

Water Availability Analysis

Vine Cliff Winery Alteration Use Permit and Minor Modification P25-00161-UP & P24-00191-MM Planning Commission Hearing – June 18, 2025

Water Availability Analysis Vine Cliff Winery, Napa County APN 032-030-027

(Applicant)

Vine Cliff Winery 7400 Silverado Trail Napa, California

Prepared by:



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Introduction

Vine Cliff Winery is seeking permits from the County of Napa to renovate winery facilities at 7400 Silverado Trail (APN 032-030-027) which is located about 2.8 miles east of Oakville in the hills east of the Napa Valley floor. The subject parcel lies outside of the boundaries of the Napa Valley Groundwater Sub-basin. This Water Availability Analysis (WAA) is an update to the prior approved WAA for the parcel prepared by OEI in December 2017. The update includes a new well search in the project area and vicinity and revisions to the Tier 1 analysis to conform with updated County of Napa Groundwater guidance from Department of Planning, Building, & Environmental Services. No change in water use is expected.

The WAA includes the following elements: estimates of existing and proposed water uses on the project parcel and within the project recharge area, compilation of drillers' logs from the area and characterization of local hydrogeologic conditions, and execution of Tier 1 and Tier 2 screening criteria including estimates of groundwater recharge relative to proposed uses (Tier 1) and the potential for well interference at neighboring wells (Tier 2). No wells are within 500 ft of the project wells; per County guidance, no additional well interference analysis is required. The project well does not lie within 1,500 ft of any County-designated significant stream; hence no additional analysis of potential surface water-groundwater interaction is required (Tier 3).

Limitations

Groundwater systems of Napa County and the Coast Range are typically complex, and available data rarely allows for more than general assessment of groundwater conditions and delineation of aquifers. Hydrogeologic interpretations are based on the drillers' reports made available to us through the California Department of Water Resources, available geologic maps and hydrogeologic studies and professional judgment. This analysis is based on available data and relies significantly on interpretation of data from disparate sources of disparate quality.

Given the significant depths to water in wells near the project parcel (160 to 626-ft), the relationship between groundwater recharge generated on the project parcel and groundwater availability at the project wells is uncertain. It is likely that water flowing to the project wells is supplied by groundwater inflows from surrounding areas as well as from recharge occurring on the overlying landscape comprised by the subject parcel. Analysis of the age and sources of the deeper groundwater occurring beneath the project parcel is beyond the scope of this study.

The water balance approach used to estimate groundwater recharge for this study simulates potential recharge from infiltration of precipitation and does not include verifiable estimates of the capacity of the project aquifer materials to accept recharge. Where bedrock of low permeability and/or fractured bedrock underlies the subject parcel and study area, a significant proportion of the potential recharge may exit the project area as shallow subsurface flow rather than percolating and recharging the local aquifer. Quantifying the proportion of the potential recharge bedrock aquifers is beyond the scope of this analysis; we have attempted to characterize aquifer hydraulic parameters from available data. Data



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describing subsurface conditions of soil and bedrock, local aquifer hydraulic characteristics, and local processes and pathways of groundwater percolation are rarely available and difficult to obtains in the absence of focused and well-funded hydrogeologic investigations.

Hydrogeologic Conditions

The tier 1 WAA focuses on estimating groundwater recharge for comparison to groundwater use. Groundwater recharge in hillside areas of Napa County results primarily from infiltration of precipitation distributed across the land surface. To accomplish Tier 1 objectives in a manner consistent with hydrogeologic principles and water balance techniques used to estimate groundwater recharge, we define an area of landscape encompassing the project parcel that represents the likely source of infiltration recharge of the aquifer utilized by the project wells. The so-defined project recharge area is also used to estimate existing groundwater use on surrounding parcels so that a more comprehensive assessment of groundwater availability can be performed to assess project groundwater use in the context of the regional project aquifer. The recharge area thus also represents the project groundwater impact area and is sometimes referred to as the project recharge /impact area.

The project parcel is located in the foothills east of the Napa Valley in the northwest portion of a relatively large (~32 square miles) block of andesitic and basaltic lava flows of the Tertiary-aged Sonoma Volcanics. These volcanic rocks comprise much of the mountains east of the Napa Valley from the northern portion of the Milliken-Sarco-Tullocay (MST) basin north to Lake Hennessey (Figure 1). At the east edge of Napa Valley within the lowest-lying portions of the project parcel and immediately west of the parcel, alluvial fan deposits (map units Qf and Qhf) overlie the Sonoma Volcanics, mapped locally to be andesite and basalt flows (map unit Tsa, Figure 1). A project recharge area was developed for this project and is bounded by ridgelines delineating groundwater flow on the east north and south sides and the geologic contact with the alluvium of the Napa Valley floor to the west. This project recharge area is approximately 306.6 acres in size Geologic cross sections in the vicinity of the project parcel indicate that the Tsa unit extends to the west beneath portions of the alluvium of the Napa Valley and that wells in the area completed to depths as high as 600-ft do not fully penetrate the Tsa unit (see geologic Sections B and C, LSCE, 2013).

The Tsa unit is part of the lower member of the Sonoma Volcanics which was described by Weaver (1949) as comprised of individual lava flows displaying great variability in thickness and texture over short distances. Given this heterogeneity it can be expected that hydrogeologic conditions exhibit similar spatial variability and yields from wells completed anywhere in the Tsa unit, ranging from minimal yield to several hundred gpm (LSCE, 2013).

Driller's logs (Well Completion Reports) for wells around the project parcel were obtained from the California Department of Water Resources and from County files. A subset of these logs was compiled and georeferenced based on parcel and location sketch information available for some wells (Figure 1). The project parcel has two wells. The upper well (Well 1) is in the central-east portion of the parcel and was completed in 1996 to a depth of 385-ft. The lower well (Well 2) is



in the south-east portion of the parcel and was completed in 1996 to a depth of 280-ft (Table 1 & Figure 1). Static water level was not reported in well 1 but was reported at 150 feet bgs in well 2 at the time of construction.

Alluvial fan deposits in the southwest corner of the subject parcel are expected to be highly permeable relative to the underlying volcanic bedrock that comprises the project aquifer. Groundwater recharge processes are likely to be enhanced by the alluvial fan deposits because water may more readily percolate into and saturate the fan deposits and establish a perched water table overlying the bedrock aquifer that could provide for more effective percolation to the bedrock. This phenomena affects only a small portion of the parcel but could have a disproportionate effect on overall recharge occurring on the subject parcel.





Figure 1: Surficial geology and locations of wells in the vicinity of the project parcel (Graymer et al., 2007). Units are as follows:



Well No.	1	2	3*	4*	5*	6	7*	8*	9*	10*	11*	12*
Year Completed	1996	1986	1977	1995	1998	2007	2004	2004	2004	2004	2004	2004
Depth	385	283	240	800	600	690	300	300	300	300	300	300
Static Water Level	-	150	15	182	350	480	-	-	-	-	-	-
Estimated Yield	120	200	220	30	20	90	-	-	-	-	-	-
Top of Screened Interval	200	183	40	60	80	360	-	-	-	-	-	-
Bottom of Screened Interval	300	283	240	80	600	690	-	-	-	-	-	-
Geologic Unit	Tsa	Tsa	Qhf	Tsa	Tsa	Tsa	Tsa	Tsa	Tsa	Tsa	Tsa	Tsa
WCR No.	547492	119629	103154	547445	324026	1073642	802399	802400	802401	802402	802403	802404
Wall No												
well NO.	13*	14*	15*	16*	17*	18	19*	20	21*	22*	23*	24
Year Completed	13 * 2004	14 * 2004	15* 2004	16* 2004	17* 2004	18 1999	19* 1999	20 1978	21* 1998	22 *	23* 1992	24 2000
Year Completed Depth	13 * 2004 300	14* 2004 300	15* 2004 300	16* 2004 300	17* 2004 300	18 1999 1125	19* 1999 753	20 1978 350	21* 1998 595	22* 1998 810	23* 1992 637	24 2000 590
Year Completed Depth Static Water Level	13* 2004 300	14* 2004 300 -	15* 2004 300	16* 2004 300	17* 2004 300 -	18 1999 1125 271	19* 1999 753 393	20 1978 350 220	21* 1998 595 275	22* 1998 810 375	23 * 1992 637 400	24 2000 590 260
Year Completed Depth Static Water Level Estimated Yield	13* 2004 300 - -	14* 2004 300 - -	15* 2004 300 -	16* 2004 300 -	17* 2004 300 - -	18 1999 1125 271 300	19* 1999 753 393 150	20 1978 350 220 20	21* 1998 595 275 60	22* 1998 810 375 100	23* 1992 637 400 60	24 2000 590 260 60
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Table 1: Well completion details for the upper well (Well 1), lower well (Well 2), and wells on nearby parcels. Wells indicated by * were not included in the 2016 analysis but have been included from improved records and well search in 2024.

Water Demand

Existing groundwater uses within the project recharge area (described below in the Groundwater Recharge Analysis section) consist of Residential Use for eight residences, Winery Use for the 48,000 gallon per year Vine Cliff Winery, and Irrigation Use for 121 acres of vineyard of which 26 acres are on the project parcel.

The existing Residential Use is estimated to total 7.15 ac-ft/yr. The existing Winery Use (Vine Cliff Winery) is estimated to total 2.41 ac-ft/yr, and the existing Irrigation Use is estimated to total 60.57 ac-ft/yr for a Total Existing Use of 70.11 ac-ft/yr. <u>Approximately 17.06 ac-ft/yr or 24% of the existing use is associated with the project parcel with the remainder associated with neighboring parcels (Tables 2-4)</u>. These values vary slightly from water use estimates associated with the 2017 WAA due to updated water use calculations and changes in land use on surrounding parcels. The proposed project actions include the addition of a commercial kitchen. However, water use on the project parcel will not change as a result of this as precious water demand estimates assume water demand based on the annual number of attendees at catered events which will not change between existing and proposed conditions as a result of this project. No change in water use is expected as part of this project. Water for the project parcel is supplied by wells 1 and 2 (Table 1 and Figures 1 & 3)



	Existing Condition (acre-ft/yr)	Proposed Condition (acre-ft/yr)
Project Parcel	17.06	17.06
Residential Use	1.80	1.80
Irrigation Use	12.84	12.84
Winery Use	2.03	2.03
Employee/Guest Use	0.39	0.39
Neighboring Parcels	53.05	53.05
Residential Use	5.35	5.35
Irrigation Use	47.70	47.70
Total	70.11	70.11

Table 2: Existing and proposed annual groundwater uses (ac-ft/yr) within the project recharge area.

Table 3: Existing and proposed water use on the project parcel. Note that landscaping water use was reported as a flat rate rather than a per-acre rate.

	# of Units	Use per Unit	Annual Water Use (AF/yr)
Residential Use			1.80
Residences, Oversized	1 Residence	1.00 AF/Residence	1.00
Residences, Secondary	2 Residences	0.35 AF/Residence	0.70
Pools	1 Pool	0.10 AF/Pool	0.10
Agricultural Use			12.84
Vineyard	25.67 Acres	0.50 AF/acre/yr	12.84
Winery Use			2.03
Process Water	48000 Gallons	2.15 AF/100,000 gal.	1.03
Domestic & Landscaping	- Gallons	0.50 AF/100,000 gal.	1.00
Guest & Employee Use			0.39
Tasting Room Visitations	14600 Guests	3 gal./Guest	0.13
Events w/ On-Site Catering	2100 Guests	15 gal./Guest	0.10
Full-Time Employees	12 Employees	15 gal./shift @ 250 shifts/yr	0.14
Part-Time Employees	4 Employees	15 gal./shift @ 125 shifts/yr	0.02
Total			17.06

	# of Units	Use per Unit	Annual Water Use (AF/yr)
Residential Use			5.35
Residences, Oversized	1 Residence	1.00 AF/Residence	1.00
Residences, Primary	4 Residences	0.75 AF/Residence	3.00
Pools	3 Pools	0.10 AF/Pool	0.30
Other Landscaping, Addtl.	21000 sq. ft.	0.05 AF/1,000 sq. ft.	1.05
Agricultural Use Vineyard	95.4 Acres	0.50 AF/acre/yr	47.70 47.70
Total			53.05

Table 4: Existing and proposed groundwater use on neighboring parcels within the groundwater recharge area.

