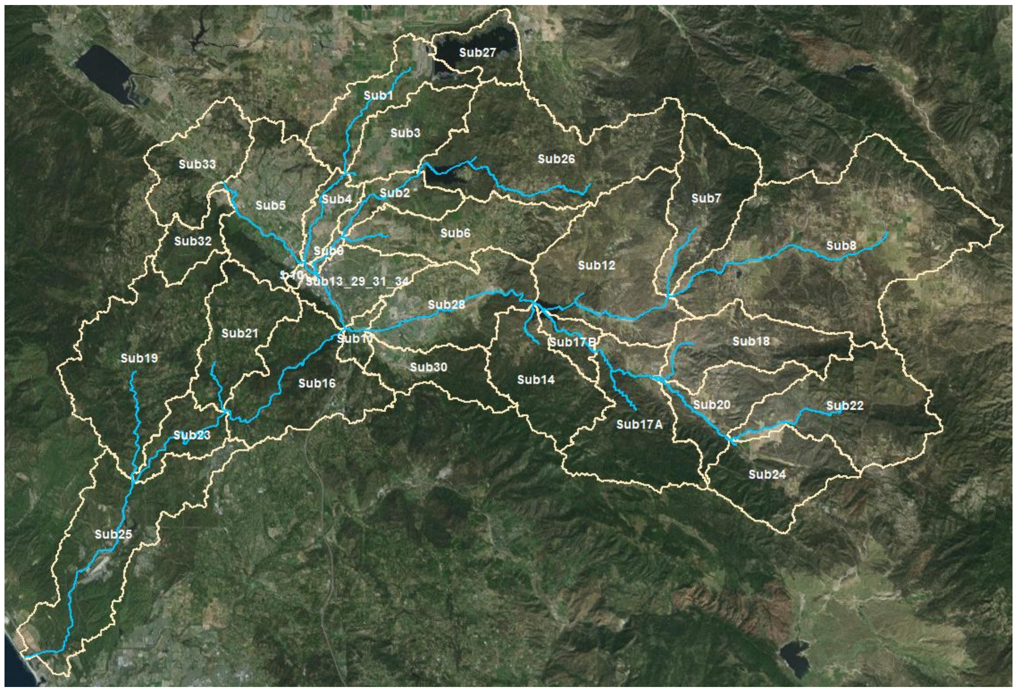
Sandia Creek Drive Bridge Replacement Project
Fallbrook, San Diego County, CA

Santa Margarita River Hydrology Report



May
2021

Final Report

Prepared for:

CALIFORNIA TROUT
FISH · WATER · PEOPLE

Prepared by:

RIVER FOCUS
WATER RESOURCE CONSULTANTS

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Hydrology Report

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Prepared for:

California Trout, Inc.
www.caltrout.org

Prepared by:

River Focus, Inc.
www.riverfocus.com

A. Jake Gusman, P.E.
River Focus Project Manager

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1 INTRODUCTION

The purpose of this hydrologic report is to provide design flows for the Sandia Creek Drive bridge replacement project. The proposed bridge will replace the aging, flood-prone Sandia Creek Drive bridge, which crosses the Santa Margarita River north of Fallbrook in San Diego County, CA. The hydrologic modeling in the current study follows San Diego County Hydrology Manual guidelines (County of San Diego, 2003).

1.1 Project Overview

The benefits of the bridge replacement project are numerous and include (1) improving reliable and safe access for residents during high flows that flood the current crossing; (2) enhancing trail user experience through better safety controls for pedestrians, cyclists, equestrian users, disadvantaged communities, and vehicles; (3) improving traffic congestion; (4) providing back-country access to emergency response personnel during strong storms; and (5) increasing quality of riparian and river habitat for multiple species.

A project location map is provided in Figure 1.1.

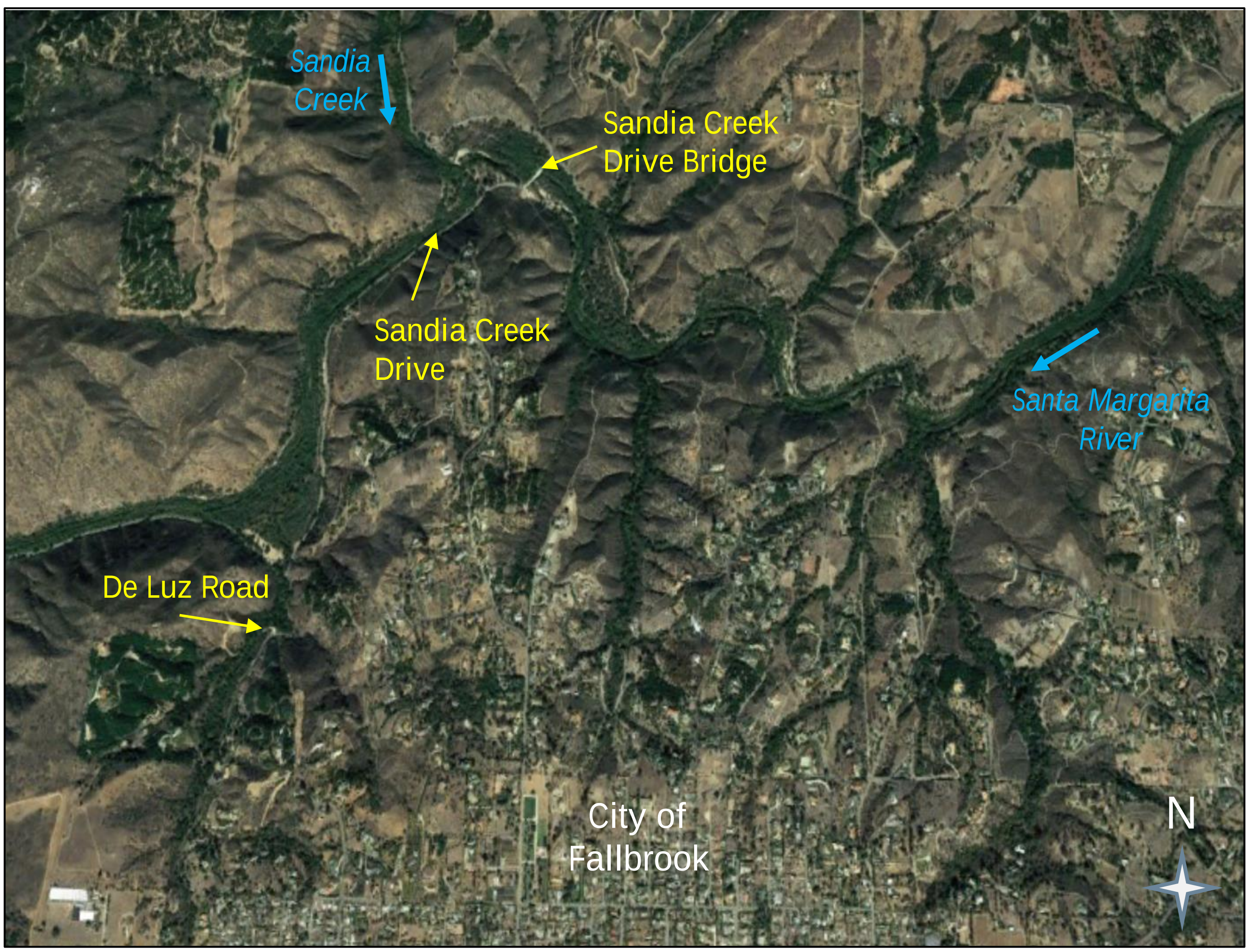


Figure 1.1. Study Area Location Map

1.2 Previous Hydrologic Studies

WEST Consultants (2000) conducted a detailed hydrologic study of the Santa Margarita River watershed for the U.S. Army Corps of Engineers, Los Angeles District, and Marine Corps Basin Camp Pendleton. The subbasins and routing reaches developed in the WEST Consultants study served as the starting point for the current modeling effort; however, all model parameters were re-developed based on the San Diego County Hydrology Manual methodology.

2 SANTA MARGARITA RIVER WATERSHED

2.1 Watershed Characteristics

The Santa Margarita River watershed encompasses 738 square miles. The Santa Margarita River—at 27 miles in length—is the longest free-flowing river on the southern California coast. The river originates with the confluence of Temecula Creek and Murrieta Creek, immediately west of Interstate 15 near Temecula. Upstream of the confluence, Temecula and Murrieta Creeks rise into the Palomar Mountains and the northern slope of the Santa Rosa Plateau, respectively. The Palomar Mountain range receives about 45 inches of rain per year, compared to about 10 inches at the coast. A watershed map is provided in Figure 2.1.

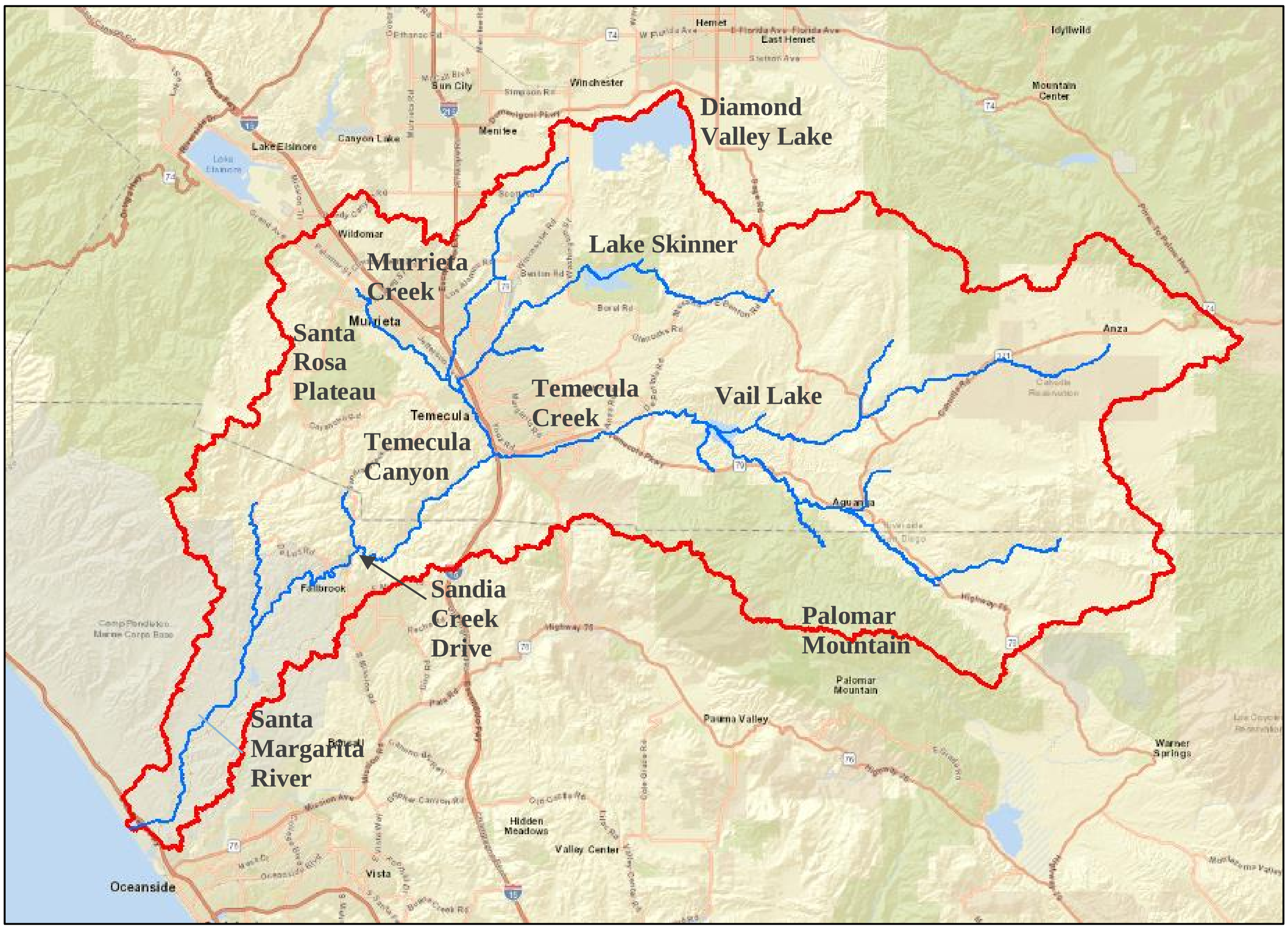


Figure 2.1. Santa Margarita River Watershed Map

Santa Margarita River

Downstream of the confluence of Temecula and Murrieta Creeks, the Santa Margarita River flows generally southwest towards the Pacific Ocean. The river first descends through the 6-mile-long Temecula Canyon, a steep-walled gorge through the southern edge of the Santa Ana Mountains.

