may approach 100. Saturated hydraulic conductivity cannot be used to describe water movement under unsaturated conditions.

The vertical saturated hydraulic conductivity K_{sat} is of interest here; it is the factor relating soil water flow rate (flux density) to the hydraulic gradient and is a measure of the ease of water movement in soil. K_{sat} is the reciprocal of the resistance of soil to water movement. As the resistance increases, the hydraulic conductivity decreases. Resistance to water movement in saturated soil is primarily a function of the arrangement and size distribution of pores. Large, continuous pores have a lower resistance to flow (and thus a higher conductivity) than small or discontinuous pores. Soils with high clay content generally have lower hydraulic conductivities than sandy soils because the pore size distribution in sandy soil favors large pores even though sandy soils usually have higher bulk densities and lower total porosities (total pore space) than clayey soils. As illustrated by Poiseuille's law, the resistance to flow in a tube varies as the square of the radius. Thus, as a soil pore or channel doubles in size, its resistance to flow is reduced by a factor of 4; in other words its hydraulic conductivity increases 4-fold.

Hydraulic conductivity is a highly variable soil property. Measured values easily may vary by 10-fold or more for a particular soil series. Values measured on soil samples taken within centimeters of one another may vary by 10-fold or more. In addition, measured hydraulic conductivity values for a soil may vary dramatically with the method used for measurement. Laboratory determined values rarely agree with field measurements, the differences often being on the order of 100-fold or more. Field methods generally are more reliable than laboratory methods.

Because of the highly variable nature of soil hydraulic conductivity, a single measured value is an unreliable indicator of the hydraulic conductivity of a soil. An average of several values will give a reliable estimate which can be used to place the soil in a particular hydraulic conductivity class. Log averages (geometric means) should be used rather than arithmetic averages because hydraulic conductivity is a log normally distributed property. The antilog of the average of the logarithms of individual conductivity values is the log average, or geometric mean, and should be used to place a soil into the appropriate hydraulic conductivity class. Log averages are lower than arithmetic averages.

Hydraulic conductivity classes in this manual are defined in terms of vertical, saturated hydraulic conductivity. Table 3-7 defines the vertical, saturated hydraulic conductivity classes. The saturated hydraulic conductivity classes in this manual have a wider range of values than the classes of either the 1951 *Soil Survey Manual* or the 1971 *Engineering Guide*. The dimensions of hydraulic conductivity vary depending on whether the hydraulic gradient and flux density have mass, weight, or volume bases. Values can be converted from one basis to another with the appropriate conversion factor. Usually, the hydraulic gradient is given on a weight basis and the flux density on a volume basis and the dimensions of K_{sat} are length per time. The correct SI units thus are meters per second.[6] Micrometers per second are also acceptable SI units and are more convenient (table 3-7). Table 3-8 gives the class limits in commonly used units.

Table 3-7. Saturated hydraulic conductivity classes

Class	Ksat (μm/s)
Very High	≥ 100
High	10 - 100
Moderately High	1 - 10
Moderately Low	0.1 - 1
Low	0.01 - 0.1
Very Low	< 0.01

Hydraulic conductivity does not describe the capacity of soils in their natural setting to dispose of water internally. A soil placed in a very high class may contain free water because there are restricting layers below the soil or because the soil is in a depression where water from

[6] The Soil Science Society of America prefers that all quantities be expressed on a mass basis. This results in Ksat units of kg s m-3. Other units acceptable to their society are m3 s kg-1, the result of expressing all quantities on a volume basis, and m s -1, the result of expressing the hydraulic gradient on a weight basis and flux density on a volume basis.

surrounding areas accumulates faster than it can pass through the soil. The water may actually move very slowly despite a high K_{sat}.

Table 3-8. Saturated hydraulic conductivity class limits in equivalent units

µm/s		m/s	cm/day	in/hr	cm/hr	kg s m^{-3}	m3 s kg^{-3}
100	=	10^{-4}	864.	14.17	36.0	$1.02X10^{-2}$	$1.02X10^{-8}$
10	=	10^{-5}	86.4	1.417	3.60	$1.02X10^{-3}$	$1.02X10^{-9}$
1	=	10^{-6}	8.64	0.1417	0.360	$1.02X10^{-4}$	$1.02X10^{-10}$
0.1	=	10^{-7}	0.864	0.01417	0.0360	$1.02X10^{-5}$	$1.02X10^{-11}$
0.01	=	10^{-8}	0.0864	0.001417	0.00360	$1.02X10^{-6}$	$1.02X10^{-12}$

Guidelines for K_{sat} Class Placement

Measured values of K_{sat} are available from the literature or from researchers working on the same or similar soils. If measured values are available, their geometric means should be used for class placement.

Saturated hydraulic conductivity is a fairly easy, inexpensive, and straightforward measurement. If measured values are unavailable, a project to make measurements should be considered. Field methods are the most reliable. Standard methods for measurement of K_{sat} are described in Agronomy Monograph No. 9 (Klute and Dirksen, 1986, and Amoozegar and Warrick, 1986) and in SSIR 38 (Bouma et al., 1982).

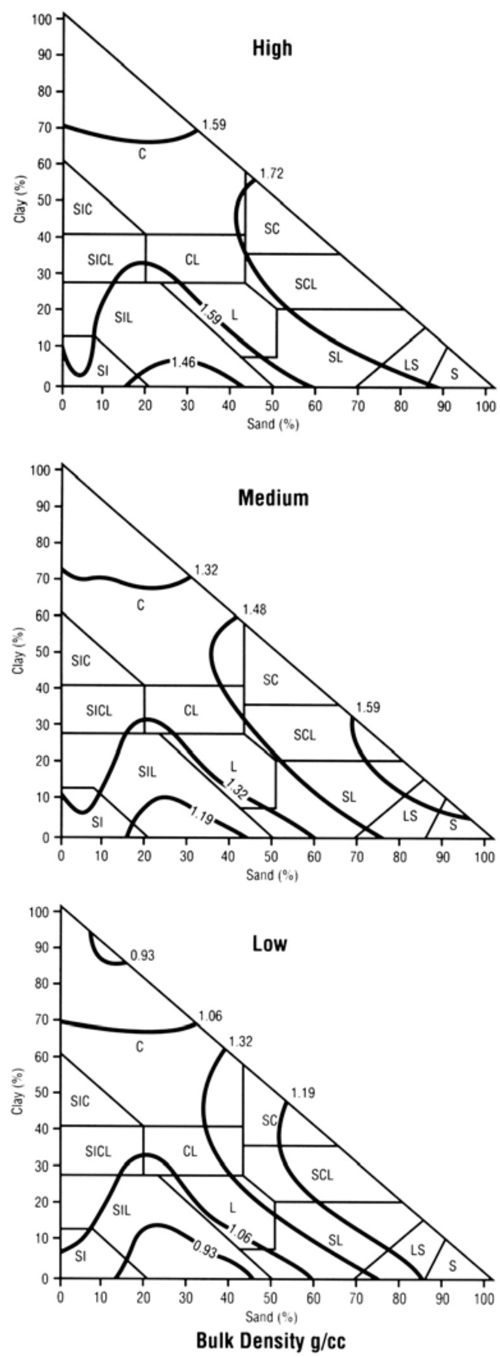
Various researchers have attempted to estimate K_{sat} based on various soil properties. These estimation methods usually use one or more of the following soil physical properties: surface area, texture, structure, bulk density, and micromorphology. The success of the individual methods varies. Often a method does fairly well in a localized area. No one method works really well for all soils. Sometimes, measurement of the predictor variables is more difficult than measurement of hydraulic conductivity. Generally, adjustments must be made for "unusual" circumstances such as high sodium concentrations, certain clay mineralogies, and the presence of coarse fragments, fragipans, and other miscellaneous features.

The method presented here is very general (Rawls and Brakensiek, 1983). It has been developed from a statistical analysis of several thousand measurements in a variety of soils. Because the method is intended for a wide application, it must be used locally with caution. The results, often, must be adjusted based on experience and local conditions.

Figure 3-11 consists of three textural triangles that can be used for K_{sat} class placement, based on soil bulk density and texture. The center triangle is for use with soils having medium or average bulk densities. The triangles above and below are for soils with high and low bulk densities, respectively.

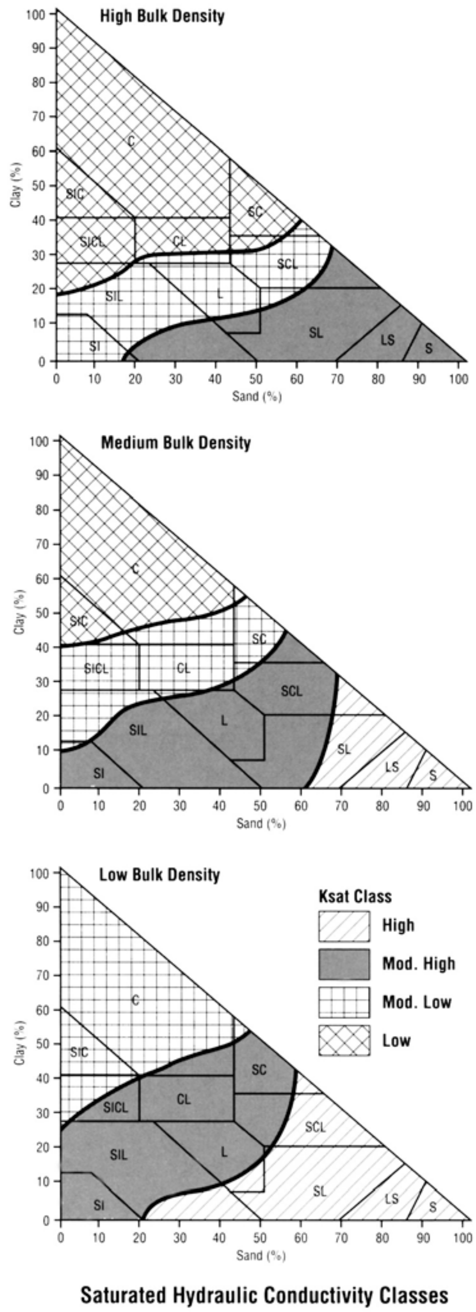
Figure 3-12 can be used to help determine which triangle in figure 3-11 to use. In each of the triangles, interpolation of the iso-bulk density lines yields a bulk density value for the particular soil texture. The triangle that provides the value closest to the measured or estimated bulk density determines the corresponding triangle in figure 3-11 that should be used.

FIGURE 3-11



Saturated hydraulic conductivity classes (Rawls and Brakensiek, 1983). A clay loam with a bulk density of 1.40 g/cc and 35 percent both sand and clay falls in the medium bulk density class.

FIGURE 3-12



Bulk density and texture relationships.

The hydraulic conductivity of a particular soil horizon is estimated by finding the triangle (fig. 3-11), based on texture and bulk density, to which the horizon belongs. The bulk density class to which the horizon belongs in Fig. 3-11 determines the triangle to be used in Fig. 3-12. The K_{sat} class can be determined immediately from the shading of the triangle. A numerical value of K_{sat} can be estimated by interpolating between the iso-K_{sat} lines; however, the values should be used with caution. The values should be used only to compare classes of soils and not as an indication of the K_{sat} of a particular site. If site values are needed, it is always best to make several measurements at the site.

The K_{sat} values given by the above procedure may need to be adjusted based on other known soil properties. Currently, there is little information available to provide adequate guidelines for adjusting the estimated K_{sat}. The soil scientist must use best judgement based on experience and the observed behavior of the particular soil.