Groundwater Recharge Analysis

Groundwater recharge within the project recharge area was estimated using a Soil Water Balance (SWB) of Napa County developed by OEI. This model implements the U.S. Geologic Survey's SWB modeling software and produces a spatially distributed estimate of annual recharge. This model operates on a daily timestep and uses daily values for precipitation and evapotranspiration along with soil hydrologic parameters and vegetation cover. The model calculates runoff based on the Natural Resources Conservation Service (NRCS) curve number approach and Actual Evapotranspiration (AET) and recharge based on a modified Thornthwaite-Mather soil-water-balance approach (Westenbroek et al., 2010). Details of this model and the hydrologic data and simulated water budget outputs are provided in Appendix B.

Groundwater recharge for this project area was previously simulated for Water Year 2010 which was selected because annual precipitation in that year was nearest to the 30-year average for the period 1981-2010. OEI's SWB modeling also estimated recharge for Water Year 2014 to represent drought year conditions. In late-November 2022, the County of Napa instituted a new policy prescribing that for purposes of estimating groundwater recharge, the mean annual precipitation to be used is that mean for Water Years 2012-2021 derived from the newest PRISM data. County of Napa has provided gridded GIS data of the mean precipitation for this period for use by WAA practitioners.

OEI's use of the SWB model is believed to provide more accurate estimates of potential groundwater recharge because it is a physically based distributed model that incorporates information characterizing the water balance in the soil column. Calculation of evapotranspiration using local climate data along with soil moisture storage and precipitation is believed to provide a more accurate representation of local conditions; evapotranspiration is the largest component of the water balance. Unfortunately, the SWB model structure does not allow



for a groundwater recharge calculation based on a mathematical average because the model is driven by daily climate data. Consequently, OEI has adapted the SWB model estimates for the prior "average year" (WY 2010) and the "drought year" (WY 2014) to provide an estimate for the average annual rainfall for the period 2012-2021 developed by County of Napa.

OEI has utilized SWB models for WY 2010 and WY 2014 for dozens of project sites in the County of Napa. We have observed that potential recharge for WY 2010 is consistently much greater than for WY 2014 across a wide variety of terrain, vegetation, soils and climate. This is most easily characterized by the percentage of annual precipitation available for recharge that we calculate for each project site. Our approach for adapting the SWB model outputs to estimate groundwater recharge for the specified annual average precipitation is to assume that the percentage of annual rainfall available for groundwater recharge is a linear function of annual rainfall and interpolating between the recharge percentage for WY 2010 and WY 2014. The water balance data from the SWB model years is tabulated in Table 5.

Results

Updated WAA guidance from the County of Napa requires the use of the updated 2012-2021 average precipitation dataset provided by County of Napa and produced by PRISM Climate Group at Oregon State University. This dataset provides spatially distributed 10-year average precipitation data at the location of this project. The 10-year average precipitation at the site is approximately 27.7 inches. We assume that a linear relationship exists between precipitation and runoff and use the simulated 2010 and 2014 SWB data to predict average recharge based on the 10-year average precipitation data. This method results in an average recharge estimate of 6.2 inches of 22.5% of average precipitation, slightly less than the 2010 normal year prediction.

	2010 Nor	mal Year	2014 D	ry Year	2012 -2021 Avg.		
	inches	% of precip	inches	% of precip	inches	% of precip	
Precipitation AET Runoff	29.4	- - -	15.1	- - -	27.7 - -	- - -	
∆ Soil Moisture Recharge	6.8	- 23.1%	2.1	- 13.8%	- 6.2	- 22.5%	



Groundwater Storage

Groundwater storage is estimated as the product of the aquifer surface area (assumed to be equivalent to the project recharge area), the depth of the saturated zone of the aquifer intersected by wells, and the porosity of the fractured bedrock. The surface area is about 306.6 acres. The depth of the saturated zone was defined as the average difference between the static water level and the bottom of the screened interval in the two project wells (Wells 1 and 2in Table 1 & Figure 1). The estimated depth of the saturated zone is therefore about 100-ft. Note that the depth of the aquifer is defined by well depth, and that the saturated zone of the aquifer probably extends to substantially greater depths. The potential aquifer storage capacity is therefore likely to be underestimated.

The porosity of the fractured bedrock is expected to lie between <1 and 10% (Freeze and Cherry, 1979; Weight and Sonderegger, 2000). Given the relatively low specific capacities (for fractured bedrock) of wells (Table 1) in the project aquifer, we assume a low-end (conservative) porosity of 1%. The estimated groundwater storage in the bedrock aquifer is calculated as 306.6 ac-ft.

Comparison of Water Demand and Groundwater Recharge/Storage

The total proposed water use for the project recharge area is estimated to be 70.1 ac-ft/yr. This represents 44% of the estimated 10-year average annual recharge of 159.4 ac-ft/yr (Table 6). This comparison indicates that the project aquifer has a modest surplus of water in terms of annual use compared to annual recharge, and that the aquifer storage is more than six times the annual recharge. When the comparison is restricted to the footprint of the project parcel, the total proposed water use is a smaller percentage (33%) of the mean annual groundwater recharge (Table 6).

		Dry	Water Year (2	2014)
Domain	Total Proposed Demand (ac-ft/yr)	Recharge (ac-ft/yr)	Recharge Surplus (ac-ft/yr)	Demand as % of Recharge
Project Recharge Area Project Parcel	70.1 17.1	159.4 51.8	89.3 34.7	44% 33%

Table 6: Comparison of total annual Water Use and groundwater recharge.

The significant volume of groundwater in storage is expected to moderate the impacts of climatic variations on aquifer conditions. The effects of dry years and wet years are likely balanced out over the period of years or decades required for water to move through the aquifer, such that short-term reductions in groundwater storage associated with periods of reduced groundwater recharge during dry years would be compensated by increases in storage during wetter years.



The use of the 2012-2021 average precipitation as required by County of Napa guidelines implicitly acknowledges this aspect of groundwater resources.

There is no new water use associated with this project at Vine Cliff Winery; the water use estimates in this report incorporate land use changes since about 2016. This updated WAA estimated an increase of 0.45 ac-ft/yr of residential use and 4.04 ac-ft/yr of vineyard irrigation. This WAA concluded that an additional 8.1 acres of vineyard were planted in project recharge area. This updated WAA also incorporated groundwater recharge estimates based on the County-wide SWB model developed by OEI (Appendix B). This iteration of the SWB model predicted a higher rate of groundwater recharge than the limited SWB model developed for OEI's prior WAA. The prior WAA estimated that groundwater use on the project parcel was 52% of mean annual recharge as compared to 33% in the updated WAA (Table 6).

Well Interference Analysis

The closest neighboring well to the two existing wells on the project parcel appears to be located about 1,275 feet northeast of well 1lk on the adjacent parcel to the north (Well 20 in Table 1 & Figure 1). <u>Based on the WAA guidance document, a Tier 2 well interference analysis is not required given that non-project wells are located greater than 500-feet from the project wells.</u>

Summary

Application of the Soil Water Balance (SWB) model and updated 10-year average precipitation data to estimate water available for aquifer recharge in the project area revealed that average recharge is ~6.2 inches/yr or 159.4 ac-ft/yr. <u>No new water use is associated with this project.</u> On the project parcel, groundwater demand is equivalent to 33% of the estimated annual recharge in an average water year; in other words, groundwater recharge is almost double groundwater use on the parcel. The total Water Use for the project recharge area is estimated to be 70.1 ac-ft/yr which represents 44% of the mean annual recharge indicating that the project is unlikely to result in significant declines in groundwater elevations or depletion of groundwater resources over time.

The closest neighboring well to the project wells is located more than 500 feet from the project wells, hence it is presumed that significant well interference is unlikely to occur per County guidance. There are no County-designated significant streams within 1,500 ft of the project parcel.



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APPENDIX A

WELL COMPLETION REPORTS



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GUADRUFLICATE Use to comply with local requirements

STATE OF CALIFORNIA THE RESOURCES AGENCY DEPARTMENT OF WATER RESOURCES. WATER WELL DRILLERS REPORT

Do not fill in

No. 119629

State Well No._

Notice of Intent No.__

Local Pérmit No. or Date	Other Well No.
(1) OWNER: New Contraction	(12) WELL LOC: 283 283
	from ft to ft Formation (Describe by calar abstration and the ft.
Address	10 - 3 tongoil & bouldarg
CityZip	3 - 25 gray rack
(2) LOCATION OF WELL (See instructions): 32-030-27	25 50 hrows & grost rock
CountyOwner's Well Number	50 100 prov & Va hyperty rock
Well address if different from above DLLV. IL. DELOW RECLOP GAIL	100 - LOU grey & Lo Drown Lock
TownshipRangeSection	100 - 125 uk. grey a green rock, nara tracta
Distance from cities, roads, railroads, fences, etc	125 - 150 grev green rock stringers red rock
	hard tractured
	150 - 200 dk & It grey & green rock hard frac
	200 - 283 dk. grey green & red rock brown
(3) TYPE OF WORK:	Reck stringers black hard fractured
New Well 🛃 Deepening 🗋	
Reconstruction	- \
Reconditioning	
Horizontal Well	(A) - //A
Destruction [] (Describe	
destruction materials and	
(4) PROPOSED USE	
Stock	
Municipal D	
WELL LOCATION SKETCH Other	
(5) EQUIPMENT:	
Rotary Reverse Reverse No Size	
Cable Air A Diameter of bore 13 3 44	
Other D Bucket D Packed from 20 to 283	
(7) CASING INSTALLED: (8) PERFORATIONS: machine	
Steel D Plastic DY Concrete VA Type of perforation or size of screen	
	i and in the second
From To Dia. Gage-or From To Slot	
	· · · ·
(9) WELL SEAL: \searrow 20	
Was surface sanitary seal provided? Yes 🕒 No 🗌 If yes, to depthft.	······································
Were strata sealed against pollution? Yes 🗌 No 🖾 Intervalft.	7/11/2 06 7/132 06
Method of sealing	Work started 1124 19 00 Completed 1724 19 00
(10) WATER LEVELS: 110	WELL DRILLER'S STATEMENT:
Standing level after well completion 150 ft	I his well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
(11) WELL TESTS:	SIGNED
Was well test made? Yes No [] If yes, by whom? driller	(Well Driller)
Type of test Pump Bailer Air lift 10	NAME DOSNIEr and Gregson Drilling, Inc.
Depth to water at start of testft. At end of test_COMPLAT	(Person, firm, or corporation) (Typed or printed)
Discharge <u>400</u> gal/min after <u>1</u> hours Water temperature	Vallejo94589
Chemical analysis made? Yes 🗌 No 🏠 If yes, by whom?	CityZipZip
Was electric log made? Yes 🗌 No 崔 If yes, attach copy to this report	License No. 294001 Date of this report 7/23/86

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED. USE NEXT CONSECUTIVELY NUMBERED FORM