Approximately 2 miles from the lower end of the gorge, the river gradient lowers, and the floodplain becomes wider again near the crossing of Sandia Creek Drive. The river continues toward the ocean, flowing through an alluvial valley and coastal plain before passing through the Ysidora Narrows. The river ends at the Santa Margarita River estuary, located within Camp Pendleton.

Major Reservoirs

Three major reservoirs are located in the Santa Margarita River watershed: (1) Vail Lake, which is fed by Temecula Creek and its tributaries, (2) Lake Skinner, which receives water from the Colorado River as well as local inflow, and (3) Diamond Valley Lake, which is used by the Metropolitan Water District (MWD) for water supply and has a minimal local contributing area.

In-Stream Flows

Studies by the Bureau of Reclamation from 2002 to 2009 culminated in a Conjunctive Use Project mandate for the Santa Margarita River basin. The objective was to enhance groundwater supplies in aquifers in Camp Pendleton, increase storage at Lake O'Neill, and provide year-round in-stream flows of 3 to 9 cfs.

2.2 Flood History

Flood of Record

The flood of record for Santa Margarita River occurred on January 16, 1993, with an estimated peak discharge of 34,000 cfs near the project site (Figure 2.2), based on the USGS streamgage in the project reach. From January 6 to February 28, 1993, a series of storms produced 20 to 40 inches of rain over much of the southern California coastal and mountain areas (USGS, 1993). The most severe flooding was in the Santa Margarita River and San Luis Rey River Basins in northern San Diego County and southwestern Riverside County. In the 24-hour period beginning at 8 a.m. on January 16th, 6.8 inches of rain was recorded at the Santa Rosa Plateau weather station on the already saturated Santa Margarita River watershed, and similar rainfall intensities were reported throughout the area.

Estimates at the time put the recurrence interval of the 6-hour rainfall to be approximately 120% of the 100-year precipitation frequency values. Extensive flooding occurred along the Santa Margarita River from Temecula to Fallbrook and through Camp Pendleton (USGS, 1993). The Sandia Creek Drive Bridge was easily overtopped by the flood wave, and extensive overbank vegetation damage occurred in the area immediately surrounding the bridge.

Reservoir Spilling

Spilling from Lake Skinner and Vail Lake was not a contributing factor during the 1993 flood event. Within the Santa Margarita River watershed, the reservoirs captured all (or virtually all) of the upstream flow.

Skinner Reservoir (a.k.a., Lake Skinner) spilled less than 10 cfs during the 1993 flood (as well as the during the 1995 and 1998 flood events). Vail Lake did not spill during the 1993 flood, nor did it spill during the 1995 or 1998 floods—all three events were analyzed in the USACE Los Angeles District study of the watershed (WEST Consultants, 2000).

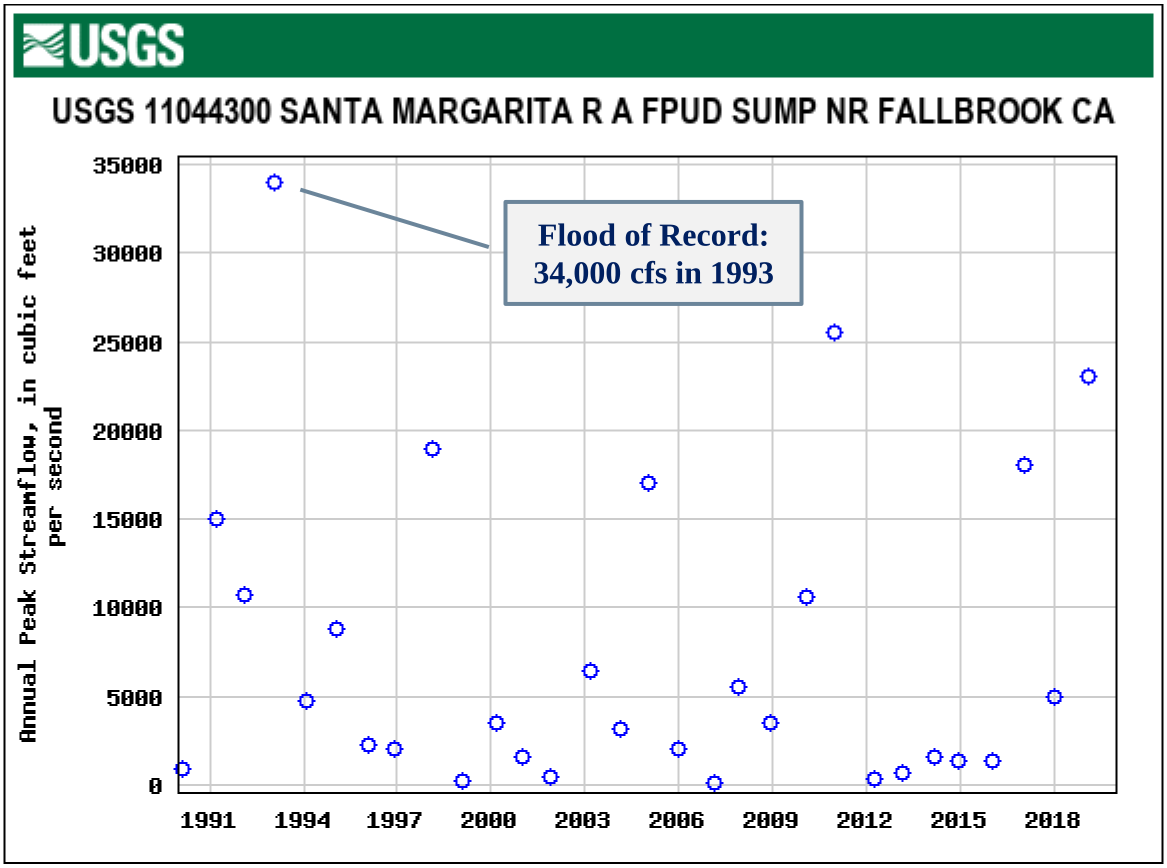


Figure 2.2. Annual Peak Streamflow at USGS Gage #11044300 (Santa Margarita River near Fallbrook)

Other Major Flood Flows

Other major Santa Margarita River flows recorded by USGS gage #11044300 occurred in 1927 (33,100 cfs), 1938 (28,800 cfs), 1969 (22,000 cfs), 1978 (22,000 cfs), 1980 (21,000 cfs), 1998 (19,000 cfs), 2010 (25,500 cfs), and 2017 (18,100 cfs), and 2019 (23,000 cfs).

Bridge Overtopping

The Sandia Creek Drive Bridge overtops regularly enough that the County of San Diego has installed a continuously-operated webcam to inform residents of current conditions at the bridge (www.sdcfcd.org/sandiacreeknew.html). Road closures are so predictable that County personnel often installs warning signs near the bridge well in advance of flooding.

3 HYDROLOGIC MODEL DEVELOPMENT

The Santa Margarita River watershed was modeled using the U.S. Army Corps of Engineers' HEC-HMS (Hydrologic Modeling System), version 4.7.1 (HEC, 2021). Model data and parameters were selected based on the methodology of the San Diego County Hydrology Manual (County of San Diego, 2003).

3.1 Watershed Data

Topographic Data

The topographic data used for the watershed is the USGS National Elevation Dataset (NED). ArcGIS was used to create a Digital Elevation Model (DEM) for the watershed, shown in Figure 3.1. The watershed elevation ranges from sea level to approximately 6,800 feet.

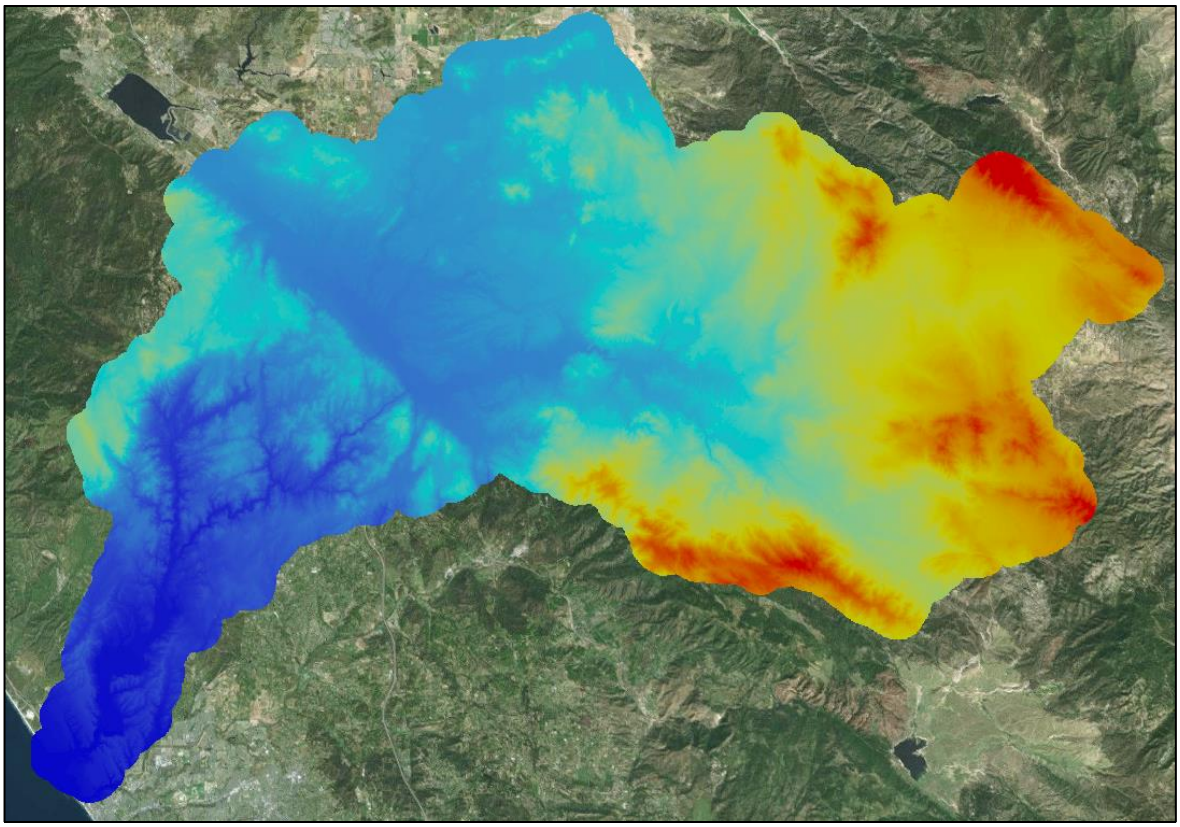


Figure 3.1. Santa Margarita River Watershed – Digital Elevation Model (DEM)

Datum and Projection

The horizontal datum/projection used for this study is NAD 1983, State Plane California Zone 6, FIPS 0406, US Feet. All elevations are referenced to the NAVD88 vertical datum. An NGVD29 to NAVD88 datum conversion factor of +2.25 feet was applied where applicable (source: VERTCON).

Soils Data

The Natural Resources Conservation Service (NRCS) produces a county-level soils dataset known as the Soil Survey Geographic (SSURGO) Database. Soils data for the watershed were used to develop a Hydrologic Soil Group layer, shown in Figure 3.2.

NRCS methodology divides soils into four hydrologic soil groups, as defined below:

- A – High infiltration rate, low runoff potential
- B – Moderate infiltration rate, moderately low runoff potential
- C – Low infiltration rate, moderately high runoff potential
- D – Very low infiltration rate, high runoff potential

A majority of the watershed is comprised of Type D soils, followed by significant percentages of Type A and Type C soils. Type B soils comprise only a small portion of the overall watershed.