Hydraulic conductivity can be given for the soil as a whole, for a particular horizon, or for a combination of horizons. The horizon with the lowest value determines the hydraulic conductivity classification for the whole soil. If an appreciable thickness of soil above or below the horizon with the lowest value has significantly higher conductivity, then estimates for both parts are usually given.

Infiltration

Infiltration is the process of downward water entry into the soil. The values are usually sensitive to near surface conditions as well as to the antecedent water state. Hence, they are subject to significant change with soil use and management and time.

Infiltration stages.—Three stages of infiltration may be recognized—preponded, transient ponded, and steady ponded. *Preponded infiltration* pertains to downward water entry into the soil under conditions that free water is absent on the land surface. The rate of water addition determines the rate of water entry. If rainfall intensity increases twofold, then the infiltration increases twofold. In this stage, surface-connected macropores are relatively ineffective in transporting water downward. No runoff occurs during this stage.

As water addition continues, the point may be reached where free water occurs on the ground surface. This condition is called ponding. The term in this context is less restrictive than its use in inundation. The free water may be restricted to depressions and be absent from the majority of the ground surface. Once ponding has taken place, the control over the infiltration shifts from the rate of water addition to characteristics of the soil. Surface-connected nonmatrix and subsurface-initiated cracks then become effective in transporting water downward.

Infiltration under conditions where free water is present on the ground surface is referred to as ponded infiltration. In the initial stages of *ponded infiltration*, the rate of water entry usually decreases appreciably with time because of the deeper wetting of the soil, which results in a reduced suction gradient, and the closing of cracks and other surface-connected macropores. *Transient ponded infiltration* is the stage at which the ponded infiltration decreases markedly with time. After long continued wetting under ponded conditions, the rate of infiltration becomes steady. This stage is referred to as *steady ponded infiltration*. Surface-connected cracks would be closed, if reversible. The suction gradient would be small and the driving force reduced to near that of the gravitational gradient. Assuming the absence of ice and of zones of free water within moderate depths and that surface or near surface features (crust, for example) do not control

ATTACHMENT B

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November 20, 2014

Thomas N. Lippe
Lippe Gaffney Wagner LLP
329 Bryant Street, Suite 3D
San Francisco, CA 94107

Subject: Review of Draft EIR
Walt Ranch Project, Napa, CA

Dear Thomas:

I am a hydrologist with over twenty five years of technical and consulting experience in the fields of geology, hydrology, and hydrogeology. I have been providing professional hydrology services in California since 1991 and routinely manage projects in the areas of surface- and groundwater hydrology, water supply, water quality assessments, water resources management, and geomorphology. Most of my work is located in the Coast Range watersheds of California, including the Northern and Southern San Francisco Bay Counties. My areas of expertise include: characterizing and modeling watershed-scale hydrologic and geomorphic processes; evaluating surface- and ground-water resources/quality and their interaction; assessing hydrologic, geomorphic, and water quality responses to land-use changes in watersheds and causes of stream channel instability; and designing and implementing field investigations characterizing surface and subsurface hydrologic and water quality conditions. I co-own and operate the hydrology and engineering consulting firm Kamman Hydrology & Engineering, Inc. in San Rafael, California (established in 1997). I earned a Master of Science in Geology, specializing in Sedimentology and Hydrogeology as well as an A.B. in Geology from Miami University, Oxford, Ohio. I am a Certified Hydrogeologist (CHg) and a registered Professional Geologist (PG).

I have reviewed the Draft Environmental Impact Report, Walt Ranch Erosion Control Plan Application (No. P11-00205-ECA), prepared by Analytical Environmental Services (AES) County of Napa and dated July 2014. In addition to reviewing the DEIR, I have reviewed the following documents and rely on technical information contained in these documents to help formulate my opinions.

<u>DEIR and Appendices</u>

- Analytical Environmental Services (AES), 2014, Draft Environmental Impact Report, Walt Ranch Erosion Control Plan, Application No. P11-00205-ECA. Prepared for: Napa County Planning, Building and Environmental Services, July, 462p.
- Edwards Engineering, Walt Ranch Vineyard Development Project, preliminary water system master plan. Prepared for Hall Wines, LLC, November, 8p.
- Gilpin Geosciences, Inc., 2013, Engineering geologic investigation, Walt Ranch Vineyard Development, Hall Brambletree Associates LP, Monticello Road (Hwy 121) & Circle Oaks Drive, Napa, CA. Prepared for: Mr. Jim Bushey, PPI Engineering, Inc., March 6, 20p.
- Napa County RCD, 2013, Walt Ranch sedimentation and erosion potential evaluation. Prepared for PPI Engineering, February 11, 4p. with Appendix of USLE calculation results.

- PPI Engineering, 2013, Hall Brambletree Associates, LP, Walt Ranch Erosion Control Plan. Package 1 and 2, Revised February.
- Richard C. Slade & Associates (RCS), LLC, 2014, Second updated report on the results and analysis of 96-hour constant rate pumping test, Irrigation-supply well no. 3, Walt Ranch, Napa County, California. Prepared for: Hall Wines LLC, April, 56p.
- RiverSmith Engineering, 2013, Hydrologic analysis of proposed vineyard blocks within the Walt Ranch property, Napa County, California. Prepared for: PPI Engineering, March, 35p.
- WRA, 2007, Section 404 Jurisdicational wetland delineation, Walt Ranch, Napa County, CA. Prepared for: Hall Wines, LLC, December, 19p.

Professional Publications

- Clahan, K.B., Wagner, D.L., Saucedo, G.J., Randolph-Loar, C.E., and Sowers, J.M., 2004, Geologic map of the Napa 7.5' Quadrangle, Napa County, California: A digital database (v. 1). California Geological Survey, scale 1:24,000.
- Delattre, M.P. and Sowers, J.M., 2006, Geologic map of the Capell Valley 7.5' Quadrangle, Napa County, California: A digital database (v. 1). California Geological Survey, scale 1:24,000.
- Farrar, C.D. and Metzger, L.F., 2003, Ground-water resources in the Lower Milliken-Sarco-Tulucay Creeks area, Southeastern Napa County, California, 2000-2002. U.S. Geological Survey Water-Resources Investigations Report 03-4229, prepared in cooperation with the Napa County Department of Public Works, 106p.
- Faye, R.E., 1973, Ground-water hydrology of Northern Napa Valley. U.S. Geological Survey Water-Resources Investigations 13-73, prepared in cooperation with the Napa County Flood Control and Water Conservation District, November, 72p.
- Fox, K.F., Jr., Sims, J.D., Bartow, J.A., and Helley, E.J., 1973, Preliminary geologic map of Eastern Sonoma County and Western Napa County, California. U.S. Geological Survey Miscellaneous Field Studies Map MF-483, 1:62,500, 4 sheets.
- Fox, K.F., Jr., Fleck, R.J., Curtis, G.H., and Meyers, C.E., 1985, Potassium-argon and fission-track ages of the Sonoma Volcanics in an area North of San Pablo Bay, California. U.S. Geological Survey Miscellaneous Field Studies Map MF-1753, 1:125,000, 1 sheet with pamphlet (10p.).
- Fox, K.F., Jr., 1983, Tectonic setting of Late Miocene, Pliocene, and Pleistocene rocks in part of the Coast Ranges North of San Francisco, California. U.S. Geological Survey Professional Paper 1239, 38p.
- Johnson, M.J., 1977, Ground-water hydrology of the Lower Milliken-Sarco-Tulucay Creeks area, Napa County, California. U.S. Geological Survey Water Resource Investigations 77-82, Open file report, August, 40p.
- Kunkel, F. and Upson, J.E., 1960, Geology and ground water in Napa and Sonoma Valleys, Napa and Sonoma Counties, California. U.S. Geological Survey Water-Supply Paper 1495, prepared in cooperation with the California Department of Water Resources, 264p.
- Napa County, 2005, Napa County Baseline Data Report – Chapter 16 Groundwater Hydrology (Version 1). 13p.
- Napa County Department of Environmental Management, 2012, Milliken-Sarco-Tulocay (MST) groundwater deficient basin. Presentation to Napa County Groundwater Resources Advisory Committee (GRAC), April 26, 2012, 9 slides.
- Sarna-Wojcicki, A.M., 1976, Correlation of Late Cenozoic tuffs in the Central Coast Ranges of California by means of trace- and minor-element chemistry. U.S. Geological Survey Professional Paper 972, 38p.

- Sims, J.D., Fox, K.F., Jr., Bartow, J.A., and Helley, E.J., 1973, Preliminary geologic map of Solano County and parts of Napa, Contra Costa, Marin, and Yolo Counties, California. U.S. Geological Survey Miscellaneous Field Studies Map MF-484, 1:62,500, 5 sheets.
- Wagner, D.L. and Gutierrez, C.I., 2010, Geologic map of the Napa 30'x60' Quadrangle, Napa County, California. California Geological Survey, scale 1:24,000.

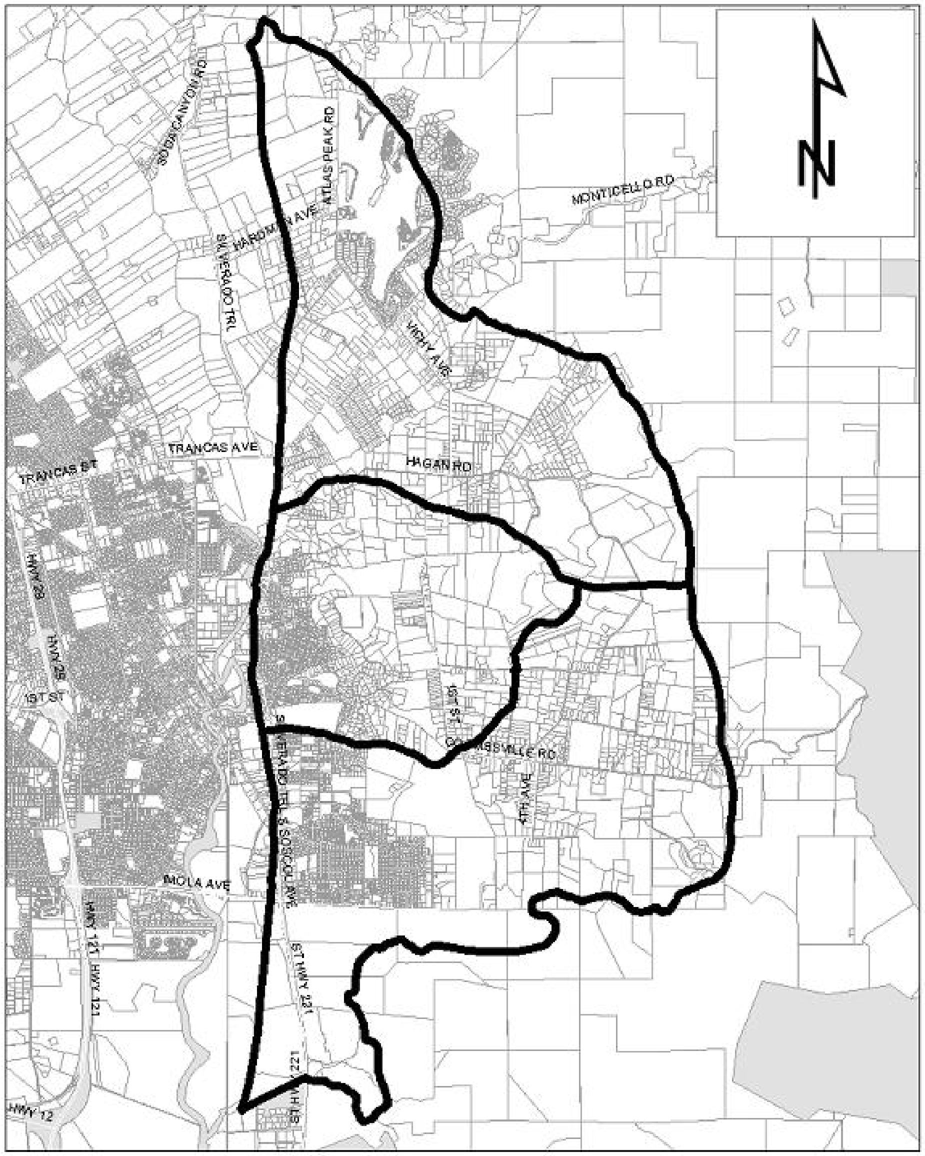
Based on my review of these materials and proposed mitigation measures, it is my professional opinion that the project has the potential to impart significant adverse impacts to vicinity groundwater supply, surface water flow and quality, and biological (vegetation and wildlife) in the Napa River and Capell Creek watersheds. The rationale for these opinions is provided below.