(ANTONION GOMEZ) QUADRUPLISATE STATE OF CALIFORNIA Do not fill in Use to comply with THE RESOURCES AGENCY No. 103154 local requirements DEPARTMENT OF WATER RESOURCES WATER WELL DRILLERS REPORT Notice of Intent No._ State Well No. Local Permit No. or Date. Other Well No .__ (1) OWNER: Nam (12) WELL LOG: Total depth 240 ft. Depth of completed well 240 from ft. ft. Formation (Describe by color, character, size or material) Address 2 soil & boulders 0 -City 17 cemented gravel 2 -(2) LOCATION **OF WELL** (See instructions): 070-09 17 -21 blue clay County Owner's Well Number Same 21 25 blue clay, ---gravel imb. Well address if different from above 25 34 brittle hard brown rock _ Township Range Sectio brown tufia, 34 multi colored hard 43 Distance from cities, roads, railroads, fences, etc., rock strs 43 multi, colored fractured rock black & green fractured rock 47 67 67 74 granular brown fractured rock (3) TYPE OF WORK: 78 red, green&black fractured frock 74New Well C Deepening 78 79 black&brown fractured rock Reconstruction 94 hard black large fractured rock 79 CARADULE CRUBS R Reconditioning 101 hard-bläck red&green lge.frac. Horizontal Well VIELIE rock Destruction [] (Describe destruction materials and procedures in Item 12 770 black&bhown lge.frac.rock hard grn. & lge.frac.rock 113 110 (4) PROPOSED USE? 119hard grid & Brn. rock sm.fractures Domestic 会加加 シ ਣ hard granular grn.grey& Irrigation semi Industrial black rock WATER 11 133 hard black rock very lge.frac. Têst Well Ó hard blk rock, sm.fractures Stocl - JAK semi hard blk&grn rock frac. 13 Municip - 146 hard blk rock, sm.fract. - 145 large fract. WELL LOCATION SKETCH 141 Other 148 hard blk rock no fractures (5) EQUIPMENT: (6) GRAVED PACK ?eş 🛋 Rotary X No Reverse 🔲 149 hard blk very lge.frac.rock Ziameter of bore Cable П Air _154 semi hard blk, red&green rock Other Bucket ked from \square 159 semi hard blk&grey frac.rock 54 (8) PERFORATIONS: Machine (7) CASING INSTALLED; Type of perforation or size of screen 159 - 161 blk volcanic foam-rock Steel Plastic \Box -Cy semi hard blk fractured rock -167 161 Dia. Gage From Fron То T۲ Wall - 171 hard blk fractured rock ft. > in. ff ft. 167 **W**8 401 -186 blk.volcanie foam rock 240 188240 171 0 186 - 194 hard blk rock fractured on top 191 - 208 black granular rock - 213 208 hard black rock fractured (9) WELL SEAL: No If yes, to depth 20 Was surface sanitary seal provided? Yest 213 - 224 black & red granular rock ft. Were strata sealed against pollution? Grout No 🛣 Interval 224 246 hard grey & red rock ft. .soft Method of sealing. Work started Completed_ (10) WATER LEVELS: WELL DRILLER'S STATEMENT: 431 Depth of first water, if known This well was drilled under my jurisdiction and this report is true to the best of my ft. 151 knowledge and belief. Standing level after well completion_ fŧ D Prehllin (11) WELL TESTS: SIGNED Drillers (Well Driller) No If yes, by whom? Bailer Was well test made? Yes 🕅 NAME Doshier-Gregson Drilling, Inc. Type of test Pump Air lift 🗌 1 O 5365 (PNapa-Varie) Hwy or printed) Depth to water at start of test ft. At end of test Discharge 220gp mil min after Addres hours Water temperature Vallejo, Ca 94590 City No 🚰 If yes, by whom? Chemical analysis made? 12/20/77

EL RETIRO VINEYARD

Was electric log made? DWR 188 (REV. 7-76)

Yes \square

Yes 🗌

No KIf yes, attach copy to this report

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

License No

294001

Date of this report

Environmental

Cover Sheet

APN	032 030-052-000
Permit #	
Program	WER
DocType	WL
Street #	
Street Name	SILVERADO TRL
Year	



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Parto	QUADRUPLICA For Local Requ	E Sector	STATE OF CALI	FORNIA ION REPOR		EONLY	
Owner's Weil No. E-19-95 7-21-95 54/445 Local Fermit Agenes, 29478 Permit Date Control Control Date Control Control Date Permit No. Select of Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Mailing Address Orden et al. Derive North Environmental I Mant Derive North Environmental I Mant Orden et al. Derive North Environmental I Mant Derive North Environmental I Mant Orden et al. Derive North Environmental I Mant Derive North Environmental I Mant Orden et al. Derive N	Page of	Ke)		Ar man a ar como			
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Permit No. 2010 2010 CECOLOGIC LOC CREMENTAND (2) X vertical metadago Ante sector DESCRIPTION DECOMPACTOR (2) Name DESCRIPTION DECOMPACTOR	Local Permit Ag	ency rapid box hap at of all a	<u>6_10_0</u>	A A A A A A A A A A A A A A A A A A A	── │└ <u>─</u> └─┴──┴──┴──		
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755 775 Black rock, fract. med. DRLING Mud & Air rotary Nater-Bentonit 775 805 Black & gray rock, fract. med. DRLING Mud & Air rotary FLUD Mater-Bentonit 775 805 Black & gray rock, fract. med. Derth Mud & Air rotary FLUD Value & Viello OF COMPLETED WELL 0 Fluid 805 Grave & Grave	735 755	REd, black & brown rock, f	Yact.	PLEASE BE ACC	URATE & COMPLETE]	
775 805 Black & gray rock, fract. med. METHOD Wethod state Fullo	755 775	Black rock, fract, med.		DRILLING MUC &	Air rotary	1	Water-Bentonite
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TOTAL DEPTH OF BORING	i			ESTIMATED YIELD	(GPM) & 1	EST TYPE	rump
TOTAL DEPTH OF COMPLETED WELL OUC (Feet) * May not be representative of a well's long-term yield. DEPTH HOLE DIA. TYPE (\angle) CASING(S) TYPE (\angle) ANNULAR MATERIAL GRADE OUC OPTH GRADE CASING(S) TYPE (\angle) NATERIAL/ GRADE OPTH GRADE OPTH GRADE DEPTH Ft. to Ft. ANNULAR MATERIAL Ft. to Ft. CE BEN MENTIONITE FILL FILTER PACK (TYPE/SIZE) 0 60 X I -C-1 S A F-480 O32 22 21 A TTACHMENTS (\angle) CERTIFICATION STATEMENT ATTACHMENTS (\angle) SIGNOL COR CERTIFICATION STATEMENT OBSIGE Log I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief. MAME OBSIGE NUMBER OBSIGE Log SIGNOL COLSPAN CITY SIGNOL COLSPAN MAME CERTIFICATION STATEMENT	TOTAL DEPTH OF B	ORING (Eget)		TEST LENGTH	(Hrs.) TOTAL DRAV	VDOWN	(Fi)
DEPTH FROM SURFACE BORE- HOLE HOLE (marges) TYPE (∠) (marges) MATERIAL/ (marges) INTERNAL (marges) GAUGE OR WALL (marges) SLOT SIZE (F ANY (marges) DEPTH FROM SURFACE ANNULAR MATERIAL TYPE Ft. to 60 Ft. 60	TOTAL DEPTH OF C	OMPLETED WELL (Feet)		* May not be repres	entative of a well's long	g-term yield.	
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DIA. (gropes) End with the second	FROM SURFACE	HOLE TYPE (∠)		SI OT SIZE	FROM SURFACE		TYPE
Ft. to Ft. <t< td=""><td></td><td>DIA. 프 프 플 프 MATERIAL/ DIAM</td><td>ETER OR WAL</td><td>L IF ANY</td><td></td><td>CE- BEN-</td><td>FILTER PACK</td></t<>		DIA. 프 프 플 프 MATERIAL/ DIAM	ETER OR WAL	L IF ANY		CE- BEN-	FILTER PACK
0 60 x i-c-1 8 F-480 300 22 x Pea Grave1 60 80 x i-c-1 8 F-480 .032 22 21 x Pea Grave1 20 800 Perf. & solid staggered 21 1 x 1 1	Ft. to Ft.		hes) THICKNE	SS (Inches)	Ft. to Ft.	(上) (上)	(⊻) (TYPE/SIZE)
60 80 x i-c-1 8 F-480 .032 22 21 x 80 800 Perf. 8 \$9110 \$\$13899ered 21 1 x 1 2 1 14 ¹¹ x 1 1 x 1 1 x 1 2 1 14 ¹¹ x 1 1 x 1 1 x 1 2 1 14 ¹¹ x 1 1 x 1 1 1 x 1 30 Geologic Log	0 60	x - - - i-c-1	F-48	0	800 22	· · · · · · · · · · · · · · · · · · ·	x Pea Gravel
80 800 Perf. & soilt staggered 21 1 x 2 1 14" x 21 1 x 2 1 14" x 21 1 x 21 2 1 14" x 21 1 x 21 1 x 21 2 1 14" x 21 1 x 1 <	60 80		F-48	0 .032	22 21		<u> </u>
2 14 ^{II} X — ATTACHMENTS (∠)	80 800	Perf. & solid stangered			21 1	- <u>x</u>	
2 144" x ATTACHMENTS (∠) CERTIFICATION STATEMENT		· · · · · · · · · · · · · · · · · · ·			······································		
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ATTACHMENTS (∠)	· · ·					· ·	9
Geologic Log Well Construction Diagram Geophysical Log(s) Soil/Water Chemical Analyses Other Matrix Chemical Analyses Geologic Log Matrix Chemical Analyses	ATTACH	MÉNTS (∠)		- CERTIFICAT	'ION STATEMEN'	[
Geologic Log Well Construction Diagram Geophysical Log(s) Soil/Water Chemical Analyses Other	, , ,	I, the undersigne	d, certify that th	nis report is comple	ete and accurate to th	e best of my	knowledge and belief.
	Geologic L	Doshi	er-Gregso	n, Inc.			
Geophysical Log(s) Soil/Water Chemical Analyses Other Other Matrix Additional INFORMATION. IF IT EXISTS. Signed Well DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED. SIGNED Soil Value State 258826 CITY STATE STATE CITY STATE	Well Const	ruction Diagram	OR CORPORATION)	(TYPED OR PRINTED)			. A4500
ATTACH ADDITIONAL INFORMATION. IF IT EXISTS. ATTACH ADDITIONAL INFORMATION. IF IT EXISTS. ATTACH ADDITIONAL INFORMATION. IF IT EXISTS. ATTACH ADDITIONAL SPACE IS NEEDED. USE NEXT CONSECUTIVELY NUMBER	Geophysic	al Log(s) 5365 Nap	a-vailejõ	nwy	Valle	ejo, Ca	1 94590
Other	Soil/Wate	Chemical Analyses			CITY	·	STATEZIP.
ATTACH ADDITIONAL INFORMATION. IF IT EXISTS. Signed WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C57 LICENSE NUMBER	Other		Mun	Sec. 1	1 .	00_01 00	258826
	ATTACH ADDITIONAL IN	FORMATION. IF IT EXISTS. Signed WELL DRIVER	AUTHORIZED REPPES	SENTATIVE		E SIGNED	C-57 LICENSE NUMBER
	WB 188 BEV 7.00		D USE NEVT	CONSECUTIVELY		<u></u>	CO. SIVENCE HUMBER

QUADRUPLICATE Use to comply with local requirements

Notice of Intent No.___

STATE OF CALIFORNIA THE RESOURCES AGENCY DEPARTMENT OF WATER RESOURCES WATER WELL DRILLERS REPORT

Do not fill in No. 095283

State Well No.