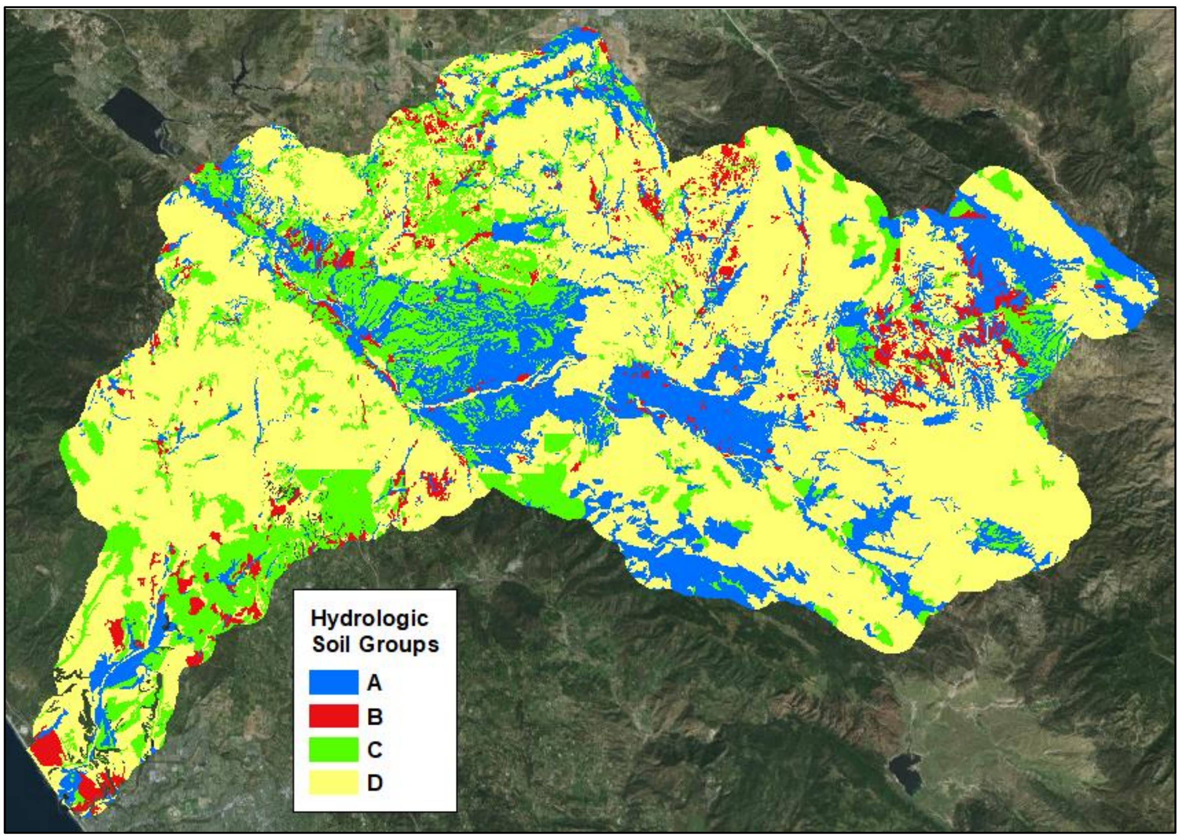


Figure 3.2. Santa Margarita River Watershed – Hydrologic Soil Groups

Land Cover/Land Use Data

Land use data for the subbasins was obtained from the 2016 NOAA Land Cover database. Figure 3.3 shows the land use/vegetation coverage for the watershed. The most dominant land use/vegetation type is shrub/scrub. There are developed areas (low, medium, and high density) and open spaces on the western side of the watershed. Cultivated land, evergreen forest, and open water areas are sparsely distributed throughout the watershed. The southwestern portion of the watershed is predominantly grassland and some developed/open spaces towards the outlet of the Santa Margarita River.

NRCS Curve Number

By combining the land cover type and hydrologic soil groups found within each subbasin, an area-weighted NRCS curve number (CN) was assigned to estimate precipitation loss rates from the watershed. This process was automated using ArcGIS and the R programming language (R Core Team, 2020), and then values were manually entered into HEC-HMS. CN values for land use types found within the watershed are listed in Table 3-1 for each of the Hydrologic Soil Groups.

Table 3-1. Land Use Type, Hydrologic Soil Group, and CN Values

NLCD Land Use	San Diego County Land Use	Hydrologic Soil Group				Hydrologic Condition
		A	B	C	D	
Open Water	Water Surface During Floods	97	98	99	99	n/a
Developed, Open Space	Open Space (lawns, parks, etc.)	39	61	74	80	Good
Developed, Low Intensity	Residential, 1-acre average lot size	51	68	79	84	n/a
Developed, Medium Intensity	Residential, 1/4-acre average lot size	61	75	83	87	n/a
Developed, High Intensity	City of San Diego High Density Residential	75	82	88	90	n/a
Barren Land	Barren	78	86	91	93	n/a
Deciduous Forest	Woodland-Grass combination	33	58	72	79	Good
Evergreen Forest	Wood or Forest land	25	55	70	77	Good
Mixed Forest	Average of Woodland-Grass and Wood	29	57	71	78	Good
Shrub/Scrub	Sagebrush with Grass understory	27	35	47	55	Good
Herbaceous	Herbaceous Mixture	40	62	74	85	Good
Hay/Pasture	Pasture or Rangeland	39	61	74	80	Good
Cultivated Crops	Cultivated Land (with conservation treatment)	62	71	78	81	n/a
Woody Wetlands	Water Surface During Floods	77	86	91	94	n/a
Emergent Herbaceous Wetlands	Water Surface During Floods	98	98	98	98	n/a

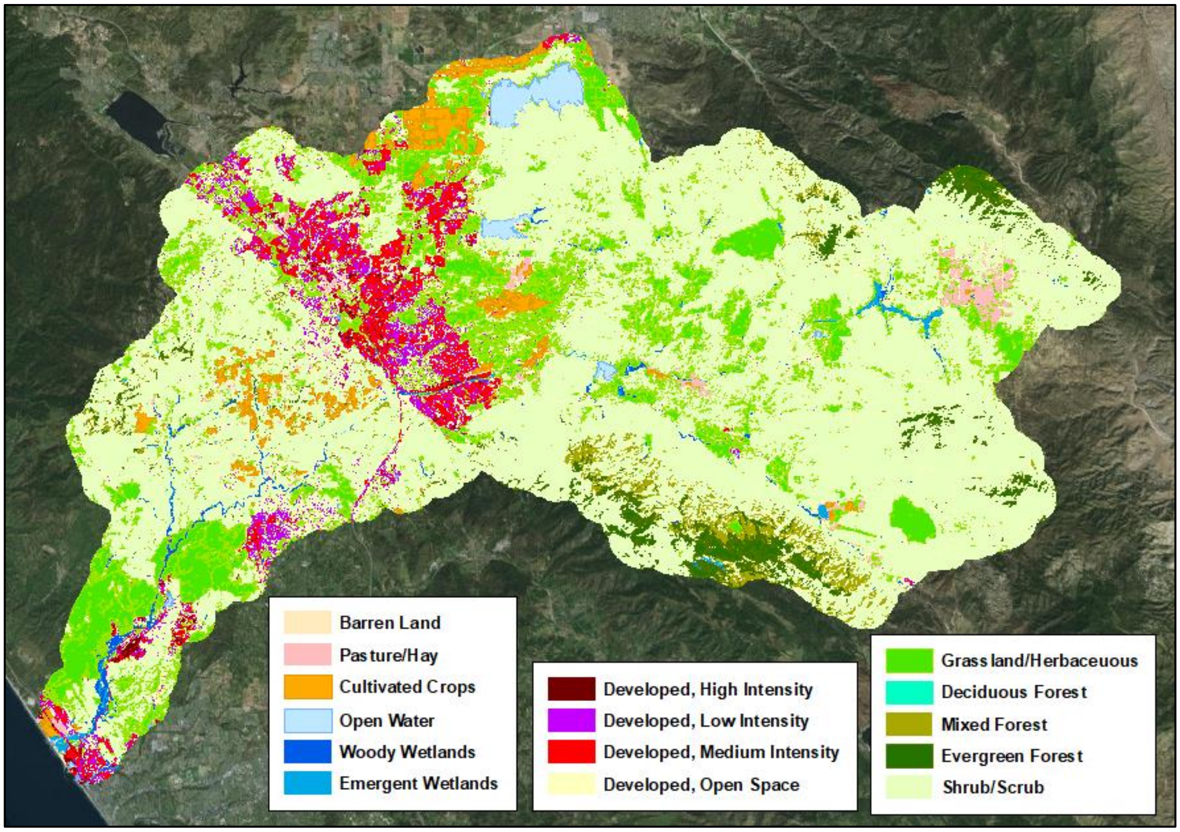


Figure 3.3. Santa Margarita River Watershed – Land Cover/ Land Use

3.2 Precipitation Data

Precipitation-Frequency Data

More than 80 percent of the watershed is located in Riverside County; therefore, precipitation from the San Diego County Hydrology Manual was not available for most of the watershed. For consistency throughout the watershed, NOAA Atlas 14 precipitation values were used for all subbasins.

Precipitation depths for the 50-year and 100-year, 24-hour duration events were obtained from the NOAA Atlas 14 precipitation-frequency estimates for California (*http://hdsc.nws.noaa.gov/hdsc/pfds/*). Gridded data were used to determine precipitation-frequency values for each recurrence interval within each subbasin.

The 100-year, 24-hour precipitation depths for the model subbasins ranged from 5.8 inches at the coast to 9.3 inches in the mountains.

Areal Reduction

NOAA Atlas 14 estimates are point estimates representative only for a limited area around the point. The Rainfall Depth Area Adjustment or Area Reduction Factor (ARF), as outlined in the San Diego County Hydrology Manual, was used to convert the point precipitation to average precipitation over the project area. The Area Reduction Factor, expressed as a percentage of the point depth, is a function of the area and duration.

3.3 Reservoir Data

The three major reservoirs in the watershed—Vail Lake, Lake Skinner, and Diamond Valley Lake—and their hydrologic model data and assumptions, are described below.

Vail Lake

Vail Lake is a large reservoir in western Riverside County located on Temecula Creek, approximately 16 miles east of Temecula, that has a drainage area of approximately 318 square miles and has a maximum storage capacity of approximately 42,680 acre-feet (LSA, 2020). Using observed storage and elevation data obtained from USGS Gage #11042510 (Vail Lake near Temecula, CA), a storage-elevation relationship was developed and used in the HEC-HMS model. Storage-elevation data is provided in Figure 3.4.

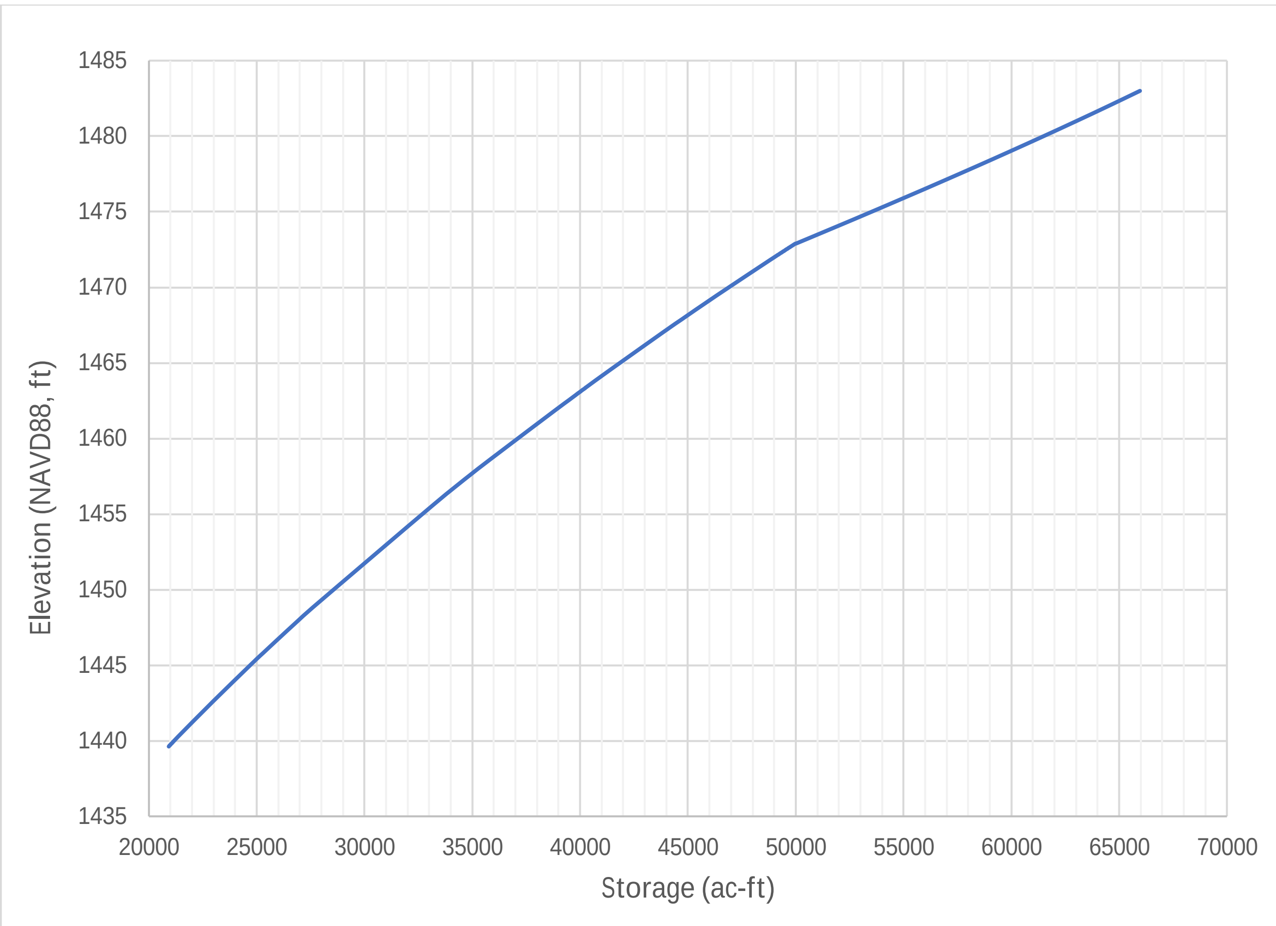


Figure 3.4. Vail Lake Elevation-Storage Curve

The spillway, which has a crest elevation of 1472.6 ft (NAVD88), consists of a 119-ft long ogee weir, a 343-ft long flat-crested weir, and a 65-ft long concrete overpour weir (LSA, 2020). Figure 3.5 illustrates the existing arch dam and spillway features.