1. Walt Ranch Project is Located in the MST Groundwater Deficient Basin

The project does not acknowledge it lies in an important groundwater recharge area for the Milliken-Sarco-Tulucay groundwater basin (MST) and has not analyzed, let alone acknowledged, the project impact of groundwater withdrawals on the groundwater supply of the MST basin. The MST is the second largest groundwater basin in the County. It is located adjacent to the city of Napa along the eastern edge of the valley floor and covers an area of approximately 15 square miles. Because of acknowledged over-pumping from MST basin, the County has designated the MST as a "groundwater deficient area", as defined in the Groundwater Conservation Ordinance. As a result, the County has established MST groundwater use thresholds of 0.3 acre-feet per acre per year - groundwater use thresholds for the MST are defined in the County's Water Availability Analysis (WAA) Policy Report, dated August 2007. The WAA also states, "*The threshold for the Groundwater Deficient Areas was determined using data from the 1977 USGS report on the Hydrology of the Milliken Sarco Tulocay region. The value is calculated by dividing the "safe annual yield" (as determined by the USGS study of 1977) by the total acreage of the affected area (10,000 acres)*."

The County appears to delineate the MST basin as indicated in Figure 1 (Napa County Ordinance No. 1294, Chapter 13.15 Groundwater Conservation). The County's MST delineation likely comes from the "Study Area" designation presented in the 1977 USGS report (Johnson, 1977) cited in the WAA. The "Study Area" outlined in 1977 USGS report defines the downstream alluvial aquifer and underlying Sonoma Volcanic groundwater storage areas associated with known groundwater overdraft. This "Study Area" encompasses a 15-square mile area within the cumulative 42-squre mile drainage area for the Milliken, Sarco and Tulucay Creek watersheds (see Figure 2). However, here is where policy and science diverge with respect to defining a groundwater basin.

The 1977 USGS study, along with the more recent follow-up study completed by the USGS (Farrar and Metzger, 2003) clearly indicate that the 27-square mile higher elevation bedrock area lying to the east (and including a portion of the Walt Ranch Project area) are in direct hydraulic connection with and provide recharge to the 15-square mile MST groundwater storage "Study Area." The DEIR claims there is no hydraulic connection between the Walt Ranch project site and the MST "Study Area"/groundwater storage area. The USGS (2013) provides a graphical representation of the groundwater system underling the MST Creeks watershed, reproduced here in Figure 3. This conceptual groundwater flow model indicates that rainfall infiltrates and recharges the Sonoma Volcanic bedrock groundwater in the Howell Mountain uplands. The groundwater in the Sonoma Volcanic bedrock then migrates eastward over time towards the main alluvium and deeper Sonoma Volcanics storage area in the valley bottom, adjacent to the Napa River. The eastern boundary of the County's designated MST basin generally occurs where the foot of the Howell Mountains intersect the valley floor. The 2003 USGS report (Farrar and Metzger, 2003) provide the following statements regarding groundwater recharge to the MST.



Map 13-1: Milliken Sarco Tulocay Groundwater Deficient Basin

FIGURE 1: County designated MST groundwater basin (Source: Napa County Groundwater Ordinance).

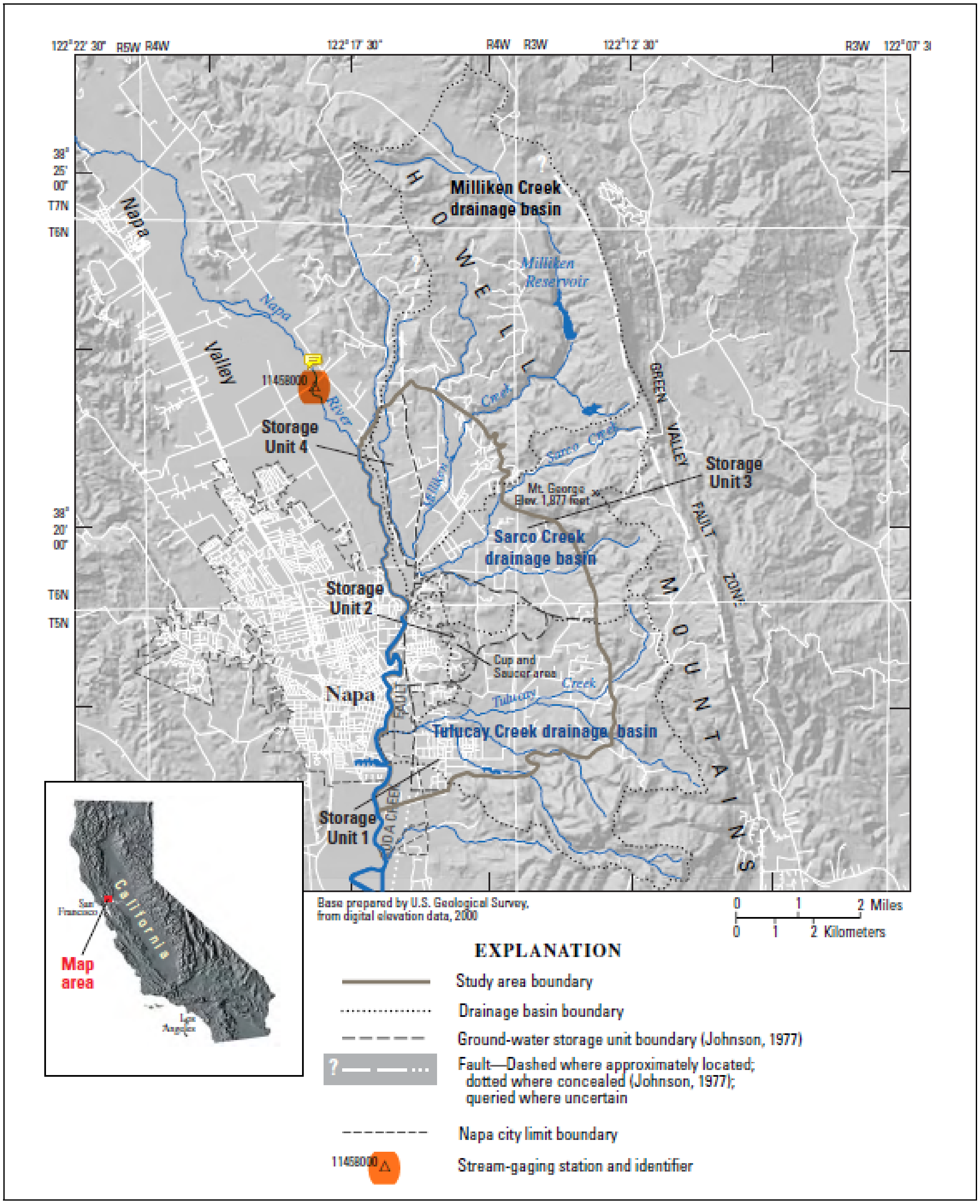


FIGURE 2: Location of 2003 USGS study area, differentiating between basin drainage area and "Study Area" boundaries (Source: Figure 1 in Farrar and Metzger, 2003).

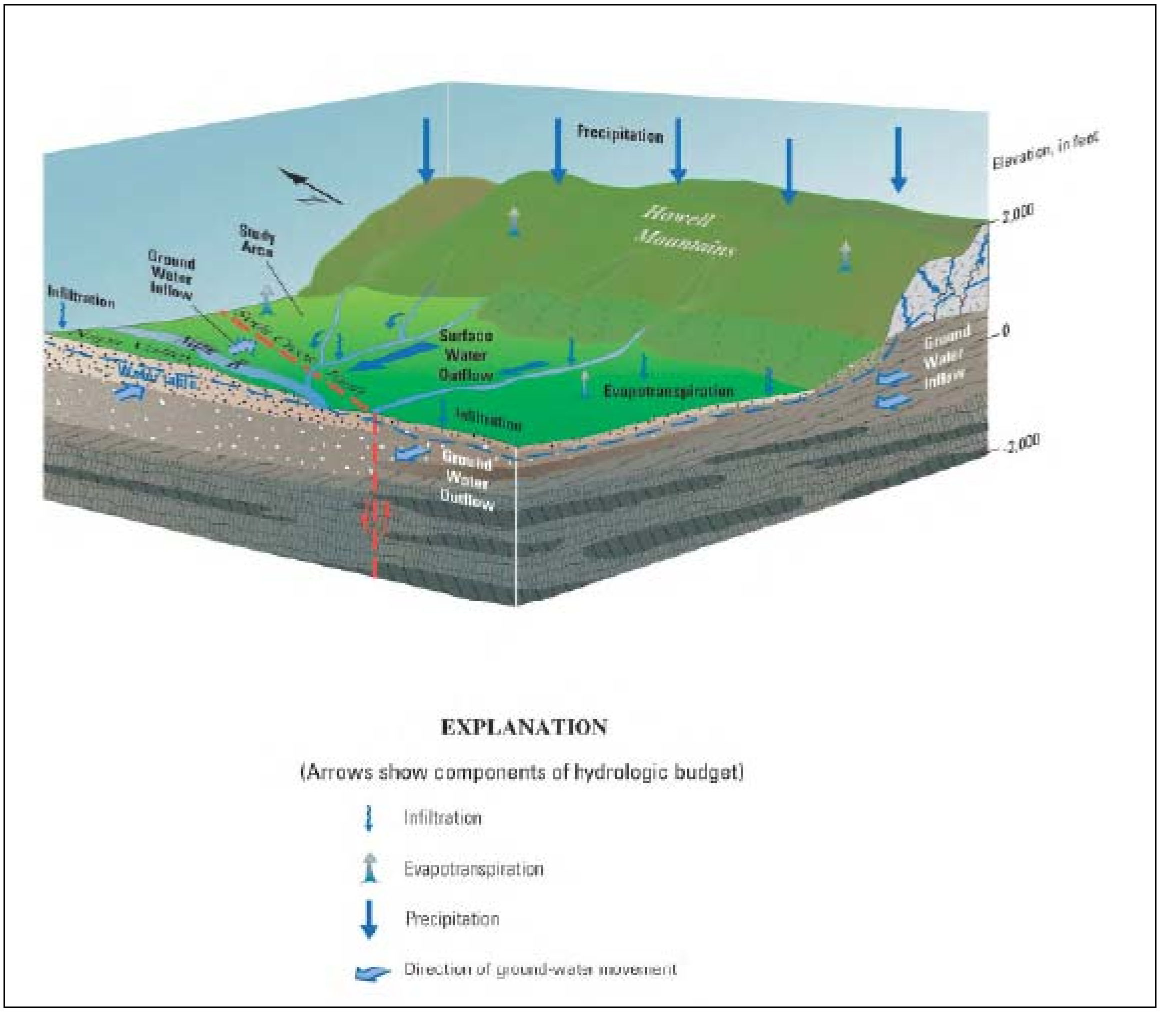


FIGURE 3: Conceptual model of groundwater flow system in the lower Milliken-Sarco-Tulucay Creeks area (Source: Figure 9 in Farrar and Metzger, 2003).