Local Permit No. or Date,	-				Other Well No),	<u> </u>
(1) OWNER: Name		(12)	WELL L	nG: Total depth	500 4 Dent		500 .
Address Charles Charle	· · · · · · · · · · · · · · · · · · ·	from_ft.	to ft. J	Formation (Descri	he hy color, cha	h of completed we	ller tt.
City.	Zin	0	- 150	Red clay	6 soft	red roc	K
(0) I OCATION OF WELL (Sectored)		150	- 175	Gray roc	;k = har	d fract.	
County County Open Structure Owner's W	ons): 7-11 Numba 32-030-0"	175	_ 200	Gray, re	d & gre	en rock,	med.har
Wall address if different from above Silverado	Trail	200	_ 225	Yellow,	it.6 br.	rock, f	caci.
Taunchin Napa Range		225	250	Green G	Cray ro	ck, soft	
Distance from cities made railmade fances etc.	_Section	250	_ 275	Black 6	brown r	ock - sfr	0 t
Distance from chies, roads, famoaus, fonces, etc.		275	- 325	Brown	TREE TO	ck. med.	hard
		325	- 350	Brown	reen 6	hlack rot	ak -sof
	- <u>-</u>	350	- 400	Green. y	ellow &	bl.rock	- soft
	(3) TYPE OF WORK:	400	7/500	Red KH.b	lack. y	ALLON & I	TRAN
1	New Well A Deepening			rock -	hard fr	act.	्रिकेल असे (क्राइ) करत
[· · · · · · · · · · · · · · · · · · ·	Reconstruction		-11-			No. No. No.	<u> </u>
,	Reconditioning		<u>`</u>	<u> </u>	77	·	
· ₇	Uprizontal Wall	634	<u> </u>	The m	<u>/.</u>		
	Destruction T. (Describe	163	5				
· · 7	destruction materials and		<u>, </u>		~~ _		
 	rocedures in item r20	·	(\)	······	\mathcal{H}		
	(4) PROPUSED USE:		<u> </u>)	<u>∦~~</u>		<u></u>
 	Jomestic XX		<u> </u>	<u> </u>	<u> </u>		<u> </u>
 	rrigation	\vdash		<u> </u>	<u>)) </u>	······································	. بې، نړۍ د <u>م</u> ېر <u>مې</u>
الله 		$\left \begin{array}{c} \\ \\ \\ \end{array} \right\rangle \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $	<u>⇒~</u>	<u>></u>			<u></u>
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· · · · · · · · · · · · · · · · · · ·	Municipal)	<u> </u>	<u>`_@``</u>	×		· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·
WELL LOCATION SKETCH	Other	[<u>`</u>	>				
(5) EQUIPMENT:			<u> </u>		·	•	
Rotary Reverse No No	j Size			~			
Cable Air Air Danneter of bore.		\square	<u></u>				
Other D Bucket D Packed from	A to	\mathbb{Z}		······			
(7) CASING INSTALLED: (8) PERFORAT	Toks: Machine	$\overline{\mathbb{N}}$	<u>م</u> ر مع				······································
Steel Plastic Concrete Type of periorati	on or size of screen	<u> </u>	-				
From To Dia. Gage-or From	To Roser			······································	· · · ·	-	
ft. ft. Wall ft.	ft. Ksize		. –				
0 000 0 100 400 V	200 483				· · ·	· :	······
	· KAI II.	「 <u> </u>		· · · · · · · · · · · · · · · · · · ·			
	UW_{H}/r						· · · · · · · · · · · · · · · · · · ·
(9) WELL SEAL:			— —				· · ·
Was surface sanitary seal provided? Yes 🎦 No 🗌 If	yes, to depthft.		-		·		·
Were strata sealed against pollution? Yes . No	J Intervalft.	`c			· · · · · · · · · · · · · · · · · · ·	12-1	<u>_</u>
Method of sealing	· · · · · · · · · · · · · · · · · · ·	Work st	arted 11.	-5 1950	. Completed	I XXHXHXX	19.80
(10) WATER LEVELS:	5	WELL	DRILLER'S	S STATEMENT	Ē:		
Depth of first water, if known		This well	ll was drilled i	under my jurisdicti	ion and this repo	ort is true to the	best of my
VILL WRETT TECTC.	L.	CTONED	the first	A. Han	· .		
Was well test made? Yes No 🗌 If yes, by w	whom? driller	OIGIVE-LA	The second	(Wel	l Driller)		
Type of test Pump AOO Bailer	Air lift 🕭	NAMÉ	No2016	r-Gregsor	L DEALLA	ng.inc.	
Depth to water at start of testft. A	at end of testft	Ì	5365 N	rson, firm, or corpo	ration) (Typed o	or printed)	
Dischargegal/min afterhours	Water temperature	Address_	11010	3 3 4 4 ···· * * ** **	1 the address of	- 94591	<u>n</u>
Chemical analysis made? Yes 🗌 No 🎦 If yes, by w	/hom?	City	29401	A T		Zip 73/4/8(<u>*</u>
Was electric log made? Yes D No X If yes, attach	1 copy to this report	License I	No	<u> </u>	Date of this repor	ct #64.736 %	<u></u>

DWR 188 (REV. 7-76)

ORIGINAL File with DWR

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STATE OF CALIFORNIA THE RESOURCES AGENCY DEPARTMENT OF WATER RESOURCES WATER WELL DRILLERS REPORT

Do not fill in

No. 324026

Notice of Intent No.		State Well No.
Local Permit No. or Date		Other Well No.
(1) OWNER Name (Stonebridge Cellar	S. Inc.	(12) WELL LOC: Total depth 600 ft Completed depth 600 ft
Address	and an and a start of the start	(12) While BOG. Polar depth R. Completed depth R.
CitySL. Helena		\sim 10 ~
	1024 050 000	55 - 70 Red Rock Soft
(2) LOCATION OF WELL (See instructions)A-P	.#031-050-069	70 - 90 Dark Grav Book Hard
CountyOwner's Well Nun	nber	90 - 110 Dark Grav & Black Rock Hard Stringers Red
Well address it different from above		110 - 130 White Light Grav Brok Stringers Red Clay S
Township Range Secti	on	130 - 150 Brown Bed Graw & Black Book
Distance from cities, roads, railroads, fences, etc.		150 - 170 White Red Black & Bysun Rock Soft
		170 - 190 White Brown Book Stringers Light Grav Clay
		190 - 230 White Brown & Black Rock Soft
	OF WORK	230 - 250 Reddish Brown Clay Stringers Black&white F
	X Deepening	250 – 270 Gray Clay
Reconstruct	ion	270 - 290 Red Rock Soft
Becondition		290 - 430 Dark Gray Black Rock Stringers Green Red
Horizontal		- Hard Fract
P Horizonia	Describe	430 - 600 Dark Gray Black Rock Stringers Green Rock
destruction destruction	materials and pro-	- Hand Ripact
HU men cedures in I	tem 12)	
$7, 0^{\circ}$ (4) PROF	OSED USE	
, Domestic		
Irrigation		AUNE
. Industrial		- Ale
Test Well		
Municipal	、 🗸 🖓	
Other		0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 -
WELL-LOCATION SKETCH	\sim	<u> </u>
5) EOUIPMENT: (A GRAVEL PACK:		
Rotary A Reverse A Yes X No	size Reav	
Cable Air Biameter of bore	3/3/40	
Other D Bucket Recked from _27_	600 m	\$(U) ~
	<u> </u>	
(8) PERPORATIONS:		
eel Plastic A Concrete Type of herioration or siz	e of screen	
From To Dia. Gage or Riom Te	Stot _	
tt. tt. in. Wall the stt.	vsize	
0 600 6 F480 80 (600	\rightarrow factory	d
	<u>}</u>	
)) WELL SEAL:	27	
as surface sanitary seal provided? Yes X No L If yes, to depth	ft	
/ere strata sealed against pollution? Yes L No 🔁 Interval	It.	- 10/16 00
ethod of sealing		Work started 09/10 19.98 Completed 10/10/ 19.98
10) WATER LEVELS:		WELL DRILLER'S STATEMENT:
eprin or first water, it known	350 th	This well was drilled under my jurisdiction and this report is true to the
	tt. ł	best of my knowledge and belief.
11) WELL TESTS:	driller ^s	Signed _ there Datenal
ype of test Pump Resider Press Bailer Resider Pump Resider Pump Resider Reside	Airlift X	McLean & Williams, Inc.
epth to water at start of testftAt end of to	est550 ft.	878 El Operson fign or corporation) (Typed or printed)
ischarge $\underline{20}$ gal/min after $\underline{6}$ hours Water tem	perature A	Address
hemical analysis made? Yes 🗌 No 🕅 If yes, by whom?	(City ZIP 24200
/as electric log made Yes 🗌 No 🕅 If yes, attach copy to thi	is report	License No Date of this report

Page of	-	Refer to Instruction	n Pamphlet		STATE WELLING	D./STATION NO.
Owner's Well No.	•	No. 1	1/3642		MOJYL	
Date Work Began	-2/05/2008, Ended	2/27/2008				
Permit No.	107-00951 Pe	ermit Date <u>12/28</u>	/2007	L	APN/TRS	/OTHER
	GEOLOGIC LOG -		1. <u>a</u>	WELL	ÓWNER —	
ORIENTATION (⊻)	VERTICAL HORIZONTAL	ANGLE	Mailing Address			
DEPTH FROM SURFACE	DÉSCRIPT	ION				
Ft. to Ft.	Describe material, grain	n size, color, etc.		WELL LO	OCATION	
	1 · · · · · · · · · · · · · · · · · · ·	ON THE	Address	Silverado 1	rail	
- 2	· · · · · · · · · · · · · · · · · · ·		County Caky	adet .		· · · · · · · · · · · · · · · · · · ·
0 6	Brown Clay & Brow	R ASTA	APN Book	Page	Parcel	54-000
6 67		<u>ALLE</u>	Township 1	Range	Section	
	Ware tupic hour,	Pome brown Gra		SEC.	DE	
57 125	Hoph stque bage			NORTH		NEW WELL
105 1100	- life file					MODIFICATION/RI
123 1200	browel d fued creat			her o	\$ *	Other (
150 240/	> brown clay & Ward	Gray Rock		ENT	S.C.	DESTROY (D Procedures ar
240 1220	And pilling and	Duck.	[\mathbb{R}	a e	Under "GĘOL USES (⊻)
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400 282	- Hard Black & Gray	Rock	The second strategy and the se		\sum	DIRECT I
ECO CHO	Mad Band Diant 6.	-1		- Continue		
		213			[Ari	SPAR
610 630 /	- Med Hard Plack & Y	Cellow Ash	- Illustrate or Describe [®] Di Fences, Rivers, etc. and	stance of Well from Roa attach a map. Use addit	ds, Buildings, ional paper if	OTHER (SPE
630 690	Med. Uard Black &	Geav Ash	WATER	LEVEL & VIELD	OF COMPLE	FTED WELL
		DECEN	TO FIRST WAT	rer (Ft:) Bi	ELOW SURFACE	
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		FNVIBONMENTAL MA	NAGPNAPINAL DE PEPTESE	niunoe oj u wen s roņ	ig-ter in yteta.	<u> </u>
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360 6 40	1 0 v	<u></u>				
АТТАСН	MENTS (\preceq)		CERTIFICATI	ON STATEMENT		
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Well Cons	struction Diagram	(PERSON, FIRM, OR CORPORATION)	TYPED OR PRINTED)			
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DWR 188 REV. 05-03 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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	1	1 1			- DE	PT.					rences, Rivers, etc. an necessary. PLEASE I	ia attach a n BE ACCURA	TE & COMP	onai paj LETE.	per if		
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DEF FROM S	PTH URFACE	BORE- HOLE	T	YPE	<u>(∠)</u>)		ASING (5)			,	FROM	PTH SURFACE		ANN	ULAŖ TY	PE
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	300	6"				12	LYETHYLGAR	<u>: 1"</u>	SOR-	- <u> </u> [U'	300'				
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	ATTAC	IMENTS	(⊻)	-			I, the under	rsigned, ce	ertify that t	this	report is complete	e and accu	rate to the	best of	my kn	owled	ge and belief.
	Geologia Well Cor	s Log	aaran	n				DC E	XPL	<u>.</u>	RATION	JE	LUELI	22	•		
	Geophys	ical Log(s)					(PERSO	N, FIRM, OR C	ORPORATION)	(TY)	PED OR PRINTED)	>	America	.)		-0	GELGE
-	Soil/Wate	er Chemical	Anal	yses			ADDRESS	<u>ECX</u>	141		$\rightarrow \bigcirc$	$\overline{\gamma}^{4}$	CITY	/ */	<u></u>	STATE	73910
-	Other						Cimod		aur	A				[4]	65-	and a	83326
ATTACH AL	DDITIONAL I	NFORMATIC	N, IF	- JT E	XIST	<i>'S.</i>	WELL [DRILLER/AUTHO	RIZED REPRES	SENTA	ATIVE		DĂT	e signed	-	ī	-57 LICENSE NUMBER