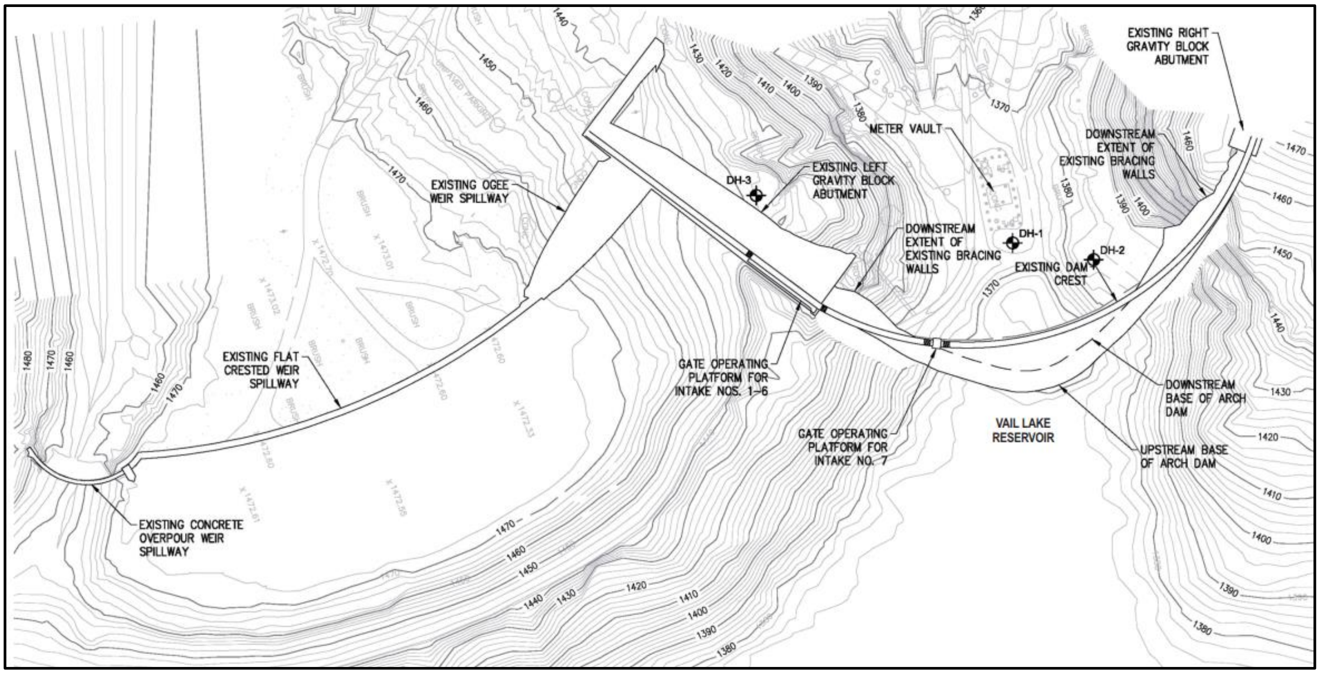


Figure 3.5. Vail Lake Existing Dam and Spillway (LSA, 2020)

To accurately model the expected reservoir outflow during the 100-year return interval event, the spillway structures were parameterized within HEC-HMS as broad crested and ogee weirs set to a crest elevation of 1472.6 ft (NAVD88).

The Maximum Normal Pool Elevation was selected as the starting reservoir condition based on FEMA guidance (FEMA, 2019) and County of San Diego direction. For Vail Lake, the maximum normal pool elevation is 1457.6 ft (NAVD88), which is mandated as the maximum elevation the reservoir can operate by the State of California Division of Safety of Dams.

To verify that the storage-elevation and spillway structures within HEC-HMS were producing reasonable outflow values, the highest recorded outflow was compared with the computed discharge. Based on the USGS data gage #11042510, the maximum elevation recorded at Vail Lake was 1475.3 ft (NAVD88), which corresponded to a discharge of 8,000 cfs. Results from the hydrologic model simulation correspond very well to observed data—a modeled reservoir elevation of 1475.3 ft (NAVD88) produced a discharge of 7,990 cfs.

Lake Skinner

Lake Skinner, which is located approximately 10 miles northeast of Temecula on Tucalota Creek, has a drainage area of approximately 51 square miles and a maximum storage capacity of approximately 43,800 acre-feet (DWR, 2021). The Lake Skinner Dam is an earthen dam that is approximately 5,150 ft long and has a crest elevation of 1,493 ft (DWR, 2021). A storage-discharge curve was obtained from the previous HEC-2 hydrologic model of the watershed conducted by WEST Consultants (2000) for the U.S. Army Corps of Engineers, Los Angeles District. The storage-discharge relationship is provided in Table 3-2.

The maximum normal pool elevation for Lake Skinner was not available; therefore, the initial storage in the HEC-HMS model was set equal to the storage capacity of the reservoir (43,800 acre-feet). This is a conservative assumption that assumes the reservoir is full when the design flood event occurs.

Table 3-2. Lake Skinner Storage-Discharge Data

Storage (Acre-ft)	Discharge (cfs)
0	0
22,284	0.1
23,921	0.2
25,559	0.3
27,331	0.4
29,104	1
30,949	1
32,866	1
34,783	1
43,800	1
44,072	65
44,616	365
45,160	820
45,568	1,250
45,840	1,495
46,520	2,250
47,900	4,400
49,300	7,125
50,667	10,250
52,000	13,750

Diamond Valley Lake

Diamond Valley Lake is a reservoir located near the northeast limits of the watershed. The reservoir was created by three separate dams, one each at the east and west ends of Domenigoni/Diamond Valley and a saddle dam at the low point on the north rim. As one of the largest reservoirs in southern California, it has a capacity of 810,000 acre-feet, providing water supply for drought, peak summer, and emergency needs. With the sole purpose of storing imported water for water supply and only a minimal local contributing area, Diamond Valley Lake is modeled as a sink in the HEC-HMS hydrologic model.

3.4 HEC-HMS Model Parameters

River Focus used the U.S. Army Corps of Engineers' HEC-HMS (Hydrologic Modeling System), version 4.7.1 (HEC, 2021) to perform hydrologic modeling of the watershed.

Subbasin Delineation

The Santa Margarita River watershed was subdivided into smaller subbasins for the hydrologic modeling effort, as shown in Figure 3.6. Subbasins are used to divide the larger watershed into manageable smaller sections with similar drainage characteristics, and to capture drainage areas upstream of dams/reservoirs. ArcGIS was used to complete the subbasin delineation and stream network creation.

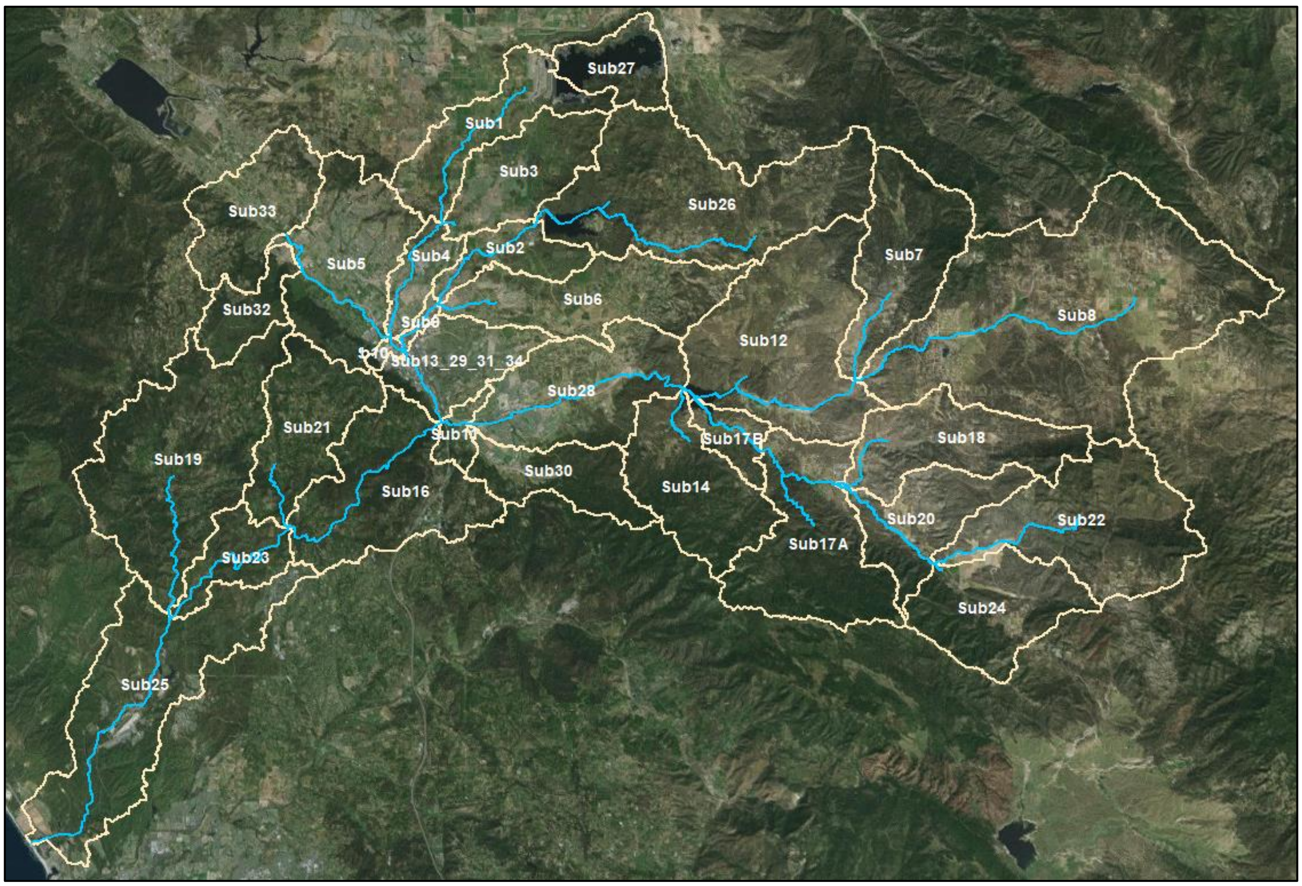


Figure 3.6. Santa Margarita River Watershed – HEC-HMS Subbasins

NRCS Curve Number Loss Rate Method

Per the San Diego County Hydrology Manual, the NRCS Curve Number (CN) method (also known as the SCS method) was used for estimating precipitation losses from the watershed. As described previously, the hydrologic soil group data (Figure 3.2) was combined with the land use/vegetation data (Figure 3.3) and the corresponding CN values (Table 3-1) yielding the area-weighted subbasin CN.

Precipitation Zone Number

The Precipitation Zone Number (PZN) is intended to be an indicator of antecedent moisture conditions and also reflects orographic effects within San Diego County. Based on guidance outlined in the Hydrology Manual, weighted CNs must be adjusted for PZN Condition based on the storm frequency and the location of the watershed within the county. Because most of the Santa Margarita River Watershed is outside of San Diego County and is within Riverside County, the San Diego County Hydrology Manual does not have sufficient coverage of PZN areas for the watershed.

To provide consistency in the hydrologic modeling methods used, the PZN zones were extrapolated into Riverside County based on terrain and elevations, which are an indicator of micro-climate and orographic effects. Once the PZN areas (coast, foothill, mountain, and desert) were extended to include the portions of the watershed that are in Riverside County, the subbasin curve numbers were adjusted based on Tables 4-6 and 4-10 in the Hydrology Manual (page 4-47). Adjusted CN values are listed in Table 3-3.

Runoff Transform and Basin Lag

Per the San Diego County Hydrology Manual, the NRCS (SCS) unit hydrograph method was selected as the rainfall-runoff transformation method in the HEC-HMS model. The NRCS method requires two input parameters: basin lag time and the peak rate factor. The calculation of basin lag was based on the U.S. Army Corps of Engineers relationship ("Corps Lag") in which lag is defined as the amount of time from the start of the rainfall to the peak of the runoff hydrograph:

$$\text{Corps Lag (hours)} = 24 * \bar{n} * ((L * L_c)/s^{0.5})^{0.38}$$

Where:

$\bar{n}$ = the average of the Manning's *n* values of the watercourse and its tributaries

L = length of the longest watercourse (miles)

L_c = length along the longest watercourse to basin centroid (miles)

s = overall slope of drainage area between headwaters and collection point (ft/mile)

Lag parameters in the Corps of Engineers' SMR HEC-1 model were used as a starting point, but all model parameters were re-developed based on the San Diego County Hydrology Manual methodology. The lag times were not adjusted directly; only the $\bar{n}$ (average Manning's *n*) values were adjusted based on basin characteristics and aerial imagery—values are provided in Table 3-3.