- On page 59 – "*The principal source of ground-water replenishment to the study area is lateral flow of ground water that is recharged in the Howell Mountains to the east of the study area.*"

- On Page 5 – "*The average total amount of precipitation received in the Milliken, Sarco, and Tulucay Creeks drainage basins is about 69,000 acre-ft/yr based on the isohyetal map (fig. 4). Of this amount, about 29,000 acre-ft/yr leaves the watershed as runoff in local streams to the Napa River. This estimate is based on streamflow records for stations on the Napa River and Tulucay Creek and is consistent with estimated unit runoff for this area given in Rantz (1968). Johnson (1977) estimated that evapotranspiration in the basins consumes about 30,500 acre-ft/yr. An estimate of about 34,000 acre-ft/yr is* *obtained when Johnson's estimate is adjusted for the slightly larger area mapped for this study. Using these estimates, it is clear that most of the water entering the basins leaves as runoff or evapotranspiration. Potential ground-water recharge can be calculated as the residual of total precipitation minus runoff and evapotranspiration, assuming no other inflows or outflows. Using this method, a residual of 6,000 acre-ft/yr is calculated based on the estimates made in this study. However, because of the uncertainty in the estimates of precipitation, runoff, and evapotranspiration, this value is not a precise estimate of potential ground-water recharge and should not be construed as the safe yield for the study area."*

- On Page 21 – "*Johnson (1977) estimated that the average annual recharge in the area of this study in 1975 was 5,400 acre-ft/yr: 3,050 acre-ft/yr from streamflow infiltration; 2,100 acre-ft/yr from subsurface inflow from the Howell Mountain block; and about 250 acre-ft/yr from direct infiltration of precipitation.*

- On Page 19 – "*Although recharge from excess irrigation sometimes can be a significant part of total recharge within some basins, within this study area it is considered minor because the predominant crop is wine grapes and local growers use highly efficient drip systems.*"

I believe that the 1977 and 2003 USGS studies provide conclusive information that that the project area lies in an important recharge area to the MST groundwater basin and a part of the Walt Ranch project site is hydraulically connected to the lower MST groundwater storage area. Further, based on Johnson's work in 1977, groundwater inflow from the Howell Mountain uplands provides around 39% (2,100 AF/yr) of average annual recharge to the Lower "Study Area" aquifer storage unit regulated by County Codes. Thus, any withdrawals from the Sonoma Volcanics within the Walt Project site will directly reduce the groundwater inflow and supply to the MST basin.

Based on conclusions in the RCS hydrogeology report, the DEIR states that the Project lies outside of the Milliken-Sarco-Tulucay (MST) groundwater basin, however based on my review of available geology maps and USGS reports, the southwest 1/3rd of the project property clearly falls within the upper recharge area of the MST basin. Of the Walt Ranch project area, 512-acres fall within the Milliken Creek watershed and MST groundwater basin and the remaining 1791-acreas fall within the Capell Creek watershed, which drains to Lake Berryessa. The project proposes to install 299-acres of vineyard in the Milliken Creek watershed and 208-acres of vineyard in the Capell Creek watershed – total water demand for the project is 213.5-AF. All proposed project groundwater wells are located in the MST basin. The WAA indicates that MST groundwater withdrawals are limited to 0.3-acre-feet (AF) per year per acre of property in the MST. Based on this policy, the project is only entitled to 154-AF. By claiming to be outside of the MST, the project avoids complying with the County's MST groundwater use thresholds.

In my opinion, the County has incorrectly drawn the boundary for the MST basin. To fully satisfy the intent of the fair share policy in the MST, the County needs to consider and incorporate the entire hydrologic basin, not just a portion that happens to be where water is stored and over-pumped. Perhaps a surface water analogy would better articulate this point. For example, if a community is experiencing a drought and a governing entity is charged with protecting and fairly managing the resource, one management strategy would be to set minimum withdrawal volumes for property owners around the reservoir. The "safe yield" and "fair share" intent of this policy assumed only those lake-front residents would be removing water from the reservoir. However, the governing entity then allows properties on the streams tributary to the reservoir to draw water out of the river at a higher rate/volume than the residents on the reservoir. Such a management strategy defeats the purpose of protecting the limited water resources and allocating those resources equally among all users. The main point here is that the County's resource management policy in the MST is tied to an arbitrary socioeconomic basin boundary, not a scientifically based, watershed scale boundary.

The project proposes to use MST basin water to irrigate out-of-basin vineyard in the Capell Creek watershed. Based on my review, it is unclear if out-of-basin transfers of MST water are acceptable/permissible per current County regulations and "fair use" policy. The bedrock and soil underlying the 2/3rds of the project area within the Capell Creek watershed does not yield significant quantities of water to wells.

2. Project Estimate of Available Groundwater Storage is Unsubstantiated

Project studies assume that all the Sonoma Volcanics (SVs) underlying the site can hold water. This is not the case as only specific units (most notably tuffaceous layers) within the SVs provide sufficient storage and permeability to provide water to wells. Review of published and project geologic maps, cross-sections and well completion information indicate that water-bearing units of the SV are limited under the project property. Johnson (1977) and Farrar and Metzger (2003) indicate that Sonoma Volcanics bedrock in the MST can be generally divided into five members: the lower andesitic member, the middle tuffaceous member, and the upper rhyolitic member, separated by two subaqueous deposits: diatomaceous deposits and sedimentary deposits, interbedded between the volcanic units. This five layer model is a useful simplification for some purposes, but it ignores the true complexity in the distribution of the various lithologies found in the Sonoma Volcanics. Many lithologic units in the Sonoma Volcanics lack wide areal extent and some units have a lenticular geometry or have interfingering contacts with adjacent lithologic units. The Gilpin Geosciences (2013) geologic map of the project site indicates rhyolite flows and andesite outcrop within the southwest portion of the site. Numerous studies (Kunkel and Upson, 1960; Johnson, 1977; and Farrar and Metzger, 2003) indicate that the principal water bearing unit of the SVs is the tuffaceous member. Farrar and Metzger (2003) report that the andesite member of the SVs has little primary permeability but, fracture zones associated with faulting and folding provides some secondary permeability, which yield small amounts of water to wells. They also report that the rhyolite member consists of low-permeability, banded rhyolitic lava interbedded with rhyolitic tuff, some densely welded, which reduces permeability. The RCS hydrogeology report (2014) also states that the SVs rock-types and their water bearing capacity is highly variable.

Information in the RCS hydrogeology report (2014) indicates that only selected horizons of the study wells[1] are screened. This suggests to me that the well driller identified and selected specific water-bearing horizons, which were preferentially screened in order to draw water. I assume the remaining lithologies encountered that were not screened are poor water-bearing materials within the Sonoma Volcanics. Therefore, understanding the thickness and extent of different rock types and their potential water bearing capacity under the site would help inform available groundwater supply.

The RCS hydrogeology report does not provide a detailed description or information regarding the specific rock types that make up the Sonoma Volcanics that lie beneath the Walt Ranch project site. The report's geologic map only illustrates the different Sonoma Volcanic units at the ground surface.

[1] Much of the water yield information reported in the RCS hydrogeology report (2014) comes from the testing, monitoring and analysis of wells on and around the project site (see page 2, 22-29, Tables 1A through 3B, and Figure 1 of the RCS 2014 report, provided in Appendix D to the DEIR), including: a) Walt Ranch wells (WR-1 through WR-5); b) the adjacent parcel Circle S Ranch wells (CS-1 through CS-4); and; c) a private well located on a parcel immediately southwest of Walt Ranch known as the Gale well.

Typically, I rely on driller's boring logs and cross-sectional profiles of geologic conditions to better understand the subsurface hydrogeology of a site. This information is lacking in the RCS hydrogeology report and DEIR. Thus, in order to gain a more complete understanding of the underlying geology/hydrogeology conditions at the site and fully review/evaluate RCS's hydrogeology study, it's necessary for me to obtain and review the drillers boring logs for the wells reference above. Treating the entire saturated thickness of Sonoma Volcanics as a single homogeneous layer (as completed in the RCS study) does not recognize and suitably address the likely water-bearing variability of these rocks. This added level of detail and understanding would benefit from review of the rock types encountered during drilling and well installation and reported in the associated drillers boring logs.

RCS also uses different saturated thickness values in their hydrogeology study. A saturated thickness value of 275-feet is used in the groundwater storage analysis (page 41 of RCS report), which is significantly greater than the 230-feet saturated thickness value used in the pump-test analysis to determine aquifer parameters (top of page 30). Using the smaller value of 230-feet in the groundwater storage analysis would result in less local groundwater storage.

It's also important to point out that the Hydrogeology study contains considerable presentation and discussion of aquifer tests and data analysis methods (e.g., theoretical drawdown calculations/modeling, theoretical cumulative impacts of pumping, calculation of aquifer parameters) but results do not reflect reality. Calculated values of aquifer transmissivity and storage coefficients by various models are discarded (although similar in magnitude) and inexplicably replaced with empirically derived values. Tables (2A and 2B; cited in text on page 27) don't exist in the report and cited values for hydraulic parameters in text don't agree with values in existing tables. Simulated drawdown at adjacent wells do not reflect actual conditions. Underlying assumptions of software and analytical solutions do not apply to heterogeneous and anisotropic conditions such as volcanic bedrock aquifers. In short, a lot of time and effort was spent on analyses that provide results that aren't realistic. This indicates the inadequacy of the solutions in providing realistic insight into the potential impacts of groundwater pumping.

3. Misleading Conclusion Regarding Available Groundwater Storage

RCS provides what they refer to as a "conservative" estimate of total groundwater storage that is very large. The DEIR claims that this magnitude of storage will mitigate any potential impacts of overdraft associated with annual groundwater withdrawals that exceed average annual recharge. However the useable groundwater storage capacity is typically considerably less. Of all the water in the storage spaces which can be pumped, not all will be removed due to the dispersed aquifer area and limited pumping radius of influence. The current well spacing, presence of fault segregated aquifers, and non-uniform distribution of groundwater in the Sonoma Volcanics make is difficult, if not impossible, to dewater the saturated material. In Johnson's 1977 study of groundwater conditions in the MST, he estimated that only 10% of the Sonoma Volcanic groundwater storage capacity is useable (accessible) storage. Thus, assuming a 2% specific yield and 10% useable storage capacity of the estimated 4301 AF of total storage, yields only 430 AF of groundwater storage beneath the project site – a value much closer to the 213.5 AF/yr project groundwater demands.