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DWR 188 REV. 11-97

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ATTACH AE	ODITIONAL I	NFORMATIC	ON, IF	= IT (EXIS	STS.	Si	igned WELI	DRILLER7	AUTHO	RIZED REPRESI	ENTA	ATIVE			یمبر مکر	DATE SLOTE		~~	57 LICENSE NUMBER	_

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DWR 188 REV. 11-97

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IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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QUADRUPLICA For, Local Requi Page <u>3</u> of Owner's Well No Date Work Began Local Permit A	TE irements <u>8-31-04</u> gency <u>NAPA</u> C	STATE COMP Refer to In Ended $9-17-04$	DF CALIFO LETIO struction 1 0.802	ORNIA DN REPOR Pamphlet 2401			
Permit No. ORIENTATION () DEPTH FROM SURFACE	GEOLOGIC I	Permit Date X	(SPECIFY)	Name Mailing Address	WELL	OWNER —	STATE ZIP
FL 10 0 100 100 160 100 240 240 300	MUDSTONE - HUDSTONE - HURD SLACK	al, grain size, color, etc W/CUBBLES I/GRAVEL HARDBUICK tx RCLK	2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2	Address 7.7.7 City NAPA County NAP APN Book 032 Township	A Page 0-30 Range	Parcel CS Section	411- 411- 411-
A Contraction of the contraction			· · · · · · · · · · · · · · · · · · · ·		ATION SKETCH	Longitude	DEG. MIN. SEC. ACTIVITY (∠) NEW WELL MODIFICATION/REPAIR Deepen Other (Specify)
			· · · · · · · · · · · · · · · · · · ·	st Act Act			DESTROY (Describé Procédures and Materials Under "GEOLOGIC LOG") PLANNED USES (∠) WATER SUPPLY Domestic Public Irrigation Industrial
		RECEIVED		WW the second seco		CO BASS	MONITORING TEST WELL CATHODIC PROTECTION HEAT EXCHANGE DIRECT PUSH INJECTION VAPOR EXTRACTION
	ENVIR	DEPT. OF CONMENTAL MANAGEMENT		Illustrate or Describe L Fences, Rivers, etc. and necessary. PLEASE BI WATER	SOUTH Distance of Well from Road attach a map. Use additi ACCURATE & COMP LEVEL & YIELD	ds, Buildings, onal paper if LETE. OF COMPL	SPARGING REMEDIATION OTHER (SPECIFY) ETED WELL
TOTAL DEPTH OF	BORING(Feet)	(East)	·····	DEPTH TO FIRST WA DEPTH OF STATIC WATER LEVEL ESTIMATED YIELD * TEST LENGTH		ELOW SURFACE	= (Ft.)
DEPTH FROM SURFACE	BORE- HOLE TYPE (∠) . DIA. (Inches) ₹ ₩ 655.4	CASING (S) MATERIAL / INTERNAL GRADE DIAMETER	GAUGE OR WALL	SLOT SIZE	DEPTH FROM SURFACE	CE- BEN-	ULAR MATERIAL TYPE FILL FILTER PACK
Ft. to Ft.		(Inches)	THICKNESS	S (Inches)	Ft. to Ft.	(⊻) (⊻) ✓ ·	(≤) (TYPE/SIZE)
ATTACI	IMENTS (∠) Log Istruction Diagram	I, the undersigned, cer	rtify that this $\chi P L O K$	CERTIFICAT s report is complete 2ATION E	ION STATEMENT and accurate to the I WELLS	Dest of my kn	owledge and belief.
Geophys	ical Log(s) er Chemical Analyses NFORMATION, IF IT EXISTS.	ADDRESS Signed WELL DRILLER/AUTHOR	IZED REPRESEN			CA	95698 state zip —

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DWR 188 REV. 11-97

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IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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ner's Well No. $HE -4$ e Work Began $S-31-04$, Ended $9-17-04$	12402 _ _ _ _ _
e Work Began <u>8-31-04</u> , Ended <u>9-17-04</u>	
- A the second s	
ocal Permit Agency A/FILFA COUNTY	
Permit No. <u>ED4 - 0364</u> Permit Date <u>8 - 26</u>	- 04
CEOLOGIC LOG	WELL OWNER
IENTATION () VERTICAL HORIZONTAL ANGLE (SPECIFY)	v) Name
DEDTH EDOM METHOD FLUID	Mailing Address,
SURFACE DESCRIPTION	
Ft. to Ft. Describe material, grain size, color, etc.	WELL LOCATION
YO HO MUNSTONE WICPONEL	Address 1110 SILVERADO TRAIL
O DUD MUDSTONE - HARD BLACK ROLK	Country A set Del 100 1
10 300 HARD PLACK ROCK	APN Book 37 Page 020 Parcel 054 - 000
	Township Bange Section
	Latitude NORTH Longitude W
	DEG. MIN. SEC. DEG. MIN. SEC.
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	- Q PLANNED USES (2)
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1 1 	
	CATHODIC PROTECTIÓN -
	GED CORE HEAT EXCHANGE A
RECENTED	Luc Minut
	VAPOR EXTRACTION _
1 1 Nilly m 7 71112	SPARGING
	Illustrate or Describe Distance of Well from Roads, Buildings, Fences Bivers etc. and attach a man Use additional paper if OTHER (SPECIFY)
DEPT. OF	necessary. PLEASE BE ACCURATE & COMPLETE.
ENVIRONMENTAL MANAGEMENT	WATER LEVEL & YIELD OF COMPLETED WELL
	DEPTH TO FIRST WATER (Ft.) BELOW SURFACE
	DEPTH OF STATIC
AL DEPTH OF BORING 300 (Feet)	TEST LENGTH (Hrs) TOTAL DRAWDOWN (Ft)
AL DEPTH OF COMPLETED WELL(Feet)	* May not be representative of a well's long-term yield.
DEPTH BORE- CASING (5)	DEPTH ANNULAR MATERIAL FROM SURFACE TVPF
DIA. 送话, SUB MATERIAL / INTERNAL GAUGE	aE SLOT SIZE CE- BEN-
t. to Ft. (Inches) 중 문 등 문 등 대 GRADE DIAMETER OR WAL	ALL IF ANY JESS (Inches) Ft. to Ft. MENT TONITE FILL (TYPE/SIZE)
2 200 Lall Danie Ciclina 11 Sono	
ATTACHMENTS (\leq)	CERTIFICATION STATEMENT
I I i, the undersigned, certify that the	this report is complete and accurate to the best of my knowledge and belief.
Geologic Log	D D D T D N S I D C I I S
Geologic Log Well Construction Diagram	IN TT I I (JIN I VICTAL)
Geologic Log Well Construction Diagram Geophysical Log(s)	$\frac{2(1)}{(\text{TYPED OR PRINTED)}} \qquad $
Geologic Log Well Construction Diagram Geophysical Log(s) Soil/Water Chemical Analyses	(TYPED OR PRINTED) 27MORA CA 95698

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IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM DWR 188 REV. 11-97

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DE		BORE	150	VV L		<u></u>	-			CAS	SING (S		l		11111 1011	i repr	eșeni 	DEPT	' <i>weu s u</i> 'H		ANN	ULAR	MATERIAL
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For.Local Requirements WELL COMPLETION REPORT Page (a _ of // _ Demonstrations remembled) Noner's Well No. <u>HE-6</u> No. 802404 Date Work Began <u>B-31-CH</u> , Ended <u>9-17-CH</u> Local Pennit Agency <u>NHE/2</u> Local Pennit Report <u>NHE/2</u> Coll Coll Cloc Coll Clock Clock ORENTATION (2) <u>VERTON</u> Determit No. <u>ECC4 - D'3(c4</u>) Permit Date Discourse Permit No. <u>ECC4 - D'3(c4</u>) Permit Date Discourse Permit No. <u>ECC4 - D'3(c4</u>) Permit Date </th <th>QUADRUPLICA</th> <th>TE</th> <th>STAT</th> <th>TE OF CALIFO</th> <th>ORNIA</th> <th>DWR U</th> <th>SE ONLY -</th> <th>DO NOT FILL IN</th>	QUADRUPLICA	TE	STAT	TE OF CALIFO	ORNIA	DWR U	SE ONLY -	DO NOT FILL IN
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Owners Weil No. PERCHAMING PERCHAMING Subject 404 Local Pennit Agency MARA CCLINITY Permit No. EC4 - D3/241 Permit Date Subject 404 ORIENTATION (2) VERTCAL Hongonital Weil L <	Page @_ of /_	- LIE-E	nejer v	No. O O C				
Dide Vork begint	Owner's Well No	0. <u>FIE B</u>	Ended 9-17-1%	JOUL	404	, L L LATITUD	اا E	LONGITUDE
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GEOLOGIC LOG WELL OWNER ORIENTATION (2) WERTCAL HOREONTAL MOLE (GPEOPT) DEPTH FROM DESCRIPTION DESCRIPTION SIALE SIALE <t< td=""><td>Permit No.</td><td>EC4-D31/11</td><td>Permit Date</td><td>8-210-</td><td>-04</td><td></td><td>APN/TRS</td><td>NOTHER</td></t<>	Permit No.	EC4-D31/11	Permit Date	8-210-	-04		APN/TRS	NOTHER
ORIENTATION (±)	<u>голік 110. </u>	GEOLOGI	C LOG			WELL	owner –	
DEPTH FROM SUMPCE DELLING Describe materials, grain size, color, etc. Mailing Address TTTO WELL LOCATION Address TTTO SHI VERDEAL CONTRACT O I CO NED CLAY SUET WI COEBLES Mailing Address TTTO SHI VERDEAL CONTRACT I CO NED CLAY SUET WI COEBLES Mailing Address TTTO SHI VERDEAL CONTRACT I CO NED CLAY SUET WI COEBLES Mailing Address TTTO SHI VERDEAL CONTRACT I CO NED CLAY SUET WI COEBLES Mailing Address TTTO SHI VERDEAL I CO NON FILLING SUED CONTRACT North Contract I CO North North I NORTH North North I NORTH	ORIENTATION (ビ	VERTICAL	HORIZONTAL ANGLE	(SPECIFY)	Name	Coloris Para 10.2	14.15.9 B a	
Bit Processor Describe materials, grain size, color, etc. STATE TERTACE STATE STATE <td></td> <td>DRILLING METHOD</td> <td></td> <td><u></u></td> <td>Mailing Address</td> <td></td> <td>li e la constanta. A transferita Masi</td> <td></td>		DRILLING METHOD		<u></u>	Mailing Address		li e la constanta. A transferita Masi	
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Geologic Log	Coologi		I, the undersigned,	l, certify that thi	s report is complete	and accurate to the	best of my kr	nowledge and belief.
Well Construction Diagram	Well Co	nstruction Diagram	NAME VALLY	1-XPIC	RATION	E WIFLI	<	
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ATTACH ADDITIONAL INFORMATION, IF IT EXISTS. Signed	Geophys Soil/Wate Other	er Chemical Analyses	ADDRESS	x 141	$\frac{z}{\sqrt{2}}$	<u>CITY</u>		STATE ZIP

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IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