A USDA Forest Service study of high-gradient streams (Yochum et al., 2014) found that Manning's *n* values for high-gradient streams were significantly higher than values that were traditionally used for modeling. According to Yochum et al., 2014, measurements of actual velocity and flow resistance indicate that reach-average resistance coefficients are substantially higher than commonly encountered in low-gradient channels, with Manning's *n* typically falling between 0.1 to 0.3 for bankfull flows in step-pool and cascade channels.

The computed Corps lag (hours) was converted to the NRCS lag (min) for use in the HEC-HMS model. The computed lag time for each subbasin is shown in Table 3-3.

Table 3-3. Subbasin Curve Numbers and Lag Time Parameters

HMS Subbasin	Area (sq. mi.)	Adjusted CN	L (mi)	L_{ca} (mi)	$\bar{n}$	Lag (min)
Sub01	18.94	84	12.514	4.534	0.08	132
Sub02	9.37	75	7.07	3.992	0.06	162
Sub03	18.03	78	9.628	4.355	0.07	120
Sub04	7.20	73	6.535	3.99	0.06	114
Sub05	28.92	73	11.308	5.778	0.05	162
Sub06	26.18	72	16.248	7.706	0.11	282
Sub07	25.06	77	11.641	6.409	0.18	174
Sub08	88.97	70	22.3	11.49	0.15	270
Sub09	1.18	68	3.326	1.791	0.06	84
Sub10	1.04	65	1.287	0.311	0.05	18
Sub11	3.50	64	2.401	0.823	0.075	30
Sub12	43.44	75	12.331	7.377	0.13	168
Sub13_29_31_34	15.16	67	9.19	5.03	0.05	126
Sub14	23.68	72	11.776	5.232	0.19	126
Sub16	32.53	67	11.73	5.639	0.15	168
Sub17A	31.87	70	13.64	6.80	0.19	138
Sub17B	5.93	69	6.34	2.61	0.15	78
Sub18	23.20	72	13.584	7.242	0.17	156
Sub19	47.87	66	16.192	7.672	0.15	252
Sub20	17.64	73	12.671	5.298	0.17	138
Sub21	21.48	68	12.009	5.675	0.11	228
Sub22	36.15	73	15.089	8.102	0.17	186
Sub23	10.38	62	8.259	4.337	0.11	162
Sub24	22.88	78	8.237	3.579	0.18	114
Sub25	44.46	64	20.763	9.478	0.10	378
Sub26	51.04	75	18.792	7.786	0.12	210
Sub27	10.65	92	7.22	3.306	0.15	162
Sub28	28.43	59	13.68	5.941	0.08	204
Sub30	14.41	66	11.271	5.454	0.12	168
Sub32	8.96	77	7.337	3.623	0.08	108
Sub33	20.37	73	7.669	2.196	0.06	60

Peak Rate Factors

The peak rate factor (PRF) is applied to the ordinates of the SCS Dimensionless Unit Hydrograph that alters the hydrograph's shape while maintaining the total volume of runoff. The default PRF for the triangular dimensionless unit hydrograph is 484. Any change in the dimensionless unit hydrograph reflecting a change in the percent of volume under the rising limb of the hydrograph would cause a corresponding change in the shape factor associated with the triangular hydrograph and, therefore, a change in the constant PRF of 484 (NRCS, 2007).

Steep terrain and urban areas tend to produce higher early peaks and thus values of the PRF will be higher, tending towards a value of 600. Likewise, flatter non-urban regions tend to retain and store the water, causing a delayed and lower peak. In these circumstances, PRFs may tend towards 300 or lower (SCS 1972; Wanielista, et al. 1997, NOAA 2005). Forested areas with significant canopies also tend to retain and store water, yielding lower PRFs.

For this study, peak rate factors were determined based on terrain and land-use/vegetation type, with guidance provided in Table 3-4:

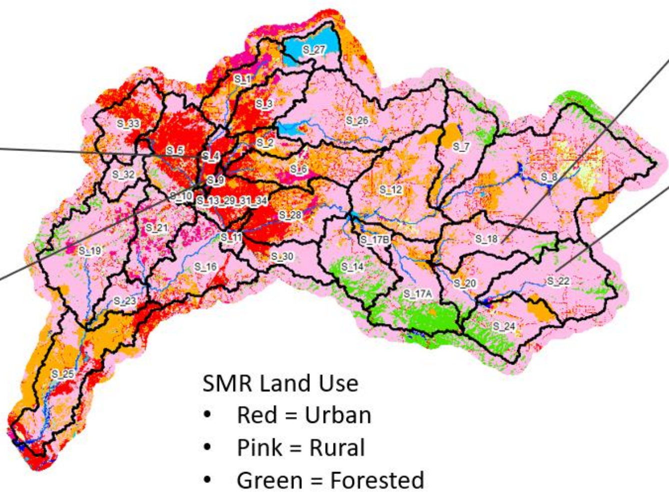
- Higher percentage of urbanization → higher PRFs
- Rural land use and/or gentle slopes; high percentage of forested area → lower PRFs

Table 3-4. Hydrograph Peaking Factors (Wanielista, et al. 1997, NOAA 2005)

General Description	Peaking Factor	Limb Ratio (Recession to Rising)
Urban areas; steep slopes	575	1.25
Typical SCS	484	1.67
Misxed urban/rural	400	2.25
Rural, rolling hills	300	3.33
Rural, slight slopes	200	5.5
Rural, very flat	100	12.0

Figure 3.7 shows the computed PRF for each subbasin considering land use/vegetation type within Santa Margarita River watershed. Selected example subbasins are highlighted.

Subbasin	Peak Rate Factor
S01	200
S02	400
S03	350
S04	500
S05	450
S06	300
S07	250
S08	100
S09	550
S10	450
S11	450
S12	150
S13_29_31_34	500
S14	200
S16	200
S17A	150
S17B	250



Subbasin	Peak Rate Factor
S18	200
S19	300
S20	250
S21	350
S22	300
S23	300
S24	150
S25	400
S26	200
S27	200
S28	350
S30	350
S32	200
S33	350

Figure 3.7. Peaking Factor Computation for Santa Margarita River Watershed considering Land Use Type for Each Subbasin

Routing Reaches

The Muskingum-Cunge method with trapezoidal channel shapes was used as the reach routing method in the HEC-HMS model. Reach and channel parameters are summarized in Table 3-5.

Table 3-5. Summary of Routing Reach Parameters

HMS Name	Length (ft)	Slope (ft/ft)	Shape	Width (ft)	Side Slope (xH:1V)	Manning's *n*
R_1 (1.1)	69010	0.0020	Trapezoid	150	5	0.04
R_2	39283	0.0061	Trapezoid	100	2.5	0.04
R_3	50424	0.0119	Trapezoid	100	2	0.03
R_4	4435	0.0044	Trapezoid	115	2.5	0.035
R_5	60984	0.0066	Trapezoid	380	2	0.04
R_6A	23574	0.0120	Trapezoid	60	3	0.05
R_6B	25098	0.0120	Trapezoid	60	3	0.05
R_7	35482	0.0205	Trapezoid	40	3	0.05
R_8	46358	0.0154	Trapezoid	60	3	0.05
R_9 (11)	20091	0.0025	Trapezoid	200	2	0.035
R_12 (13)	13781	0.0035	Trapezoid	200	5	0.04
R_14	33528	0.0095	Trapezoid	200	5	0.04
R_15	4259	0.0023	Trapezoid	200	5	0.04
R_18	31786	0.0029	Trapezoid	50	2	0.035
R_16	32736	0.0069	Trapezoid	50	2	0.04
R_17	55334	0.0039	Trapezoid	50	2	0.04
R_19	8818	0.0060	Trapezoid	200	5	0.035

4 HEC-HMS MODEL RESULTS

Peak discharges for the study reach were computed using HEC-HMS for the 2% annual chance exceedance (50-year) and 1% annual chance exceedance (100-year) events. This chapter provides the computed design discharges and compares them with flood-frequency results and other study discharges in the watershed.

4.1 Design Discharges

The 50- and 100-year computed Santa Margarita River peak discharges for the Sandia Creek Drive Bridge are presented in Table 4-1. Computed values were rounded based on standard USGS rounding rules—all flow values from 10,000 cfs through 100,000 cfs are rounded to the nearest 100 cfs.

Table 4-1. HEC-HMS Computed Peak Flows for Santa Margarita River – Bridge Design Discharges

Flood Event	Percent Chance Exceedance	Project Location (cfs)
50-year	2%	31,100
100-year	1%	38,600

Downstream of the proposed bridge, Sandia Creek joins the Santa Margarita River, increasing the flow in the river. Peak discharges below the confluence of Sandia Creek are presented in Table 4-2.

Table 4-2. HEC-HMS Computed Peak Flows for Santa Margarita River – Downstream of Sandia Creek

Flood Event	Percent Chance Exceedance	Downstream of Sandia Creek (cfs)
50-year	2%	34,500
100-year	1%	42,600

4.2 Peak Flow Comparison

To confirm that computed peak discharges from the hydrologic model were producing reasonable results, computed flows were compared to flood-frequency analysis results at three USGS stream gage locations. Using Bulletin 17C Guidelines (England et al., 2019), River Focus performed a statistical analysis of annual peak flows using the U.S. Army Corps of Engineers' HEC-SSP (Statistical Software Package) software (HEC, 2019).

The USGS gage locations included in the flood-frequency analysis are listed below and are shown in Figure 4.1. A full description of the flood-frequency analysis and results can be found in Appendix A.

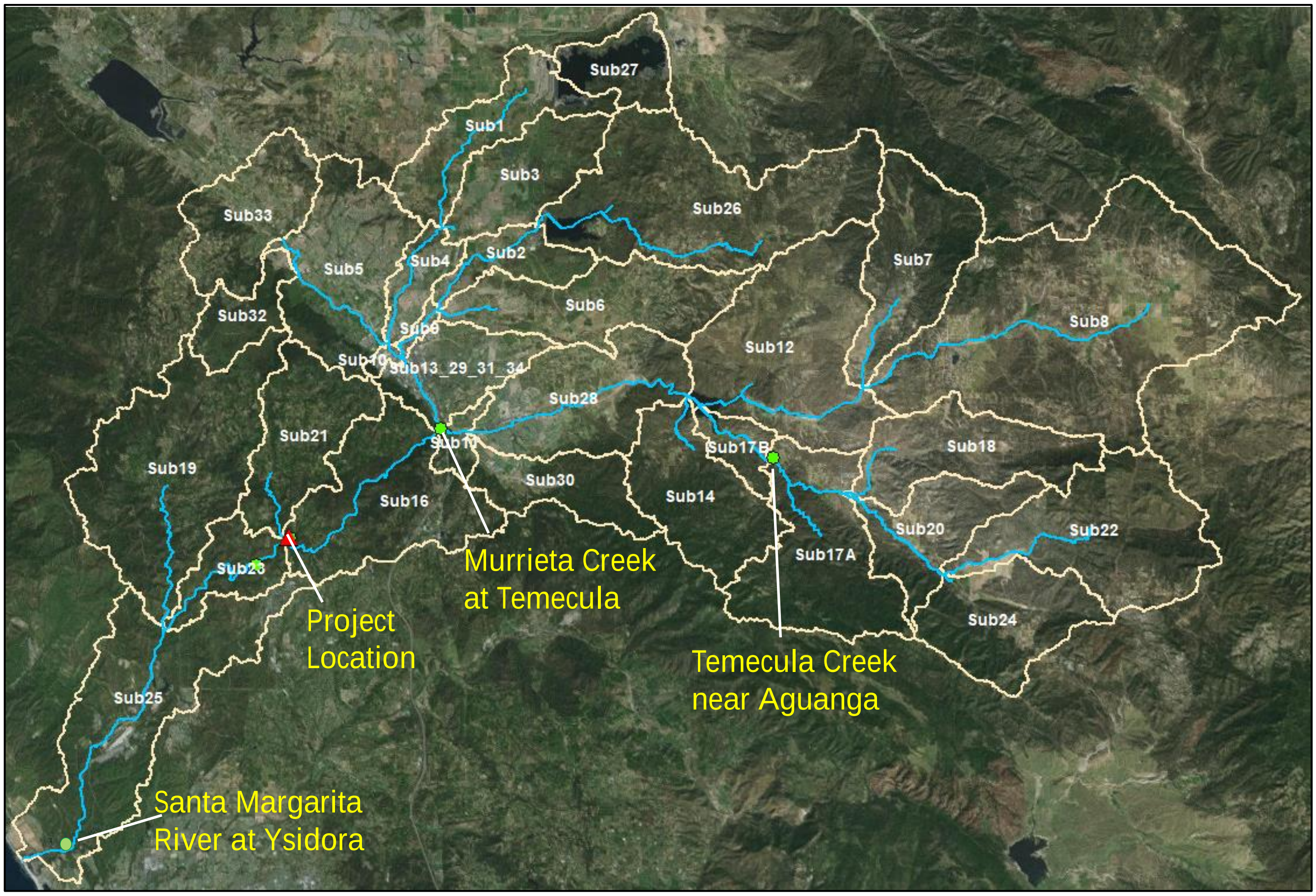


Figure 4.1. Peak Flow Comparison Locations

- Temecula Creek near Aguanga (USGS 11042400). This USGS gage provides unregulated flows for a 131 square-mile watershed above Vail Lake (Figure 4.2). This gage provides 63 years of recorded peak flow data.
- Murrieta Creek at Temecula (USGS 11043000). This USGS gage and FEMA FIS flow location provides flows for the 222 square-mile Murrieta Creek limited-regulated watershed (Figure 4.3). This gage has been studied extensively by U.S. Army Corps of Engineers and provides 90 years of recorded peak flow data.
- Santa Margarita River at Ysidora (USGS 11046000). This USGS gage located downstream of the project location and near the outlet of the Santa Margarita River Watershed provides flows for the 723 square-mile watershed (Figure 4.4). This gage has almost 100 years of recorded peak flow data before and after Vail Dam construction (1948). The gage includes flow contributions from Murrieta Creek, Temecula Creek and local creek flows.