4. Project Overestimates Groundwater Recharge – No Assessment of Cumulative Impacts

The RCS hydrogeology report (pages 48-49) presents estimates of deep groundwater recharge assuming 7- to 9-percent of annual rainfall goes to deep percolation. These estimates yield average annual recharge rates of 2.59- to 3.15-inches/yr and volumes of 161- to 207-AF/yr, assuming an average annual precipitation total of 35 inches. In either case, average annual recharge rates are less than the annual water project demands. The 7% of annual rainfall deep groundwater recharge value is based on RCS staff professional experience, while the 9% recharge estimate comes from the 1977 USGS report for the entire

MST Creeks drainage basin. The problem with applying the 9% recharge rate to the Walt Ranch project site is that it reflects a watershed-wide average, incorporating the high stream and volcanic tuff infiltration rates in the lower elevations of the eastern hills with much lower infiltration rates representative of the higher elevation volcanic terrain, including a portion of the Walt Ranch Project site. The 1977 and 2003 USGS studies indicate that of the total 5,400 AF of average annual recharge to the MST, 3,050 AF/yr is supplied by stream flow infiltration along the eastern margin of 15-square MST storage area, 2,100 AF/yr comes as subsurface inflow from the 27-square mile Howell Mountain block (higher elevation volcanic terrain), and 250 AF/yr is direct infiltration of precipitation to the 15 square mile lower MST storage area on the valley floor. Assuming the Howell Mountain block covers 27 square miles in area (Johnson, 1977, suggests this area may be up to 33 square miles) and the 2,100 AF/yr of groundwater inflow from the block reflects the annual deep groundwater recharge rate, the annual deep groundwater recharge rate for the higher elevation volcanic terrain, including the Walt Ranch project site is only 1.46 in/yr (4% of average annual precipitation). Applying this recharge rate to the project area covered with Sonoma Volcanics (790-acres) yields an average annual deep groundwater recharge volume of 96 AF/yr, a value less than half (45%) of the estimated maximum annual project groundwater demand. Clearly the project has the potential to lead to localized groundwater overdraft, especially if the groundwater storage volume discussed above is less than estimated.

5. Insufficient Site Specific and Cumulative Impact Assessments of Groundwater Withdrawals
Regardless of which deep groundwater recharge rate is applied, all rates presented in the DEIR and above indicate groundwater withdrawals will exceed groundwater recharge. Under Impact 4.6-4, the DEIR states that increased groundwater pumping would not impact groundwater supplies in the project region and pumping would be a less than significant impact, even knowing that pumping rates exceed deep groundwater recharge rates. The justification that this will not be a significant impact is that there is more than enough existing storage in the underlying aquifer to absorb the imbalance. However, as discussed above, there has not been adequate or accurate quantification of existing groundwater storage in the bedrock aquifer underlying the site. Therefore, no conclusions on potential impacts are substantiated.

The hydrologic analyses supporting the DEIR have only looked at interference of pumping on local wells. There is clear admission that the DEIR has not done a regional impact analysis on groundwater supply due to heterogeneous nature of geology (pg. 4.6-47). The DEIR also claims it is infeasible to predict long-term impacts associated with groundwater extractions (pg. 4.6-49). The lack of analysis or inability to complete an impact assessment does not constitute the conclusion of "no potential impact." The impact should be considered potentially significant until demonstrated otherwise.

As explained above, proposed project groundwater withdrawals will reduce deep groundwater recharge to the main valley-bottom MST aquifer storage area. The RCS hydrogeology study does not provide any assessment of project impacts of groundwater resources in the water deficient MST basin. Therefore, this impact is still potentially, if no likely, significant.

6. Invalid Mitigation Measure Associated with Potential Impacts from Groundwater Pumping
Groundwater monitoring is listed as Mitigation Measure 4.6-4 in the DEIR. From a scientific perspective, monitoring in itself is not a mitigation. Monitoring is used as a way to identify triggers that define an impact (e.g., lower groundwater levels). Specific triggers that identify an impact and the resulting management changes implemented to mitigate the impact are the "Mitigation Measure". These triggers and corresponding management/operational changes have not been developed/defined in the DEIR. Therefore, it is my opinion that a Mitigation Measure does not exist for the potential impact(s) associated with groundwater pumping.

7. Incomplete Hydrology Assessments of Potential Impacts to Ecosystem and Water Supply
The DEIR does not provide adequate assessment on the potential project-induced changes in the volume and timing of water supplies to wetlands, riparian corridors and the associated biological habitats. Nor does the DEIR provide an assessment on how changes in land-use, vegetative cover and installation of drainage systems affect groundwater recharge rates.

Hydrologic analyses supporting the DEIR are somewhat compartmentalized – there is no comprehensive monthly or seasonal water budget to fully quantify runoff or groundwater recharge through the year. The seasonal distribution and duration of surface water flow rates are an integral variable in the support of existing wetland and riparian vegetation and wildlife. There is no hydrologic evaluation on how the project elements will impact the volume and timing of water movement in and through the site and associated ecological habitats. Of particular emphasis at the Walt Ranch site are groundwater dependant wetlands mapped by WRA (2007), including: 0.42 acres of freshwater seeps; 1.49 acres of seasonal volcanic seeps; small portions of perennial flow in Milliken Creek; and a number of intermittent streams. Project elements that affect site hydrology include: changes in land use; changes in vegetation types; tree clearing; grading and filling that changes site topography; rock filling; facility construction; and installation of a variety of surface water and groundwater drainage systems. Any one of these project elements can have a profound effect on the timing and volume of surface water and shallow groundwater movement through the site. A standard analysis to evaluate project impacts on hydrology is the development of a comprehensive and integrated water budget. Important water budget variables for the Walt Ranch project include: rainfall, runoff, evapotranspiration, open water evaporation, soil moisture storage, infiltration, surface water storage, groundwater recharge, groundwater flow, and groundwater storage. A comparison of existing and project condition water budgets should be used to address project changes to site ecosystems such as: seasonal volumes, rates and duration of water supply to on- and off-site riparian and wetlands and associated wildlife; shallow groundwater supply to local wetlands that are documented (WRA, 2007) to rely on groundwater, including freshwater seeps, seasonal volcanic seeps and perennial/intermittent creek channels; and deeper groundwater recharge that supplies creek flow that supports aquatic habitats in the lower elevations of the MST basin, including known seeps and intermittent creeks at the adjacent Circle S property as well as flow in lower Milliken Creek, even potentially downstream of the reservoir. This project analysis is warranted given the presence of California red-legged frog, Foothill yellow-legged frog, and Western pond turtle at the site, which depend on the preservation of suitable water supply to creeks, wetlands and riparian corridors on site, as well as potential off-site impacts to salmonids in Milliken Creek.

8. Inaccurate Quantification of Project Storm Water Runoff Estimates
The project contends that development activities will reduce runoff rates from vineyard areas. One way the project contends to achieve this goal is by ripping soil in targeted areas to increase infiltration rates and reduce runoff rates. While this is likely a short-term result of soil-ripping, my professional experience is that the increased infiltration rate associated with ripping is short-lived, and soil will recompact over a relatively short period (single years), resulting in soil with infiltration rates similar (or lower) than pre-project conditions. Thus, the reduced runoff associated with the project will be temporary. RiverSmith Engineering's hydrology report (2013) has only analyzed storm runoff rates for this short-term condition, not the long-term return to pre-project soil properties. A return toward pre-project soil properties will increase the magnitude of estimated project peak flows.

The project proposes a number of surface drains, subdrains and utility corridors that will intentionally and unintentionally concentrate and accelerate runoff off through proposed vineyard blocks. A primary runoff treatment strategy recommended in the RiverSmith Engineering hydrology study is to "detain water" onsite as a means to reduce peak flows. However, this is contrary to intent of the project drainage plan, which will effectively concentrate and accelerated storm water runoff. The hydrology storm runoff analysis does not incorporate these drainage elements into the storm water runoff calculations, where applicable. Both the likely reduction in infiltration capacity of ripped soil areas and project drainage elements will lead to significant increases in the estimated runoff rates, both on- and off-site. Thus, the peak flow rates for project conditions are underestimated, which means the potential impacts associated with high storm flows have not been accurately identified and evaluated.

9. Incomplete Erosion Potential Analysis: Potential Surface Erosion vs. Channel Erosion
For purposes of the following discussion, surface erosion is defined as that process by which rainfall and non-concentrated (sheet flow) rainfall-runoff erode and transport sediment off of relatively flat upland surfaces. In contrast, channel erosion refers to the erosion (down cutting and side cutting) in swales, ditches and channels by concentrated runoff and flow.

The project sedimentation and erosion potential evaluation for the site was completed by PPI and Napa RCD utilizing the empirically-based Universal Soil Loss Equation (USLE) to determine changes in annual erosion rates between existing and project conditions. The erosion potential assessment using the USLE only addresses surface erosion from individual vineyard blocks. The project erosion potential analysis does not consider or evaluate the potential for channel erosion within intervening or downstream receiving slopes, swales, and creeks outside of the vineyard blocks. This is a significant omission of potential erosion and sediment sources, especially in light of the fact that the project is underestimating the peak runoff from vineyard blocks. Thus, without considering the increase in channel runoff and associated channel erosion due to project development, the erosion potential analysis should be considered incomplete.

10. Presentation of Cumulative Erosion Potential Impacts Obscure Potential On-Site Impacts
The DEIR conclusions regarding project-induced changes in erosion potential are based on summing vineyard block soil loss subtotals within the Milliken and Capell Creek watersheds and presenting the total (net) change for each watershed (Milliken and Capell). The net results indicate that there are 44- and 13-percent reductions in potential soil loss from the Milliken and Capell Creek watersheds, respectively. However, this type of lumping of results masks localized impacts, which when considered alone, could be considered a significant impact. A more thorough review of changes in modeled soil loss results indicates localized increases in erosion potential from multiple vineyard blocks that contribute drainage and sediment to onsite Corps designated waters and wetlands located downstream of the proposed vineyards. These downstream creek, riparian and wetland areas host potentially sensitive biological resources, which would be potentially adversely impacted by increases in water and sediment runoff. Localized "hot spots" of anticipated increased sediment loading reported in the DEIR include: a) Corp wetlands receiving runoff from blocks 16B1, 16B2 and 16C1; b) Corp waters receiving drainage from blocks 17A-17C; c) Corp waters receiving runoff from blocks 34A3, 34C, and 49; d) Corp waters receiving drainage from blocks 36A and 36B; e) Corp wetlands receiving drainage from blocks 37D and 37E; f) Corp waters receiving drainage from blocks 38 and 53; g) Corp waters and wetlands receiving drainage from blocks 19A4, 19B, and 18A1-18A4; h) Corp waters receiving drainage from blocks 31A and 31B; and i) Corp waters receiving drainage from blocks 29, 29A1, 29A2, and 29B2. As indicated in the DEIR, increases in sediment delivery to any Corps designated water or wetland should be considered a significant potential impact.

11. Suitability of Project Erosion Control Measures

Review of project erosion control plans indicate that proposed vineyard block erosion control treatments include one or more of the following: straw wattle; rock check dams; overflow structures; and various types of energy dissipaters. No sediment basins are proposed at these locations. Although cover crops are listed as a project erosion control measure, they are incorporated into the USLE computations, including those vineyard blocks where erosion potential is anticipated to increase over existing conditions.

Straw wattle is a temporary surface erosion control measure and will degrade over time. This appear to be the only erosion control measures at many vineyard blocks and ability for straw wattle to provide long-term mitigation is highly limited.

Rock check dams are designed to dissipate concentrated flow energy and trap sediment. They reduce channel erosion potential and trap sediment from both surface and channel erosion. The potential for rock check dams to function properly over the long-term is mixed. They will require constant long-term maintenance to function as desired. If sediment built up behind rock check dams is not removed, they will lose their ability to dissipate energy and trap sediment allowing the unimpeded passage of high flows, leading to increased downstream channel erosion potential. Based on my experience, during very wet winters and/or extreme storms, rock vanes can be overwhelmed, buried and cease to function very quickly.