For Local Requirements WELL COMPLETION REPORT STATE WELL NO./STATION NO.	
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$\frac{\text{rage}}{\text{Owner's Well No.}} + E - 7$	
Date Work Began <u>8-31-64</u> , Ended <u>9-17-64</u> OUC 400	
Local Permit Agency NAPA COUNTY	
Permit No. $E04 - 0364$ Permit Date $8 - 26 - 04$	
GEOLOGIC LOG	
ORIENTATION (∠) VERTICAL HORIZONTAL ANGLE (SPECIFY) IN ame DRILLING Mailing: Address	
DEPTH FROM SURFACE DESCRIPTION DESCRIPTION	
Ft. to Ft. Describe material, grain size, color, etc.	IP
0 100 RED CLAY SOFT WILCOBBLES Address 7770 SICVERADO TRAIL	······
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Procedures and Under "GEOLO	Materials GIC LOG"
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ENVIRUNING WITH WATHER (SPECI Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.	=Y)
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TOTAL DEPTH OF BORING 300 (Feet) TEST LENGTH (Hrs.) TOTAL DRAWDOWN (Ft.)	<u> </u>
TOTAL DEPTH OF COMPLETED WELL (Feet) * May not be representative of a well's long-term yield.	
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Date Work Began Local Permit A Permit No	<u>8-31-04</u> gency <u>NHPH</u> <u>E04-0364</u> GEOLOG	, Ended <u>4-17</u> <u>COUNTY</u> Permit D	<u>-04</u> Jate <u>8-26</u>	-04		APN/TRS/	
ORIENTATION (∠) DEPTH FROM SURFACE	VERTICAL DRILLING METHOD	HORIZONTAL ANG FLUI! DESCRIPTION	3LE (SPECIFY)	Name Mailing Address			
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Other Other ATTACH ADDITIONAL	INFORMATION, IF IT EXIST	S. Signed WELL DRI	LLER/AUTHORIZED REPRES	SENTATIVE	CITY DATE	SIGNED	STÂTE ZIP

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ORIENTA	TION (∠)		G ERTI	EO		•GI(ZONTAL F	ANGLE		(SPECIFY)		Name Mailintg Address		- WELL	OWNI	ER —		
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140 2410	300	11/1/12		57	52	IVE AC	K	- HORL RCLK	<u>> Br</u>	<i>}-\K.</i> #	CRICK		County <u>NAP</u> APN Book <u>32</u> Township	/-/ Pag Ran	ge	Parce Secti	on	54-	- 000
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ATTACH AL	Soil/Wate Other DDITIONAL I	er Chemical	Ana DN, II	lyse F 17	es EXI	ISTS.		ADDRESS Signed	DRILLER/	AUTHO	RIZED REPRESI		C INF	<u>nr</u>	CITY		 	STATE	<u>12698</u> 283326 -57 LICENSE NUMBER

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Page $10 \text{ of } 11$	emento	Refer to Instructi	on Pamphlet		TE WELL NO./	/STATION NO.
Owner's Well No	<u>. HE-10</u>	No. 8()2408			
Date Work Began	8-31-04,	Ended <u>9-17-04</u>	f Salapa E Sher maker		<u> </u>	LONGITUDE
Local Permit Ag	ency <u>AFPFI</u>	UUNTY Q.D	· · · · · · · · · · · · · · · · · · ·	- <u> </u>	APN/TRS/O	
Permit No/	GEOLOGIC	Permit Date 75-4	6-04	WELL O	WNER	4
			Name			· · · ·
	DRILLING		Mailing Address			
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Ft. to Ft.	Describe mater	ial, grain size, color, etc.	CITY	WELL LOC	ATION	STATE ZIP
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1011 140	MID STUNE	W/GRAVEL	City /VAIMA	ANT		
741 300	LIAVIS BING	-FINKI) POILAK KU	K County AV MICA	2 Dam (23/2 D	I GS	<u>u_100</u>
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Well Cons	struction Diagram	NAME W/ EXPL.	RATICN &	LUELLS		<u>.</u>
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IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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	CERTIFICATION ST	ATEMENT	
Geologic Log	I, the undersigned, certify that this report is complete and accurate to the best	of my knowledge and belief	
Well Construction Diagram	NAME HUCKFELDT WELL DRILLING, INC.	or my knowlodge and belief.	
Geophysical Log(s)	(PERSON, FIRM, OR ODRPORATION) (TYPED OR PRINTED)		·
Soil/Water Chemical Analysis	2110 Penny Lane	Napa	CA 94559
Other	ADDRESS	CITY	STATE ZIP
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS	Signed VV I'V VVVAPVY	07/24/13	439-746
	WELL DRILLER/AUTHORIZED REPRESENTATIVE	DATE SIGNED	C-57 LICENSE NUMBER

DWR 188 REV. 11-97

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For Local	r Requir	ements			WELL C	COMP. Refer to In	Struction P	on 1 amphle	REPOR		STATE WI	ELL NO.	/STATIC	DN NO.
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APPENDIX B

NAPA COUNTY GROUNDWATER RECHARGE ANALYSIS



Napa County Groundwater Recharge Analysis

Introduction

Developing accurate estimates of the spatial and temporal distribution of groundwater recharge is a key component of sustainable groundwater management. Efforts to quantify recharge are inherently difficult owing to the wide variability of factors controlling hydrologic processes, the wide range of available tools/methods for estimating recharge, and the difficulty in assessing the accuracy of estimates because direct measurement of recharge rates is, for the most part, infeasible (Healy 2010, Seiler and Gat 2007).

Numerical modeling is a common approach for developing recharge estimates. Soil-waterbalance modeling is one category of numerical models particularly well-suited for estimating recharge across large areas with modest data requirements. This study describes an application of the U.S. Geological Survey's (USGS) Soil Water Balance Model (SWB) (Westenbroek et al. 2010) to develop spatial and temporal distributions of groundwater recharge across Napa County. This model operates on a daily timestep and calculates surface runoff based on the Natural Resources Conservation Service (NRCS) curve number method and potential evapotranspiration based on the Hargreaves-Samani methods (Hargreaves and Samani 1985). Actual evapotranspiration (AET) and recharge are calculated using a modified Thornthwaite-Mather soil-water-balance approach (Westenbroek et al. 2010).

It is important to note that the SWB model focuses on surface and soil-zone processes and does not simulate the groundwater system or track groundwater storage over time. The model also does not simulate surface water/groundwater interaction or baseflow; thus, the runoff estimates represent only the surface runoff component of streamflow resulting from rainstorms and the recharge estimates represent only the infiltration recharge component (also referred to as diffuse recharge) of total recharge (stream-channel recharge is not simulated).

This modeling work and summary report has been prepared by O'Connor Environmental, Inc., for it's private use in relation to Water Availability Analyses (WAA) prepared on behalf of private clients for projects using groundwater in "hillside" areas of Napa County as required by Napa Planning, Building & Environmental Services. The modeling to-date is complete in its current form but remains subject to revision; it is considered a working draft with information suitable for use to support WAA projects. Parties interested in obtaining more information regarding the modeling or who may wish to offer comments should contact O'Connor Environmental, Inc.



Model Development

The model was developed using a 30-meter (98.4 ft) resolution rectangular grid. Water budget calculations were made on a daily time step. Key spatial inputs included a flow direction map developed from the USGS 1 arc-second resolution Digital Elevation Model (DEM), a land cover map derived from the U.S. Forest Service (USFS) CALVEG dataset that was supplemented by a database of agricultural areas maintained by the County of Napa (Figure 1), a distribution of Hydrologic Soil Groups (A through D classification from lowest to highest runoff potential; Figure 2), and a distribution of Available Water Capacity (AWC) developed from the NRCS Soil Survey Geographic Database (SSURGO) (Figure 3).

A series of model parameters were assigned for each land cover type/soil group combination including an infiltration rate, a curve number, dormant and growing season interception storage values, and a rooting depth (Table 1).

Infiltration rates for hydrologic soil groups A through D were applied based on Cronshey et al. (1986) (Table 2) along with default soil-moisture-retention relationships based on Thornthwaite and Mather (1957) (Figure 4). Curve numbers were assigned based on standard NRCS methods. Interception storage values and rooting depths were assigned based on literature values and from previous modeling experience including a SWB model covering Sonoma County and calibrated using runoff volumes from several stream gages (OEI 2017).





Figure 1: Land cover distribution used in the Napa County SWB model.





Figure 2: Hydrologic soil group distribution used in the Napa County SWB model.





Figure 3: Available water capacity distribution used in the Napa County SWB model.



Land Cover	Interception Storage Values ()		Curve Number by NRCS Soil Type ()				Rooting Depth by NRCS Soil Type (ft)			
	Growing Season	Dormant Season	Туре А	Туре В	Type C	Type D	Туре А	Туре В	Туре С	Type D
Agriculture, Other	0.080	0.040	38	61	75	81	2.0	1.9	1.8	1.7
Barren	0.000	0.000	77	86	91	94	0.0	0.0	0.0	0.0
Developed	0.005	0.002	61	75	83	87	2.3	2.1	2.0	1.8
Grassland/Herbaceous	0.005	0.004	30	58	71	78	1.3	1.1	1.0	1.0
Forest, Coniferous	0.050	0.050	30	55	70	77	5.9	5.1	4.9	4.7
Forest, Deciduous	0.050	0.020	30	55	70	77	5.9	5.1	4.9	4.7
Shrub/Scrub	0.080	0.015	30	48	65	73	3.2	2.8	2.7	2.6
Orchard	0.050	0.015	38	61	75	81	3.2	2.8	2.7	2.6
Vineyard	0.080	0.015	38	61	75	81	2.2	2.1	2.0	1.9
Water	0.000	0.000	100	100	100	100	0.0	0.0	0.0	0.0

Table 1: Soil and land cover properties used in the Napa County SWB model.

Table 2: Infiltration rates for NRCS hydrologicsoil groups (Cronshey et al. 1986).

Soil Group	Infiltration Rate (in/hr)
А	> 0.3
В	0.15 - 0.3
С	0.05 - 0.15
D	<0.05

SOIL MOISTURE RETAINED, IN INCHES



Figure 4: Soil-moisture-retention table (Thornthwaite and Mather 1957).



The SWB model utilizes daily precipitation and mean daily temperature data derived from climate stations. To account for the spatial variability of these parameters, daily precipitation and mean daily temperature were input as gridded (spatially-distributed) time-series. The gridded precipitation time-series was created using data from 15 weather stations in Napa County, and the gridded mean temperature time-series was created using data from 8 stations (Table 3). These stations were selected based on completeness of the records and to provide station data representative of the range of climates experienced in the county. Data was obtained from the California Data Exchange Center (CDEC), the National Climatic Data Center (NCDC), and from Napa One Rain.

To create the gridded time-series, the model domain was divided into discrete areas represented by individual weather stations (Figures 5 and 6). This delineation was based on climate variations described by existing gridded mean annual (1981-2010) precipitation and temperature data (PRISM 2010) and local knowledge of climatic variations across the county.

For the precipitation time-series, each area representing a weather station was subdivided into four to twenty-three zones based on 1-inch average annual precipitation contours. Within each zone the raw station data was multiplied by a unique scaling factor. This scaling factor was calculated as the ratio of average annual precipitation within a zone to average annual precipitation at the representative rain gage. In certain locations, typically near the boundary of areas represented by gages located on the valley bottom and at higher elevations, this scaling was unable to smoothly resolve differences in annual and event precipitation totals. To more accurately estimate precipitation near these boundaries, precipitation records from the two gages in question were averaged using weights calculated proportionally to the difference between PRISM mean annual precipitation at a rain gage and within a selected zone. The resulting gridded time-series is comprised of 220 individual time-series based on the scaled station data from 15 stations.

The assignment of temperature stations was based on the understanding that the spatial variability of temperatures across Napa County is relatively homogenous, with elevation being the primary variable. Temperature records were classified either as Mountain, Valley Bottom, or East County and applied within areas the PRISM datasets described as being similar. To smooth the transition from Mountain zones to Valley Bottom and East County zones, Hillside zones were created where the temperature records of the two nearest gages were averaged.

Missing and suspect data was encountered in the raw precipitation and temperature data from the weather stations used by the model. Values that were significantly outside the typical range, and where similar observations were not found at nearby stations, were removed from the datasets. These and missing values were filled using scaled data from other nearby stations. Precipitation data used for gap filling was scaled using the ratio of the 1981 to 2010 mean annual precipitation (PRISM 2010) between the two stations. Temperature data was scaled using the ratio of the 1981 to 2010 mean monthly minimum and maximum temperatures (PRISM 2010) between the two stations.