HEC-HMS flows were computed with the variable peak rate factors described in Section 3.4, as well as the default peak rate factor (484) for comparison purposes, i.e., to verify that the HMS model with variable peak rate factors used in this study provides better results than the default peak rate factor.

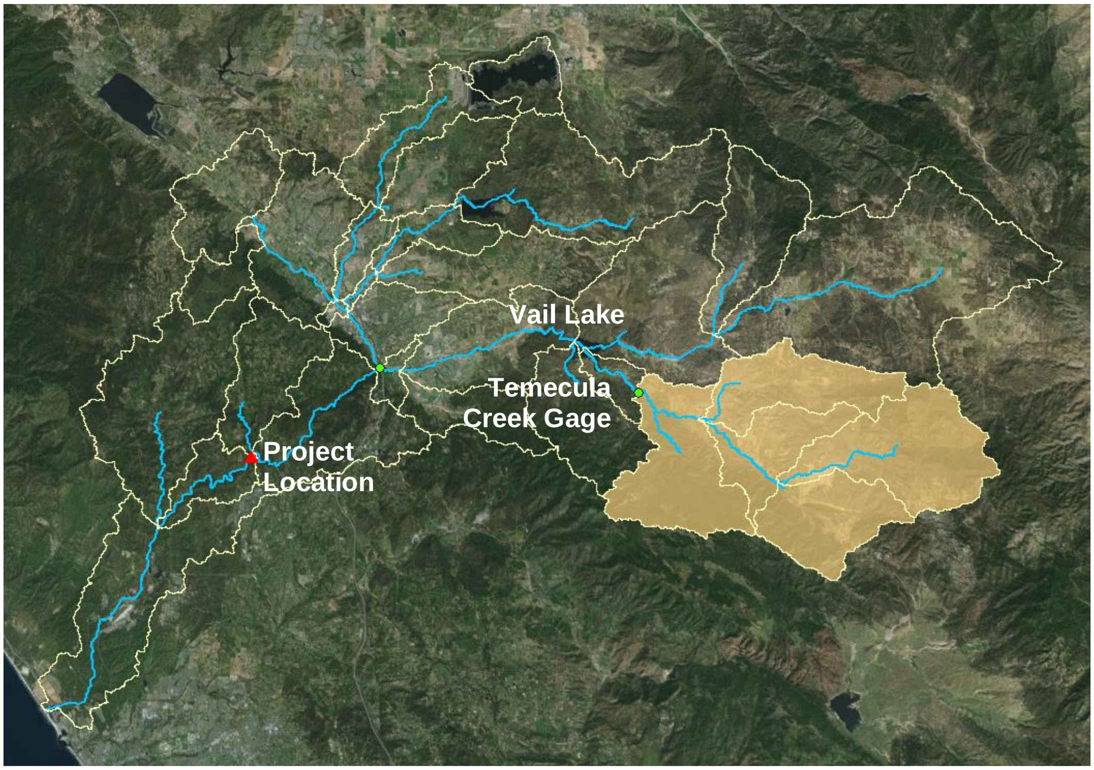


Figure 4.2. Temecula Creek USGS Gage with Unregulated Watershed Upstream of Vail Lake

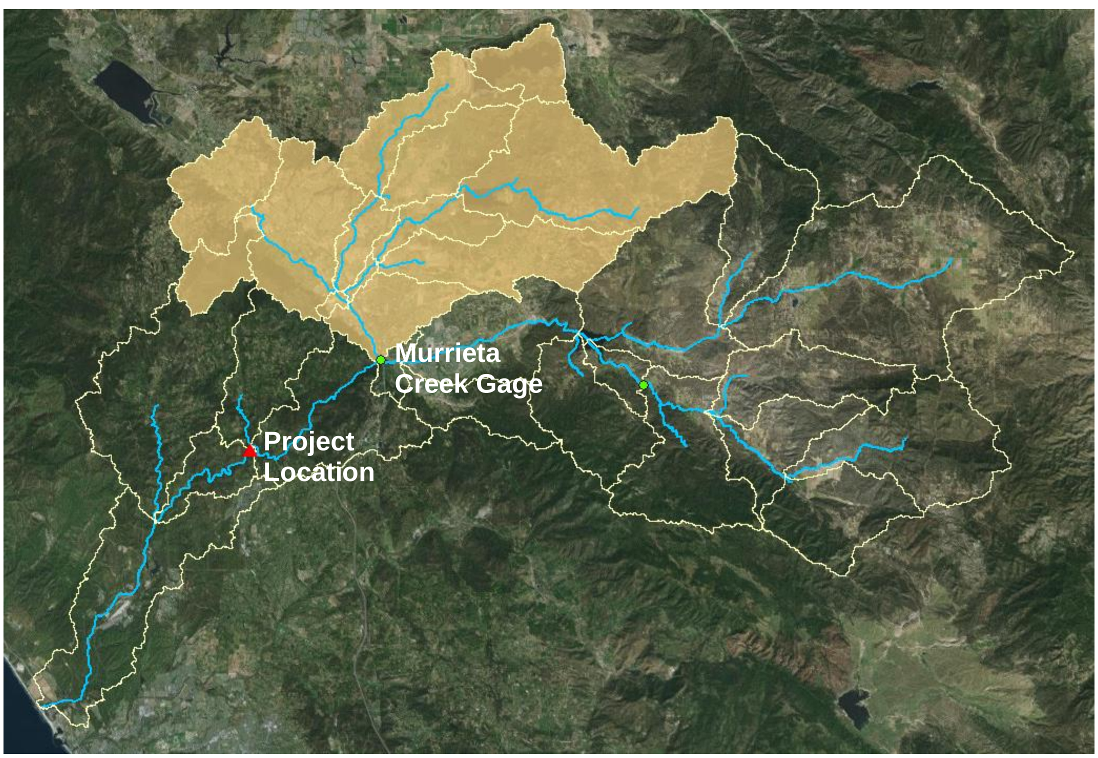


Figure 4.3. Murrieta Creek Watershed (Limited Regulation)

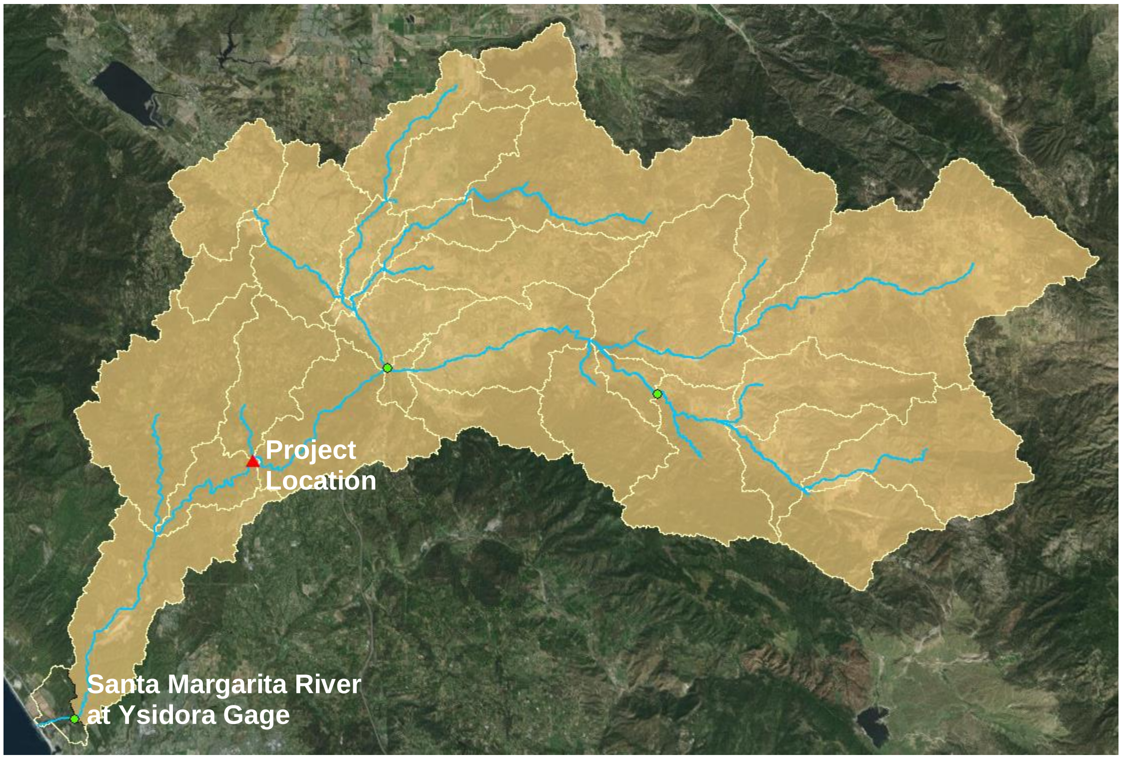


Figure 4.4. Santa Margarita River Watershed at Ysidora USGS Gage

Temecula Creek Upstream of Vail Lake

As shown in Table 4-3, the HMS computed flow with variable peak factors—used in the current study—are consistent (and somewhat conservative) when compared to the flood-frequency analysis flows based on observed gage data. For comparison, the HMS computed flows with the default peak factor are much larger than the flood-frequency flows. The regression flows are even larger—more than double the flood-frequency flows. Figure 4.5 compares the observed annual peaks recorded at the gage over 62 years to the computed flows.

The results at this unregulated watershed gage show that the HMS model used for the project provides reasonable and conservative flows at this gage, while the default peak factor HMS model and regression equations do not provide realistic results based on observed data.