The runoff overflow and energy dissipation measures proposed in association with vineyard block drainage are designed to armor or dissipate flows at vineyard drainage outfalls in order to eliminate or reduce both surface and channel erosion potential - they are not designed to capture and retain sediment carried in runoff. These erosion control measures also require constant long-term maintenance to function and provide the necessary surface erosion protection at outfalls. However, many of these erosion control elements are located on steep slopes and water draining through them can become re-concentrated in swales and channels a short distance down-slope. It's important to restate that the RiverSmith Engineering storm runoff calculations did not take into account the drainage systems proposed in the vineyard blocks. Based on my review of vineyard drainage plans, these systems will collect and accelerate runoff through the vineyards, leading to higher project flow rates than those predicted in the RiverSmith Engineering hydrology study. These increased flows won't be detained by the proposed overflow energy dissipation structures, especially on steep slopes. This will lead to increased channel erosion potential in downslope receiving swales, channels and ditches and may adversely impact associated waters, wetlands and wildlife habitat.

The suitability of the pipe level spreader erosion control measure deserves further mention here. Based on review of standard pipe level spread design criteria, this erosion control measure seems poorly suited to the project site. In 2002, Caltrans completed an evaluation on the effectiveness of level spreaders[2]. Their report includes the following information:

- *Level spreaders are structures that are installed at points of concentrated storm water discharge. Level spreaders disperse the concentrated storm water over wide, relatively flat slopes so that erosion from concentrated runoff is minimized.*

- *Level spreaders are hydraulic conveyance systems that are constructed at a uniform elevation (zero grade) across a slope. The level spreader consists of a vegetated or mechanical lip or weir installed at surface grade that disperses (spreads) the water flow*

[2] Caltrans, 2002, Final Report – level spreader effectiveness evaluation. CTSW-RT-02-020, Caltrans Environmental Program, Office of Environmental Engineering, Sacramento, CA, 16p.

across a gentle slope. For construction applications, use of a mechanical lip constructed of timber, asphalt, or concrete would be preferred because those materials are likely to be durable. The structure must be installed in an undisturbed or finished area, should be level, and should disperse onto a vegetated slope that has a gradient of less than 1:10 (V:H). At a minimum, the final 6 meters (20 feet) of the conveyance structure entering the level spreader should have a finished gradient of less than 1:100. The lip can be constructed of either stabilized grass for low flows, or timber/concrete for higher flows. Typically, the minimum length for the level spreader lip is 2 meters (6 feet). The length of the level spreader lip is dependent on the volume of water that must be discharged. Typical rules-of-thumb are that storm water passing over the weir should be limited to a depth of approximately 0.15 meters (6 inches) and a velocity of approximately 0.3 meters per second (1 foot/sec).

- *For proper operation, runoff entering the level spreader must not contain significant amounts of sediment. Therefore, an upstream sediment removal BMP may be required in addition to the level spreader.*

- *The tributary area for the storm water should be less than two hectares.*

Based on the Caltrans design criteria, level spreaders are designed to be installed on very flat slopes and discharge onto similarly flat, vegetated slopes. Review of project erosion control plans indicate pipe level spreaders occupy relatively steep slopes, exceeding design criteria. Thus, these erosion control measures will not fully mitigate potential project impacts.

12. Project Potential to Active Dormant Landslides

The Gilpin Geosciences engineering geologic evaluation (2013) for the project states (page 17), "*We have reviewed the details shown for storm water drainage outlets and other water diversion facilities. These have appropriate armored, erosion-resistant surfaces that do not direct surface or subsurface runoff into slopes susceptible to landslide failure.*" They also state on page 13, "*Deep-seated landslides may be activated by undercutting of the toe, by adding significant weight to the top or body of the deposit, or by significantly altering the groundwater conditions which in turn increases the level of groundwater and pore water pressure. The rates of movement of deep-seated landslides are responsive to extended periods (multiple years of above average precipitation) of rainfall unlike shallow landslide that react to relatively short (single storm) bursts of intense storm activity (Iverson, 2000). Therefore any significant change in the regional groundwater regime could potentially affect the landslide stability*."

I've cross-referenced the proposed vineyard drainage outfall locations on the project Erosion Control Plans against Gilpin's landslide maps to determine if any vineyard runoff would be directed onto mapped landslides. Contrary to the statement contained in the Gilpin report, there are a number of vineyard block drainage outfalls directed above or onto mapped landslides, including vineyard blocks: 4E; 4H; 4I; 5A3; 19A; 31A; 31B; 36A; 36B; 62A; and 62B. Undoubtedly, the drainage discharge will increase the local infiltration and soil water content of the receiving landslide areas over existing levels. Based on the Gilpin text cited above, it is assumed that this may increase the potential to activate landslides – an increased potential adverse impact not acknowledged in the DEIR.

13. Invalid Analysis of On-Site and Cumulative Impacts

From my perspective, the DEIR failed at completing hydrologic and erosion assessments that evaluate potential impacts on surface water supply, groundwater supply, erosion and sediment transport to the on-site or surrounding environment. Runoff and erosion potential analyses were completed in a compartmentalized fashion, without regard to findings and potential impacts from their mutual effect and recommendations. Specific deficiencies of these analyses included:

- Erosion control measures designed to reduce sedimentation lead to increased magnitude of stormwater runoff;
- Stormwater runoff estimates did not consider the vineyard drainage systems proposed as erosion control measures, which will lead to high magnitude flows and increased erosion potential to downstream drainages;
- No comprehensive water budget of the project site was developed to look at project-induced changes in the way surface and groundwater move through and interact with the site and each other;
- The erosion potential assessment only addressed vineyard blocks, not the intervening or downstream receiving slopes, swales, creeks and wetlands;
- Potential changes in surface and groundwater supply to wetlands, riparian corridors and associated habitats, both on-site and off-site were not evaluated; and
- Regardless of whether Walt Ranch lies within the formal MST designated area, the site provides groundwater recharge to the basin. The DEIR does not evaluate how long-term withdrawals from the project site, combined with all recent and planned vineyards and developments in the basin will affect the groundwater deficient MST basin.

Without having properly quantified the water flow and sediment volumes moving through and off-site, the project has not fully evaluated potential impacts to the associated environments. As such, no cumulative impact assessments are possible. Without completing these assessments, the DEIR has not demonstrated that the project will not impart impacts to flooding, erosion, wetland/riparian water supply and habitats, and other sensitive aquatic habitats.

Please feel free to contact me with any questions regarding the material and conclusions contained in this letter report.

Sincerely,

Greg Kamman, PG, CHG
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January 26, 2013

Thomas N. Lippe
329 Bryant Street, Suite 3D
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re: Napa River Sediment TMDL Vineyard Waiver and ISMND

Dear Mr. Lippe:

You have asked me to review and comment on the proposed *Conditional Waiver of Waste Discharge Requirements for Discharges from Vineyard Properties in the Napa River and Sonoma Creek Watersheds* (Draft Conditional Waiver) and its Initial Study and proposed Mitigated Negative Declaration (ISMND). The Draft Conditional Waiver for Vineyard Properties is a part of the Implementation Plans of the Sediment TMDLs for the Napa River and Sonoma Creek.

This letter addresses two issues that could result in either additional erosion as the result of implementing the Draft Conditional Waiver or additional erosion due to ongoing channel incision. I give a brief description of these issues and then a more in-depth discussion of them below.

The unjustified assumption that stormwater can be infiltrated, without careful planning, may result in increased erosion that would not occur if the Draft Conditional Waiver was not adopted. There is a lack of discussion of subsurface storm flow in the Draft Conditional Waiver and the ISMND. An assumption is made that it is always beneficial to infiltrate excess stormwater. No evidence is presented that demonstrates that such an assumption is justified. There are situations when infiltrating excess runoff is no better than keeping it on the surface or may actually be more harmful then keeping it on the surface. In instances where surface runoff is directed to an inappropriate place for infiltration there is the potential to either generate additional surface runoff, through a process called saturation-excess flow, or to increase the amount of subsurface flow which has the potential to cause erosion downslope. These mechanisms will be described in a subsequent section of this letter. The directing of storm water to an inappropriate location for infiltration would be done in order to comply with the Draft Conditional Waiver. Therefore, any adverse environmental impacts that arise from the inappropriate siting of locations for stormwater infiltration pursuant to the Draft Conditional Waiver would be the result of adopting the Draft Conditional Waiver. The mitigations proposed in the ISMND would be insufficient to prevent these impacts.

The approach of actively only reducing sediment discharge to the Napa River or Sonoma Creek has the potential to result in these two river systems having greater capacity to transport sediment than is actually available. This type of imbalance drives channel incision and produces sediment. The Draft Conditional Waiver does not directly require actions that would reduce stormwater discharge so the problem of incision may be reduced but not completely stopped which would continue adverse environmental impacts.

Storm Runoff

The goal of the Napa River Sediment TMDL is to reduce the sediment load of the Napa River to 125% of the natural load. It is my opinion that, in addition, to reducing the sediment load to 125% of the natural background sediment load the TMDL and Basin Plan Amendment (BPA) should require that the stormwater discharge regime of the Napa River be brought into alignment with the natural hydrograph that would transport no more than 125% of the background sediment load. In contrast, the TMDL, Draft Conditional Waiver and the ISMND for the Draft Conditional Waiver aim for no net increase in storm discharge volume, velocity or duration. Staff has stated that concentrating on reducing sediment discharge will simultaneously reduce storm water discharge. I agree that there will be a reduction in storm water volume, velocity and duration if the sediment discharge is reduced to the target levels. However, Staff has offered no factual evidence to demonstrate that the reduction in storm water discharge that will result from their approach will result in a balance between the discharge regime of the Napa River and Sonoma Creek and their respective target sediment loads. I contend that, without actually reducing the runoff from vineyard properties, the resulting discharge regime in the Napa River and Sonoma Creek, after the target sediment loads are obtained, will be capable of transporting more than 125% of the background sediment load.

If the approach of only reducing sediment discharge, as outlined in the TMDL and Draft Conditional Waiver, does not sufficiently reduce storm water discharge to bring the sediment transport capacity of the Napa River and Sonoma Creek into balance with the supplied sediment load then the process of streambed incision will continue. This adverse impact to the environment is not fully mitigated by the measures proposed in the ISMND for the Draft Conditional Waiver.

In my August 2010 comments on the Napa River Sediment TMDL, I demonstrated that the water discharge regime during the 1994-2003 period (the time period used to determine that the sediment load was 185% of background) would have to be reduced between 14% and 24% to be in balance with the target sediment load of 125% of background in the Napa River. Requiring existing vineyards to reduce their peak storm water discharge by 20%, as measured by TR-55 or other model, would shift the discharge regimes of the Napa River and Sonoma Creek towards being in balance with the target sediment load of 125% of background.

Inappropriate Infiltration

An assumption is made in the Draft Conditional Waiver and the ISMND that it is always beneficial to infiltrate excess stormwater. No evidence is presented that demonstrates that such an assumption is justified. There are situations when infiltrating excess runoff is no better than keeping it on the surface or may actually prove to be more harmful then keeping it on the surface.

This argument requires some background on the mechanisms of storm runoff. The following discussion of runoff mechanisms is based on Dunne and Leopold (1978) and on Selby (2000). See Figure 1, adapted from Selby's Figure 11.10 (2000) at the end of this letter for a conceptual drawing of the various runoff processes on a landscape.