The current analysis focuses on Water Year 2010 (October 1, 2009 – September 30, 2010) and Water Year 2014 (October 1, 2013 – September 30, 2014). These years were selected because they represent periods with data available from most weather stations in the county and where most stations reported annual precipitation totals close to the long-term average (WY 2010) and significantly below the long term average (WY 2014). Based on a comparison between station data and PRISM average precipitation depths during Water Year 2010, rainfall averaged 101% of long-term average conditions and ranged from 78% at Lake Hennessey to 111% at the Napa County Airport. In Water Year 2014, rainfall averaged 55% of long-term average conditions and ranged from 41% at Lake Hennessey to 73% at the Napa State Hospital (Table 3).

		1981 - 2010 Mean	WY 20)10	WY 20)14
Station	Data Used	Annual Precip (in)	Precip (in)	% Avg	Precip (in)	% Avg
Angwin ¹	Precip & Temp	42.54	44.64	105%	25.04	59%
Atlas Peak ¹	Precip & Temp	41.76	39.04	93%	20.08	48%
Berryessa ¹	Precip & Temp	28.97	28.16	97%	13.97	48%
Calistoga ²	Precip	39.41	41.75	106%	18.18	46%
Knoxville Creek ¹	Temp Only	-	-	-	-	-
Lake Hennessey ³	Precip Only	34.09	26.52	78%	13.92	41%
Mt. George ³	Precip Only	31.15	29.64	95%	18.24	59%
Mt. Veeder ³	Precip Only	44.81	46.44	104%	28.6	64%
Napa County Airport ²	Precip & Temp	21.14	23.56	111%	9.87	47%
Napa River at Yountville Cross Rd ³	Precip Only	31.86	32.72	103%	14.93	47%
Napa State Hospital ²	Precip & Temp	26.81	28.85	108%	19.66	73%
Petrified Forest ³	Precip Only	42.39	46.6	110%	22.84	54%
Redwood Creek At Mt. Veeder Road ³	Precip Only	34.71	37.36	108%	23.48	68%
Saint Helena ²	Precip & Temp	37.43	39.11	104%	19.11	51%
Saint Helena 4WSW ¹	Precip & Temp	45.44	47.88	105%	28.88	64%
Sugarloaf Peak ³	Precip Only	32.20	26.16	81%	17.12	53%

			• • • • •
Table 3: Weather stations used in the Na	ipa County SWB mode	el. See Figures 7-9 for	associated timeseries.

1 – Data accessed from California Data Exchange Center (CDEC)

2 – Data accessed from National Climate Data Center (NCDC)

3 - Data access from Napa One Rain





Figure 5: Precipitation zones used in the Napa County SWB model. Hatching indicates areas where two precipitation records were averaged across a zone.





Figure 6: Temperature zones used in the Napa County SWB model. Hatching indicates areas where two temperature records were averaged across a zone.





Figure 7a: Daily precipitation data used in the Napa County SWB model for WY 2010.





Figure 7b: Daily precipitation data used in the Napa County SWB model for WY 2014.

OEI



Figure 8: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.



DRAFT



Figure 8 – cont.



DRAFT



Figure 9: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.





Figure 9 – cont.



Model Calibration

Available data are insufficient to calibrate the Water Year 2010 and 2014 SWB simulations; however, the land cover and soil properties used in the model were obtained from a previously prepared and calibrated SWB model of Sonoma County (OEI 2017). The Sonoma County model was calibrated against total monthly runoff volumes derived using baseflow separation of streamflow data for five watersheds within Sonoma County. Gages were selected because they represented relatively small watersheds ($1.2 - 14.3 \text{ mi}^2$) without significant urbanization, diversions, groundwater abstraction, reservoir impoundments, or large alluvial bodies where significant exchanges between surface water and groundwater may be expected. These attributes are desirable because the hydrographs can more readily be separated into surface runoff and baseflow components and the surface runoff pattern is more directly comparable to the SWB simulated surface runoff which does not account for water use, reservoir operations, or surface water/groundwater exchange.

SWB utilizes a simplified routing scheme whereby surface runoff is routed to downslope cells or out of the model domain on the same day in which it originates as rainfall, thus it is not capable of accurately estimating streamflow over short time periods. The use of the total monthly surface runoff volumes provided a means of calibrating the Sonoma County SWB model to measured surface runoff data within the limitations of the model's approach to simulating surface runoff.

The SWB model of Sonoma County reproduced seasonal variations in surface runoff in all five calibration watersheds. Monthly Mean Errors (ME) ranged from -0.2 to 0.4 inches with a mean value of 0.1 inches. Annual surface runoff totals ranged from an under-prediction of approximately 10% at Franchini Creek to an over-prediction of approximately 19% at Buckeye Creek, with a mean over-prediction of approximately 6% across the five watersheds. These results indicate that the SWB model was able to reproduce monthly surface runoff volumes with a reasonable degree of accuracy and that the model tends to over-predict surface runoff somewhat, suggesting that the model may generate a low-range estimate of recharge.

Although the climate in Napa County is slightly drier than in Sonoma County, the vegetation, soils, and geology are similar and parameters calibrated using data from Sonoma County should be applicable to Napa County. Calibration of the Napa County SWB model was not performed due to a lack of publicly-available contemporary discharge records in suitable watersheds. Contemporary discharge records exist for USGS gaging stations located along the Napa River near St. Helena and Napa, but the watersheds above these gages are large and contain significant groundwater abstraction, reservoir impoundments, and alluvial bodies. USGS gages on smaller watersheds in Napa County have been inactive since 1983 or earlier. Discharge records exist through Napa One Rain for several streams gaged by the Napa County Resource Conservation District (RCD) but the RCD has cautioned against use of these discharge records for calibration purposes due to incomplete rating curve development.



Estimates of groundwater recharge are also available from an earlier model prepared by Luhdorff and Scalmanini Engineers and MBK Engineers (LSCE 2013). This report provided estimates of average annual recharge as a percentage of average annual precipitation for nine watersheds in Napa County. Averaged across the same nine watersheds, the SWB model predicts significantly higher rates of recharge than the model prepared by LSCE, which predicts slightly lower AET but significantly more runoff (Table 4). Differences in methodology between these two models complicate direct comparisons. The LSCE model calculated infiltration into the soil as the difference between monthly precipitation and discharge volumes within each watershed. Discharge volumes were calculated from USGS stream gages and included both direct runoff and baseflow from groundwater. Inclusion of baseflow with direct runoff in these calculations may inappropriately reduce the estimated volume of water infiltrated into the soil and available for recharge.

USGS Gage	HUC	Mean Precip, 2010 (in)	Mean A (% Pr	ET, 2010 ecip)	Mean l 2010 (%	Runoff, Precip)	Mean Re 2010 (%	echarge, Precip)
			SWB	LSCE	SWB	LSCE	SWB	LSCE
Conn Ck nr Oakville	11456500	34.8	59%	53%	21%	25%	21%	21%
Dry Ck nr Napa	11457000	41.5	56%	50%	18%	43%	25%	6%
Milliken Ck nr Napa	11458100	32.3	52%	41%	20%	51%	28%	8%
Napa Ck at Napa	11458300	36.6	61%	43%	16%	46%	23%	11%
Napa R nr Napa	11458000	39.5	56%	48%	20%	35%	24%	17%
Napa R nr St Helena	11456000	47.9	46%	45%	23%	42%	30%	14%
Redwood Ck nr Napa	11458200	39.6	53%	49%	26%	40%	22%	10%
Tulucay Ck nr Napa	11458300	27.0	64%	49%	16%	47%	20%	5%

Table 4: Comparison of results from SWB model and Luhdorff and Scalmanini model.

Model Results

The principal elements of the annual water budget simulated with the Napa County SWB model for Water Years 2010 and 2014 are presented in map form in Figures 10 - 19 and in tabular form for 27 major watershed areas in Napa County (Tables 5 - 8). The watersheds are based on USGS HUC-12 watersheds and are named for the stream which comprises the largest proportion of the area; in many cases the areas consist of multiple tributary streams (Figure 20).

In Water Year 2010 (representing "average" hydrologic conditions) precipitation varied from 21.8 inches in the Ledgewood Creek watershed to 53.3 inches in the Saint Helena Creek watershed (Figure 10, Table 5). Actual evapotranspiration (AET) ranged from 13.4 inches in the Jackson Creek watershed to 25.2 inches in the Saint Helena Creek watershed (Figure 11). Surface runoff ranged from 3.4 inches in the Ledgewood Creek watershed to 13.5 inches in the Saint Helena Creek watershed (Figure 12). Recharge ranged from 3.3 inches in the Ledgewood Creek watershed to 14.4 inches in the Saint Helena watershed. (Figure 13). Small decreases in soil moisture storage (up to 1.8 inches) occurred in most watersheds, with changes in most



watersheds being less than an inch (Figure 14). Note that the San Pablo Bay estuaries have been excluded from these comparisons.

Expressed as a percentage of the annual precipitation, AET ranged from 77% in the Ledgewood Creek watershed to 45% in the Jackson Creek watershed (Table 6). Surface runoff ranged from 15% of precipitation in the Ledgewood Creek watershed to 42% in the Jackson Creek watershed. Recharge ranged from 10% of the precipitation in the Jackson Creek watershed to 27% in the Saint Helena watershed.

In Water Year 2014 (representing "dry" hydrologic conditions during the second year of an extreme three-year drought) precipitation varied from 10.1 inches in the American Canyon Creek watershed to 32.2 inches in the Saint Helena Creek watershed (Figure 15, Table 7). Actual evapotranspiration (AET) ranged from 10.3 inches in the Jackson Creek watershed to 17.8 inches in the Saint Helena Creek watershed (Figure 16). Surface runoff ranged from 0.7 inches in the American Canyon Creek watershed to 13.2 inches in the Saint Helena Creek watershed to 13.2 inches in the Saint Helena Creek watershed (Figure 17). Recharge ranged from 0.6 inches in the Wragg Canyon watershed to 4.1 inches in the Saint Helena watershed. (Figure 18). Large decreases in soil moisture storage of between 2.3 and 4.3 inches were also simulated (Figure 19).

Expressed as a percentage of the annual precipitation, AET ranged from 55% in the Saint Helena Creek watershed to 121% in the Jackson Creek watershed (Table 8). These very large AET rates caused significant decreases in soil moisture. Decreases in soil moisture ranged from 9% of precipitation in the Saint Helena watershed to 36% in the American Canyon Creek watershed. Surface runoff ranged from 7% of precipitation in the American Canyon Creek watershed to 41% in the Saint Helena Watershed. Recharge ranged from 18% in the Milliken Creek Watershed to 5% in the Jackson Creek and Wragg Canyon watersheds.





Figure 10: Water Year 2010 precipitation simulated with the Napa County SWB model.





Figure 11: Water Year 2010 AET simulated with the Napa County SWB model.





Figure 12: Water Year 2010 runoff simulated with the Napa County SWB model.





Figure 13: Water Year 2010 recharge simulated with the Napa County SWB model.





Figure 14: Water Year 2010 change in soil moisture content simulated with the Napa County SWB model.





Figure 15: Water Year 2014 precipitation simulated with the Napa County SWB model.





Figure 16: Water Year 2014 AET simulated with the Napa County SWB model.





Figure 17: Water Year 2014 recharge simulated with the Napa County SWB model.





Figure 18: Water Year 2014 recharge simulated with the Napa County SWB model.





Figure 19: Water Year 2014 change in soil moisture content simulated with the Napa County SWB model.



 Table 5: Simulated precipitation and recharge values averaged across HUC-12 watersheds in Napa County for

 Water Year 2010 expressed as depths.
 See Figure 20 for watershed locations.