Table 4-3. Peak Flow Comparison – Temecula Creek at Aguanga (upstream of Vail Lake)

Return Interval Event	Percent Chance Exceedance	HMS Computed Flow (cfs) *Variable PRF*	Observed Gage: Flood Frequency Analysis (cfs)	HMS Computed Flow (cfs) *Default PRF (484)*	Regional Regression Analysis (cfs)
50-year	2%	9,900	7,470	15,300	18,700
100-year	1%	12,500	11,300	19,300	25,900

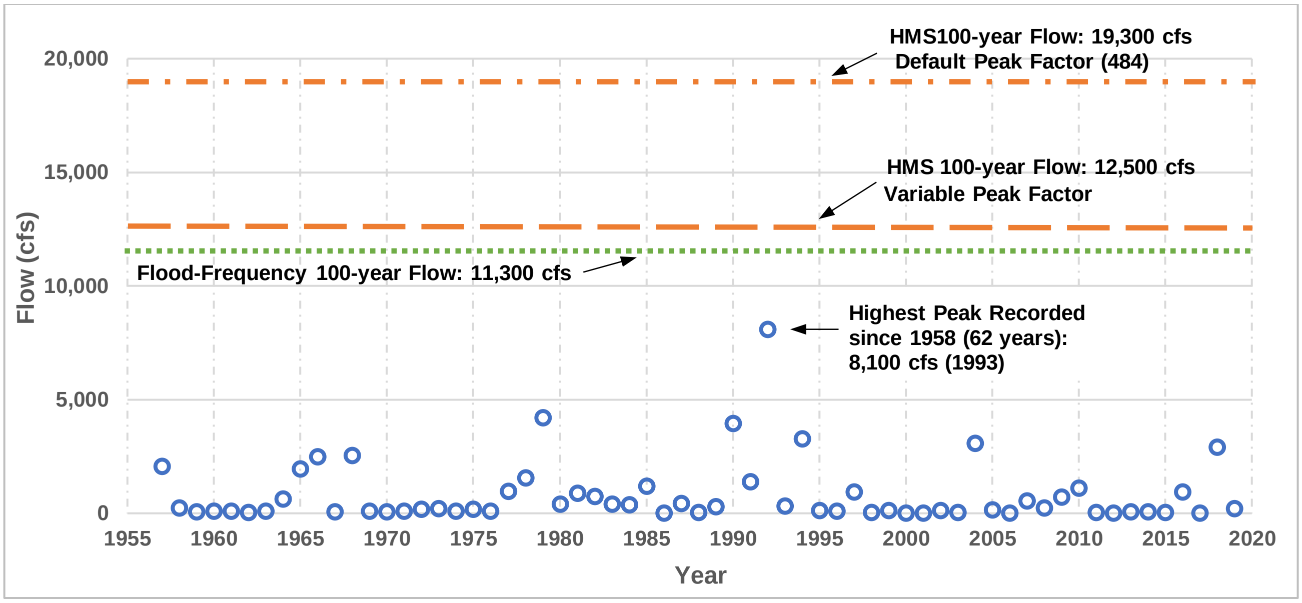


Figure 4.5. Temecula Creek Peak Flow Comparison at Aguanga USGS Gage

Murrieta Creek at Temecula

Table 4-4 shows that the HMS computed flows from the current study are in line with the current FEMA peak flow, the flood-frequency analysis peak flows, and peaks flows from the U.S. Army Corps of Engineers. Figure 4.6 compares the observed annual peaks recorded at the Murrieta Creek gage (over 88 years of peak flow data) to the computed flows.

The results at this location show that the HMS model used for the project provides reasonable flows in line with other studies. The regional regression equations provide lower values in this case because the Murrieta Creek watershed has significant urbanization, while the regression equations are based on non-urbanized watersheds.

Table 4-4. Peak Flow Comparison – Murrieta Creek at Temecula

Return Interval Event	Percent Chance Exceedance	FEMA Flood Insurance Study Peak Flow (cfs)	HMS Computed Flow (cfs) Variable Peak Factor	Observed Gage: Flood Frequency Analysis (cfs)	U.S. Army Corps of Engineers Murrieta Creek Study	HMS Computed Flow (cfs) Default Peak Factor (484)	Regional Regression Analysis (cfs)
50-year	2%	n/a	25,200	26,100	27,000	28,800	21,200
100-year	1%	30,900	31,000	32,500	32,700	35,300	28,900

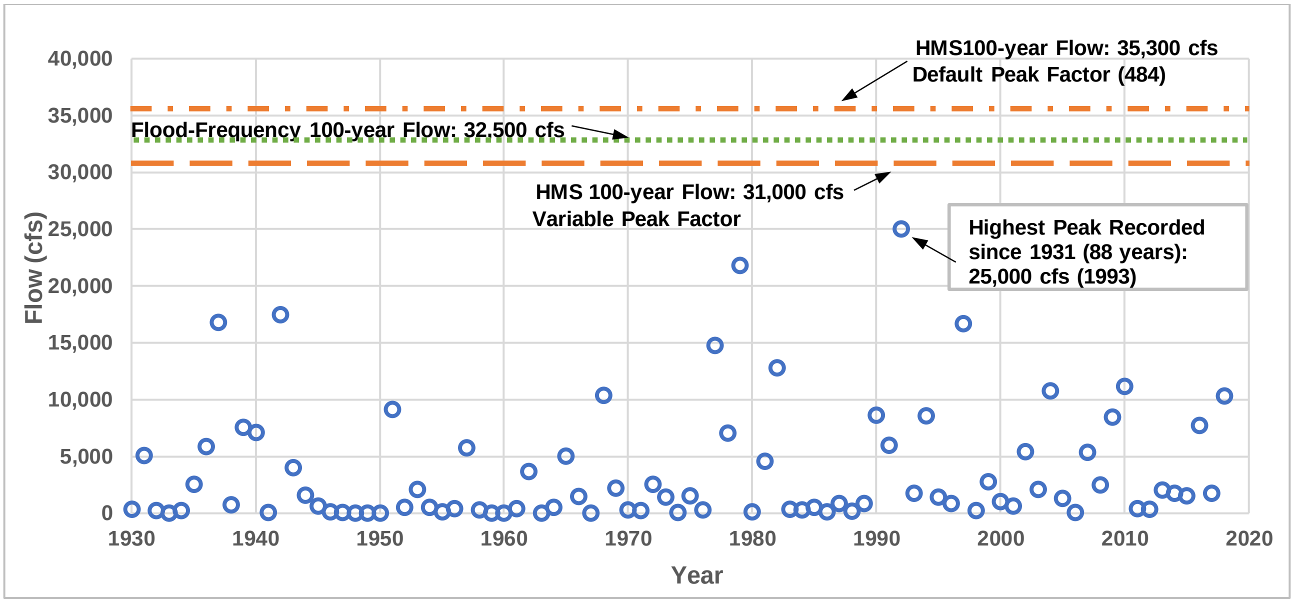


Figure 4.6. Murrieta Creek Peak Flow Comparison at Temecula USGS Gage

Santa Margarita River at Ysidora

Figure 4.7 compares observed flows over an almost 100-year period of record with the computed flows at this location. Again, the HMS model with variable peak runoff factor provides reasonable results based on the historic record.

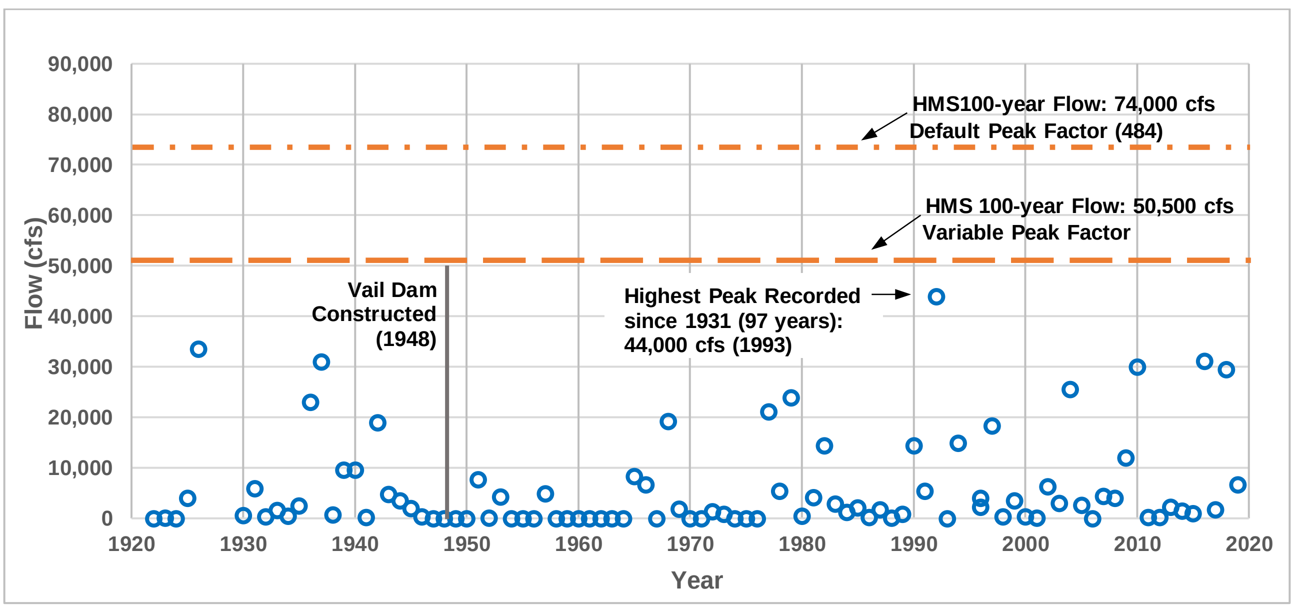


Figure 4.7. Santa Margarita River Peak Flow Comparison at Ysidora USGS Gage

USGS regional regression equations are not applicable in this case because the two watersheds/creeks that combine to create the Santa Margarita River—Murrieta Creek and Temecula Creek—have very different rainfall-runoff responses. The Murrieta Creek watershed has significantly more urbanization and includes the cities of Temecula and Murrieta, while the Temecula Creek watershed consists of mostly very rural scrub and forested areas.

As shown in Figure 4.8, the "flashier" hydrograph associated with the more urbanized Murrieta Creek watershed appears at the project location first, followed by a second peak from the Temecula Creek watershed, which occurs approximately 12 hours later due to long lag times and flow regulation. Because the peaks are not concurrent, or close to concurrent, the total peak flows are lower than they would be for a more uniform watershed of the same size.

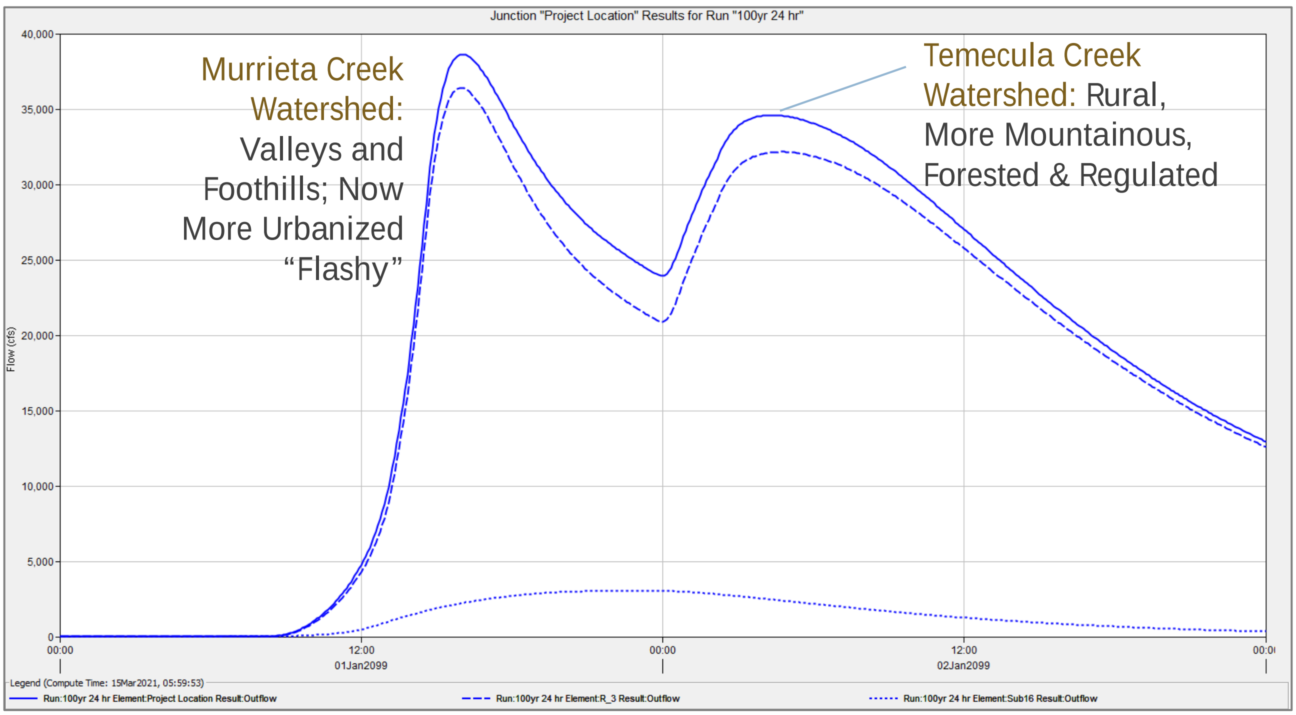


Figure 4.8. 100-year hydrograph at the Project Location

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6 ACKNOWLEDGMENTS

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APPENDIX A. FLOOD-FREQUENCY ANALYSIS

River Focus performed a statistical analysis of annual peak flows using the U.S. Army Corps of Engineers' HEC-SSP (Statistical Software Package) software (HEC, 2019). The analysis was completed at two USGS streamgage locations within the watershed. These gages are listed in Table A-1 and shown in Figure A-1.