Runoff Processes

The rainfall-runoff process is complex and occurs through several mechanisms. According to Dunne and Leopold (1978) the runoff processes are:

1. Hortonian overland flow,
2. Subsurface flow,
3. Saturated overland flow (saturation-excess flow)

4. Groundwater flow and,
5. Channel Precipitation

Hortonian overland flow (infiltration-excess overland flow) is caused when the rainfall intensity exceeds the infiltration capacity of the soil. Hortonian overland flow is what many people imagine when thinking about the runoff process. In forested environments or areas with undisturbed vegetation and deep permeable soils, infiltration rates tend to exceed all but the most intense rainfall intensities. In forested environments, Hortonian overland flow is usually limited to rock outcrops, or to small areas during extremely intense (rare) rainfall bursts, and disturbed areas such as roads.

The following quotes, describing the runoff process are from M.J. Selby (Hillslope Materials and Processes, second edition, 2000, page 213):

> Field observations indicate that Hortonian overland flow is a rare phenomenon, especially in areas with undisturbed vegetation cover and deep permeable soils. Overland flow is most readily generated in semiarid environments with thin, impermeable soils with low water-storage capacity, and in any environment where loss of soil structure (and therefore macropores) by compaction, removal of vegetation, freezing, and blocking of pores are associated with prolonged and/or high intensity rainfalls.
>
> In areas of permeable soils where hydraulic conductivity decreases with soil depth, subsurface flow moves laterally as throughflow within the soil profile. When and where the profile becomes completely saturated, saturation-excess overland flow will occur. Both processes may occur at rainfall intensities and durations which are well below those required to produce Hortonian overland flow. Furthermore, both throughflow and saturation-excess flow may be generated from source areas which are variable in extent and different in location from source areas of Hortonian overland flow.
>
> **Subsurface stormflow is now regarded as the major runoff-generating mechanism in most humid environments**, both because of its influence on the development of saturated zones and as an important contributor to stormflow in its own right (Anderson and Burt 1978). (Emphasis added)

Subsurface storm flow can occur through open rock joints, coarse talus, soil pipes and permeable soil (Selby, 2000). The following excerpts are from Selby's (2000, page 217) discussion of soil pipes.

> Pipe-Flow
>
> Flow in pipes has been greatly underestimated as a hydrological process, according to experimental work in a very small number of catchments (Jones 1987a, b; Bryan and Yair 1982: McCaig 1983). It is now recognized that subsurface natural pipes exist in many environments ranging from arid through semiarid to humid temperate and humid tropical. They occur in many soil types and at various depths. Natural pipes are known with diameters ranging from 0.02 m (0.8 inch) to > 1m (3.3 feet) and lengths of a few meters to >1 km; they may carry perennial or ephemeral flows. The major requirement for their existence appears to be a soil body which is strong enough to support the walls and roof of a pipe but not so strong that it inhibits pipe erosion by flows which, at least initially, are of low volume and velocity. The mechanics of pipe development are discussed in Chapter 12.
>
> Pipe-flow may be derived from areas of saturated soil, areas of cracked surface soils or with many large, open macropores, or zones of converging saturation flow in macropores. Some pipe-flow may come from concentrated overland flow and channel flow which is diverted into a pipe. The velocity of pipe-flow has been variously estimated as being in the range of that of overland flow (0.1 m/s or 0.33 ft/s) to being an order of magnitude more rapid. It can therefore be a major contributor to storm runoff and especially to peak flows, Furthermore networks of pipes extend the areas of a catchment which contribute to storm runoff and they may be major contributors of water to saturated zones from which saturation-excess overland flow occurs. In some catchments pipe-flow has been assessed as contributing up to 50 per cent of the total storm discharge.

> The total significance of pipe-flow in both catchment hydrology and in geomorphic development of hillslopes is, however, not well understood. The proportion of large regions in which pipes occur is usually regarded as being small; but as they are difficult to detect, unless their roofs collapse, they may be underestimated. Research into pipe-flows and the effects of pipes on delivering water to erodible sites, such as hollows and those with unstable soil masses, is rather neglected.

Saturated-excess flow occurs on saturated sites. A site is saturated when the water table rises to the surface. When subsurface flow encounters a saturated site some of the subsurface water flows over the ground surface and is called *return flow*. Since the water table is at the ground surface, the infiltration rate is zero and any rain falling on to the area will flow down-slope as surface runoff. Saturated-excess flow tends to occur in swale bottoms or the lower portion of hillslopes and near stream channels. The area subject to saturation-excess overland flow expands as the duration of a storm increases. Selby (2000) observes that;

> Storm-runoff contributing areas commonly develop first alongside stream channels and in concavities and then expand as surface runoff occurs from operation of several processes.

Selby's (2000) entire discussion of runoff processes is attached to this letter.
A section in Chapter 12 of Selby (2000, page 241) describes the formation of soil pipes as follows.

> Pipe Erosion
>
> Subsurface pipe erosion has been described by a number of terms including pothole erosion, suffusion, subcutaneous erosion, tunneling, and tunnel-gullying, but the most widely used term is *piping* (Parker and Jenne 1967; Crouch 1976; Jones 1987). Natural pipes and their role in slope hydrology were described in the previous chapter.
>
> Among the factors which dispose a soil to piping are: a seasonal or highly variable rainfall; a soil subject to cracking in dry periods; a reduction in vegetation cover; a relatively impermeable layer in the soil profile; the existence of a hydraulic gradient in the soil; and a dispersible soil layer.
>
> Examples of piping are particularly common in semiarid badlands formed on smectite clays which have strong swelling and shrinkage properties and may also have high exchangeable sodium percentages (Heede 1971; Guiterrez et al. 1988; Lopez-Bermudez and Romero-Diaz 1989; Swanson et al. 1989). Loess and loessic colluvium with high sodium content are also subject to piping (Laffan and Sutherland 1988).
>
> The most commonly reported situation in which pipes develop is one in which a surface soil cracks as a result of desiccation. In a rainstorm water then infiltrates rapidly down the cracks and supersaturates a relatively permeable horizon in the subsoil. Lateral seepage may be fast enough to move soil particles and develop a channel, or, if the soil has dispersible clays, these may lose aggregation. Movement of water through subsurface cracks and voids is slow until water breaks through the soil surface further down the slope, and rapid flow can then work headwards within the soil and form a gully or enlarge a pipe (Figs 12.13 and 12.14).

Ziemer and Albright (1987) studied storm flow in soil pipes in two swales in the Caspar Creek watershed located in Jackson State Forest in Mendocino County, California. The following excerpts are from their 1987 paper.

> ABSTRACT Pipeflow dynamics are being studied at Caspar Creek Experimental Watershed in north-coastal California near Ft. Bragg. Pipes have been observed at depths to 2 m within trenched swales and at the heads of gullied channels in small (0.8 to 2 ha) headwater drainages. Digital data loggers connected to pressure transducers monitor discharge using calibrated standpipes. During storms, pipeflow up to 8 1 s~ has been measured» while, within the same swales, no surface channel flow occurred. Pipeflow discharge has been correlated with antecedent precipitation.

INTRODUCTION

Most of the geomorphic literature attributes drainage network evolution, except in karst areas, to surface runoff processes. Recently, the influence of near-surface groundwater flow in promoting subsurface erosion in non-karst areas and the development of drainage networks has received increasing attention (Higgins, 1984). The geomorphic features resulting from erosion by the flow of subsurface water in non-calcareous rocks have been referred to as "pseudokarst" (Halladay, 1960; Parker et al., 1964). In arid regions, the role of piping in gully development has been recognized for some time. In humid regions, however, the geomorphic significance of piping was largely overlooked until Kirkby & Chorley (1967) presented a model of soil water throughflow and saturated overland flow as an alternative to Horton overland flow on vegetated slopes.

Under favorable conditions, subsurface drainage can promote accelerated erosion by chemical (solution), physiochemical (suffusion), and physical (piping and landsliding) processes. Biological processes generate organic acids that accelerate the dissolution of primary soil minerals and also disperse secondary minerals (Durgin, 1984). These minerals can be transported through the soil, and eventually to a stream channel, by subsurface drainage. As chemical erosion progresses and the soil becomes more porous, water flowing through the soil can detach and move colloids through soil pores—a process called suffusion. Suffusion can lead to soil piping as progressively larger material is eroded. In addition, stress fractures in the soil, as well as biotic activity by invertebrates and vertebrates and by root networks may contribute to the initiation and subsequent development of piping systems.

Water infiltrates the pipe as laminar flow, but within the pipe, flow becomes turbulent and erosion is primarily by corrasion and undermining of pipe walls (Dredge & Thorn, 1976). As subsurface erosion continues, pipe roofs may collapse, forming pseudokarst topography. Goldsmith & Smith (1985) summarized the conditions essential for piping: (a) a source of water, (b) a surface infiltration rate that exceeds the subsurface permeability at some depth, (c) a zone of potentially dispersive soil, (d) a hydraulic gradient to cause water to flow, and (e) an outlet for the lateral flow.

CONCLUSION

Nearly all of the discharge that we observed at our sites came from pipeflow. There was very little seepage from the excavation face, even during storm periods. This is similar to observations by Tsukamoto et al. (1982). They reported that pipeflow was responsible for 95% of the outflow from a small granitic headwater catchment in Japan. Seepage through the soil matrix at their location was negligible. In another setting, Jones & Crane (1984) found that pipeflow accounted for 46% of the streamflow generated from their study area. (Emphasis Added)

Climate and geology vary for the limited number of studies of pipeflow hydrology conducted to date. These studies firmly establish the concept that macropore and piping networks are locally significant mechanisms for routing water and sediment from steep upland watersheds.

The runoff mechanisms, described above, must be thoroughly understood to avoid creating unintended erosion when designing new drainage facilities or modifying existing drainage facilities. It is an assumption that diverting stormwater runoff into a detention basin is always less environmentally damaging than not doing so. For example, in an attempt to meet the requirements of the Draft Conditional Waiver, a property owner might convert an existing swale into a stormwater detention basin that infiltrates the water into the subsurface. Below, I discuss the potential problems of constructing a detention basin in a swale.

A swale is a concave depression on a hillslope without a surface channel. Swales are also called zero-order basins since they are upslope of Stahler first-order channels. A second-order channel is created when two first-order channels join. Class III channels, as defined in the Draft Conditional Waiver, are generally first-order or second-order streams under the Stahler system of stream order. In general, swales are located upslope of a stream channel. The point of channel initiation (channel head) is typically located at the downslope end of a swale. Subsurface flow from a swale can also enter a stream channel from the side.

Let's examine what is happening in a swale during a significant storm event. The colluvium that comprises a swale will be saturated during storm events that generate significant amounts of runoff. So, the water table in a swale will be at or close to the ground surface during storm events. The high groundwater table means that swales are sites where saturated overland flow (saturation-excess flow) occurs. Subsurface flow from the adjacent hillslopes may come to the surface along the margin of the swale and flow across the surface. Rain falling on a saturated area cannot infiltrate into the ground and so becomes surface runoff. A saturated area acts, in some respects, as an impervious surface.

Subsurface flow out of the swale may eventually come to the surface and initiate a channel head. The channel initiation process is more likely to occur when the soil is saturated. As discussed above, the soil of a swale will tend to be saturated during a significant storm event. So channel heads often form at the downslope end of a swale.