Name	Drainage Area (mi ²)	Precipitation (in)	AET (in)	Surface Runoff (in)	Recharge (in)	Soil Moisture Change (in)
American Canyon Creek	10.8	24.1	16.3	3.7	4.7	-0.6
Bucksnort Creek	1.9	47.9	24.5	12.1	11.1	0.1
Butts Creek-Putah Creek	49.9	33.0	17.4	9.7	6.2	-0.7
Capell Creek	43.0	31.1	19.1	7.4	5.0	-0.6
Carneros Creek	29.7	28.0	18.6	5.2	5.5	-0.6
Chiles Creek	32.0	34.6	21.1	7.1	6.8	-0.5
Dry Creek	28.8	37.0	22.2	7.2	8.4	-0.5
Hunting Creek	12.0	33.7	19.0	9.7	5.7	-0.8
Jackson Creek-Putah Creek	54.5	29.9	13.4	12.6	3.0	-0.5
Lake Curry-Suisun Creek	16.4	30.7	18.9	6.5	5.9	-0.6
Lake Hennessey-Conn Creek	20.0	35.1	19.6	8.5	7.3	-0.4
Ledgewood Creek	6.4	21.8	16.9	3.4	3.3	-1.8
Lower Eticuera Creek	44.0	30.0	17.7	8.1	4.7	-0.7
Lower Napa River	45.0	31.7	19.9	5.6	6.7	-0.6
Lower Pope Creek	31.8	33.9	18.0	9.7	6.5	-0.6
Maxwell Creek	35.1	34.7	19.6	8.7	6.9	-0.6
Middle Napa River	60.3	39.9	22.8	8.5	9.2	-0.5
Milliken Creek	29.7	30.9	16.9	6.6	7.9	-0.6
Rector Creek-Conn Creek	22.3	32.8	18.0	7.1	8.2	-0.7
Saint Helena Creek	7.7	53.3	25.2	13.5	14.4	0.1
San Pablo Bay Estuaries	19.5	23.9	8.1	13.8	2.3	-0.3
Tulucay Creek	34.2	26.1	16.7	4.6	5.4	-0.7
Upper Eticuera Creek	25.6	31.2	17.2	8.6	6.1	-0.8
Upper Napa River	44.6	44.7	23.6	10.6	10.8	-0.4
Upper Pope Creek	21.7	44.5	22.7	10.5	11.5	-0.3
Wooden Valley & Suisun Creeks	23.3	29.0	19.0	5.1	5.5	-0.6
Wragg Canyon-Putah Creek	34.2	28.3	16.3	8.6	3.3	-0.6



 Table 6: Simulated precipitation and recharge values averaged across HUC-12 watersheds in Napa County for

 Water Year 2010 expressed as a percentage of precipitation.

 See Figure 20 for watershed locations.

Name	Drainage Area (mi ²)	Precipitation (in)	AET (%)	Surface Runoff (%)	Recharge (%)	Soil Moisture Change (%)
American Canyon Creek	10.8	24.1	67%	15%	19%	-3%
Bucksnort Creek	1.9	47.9	51%	25%	23%	0%
Butts Creek-Putah Creek	49.9	33.0	53%	29%	19%	-2%
Capell Creek	43.0	31.2	61%	24%	16%	-2%
Carneros Creek	29.7	29.7	66%	19%	20%	-2%
Chiles Creek	32.0	34.6	61%	21%	20%	-1%
Dry Creek	28.8	37.8	60%	20%	23%	-1%
Hunting Creek	12.0	33.7	56%	29%	17%	-2%
Jackson Creek-Putah Creek	54.5	29.7	45%	42%	10%	-2%
Lake Curry-Suisun Creek	16.4	30.7	61%	21%	19%	-2%
Lake Hennessey-Conn Creek	20.0	36.0	56%	24%	21%	-1%
Ledgewood Creek	6.4	21.8	77%	15%	15%	-8%
Lower Eticuera Creek	44.0	30.0	59%	27%	16%	-2%
Lower Napa River	45.0	31.7	63%	18%	21%	-2%
Lower Pope Creek	31.8	33.9	53%	29%	19%	-2%
Maxwell Creek	35.1	34.7	56%	25%	20%	-2%
Middle Napa River	60.3	40.4	57%	21%	23%	-1%
Milliken Creek	29.7	30.9	55%	21%	26%	-2%
Rector Creek-Conn Creek	22.3	32.8	55%	22%	25%	-2%
Saint Helena Creek	7.7	53.3	47%	25%	27%	0%
San Pablo Bay Estuaries	19.5	23.9	34%	58%	10%	-1%
Tulucay Creek	34.2	26.1	64%	18%	21%	-3%
Upper Eticuera Creek	25.6	31.2	55%	28%	19%	-3%
Upper Napa River	44.6	44.7	53%	24%	24%	-1%
Upper Pope Creek	21.7	44.5	51%	23%	26%	-1%
Wooden Valley & Suisun Creeks	23.3	29.0	65%	18%	19%	-2%
Wragg Canyon-Putah Creek	34.2	28.3	58%	31%	12%	-2%


Table 7: Simulated precipitation and recharge values averaged across HUC-12 watersheds in Napa County for

 Water Year 2014 expressed as depths.
 See Figure 20 for watershed locations.

Name	Drainage Area (mi ²)	Precipitation (in)	AET (in)	Surface Runoff (in)	Recharge (in)	Soil Moisture Change (in)
American Canyon Creek	10.8	10.1	12.3	0.7	0.7	-3.6
Bucksnort Creek	1.9	28.8	17.6	11.5	2.6	-3.0
Butts Creek-Putah Creek	49.9	16.9	14.2	3.9	1.9	-3.2
Capell Creek	43.0	15.8	14.8	3.1	1.1	-3.1
Carneros Creek	29.7	15.0	14.7	4.6	2.0	-3.7
Chiles Creek	32.0	18.3	16.5	3.7	1.5	-3.3
Dry Creek	28.8	21.5	16.5	6.8	2.5	-3.7
Hunting Creek	12.0	16.7	15.4	3.1	1.6	-3.4
Jackson Creek-Putah Creek	54.5	14.9	10.3	6.1	0.7	-2.3
Lake Curry-Suisun Creek	16.4	18.4	16.1	3.7	1.9	-3.4
Lake Hennessey-Conn Creek	20.0	19.1	14.8	5.7	2.2	-3.2
Ledgewood Creek	6.4	12.2	13.9	1.7	0.8	-4.3
Lower Eticuera Creek	44.0	14.9	14.0	2.6	1.3	-3.1
Lower Napa River	45.0	19.4	15.9	5.0	2.2	-3.6
Lower Pope Creek	31.8	17.8	14.5	4.5	2.0	-3.2
Maxwell Creek	35.1	18.3	15.9	3.8	2.0	-3.3
Middle Napa River	60.3	21.3	16.5	6.6	2.5	-3.7
Milliken Creek	29.7	18.7	13.7	4.5	3.4	-2.9
Rector Creek-Conn Creek	22.3	16.5	13.6	4.0	2.3	-3.4
Saint Helena Creek	7.7	32.2	17.8	13.2	4.1	-3.0
San Pablo Bay Estuaries	19.5	10.4	6.0	5.6	0.5	-1.6
Tulucay Creek	34.2	14.6	13.5	2.6	1.7	-3.3
Upper Eticuera Creek	25.6	15.5	14.1	2.5	2.1	-3.2
Upper Napa River	44.6	22.9	16.2	6.9	3.3	-3.5
Upper Pope Creek	21.7	25.6	16.8	8.5	3.5	-3.2
Wooden Valley & Suisun Creeks	23.3	17.9	16.4	3.1	2.0	-3.5
Wragg Canyon-Putah Creek	34.2	14.1	12.6	3.6	0.6	-2.8



 Table 8: Simulated precipitation and recharge values averaged across HUC-12 watersheds in Napa County for

 Water Year 2014 expressed as a percentage of precipitation.

 See Figure 20 for watershed locations.

Name	Drainage Area (mi ²)	Precipitation (in)	AET (%)	Surface Runoff (%)	Recharge (%)	Soil Moisture Change (%)
American Canyon Creek	10.8	10.1	121%	7%	7%	-36%
Bucksnort Creek	1.9	28.8	61%	40%	9%	-10%
Butts Creek-Putah Creek	49.9	16.8	84%	23%	11%	-19%
Capell Creek	43.0	15.8	94%	20%	7%	-20%
Carneros Creek	29.7	17.6	98%	30%	13%	-25%
Chiles Creek	32.0	18.4	90%	20%	8%	-18%
Dry Creek	28.8	22.1	77%	32%	12%	-17%
Hunting Creek	12.0	16.7	92%	18%	10%	-20%
Jackson Creek-Putah Creek	54.5	14.7	69%	41%	5%	-16%
Lake Curry-Suisun Creek	16.4	18.4	88%	20%	10%	-19%
Lake Hennessey-Conn Creek	20.0	19.6	78%	30%	12%	-17%
Ledgewood Creek	6.4	12.2	114%	14%	7%	-35%
Lower Eticuera Creek	44.0	14.9	94%	18%	9%	-21%
Lower Napa River	45.0	19.4	82%	26%	11%	-19%
Lower Pope Creek	31.8	17.8	81%	25%	11%	-18%
Maxwell Creek	35.1	18.3	87%	21%	11%	-18%
Middle Napa River	60.3	21.8	77%	31%	12%	-18%
Milliken Creek	29.7	18.7	74%	24%	18%	-16%
Rector Creek-Conn Creek	22.3	16.5	83%	24%	14%	-21%
Saint Helena Creek	7.7	32.2	55%	41%	13%	-9%
San Pablo Bay Estuaries	19.5	10.4	58%	53%	4%	-16%
Tulucay Creek	34.2	14.6	93%	18%	12%	-23%
Upper Eticuera Creek	25.6	15.5	91%	16%	14%	-21%
Upper Napa River	44.6	22.9	71%	30%	14%	-15%
Upper Pope Creek	21.7	25.6	66%	33%	14%	-12%
Wooden Valley & Suisun Creeks	23.3	17.9	91%	17%	11%	-20%
Wragg Canyon-Putah Creek	34.2	14.1	90%	26%	5%	-20%





Figure 20: Major watersheds areas used to summarize water budget information in Tables 5 - 8.



Discussion and Conclusion

Numerous previous modeling studies have estimated water budget components in several larger watershed areas in Sonoma and Napa Counties including the Santa Rosa Plain, the Green Valley and Dutch Bill Creek watersheds, and the Sonoma Valley (Farrar et. al., 2006; Kobor and O'Connor, 2016; Woolfenden and Hevesi, 2014). Comparisons to these water budgets are useful for evaluating the SWB results, but one would not expect precise agreement owing to significant variations in climate, land cover, soil types, underlying hydrogeologic conditions, and different spatial scales of modeling studies. These regional analyses estimate that average annual recharge varies from 7% to 19% of the annual precipitation. The equivalent county-wide value from this study is slightly higher at 20%.

Water budgets for the Napa River and selected sub-basins were also estimated in a previous study by Luhdorff and Scalmanini Engineers and MBK Engineers (LSCE 2013). The LSCE study estimated that, as a percentage of annual precipitation, AET comprised slightly less, runoff significantly more, and recharge substantially less of the typical annual water budget. LSCE (2013) calculated infiltration of precipitation based on the difference between total monthly streamflow at selected gaging stations and total monthly precipitation for the gages' drainage area. Streamflow volumes include both direct runoff (overland flow and interflow) and baseflow Inclusion of baseflow with direct runoff in these calculations may from groundwater. inappropriately reduce the estimated volume of water infiltrated into the soil and available for recharge; the LSCE approach therefore tends to underestimate groundwater recharge. Additionally, many of the gauging stations used for the analysis are located in reaches that may be significantly influenced by upstream reservoir releases, surface water diversions, groundwater abstraction, and/or surface water groundwater exchanges, further complicating the interpretation of the LSCE (2013) runoff rates and the interrelated calculations of AET and recharge rates. In contrast, the SWB model presented here is based on calibrated parameter values developed for a similar model in Sonoma County which was calibrated to gauges specifically selected to minimize the effects of reservoir releases, water use, or significant surface water/groundwater interaction, and after separating and removing the baseflow component of streamflow.

The recharge estimates presented here arguably represent the best available county-wide estimates produced at a fine spatial resolution using a consistent and objective data-driven approach. This analysis focused on two Water Years, 2010 and 2014, which represent average and drought conditions respectively. Input parameters were determined based on literature values and values calibrated through prior modeling experience in Sonoma County.



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