Table A-1. USGS Streamgage Stations

USGS Streamgage Name	USGS Station #	Drainage Area (sq. mile)	Period of Record (Annual Peaks)
Temecula Creek near Aguanga	11042400	131	1958 – 2019
Murrieta Creek at Temecula	11043000	222	1931 – 2021

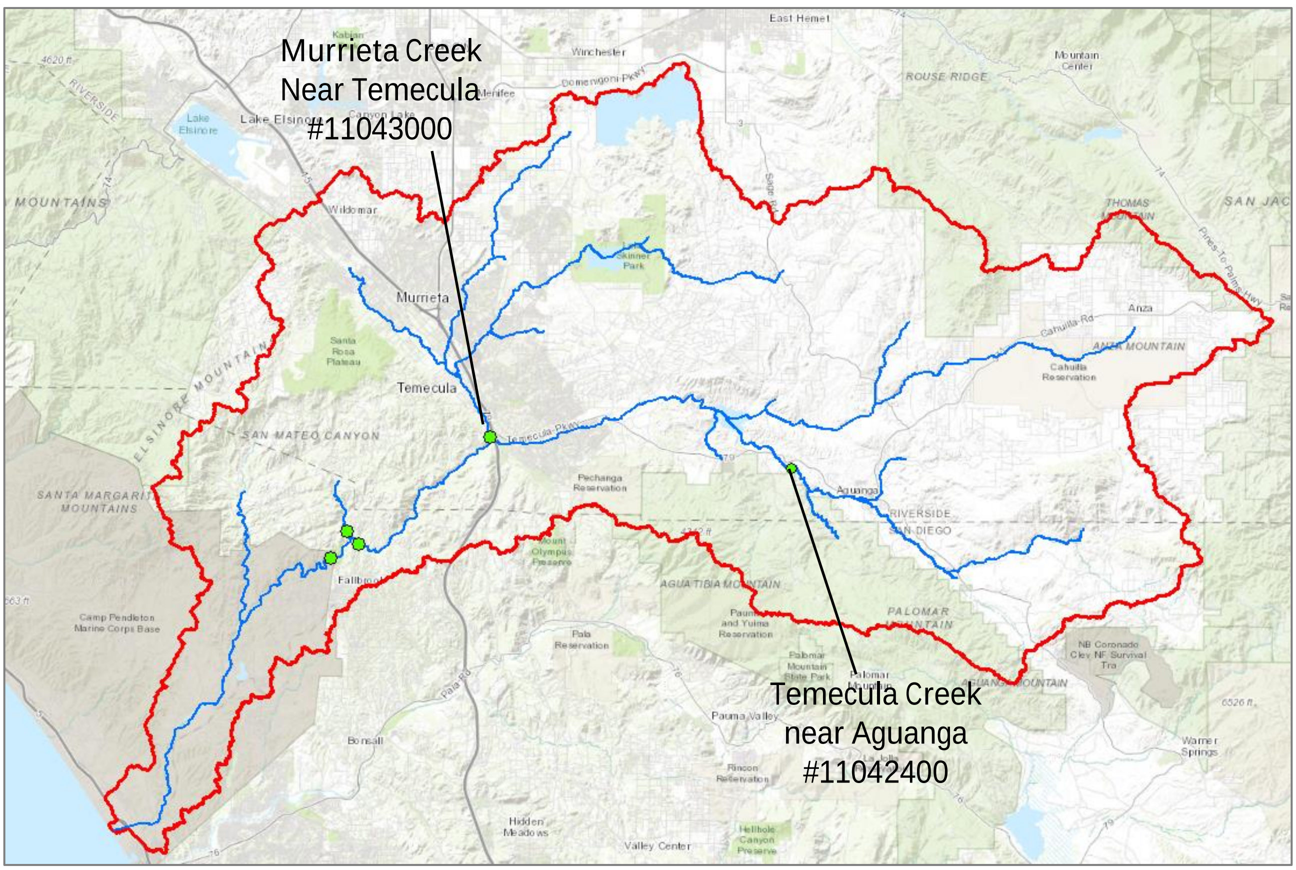

Figure A-1. USGS Streamgage Locations used in the Flood Frequency Analysis

Peak flows were analyzed from the USGS streamgage on Temecula Creek near Aguanga (#11042400), which is located approximately 23 miles upstream of the project location and upstream of Vail Lake. The gage has 61 years of unregulated annual peak flow records.

The USGS streamgage on Murrieta Creek near Temecula (#11043000), which is located approximately 10 miles upstream of the project location, has 90 years of annual peak flow records. The Murrieta Creek watershed has limited regulation in terms of contributing area affected, primarily by Lake Skinner.

Flood Frequency Analysis

Bulletin 17C Guidelines (England et al., 2019) were used for the flood-frequency analysis and for the observed data plotting positions.

The computed flood frequency curves for USGS gage (#1142400) on Temecula Creek and USGS streamgage (#11043000) on Murrieta Creek are shown in Figure A-2 and Figure A-3, respectively. The corresponding 50- and 100- year peak flows from the adopted frequency curves are presented in Table A-2 and Table A-3 for the two gages.

Table A-2. Flood-Frequency Flows for Temecula Creek near Aguanga (USGS #11042400)

Flood Event	Percent Chance Exceedance	Flow (cfs)
50-year	2%	7,470
100-year	1%	11,300

Table A-3. Flood-Frequency Flows for Murrieta Creek near Temecula (USGS #11043000)

Flood Event	Percent Chance Exceedance	Flow (cfs)
50-year	2%	26,100
100-year	1%	32,500

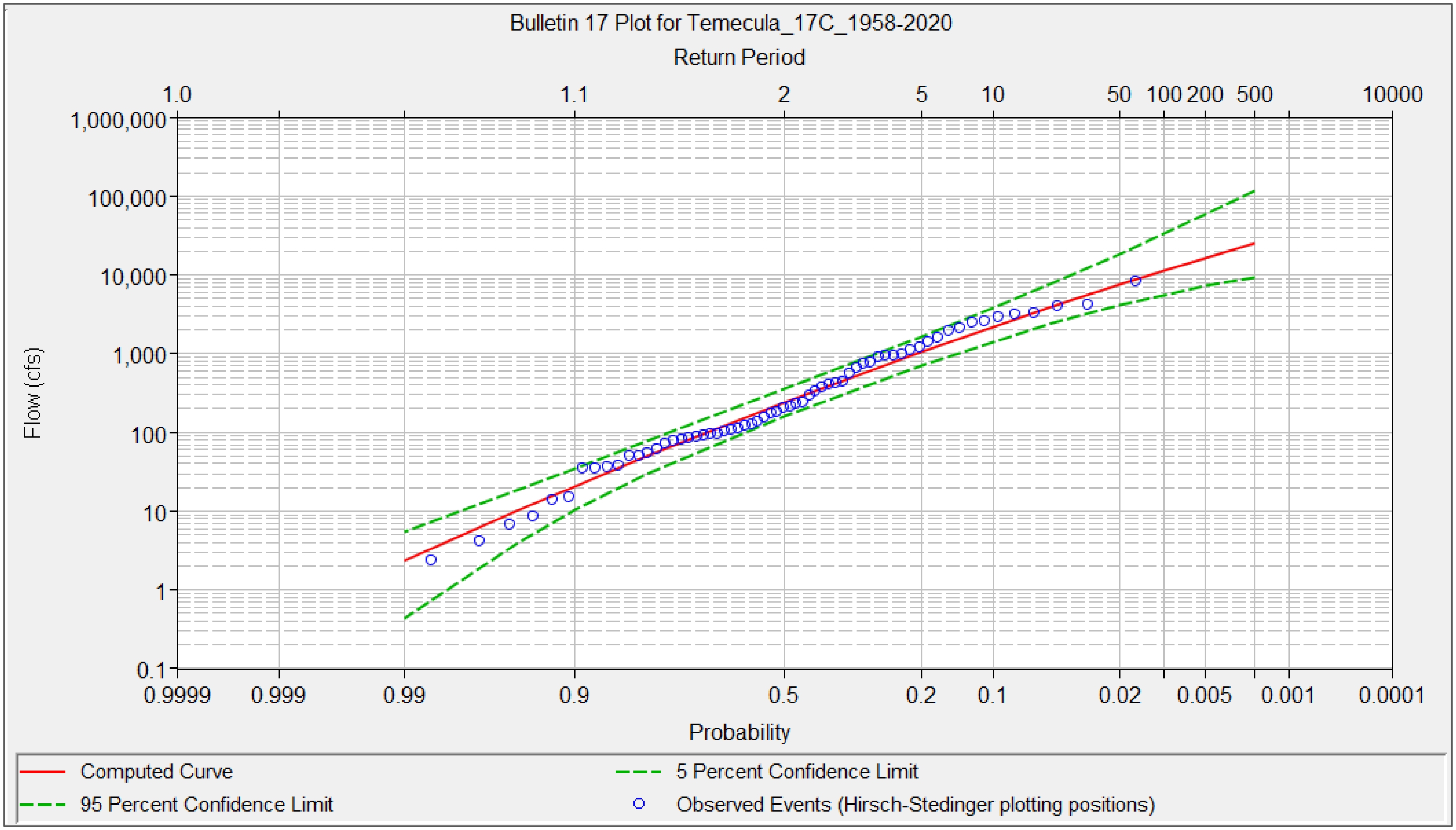

Figure A-2. Temecula Creek near Aguanga Flood-Frequency Curves from HEC-SSP (USGS gage #11042400)

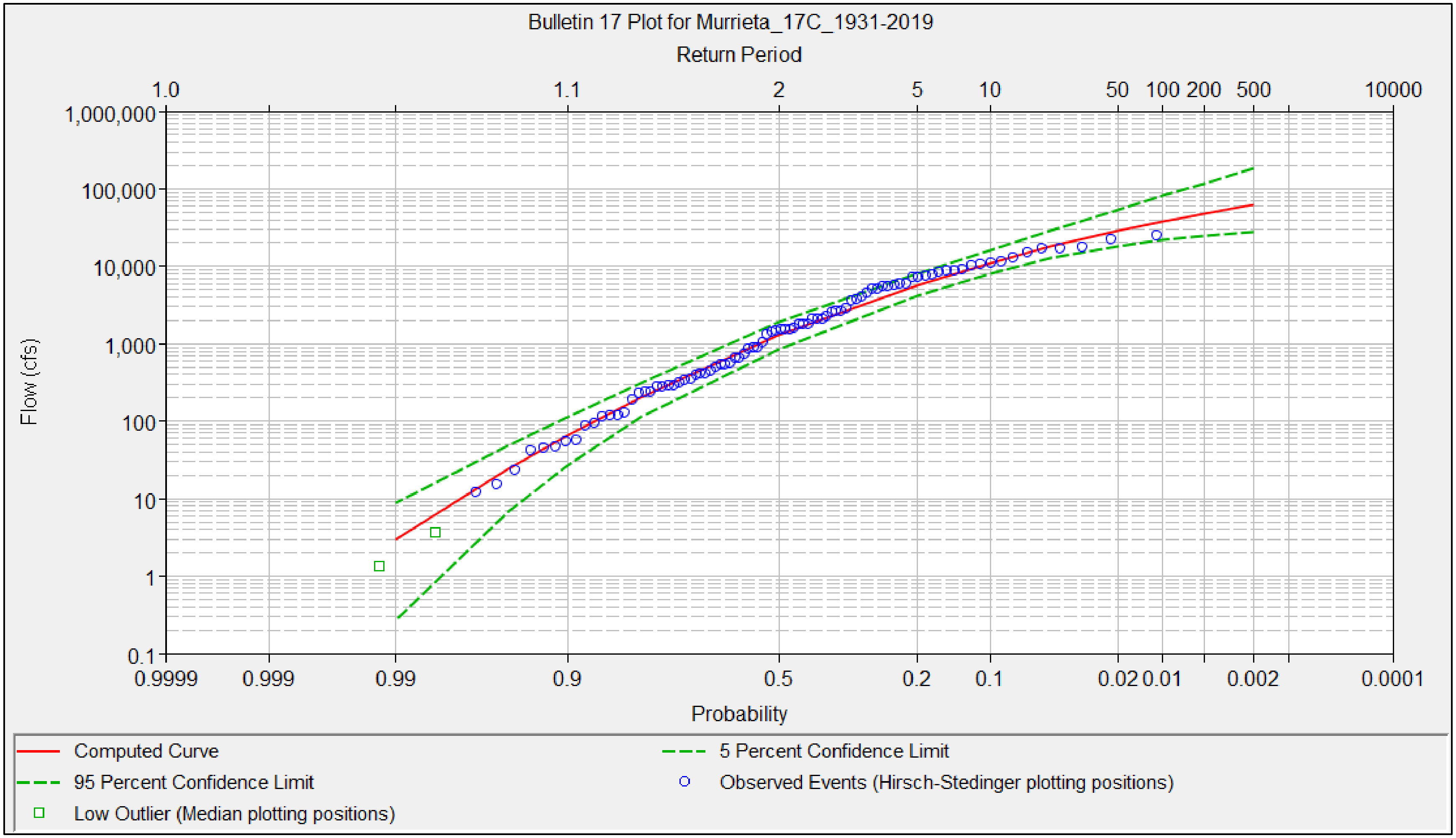

Figure A-3. Murrieta Creek near Temecula Flood-Frequency Curves from HEC-SSP (USGS gage #11043000)