Subsurface flow out of the swale may also occur in soil pipes. In fact, Ziemer and Albright (1987) found that most of the flow from the two swales they studied was carried in soil pipes. Well-developed soil pipes are known to carry both water and sediment. Soil pipes will discharge the water and sediment they carry to the surface at some point downslope.

Now suppose that a property owner constructs a stormwater detention basin in a swale. The stormwater detention basin, formerly a swale, captures surface runoff and holds it until it seeps into the ground or evaporates. So, the stormwater runoff from the property has been decreased and it would appear that the project is meeting the goal of the Draft Conditional Waiver. However, we have to understand what happens to the stormwater that infiltrated into the swale.

The stormwater that enters the detention basin constructed in the swale would not have been delivered to the swale prior to the construction of the detention basin. Some of the stormwater will evaporate but much of this additional water infiltrates into the subsurface. The water that infiltrates will potentially increase the rate of subsurface storm flow and prolong the duration of subsurface storm flow. The increased rate and duration of subsurface storm flow may result in the point of channel initiation (channel head) moving upslope causing additional erosion that would not have occurred prior to the construction of the detention basin. This would be an unmitigated adverse impact directly attributable to adopting the Draft Conditional Waiver.

The increased volume of water infiltrating into the swale from the detention basin would increase the rate and duration of flow in any soil pipes draining the swale. An increase of the rate or duration of flow through a soil pipe would likely erode the walls of the soil pipe. The eroded material would be transported downslope and discharged to the surface, potentially into a stream channel. Or the water infiltrated from the detention basin could possibly initiate the formation of new soil pipes. This would be an unmitigated adverse impact directly attributable to adopting the Draft Conditional Waiver.

One of the processes that cause the formation of gullies is the collapse of the roof of soil pipes (Selby, 2000). The creation and/or expansion of soil pipes, from water infiltrating from an improperly sited detention basin, could result in the formation of a new gully. This would be an unmitigated adverse impact directly attributable to adopting the Draft Conditional Waiver.

In some situations, the erosion caused by the increased subsurface flow out of a swale that has been converted into a stormwater detention basin may exceed the erosion caused by not using such a detention basin. The increased subsurface stormflow from a swale containing a detention basin may result in the upslope migration of a channel head, or the erosion of soil pipes, and even the formation of a gully through the collapse of the roof of a soil pipe. These potential significant adverse impacts were not considered by the ISMND.

Vineyards are one example of a location where the permeability decreases with depth. When a new vineyard is installed, it has been common practice to rip the soil with heavy equipment. The zone of soil that was ripped will be more permeable than the undisturbed material below the ripped layer. When the ground surface has a slope, even of just a few percent, there will be subsurface storm flow at the interface of the ripped soil and the undisturbed material below it give sufficient rainfall.

Undisturbed hillslopes also tend to exhibit a decrease in permeability with depth. Therefore, subsurface storm flow can be expected to occur on most hillslopes, give sufficient rainfall. Subsurface storm flow is expected to be widespread in the Napa River and Sonoma Creek watersheds.

Soil pipes can form in soils with at least some shrink-swell potential. Such soils exist in Napa River and Sonoma Creek watersheds. Therefore, it is likely that soil pipes will be an important mechanism for transporting subsurface storm flow, after sufficient rainfall has occurred, in areas with soils that have at least some shrink-swell potential.

Subsurface Flow not Considered in the Draft Conditional Waiver

The Draft Conditional Waiver does not consider the importance of subsurface storm flow as a runoff process. The following passages from the Draft Conditional Waiver demonstrate a failure to consider the importance of subsurface storm flow.

On page 23 the Draft Conditional Waiver defines point(s) of discharge.

> **Point(s) of Discharge**. *Point(s) of Discharge* include all locations where storm runoff is discharged via concentrated surface flow into a defined channel that has a bed and banks. Also, at locations where engineered drainage has been installed and storm runoff is collected first (e.g., subsurface drainage pipes or tiles in a vineyard block, an inboard ditch along a Road, etc.), a Point of Discharge is located at the outlet of the engineered drainage feature, whether that location is on a hill slope or in a defined channel.

This definition does not consider the discharge of soil pipes since soil pipes are a subsurface flow process and not a surface flow process. Failing to specifically include the discharge from a soil pipe as a point of discharge seriously undermines the effectiveness of the Draft Conditional Waiver. It is likely, that a significant amount of stormwater discharge is carried by soil pipes in the Napa River and Sonoma Creek watersheds.

Attachment D item 2(d) seeks to encourage on-site infiltration of stormwater to reduce erosion and flow peaks.

> 2. Vineyard Management Practices Element
> d. Management practices and infrastructure that promote and maximize infiltration on-site to reduce erosion and to prevent increase in stormwater peak flows.

However, the Draft Conditional Waiver should include statements that on-site infiltration should be designed in a manner that avoids increasing erosion from subsurface storm flow processes.

Attachment D item 5(a) also fails to mention the importance of designing on-site infiltration projects in a way that does not generate erosion from an increase in subsurface storm flow.

> 5. Stormwater Runoff Management Element
> a. Depict runoff flow patterns, including areas where runoff will be infiltrated, detained, and discharged via sheet flow and via a drainage system into the receiving waters.

Attachment D item 5(c) will not address erosion where soil pipes discharge since such locations are not included in the definition of point(s) of discharge.

> c. Describe erosion features, if any, at Points of Discharge and specify to address such erosion.

Attachment D item 6 does not explicitly recognize the role of subsurface storm flow in the formation of gullies (see Selby 2000).

> 6. Gullies and Shallow Landslides Element
> Unstable areas, such as gullies, rills, landslides, mudflows, rock falls, and channel erosion are significant sources of sediment. Where they exist, the Farm Water Quality Plan shall:
>
> a. Describe the location of erosional features including gullies, rills, landslides, mudflows, and channel erosion that have the potential to deliver more than 10 cubic yards (as defined above) of sediment to the channel that are a result of past or current Road and vineyard operations on the Vineyard Property.
>
> b. Identify and implement management practices needed to promote natural recovery or to actively stabilize unstable areas and to minimize increases in sediment delivery to receiving waters, including actions to disburse runoff causing or contributing to gullies and other erosional features.
>
> c. Indicate areas where active restoration of gullies, shallow landslides, or other unstable areas has already occurred.

The above passages from the Draft Conditional Waiver are not meant to be an exhaustive list of all the places where the Draft Conditional Waiver disregards the importance of subsurface storm flow but serve to demonstrate its disregard for this important runoff mechanism.

Summary

In addition to reducing the sediment load to 125% of the natural background sediment load the TMDL, BPA, and the Draft Conditional Waiver should require that the stormwater discharge regime of the Napa River be brought into alignment with the natural hydrograph that transports no more than 125% of the background sediment load. An enforceable storm water discharge performance standard should be applied to all four land use categories listed in BPA Tables 4.1 through 4.4. The storm water discharge performance standard should be applied to all lands in the Napa River watershed including upstream of the municipal water supply reservoirs.

Reducing the sediment load from 185% down to 125% of the natural sediment load without actively reducing excess storm discharge from all land uses in the Napa watershed will create an imbalance between the target sediment load of 125% of the natural load and the sediment transport capacity of the Napa River and its tributaries. Such an imbalance has the potential to result in erosion of the banks and/or bed of the Napa River and its tributaries. Therefore, implementing the current version TMDL and BPA, through the Draft Conditional Waiver, has the potential of causing erosion of the banks and/or bed of the Napa River and its tributaries.

The Draft Conditional Waiver does not recognize the importance of subsurface storm flow in generating streamflow or erosion. Selby (2000) observes that subsurface stormflow is the major runoff mechanism in humid environments.

> Subsurface stormflow is now regarded as the major runoff-generating mechanism in most humid environments, both because of its influence on the development of saturated zones and as an important contributor to stormflow in its own right (Anderson and Burt 1978).

The failure to recognize the role of subsurface storm flow in the generation of streamflow and erosion is the reason that the Draft Conditional Waiver does not point out the need for on-site infiltration projects to be designed to minimize increased subsurface storm flow. On-site infiltration projects carried out to satisfy the requirements of the Draft Conditional Waiver may result in increased subsurface storm flow and result in erosion or gully formation that would not have occurred if the Draft Conditional Waiver was not adopted. These potential significant adverse impacts were not considered by the ISMND.

Sincerely,

Dennis Jackson

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Hydrologist

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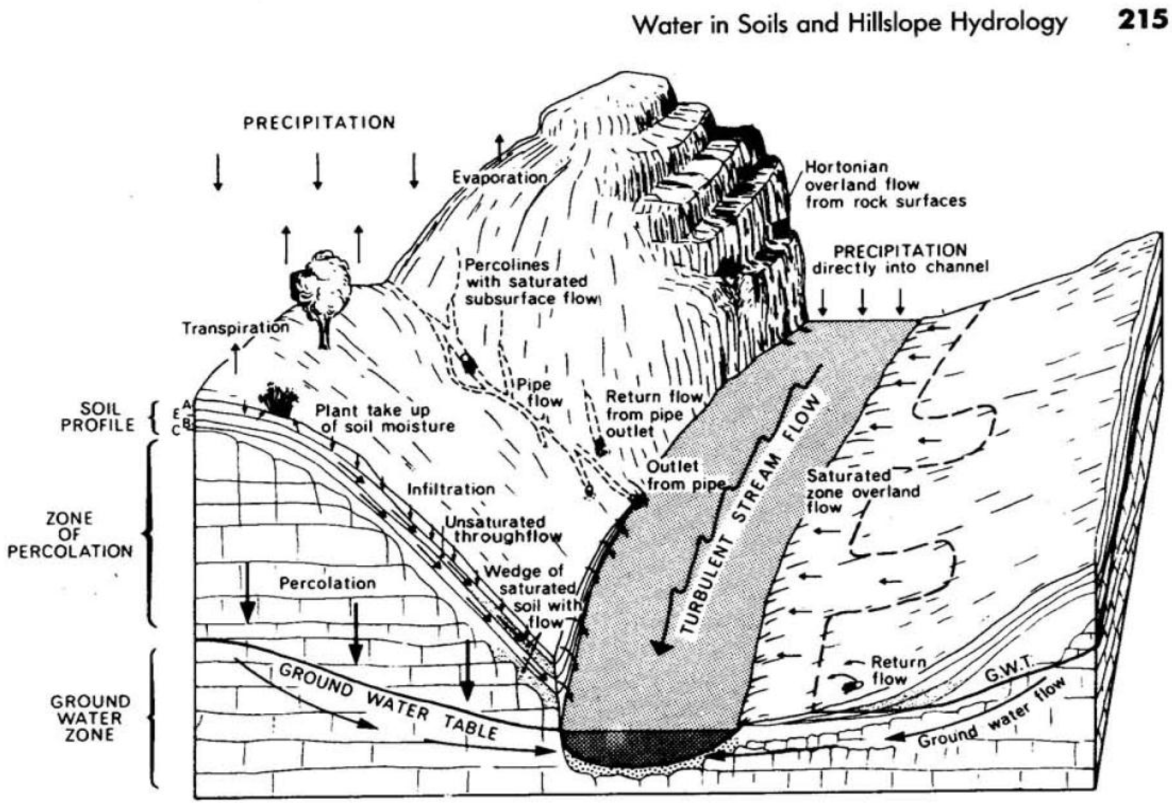

Figure 1. Adapted from Selby (2000) Figure 11.10(a). A schematic landscape with the various types of runoff from hillslopes and the sources and paths of runoff.